The 10th International Conference
on Architecture and Built Environment

S.ARCH 2023

04-06 April 2023 I Berlin, Germany

ISBN 978-3-9820758-9-1

Proceeding

The 10th International Conference
on Architecture and Built Environment

S.ARCH 2023

04-06 April 2023 I Berlin, Germany

Conference Proceeding

978-3-9820758-9-1

S.ARCH Conferences and AWARDs
www.s-arch.net
conference@s-arch.net

Published in Germany

CONTENT

PAVEPRO - PERFORMATIVE SIDEWALK DESIGN

Magdalena WOJNOWSKA-HECIAK [1,*], Jakub HECIAK [2,*] and Adam KŁAK [2,*]

[1] Department of Landscape Architecture, Institute of Environmental Engineering, Warsaw University of Life Sciences—SGGW, ul. Nowoursynowska 166, 02-787 Warsaw, Poland
[2] Faculty of Civil Engineering and Architecture, Kielce University of Technology, al. Tysiąclecia Państwa Polskiego 7, 25-314 Kielce, Poland
* Correspondence: magdalena_wojnowska-heciak@sggw.edu.pl (M.W.-H.); jheciak@tu.kielce.pl (J.H.); adamklak@tu.kielce.pl (A.K.)

Abstract

The research aimed to develop a concept of a sidewalk system for pedestrian mobility comfort, rainwater infiltration and urban tree growth. The results of the social studies on the mobility of people with motor disabilities, conducted as part of the Pavepro project, served as the basis for formulating the parameters of a permeable and easily accessible paving slab. Constructing the paving slab 3D models used the heuristic Research-by-Design technique. As a result, four performative sidewalk models were designed to satisfy the pedestrian preferences collected and analyzed in our previous social studies. Further research will focus on the detailed calculation of vibrations and building the optimal prototype of the Pavepro pavement system.

Keywords

sidewalk design; equitable use; universal design; urban tree protection; rainwater drainage.

1 Introduction

1.1 Sidewalk design worldwide

Sidewalk surfaces vary from country to country. In the United States and Canada, concrete sidewalks are most commonly poured as a continuous strip. In the UK, Australia and France, suburban sidewalks are primarily constructed of asphalt, while urban or inner-city pavements are made of slabs, tiles, or bricks [1]. Paving with concrete blocks is popular in Europe, particularly Germany and Poland [2]. The paved surface must provide pedestrians with a sense of comfort and safety. Still, it can also be entirely original, for example, made of durable 2.5 cm thick glass and running at the height of 1,430 meters [3].

1.2 Challenges for sidewalk design and installation

The complexity of the urban environment (a conflict between green and street infrastructure, ensuring walking and driving comfort and safety, optimization of parking spaces, etc.) requires new, highly functional, and flexible sidewalk solutions for pedestrians. In our search for ways to accommodate urban nature, pedestrian comfort, city inclusivity, and visible climate change in urban areas (e.g., flash floods) in one innovative technology, we used the experience from design work and preparing submissions for urban planning competitions. Asphalt surfaces, though cheaper to build, require large machinery for installation and pose maintenance problems, whereas concrete is durable and needs less maintenance. Permeable stabilized mineral surfaces are not pedestrians' first choice [4]. Additionally, stabilized mineral surfaces, commonly used in city parks, may not match other contexts of the urban fabric, such as ancient city squares and downtown sidewalks [4]. Our Pavepro project seeks to address these issues.

High-intensity rainfall affects residents through sewage system overload, local flooding and infrastructure damage [5]. Therefore, there is a need to create adaptable, eco-friendly solutions for managing rainwater in densely populated places because downtown structures are rarely designed for periods of severe rain [6,7,8]. Furthermore, relieving the municipal sewage system after rainfall by installing surfaces capable of water infiltration may also reduce the risk of river floods indirectly associated with sealing the catchment area.

The proper pavement design involves many factors, including determining stress, strain, deformations [9] and weather conditions [10, 11]. Other researchers [8] point to the importance of the foundation layer and the arrangement of the foundation materials for the appropriate hydraulic conductivity and/or thickness of the top layer. Meanwhile, citizen science and community involvement in developing and applying new solutions, particularly those pertaining to common places, are also relevant.

1.3 Pedestrians and urban trees

The presence of trees along the sidewalks has an impact on the comfort of walking along pedestrian routes, as well as on the general well-being of the inhabitants. By serving environmental, economic, aesthetic, social, and health functions, tree stands in cities significantly influence the life satisfaction of city residents [12, 13, 14]. Trees and other urban greenspaces are known to combat many civilization diseases, alleviate social stress and help build friendly and inclusive neighbourhoods [14, 15]. In addition, the proximity to green areas and the high frequency of visits are associated with a noticeable improvement in mental well-being and better physical health [16, 17, 18].

People without or with limited contact with nature are more prone to depression and reduced functional efficiency, which can lead to a significant quality of life deterioration [19, 20]. That is why it is critical that green spaces be accessible to everyone. For many people, spending time walking along a tree-lined avenue, a street, or a paved path in a park is their only opportunity to interact with nature and others in their daily routines. Greenery, including trees, appears to be especially important for people with disabilities or mobility issues, providing an alternative environment for rehabilitation and alleviating health disparities [21].

Tree roots must find water and oxygen to grow. Poorly drained and compacted soil encourages shallower root growth. Water collected underneath the sidewalk up to 30 cm is used by roots to increase their diameter, thereby cracking and raising the sidewalk pavement. Good quality soil necessary for the growth, breathing and nourishment of the root system is up to 60 cm below the surface. Although the solutions available on the market are suitable for newly planted trees, they do not apply to existing mature trees and their extensive root system [22, 23].

1.4 People with motor difficulties in public spaces

People with a disability cover a broad group of public space users [24]. Insufficient physical activity is a common problem among people with a disability, including seniors [25], but it can also temporarily affect people in their prime [26]. Caregivers or assistants share the everyday struggle with their wards to overcome physical obstacles in the urban space. A stress level similar to that of people with mobility impairments is experienced by parents pushing prams or strollers [27, 28]. Although people vary, indicating different things that may pose difficulty in their mobility, they all suggest that a smooth sidewalk without bulges or cracks, planted along with urban trees, is the preferable pedestrian route [29, 30]. Therefore, considering the diversity of social groups affected by difficulty walking, the Pavepro project is aimed at all sidewalk users.

1.5 Originality & Aim

Sidewalks are usually tested either for water permeability or to prevent soil compaction, or for the comfort of mobility. Our pavement system is being developed in an interdisciplinary way, considering the element of social participation and engineering research. The research focused on constructing a sidewalk system that would ensure the comfort of pedestrian mobility and rainwater infiltration and would be friendly for urban trees.

2. MATERIALS & METHODS

2.1 Social studies - a preliminary step to determine paving slab parameters

It was assumed that the paving slab has a crucial impact on walking comfort. The substructure of the system should guarantee stability and firm, uniform support for the pavement. The first analysis focused on such issues as slab/tile size, joint width, perforation, roughness, and colours. Preferences of the pedestrians regarding the preferable paving slab features are presented below. The initial parameters were established based on the results of social studies (Figure 1) [31, 32].

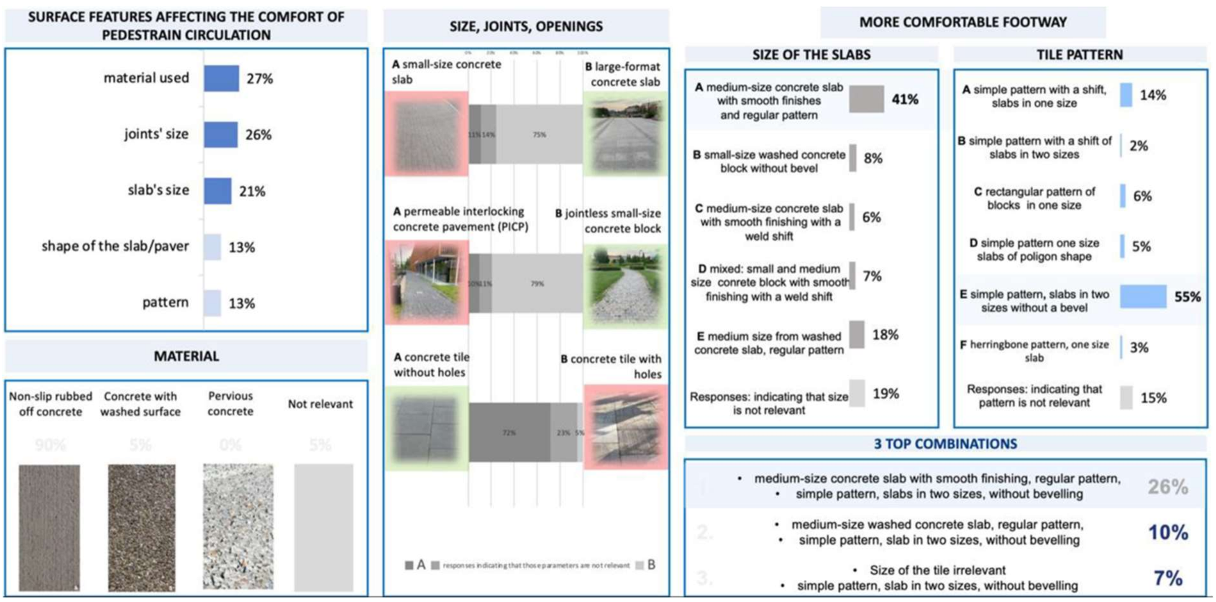


Figure 1. Evaluation of the optimal pedestrian surface features [31].

In the next research phase, detailed 3D models of the paving slabs were developed using the heuristic research-by-design method (Vectorworks 2019; author's licence). The material strength was checked based on analyses in ABAQUS 2017 (licence from the Kielce University of Technology).

2.2 Design assumptions for sidewalk module

A single module of the presented system consists of a paving slab and a substructure filled with soil. The substructure is a monolith made of concrete in the form of 4 columns connected with the slab at the bottom. The determination of the length, width, and thickness of the paving slab, the appropriate module connection system, and the spatial visualization in the form of a 3D model were based on the following design assumptions:

- the dimensions of the modular elements of the system would be selected so that they could be installed without the use of heavy equipment quickly and comfortably;
- a single module would not weigh more than 50 kg and would have an area of less than 1.0 m^2;
- the minimum width of the pavement is 2.0 m, with the module size being a multiple of 20 or 25 cm. It was assumed that the optimal width would be 40 cm or 50 cm as it would correspond to the preferences of most of the respondents, i.e., a medium or large-format slab with a regular arrangement;
- at the assumed concrete density of 2300 kg/m^3, the slab thickness should be from 3 cm to 8 cm thick. The final slab thickness will be determined after the analysis in the element load simulation program and the analysis of other elements that may affect the comfort of pedestrian mobility.

2.3 Design assumptions for water infiltration

The width of the joints between the slabs and openings performed in the slabs is one of the key factors affecting the comfort of movement of people with disabilities (creating vibrations). Therefore, it is crucial not to overscale them but to ensure water permeability rates at levels achieved by other products offered for the pavement (like the Climate Tile or AquaSix Metten systems) [32,33]. Therefore, it was assumed that the starting point for the tests would be the classic joint width of 5 - 15 mm. For each pattern of the openings in the slabs, we performed separate calculations [35].

The value of the filtration coefficient for the soil inside the substructure was set at fine-grained sands: k=1·10-4¬ m/s. The rainfall value was assumed to be 150 $l/m^2/h$. Research on specific infiltration values is the subject of a separate study as part of the current project phase [35, 36].

2.4 Design assumptions for material selection

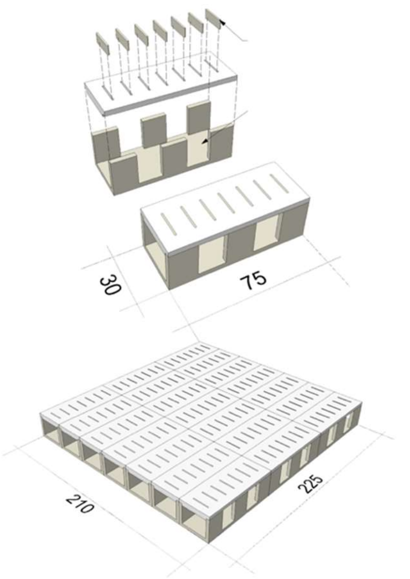
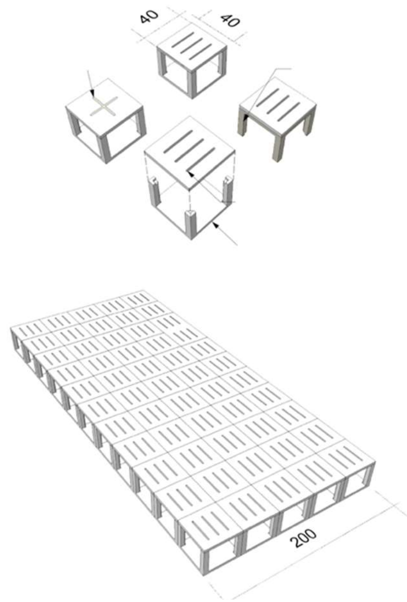
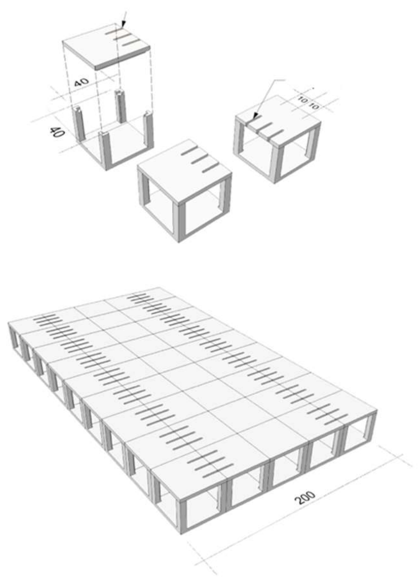
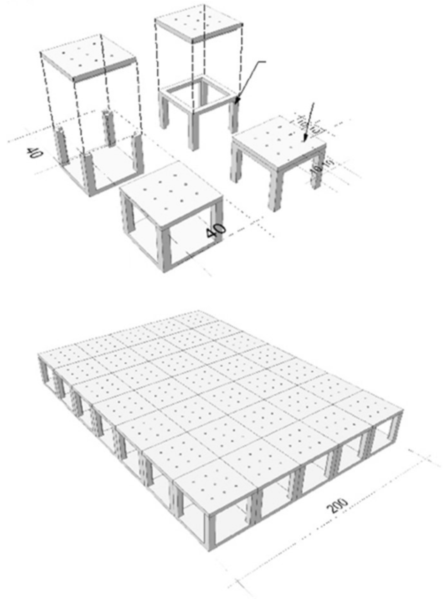
Due to the harsh environmental conditions, e.g., cyclic freezing and thawing, deicing salt, and possible loads, cement concrete was selected to design modular pavement elements. The concrete grade from C40/50 was checked in the following models. The load capacity of the top slab at a concentrated force of 115 kN, which corresponds to a pressure area of a circle with a diameter of 32 cm, was tested (stress of 850 KPa in the element) [36].

3 RESULTS

3.1 Models

The developed models are presented in Table 1 (Models 1, 2, 3, 4).

Table 1: Models of a performative sidewalk system called Pavepro (source: processed by the Authors).

	
Model 1	Model 2
	
Model 3	Model 4

3.2 Rainwater infiltration

Paving Slabs

According to our calculation, 1 m^2 of Model 1 and Model 2 of the designed sidewalk would ensure water permeability at 424,800 l/m^2/h. Considering Model 3, 1 m^2 would infiltrate 218160 l/m^2/h. Water permeability for 1 m^2 of Model 4 is estimated at 60840 l/m^2/h [35].

Substructure

Assuming that fine-grained sand k= k=1·10-4¬ m/s will be used as the filling, the infiltration rate Q will be 6.5 l/h. This value will be the level at which a given surface is to relieve the optional surface drainage system [35].

3.3 Paving Slab Weight and Load Capacity

Verification of the weight and load capacity for a 115 kN vehicle showed that model 1 and 3 did not meet the assumed conditions. Models 1 and 4 are subject to further research [36].

4 CONCLUSIONS

The analysis showed significant differences in the values of the obtained infiltration rates. Nevertheless, all variants met the established assumptions regarding the required water permeability (infiltration). While continuing the research, the possibility of reducing the area of openings in the slab should be taken into account, which should positively impact the comfort of mobility.

Considering the weight and load capacity of the paving slab module, only model 1 does not fulfil the weight and size assumption (it weighs 55kg). To develop a durable, multifunctional sidewalk system for pedestrian mobility comfort, rainwater infiltration, and urban tree growth, Models 2 or 4 should be adopted.

Further research will focus on the mobility comfort of the developed novel pavement. We assume that the range of applications of our solution can be extended to include the aspect of energy acquisition or filtering smog pollution from the air.

Funding

This research was funded by the National Centre for Research and Development (Poland) grant Rzeczy są dla ludzi/0052/2020-00 (NCBiR) entitled Pavepro – multifunctional pavement system for people with disabilities (Polish: „Pavepro - wielofunkcyjna nawierzchnia dla osób niepełnosprawnych”). The APC was funded by grant sources.

References

[1] “A Guide For Maintaining Pedestrian Facilities For Enhanced Safety - Safety | Federal Highway Administration,” *U.S. Department of Transportation*, (2013). [Online]. Available: https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa13037/chap3.cfm. [Accessed: 29-Sep-2022].

[2] “Conventional And Permeable Concrete Block Pavements | CPI-Worldwide.com,” *Concrete Plant International*, (2022). [Online]. Available: https://www.cpi-worldwide.com/en/journals/artikel/67100. [Accessed: 29-Sep-2022].

[3] “Chodnik - Wynalazki I Odkrycia,” (2021). [Online]. Available: https://wynalazki.andrej.edu.pl/wynalazki/12-c/1158-chodnik. [Accessed: 29-Sep-2022].

[4] M. Wojnowska-Heciak, M. Suchocka, M. Błaszczyk, and M. Muszyńska, “Urban Parks as Perceived by City Residents with Mobility Difficulties: A Qualitative Study with In-Depth Interviews,” *IJERPH*, vol. 19, no. 4, p. 2018, (2022), doi: 10.3390/ijerph19042018.

[5] N. Kang, S. Kim, Y. Kim, H. Noh, S. Hong, and H. Kim, “Urban Drainage System Improvement for Climate Change Adaptation,” *Water*, vol. 8, no. 7, p. 268, (2016), doi: 10.3390/w8070268.

[6] T. Emilsson and Å. Ode Sang, “Impacts of Climate Change on Urban Areas and Nature-Based Solutions for Adaptation,” pp. 15–27, (2017), doi: 10.1007/978-3-319-56091-5_2.

[7] D. Lu, S. L. Tighe, and W.-C. Xie, “Impact of flood hazards on pavement performance,” *International Journal of Pavement Engineering*, vol. 21, no. 6, pp. 746–752, (2020), doi: 10.1080/10298436.2018.1508844.

[8] M. K. Nivedya, M. Tao, R. B. Mallick, J. S. Daniel, and J. M. Jacobs, “A framework for the assessment of contribution of base layer performance towards resilience of flexible pavement to flooding,” *International Journal of Pavement Engineering*, vol. 21, no. 10, pp. 1223–1234, (2020), doi: 10.1080/10298436.2018.1533637.

[9] P. Pereira and J. Pais, “Main flexible pavement and mix design methods in Europe and challenges for the development of an European method,” *Journal of Traffic and Transportation Engineering (English Edition)*, vol. 4, no. 4, pp. 316–346, (2017), doi: 10.1016/j.jtte.2017.06.001.

[10] M. P. Wistuba and A. Walther, “Consideration of climate change in the mechanistic pavement design,” *Road Materials and Pavement Design*, vol. 14, no. sup1, pp. 227–241, (2013), doi: 10.1080/14680629.2013.774759.

[11] H. Yilmaz, S. Yilmaz, M. Yavaş, E. Mutlu, and A. Koç, “Climate-sensitive Pavement Modelling for Pedestrian Ways,” *Procedia Engineering*, vol. 169, pp. 408–415, (2016), doi: 10.1016/j.proeng.2016.10.050.

[12] R. S. Ulrich and D. L. Addoms, “Psychological and Recreational Benefits of a Residential Park,” *Journal of Leisure Research*, vol. 13, no. 1, pp. 43–65, (1981), doi: 10.1080/00222216.1981.11969466.

[13] N. Humpel, “Environmental factors associated with adults’ participation in physical activity A review,” vol. 22, no. 3, pp. 188–199, (2002), doi: 10.1016/s0749-3797(01)00426-3.

[14] A. L. Bedimo-Rung, A. J. Mowen, and D. A. Cohen, “The significance of parks to physical activity and public health,” *American Journal of Preventive Medicine*, vol. 28, no. 2, pp. 159–168, (2005), doi: 10.1016/j.amepre.2004.10.024.

[15] F. Romagosa, “Physical health in green spaces: Visitors’ perceptions and activities in protected areas around Barcelona,” *Journal of Outdoor Recreation and Tourism*, vol. 23, pp. 26–32, (2018), doi: 10.1016/j.jort.2018.07.002.

[16] V. Houlden, J. Porto de Albuquerque, S. Weich, and S. Jarvis, “A spatial analysis of proximate greenspace and mental wellbeing in London,” *Applied Geography*, vol. 109, p. 102036, (2019), doi: 10.1016/j.apgeog.2019.102036.

[17] Y. Liu, R. Wang, G. Grekousis, Y. Liu, Y. Yuan, and Z. Li, “Neighbourhood greenness and mental wellbeing in Guangzhou, China: What are the pathways?,” *Landscape and Urban Planning*, vol. 190, p. 103602, (2019), doi: 10.1016/j.landurbplan.2019.103602.

[18] L. Martin, M. P. White, A. Hunt, M. Richardson, S. Pahl, and J. Burt, “Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours,” *Journal of Environmental Psychology*, vol. 68, p. 101389, (2020), doi: 10.1016/j.jenvp.2020.101389.

[19] B. Xie, J. Jiao, Z. An, Y. Zheng, and Z. Li, “Deciphering the stroke–built environment nexus in transitional cities: Conceptual framework, empirical evidence, and implications for proactive planning intervention,” *Cities*, vol. 94, pp. 116–128, (2019), doi: 10.1016/j.cities.2019.05.035.

[20] M. Saitta, H. Devan, P. Boland, and M. A. Perry, “Park-based physical activity interventions for persons with disabilities: A mixed-methods systematic review,” *Disability and Health Journal*, vol. 12, no. 1, pp. 11–23, (2019), doi: 10.1016/j.dhjo.2018.07.006.

[21] M. A. Perry, H. Devan, H. Fitzgerald, K. Han, L.-T. Liu, and J. Rouse, “Accessibility and usability of parks and playgrounds,” *Disability and Health Journal*, vol. 11, no. 2, pp. 221–229, (2018), doi: 10.1016/j.dhjo.2017.08.011.

[22]M. Suchocka and A. Malinowska, “Przegląd technik poprawy warunków siedliskowych dla drzew miejskich pod kątem możliwości zastosowania ich w warunkach polskich,” *Człowiek i Środowisko* , (2013). [Online]. Available: http://obserwatorium.miasta.pl/wp-content/uploads/2016/08/04-Suchocka-Milanowska.pdf; [Accessed: 29-Sep-2022].

[23] J. Urban, “Comparing Silva Cells And Structural Soil | DeepRoot Blog,” *Deeproot* (2011). [Online]. Available: https://www.deeproot.com/blog/blog-entries/comparing-silva-cells-and-structural-soil. [Accessed: 29-Sep-2022].

[24]“World Report on Disability 2011,” (2011).

[25] M. Hirvensalo, T. Rantanen, and E. Heikkinen, “Mobility Difficulties and Physical Activity as Predictors of Mortality and Loss of Independence in the Community-Living Older Population,” vol. 48, no. 5, pp. 493–498, (2000), doi: 10.1111/j.1532-5415.2000.tb04994.x.

[26] L. I. Iezzoni, E. P. McCarthy, R. B. Davis, and H. Siebens, “Mobility difficulties are not only a problem of old age,” *J Gen Intern Med*, vol. 16, no. 4, pp. 235–243, (2001), doi: 10.1046/j.1525-1497.2001.016004235.x.

[27] J. L. Currie and E. Develin, “Stroll Your Way To Well-Being: A Survey Of The Perceived Benefits, Barriers, Community Support, And Stigma Associated With Pram Walking Groups Designed For New Mothers, Sydney, Australia,” *Health Care for Women International*, vol. 23, no. 8, pp. 882–893, (2002), doi: 10.1080/07399330290112380.

[28] S. Oh, S.-M. Lee, and S.-J. Park, “Spatial Factors on Satisfaction Level of Baby Stroller’s and Parenting Stress,” *Journal of the architectural institute of Korea planning & design*, vol. 31, no. 7, pp. 75–82, (2015), doi: 10.5659/jaik_pd.2015.31.7.75.

[29] “Accessible Clay Brick Pavements,” *TECHNICALNOTESonBrickConstruction*, (20120. [Online]. Available: https://www.gobrick.com/docs/default-source/read-research-documents/technicalnotes/14e-accessible-clay-brick-pavements.pdf?sfvrsn=0. [Accessed: 29-Sep-2022].

[30] E. Wolf *et al.*, “Vibration exposure of individuals using wheelchairs over sidewalk surfaces,” *Disability and Rehabilitation*, vol. 27, no. 23, pp. 1443–1449, (2005), doi: 10.1080/09638280500264709.

[31] M. Wojnowska-Heciak, J. Heciak, and A. Kłak, “Concrete Paving Slabs for Comfort of Movement of Mobility-Impaired Pedestrians—A Survey,” *IJERPH*, vol. 19, no. 6, p. 3183, (2022), doi: 10.3390/ijerph19063183.

[32] M. Wojnowska-Heciak, J. Heciak, and A. Kłak, “Perceptions of street trees among Polish residents with motor disabilities,” *Journal of Transport & Health*, vol. 27, p. 101490, (2022), doi: 10.1016/j.jth.2022.101490.

[33] “Climate Tile - Tredje Natur,” *Tredje Natur*. [Online]. Available: https://www.tredjenatur.dk/en/portfolio/climatetile/. [Accessed: 14-Feb-2023].

[34] “Aquasix | Public Spaces: Ecological Paving | Metten Stein+Design.” [Online]. Available: https://www.metten.com/products/ecological-pavers/AquaSix/. [Accessed: 14-Feb-2023].

[35] A. Kłak, “Report On The Implementation Of The Research Work 'Things are for people'/0052/2020 To the contract of 01/12/2021 entitled: Pavepro - a multifunctional surface for people with disabilities/ Sprawozdanie z realizacji pracy badawczej "Rzeczy są dla ludzi"/0052/2020 Do umowy, z dnia 01.12.2021 pt: Pavepro – wielofunkcyjna nawierzchnia dla osób niepełnosprawnych. Zadanie 1,” Feb. 2022.

[36] A. Kłak, J. Heciak, M. Wojnowska-Heciak, and G. Mazurek, “Report On The Implementation Of The Research Work 'Things are for people'/0052/2020 To the contract of 01/12/2021 entitled: Pavepro - a multifunctional surface for people with disabilities/ Sprawozdanie z realizacji pracy badawczej "Rzeczy są dla ludzi"/0052/2020 Do umowy, z dnia 01.12.2021 pt: Pavepro – wielofunkcyjna nawierzchnia dla osób niepełnosprawnych. Zadanie 1,” Feb. 2022.

LIFE CYCLE ASSESSMENT OF A RED BRICK IN SAN LUIS HUEXOTLA, TEXCOCO, STATE OF MEXICO, MEXICO.

Miguel Arzate Pérez[1], Javier Aguirre Contreras[1], Gerardo Arzate Pérez[1], Javier Aguirre Muñoz[2]

[1]Autonomous Metropolitan University, Environment Department, [2]Centers for Technological Industrial Studies and Services No. 29

Av. San Pablo No. 180 Col. Reynosa Tamaulipas C.P. 02200 Delegación Azcapotzalco Distrito Federal México. Email: acj@azc.uam.mx

Abstract

This article describes the methodology whose objective was to carry out a life cycle assessment (LCA) of a red brick made in San Luis Huexotla, Texcoco, State of Mexico, a material which houses are built and everyday products are manufactured in Mexico. LCA included the impact on the environment of the extraction of materials, and the manufacture and distribution of the brick. ISO 14025 was used, with OpenLCA software (free and open source), with ecoinvent version 3.7 databases and local databases (Berumen-Rodríguez 2021). The environmental indicators were evaluated with Recipe 2016 Midpoint. The allocation of impacts was made with the weight of the brick (2.121 kg), according to the results, (from the extraction of materials, production, and distribution of the brick) environmental impact obtained in global warming was 1.52620e-1 kg CO_{2eq}, in the human non-carcinogenic toxicity emission was 0.131692 e-1 kg 1.4-DCB, in marine ecotoxicity was 0.131692 e-1 kg 1.4-DCB and in terrestrial ecotoxicity emission was 0.0455962e-1 kg 1.4-DCB. The LCA was carried out from the Cradle-to-gate, which is an evaluation of a partial life cycle of the product from the extraction of resources (cradle) to the consumer's gate. The phase of use and disposal were omitted in this case. The study, analysis, and access to information on the environmental impact generated by materials for architecture or products is essential for decision-making in the design of projects since they directly affect our environments, such as global warming or water depletion.

Keywords

Architecture, life cycle assessment, red brick, OpenLCA, ecoinvent, global warming.

Introduction

Today's society is aware that we must migrate towards more sustainable energy consumption models if we want to ensure the climate sustainability of the planet. As established by the SDG (Sustainable Development Goals) [1] and the guidelines established in various world congresses on energy and sustainability, the decarbonization of all production processes is necessary in both developed and developing economies, to ensure the improvement of energy quality and directly influence the mitigation of global warming and climate change (CC). Aware that the energy demand will increase exponentially in this decade, it will be necessary to implement better energy consumption systems [2], so this analysis was carried out on the red brick, in order to identify all the processes of its life cycle as well as the repercussions it has at an environmental level.

To do this, the tool known as LCA (Life Cycle Assessment) is used, which is referred to as environmental balance or ecological balance. The LCA is considered as an instrument for research and evaluation of the environmental impacts of a product or service during all stages of its existence: extraction, production, distribution, use and end of life [3]. LCA is a methodology for studying the life cycle of a product and its production process. To carry out this analysis, a process or activity is taken into account throughout its life cycle by quantifying the use of resources [3]. It is divided into two essential elements associated with the system. In the first, inputs are considered, such as energy and raw materials, while in the second, emissions or outputs to the air, water, and soil are taken into account.

LCA is a methodological tool used to quantitatively analyze the life cycle of products or activities in the context of environmental impact. For this, specific calculation software is being applied. In the ECV, the total life cycle of a product or activity is considered; from the extraction of resource materials to the waste treatment stage, also known as cradle to grave [4]. LCA comprises a series of steps. The most important are:

- LCI (Life Cycle Inventory): In this step, information is being collected on the use of resource and energy materials that are used within the life cycle, as well as the emission of harmful substances throughout the life cycle [5].
- LCIA (Life Cycle Impact Assessment): In this step, the inventory data (Life Cycle Inventory) are analyzed. Based on the LCIA, an image of the environmental impact caused by the product or activity is created [5].

The result of an LCA study is an environmental profile of a product or activity, which shows the major environmental problems caused by a product, as well as indicating in which stages of the life cycle they originate. In this way, the LCA contributes to the definition of management changes to improve the environmental friendliness of a product, as well as to show the consequences that different alternatives may have [5].

In this article, the environmental impacts of a brick were analyzed by LCA using OpenLCA software. The LCA was carried out from the cradle to the door, the former being an evaluation of a partial life cycle of the product from the extraction of resources (cradle) to the consumer's door. The phase of use and disposal of the product are omitted in this case [4].

The impacts associated with the production of a brick (**Figure 1**) in San Luis Huexotla, Texcoco, State of Mexico, Mexico, from the extraction of the mineral, its manufacture and even its distribution, were analyzed.

Figure 1. Weight in kg of a red brick manufactured in San Luis Huexotla, Texcoco, State of Mexico, Mexico.

The objective and scope of this simulation are as follows:

- Identify and evaluate the impacts associated with the extraction, manufacturing and distribution processes of red bricks produced in San Luis Huexotla, Texcoco, State of Mexico, Mexico.

Methodology

The methodology for evaluating the brick was as follows:

1. For Life Cycle Assessment, the ISO 14025 methodology was used.
2. Software used OpenLCA
    - The database used was the ecoinvent version 3.7, as well as the database obtained by Berumen-Rodríguez (2021).
3. The method used was Recipe 2016 Midpoint

ISO 14025

The methodology for LCA is the one standardized by the International Organization for Standards (ISO Serie 14040) and its corresponding Mexican standards NMX-SAA-14025-IMNC-2008 Environmental Management-Life Cycle Analysis-Principles and reference framework and NMX- SAA-14025-IMNC-2008 Environmental management-Life Cycle Analysis-Requirements and guidelines [6].

The ISO 14025 methodology allows knowing what resources are used in the manufacture of the brick, to design a scheme that allows having a notion of the complete system. The representation of the necessary flows to characterize a unit is essential to carry out the above (**Figure 2**) [7]. In general, numerous processes are required to manufacture most products.

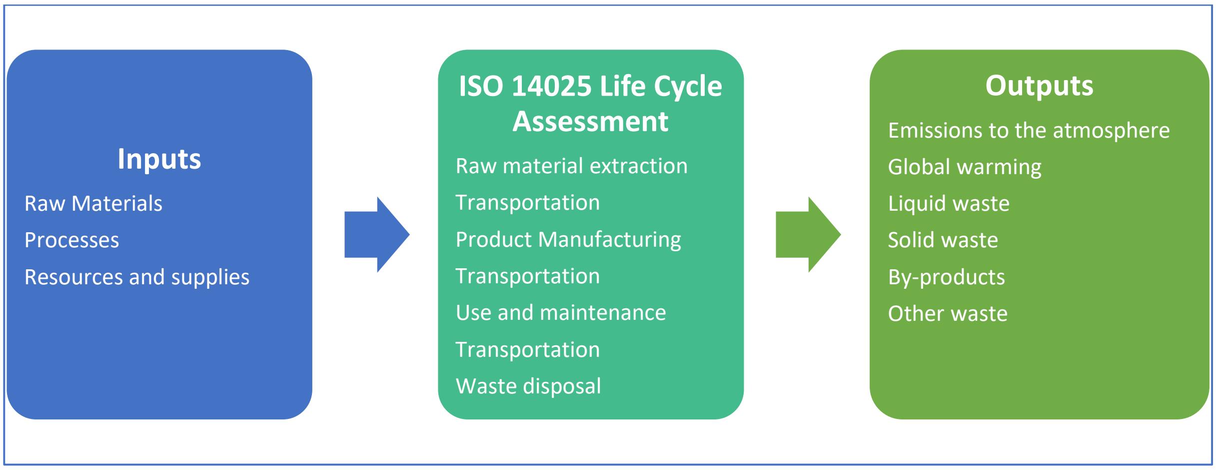


Figure 2. Life Cycle Assessment Methodology according to ISO-14025.

According to the ISO-14025 methodology, the table of processes in modules was developed, based on the Environmental Product Declaration (EPD) [8]. This LCA was carried out from the cradle to the door and covers the stage of production and process stage (from module A1-A4) (**Table 1**) [7].

Table 1. Scope of the LCA

Product stage			Construction process stage		Use stage							End of life stage				Benefits & loads beyond the system boundaries
Raw meterial supply	Transport	Manufacturing	Transport to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport disposal	Waste disposal	Disposal	Reuse-recovery-recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND
X: included in LCA MND: module not declared or NR: for no relevant																

The methodology for brick ranges from obtaining the raw material, production and distribution (**Figure 3**).

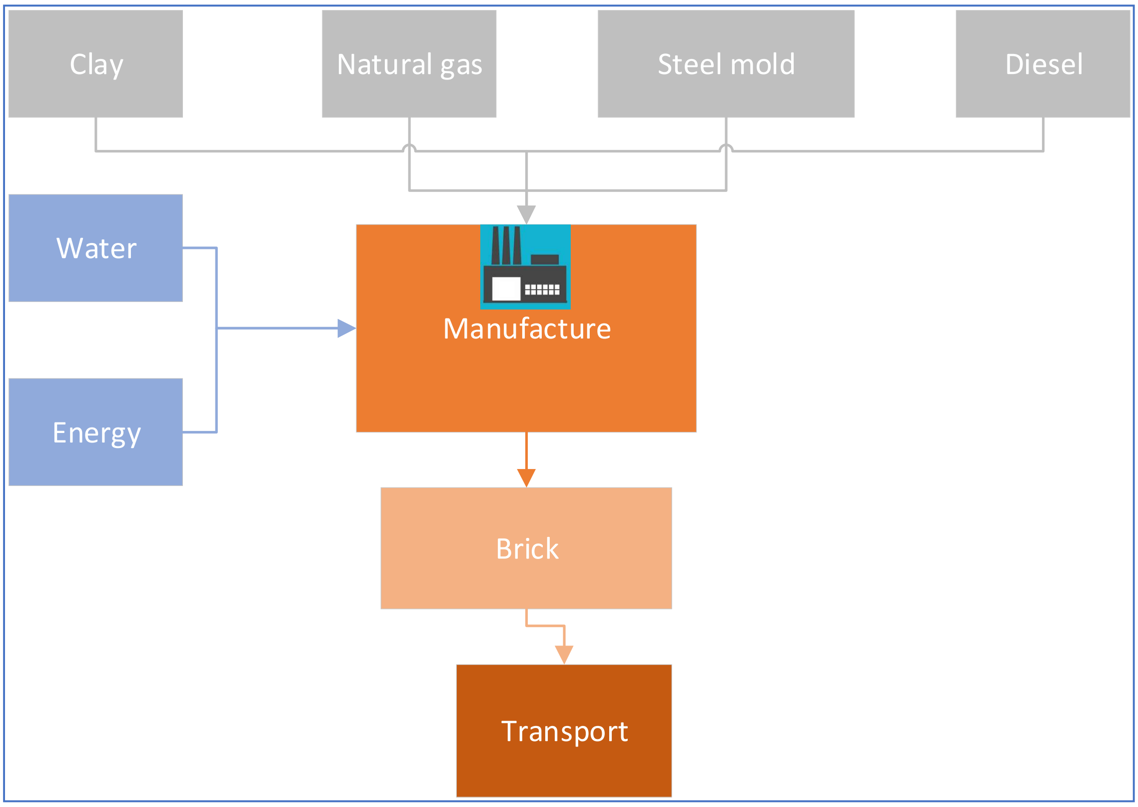


Figure 3. Brick Life Cycle Assessment methodology

LCA information:

- Geographic location: San Luis Huexotla, Texcoco, State of Mexico, Mexico.
- Functional unit/declared unit: 1 kg
- Reference useful life: not applicable
- Database and ECV software used: The ECA software used is the OpenLCA tool, version 1.10.3. The OpenLCA uses the ecoinvent version 3.7 database and also the database obtained by Berumen-Rodríguez (2021).
- This system includes extraction, manufacturing and transportation:
    - The clay comes from quarries located near the brickyard, so the contribution to transportation is negligible.
    - A scenario of 100 km distance was considered for the distribution of the brick.
    - The impacts of the end of life, transportation and waste treatment were not taken into account.

All inputs to the system are related to energy consumption (fuel and electrical energy) as well as to its natural sources (clay and water).

Outputs include emissions to air, water, and waste generation from processes including extraction, manufacturing, and transportation.

2.1.2 Inputs

Extraction of raw materials:

The raw material for making bricks are: clay and water. The clay and the water comes from quarries located near the production ovens, within the same area.

Manufacture:

- Molding: Steel molds are used, in addition the molding is done by extrusion in plastic molding machines. In this process, a continuous molding is formed, which is cut according to the measurements of the brick to be produced.
- Drying: Drying consists of reducing the humidity of the raw brick before it enters the firing kiln. In manufacturing, this process is done outdoors.
- Firing: Lastly, the raw and pre-dried brick is carried out in the firing kiln. In this stage, through the action of fire and heat, chemical changes take place that transform the clay and the other components into sintered or vitrified products with structural characteristics of resistance to compression. Firing generates the greatest amount of environmental impact, due to emissions into the air from the burning of fossil fuel in the brick firing kilns, mainly natural gas being used.

For the manufacture of one kg of brick the following inputs are needed [9] (**Table 2**).

Table 2. Inputs to make one kg of brick.

Life Cycle Inventory (ICV)	**Values**
Inputs	
Clay	1.22 kg
Water from well	0.0000955 m^3
water for domestic use	0.00000225 m^3
Electricity	0.0338 kWh
Natural gas	1.10 MJ
Diesel	0.0214 MJ
Steel molds	0.00000955 kg
Product transportation	100 km

The production of one kg of brick emits the following outputs [9] (**Table 3**).

Table 3. Outputs to make one kg of brick.

Life Cycle Inventory (ICV)	**Values**
Outputs	
CO	0.000571kg
CO_2	0.065 kg
N_2O	0.0000435 kg
SO_2	0.0000356 kg
As	0.0000000135 kg
Cd	0.000000000751 kg
Cr	0.0000000255 kg
Cu	0.000000000421 kg
Hg	0.00000000375 kg
Ni	0.000000036 kg
Pb	0.000000075 kg
Zn	0.0000000144 kg
PM10	0.0000193 kg
NMVOC	0.0000197 kg

OpenLCA

The GreenDelta organization develops and distributes software called OpenLCA. This is open source software [5]. It was developed to make LCA and its sustainability assessment more accessible and affordable initially in Europe and later in other countries, especially the United States and Mexico [5].

This software, available in various versions and platforms, allows you to carry out this study for free. OpenLCA version 1.10.3 [5] was used together with the ecoinvent 3.7 database and Berumen-Rodríguez (2021). The above software allows you to gain a deeper understanding of the environmental impacts of your products and services. The databases model human production activities or processes, measuring the following factors:

a) Natural resources extracted from the environment

b) Emissions released into water

c) Soil and air used in the process

d) Products demanded from other processes such as the electricity required for their development

e) Products, co-products and waste produced.

It should be added that ecoinvent is a data source compatible with studies and evaluations based on ISO 14025 [10].

Recipe 2016 Midpoint

ReCiPe is a method for LCA, which translates emissions and resource extractions into a limited number of environmental impact scores using so-called characterization factors [11].

There are two main ways to derive characterization factors, these being the midpoint level and the endpoint level. The ReCiPe allows to calculate the following [11]:

- 18 midpoint indicators
- 3 end point indicators

Midpoint indicators focus on individual environmental problems, for example climate change or land or ocean acidification. The endpoint indicators show the environmental impact at the three highest levels of aggregation, which are [10]:

1. The effect on human health.
2. Biodiversity.
3. The scarcity of resources.

Converting midpoints to endpoints simplifies the interpretation of LCIA results. However, with each aggregation step, the uncertainty in the results increases [11].

Results and discussion

The environmental impacts were calculated per one kg produced, later the calculation was made with the total weight of the brick (2.121 kg) (**Figure 4**). Air emissions are generated in the material extraction, manufacturing and, distribution phase according to the ReCiPe Midpoint method.

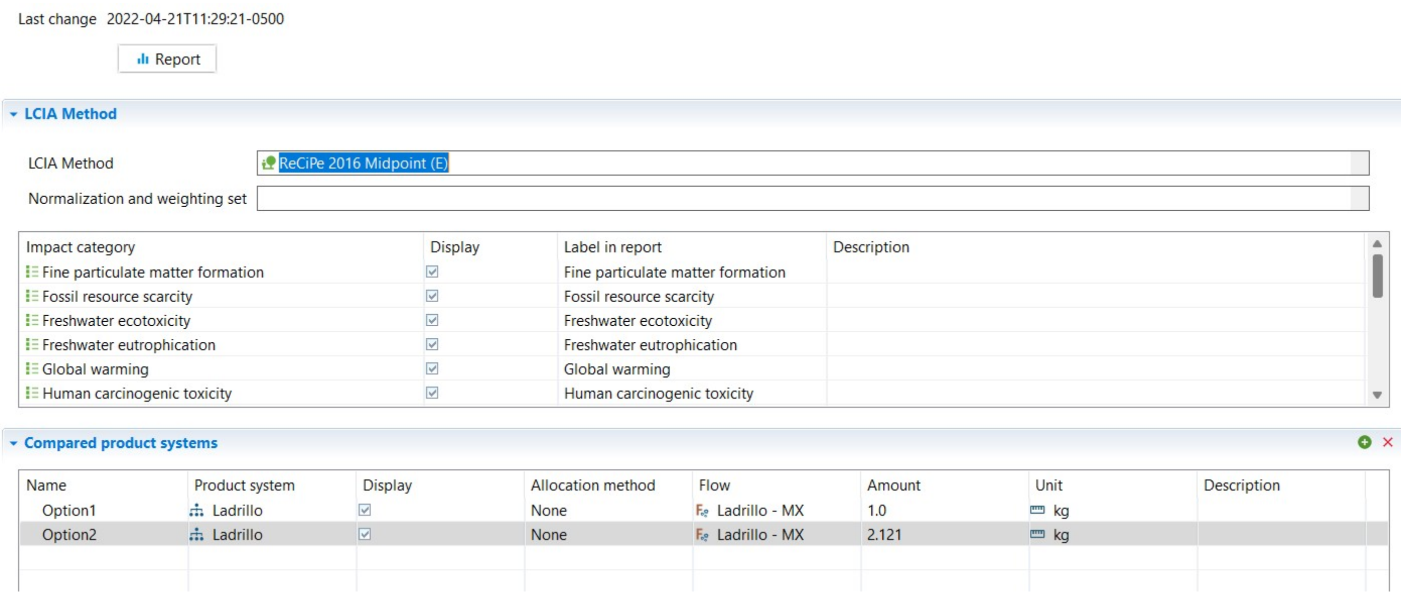


Figure 4. Impact generated by one kg of brick, the weight of the brick (2.121 kg) according to the ReCiPe Midpoint method.

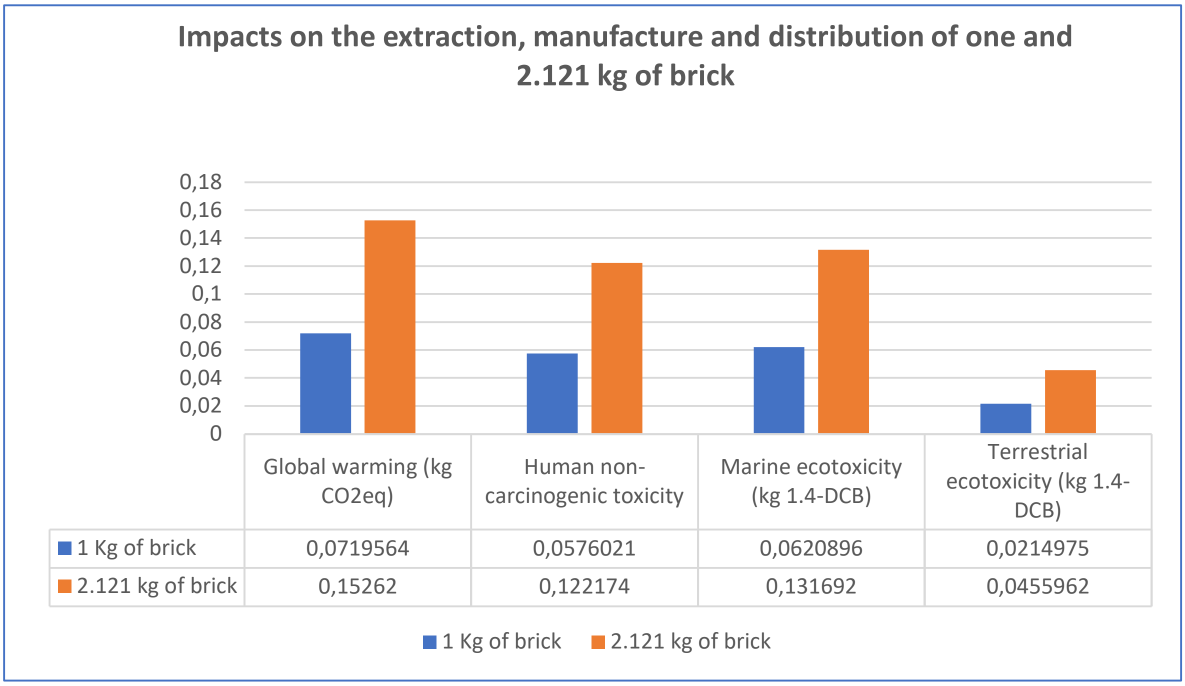
Table 4 shows the LCIA results of the project variants. Each selected LCIA category is displayed in the rows and the project variants in the columns. The unit is the unit of the LCIA category as defined in the LCIA method.

Table 4. LCIA results.

Indicator	**one kg of brick**	**2.121 kg of brick**	**units**
Fine particulate matter formation	0.0000171991	0.0000364794	kg PM2.5 EQ
Fossil resource scarcity	0	0	kg oil eq
Freshwater ecotoxicity	0.00000205203	0.00000435235	kg 1.4-DCB
Freshwater eutrophication	0.00000000579312	0.0000000122872	kg P eq
Global warming	0.0719564	0.15262	kg CO_{2eq}
Human carcinogenic toxicity	0.0000504237	0.000106949	kg 1.4-DCB
Human non-carcinogenic toxicity	0.0576021	0.122174	kg 1.4-DCB
Ionizing radiation	0.000213004	0.000451782	kBq Co-60eq
Land use	0	0	m^2 a crop eq
Marine ecotoxicity	0.0620896	0.131692	kg 1.4-DCB
Marine eutrophication	0.0000000231080	0.0000000490120	kg N eq
Mineral resource scarcity	0.013177	0.0279495	kg C eq
Ozone formation, Human health	0.00000282326	0.00000598814	kg NOx eq
Ozone formation, Terrestrial ecosystems	0.00000336754	0.00000714255	kg NOx eq
Stratospheric ozone depletion	0.000000754536	0.00000160037	kg CFC11 eq
Terrestrial acidification	0.0000584468	0.000123966	kg SO_2 eq
Terrestrial ecotoxicity	0.0214975	0.0455962	kg 1.4-DCB
Water consumption	0.00000384583	0.00000815699	m^3

According to table 4 in figure 5 it is represented the most significant impacts of making one and 2.121 kg of brick[1].

[1] Global warming is given in kilograms of carbon dioxide equivalent ($kgCO_{2eq}$). Ecotoxicity is expressed in 1.4-dichlorobenzene (kg1.4-DCB) [12].



	Global warming (kg CO2eq)	Human non-carcinogenic toxicity	Marine ecotoxicity (kg 1.4-DCB)	Terrestrial ecotoxicity (kg 1.4-DCB)
1 Kg of brick	0,0719564	0,0576021	0,0620896	0,0214975
2.121 kg of brick	0,15262	0,122174	0,131692	0,0455962

Figure 5. Most significant impacts of one kg and 2.121 kg of brick.

According to the results obtained, the brick areas present high levels of environmental contamination in addition to serious effects on the health of the surrounding populations. More studies focused on the analysis of the site, the workers and their families are required. Adding to all of the above and the fact that the majority of the populations referred to present various types of vulnerabilities such as ecological, economic, physical, emotional, for which the intervention of the three levels of government is forced to help control all dimensions affected. With this study, the environmental indicators produced by the extraction of materials, manufacture and distribution of a brick would be made visible. This would allow the development of alternatives that make it possible to reduce labor, environmental and health risks in the sectors involved in brick manufacturing.

Conclusion

The LCA constitutes an important methodology for the evaluation of the sustainability of the construction, however, there are still certain gaps regarding the environmental indicators chosen for the study and even the representation and understanding of the results obtained, resulting in a difficult adaptation of the methodology for carrying out this type of study. The purpose of using the LCA is mainly focused on the design of products or materials with low environmental impact on CC, since it is an informative method to understand the environmental impact that the human being produces for each product or service.

The LCA methodology was used in the phase of material extraction, manufacture and distribution of the brick, obtaining as a result:

- The Global warming emission was:
  - In one kg 7.1956e-2 kg CO_{2eq}
  - In 2. 121 kg 1.52620e-1 kg CO_{2eq}

- The Human non-carcinogenic toxicity emission was:
  - In one kg 0.0576021e-2 kg 1.4-DCB
  - In 2. 121 kg 0.122174 e-1 kg 1.4-DCB
- The Marine ecotoxicity emission was:
  - In one kg 0.0620896 kg 1.4-DCB
  - In 2. 121 kg 0.131692 e-1 kg 1.4-DCB
- The Terrestrial ecotoxicity emission was:
  - In one kg 0.0214975 kg 1.4-DCB
  - In 2. 121 kg 0.0455962e-1 kg 1.4-DCB

In order to know and adopt, if necessary, the appropriate measures for the reduction of these, since this material was chosen since in Mexico there are 35,219,141 habited private homes, of which In 92% of inhabited private homes the walls are built with this material or similar [13].

The LCA allowed a quantitative evaluation of the impact of the CC of the manufactured brick, translating into information that can be used to understand the stages of the life cycle that need improvements, either in their processes, in economic viability or in the environmental part in its manufacture. The LCA of brick was only carried out from the cradle to the door, due to the lack of knowledge of the intermediate and final use of the brick. As soon as the final destination of the same is known, an environmental evaluation of the materials can be carried out, including reuse, recovery and recycling potential (from cradle to cradle).

The LCA was carried out with OpenLCA, which has all the potential to carry out these studies, thanks to its light architecture, the possibility of inserting various databases and calculation models and also considering that it is free software. This allows its accessibility to the entire scientific community.

The OpenLCA helps us make short-term decisions with the importance of the scarcity of resources in the present, in addition to knowing the maintenance and operation costs of the future and the impact on the environment. With the OpenLCA it was possible to evaluate, quantify and compare the environmental impacts in the life cycle of the brick produced in San Luis Huexotla, Texcoco, State of Mexico. This precedent made it possible to achieve the following achievements:

- Analyze, quantify and compare the CO_{2eq} and 1.4-DCB emissions produced by a brick.
- The stages that generated the greatest environmental impact during the production of the bricks were identified, in order to evaluate the opportunities to mitigate said impacts.

Acknowledgement

Thanks to the Metropolitan Autonomous University Azcapotzalco unit for the support provided in the preparation of this article.

References

[1] ONU, Objetivos de Desarrollo Sostenible/2022/Organización de las Naciones Unidas, Link: https://mexico.un.org/es/sdgs?msclkid=259a6d6dc01a11ec903cf8a48a0eda55

[2] Zapata Garza Gabriela Claudia; Uribe Urán Adriana; Demmler Michael, La eficiencia energética como ventaja competitiva empresarial sostenible, Daena: International Journal of Good Conscience, (2017), pp. 24, ISSN 1870-557X

[3] Vega-González Luis Roberto, Evaluación, avalúo y ciclo de vida de la tecnología (Parte 1), Ingeniería Investigación y Tecnología, volumen 4, (2003), pp 12, DOI: https://doi.org/10.22201/fi.25940732e.2003.04n3.012

[4] López López Víctor Manuel, Sustentabilidad y desarrollo sustentable: origen, precisiones conceptuales y metodología operativa, Instituto Politécnico Nacional, México, 2006.

[5] GreenDelta, OpenLCA/2022/GreenDelta, Link: https://www.openlca.org/greendelta/

[6] INECC, Estudio de Análisis de Ciclo Vida (ACV) del manejo de envases de polietilentereftalato (PET) en bebidas en su fase de pos-consumo/2022/ Instituto Nacional de Ecología y Cambio Climático, Link: https://www.gob.mx/cms/uploads/attachment/file/416326/2013_CGCSA_Estudio_de_Analisis_de_Ciclo_de_Vida_de_Envases_de_Bebidas_de_Polietilen_Tereftalato_en_la_Fase_de_Pos-Consumo.pdf#:~:text=El%20An%C3%A1lisis%20de%20Ciclo%20de%20Vida%20%28ACV%29%20se,en%20t

[7] Hernández Moreno Silverio, Análisis comparativo por ciclo de vida de tres tipos de luminarias empleadas en los interiores de edificios, Nova scientia, volumen 7, (2017), pp. 22, versión On-line ISSN 2007-0705

[8] EPD, The international EPD System, Link: https://www.environdec.com/all-about-epds

[9] Berumen-Rodríguez Alejandra Abigail; Pérez-Vázquez Francisco Javier; Díaz-Barriga Fernando; Márquez-Mireles Leonardo Ernesto; Flores-Ramírez Rogelio, Revisión del impacto del sector ladrillero sobre el ambiente y la salud humana en México, Salud Pública de México, volumen 63, (2021), pp. 100-108, 9p, DOI: 10.21149/11282.

[10] ecoinvent, Database/2022/ecoinvent, Link: https://ecoinvent.org/the-ecoinvent-database/

[11] NEHPI, LCIA: the ReCiPe model/2018/National Institute for Public Health and the Environment, Link: https://www.rivm.nl/en/life-cycle-assessment-lca/recipe

[12] Guinée B. Jeroen; Gorrée Marieke; Heijungs Reinout; Huppes Gjalt; Klejin René; Koning de Arjan; Oers van Lauran; Sleeswijk Wegener Anneke; Suh Sangwon; Udo de Haes A. Helias, Handbook on Life Cycle Assessment Operational Guide to the ISO Standards, Kluwer Academic Publishers, New York, Boston, Dordecht, London, Moscow, vol. 7, (2002), pp. 10- 605, Print ISBN 1-4020—0228-9

[13] INEGI, Cuéntame de México/2022/Instituto Nacional De Estadística y Geografía, Link: https://cuentame.inegi.org.mx/poblacion/vivienda.aspx?tema=P

THE ROLE OF MATERIAL EXPERIMENTATION IN THE CONSTRUCTION OF DESIGN SPACE: THE CASE OF ATELIERZ

Irem KÜÇÜK*, Adnan AKSU

Gazi University

Gazi University Architecture Faculty Department Of Architecture Eti Mahallesi Yükseliş Sokak no:5 Maltepe/Ankara, 06570 & Ankara, Turkey; iremkucuk@gazi.edu.tr, adaksu@gazi.edu.tr

Abstract

The design space, as a unity of senses and expressions leading to the creation of architectural space, forms a spatiotemporal informational structure. The impact of design actions on material and immaterial things is crucial in shaping this structure. Intervening in the material things connects the design space to the real world. As digital technologies develop, new ways of interacting with material reality emerge, but the simultaneous encounter and experience with the unknown instantaneous response of the material to the action are still limited compared to analogue ones. In this context, this paper discusses the extension of the design space towards material reality in an architectural design studio that allows the use of all types of tools, digital or analogue, and encourages the interactive use of tools. It exemplifies an experimental pedagogical approach exploring material experimentation possibilities in architectural design education.

The first part of the study, which consists of three parts, carries out a conceptual analysis to provide a perspective on the construction of design space in the architectural design studio. The second part applies critical discussion to examine the fictionalization of the architectural design studio and the situating of design space for material experimentation. The third part reflects on the work of atelierz regarding the materialization of design space. Accordingly, the studio's proposal of installations and prototypes as channels of contact with material reality is introduced, and the studio's work is exemplified. Concerning the studio's experience, the benefits and problems of moving design practice into these channels have been identified.

Keywords

architectural design studio, design space, material experimentation, experimental pedagogical approach, atelierz

1 Introduction

The design space encompasses the unity of senses and expressions created by the act of designing, leading to the creation of architectural space. It forms a spatiotemporal informational structure that is constantly changing in becoming through the flow of design action. It is shaped by networks of mediated and unmediated relations in immaterial and material realities.[1] Philip Boudon's ontological distinction between design space and architectural space provides conceptual clarity to explain the design space as a being in a constant state of becoming. According to him, when design shifts to the design space that produces itself, it has access to a field of knowledge that transcends itself. He develops this distinction inspired by Gaston Bachelard's "space under space". According to Bachelard, the space in everyday life and the space created to understand this space are different. With this perspective, drawing on Henry Poincare, Boudon defines design space as representational space created to bring tangible space into existence, whereas he defines architectural space as tangible space.[2] In this sense, design space, structurally different from architectural space, is a transcendental formation that transcends architectural space, extends to all the elements and contents that make it up, and carries within itself the possibility of creating many different architectural spaces. It is characterised by its dynamic nature, offering infinite variation and constant change, open to intervention. [3]

There is a iterative production of sense and expression in the design space. The design space is extended to mediate, to transfer and to negotiate from one medium to another, to produce different sensations and expressions. Robin Schuldenfrei's concept of iteration, which she proposes to examine mediation in architecture in terms of the inventiveness of creative processes, provides a reference for explaining the continuous transfer and negotiation within the same or different media. Iteration, as a way of interweaving thinking and doing/making, offers a productive flexibility to mediate in art and architecture through forms of expression. [4] Gail Peter Borden and Michael Meredith mention that contemporary architecture produces a myriad of mediations using different forms of representative expressions such as drawings, photographs, videos, models, prototypes, installations, performances, websites and texts, all of which can be expressed under the name of medium. As they suggest, in discussing the shaping of architecture in terms of mediation, the relationship between matter and medium becomes an important issue, and how different forms of representation mediate becomes a subject of research. [5] Although design space can cover both immaterial and material expressions, this study focuses on the pervasive material expressions of design space.

As Achim Menges mentions, practising with physical artefacts of architectural design is critical for the designer's senses and intuition to come into play.[6] Designing with physical artefacts allows interaction between dualities of design intention and material world, intent and artefact, representation and realization, and descriptive practice and material practice.[7][8] A dialogue is developed between immaterial and material realities through intuition and action. This dialogue leads to creative moment and can be "intuitive, rational, irrational, associative and informed, all at the same time."[9] It depends on the ways of engagement with material reality. Although the means and methods may vary, there are two main types of doing in engagement with materiality: "to act/to do" and "to make/to produce". Among these two different kinds of doing, whose roots go back to the categories of "praxis" and "poiseis" in ancient Greece, the first refers to performing/doing itself the second to knowing/cognition. [10] Acting/doing something is related to realising itself by embodying its own result in itself. On the other hand bringing something into being/producing something is related to realising something other than itself by containing a result other than itself. For example, playing the flute only realises itself and does not contain any result other than itself whereas building a building creates a result other than itself by realising something beyond itself. [11] With this understanding, performing/doing something is explained in terms of practical intellect/phronesis. whereas making/producing something is explained in terms of technical skill (technical skill, techne) Although both are realised in accordance with intention, in the case of the former there is a spontaneous intention that is not conditioned. [12] In this understanding, the act of design involves both types of doing. It can be challenging to separate the two. On the one hand, the creative potential leading to novelty emerges by performing/doing with unconditioned intention. On the other hand, making/producing artefacts with conditioned intention provides a unique sensation for acting/doing. John Fernandez expresses this unity of two kinds of doing in terms of connecting the poetic and pragmatic or the lyrical and the technical.[13]

Extending the design space to cover material experimentation opens up a field of action for inventing, discovering, and experiencing within the unity of doing iteratively. Owain Pedgley, Valentina Rognoli and Elvin Karana define this field as "a vibrant investigative and inspirational practice" based on the designer, the material and the artefact, and their relationship [14]. As they also suggest, this field of action should be experienced and explored in depth in different contexts of architectural practice. In particular, design education needs to be rethought to include material experimentation practices to allow students to experience what they are designing concretely. In this context, this paper discusses the extension of the design space towards material reality in an architectural design studio that allows the use of all types of tools, digital or analogue, and encourages the interactive use of tools. The first part of the study, which consists of three parts, carries out a conceptual analysis to provide a perspective on the construction of design space in the architectural design studio. The second part applies critical discussion to examine the fictionalization of the architectural design studio and the situating of design space for material experimentation. The third part reflects on the work of atelierz[1] regarding the materialization of design space. Accordingly, the studio's proposal of installations and prototypes as channels of contact with material reality is introduced, and the studio's work is exemplified. Concerning the studio's experience, the benefits and problems of moving design practice into these channels have been identified.

[1] atelierz is one of the vertical design studios at Gazi University, Faculty of Architecture, Department of Architecture, where 2nd, 3rd and 4th-year students work together. atelierz, which creates experimental studio fiction shaped in thematic series, defines an original and autonomous workspace that integrates design education and research. Founded in 2014 by Adnan Aksu and İrem Küçük, atelierz has since shaped its educational content around the thematic series "Figure of the Architect", "Back to the Future/the Slum", "Becomings of the House", "Codes of Contemporary Architecture", with the invaluable contributions of full-time and part-time conductors who joined the studio in different study terms. Among them, the 'Codes of Contemporary Architecture' series, which is the case of this article, was led by Adnan Aksu, İrem Küçük, Tuğba Ersen, Ezgi Başar, Sinem Yıldırım and Deniz Uygur. In order to support the integrity of the studio's design education, former studio students were also involved in the process. They assisted the studio with the different themes of the series. Sinem Görücü, Sefa Ercan Aysu Kuştaş, Selcan Ünal, Beyza Saral, and Emin Akdemir are the ones who contributed at different stages.

2 On the construction of design space in architectural education

The construction of the design space is mainly shaped by the contexts in which the design action takes place and which it addresses as the problem, the tools which are used in the design and the actors who realise the design. [15] Since all these factors can lead to many variable situations, design space construction can only be partially defined. Nevertheless, an awareness of the design space can be created by understanding the factors that shape its construction. Particularly in architectural design education, developing an understanding of design space provides a perspective for the students to advance their design practice. In this sense, the fictionalisation of architectural design studios in a way that includes a versatility that allows for the construction of design spaces of different characters is crucial to enrich the students' experience. In line with this, promoting the interaction of various disciplines and allowing the theoretical and the practical to coexist extends the studio inwards and outwards of architecture and provides a suitable environment for differentiation.

The underlying logic of the design space is critical to the design of both **the intention** and **the artefact**, as well as the nature of the practice. [16] While this logic is developed through contexts, tools, actors and their relationships, hybridisation has significant potential for creative interrelationships. As it leads to the free encounter of diversities, it is also crucial for constructing a more integrated design space. Hybridisations between different disciplines and different structures of theoretical and practical fields create a more diffuse design practice, thus expanding the content and diversifying the representations of the design space. As explained earlier, the design space creates a medium of different representative forms of material and immaterial things. The type of action that each form of representation triggers is unique to itself. Increasing the possibilities of experimenting with the diversity of relationships between different forms of representation, rather than comparing them or favouring one over the other, is essential to constructing the spatio-temporal informational structure of the design space. In this sense, the sphere of diffusion of representations situates the design space. Similarly, in the studio, the extensions and interactions offered by the studio fiction are crucial in shaping how the design space is situated.

3 On the fictionalization of the architectural design studio and the situating of design space

The architectural design studio has the potential to be transformed into an integrative medium, open to the use of all kinds of knowledge and skills, both within and outside the scope of architectural education. [17] **The thematic framework and content of the studio, its programme, environment and equipment, instructor and student profiles, the other environments the studio extends and the set of activities that support the studio** can activate this potential by shaping the pedagogical fiction. Studio fictions need to be rethought to guide working with the material and extend design activities to material experiments as well as the immaterial. With this understanding, atelierz diversifies its studio fiction by adopting installations and prototypes as channels of contact with material reality. The thematic series "Codes of Contemporary Architecture"[2] is one of these fictional

[2] Codes of Contemporary Architecture series is consisted of the sub-themes: 1 Puzzle Architecture/ Memory of Space, 2 Porsuk River Forced to Flow Still, 3 2020+20, 4 Becomings of Earth, 5 Becomings of City,

variations. **The themes** of the series are developed as inspiring, open frameworks that allow the instructor and the student to develop specialized design problems. **The content** of the studio is kept as broad as possible in an expandable and interpretable structure so that students can build on the content through their research and incorporate knowledge from non-architectural fields. It is also structured to allow the activity of designing to extend towards different types of construction processes besides drawing and modelling within the duration of the studio. **The programme** of the studio is shaped in some training periods divided into two parts, namely "excessively undisciplined works" and "undisciplined works", and intertwined into one part in some. The "Excessively undisciplined works" part covers design activities spreading broad design contexts by producing artistic works such as installations, videos, performances and objects without being confined to a particular discipline. Students working in groups are asked to develop specialized perspectives and discussions regarding the studio theme by producing an artwork. Working through different disciplinary methods/tools, acquiring skills and gaining different perspectives, using all kinds of doing and making via digital or analogue tools/devices is promoted. Whereas the "Undisciplined works" part covers design activities focusing on spatial design studies taking advantage of the acquired skills and perspectives while producing excessively undisciplined works. Students working in groups or individuals are asked to shape the context of their spatial design problem within the framework of the studio theme and to design an artefact experimenting on space in its formal, programmatic and structural aspects. The formation of hybrid forms of doing and making is promoted in this part also by the interactive use of any methods/tools. While in the fiction in which these two parts are intertwined, the works produced are situated on a threshold that opens towards the outside of architecture. In both of the parts, be constructed separately, or as a whole, it is aimed that students produce artistic or architectural works as designers who instrumentalize technology and create with artistic sensitivity and craftsmanship. Although **the studio environment** does not offer a very large-scale spatial structure, other spaces in the faculty, such as corridors and common areas, are also used for design activities, and the opportunities for interaction with other students and professors in the faculty are taken advantage of. Also, while **the studio's equipment** is limited to computers, tablets, projectors, and analogue drawing and modelling tools owned by students and lecturers, technical support is provided according to the needs of the design activity. The fact that **the students** attending the studio are from the 2nd, 3rd and 4th years allows them to learn from each other and to make up for each other's shortcomings following the difference and diversity of their knowledge, experience and skills. The fact that some of **the studio instructors** specialise in the theoretical field, some in both theoretical and practical fields, and some in different practical fields adds to the studio's know-how. In addition, depending on the content of the students' research and design work, external know-how is sought, and experts are invited to organise workshops or to give lectures. Besides, trips to architectural or art biennales and exhibitions are organized to increase the studio's familiarity with different types of expression and ways of doing things.

In addition to studio fiction, the medium through which the design spaces of the studio are situated is crucial to material experimentation. As Nithikul Nimkulrat quotes, Lambros

6 Becomings of Body and Space, 7 Temaşa I/ Educational Spaces, 8 Temaşa II/Living Capsules, 9 Temaşa III/ Urban Collages at the Intersection of Remembering, Forgetting and Dreaming, 10 Centennial Architecture and it is still continuing.

Malafouris discusses material engagement in terms of **a situated skilled practice** in which **the maker**, **the material** and **the tool** are related. According to him, agency and intentionality are key terms to explain this kind of practice. In material engagement, "action comes before intention and material engage maker agents in dialogue". As he stated, the artefact is more than "a passive object of maker's intentionality" in such a practice. Instead, it is an active component of the design experience. [18] [19] In this sense, the media in which the design space is situated is determined by the tools establishing the dialogue and the material employed to be in dialogue. And the artefacts created from within the design space become active agents of reflection. In these experimental processes, which proceed with spontaneous intentionality, the interventions applied to the material, on the one hand, reveal the inherent properties of the material and, on the other, make the design space visible and tangible to a certain extent through the created artefacts. In this respect, the studio's knowledge of tools and materials determines the unity of media in which the design space is situated and how this unity will mediate for material experimentation. However, constructing design space interacting with material reality forms a craft beyond technical skill, creating sensibility. As Richard Sennett mentions, craft intervention is not only an instrumental act but also practical, comprising more than just techniques. [20] With this conception, a design practice based on the constant change of material and immaterial realities becomes possible through crafty intervention in material experimentation. And design space is situated on the unity of these realities, providing agency for the spontaneous development of intention.

4 On the material experimentation constructing the design space

In experimenting with materials, installations and prototypes emerge as engagement channels with different characteristics. While the former offers the possibility of directly building a full construction on a 1:1 scale, the latter allows experimentation with small-scale representations or partial constructions on a 1:1 scale. These channels, which provide different possibilities of interaction with the material to design the space, can be involved in various pedagogical constructs in the architectural design studio. This study, which exemplifies the use of installations and prototypes in the studio, takes two periods of atelierz, fictionalized with the theme of "Contemplation" as a case study.[3] In the context of the theme, the studio adopts a pedagogy in which the intention and the artefact shape each other in complex, non-linear relationships. Spatial constructions are built materially by using all kinds of digital or analogue tools through diverse modes of doing/making and material interventions.

[3] The theme of "contemplation" that frames the both working periods, explores "carnivalesque" architectural formations by experimenting with playful spatial constructions. The first period is taken to exemplify the installation works realised in the context of Contemplation Spaces I/ Educational Spaces, sub-theme 7 of the Contemporary Codes Of Architecture thematic series, and the second one is the prototype works realised in the context of Contemplation Spaces II/Living Capsules, sub-theme 8 of the same series.

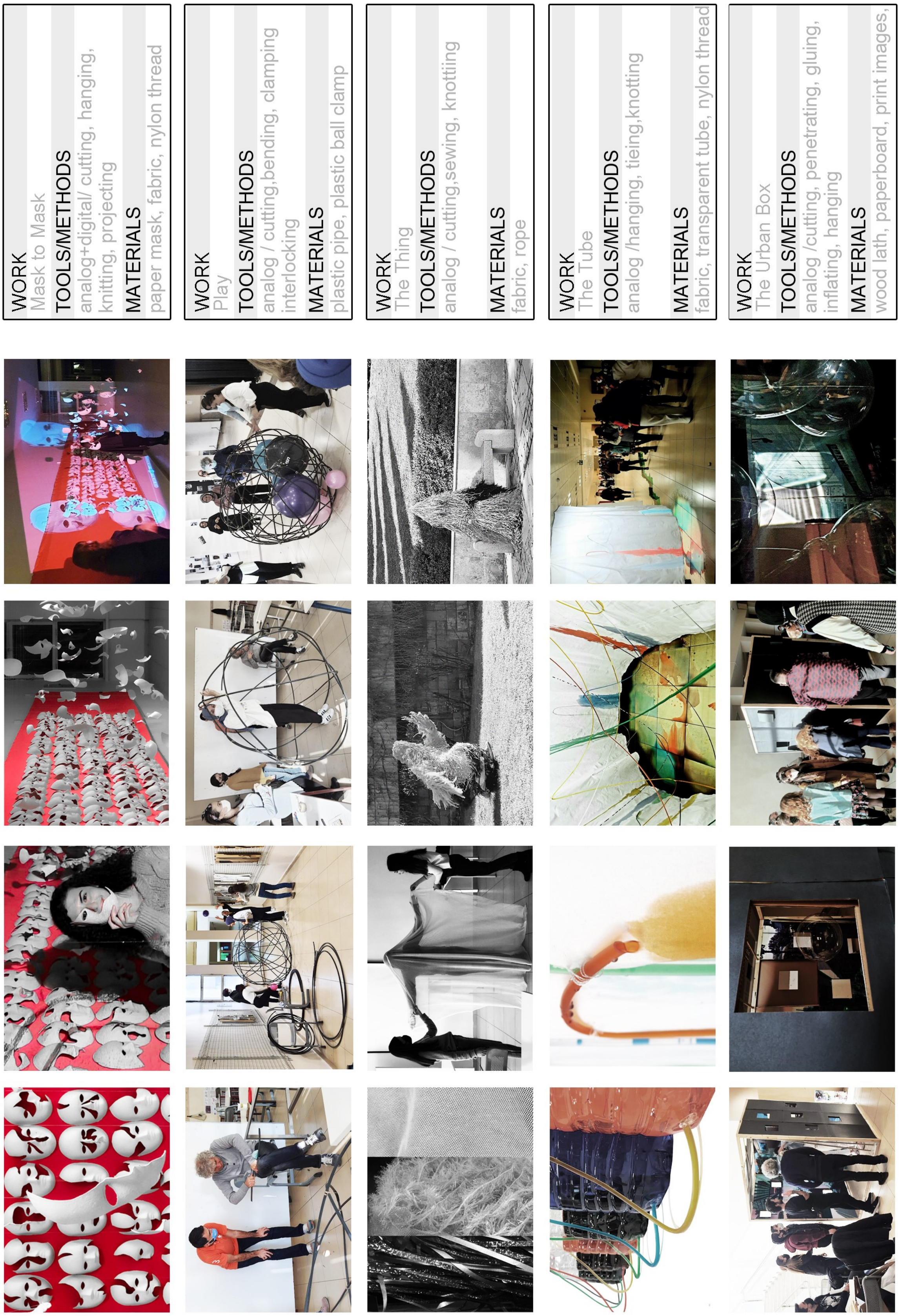


Figure 1. Material Experimentation via Installations

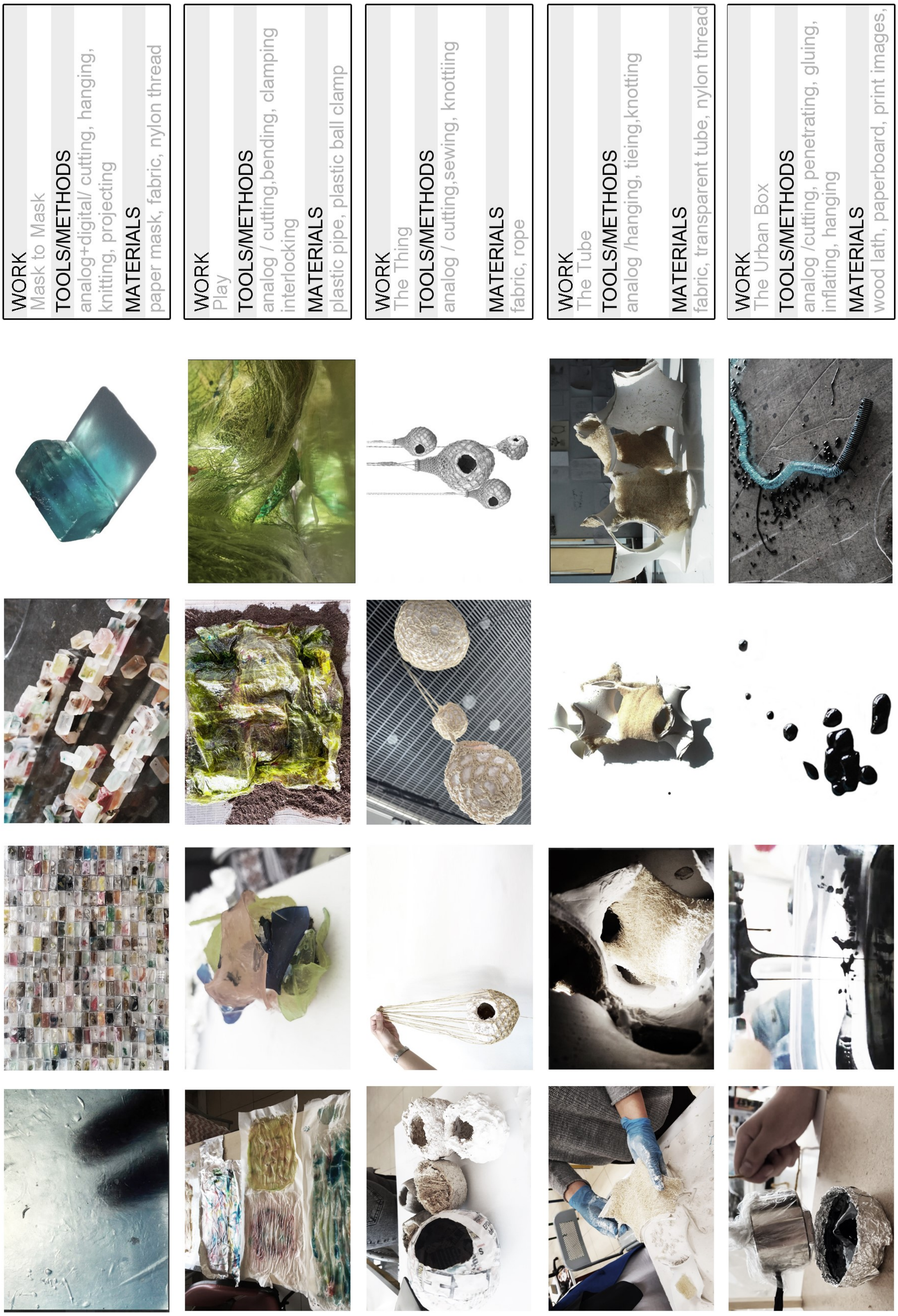


Figure 2. Material Experimentation via prototypes

experimenting via installations

"Contemplation Spaces I/ Educational Spaces, which is divided into two parts, problematizes carnivalesque spatial arrangements in education. The first part of this period was devoted to discussing and experiencing carnivalesque space arrangements via installations. The students, divided into nine design teams of 6-7 people, turned the spaces of the architecture department into a playground by producing installation works. Using materials of fabric, masks, cardboard boxes, plastic pipes, balls, balloons, aluminium foil, newspaper, printing materials, paints and methods such as sewing, hanging, bending, interlocking, clamping, framing/penetrating, gluing, and fastening, the installations were designed based on performance. The designed group works were placed in relation to each other in the meeting spaces where the architecture department classrooms were opened. A carnival was constructed in which the space was reconstructed through play.

experimenting via prototypes

In the "Contemplation Spaces II/Living Capsules", the studio period, which is intertwined in one part, was devoted to designing life capsules dispersed within the city. The students, divided into twenty-three design teams of 2-4 people, designed capsules that could accommodate individual or collective living practices within a volumetric limit of 1000m3, programmatically shaped by various activities such as wandering, performing, recycling, etc., beyond shelter. Small-scale prototypes were made to experiment directly with the building materials to be used. Employing experimental materials and unknown methods, or existing materials and unknown methods, or, experimental materials and known methods, or existing materials and known methods, life capsules are designed 1/20, 1/10 or 1/1 scaled material experimentation .

5 Conclusion

The construction of design space is fundamental to shaping architectural design practice. Depending on the media through which it is disseminated, the design space is constructed within the immaterial or material realities. However, acting on a material thing to build a representation of another material thing causes a disconnection that prevents us from touching the essence of the things themselves and the things they represent and discovering their nature. Therefore, interacting with the material thing that constructs the space provides a direct interaction channel in the iterative formation of sense and expression. In this interaction, including all kinds of tools that enable analogue or digital experimentation in the design process and even promoting hybridisation increases the possibilities of interaction and supports the construction of a more integrated design space. With this perspective, the architectural design studio is a convenient environment for developing a pedagogical fiction that allows the design space to extend towards material reality.

Accordingly, this study presents an experimental pedagogical approach to expand and diversify the field of experience of designing and constructing space in the architectural design studio. It expresses the studio fictions of using installations and prototypes as material channels of engagement in architectural design education and presents a selection of works produced at atelierz and their production processes. As this fiction is developed from a single design studio's case study, it is clear that a wider case study and comparative analysis between different studios' fictions and experiences would add to our understanding. Nevertheless, the study constitutes a conceptual and experimental mechanism that gives educators and designers an idea of how to fictionalise the architectural design studio for material experimentation. It also contributes to the studies that seek ways to integrate theory and practice and ensure collaboration between disciplines.

Concerning the studio's experience, it is seen that during the studio processes, know-how about the material, the different tools used in material intervention and the use of the tools together, the skills of using the tools have developed, and an awareness of the relationship between crafter intervention and designer reflection has been formed. On the other hand, restrictions of access to certain tools, knowledge and skills in the use of certain tools and materials limit the field of movement and constrict the experiments to a narrow framework. In this sense, the equipment and know-how of the studio or external support for them in the development of studio fictions based on material experimentation emerges as a determining factor in the effectiveness of the training.

References

[1] Yılmaz, İrem, Rethinking Design Space in Architecture, Phd Thesis, Gazi University, Ankara, Turkey, 2018

[2] Boudon, Philip, *Mimari Mekan Üzerine: Mimarlık Epistemolojisi Üzerine Deneme,* Janus Publications, İstanbul, Turkey, 2015

[3] Opcit. Yılmaz, İrem, 2018

[4] Schuldenfrei, Robin, Introduction, in *Iteration: Episodes in the Mediation of Art and Architecture*,(Schuldenfrei, Robin), Routledge, New York, USA, 2020

[5] Borden, Gail Peter and Meredith, Michael, Introduction and Material Premise, in *Lineament: Material, Representation and the Physical Figure in Architectural Production*,(Borden, Gail Peter and Meredith, Michael), Routledge, New York, USA, 2017

[6] Menges, Achim, Design Computation and Material, , in *Lineament: Material, Representation and the Physical Figure in Architectural Production*,(Borden, Gail Peter and Meredith, Michael), Routledge, New York, USA, 2017

[7] Fernandez, John, *Material Architecture*, Routledge, Oxford, UK, 2012

[8] Ayres, Phil, Tamke, Martin and Thomsen, Mette Ramsgaard, Making A Digital Material Practice, in *Performative Materials in Architecture and Design,* (Ng, Rashida and Pate, Sneha), Intellect Books, Bristol, UK, 2013

[9] Opcit. Fernandez, John, 2012

[10] Agamben, Giorgio, Poiseis and Praxis, in *The Man Without Content*, Stanford University Press, California, USA, 1999, pp. 68-94.

[11] Crisp, Roger, *Aristotle: Nicomachean Ethics*, Cambridge University Press, Cambridge, UK, 2014

[12] Opcit. Agamben, Giorgio, 1999

[13] Opcit. Fernandez, John, 2012

[14] Pedgley, Owain, Rognoli, Valentina and Karana, Elvin, expanding Territories of Materials and Design, in *Materials Experience 2: Expanding Territories of Materials and Design,* (Pedgley, Owain, Rognoli, Valentina and Karana, Elvin), Butterworth-Heinemann, Oxford, UK, 2021

[15] Opcit. Yılmaz, İrem, 2018

[16] Opct. Ayres, Phil, Tamke, Martin and Thomsen, 2013

[17] Aksu, Adnan, Küçük, İrem and Çağlar, Nur Mimari Tasarim Eğitimi Söylemleri 2: Bütünleşme*, 2. Ulusal Sempozyum-Mimari Tasarım Eğitimi:"Bütünleşme 2",* YTÜ Mimarlık Fakültesi Mimarlık Bölümü, İstanbul , Türkiye, 2011, pp.323-332.

[18] Malafouris, Lambros At the potter's wheel: an argument for material agency, in *Material agency: Towards a non-anthropocentric approach*. (Knappett, Carl and Malafouris, Lambros) , Springer, New York, 2008, pp.19–36.

[19] Nimkulrat, Nithikul, Experiential Craft: knowing through analog and digital materials experience, in *Materials Experience 2: Expanding Territories of Materials and Design,* (Pedgley, Owain, Rognoli, Valentina and Karana, Elvin), Butterworth-Heinemann, Oxford, UK, 2021

[20] Sennett, Richard, *The Craftsman*, Penguin Books Limited, London, England, 2009

APPROACHES TO THE CRITICAL STUDY OF THE ITALIAN COASTAL TERRITORY: A REVIEW OF TOOLS AND A STRATEGIES

Giulio MINUTO
Università degli Studi di Roma Tor Vergata
Via del Politecnico 1, 00133 Roma RM, Italy; giulio.minuto@outlook.it

Abstract

Nowadays, Italian coastal territories are challenged by defining new perspectives for large parts of the built landscape. These places have been profoundly altered, since the second half of the 20th century, as an outcome of economic growth and mass tourism. This process resulted in a heavily urbanised and incongruent coastal belt: large areas of residential sprawl succeed seamlessly, encompassing and obliterating landscapes and identities.

Within this pattern, a great variety of places designed for specific uses now ceased, appears as a set of closed and isolated entities. These include the vast built heritage of disused seaside colonies, industrial sites, and maritime or shipbuilding activities. The resulting landscape is a set of nameless and disconnected places, but also open and available to new interpretations and perspectives.

The way towards a new vision for these places passes through the reconnaissance, a critical analysis of the territory to identify components, connections and highlight hidden patterns, prefiguring potential transformation.

Through disassembly, isolation, overlapping and recomposition, it is possible to find a rule, to reconnect elements, places and meanings. It is a process that, by combining existing traces with socio-cultural references and today's opportunities, allows the discovery of new significances.

The present research approaches the critical study of the Italian coastal territory as a chance to explore investigation tools at different scales and propose a methodological itinerary for the analysis of similar contexts.

The study considers and combines different methods of reading, filing, indexing and representing, through the implementation of innovative digital tools and attempts to define critical processes for data interpretation and representation.

The reshaping of information, accomplished through graphical elaborations, defines a narrative through which a new level of knowledge is based, a fundamental process of projection from premises to deductions.

Keywords

Coastal territories, Italy, Analysis, Representation, Methodology

Full Paper

Goethe writing about his tour between 1786 and 1788 in "Italienische Reise", poetically describes splendid Italian coastlines where nature and human activities seemed to act in harmony, referring to "sown green and luxuriant" landscapes [1].

Starting from 1950s, these coastline landscape began to change due to a widespread process of urbanisation, that increased land consumption from 2.7% to 7.1%, with the urban development of 21,398 km^2 of coast [2].

In many cases the seaside became attractive for a new mass tourism linked to the paid holidays. Large housing settlements were built and then purchased as second houses. Major tourist facilities were also built, such as the several 'seaside colonies' or resorts. The economic boom brought to the coast manufacturing activities linked to shipbuilding, steel and energy sectors, as well as new infrastructures such as motorways and railway lines.

Today along Italian coastlines, vast areas of residential sprawl succeed seamlessly, encompassing and obliterating landscapes and identities as an urbanised and incongruent coastal belt. The output of the extensive urban expansion of last century results often in a pattern of incomplete and disconnected elements but also a scenario open to new perspectives.

The major socio-economic changes of the last two decades have altered many of the premises that had given birth to these places. New paradigms of contemporary tourism, changes in product and energy production chains have shifted many activities to other regions of the world.

Coastal territories are challenged today by defining new perspectives for large parts of this built landscape. The way towards a new vision passes through the reconnaissance, a critical analysis of the territory to identify components, connections and highlight hidden patterns, prefiguring potential transformation.

Territorial analysis strategies are based on a framework of established practices, but they also require continuous revision and critical adaptation of methods to adapt to the specifics of the cases analysed, and to new available data and processing tools

In this study's case, coastal territories are singular for many reasons: for the landscape morphology, the historical background, the urban pattern, but above all for the specific criticalities they must face. Therefore, has been necessary to develop and implement analysis specifically for this context.

The results are presented through a series of representative graphics, contextualised within a broader methodological framework. The examples provide an essential documentary contribute, they recount the process through the specificity of the application, integrating the steps that cannot be generalised.

These can be transferred by analogy into as many solutions and therefore do not bind to the specific solution adopted. Indeed, the empirical nature of the investigation process lends itself to a description mediated by examples that do not exclude variants.

A fundamental premise is the definition of the investigation scale: a medium-distance approach that allows the relational and overall aspects of an urban landscape to be grasped.

The definition does not limit the scale of representation, which may also vary considerably to analyse the effects of the *micro* and *macro* in relation to the scale of investigation. So, more closely focused investigations and photographic studies can be developed and combined in sequences (e.g. Figure 1) or linked to the overall frame in order to gain insight and relate specific aspects to an aggregate scheme.

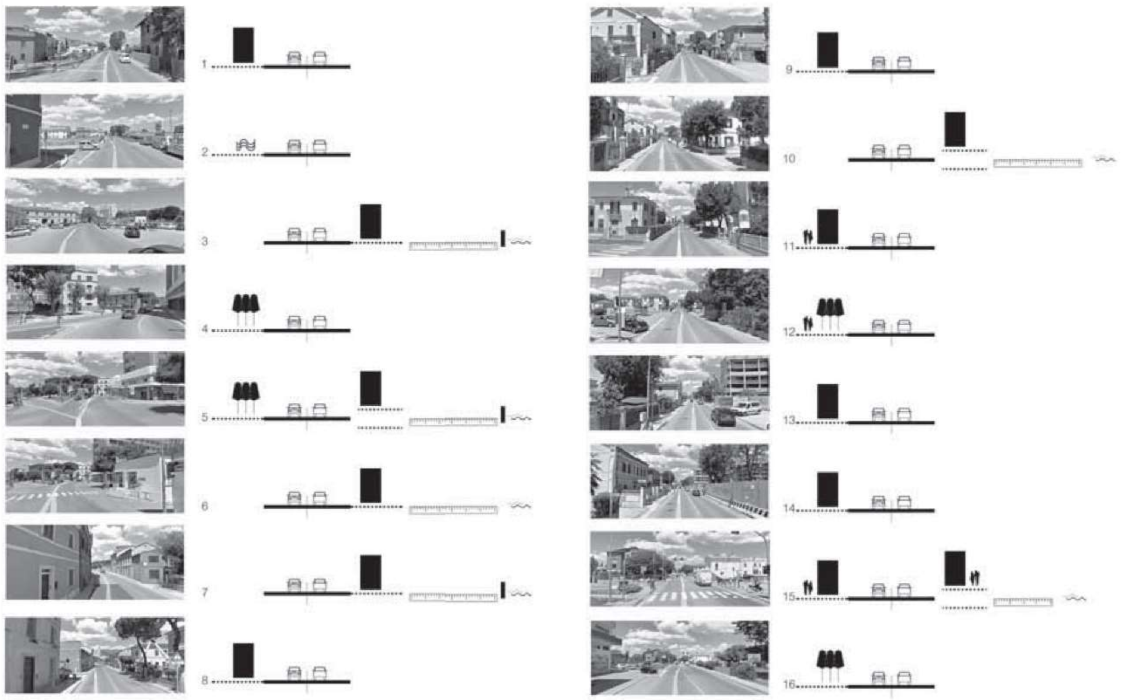


Figure 1. Sequence of photographic views and conceptualizations (Falzetti A.)

Graphical territorial analysis can be conceived as a sequence of reconstructions and graphical reinterpretations of the landscape traces. The process is therefore incremental. It starts with a drastic simplification through decomposition and isolation and then deepens the individual components.

Thus, proceeds by association building together frameworks with different methods of combination and overlapping. Results are completed by written comments, integrating the information expressed graphically with a different layer of description.

The main trace that defines coastal landscapes is the coastline. It neatly divides the landscape into two parts: the sea and the land. It is a sharp and barely alterable trace, a boundary between two complementary systems, of which only one the land is habitable and therefore alterable by man.

As a first step, therefore, it is to isolate this element to study its topography and features. On this thin line, often lie the important premises of how human presence is organised on the coast. Figure 2

The pattern of the bays, marked by the capes, represents the first spelling, the primary trace, on which man reads and recognises the coastal landscape. Then the shape of its parts beaches or cliffs, represent a secondary aspect, which determine how man can habit and use this boundary. Finally, the structures: harbours. The last and boldest man's trace before the sea, linking to other remote lands

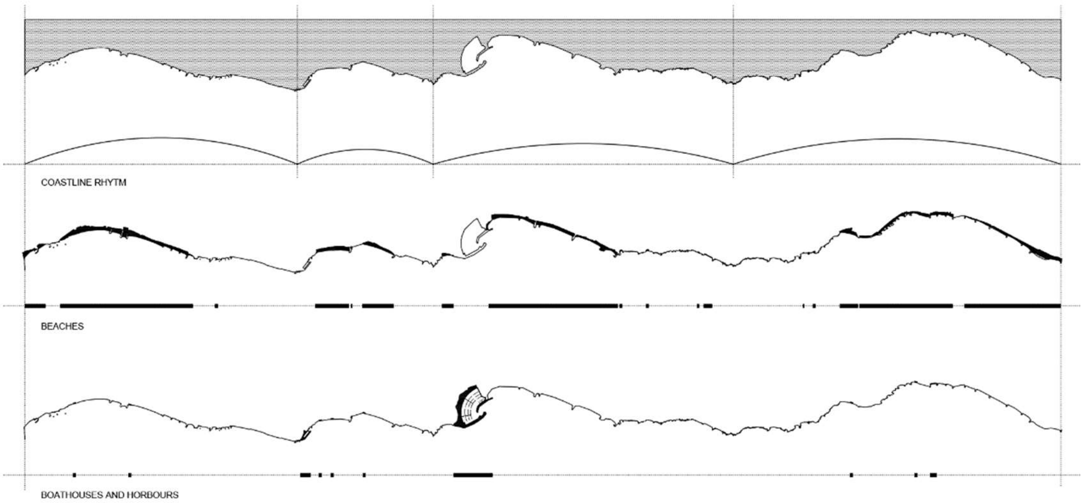


Figure 2. Coastline analysis (Author)

Next, the territorial analysis focuses on the landscape-built area. This aspect could be mapped according to different levels of morphological interpretation, as isolating either specific parts as infrastructures or differentiating volumes and voids. This last point of view allows to identify within the continuity of the built landscape, contexts as concluded and morphologically distinct parts [3]. Figure 3

However, starting from the well-known solids and voids simplification, it is possible to implement the analysis through further conceptualisations. The reduction of the variables could be achieved through the simplification of geometries (straight coastline) and contents. By simplifying the space to a regular grid, it is possible to highlight the distribution of the buildings, clearly showing focal points as existing and potential polarities.

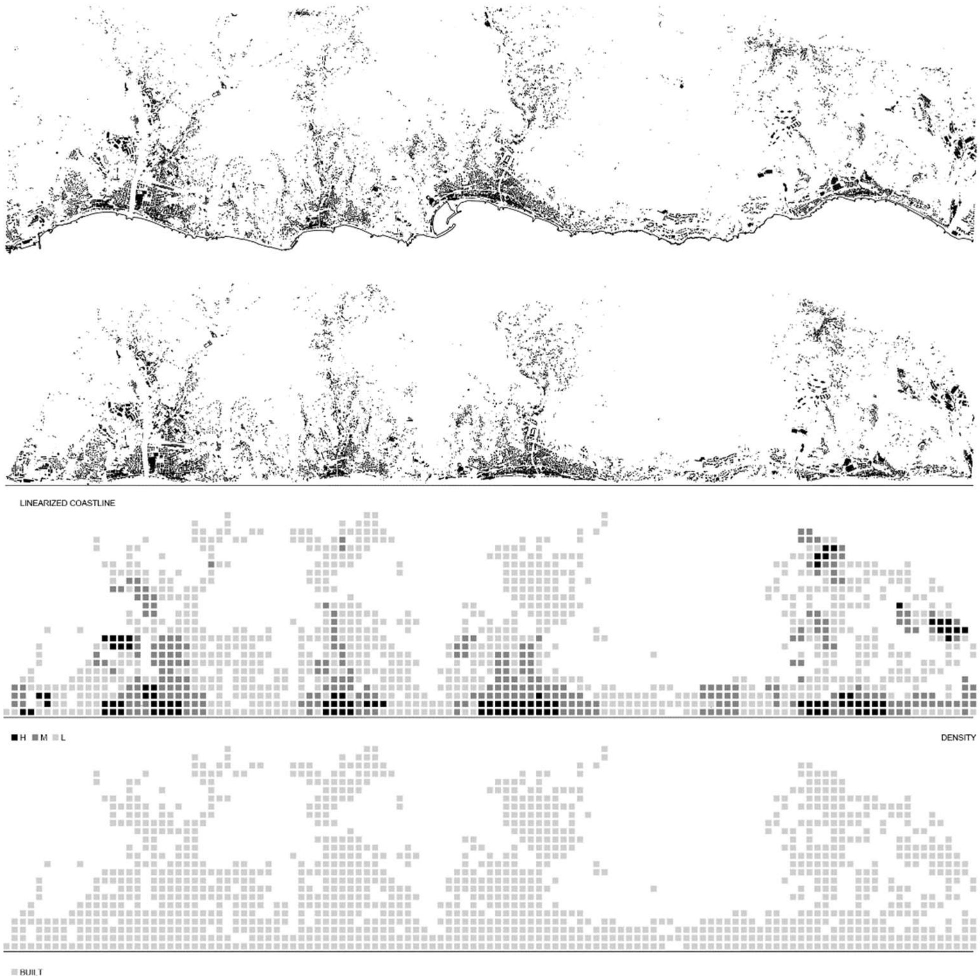


Figure 3. Map of coastal built landscape morphology (Author)

The territorial analysis on map can be enhanced by integrating graphical studies based on human's point of view. In this case, the representation is built on perspective views, collected by photographic data. Perspective, which characterises real experience, highlights relationships between volumes, views and alignments, impossible to detect through the map's plain representation. Figure 4

Photography thus becomes fundamental as first knowledge and documentation source; hotographic sequences provide a visual reconstruction of landscapes, leading to the identification of common features [4].

Again, the photographic reproduction is followed by a process of conceptualisation that, through reduction to the binary b/w ratio on the two-dimensional plane, highlights the relevant elements and directly compares them in terms of size and position.

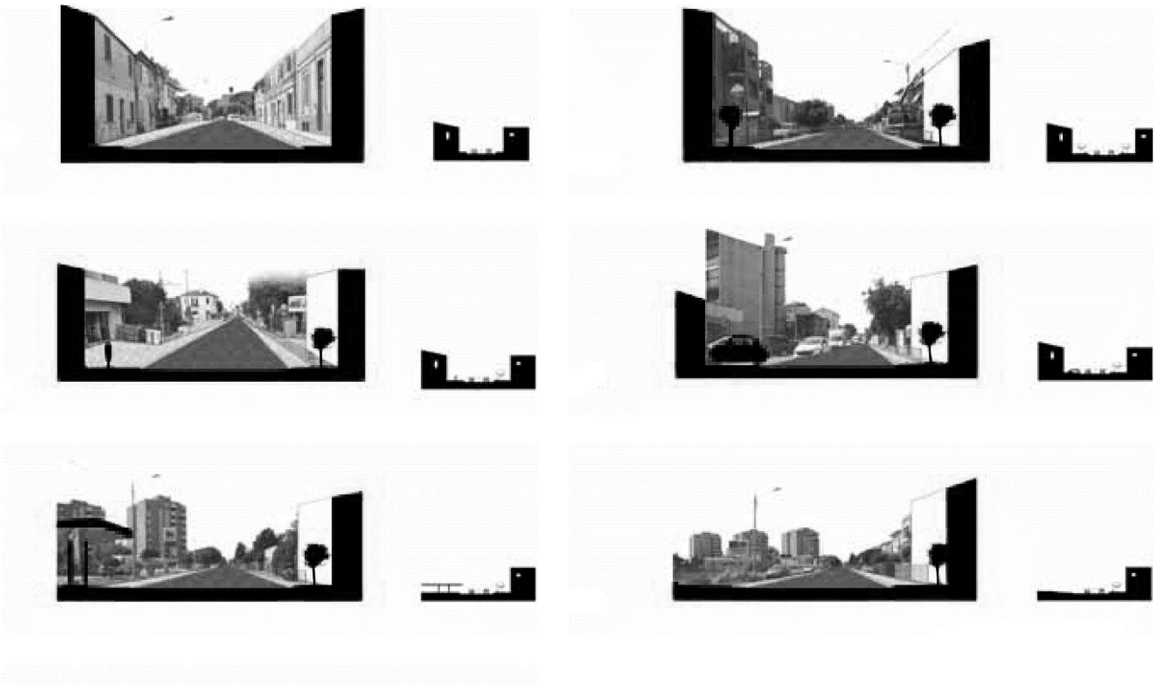


Figure 4. Perspectives and conceptualizations (Falzetti A.)

The overlapping and matching of photographic images with schematic drawings is an effective approach to knowledge. Within the iterative process of observation - representation - review, the ability to maintain a faithful reproduction of reality, placed side by side with a schematic representation, allows to extend the understanding of the subject, through the paired reading and the constant comparison between reproduction (faithful) and representation (schematic).

In this context could be explored how to extend the approach to a wider scale. Using three-dimensional models of terrain, are realised photorealistic perspective sections. Such accurate simulations can be used as a level of knowledge between photography and map's analysis, making it possible to explore and draw with perspective wide-scale territorial representations. Figure 5 This allows for a constant comparison between the complexity of reality and graphical conceptualisation, such as reduction to a planar section line or a linear sequence of symbols.

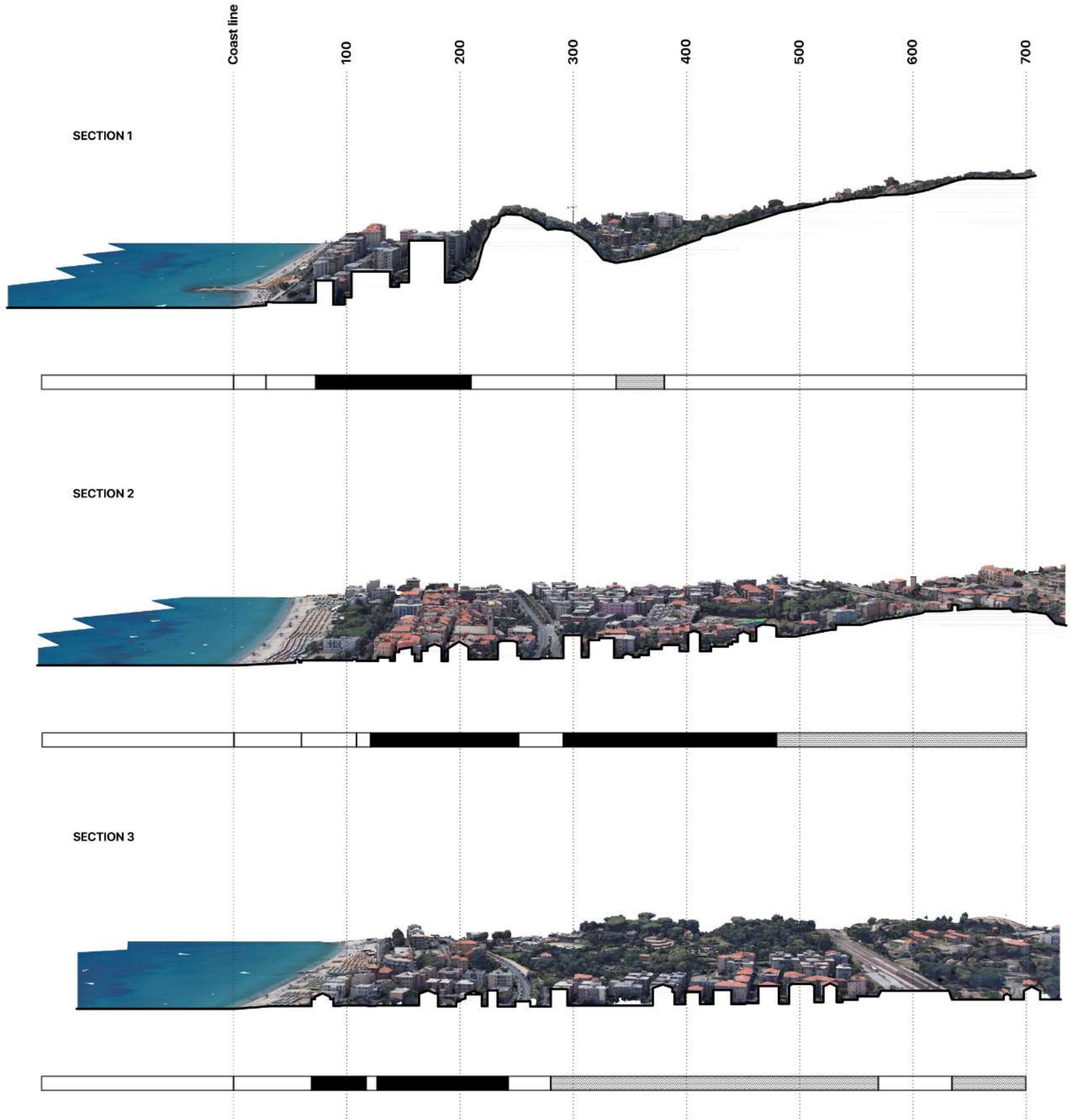


Figure 5. Perspective (Author)

The reshaping of information, accomplished through the presented graphical elaborations, defines a new base on which investigate and deepen separately different aspects.

Hence the design process proceeds through experimental associations and hypotheses that can be graphically verified through comparison with previous analyses. The design process evolves, made up of continuous comparisons and changes of direction. The uncertainty of the design process points to the importance of the territorial analysis as the only element through which to legitimise the coherence of the design outcomes.

References

[1] Goethe, J. W., *Ricordi di Viaggio in Italia,* Stab. Tipog. Librario Ditta Editrice F.Manni, Milano, 1875.

[2] Munafò, M., Consumo di suolo, dinamiche territoriali e servizi ecosistemici, 15/20, Report SNPA, Italy, 2020.

[3] Amistadi L., *La costruzione della città. Concetti e figure,* Il Poligrafo, Padova, 2012.

[4] Basilico G., *Architetture, città, visioni*, Bruno Mondadori, Milano, 2007.

Falzetti A., *ISity dispositivi progettuali per la statale 16 di Senigallia.* Gangemi Editore, Roma, 2018.

Falzetti A. E Ramazzotti L., *Paesaggi da decifrare. Gli sguardi del progetto*, Gangemi, Roma, 2012.

Dewey J., *Logica, teoria dell'indagine,* (A. Visalberghi, Trad.) Einaudi, Torino, 1974.

Lynch K., *L'immagine della città,* (G. C. Guarda, Trad.) Marsilio Editori, Padova, 2006.

LOCALLY ACTIVE ARCHITECTURE

Gábor FÁBIÁN

Budapest University of Technology and Economics, Faculty of Architecture, Department of Explorative Architecture
H1111 Budapest, Hungary; fabian.gabor@epk.bme.hu

Abstract

How can a group of young architects find their home in today's world?

Only if they create a suitable environment for themselves, from which the local community can also profit.

We contacted the local government to provide us with a building that no one finds the inspiration to refurbish. We were granted a fifteen-year lease of the decaying state-owned building. We had outlined a sustainable model hinged on local needs: we had undertaken to implement a value-added reconstruction and fill the building with cultural content.
In a collaboration involving the social sphere, the institutional sphere, and the construction industry, we managed to realize an exemplary renovation, making use of already available resources, without seed capital and cash flow.
We reversed the usual course of planning: first, we found material support for the required tasks and then came up with architectural solutions to match the materials offered by sponsors. In less than a year, we managed to renovate the building using the materials received and recycling the objects found on site. In addition to NGO sponsors and our contacts in the construction industry, we involved students of a local polytechnic high school and convicts from the local penal institution in the process. The planning process gained new meaning, and the construction became a collective activity. The greatest added value of the project turned out to be the growing social network of the collaborators.

Keywords: local, collective activity, collaboration, sustainability

Topic: T2 Conceptual and Methodical Concepts

The idea of the arkt arts centre was conceived in 2013, as a large proportion of our time and mental capacities were liberated on account of the economic recession. In recent years, the revitalization of existing buildings has come to the fore. Throughout our work, we experiment with different renovation strategies, in terms of design as well as financing. Out of this impulse, as our own initiative, we contacted the local government to provide us a building that no one found the inspiration to refurbish and was too expensive to maintain. Unfortunately, but luckily for us, there were a number of choices. We opted for the former GAMESZ (Economic Technical Supplier and Service Provider Organization) building, located on the premises of the historical Gárdonyi Garden, next to the Géza Gárdonyi Memorial Museum, vacant for years and deteriorated by slow decay, marked as dangerous in the city's cadastre. We received the building of nearly 400 m2 floor space and the 4200 m2 plot with native trees for a 15-year lease. We had outlined a sustainable model hinged on local needs: we had undertaken to implement a value-added reconstruction and fill the building with cultural content. The realization of the project was founded on mutual trust, with a focus on communication, involving the continuous presentation of partial results. The municipality's responsibility and risk-taking, as well as their conscious participation, were indispensable elements of the process. In this case, dependency on the local government equalled an opportunity for a long-term innovative cooperation.

In defining our requirements and aesthetic standards, our guideline was to satisfy the basic technical requirements, but in terms of usability, we sought to achieve maximal functionality. In a collaboration involving the social sphere, the institutional sphere, and the construction industry, we managed to realize an exemplary renovation, making the most efficient use of only already available resources, entirely without seed capital and cash flow. We reversed the usual course of planning: first, we found material support for the required tasks and then came up with architectural solutions to match the materials offered by sponsors. Using the construction materials received and recycling the objects found on site, we managed to activate the building in less than a year.

In addition to our contacts in the construction industry, established throughout the years, we involved some students of the local Bornemissza Gergely Polytechnic High School who specialized in the sector. We thus provided them with a site for field practice that not only raised their interest, but also resulted in a possible improvement of the quality of technical education. Through our contacts in the municipal library, which offers tale reading therapy sessions, we reached out to the Heves County Penitentiary. For the convicts of the institution, participating in a collective construction project provided an excellent opportunity to improve their social acceptance and self-esteem, and facilitate their rehabilitation. These collective efforts proved constructive for the participants and the community at least as much as for the building itself. Planning gained new meaning and construction became a collective activity. The greatest added value of the project turned out to be the growing social network of organizers and collaborators. The process rendered people's presence personal, owing to which friendships and relationships were formed, and as a result, the building itself lost some of its significance, as the human relationships became much more important. A community was formed, integrating engineers, artists, college students, polytechnic students and teachers, experts, civilians, and last, but not least, convicts and their guards.

This is how the *Arkt Művészeti Ellátó* (Arkt Art "Provider") was brought to life as a centre for engineering, arts, and culture, offering exhibition spaces, workshops, studios, and a community space. In cooperation with the café and wine garden, as well as the Eger-based

Eszterházy Károly University's Department of Visual Arts, the "Provider" endeavours to operate a new form of institution with exhibitions, workshops, performances, and events. Owing to architectural presence and active engagement, a building that was once considered worthless has become a space full of life: a small but emblematic example of the power of community and the will to make a difference.

Aesculus

The celebrated Hungarian novelist Géza Gárdonyi (1863–1922)—whose most famous novel, Stars of Eger, is a fundamental part of the curriculum in primary schools—fashioned a botanical garden around his house in the early 1900s. In addition to having a significant role in the formation of local identity, by planting horse chestnut trees, he became the first activator in the process. The Gárdonyi Garden became our point of departure: the place that captivated and empowered us throughout the project, the place where thoughts are conceived. Its presence has also determined the destiny of the abandoned, crumbling building it accommodates.

Figure 1. The Gárdonyi Garden

Cooperation

Some necessary interventions had to be implemented in the building in order to develop its new function. Besides solving technical problems, we opened up spaces and tore down walls. We continuously presented our ideas to the municipality on site. During the first such presentation, we organized an exhibition to demonstrate how the building was already prepared to fulfil its new cultural function even in its ruinous condition.

The exhibited objects should be interpreted in an unusual context, in unison with the components of built-in furniture, their imprint of decades of history, and the signs of the building's deterioration.

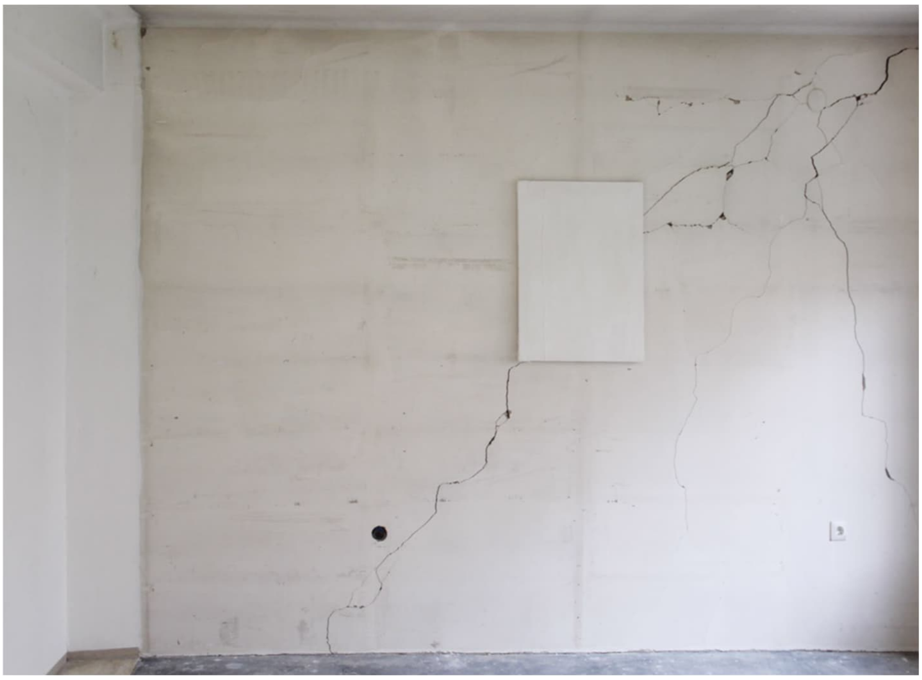


Figure 2. The first exhibition

Practical education

We had thought about involving polytechnic students in the processes of implementation even before this project. During the construction of our buildings, we had often experienced that we were not on the same page with the workers, and the results were unsatisfactory. We believe that the presence of architects (i.e. engineers) is necessary in training skilled workers in order for the appropriate way of thinking, high standards, and professional commitment to develop in future specialists.

Figure 3. Zoltán Varga specialized teacher, Bornemissza Gergely Polytechnic, Eger

"Dénes found us last September with his idea that we could implement the electrical installation works in the building they were reconstructing. We agreed on the project. The electrical installation works were done in two phases. Constructors installed the pipes in the

walls and then our students did the external mounting work, so to say the fitting of switches and lamps. Our students are 18–19 years old boys who did this work as part of their external traineeship."

"We came to work here every second week, in small teams formed according to the skills of the students and they received tasks to match up their skills. We discussed what kind of works we had to do, what materials were needed, Dénes purchased the materials and we did the job. It all went wonderfully."

"If you look in the first room of the gallery, there we fitted lots of rubbish lamps, only four working out of the 36, so they are decorations on the ceiling. Practically we installed lamps of our fathers and grandfathers."

"The installation of the covering canvas was also a special task for the guys. They made it with pleasure even though it was not an electrical fitting task. Still it proved to be useful as the plugging and fixing of it required handiness. They also learned how to behave in an external workplace and gained some experience in teamwork and work management."

Figure 4. Sándor Makovics, painter-caretaker, Bornemissza Gergely Polytechnic, Eger

"I was really looking forward to see the outcome, because I could hardly imagine it when I saw the building for the first time."

"We worked with second grade students, the painting works as well. Of course there were challenges with the painting, it was quite strange for us to leave some faults uncorrected, for example cracks and other faults and that we didn't have to make it perfect."

"I am really impressed by the premise where the 44 lamps are installed on the ceiling. They are a bit rusty, so I asked Dénes if we should paint the sides but he said that's the point, that makes them look special."

"There was also a restroom which was surprising for us, as it was not even plastered, we just had to paint it, even the window, in grey. Well, this was a bit strange for us because nobody has asked such a thing before."

Figure 5. Polytechnic students

In-kind sponsorship

While negotiating with the municipality, we queried our contacts in construction industry whether they would back this initiative. To our greatest joy, not many doors remained shut even in these dire times. Most of the support came from local enterprises. They helped us with the concrete flooring, with the replacement of glazing in all of the doors and windows, and with smaller demolition and construction tasks, to mention a few. We were offered uniformly sliced logs for the terrace flooring. We also received used construction safety nets, which were installed on the building's exterior with the help of electrician students. The net serves as protection against prying eyes and sunshine, providing diffused light in the exhibition spaces, and can also be used as a projection screen. Our decisions were determined by a set of architectural tools that came from sponsors, making the process self-explanatory.

Figure 6. Installation of construction safety net

Involvement of convicts

Figure 7. Attila Juhász warden, Heves County Penitentiary

"Our aim was to offer a possibility for the prisoners that has a kind of social benefit, through which they can achieve some sort of relief. From the point of view of the prisoners volunteering was a key aspect. It wasn't compulsory for any of them to participate in the program, only volunteers came. It's also important to know that on the days of external works they aren't in regular employment so they don't get paid for these days. Still they like to participate in the program, there is oversubscription. These people in prison have low self-esteem, and obviously have other problems, too, so it means a lot for them when they accomplish a task. It has happened several times that locals came up to us saying thank you for doing something good. It means a lot for these people when they feel they can become useful members of the society. When they feel they can compensate for what they have committed against the society."

Figure 8. Convict contributing to the construction

“I was so surprised when we were offered this possibility. We were happy that the security department had trust in us, and the employer had trust in us and so they took us out for work. And they selected who they’d take out.”

“First we did some wrecking, brought out the rubbish, removed the mortar off the walls and we also took part in outdoor works like cleaning, clearing the leaf-litter, litter picking, and things like that. We did our best and worked wholeheartedly just like we were doing our own back at home.”

“It felt like we were free people those days, it was so different out there.”

“We got out of this closed world for a while, we were more relaxed, even the air was better and we were happy to go out for a few times to work in this reconstruction. And it was also good to help others.”

Figure 9. Convict contributing to the construction

“I was open for this—how shall I put it—reintegration to society, and I also liked that I was not in the prison for that time but with regular people. I was trying to get used to what I’ll have to face when I get out. Because it’s a new world for me. We didn’t have to adapt to them, but rather they tried to comply with our things. We didn’t really get to know each other. They told us what to do, but also let us evolve, we could do things in our ways and rhythm. It was good.”

“I worked in my profession, worked on the windows, we did some landscaping. We transformed the whole place, but that right old feeling is still there. Just to make you feel whose it was and how it was.”

“Getting out of this monotone life that we have in here, which is the same every day from Monday to Sunday, it was a feeling I can’t really describe.”

Cultural sustainability

Cultural sustainability and constant renewal is made possible most of all by the collaborative presence of the Department of Visual Arts of the Eszterházy Károly University of Eger.

The exhibition spaces provide an opportunity for the students to publicly display their works and freely experiment with their ideas. The flexible and dynamic relations make students more enthusiastic to exhibit. The building is now filled with life owing to the combined energy of the exhibitions that open every other week and the atmospheric Brancs Café and Wine Garden.

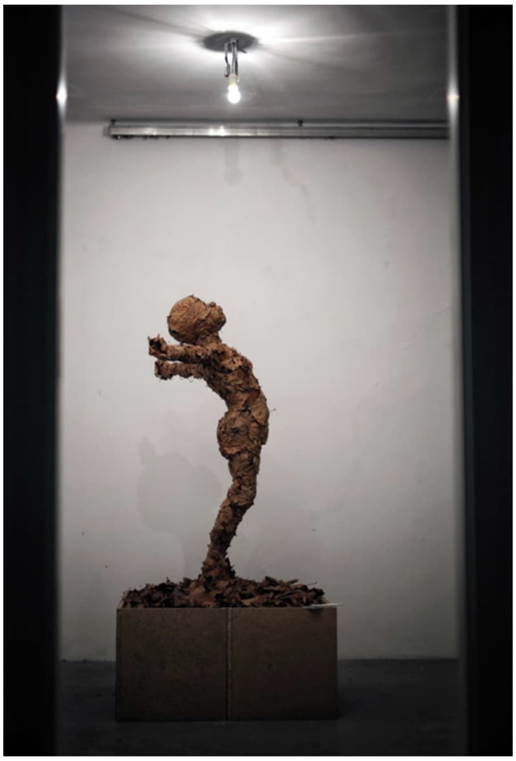


Figure 10. Exhibition

Getting the local community involved in crisis can give an opportunity for reformation. During working as a community to build there is not just a building that's built but the community as well. The planning process gets a new meaning, and the building process rises to another, communal level.

CREATIVE DEMOLITION; A CONTINUING TRADITION OF EXPERIMENTAL DESIGN IN DESSAU

Rene DAVIDS

U.C. Berkeley
1501, 37th Ave.& Oakland, CA.USA; rdavids@berkeley.edu

Abstract

Like many cities in eastern Germany, since reunification in 1990 the former manufacturing centre of Dessau has lost entire industrial sectors and population to the west's more dynamic economy. The long-term recovery plan to manage Dessau's decline proscribes demolition and replacement of empty, under-utilized, or dilapidated buildings adjacent to more densely populated areas with vegetation, producing an archipelago of urban islands in a sea of green. The plan is a re-envisioning of the clusters surrounded by foliage created to support cultural and commercial facilities after bombardment nearly destroyed the city in 1945, each one connected to the 18th century landscape park Dessau-Wörlitz Gartenreich at the confluence the Elbe and Mulde Rivers. Unlike a traditional park with a fixed layout, the greenbelts of vegetation encircling the urban islands dissolve the boundaries between urban and rural, forming a continuous constantly evolving hybrid landscape composed of gardens, areas for community appropriation including agriculture, and informal spaces to encourage spontaneous activities. This paper argues that the innovative planning strategy implemented in Dessau should be considered not only for shrinking cities impacted by emigration or demographic decline but more generally as a model for future urban neighbourhoods.

Keywords

shrinking cities, landscape, urban design, Bauhaus, Germany, DDR, demolition, depopulation.

.

1 Introduction

At the beginning of the twentieth century, a strategic location at the confluence of the Elbe and the Mulde Rivers combined with the development of energy, mechanical engineering, chemical, and aircraft industrie**s** using material extracted from nearby brown coal sites seemed to hold the promise of a prosperous future for the city of Dessau. [1] These same conditions appealed to Walter Gropius, founding director of the Bauhaus School specializing in design, architecture, and applied arts as he began the transition away from craft-based programs towards a greater involvement with mass production and industrialization. The school had originally been based in Weimar but moved to Dessau after local support was withdrawn. The move was facilitated by Mayor Fritz Hesse's offer to fund the construction of a new headquarters building and a promise that the school's associates would receive one-sixth of all municipal building contracts. (Pritchard 1969) Machines filled the architecture and design studios of the new building designed by Gropius, also known as the Prellerhaus, while performance art evolved in the theatre workshop. The students lived and worked in the studio building, meeting in the canteen or gymnasium, while their professors designed and occupied the nearby Masters' Houses, formal experiments intended to establish new templates for middle-class domesticity. [2]

As rapid industrialization and urbanization in the decades preceding World War I and during the Weimar Republic required large numbers of efficiently designed residential units. Bauhaus architects also had a keen interest in developing designs for standardized workers housing. As widespread concern that deficient living conditions in large cities would further harm vulnerable populations adversely affected by the war gave the project of urban reform a sense of urgency, the time was ripe for the flowering of modernist/functionalist models of city planning. (Diefendorf, 2009) Gropius's goal was to rationalize construction by dividing buildings into component parts and mass-producing them in factories, improving quality while decreasing costs, with beneficial effects on the lives of residents. (Shand, 1935) An opportunity to test these ideas came when the city of Dessau commissioned Gropius to design and build Siedlung Torten (1926-28), an estate of 370 attached low-rise terrace houses with rows of strip windows a garden plot of 350-400 square meters for cultivating vegetables and breeding small animals, and small front yards which converged on an asymmetric square. [3] Influenced by industrial models, Gropius attached great importance to the fabrication of construction materials and building site organisation. All components were fabricated on site, including the concrete beams maneuvered by a crane onto load-bearing fire-resistant walls.

Figure 1.

Siedlung Törten, Dessau (photo by Author). Commissioned by the city of Dessau to produce a solution to alleviate the shortage of affordable housing during the Weimar Republic, Walter Gropius designed the Siedlung Törten as a solution for cost-effective mass housing available to a large share of the population.

Although lesser known as a housing estate, the relationship of house to garden in Siedlung Knarrberg (1926-29) erected almost concurrently with Siedlung Torten, was more sophisticated. Located in the Ziebigk district of Dessau and designed by architect Leopold Fischer, who initially worked in the Gropius construction office, and Leberecht Migge, a landscape architect and activist, Siedlung Knarrberg was a two-story estate in which each house had a glass-roofed conservatory and a 400 square meter kitchen garden with a rainwater irrigation system, separated by high wooden fences, also called fruit walls. The estate was known as the *selbstversorgersiedlung* or self-sufficient settlement, based on Migge's belief that the social and economic problems of the German nation could be solved by creating many small vegetable gardens where each household could grow their own food and recycle household wastes. [4] Unlike Siedlung Torten, the gardens and conservatories at Siedlung Knarrberg were not intended simply to ensure economic independence but also bring about a new, improved way of life that included a self-sustaining cycle. Compared with early 20th century English garden cities - Letchworth Garden City and Welwyn Garden City, among others - the layout of the Ziebigk *siedlung* placed more emphasis on individual gardens. By combining gardening principles with architecture and planning, Migge established the foundation of ecological principles in residential design half a century before they became a focus of popular interest. [5] (Both *siedlungen* exemplified the Bauhaus values of building process rationalization and the development of a just, progressive modern society.

The dreams of the Bauhaus generation ended in 1932 when the Nazis took control of the local government, fired the mayor, and cancelled the school's financial support. The Bauhaus then moved to Berlin for one final, difficult year as a private institution, but closed several months after Hitler became chancellor in 1933. The Nazis embarked on a vast program of military rearmament, demanding ownership of all market shares and patents of the Dessau-based Junkers aircraft factory to produce the planes for the Luftwaffe that enabled German *blitzkrieg* offensives during the early years of World War II. (Other Dessau-based industrial plants that supported the Nazi war effort included the Berlin-Anhaltische Maschinenbau Aktiengesellschaft (BAMAG), parts of Interessengemeinschaft Farbenindustrie AG (I. G. Farben), Wolfen, and *Deutsche Gesellschaft für Schädlings-bekämpfung m.b.H.* (Degesch), manufacturers of Zyklon B, the cyanide-based pesticide used in the gas chambers of the concentration camps. [6]

2 Post-World War II

As an important manufacturing centre for the Nazi war machine, Dessau was a frequent target of Allied bombing raids, the largest of which nearly reduced it to rubble on March 7, 1945, two months before the end of the war. [7] After Germany's surrender, Dessau was included in the Soviet occupation zone which eventually became the German Democratic Republic (GDR), lost its district seat administrative position to the city of Halle, and had most of its defense industries removed to the Soviet Union as war reparations. Despite the grim state of local affairs, there was also a prevailing sense of optimism as land reform transferred former ducal holdings to city ownership, opening opportunities to envision a new urban future. Restoration of the dense pre-war city blocks and narrow streets vulnerable to bomb attacks was opposed by urban planners from different political camps while there was general agreement that reconstruction should create a better balance between built fabric and the natural landscape. S*tadtlandschaft*, a more open and loosely organized city fabric integrated with green spaces, became the ideal postwar configuration, and resonated with a populace seeking distance from the Nazi past. [8]

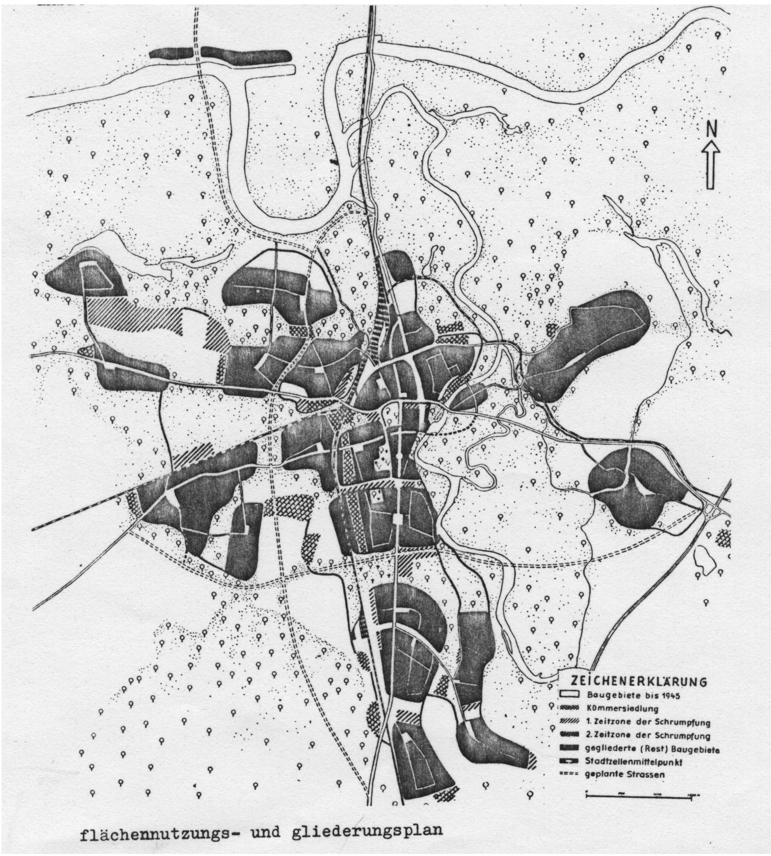


Figure 2.

Dessau Innenstadt Flächen Nutzung's und Gliederungs Plan by Hubert Hoffmann (image courtesy of Stiftung Bauhaus Dessau). Entrusted with post-war city planning in Dessau, Hubert Hoffmann was a proponent of the modernist concept of a segmented and loosened city, consisting of districts surrounded by continuous green surface

Among these visionary plans was a proposal by Hubert Hoffmann, a former Bauhaus student and state planner in Nazi-occupied Lithuania where he produced monumental compositions celebrating the dictatorship but focused his post-war efforts on improving the urban environment in Dessau.[9] To achieve better liveability, he proposed the creation of neighbourhood clusters each with approximately 5000 residents, a number he estimated sufficient to support cultural and commercial facilities, surrounded by greenbelts with parks and cemeteries; the plan would reduce commuting distances, result in cleaner air, and provide easy access to recreation spaces. Because Dessau's population was expected to shrink, new buildings were to be aggregated at lower densities, with two stories as opposed to the pre-war average of three. In the early post-war years, it was possible to conceive far-sighted plans in the belief that they would materialize but Hoffmann became disillusioned when the unique opportunity to heal German cities was in his words "blindly and maliciously" thrown away) Rather than rebuild East German cities inspired by radical new ideas, the socialist regime decided to soothe their traumatized populations with familiar stripped neoclassical architecture, also intended as a response to West Germany's architectural "modernist imperialism" approach to reconstruction. [10] Paradoxically, the East German version of neoclassicism reappropriated architectural styles and symbols from the recent Nazi past, but given its cost and inherent ideological contradictions, enthusiasm for the neoclassical revival was short-lived. ([11]

In 1954, following Soviet leader Nikita Khrushchev's call to industrialize construction throughout the Eastern bloc, the GDR officially rejected historicism and in 1956 began mass production of housing, typically consisting of prefabricated concrete high-rise slabs (*plattenbau*), regarded in the early years as optimistic symbols of progress. [12] As alternative layouts would have incurred the additional costs of utilities installation, most *plattenbau* were aligned parallel to existing roads, eliminating cross streets where necessary. The interiors of the perimeter blocks contained children's playgrounds, recreational areas, and parking, creating a more spacious, greener environment than had existed in the pre-war city. From 1961 to 1969 the Sozialistische Einheitspartei Deutschlands (SED), the Socialist Unity Party of Germany, invested heavily in infrastructure and worked towards making the country an industrial powerhouse. The housing program was to have been the "centrepiece of social policy" [13]and in 1973, the GDR adopted as its goal the elimination of housing shortages by 1990. However, the housing shortage was never fully eliminated, contributing to widespread dissatisfaction with the government's inability to finance even modest social programs, which culminated with the fall of the Berlin Wall in 1989, and eventually the unification treaty between the two Germanys in August 1990. [14]

3 Post-Unification Dessau

After reunification, because its state-subsidized manufacturing industries were not economically competitive, Dessau lost a significant portion of its economic base to the West, retaining only a fifth of its industrial capacity ten years later. In 1999 as the largest industrial syndicates were forced to close, the unemployment rate in Dessau reached 23.6 percent, causing the emigration of younger skilled workers, a decline of more than 20 percent of its population and a mortality twice as high as the birth rate. [15] [16] [17] [18] During the 1990s, significant investments in infrastructure were made to attract new companies to the area, including expansion of motorway junctions, construction of new bypass roads, and the re-opening of the airport. Some mechanical engineering, pharmaceutical, and chemical companies did arrive, but in 2005, the unemployment rate remained at 20 percent. As a result, many of the high-rise housing slabs erected after the war, half of them owned by the city or cooperatives, were vacant and decaying. With a declining number of residents, decreased revenues from business taxes, and dwindling local government resources, Dessau struggled to cope with social and economic problems. [19]

To devise a range of innovative planning projects that could improve public spaces, social services, and economic opportunities in the shrinking towns and cities of eastern Germany, from 2002 to 2010, the Internazional Bauaustellung (IBA) Stadtumbau "Weniger ist Zukunft" ("Less is Future") urban redevelopment program focused on renewal in Saxony-Anhalt, combining urban and regional policy objectives with project development in 19 participating cities. [20] *To participate in the program, in July 2007, Dessau effectively merged with the neighbouring town of Roßlau to form Dessau-Roßlau,* where social networks would be strengthened, surplus housing demolished, and small, stable core areas with specific urban qualities integrated with a central landscape zone designed according to principles adapted from the Dessau-Wörlitz Gartenreich; the demolition sites would be planted as wild meadows, allowing diverse and easily maintained landscapes to flourish. The organizing concept was the creation of a contiguous public green space, the so called Landschaftszug, or greenway, surrounding several stable urban cores.

Figure 3.

Dessau Greenway (drawing by author). The central goal of Dessau's greenway was the connection of individual areas of vacancy to green zones situated around recognizable urban cores, where demolition sites were planted as wild meadows, allowing diverse, easily maintained landscapes to flourish around stable urban cores.Unlike Haussman's Paris where the new order harshly cut through dense medieval city fabric, in Dessau the demolitions consisted of *plattenbau* housing that had become unpopular after the fall of the communist regime, disused factories or buildings that were empty, derelict, not built to Western standards, acquired through negotiations with creditor banks, or land swaps with property owners, as well as infrastructure belonging to the city. [21]

Conceived as autonomous neighbourhoods with shops, social services, and cultural amenities, the IBA proposal recalled another made in 1977 by a group of architects including Mathias Ungers and Rem Koolhaas which introduced the archipelago concept to address Berlin's post-war depopulation: abandoned or deteriorating areas would be razed, those where people still lived consolidated into urban islands surrounded by green zones. Inspired by *schrebegarten*, cottages with gardens for growing vegetables to which city-dwellers would retreat during the summer months, residents could also adopt plots of land and assume responsibility for their maintenance**.** [22] [23] Similar to American suburbs, the nominally green areas would also contain supermarkets, drive-in movies, banks, and other services, but also woodlands, shooting preserves, family allotments, and urban agriculture, along with gardens and wild vegetation. Perhaps even more removed from the image of the typical suburb was the notion that those who preferred a nomadic way of life could live there in tents or mobile homes. [24] As a concept, the Ungers/Koolhaas team's plan was reminiscent of the post-war urban clusters proposed by Hoffmann and others, with which Ungers, as a student of architecture between 1947 and 1950, is likely to have been familiar. The Ungers/Koolhaas proposal differed from the latter in that it combined the physical fabric of suburban capitalism with gestures that simultaneously subverted it and bore greater similarities to the Dessau-Roßlau greenway, incorporating wild areas, urban agriculture, and accommodation of the ephemeral. [25]

Three main strategies were implemented to ensure the greenway's viability in *Dessau-Roßlau*: intensive municipal landscape maintenance close to residential neighbourhoods, bordering infrastructure, and near the boundaries of the urban cores to encourage the perception that the new landscape belonged to the public realm; detailed analysis of ground water and soil conditions to determine the species of native vegetation most likely to flourish in large open areas, resistant to drought, diseases, and infestations reducing need for fertilizers and pesticides while attracting a diverse range of native flora and fauna; the third strategy was to bring the Dessau-Wörlitzer Gartenreich into the city. [26] Created in the late 18th century under the regency of Duke Leopold III of Anhalt Dessau (1740-1817), the Wörlitzer Gartenreich includes pastures, orchards, meadows, rivers, dykes, lakes, fields of crops, and even animal herds, following the contemporary English notion that human creation is most successful when indistinguishable from nature; bridges, pavilions, palaces, and classical temples provide ever-changing vistas along its passages. Similarly, a path called Der Rote Faden, or red thread, weaves through the greenway, punctuated by clumps of oaks, ruins left from mostly demolished industrial buildings such as a meat smoking tower and the chimney of a former dairy, as well as existing structures including the old water-tower, connecting these scattered episodes and the urban islands with each other. [27] Additional features in the landscape are provided by 400 square meter fenced plots available to residents with 10-year leases at no cost for growing vegetables or any other activity. To date, as only a handful of them have been leased some observers speculate that the plots are too large to be readily appropriated.

The meticulously laid out Wörlitzer Gartenreich is one of the most beautiful places in Germany, but former wastelands such as Natur-Park Südgelände and Park am Gleisdreieck, both in Berlin, have been successfully transformed into popular ecological preserves. (Werner, 2014) The *Dessau-Roßlau* greenway can variously appear barren, overgrown, or vacant, suggestive of *terrain vague*, the term used by Ignasi de Solà-Morales to describe abandoned, obsolete, or unproductive urban territory [28] but Rem Koolhaas provides an alternative view of the depopulated city: "Missing urban presences or entirely erased architectural entities nevertheless generate what can be called an urban condition … For me, the important thing is not to replace it, but to cultivate it. This is a kind of post-architectural city, and now it's becoming an architectural city." [29] When natural processes are allowed to take over, designers relinquish much of their control, a strategy contrary to traditional notions of beauty as defined within a fixed framework. The greenway's appearance of neglect in some areas may suggest *terrain vague*, but the wild grasses thriving on its surfaces are mowed biannually. Rather than conform to the familiar but static imagery of conventional parks, provisional landscapes such as the greenway have the flexibility to accommodate current and future social trends by adjusting to the changing circumstances, what Langner has called the navigational approach to design. [31] [30]As biologist Peter Werner's research has shown, more flexible management techniques, larger uncultivated green areas, and less dense cities can reduce the use of non-native plant species, require fewer pesticides, eliminate the need for fertilizers, help prevent erosion, and replenish the water table. [32]

The *Dessau-Roßlau* greenway has received mixed reviews locally as some residents regret the extent of the demolitions and regard the meadows as weed pastures with little or no aesthetic value. Perceptions may change as the benefits of encouraging biodiversity become more widely appreciated, and the greenway's aesthetic appeal is enhanced with the addition of some ornamental plants that can thrive among naturally emerging species or dry formal gardens. [33]One of the greenway's advantages is its easy access from neighbourhoods throughout the city and anecdotal evidence suggests that visitors comprise small but diverse groups of citizens, including people walking dogs, riding BMX bicycles around the purpose-built track, or sharing a meal**.** The perception that it is largely unused is likely related to its large size in proportion to the city's population and some disappointment that it is not a traditional park. While the number of visitors is not the only measure of success, similar places such as the Park am Gleisdreieck have shown that relatively few formal gestures combined with native vegetation can produce beautiful, popular public spaces. A wasteland abandoned at the end of World War II, over time the railway area around the traffic junction at Gleisdreieck naturally developed a rich diversity of vegetation as it became surrounded by dense redevelopment. The planning process to preserve what had become an urban refuge, including some of the old signals and railway facilities, was notable for its public involvement, which continues as parts of the park are now cultivated by various neighbourhood communities.

4 Conclusion

The history of Dessau affirms that insertion of green areas into its urban fabric has been a longstanding ambition among successive generations of planners. While the *Landschaftszug* differs in many respects from the productive backyards of the Weimar *siedlungen*, it shares with Hoffman's clusters the ambition that the countryside should penetrate the city. The Landschaftszug constitutes both a productive landscape and a reclamation initiative, a deliberately ambiguous territory combining aspects of urbanity, the rural, and wilderness, and, offering easy access to open spaces, large areas of native landscape able to withstand and adapt to changing conditions, as well as places to grow vegetables, flowers, or medicinal plants, even for limited commercial purposes, opportunities typically found at small farms or allotment gardens rather than in public parks. [34] With consistent monitoring and readjustment, the design of the *Dessau-Roßlau* greenway embraces change, including acceptance of what would be inadmissible in more traditional layouts: ruination, obsolescence, decay, the random, unplanned, and haphazard, the lack of immediate visual appeal. Although implementation of the redevelopment strategy underway at *Dessau-Roßlau* is unique among planning approaches to shrinking cities in Saxony, elsewhere it is perceived as an inspiration for other districts in Germany also suffering from depopulation such as the Upper Palatinate in Bavaria and the Sauerland in North Rhine-Westphalia. [35] While Dessau's urban clusters and greenway emerged after the war as a place-specific strategies to create a more liveable city while mitigating the effects of population decline, they have the potential for wider application beyond shrinking cities with valuable lessons for building desirable neighbourhoods in metropolitan centres throughout the world.

References

[1] Elkins, T. H., The Brown Coal Industry of Germany, *Geography* 38, 1 (1953) pp. 18-29.

[2] Thöner, Wolfgang, Urban Planning and Architecture in Dessau 1945-1990, *Architectural Guide, Dessau Woerlitz*. Berlin: Dom Publishers. 2016.

[3] Reuleke Jürgen, Population Growth and Urbanization in Germany in the 19th Century, *Urbanism Past and Present* 4 (1977) pp. 21-28, 31-32.

[4] Baller, Inken. 2022, The Relationship between City and Nature in History, *Biotope City Journal*. Accessed May 26, 2022. https://biotope-city.net/en/das-verhaeltnis-stadt-und-natur-in-der-geschichte-2-

[5] Wolter, Frank, Die Siedlung Knarrberg in Dessau, *Leopold Fischer - Architekt der Moderne: Planen und Bauen im Anhalt der 20er Jahre*. Thuringia: Funk Verlag. 2010. Pp.28-39. https://www.yumpu.com/de/document/read/4444822/leopold-fischer-

[6] Wollheim Memorial. http://www.wollheim-memorial.de. Accessed May 17, 2022.

[7] Thöner, Wolfgang, Urban Planning and Architecture in Dessau 1945-1990, *Architectural Guide, Dessau Woerlitz*. Berlin: Dom Publishers. 2016.

[8] Lachmund, Jens. "Exploring the City of Rubble: Botanical Fieldwork in Bombed Cities in Germany after World War II." *Osiris* 2, 18 (2003) pp. 234-254. http://www.jstor.org/stable/3655294

[9] Nerdinger, Winfried. "Bauhaus Architecture in the Third Reich." *Bauhaus Culture from Weimar to the Cold War,* Kathleen James-Chakraborty, ed. Minneapolis: University of Minnesota Press. (2006) pp. 139-152Aureli, Pier Vittorio. *The Possibility of a Total Architecture*. Cambridge, MA.: MIT Press, 2011.

[10] Hoffmann, Hubert, Eine Analyse: der Stadt Dessa, *Bauhelfer* 4, 2, (1949) pp.541-549.

[11] Castillo, Greg, Building Stalin's Germany: Architecture and Cultural Revolution, ACSA International Conference Proceedings. Beth Young & Thomas C. Gelsanlite, eds. 1997

[12] Diefendorf, Jeffry M., Urban Reconstruction in Europe After World War II. *Urban Studies* ,26 (1989) pp. 128-143. https://doi.org/10.1080/00420988920080101

[13] Hoffmann, Hubert, Eine Analyse: der Stadt Dessa, *Bauhelfer* 4, 2, (1949) pp.541-549.

[14] Ladd, Brian, Socialist Planning and the Rediscovery of the Old in the German Democratic Republic, *Journal of Urban History*, Vol. 27 , 5 (2001) pp.584-603. https://doi.org/10.1177/009614420102700502

[15] Pallagst, K., The Planning Research Agenda: Shrinking Cities - A Challenge for Planning Cultures, *Town Planning Review* 81, 5 (2001) pp. I–VI.

[16] Oswalt, Philipp, ed. *Shrinking Cities. Volume 1 – International Research*. Ostfildern: Hatje Crantz Verlag, 2006.

[17] Oswalt, Philipp, ed. *Shrinking Cities*. Volume 2 – Interventions, Ostfildern: Hatje Crantz Verlag. 2006.

[18] Sowa, Charline, Reconsidering the Ground: New Opportunities for Shrinking Cities. Lessons from the Cases of Dessau and Halle, *Development and Well-Being*, Jean-Christophe Dissart, and Natacha Seigneuret, eds. (2020) pp.36–57. Edward Elgar Publishing. Cheltenham, UK; Northampton, MA. USA. DOI: 10.4337/9781789908619.

[19] Bernt, Matthias., Partnerships for Demolition: The Governance of Urban Renewal in East Germany's Shrinking Cities, *International Journal of Urban and Regional Research,* 33 , 3 (2009) pp.754-769. bauhausverein. Accessed May 25, 2022.

[20] Steglich, Ulrike, Dessau-Roßlau: Urbane Kerne - Landschaftliche Zonen, in: Ministerium für Landesentwicklung und Verkehr des Landes Sachsen-Anhalt (Hg.), Internationale Bauausstellung Stadtumbau Sachsen-Anhalt 2010. *Weniger ist Zukunft. 19 Städte - 19 Themen,* Berlin, (2010) pp. 611-619.

[21] Leitfaden Landschaftszug Dessau-Roßlau. https://verwaltung.dessau-rosslau.de/stadtentwicklung-und umwelt/stadtentwicklung/stadtumbau/konzepte/leitfaden-landschaftszug.html. Accessed May 26, 2022

[22] Hertweck, Florian ed. Sebastian Marot, ed. *The City in the City - Berlin: A Green Archipelago*., Zürich: Lars Müller Publishers, 2013.

[23] Aureli, Pier Vittorio. *The Possibility of a Total Architecture*. Cambridge, MA.: MIT Press**,** 2011**.**

[24] Ungers, O.M., Rem Koolhaas, Peter Riemann, Hans Kolhoff, Arthur Ovaska, Cities within the City, *Lotus International* 19 (1978) pp.82-97.

[25] Desimini, Jill, From Planned Shrinkage to Formerly Urban: Staking Landscape Architecture's Claim in the Shrinking City Debate, *Landscape Journal* (2014) pp. 17–35. DOI: 10.3368/lj.33.1.17.

[26] Langner, Sigrun, Mapping Urban Landscapes – Between Understanding, Interpreting and Negotiating, In *Variations of Suburbanism*: *Approaching a Global Phenomenon*, Barbara Schönig, ed. Stuttgart: Ibidem Verlag. (2015.) pp 4-17.

[27] Rink, Dieter, Wilderness: The Nature of Urban Shrinkage?, The Debate on Urban Restructuring and Restoration in Eastern Germany, *Nature and Culture* 4 ,3 (2009) pp. 275-292. .

[28] Solà-Morales, Ignasi de. Terrain Vague, *Anyplace,* Cynthia C. Davidson, ed. Cambridge, MA: MIT Press (1995) pp. 118–123.

[29] Obrist, Hans Ulrich. “Cultivating Urban Emptiness. Interview with Rem Koolhaas.” Accessed May 24, 2022.

[30] Rudolph. Michael: Orientierungs- und Handlungshilfen für die Planung und Entwicklung des Landschaftszuges. 2010: *Urbane Kerne und landschaftliche Zonen. Projekte und Erfahrungen IBA Stadtum*bau 2010 in Dessau-Roßlau, S.32-4 https://stationc23.de/de/15/p1/veroeffentlichungen.html

[31] Langner, Sigrun, Mapping Urban Landscapes – Between Understanding, Interpreting and Negotiating, In *Variations of Suburbanism*: *Approaching a Global Phenomenon*, Barbara Schönig, ed. Stuttgart: Ibidem Verlag. (2015.) pp 4-17.

[32] Werner, Peter, Urban Form and Biodiversity, *Shrinking Cities: Effects on Urban Ecology and Challenges for Urban Development,* Marcel Langner, Wilfried Endlicher, eds. Second revised edition. Frankfurt: Peter Lang GmbH, Internationaler Verlag der Wissenschaften. (2014) pp. 57-68.

[33] Kühn Norbert, “Intentions for the Unintentional: Spontaneous Vegetation as the Basis for Innovative Planting Design in Urban Areas.” *Journal of Landscape Architecture* 3(2006): pp.46–53.. https://doi.org/10.1080/18626033.2006.9723372.

[34] Urbane Kerne und Landschaftliche Zonen Projekte und Erfahrungen, 2010. .https://verwaltung.dessaurosslau.de/fileadmin/Verwaltungsportal_Dessau-Rosslau/Stadtentwicklung_Umwelt/Stadtentwicklung/Stadtumbau/IBA/Meldungen/Meldungen_IBA_Broschuere_20101215.pdf. Accessed May 25, 2022.

[35] Müller, Rainer. 2010 “Eastern German Project Provides Hope for Shrinking Cities” Spiegel International. 09.04.10 Accessed July 2, 2022. https://www.spiegel.de/international/germany/when-less-is-more-eastern-german-project-provides-hope-for-shrinking-cities-a-688152.html.

[36] https://www.acsa-arch.org/chapter/building-stalin-s-germany-architecture-and-cultural-revolution/.

CITY IN TRANSITION: URBAN PROJECTS IN THE CENTRAL METROPOLITAIN AREA - RIO DE JANEIRO-BRAZIL

Denise Barcellos Pinheiro Machado*
Bernardo Mercante Marques **

PROURB-FAU-UFRJ
Av. Pedro Calmon, 550 - 21941-596 - Rio de Janeiro, Brasil.
denisepm10@gmail.com*; bernardomercadante@gmail.com**

Abstract

Urban projects, for being specific and unique, consolidate themselves as one of the privileged ways of intervention in the contemporary metropolis. Societal and urban issues that reflect the social and spatial fragmentation and the ephemerality and diversity of the use of space in the city, lead us to rethink and incorporate new scopes and complexities for the urban project.

This work focus on two urban projects for the central area of Rio de Janeiro, Brazil, which with different scales, durations, characteristics and objectives, act on contiguous territories: the Reviver Centro and the Porto Maravilha projects.

The Reviver Centro project, started in 2021, is an urban requalification plan whose main purpose is to promote the population density in the Center of Rio de Janeiro. It is a normative construction that, rhetorically, seeks to address a wide range of dimensions of social life in the city of Rio de Janeiro, involving cultural, environmental, heritage, economic and social aspects. However, Reviver Centro has been the object of criticism from different sectors of civil society for the adoption of controversial urban instruments, such as the Interconnected Urban Operation and for the accelerated way in which it was treated at a time when the city was debating, and is still debating, its urban planning, through the revision of its Master Plan.

Porto Maravilha is a large urban project developed in the context of two sporting mega-events (2014 World Cup and 2016 Olympics) with the aim of revitalizing the port region of the city. This is a Consortium Urban Operation that sells certificates of additional construction potential. It is also an initiative marked by a wide range of technical and political contradictions.

The intention is to assess complementarities and contradictions of recent public initiatives to revitalize the metropolitan center, seeking to reflect on the potential of urban projects to respond to the demands and transformations of the contemporary city in order to achieve a better quality of life.

Keywords

Urban project, interscale, Rio de Janeiro, unpredictability, mutations.

1 Introduction

This paper deals with the potential and the role of urban projects in contemporary cities, focusing on projects for metropolitan urban centers.

Societal and urban issues that reflect the social and spatial fragmentation and the ephemerality and diversity of the use of space in the city, lead us to rethink and incorporate new scopes and complexities for the urban project. Urban projects, for being specific and unique, consolidate themselves as one of the privileged issues of intervention in the contemporary metropolis.

For that we will analyze two urban projects for the central area of Rio de Janeiro, Brazil, which with different scales, durations, characteristics and objectives, act on contiguous territories.

The central area of Rio de Janeiro brings together six neighborhoods (Centro, Santo Cristo, Gamboa, Saúde, Cajú and Lapa) and is basically composed of the historic center, where the city was founded, and the old port area built at the beginning of the 20th century, which today has numerous urban functions. At the same time that it concentrates the capital's financial institutions, it contains administrative buildings and the judiciary, and a low and middle income residential area. It is an urbanistically consolidated region, with an adequate offer of urban infrastructure, and an important architectural-historical background. Different uses and social, political, cultural and economic meanings are concentrated there.

In recent decades, the area has again attracted the attention of governments and the real estate market, which see an opportunity to obtain profits from processes of revaluation and gentrification of degraded space, as has been happening in central areas of several other metropolises. Two important projects are proposed for the downtown area of the city: Porto Maravilha (2009) and Reviver Centro (2021).

Porto Maravilha is a large urban project developed in the context of two sporting mega-events (2014 World Cup and 2016 Olympics) with the aim of revitalizing the port region of the city. This is a Consortium Urban Operation that sells certificates of additional construction potential. It is also an initiative marked by a wide range of technical and political contradictions.

The Reviver Centro project is an urban requalification plan whose main purpose is to promote the population density in the Center of Rio de Janeiro. It is a normative construction that, rhetorically, seeks to address a wide range of dimensions of social life in the city of Rio de Janeiro, involving cultural, environmental, heritage, economic and social aspects. However, Reviver Centro has been the object of criticism from different sectors of civil society for the adoption of controversial urban instruments, such as the Interconnected Urban Operation and for the accelerated way in which it was treated at a time when the city was debating, and is still debating, its urban planning, through the revision of its Master Plan.

Both projects intend to bring urban improvements and valorization of the central area. Although they are located in contiguous zones, they have different scopes and methodologies. The first one, Porto Maravilha, had its legal apparatus defined in 2009, but its implementation was consolidated in 2016 with the Olympic Games. It intended to bring a new configuration to the port area, which had many voids and important landscape potential due to its location on the seafront. Reviver Centro, institutionalized in 2021, intended to rescue the dynamics of the historic center by recovering the built environment, public spaces and the return of housing in the central area, taking advantage of local pre-existing conditions.

The interest of this work is to assess complementarities and contradictions of recent public initiatives to revitalize the metropolitan center, seeking to reflect on the potential of urban projects to respond to the demands and transformations of the contemporary city in order to achieve a better quality of life.

Figure 1. Rio de Janeiro’s central area and the two urban projects

2 Porto Maravilha

Porto Maravilha is an urban project in the central and port area of Rio de Janeiro. It is a complex area, close to the historical and financial downtown areas of the metropolis, of large dimensions and with particular land features.

This is a pericentral area that, since the 1980s, when the port activities ceased, has been the object of frustrated proposals for renovation, seeking to recover dynamism through new uses. The Rio de Janeiro Olympic Games in 2016 and the 2014 World Cup in Rio de Janeiro created the opportunity to implement this project.

The Porto Maravilha foresees the construction of approximately 4.5 million m2 in 489 ha, in a time window of 30 years, in an area consisting of obsolete port infrastructures, urban voids, historic fabric and low-income housing. There is different contents and urban fabrics that although contiguous, do not interact. And for many decades has been outside the radius of operation of the real estate market in Rio.

A legal, financial and urban development operation was established to enable a design based on a public-private partnership that envisaged the additional construction involving significant amount of resources. New institutional and financial arrangements to make it viable, meant, for these reasons, a very particular system in the recent practices of urban planning in Rio de Janeiro.

The project is based on sustainability goals, with road rehabilitation, infrastructure recovery and expansion, light rail vehicle (VLT) implementation, tunnel construction, and the implementation of street furniture and bicycle networks. The Porto Maravilha project also aims to enhance the historical heritage and promote the social and economic development of the region. It also aims to raise the quality of life of the population living in the region through urban requalification.

In fact, the legal and financial operation privileged a large business area with housing for the middle and upper classes. In practice, the government carried out the infrastructure works, and the waterfront was revitalized with the insertion of new leisure and cultural equipment. But no action has been taken to improve the living conditions of the low-income population.

The major instrument for that project is Porto Maravilha`s Consortium for Urban Operations, enforced by a municipal Law in 2009. This Law defined a basic program for the use of the land with some important urban interventions – most of them for road works – and new urban parameters that enable constructions and densification in the port area.

The adopted urban concept for the Project does not present any substantial difference from the traditional Brazillian urbanism approach. It considers the area as being a void to be occupied and, under this notion, the existing urban fabric is not fundamental in the design concept. The renovated site overlaps the existing one and, also, suggests, as it can be seen in the images of the new developments, the creation of a generic landscape.

Figure 2. Porto Maravilha Water Front and generic landscape

The urban operation is mostly based upon the opening of some roads, local transportation system modernization, infrastructure implementation and the grant of new urban parameters. An ingenious financial arrangement comprising of public budget, selling of public real estate and fiscal benefits supports and guarantees the realization of the planned public works. This financial arrangement is under the denomination of a public private partnership, enabled by the creation of the Urban Operation Consortium (OUC). This instrument is previewed to use private resources to finance basic urban interventions. However, what it is seen in the port area of Rio de Janeiro is the opposite. The public sector paid for the infrastructure in the area, with minor participation of private investments.

The Porto Maravilha project was object of not only specific norms that provide legality and legitimacy to the whole urban operation but, specially, it is structured on financial models and on tax exemptions. An important aspect in Porto Maravilha´s model was the creation of additional potential certificate (CEPAC), that is, the acquisition by the real estate sector of rights to build beyond the permitted municipal parameters. The idea was to sell those certificates to the private sector, so that the public sector could invest in infrastructure in the area. Nonetheless, the operation did not happen as desired. The private sector, usually interested in investing with small risks, was not attracted by those certificates, and the one who anticipated the resources for the realization of the planned construction work in the operation was the public sector. So, a public bank was in charge of all expenses in this public private partnership, resulting in a total of US$2 billion dollars to buy those certificates expecting the return over the investment through the sales of the certificates for the real estate market, which did not take place.

The Porto Maravilha urban operation was supposed to provide urbanistic structural transformations, social benefits and environmental valorization. It refers to expansion, interaction and re-utilization of free spaces for public use as strategy for urban reconfiguration of the port area. However, the objectives of the actions are not clearly defined and the basic program for use of land does not allow a forecast of the type of occupation to be achieved.

The evaluation of the distribution of urbanistic parameters in different sectors and subsectors as defined by the basic program enables the identification of big parcels, where, effectively, it has been planned new urbanistic parameters, considering a substantial increase in construction potential. It is a stock of additional construction potential that can be used by those that purchase the Additional Construction Potential Certificate.

The maximum utilization coefficient is very high, allowing the construction of 50-floor buildings in some subsectors, despite all the risks that they may bring to the local landscape.

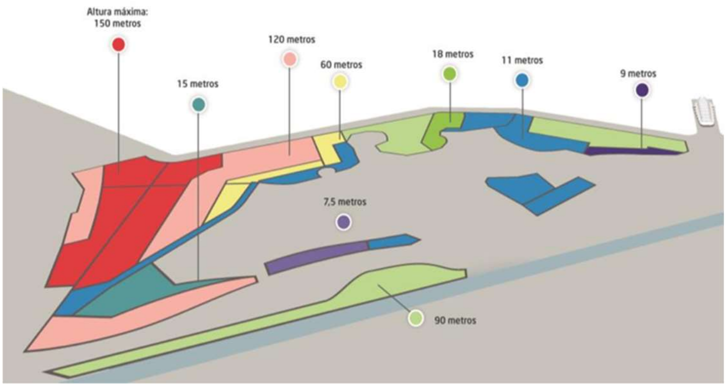


Figure 3. Construction potential Porto Maravilha

According to the guidelines for the urban operation, the new urban pattern for the area will not be determined by a project that would drive the process of renovation and occupation, but by the total number of independent developments to be built over time. In the areas where it is possible to buy the certificates of the additional construction potential, the buildings will not be subject to restrictions on typology, horizontal occupation, number of buildings in the lot and number of units per building.

The operation plan did not specify the distribution of the occupation of the land by sector; a resource that is frequently applied to implement use diversity and to define the financial aspects, such as residential and non-residential uses that have different market coefficients. Even though, there are expected equivalence rates for residential and non-residential uses for the selling of additional construction potential in each sector, the operation did not fix quotas. Without induction mechanisms, it is the market that establishes the use and, certainly, it will favour what is more profitable. As it happens, it was not established quotas for housing of social interest in the different sectors or for new developments. This element, if present, could promote social diversity in the future.

Without having clear guidelines to the occupation of the parcels, it is also impossible to see the re-design of public spaces as being the structuring element in the Rio de Janeiro´s port urban project.

In essence, the works foreseen in the operation are basically road ones. The main works are the two big roads that cross all the area to be renovated and the implementation of the Light Transportation Vehicle which redefines the mobility in the perimeter of Porto Maravilha, connecting it to the regional airport in downtown Rio and to the Central Bus station, located at the junction of two major roads to the rest of downtown area and to the rest of the metropolitan region.

Figure 4. Porto Maravilha in the Olimpic Games 2016

Although, paradoxically, the operation admits new urban parameters that, depending on the sector, it would result in the construction of new buildings, 90, 120 or 150 m high. Should these 50-floor buildings be built, although being foreign to the urban tradition of Rio de Janeiro, they will probably create obstacles to the perception of the mountains that frame the central area of Rio de Janeiro and its skyline, that since 2012, is part of UNESCO´s World Heritage site in the category of cultural landscape.

3 Reviver Centro

The Reviver Centro Program, created in 2021, aims to establish urban guidelines for the requalification of the central area of the city of Rio de Janeiro, through a set of programs and tax incentives, aiming at the population density of this region of the city, encouraging housing and promoting social mixing, and encouraging economic dynamism and occupying public spaces in the central region of the city.

Historically, the central area of the city of Rio de Janeiro has systematically suffered from the effects of economic depletion due to the deconcentration of productive activities. Among several reasons for this phenomenon, we can mention the successive economic and political crises, on different scales, the emergence of new centralities in the city of Rio de Janeiro, technological transformations related to the forms of organization of the world of work, among other causes.

During the 20th century, with the opening of new vectors of urban expansion (in particular, for the neighborhoods of the South Zone, North Zone and the formation of the Carioca suburbs), the central area of Rio de Janeiro was configured as a place of great concentration of financial and economic activities related to the rendering of services. On the other hand, it has a low population density. More recently, another determinant element for the worsening of this process of deconcentration and economic emptying were the social and economic effects produced by the Covid-19 pandemic.

Among the strategies of the Reviver Centro Program is the creation of mechanisms to encourage population density in the central area by transforming the uses of commercial properties (offices, stores, among others) for residential use. According to data from the City Hall of Rio de Janeiro, the area covered by the program (which includes the neighborhoods of Centro and Lapa, see figure 1) had a low population percentage when compared to other areas of the city. Even though it was the site of the initial urban settlement of Rio de Janeiro, when it had a significantly higher density of residents, the Center experienced a process of population loss over the centuries. With the urbanistics reforms of the early 20th century, under the influence of modernism, the image of the city center crystallized as an area that should exercise exclusively administrative and economic functions, to the point of restricting residential use in this region in a 1976 decree which regulated municipal zoning.

Figure 5. Reviver Centro Area

The Reviver Center Program strategy, in principle, is not wrong. The housing issue is an important element for the municipality. As is known, Rio de Janeiro is a socially unequal city, due to a vast set of social, economic and political aspects that, among many ways, are reflected in poor income distribution, spatial segregation, precariousness in housing and access to urbanized land. Stimulating the population density of a region with so many qualities and potential is something important. However, throughout its implementation, the Reviver Centro Program has been the target of criticism from different sectors of civil society, such as class entities and social movements, in addition to some members of the municipal legislative power.

Among some of the main criticisms made is the rush with which the law proposal was processed from the submission of the Municipal Executive until its approval by the City Council. In addition to the speed of its approval, another highly criticized element refers to the fact that the city of Rio de Janeiro, since 2019, was - and still is - debating the revision of its Municipal Master Plan which, among other purposes, will guide the guidelines of municipal urban planning and development. From the point of view of Brazilian urban policy, the Municipal Master Plan is the main instrument of territorial organization, being responsible for the construction of the formatting parameters of the urban instruments, having a direct influence on the elaboration of programs and other sectorial plans. Even though this fact is a consensual element among urbanists and urban planners, the Reviver Centro Program uses, as a normative basis, the Municipal Master Plan from 2011, which is the object of the current revision process.

Another aspect that has been criticized is the adoption of the Interconnected Operation. It is an urban instrument characterized by the authorization, by the public authorities, of the flexibility of urban parameters through the payment of a counterpart by the agents of the real estate market. In the case of the Reviver Centro Program, the construction of a new residential or mixed building, in addition to the reconversion of existing buildings for, likewise, residential or mixed uses, allows the property owner the possibility of transferring the total buildable area of up to 60 % of what was built or converted in the central region of the city to areas of the city where some of the neighborhoods where real estate dynamics are already significantly active are located, such as Copacabana, Ipanema, Leblon, Botafogo and Tijuca.

Figure 6. Reviver Centro 3D monitoring panel

The modeling of the Interconnected Operation adopted by the Reviver Centro Program was carried out based on the 2011 Municipal Master Plan which, as mentioned, is currently under revision. Additionally, the flexibility of urban parameters and indexes of the Interconnected Operation, in the Reviver Centro Program, is constituted in a general way, disregarding the urban particularities of the places where the building potential is received, enhancing a dubious interpretation of the law and, consequently, a disorderly use of the instrument. The proposal for the morphological recomposition of the blocks to use the constructive potential in consolidated areas of the city, provides for the same pattern of occupancy as the neighboring properties. This incentive strategy has been the subject of concern due to its impact on thermal comfort standards, increased demographic density in receiving neighborhoods, overloading aspects of urban life such as traffic and infrastructure capacity, among other factors.

Finally, in the Reviver Centro Program, there is a lack of clear criteria related to the application of funds from the counterparts collected in interconnected operations, in particular, in social housing programs and policies. From a normative point of view, the Reviver Center Program establishes a set of social programs (Social Interest Housing, Social Leasing, Assisted Housing, Technical Assistance for Social Interest Housing, for example), but without clarity as to the forms of monitoring and control social impact of the execution of these programs. Still, social programs lack objectivity in terms of detailing strategies, ways of implementing them and percentages of funds raised for achieving their objectives.

The Centro Reviver Program provides tax incentives to boost housing construction in the downtown area. Among the foreseen benefits are the total exemption from the Tax on Real Estate and Urban Territorial Property – IPTU, for example, during the period of works, reduction and total exemption, in some cases, from the Tax on the Transfer of Real Estate Property – ITBI, and, for example, exemption from administrative licensing fees for works. The ways of obtaining tax benefits vary according to the situation (conversion, retrofit, construction of new residential or mixed units, conclusion of stopped works, restoration of properties in poor condition or financing of social leasing programs).

Among the most scathing points of criticism regarding the tax incentives granted by the Reviver Centro Program is the absence of studies that demonstrate the economic viability of the relationship between what will be collected, for example, with the payment of counterparts of the Interconnected Operation, and the volume of resources that will be exempted or will have collection suspended by the City Hall. The lack of clarity regarding the viability of the Program's strategies is a matter of concern since, as initially presented, the city, over the last few years, has been the scene of strong economic crises, making the collection strategies of financial resources, more than ever, essential for good municipal budget management.

4 Final considerations

On this paper, we sought to reflect on the significance of both urban projects to the central area of Rio de Janeiro: the renovation process in the port area of Rio de Janeiro and the implementation of the Reviver Centro project, which are set into a contiguous area (figure 1).

Beyond the fact that they are located in the same expanded area, they have some objectives in common: revitalize and renew the central area of the metropolis, renew and enhance public spaces, urban infrastructures and housing. Despite some similarities, they are different proposals and methodologies for intervening in space.

Porto Maravilha is a project that proposes to structure a large area interspersed with empty spaces, obsolete buildings and low-income housing. With a unique landscape potential for being in front of the sea, it becomes coveted by real estate speculation.

Reviver Centro, on the contrary, seeks to reuse an urban infrastructure and a built environment whose architectural richness has been built over the centuries. It houses a middle and low-income population, and the project aims above all to promote the area's densification to enhance and socially and economically boost the financial and historic center of the metropolis.

Both create fiscal and legal mechanisms to make occupation viable and attract private capital. In Porto Maravilha, the public authorities ended up assuming the costs of a consortium operation that has been slowly attracting the private sector. Despite the infrastructure, cultural and transport facilities implemented by the government, the private sector's response to new investments in the area is still timid.

The interconnected operation proposed at Reviver Centro seems to attract real estate capital more effectively. Acting in consolidated and dense space, proposing retrofit systems and enhancement of the pre-existing built environment, makes the private sector find better and safer opportunities. In addition to using the attributes of the center, the operation allows investors to receive constructive potential in consolidated and wealthy areas of the city as an incentive.

They are both long-term projects. However, the urban context where they are located and the methodologies employed end up defining different rhythms.

The Reviver Centro project covers only part of the central area, fragmenting the region into proposals that do not articulate with the infrastructure and investments made in the port region by the Porto Maravilha project. On the other hand, the difficulties in consolidating the Porto Maravilha project promoted a fragmented mix of uses in the port region, with tourist sites, commercial points and corporate buildings, coexisting with popular residences, occupations of buildings that were empty without fulfilling their social function, constructions underused or empty, and deteriorating structures. So far the private sector has invested shyly in the area, we still have uncertainties about the transformation of this space.

Although there are significant problems and shortages in both Porto Maravilha and Reviver Centro projects, it is important that the central area of the metropolis has been receiving the attention of the public authorities for its recovery and enhancement, seeking to accentuate its social and economic dynamism. This perhaps minimizes the existing tension between the emergence of new centralities in expansion areas and the reaffirmation of the historical and financial center as a symbol of the strengthening of the metropolis.

It can perhaps be said that a scenario of uncertainties concerning those projects gives the possibility to review the on-going projects. Preferably, leaving aside empty images and formulating urban projects that promote social diversity and different uses of space, combining good architecture with quality public spaces.

Acknowledgements

The authors gratefully acknowledge CAPES - PrInt, FAPERJ and CNPq for supporting research and this work.

References

[1] Barandier, Henrique G.; Pinheiro Machado, Denise B., *'Porto Maravilha' e o Destino da Área Portuária do Rio de Janeiro*, UPM; PUC Campinas, Anais do III ENANPARQ, Encontro Nacional de Pesquisa e Pós-graduação em Arquitetura e Urbanismo, São Paulo, 2014, http://www.anparq.org.br/dvd-enanparq-3/htm/XFramesSumarioST.htm

[2] Magalhães, Roberto A., *Porto Maravilha descuidado da paisagem, Porto Maravilha para quem?*, 10 de novembro de 2012, http://portomaravilhaparaquem.wordpress.com/2012/11/10/porto-maravilha-descuidado-da- paisagem/

[3] Martins, Mayã, *Entre Memórias e Futurismos: Enquadramentos Sobre o Projeto Porto Maravilha*, Cidade do Rio de Janeiro, Ponto Urbe, 2015, http://pontourbe.revues.org/2584

[4] Masboungi, Ariella (coord.), *Projets Urbains Durables: strategies, Ministère de l'Écologie, du Developpement Durable, des Transports et du Logement (Collection "Projet Urbain"),* Éditions du Moniteur (Collections Architecture), Paris, France, 2012.

[5] Tsiomis, Yannis; Volker, Ziegler, *Anatomie de Projets Urbains*, Editions de La Vilette, Paris, France, 2007.

[6] Porto Maravilha, CDURP, Prefeitura do Rio de Janeiro, http://www.portomaravilha.com.br/web/sup/OperUrbanaApresent.aspx

[7] Coelho, Fernanda A., *O curso da mercantilização da cidade: uma crítica urbanística ao programa Reviver Centro*, dissertation, PROURB/FAU-UFRJ, Rio de Janeiro, Brazil, 2022.

[8] Maricato, Ermínia, *Para entender a crise urbana*, Expressão popular, São Paulo, Brazil, 2015.

[9] Pinheiro Machado, Denise B., *Urban Project Issues: Dealing with Porto Maravilha Project in Rio de Janeiro*, Modern Enviromental science and engineering, v.6, pp. 542-552, ISSN 2333-2581.

[10] Reviver Centro, Secretaria Municipal de Planejamento Urbano [SMPU], https://pcrj.maps.arcgis.com/sharing/rest/content/items/419a69cd253e48e6816a7b66ccf3bc64/data

[11] Rolnik, Raquel, *Guerra dos lugares. A colonização da terra e da moradia na era das finanças*, Boitempo, São Paulo, Brazil, 2015.

[12] Roppa, Vitor F., *Megaeventos, imagem e promoção imobiliária: a apropriação do city marketing por incorporadores no Porto Maravilha*, dissertation, UFF, Niterói, Brazil, 2020.

[13] Santos Jr, Orlando; Terra, Beatriz; Fidalgo, Tarcyla, *Para quem? Análise preliminar sobre o programa apresentado pela prefeitura do Rio de Janeiro*, Observatório das Metrópoles, Rio de Janeiro, Brazil, 2021.

[14] Sassen, Saskia. *Expulsions: brutality and complexity in the global economy*, Harvard University Press, Cambridge, United States, 2014.

AI-ASSISTED EVOLUTIONARY AND BIO-INSPIRED SCENARIOS FOR CARBON-POSITIVE RESILIENCE MASTER PLANNING OF COASTAL CITIES

Prof. Thomas Spiegelhalter

Florida International University, Miami, 33174, FL, USA, tspiege@fiu.edu

Abstract

This paper presents the results of a four-year research project funded by EU-Horizon 2020, EU-Belmont, and the U.S. National Science Foundation, which aims to develop an AI-ML-assisted water-energy-food nexus design scenario for the greater Miami islands. The project addresses climate change, sea-level rise, flooding, hurricane impacts, heat waves, and saltwater intrusion by operating cities with zero carbon emissions. The study is conducted in collaboration with numerous partners globally. It critically compares two transdisciplinary methods for producing an interactive Citizen and Stakeholder App with scenarios and bio-inspired design scenarios at infrastructure, architectural, and city scales.

The first approach uses AI-assisted generative design with evolutionary topological optimization research workflows, while the second uses synthetic biology coding via BioScripting. Both techniques are combined by integrating cloud-based A.I. and evolutionary machine learning modelling engines. The developed app uses grid layers with maximum envelopes of maximum water heights for all scenarios with drone-cloud-supported digital twin simulations for adaptive community developments above the current sea level targeting 2100 levels. The research aims to support Local, National, and International Governments with Resilience Master Plans and to promote and increase the understanding of the pressing, socially relevant topic of resilience to future human habitats now and in the future. The Miami-based FIU Urban Living Lab (ULL) research group developed the scenario simulations for two low-lying coastal cities in Miami-Dade. The research areas of the ULL include "green-blue" infrastructure for addressing sea-level rise, scripted synthetic biology, robotic urban agriculture, locally produced and hydroponics foods, and hybrid renewable energy designs (1).

The paper critically compares the results of the two methods and open-access synthesis by developing and comparing several combined scenarios of different sizes for different units and locations of the Miami communities in the research study. The methods quantified social and economic impacts from sea-level rise and storm surges for designing adaptive, blue-green infrastructure and buildings from 2018 through 2100. The paper's main contribution is to provide insights into the potential of AI-ML-assisted design methods in addressing the challenges posed by climate change and promoting resilience in coastal cities.

Keywords: Generative AI, Machine Learning, Digital Twin, Evolutionary Algorithm

1 Introduction

This research project delves into the unleashed pool of creativity of generative artificial intelligence (A.I.) in designing and optimizing a water-energy-food nexus for the greater Miami low-lying areas to reduce greenhouse gas emissions and create carbon-positive infrastructure, landscapes, and building scenarios in line with the Paris COP21 and following COP27 Agreements. It employs a transdisciplinary approach that integrates cutting-edge techniques such as A.I., machine learning, evolutionary and genetic algorithms, swarm intelligence, generative design, topological optimizations, deep neural networks, synthetic biology, and carbon-positive architecture, among others. Utilizing digital twin models, this project critically evaluates the social and economic impacts of sea-level rise and storm surges of up to 10 meters over a century, employing cellular automata and swarm intelligence algorithms-driven design scenarios on how to adapt to Hurricane 5 storm surges. The results of this research are presented in various scenarios, accounting for different scales, units, and locations in the low-lying areas of Miami (2). The paper concludes by providing highly relevant insights to designers, policymakers, and researchers looking to build more resilient, sustainable, and equitable communities facing climate change.

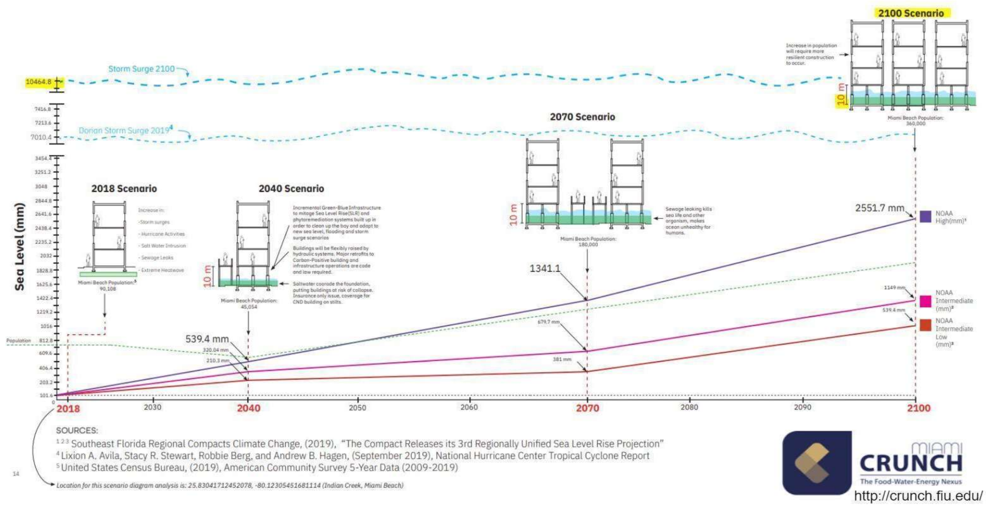


Figure 1. Diagram of the projected Sea Level Rise and Hurricane 5 storm surge impacts with hypothetical population change and carbon-neutral infrastructural and building adaptation scenarios from 2018-2100. Source: CRUNCH PI-Team of Thomas Spiegelhalter [3].

2 CRUNCH Research Questions for a transdisciplinary project

Miami's Greater Islands are experiencing rapid growth and development, necessitating innovative, sustainable, carbon-positive, and bio-inspired infrastructure, architecture, and urban planning to adapt to sea level rise, heat waves, and storm surges. These impacts raise the question of what transdisciplinary methods can generate scenarios from 2018 (baseline) to 2100 and beyond. The Climate Resilient Urban Nexus Choices (CRUNCH) project, spearheaded by the Florida International University Miami research team under P.I. Prof. Thomas Spiegelhalter, seeks to address this question by exploring the integration of cloud-based artificial intelligence and machine learning simulation engines. In addition, this project aims to uncover these methods' potential in producing bio-inspired solutions.

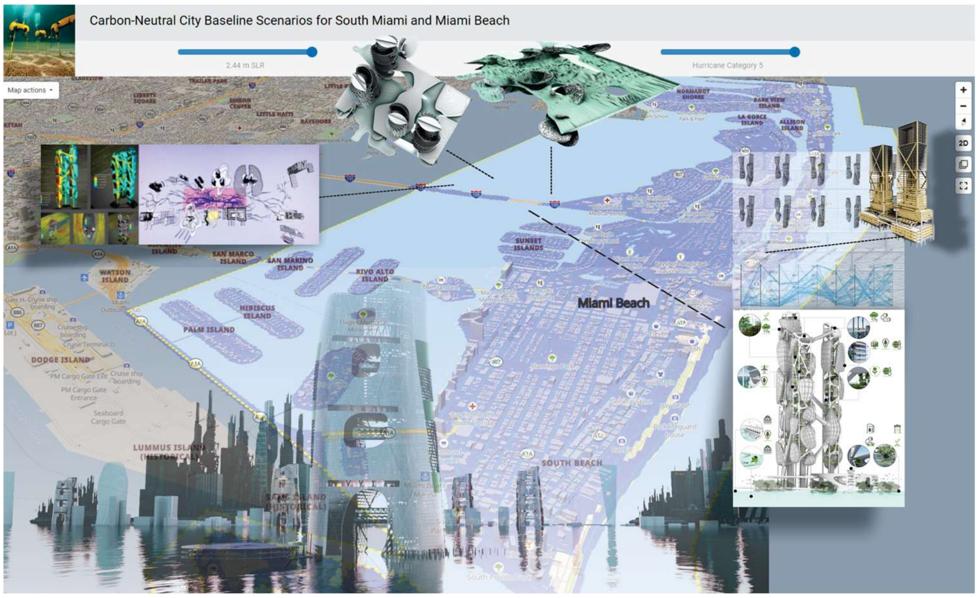


Figure 2. IDSS scenario displays the projected Sea Level Rise and Hurricane 5 storm surge impacts with bio-growth-inspired carbon-neutral infrastructural and building adaptation scenarios from 2018-2100. Source: CRUNCH PI-Team of Thomas Spiegelhalter.

for Miami's Greater Islands in the future. The research goals of the CRUNCH project are to generate various simulation scenarios that can inform decision-making processes for the development of the Greater Islands. The project addresses the central questions: What transdisciplinary methods produce bio-inspired infrastructural, architectural, and urban scale scenarios for Miami's Greater Islands? How do these methods integrate cloud-based artificial intelligence and machine learning simulation engines? Finally, what are the research scenario goals of the project? These questions are illustrated in Figures 1, 2 and 3.

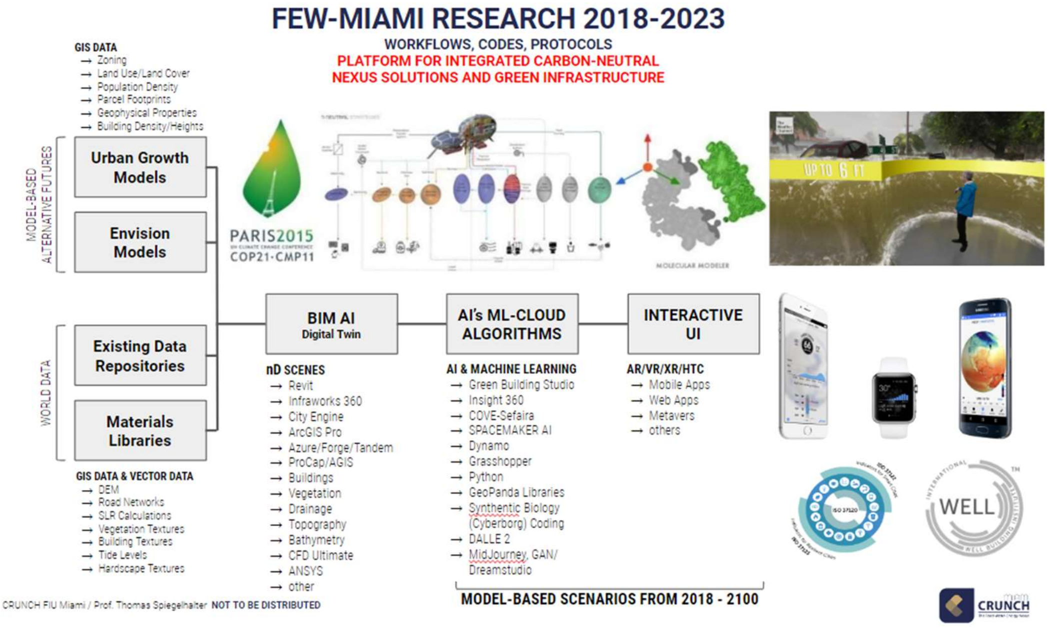


Figure 3. AI-assisted Food-Energ-Water Nexus (FEW), IDSS open-data workflows for green-blue infrastructure scenarios. Source: CRUNCH Miami, Thomas Spiegelhalter

2.1 Methods and Experiments

The research paper discusses the development of an Integrated Decision Support System (IDSS) (Fig. 3 and 4), [4] using two different methods. The first method utilized AI-ML-assisted GIS-BIM analysis, urban growth modelling, and generative design scenario workflows with interactive user interfaces. The second method used synthetic biology tools such as Autodesk's Bio/Nano Protein modeller, Wet Lab Accelerator, and Dreamcatcher A.I. to conduct scenario experiments. These cloud-based AI-ML-assisted modelling and testing tools were appropriate for the research team's experiments.

However, it is crucial to consider the potential risks associated with General Artificial Intelligence, as it could have full access to synthetic biology coding and the ability to alter living systems, including the human body. This poses a significant risk to both the natural and built environment, and it is vital to carefully monitor and control its development to avoid any negative consequences in the future.

Figure 4. Fig. 3: Franco Angeli Studio publications, Milano, Vol. 1-4 above. Left: IDSS web dashboard visualizes 90cm SLR impact on resident demographics. Right: 3D web dashboard shows inundated Miami Beach view. Source: CRUNCH Miami by Prof. Thomas Spiegelhalter, 2020-2022 [1].

The Urban Living Lab (ULL) research team at FIU Miami created all the simulation scenarios based on scenarios from 2018 (baseline) to 2100. The ULL research areas include green-blue infrastructure, synthetic biology scripting, robotic urban farming, local food production, hydroponics, mixed renewable energy design, and carbon-positive, plus-energy power generation with adaptive green-blue infrastructure projects. Both research methods focus on the Water-Energy-Food Nexus Design Research Scenarios for Miami's Greater Islands, considering the Paris Agreement and the United Nations Framework Convention on Climate Change. The objective is to assist governments, stakeholders, NGOs, and citizens in creating sustainability master and transportation plans, raising awareness about urban resilience's importance, and forensic knowledge transfer for the future of carbon-positive human habitats.

The simulation scenarios generated by the FIU-ULL research team in Miami consider the impacts of sea-level rise, flooding, hurricanes, heat waves, and saltwater intrusion. Integrating cloud-based A.I. and machine learning simulation engines addresses the need for comprehensive and user-friendly urban scenario modelling and interactive visualization for policymakers, practitioners, and civil society organizations [5]. Furthermore, it's essential to ensure that the integration of AI-ML with synthetic biology is carried out with caution and responsibility, as it could pose a potential threat to the environment and human life.

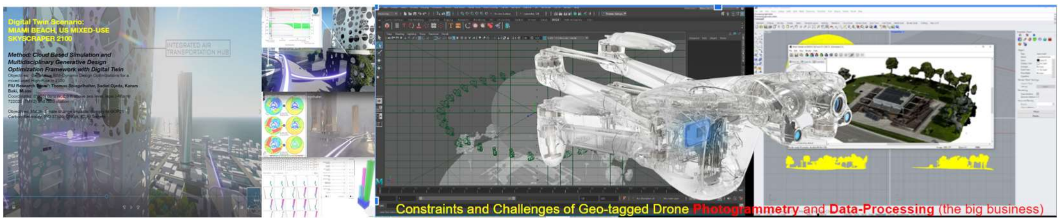


Figure 4. Left: Digital Twin of High Rise on 10m stilts in Miami Beach generated by Anafi AI Parrot Drone cloud point and BIM processed. Right: Parametric Dynamo geometry and building optimisation dashboard. Source: CRUNCH Master Thesis by Prof. Thomas Spiegelhalter and Sadiel Ojeda [1].

Figure 5. The American Institute of Architects (AIA) MIAMI 2020 Design Award project by Master Thesis Student Amalia Tomey. Source: CRUNCH Prof. Thomas Spiegelhalter, Amalia Tomey [1].

2.2 Method 1: Integrated Decision Support System (IDSS)

Miami, also known as Ex Palude Aegre, is a Latin phrase that translates to "with difficulty from the marsh", which means Miami is built on reclaimed wetlands. The Integrated Decision Support System (IDSS) was developed specifically for the zip-code-based areas of Miami Beach and the City of South Miami. These areas are particularly vulnerable to the combined impact of Sea Level Rise (SLR) and the worst-case storm surge scenario of Hurricane Category 5. The research is based on data from the National Oceanic and Atmospheric Administration and the U.S. Department of Commerce. The IDSS uses this data to project the potential impact of SLR and Hurricane storm surge, considering hypothetical population changes and carbon-neutral infrastructure adaptation scenarios from 2018 to 2100 [6]. By considering these factors, the IDSS aims to assist policymakers, stakeholders, and citizens in creating sustainable and resilient master plans for the future of Miami.

2.3 The interactive IDSS-Method and future UI connection

The IDSS scenario simulator for sea-level rise (SLR) and storm surge impact assessment in urban areas have been developed to take into account the potential effects on various aspects of society, including infrastructure, energy, water, food, properties, facilities, land use, and social and economic impacts. However, with the likelihood of future flooding in certain areas, there will be enormous relocation efforts for citizens who reside in flood-prone neighbourhoods. As a result, even big ReInsurance companies like SwissRe or ReMunich have stopped issuing flooding insurance in flood zones.

A smaller version of the IDSS app has also been created for the Flamingo/Lummus neighbourhood in Miami Beach. This app considers the food-water-energy balance explicitly, using the IPCC Representative Concentration Pathways (RCP) 2.6, 4.5, and 8.5 for climate modelling benchmarks [6]. The IDSS and the Carbon-Positive City Scenarios Tool were developed by the FIU-CRUNCH team, the FIU-GIS Center, and the International Hurricane Research Center (IHRC). The IDSS is intended for use by citizens and decision-makers. At the same time, the Carbon-Positive City Scenarios Tool is designed for professionals such as stakeholders, designers, engineers, architects, and town planners. The IHRC also actively guides SLR inundation and storm surge modelling for the Miami basin. As the IDSS and the Carbon-Positive City Scenarios Tool evolve, they will be connected to multiple user interfaces (UIs). Despite the challenges posed by future flooding and the subsequent relocation of residents, these tools are designed to help citizens, professionals, and decision-makers prepare for the potential impacts of SLR and storm surges in urban areas [7].

2.4 Method 2: Synthetic Biology Urban Growth Computation (SynBio-UC)

The SynBio-UC simulations tests use two innovative methods to measure the effects of sea-level rise (SLR) accurately, and storm surges on the adaptive design scenarios for adaptable green-blue infrastructures and building types between 2018 and 2100. The first method, Parametric-Open-Data Integration, involves using data-driven simulations incorporating large amounts of data from various sources to analyze and quantify the impacts of SLR and storm surges on urban areas. The workflow allows for a more precise assessment of the potential impact of these events on infrastructure and communities. The second method used in the SynBio-UC simulations is called Bio-Scripting, a cutting-edge technique that uses synthetic biology growth computation to analyze and quantify the growth and development of biological systems in response to environmental stressors such as SLR, heat waves and storm surges. This method enables researchers to understand better how biological systems respond to these stressors and develop strategies to help them adapt and become more resilient. Both methods were used to develop multiple combination scenarios for differently sized units within the study area, with ARC-GIS retrieving U.S. census blocks used as spatial units for the study [8]. The SynBio-UC Adaptation Scenario Simulations results showed that these methods provide valuable insights into the potential impacts of SLR and storm surges on urban areas, allowing for informed decision-making in designing adaptable and resilient infrastructures and communities [9].

3 Unlocking the Insights and tools of the IDSS Method 1

The AI-ML-assisted Parametric Open Data Integration System is a design approach that integrates open data to achieve specific simulation goals. For example, CRUNCH Miami aimed to simulate urban scenarios to inform the development of the Integrated Decision Support System (IDSS). The IDSS scenario tool allows users to visualize the extent of flooding in response to sea level rise (SLR) and storm surge scenarios in South Miami and Miami Beach, ranging from 0 to 10 meters, with hurricane impacts ranging from category 1 to 5 on the Saffir-Simpson Hurricane Wind Scale. In addition, the scenarios visualize the potential impact on the local population, properties, transportation networks, key services, community facilities, and other service infrastructures such as energy, water, and food [Figure 3,4].

The data model for the scenario uses open data and AI-ML cloud-assisted software, including Autodesk Dynamo-Python, Deep Neural Networks (GNNs), Infraworks and ESRI ArcGIS Pro, Civil 3D, Navisworks, Revit-BIM, Insight360, AI-Spacemaker, Grasshopper for Rhino in Revit, GeoPanda, Bootstrap, Turf, popper.js, Mapbox GL, J.S., and Open Map Tiles. In addition, the scenarios incorporate adaptable new buildings and infrastructures capable of being raised hydraulically and adapting quickly. The research locations are the City of Miami Beach and the City of South Miami. Figure 1 shows an adaptation scenario analysis of Indian Creek in Miami Beach from 2018 to 2100.

Method 1 shows that the IDSS scenarios demonstrate parametric resilient geometries with real-world engineering applications, potentially disruptive technologies, and carbon-positive innovations. The scenarios included multi-functional systems, modules, and mixed renewable energies from solar/wind/water/kinetic building and infrastructure tectonics, autonomous transportation, artificial intelligence with deep neural networks, the internet of things, robotics, and urban outdoor and indoor farming with self-healing facade tectonics for climate emergencies towards 2100 and beyond. The results show the potential of the IDSS to demonstrate carbon-neutral, resilient geometries and innovative technologies for addressing the impacts of sea level rise, storm surges, heat wave mitigation, and adaptation intelligence for South Miami and Miami Beach.

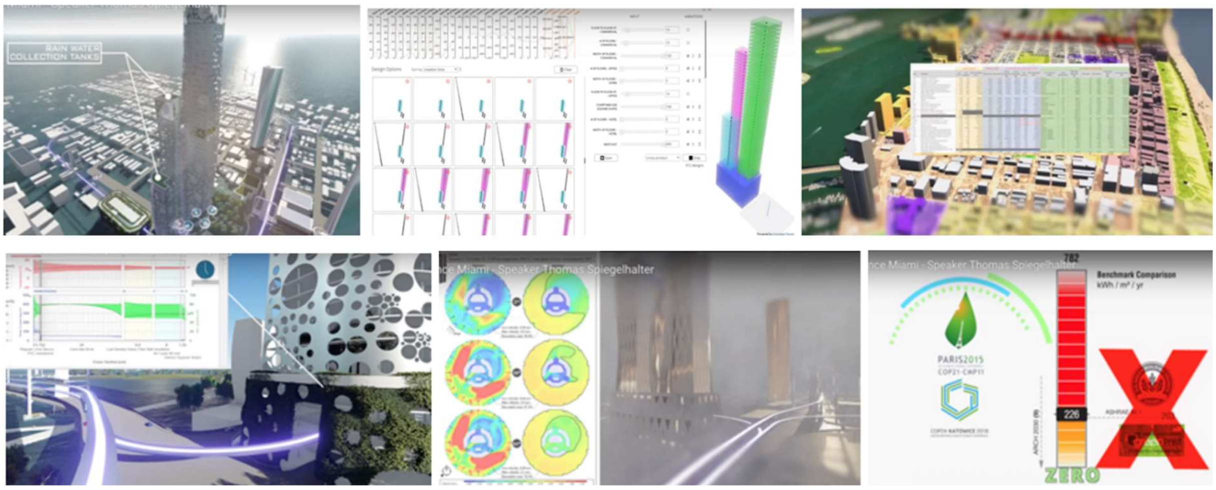


Figure 6: These images illustrate hypothetical scenarios created with the Miami Beach Dynamo-BIM script workflow for massing, building schedule, and orientation testing, as well as adaptive blue-green infrastructure. The lower images depict CFD simulations of hurricane category forces. Source: Master Thesis Studio Prof. Thomas Spiegelhalter with Sadiel Ojeda, 2019-2020.

4 Summary of Method 2 - Generative AI-ML-Bio-Scripting and Growth Computation for Creative Problem-Solving

Method 2 show an innovative approach to AI-ML-assisted data-driven design for adaptive structures in response to the dynamic changes in sea level rise and storm surge in urban environments. The proposed alternative Parametric Open Data Integration approach uses multi-agent bio-scripting with a mix of cartesian building scenarios based on natural growth principles inspired by biology. The approach was realized using computational fluid dynamics (CFD) with a team of graduate design research students planning 17 carbon-positive high-rise buildings for Miami Beach in spring 2021. The research was divided into two approaches, simulating natural/biological growth behaviour through computational biology based on Physarum polycephalum, amoeboid organisms, and utilizing biological material like mycelium bio-composites based on the plant-fungi hybrid organism Myxorhizal [10, 11]. The design study results showed that combining computational biology and biological material offers new possibilities for designing adaptive growth structures that respond to the challenges of dynamic changes in sea level rise and storm surge. The generative CRUNCH Bio-Scripting approach shows promising results for integrating natural growth principles and synthetic biology in urban design for the Miami Harbor redevelopment design in Figure 7. However, more research is needed to fully realize the potential of this method in a real-world implementation. The future of urban design tools and methods will likely see continued integration of generative AI-assisted synthetic biology workflows with biodiversity frameworks, leading to new and innovative solutions to cities' challenges [9].

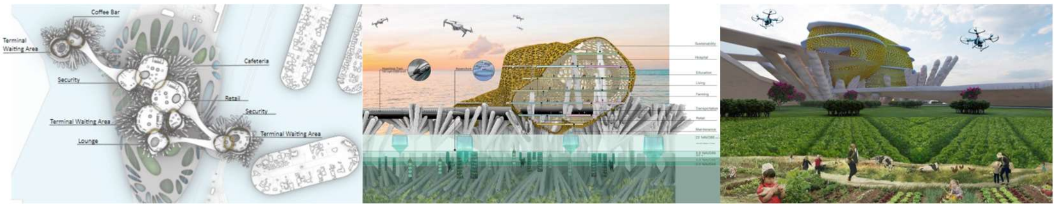


Figure 7. Images of the Midterm designs by Gianna Martinez, Maria Pardilla, Soroya Friedwald. Source: CRUNCH Miami Design Research Studio Thomas Spiegelhalter, Fall 2021.

5. Conclusion

The research presented in this paper has demonstrated the potential of generative AI-driven design with evolutionary growth algorithms to address the challenges of climate change in coastal cities like Miami. As A.I. engineering and design technology evolve, there is an opportunity to integrate more Deep Neural Networks and Graph Neural Networks into general AI cloud modelling engines, creating the most potent A.I. engines for designing carbon-positive, resilient, resilient, green-blue building and city designs. Furthermore, integrating synthetic biology into these engines will enable the creation of adaptable and sustainable living structures that can withstand extreme weather conditions. However, ethical, cultural, and environmental implications must be considered in using AI-generated designs in the built environment. Therefore, investment in design research for A.I. and synthetic biology applications is necessary. Interdisciplinary collaboration is critical to developing better A.I. algorithms that effectively incorporate sustainability, resilience, and adaptability principles into their designs.

In conclusion, the potential of A.I., generative design, and evolutionary algorithms to shape the future of the built environment is immense, and a focus on sustainability, resilience, adaptability and the integration of synthetic biology can create a more equitable and carbon-positive built environment for future generations. There are significant opportunities for researchers, developers, and practitioners to collaborate and innovate in this space. They can explore cutting-edge future scenario tools such as augmented and virtual reality, mixed reality, and immersive environments, allowing architects and engineers to experience and test their designs realistically. In addition, protocols and methods such as life cycle assessment, circular economy principles, and regenerative design can help architects and engineers create buildings and cities that not only mitigate the impact of climate change but also regenerate ecosystems, promote social equity, and foster a circular economy.

Acknowledgements

The authors would like to express their sincere gratitude to the students enrolled in the FIU CRUNCH research design studios (D7, D8, D9, D10, and master level) and all members of the research team at http://crunch.fiu.edu/about/team/. The case studies presented in this paper were made possible by generous funding from the European Union (EU) BELMONT program, the Intelligent Europe initiative, and the US National Science Foundation (NSF) under Grant No. 730254. The authors would like to clarify that the opinions, findings, conclusions, and recommendations expressed in this material are solely those of the authors and do not necessarily reflect the views of the NSF or FIU located in Miami, Florida, USA.

References

[1] Thomas Spiegelhalter[1], L. N. S. Juhasz, "Genetic Water-Energy-Food Nexus Design Research for Miami's Greater Islands," in 2021 International Conference: 27th World Congress of Architects, 2021, 2021, pp. 994-998.

[2] S. Jevrejeva, A. Grinsted, D. Lincke, and B. Marzeion, "Flood damage costs under the sea level rise with the warming of 1.5 C and 2 C," Environmental Research Letters, vol. 13, no. 7, p. 074014, 2018.

[3] Thomas Spiegelhalter[1],"Crunch Research IDSS and Urban Green-Blue-Infrastructural and Environmental Design Scenarios from 2018 to 2100" http://crunch.fiu.edu/about/research/#iLightbox[gallery_image_1]/ (accessed 17.02.2023).

[4] Thomas Spiegelhalter[1], A. Andia, J. Levente, and S. Namuduri, "Part 1: The Integrated Decision Support System-Generative and synthetic biological design imaginations for the Miami bay area," in *Werner, L and Koering, D (eds.). Anthropologic: Architecture and Fabrication in the cognitive age - Proceedings of the 38th eCAADe Conference - Volume 2, TU Berlin, Berlin, Germany, 16-18 September* 2020, vol. 2, pp. 11-20.

[5] L.-D. Radu, "Disruptive technologies in smart cities: a survey on current trends and challenges," *Smart Cities,* vol. 3, no. 3, pp. 1022-1038, 2020.

[6] Thomas Spiegelhalter[1],"Beta IDSS-APP and IDSS-IPCC-2030, Explore", Miami." FIU https://slr.fiu.edu/CRUNCH/ (accessed 17.02.2023).

[7] Hall, J. A., Weaver, C. P., Obeysekera, J., Crowell, M., Horton, R. M., Kopp, R. E., Marburger, J., Marcy, D. C., Parris, A., Sweet, W. V., Veatch, W. C., & White, K. D. (2019, 3 4). Rising Sea Levels: Helping Decision-Makers Confront the Inevitable. *Coastal Management*, *47*(2), 127-150. https://doi.org/10.1080/08920753.2019.1551012

[8] M. Schlossberg, "GIS, the US Census and neighbourhood scale analysis," *Planning, Practice & Research,* vol. 18, no. 2-3, p. 213, 2003.

[9] Jeanet Mante, Yikai Hao, Jacob Jett, Udayan Joshi, Kevin Keating, Xiang Lu, Gaurav Nakum, Nicholas E. Rodriguez, Jiawei Tang, Logan Terry, Xuanyu Wu, Eric Yu, J. Stephen Downie, Bridget T. McInnes, Mai H. Nguyen, Brandon Sepulvado, Eric M. Young, and Chris J. Myers. *Synthetic Biology Knowledge System,* ACS Synthetic Biology 2021 *10* (9), 2276-2285, DOI: 10.1021/acssynbio.1c00188

[10] N. Attias *et al.*, "Mycelium bio-composites in industrial design and architecture: Comparative review and experimental analysis," *Journal of Cleaner Production,* vol. 246, p. 119037, 2020.

[11] T. Nakagaki, H. Yamada, and Á. Tóth, "Intelligence: Maze-solving by an amoeboid organism," *Nature,* vol. 407, no. 6803, pp. 470-470, 2000.A

LIFE IN THE URBAN PERIPHERY, A CASE FROM ISTANBUL: OMERLİ

Guliz OZORHON* and Ilker Fatih OZORHON

Ozyegin University
Çekmeköy Campus, Nişantepe District, Orman Street, 34794 Çekmeköy, İSTANBUL-TURKEY; guliz.ozorhon@ozyegin.edu.tr, ilker.ozorhon@ozyegin.edu.tr

Abstract

This study focuses on the periphery of the city and investigates a case from İstanbul. Some of the questions of the research are as follows: -1- What happens in the periphery as the city grows as the city grows steadily every day? 2- What are the characteristics of the residential areas in the periphery? In the study, answers to these questions were sought in the examples of Çekmeköy district and Ömerli Neighbourhood located on the periphery of Istanbul, and the changing settlement pattern in the neighborhood at the urban-rural intersection was first shown chronologically and then with current determinations.

Keywords

periphery, Istanbul, urban periphery

1 Introduction

The periphery is interesting in many ways, especially in big cities, it receives a large amount of immigration for various reasons. It is the place of those fleeing the city, it is calm and clean compared to the center. Moreover, it is economical. It is far and nowadays being far away is sometimes desirable. Periphery is both close to the city and at a distance from the chaos of the city. However, over time, the formation of transportation alternatives and the increase in the number of people coming from the center also creates density on the periphery. Thus, the first causality in the formation of the periphery settlements disappears, the periphery loses its character as a periphery, it transforms and it is pushed. Undoubtedly, this story is written through other routes for other cities of the world. But in Istanbul, this story is repeated endlessly. As the city keeps getting bigger the periphery changes as well and borders keeps expanding. Istanbul offers many routes to explore, understand and tell this story.

The word peripheral is a word that is frequently used both in geography (eg, the periphery of the country) and in medicine (eg, peripheral nervous system). Its meaning is far from the center and close to the edge. Peripheral means outskirts of a region or area. It also includes the meanings of the border of a place or something; The outlying area; the settlement far from the centre; edge, fringe. In urban and architectural terminology, the concept of periphery is often included as “urban periphery” and refers to a location, a geographical place.

This position also includes life, life in the periphery. In other words, the concept of the periphery has a social content as well as being geographical (eg, social periphery, being a woman in the periphery, children in the periphery, art in the periphery). Periphery is a hybrid, a new kind of place, mostly on the border of the city, where the countryside and the city meet, fall side by side, mingle and transform into each other.

The formation of the periphery in the city can be explained with the concept of 'urban sprawl'. Gotmann described the spread of settlements towards the periphery as sprawl in the process of transforming rural areas into urban areas as a result of the rapidly increasing population in metropolitan cities and accompanying suburbanization after the 1920s [1]. Although the rapid growth of cities seems to be the main reason for urban sprawl, there are other factors that cause it. According to Karataş (2007), these reasons can be listed as follows: the high income group moving their own housing areas to the peripheries, developments in housing technology and mass housing sector, changes in housing preferences, air pollution in the center, crime rate, increase in noise rate and lack of open space, the limited availability of land in the city center and the high price, population growth and low agricultural income compared to the income to be obtained as a result of the transformation of land to urban use, land speculation, the inability to create restrictive and effective planning-zoning and taxation policies [2].

Urban sprawl causes many problems. One of these problems is the damage to natural resources. According to Sezgin and Varol, the fact that urban developments in the peripheries of metropolitan areas cause urban sprawl with a discontinuous, low-density structuring poses a threat to urban sustainable development and causes an increase in waste with the consumption of soil, water, energy and other resources. In this process, soil, which is an indispensable natural resource for the continuation of the ecosystem, also faces the threat of being destroyed by misuse. [1]

2 Life in the Periphery: Çekmeköy

When viewed in ten-year periods since 1950, it is seen that a fringe extending the walls beyond the municipal boundaries of Istanbul has expanded the macroform of the city [3]. Bosphorus bridges and connection roads have come to the fore as the most important determinants of legal and illegal housing location selections in the 1970s and 1990s in Istanbul, which continues to be attractive in the industry and services sectors. These transportation policies, which also affected the population movement in Istanbul and the population differentiation between the two sides, became a factor that enlarged the periphery settlements that make up the rural texture of Istanbul in a short time and united them with the central texture of the city. Çekmeköy (Fig. 1), Alemdağ, Taşdelen and Ömerli regions stand out as urban foci that enrich their demographics with the demands for new housing, where the city is fringes and combined with the center with strong transportation networks in these years [3].

Figure 1. Istanbul and Çekmeköy

As a result of the failure to manage the housing problem in Istanbul in a healthy way over the years, slum formations were observed around Zeytinburnu, Topkapı and Beyoğlu in the city center, while agricultural lands or forested 2B lands in districts such as Esenler, Pendik, Ümraniye, Çekmeköy, Sarıyer were illegally removed with the effect of the city's fringes on the periphery of the city. appears to be built. With the opening of the 2nd Bosphorus Bridge and the TEM connection, Istanbul entered a period of rapid growth and fringing [4], the city grew in large pieces and spread to the forest areas in the north of the city.

Located on the Anatolian side of Istanbul, Çekmeköy District, formerly a town municipality affiliated to Ümraniye, was formed in 2009 with the termination of the legal entities of Ömerli, Alemdağ and Taşdelen first-level municipalities and the incorporation of 17 neighborhoods and 4 villages affiliated to these municipalities. Çekmeköy was established on the southern slopes of Keçiağılı Hill, located in the southwestern part of the Alemdağ forests on the Anatolian side of Istanbul, and has an altitude of 100 m from the sea. The district is located on an area of 148.08 km2 and has a population of 264,508. It is surrounded by Beykoz in the northwest, Şile in the northeast, Ümraniye in the southwest and Sancaktepe in the southeast [5].

The urbanization history of Çekmeköy is quite recent. Having the status of a village in the 1970s, Çekmeköy entered a rapid urbanization process in the 1990s. Especially after the 1999 Marmara earthquake, a rapid construction has started, which continues until today. The most important attraction of the region is its proximity to the center and its distance from the noise and pollution of the city. [6].

Cekmekoy district, located in the periphery of Istanbul, has developed rapidly due to both the increase in transportation opportunities and its geographical advantages. As Özgür [7] stated, Çekmeköy, located on the Şile connection to the TEM road, has become the target of large construction companies due to its proximity to the TEM and being surrounded by Alemdar forests. The rapidly increasing construction on the peripheries of the Istanbul Metropolitan Area in recent years has been effective in the Çekmeköy district, in particular, after the 1999 Marmara earthquake and its becoming a district in 2009. With the effect of the ring roads added due to the 3rd Bridge added to the Bosphorus in 2016, the interest in the district has increased and still continues to increase. Cekmekoy, which was once a small village far from the center, has now become a large municipality [8]. The demographic structure of the district and, accordingly, the living areas also vary. There are many different types of living environments ranging from slum settlements to mass housing estates and luxury single family homes. Çekmeköy also has a rich diversity in terms of socio-economic status. The most distinctive feature of Çekmeköy is the juxtaposition of low-rise housing estates and shantytowns or areas with irregular and unplanned structures made up of illegal structures. Ekici, in his study examining Çekmeköy, draws attention to the richness of natural resources, but the concentration of gated communities that spread rapidly towards these natural areas [9].

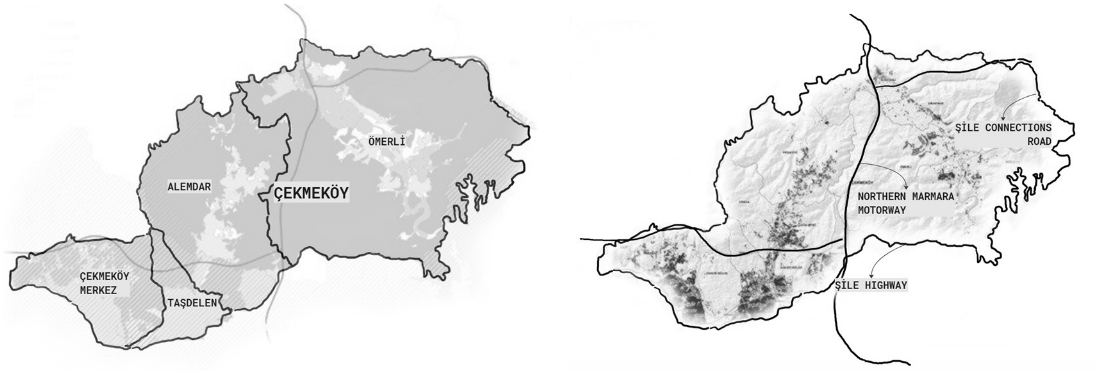


Figure 2. Çekmeköy, Neighborhoods of Çekmeköy and Important Transportation Axes

Cekmekoy residential areas are concentrated in the center and fringed towards the rural areas (Fig.2). The center of Çekmeköy is now moving away from the calm and peaceful environment with its dense construction. Construction is gradually moving towards forests and water basins and threatens these protected areas [10].

3 The Case of Omerli Region: Periphery of the Periphery

Ömerli neighborhood (Fig.3) is the northeast neighborhood of Çekmeköy district and is a naturally bounded area by Ömerli Forest and Ömerli Dam. Thanks to the Şile highway, the area has become a favorite center for those seeking a quiet and peaceful life away from the city [4].

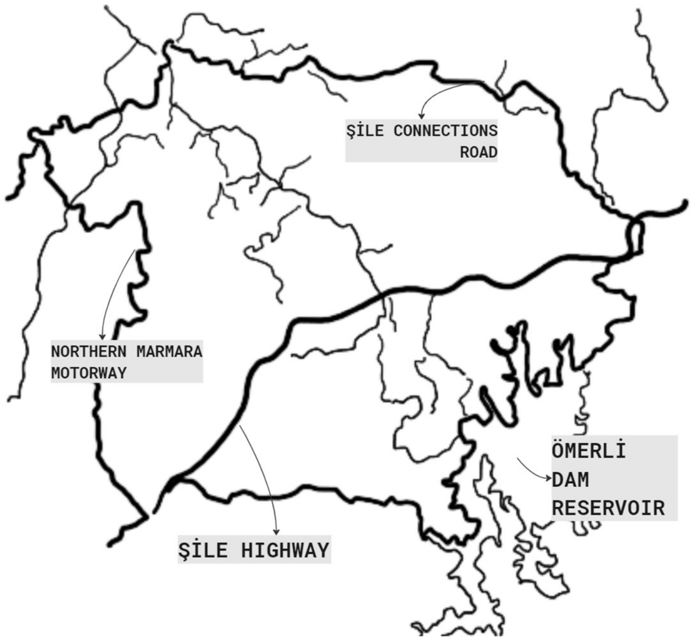


Figure 3. Ömerli Neighbourhood and its surroundings

According to 2022 data, 5,313 people live in the neighborhood. Although the neighborhood showed minor changes in the past, the situation after 2017 (Fig. 4) are remarkable. In this increase, the transportation arrangements that increase/facilitate the neighborhood-city connection - eg. opening of the north marmara highway has a large share.

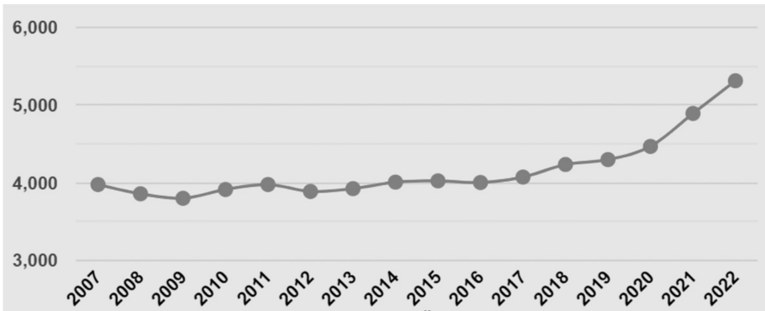


Figure 4. Omerli District Population Data
(Provincial District Neighborhood Village Population of Turkey, 2023)

Ömerli Region is defined as the area where rural life development will be kept under control in 1/100,000 environmental assessment report approaches of Istanbul. This area (because it is within the İSKİ protection area) is located within the boundaries of the protection area and the water catchment basin. The region is defined as a rural settlement area whose development will be kept under control within the urban and regional green area, ecological agricultural area, water catchment forest area. Besides, it is a settlement that can be given as an example for the rural new settlement areas of Istanbul. [4]

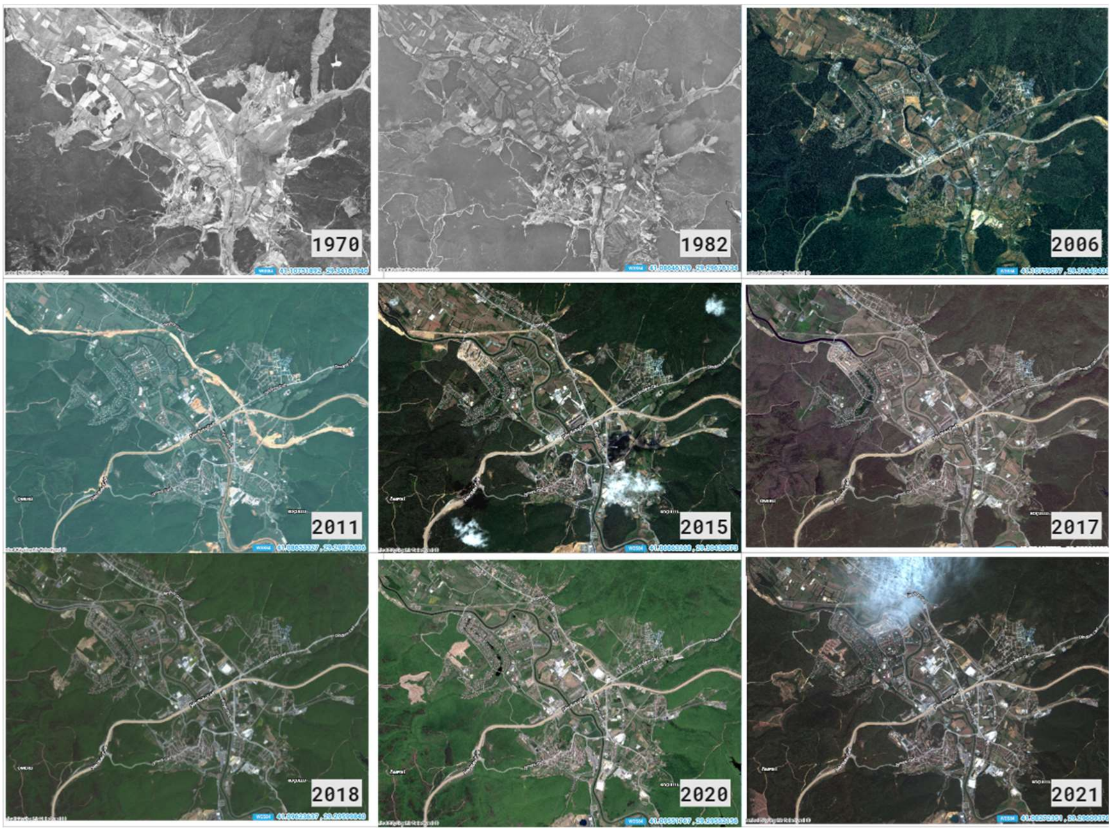


Figure 5. Ömerli between 1970-2021
(https://sehirharitasi.ibb.gov.tr/)

In the 1970 aerial photograph included in the municipal map archives, a small rural settlement can be seen in the southern part of the neighborhood, apart from that the area consists of agricultural and forest lands. Despite the increase in the number of households in the village in the aerial photograph dated 1982, it is observed that the rural structure of the area continues. This situation started to change with the use of the Şile road in the 90s. The change in the area since 1970 can be easily read through aerial photographs (Figure 5).

Figure 6. Ömerli Neighbourhood, Şile Highway (2023)

Today, Şile road divides Ömerli neighborhood into two. The dynamics of life (social, physical and cultural) in these two parts are quite different from each other.

The settlements on the northern side of the Şile Highway consist of low-rise residential complexes. The biggest of these sites is the Kasaba Houses, the construction of which started in 1998-99 and continues to develop step by step. The purpose of the settlement is to create a living space in a calm and peaceful environment outside the city. In the site catalogue, "…a calm life in the arms of nature, with the urban chaos left behind" is promised, and here "life is calm and peaceful, time does not go by quickly, every second is lived to the fullest. Negative effects arising from business life or urban chaos are left behind when you enter your home in Kasaba, and you literally step into a new life" (….) is added. A new life is marketed with its tastes, smells and colors. Indeed, the site is set in a rich landscape. Here you can do any sport you want and meet many of your needs without leaving the site. In addition, there are two large school campuses in this region that provide education at different levels from kindergarten to high school. Your children can safely go to the neighboring college on foot or on their bikes without getting into the traffic jam, and they can spend time with their friends on the site after school.

Figure 7. The northern and southern settlements of Ömerli District 1 (2023)

With the 2000s, the number of sites in this area has increased gradually. With the increase in the number and variety of living spaces -especially in recent years- shopping units of various scales have been added.

Another example of a site that has been implemented recently is Volony Ömerli Mansions. This time, the approach and the character of the settlement are quite different. The prominent subject in the catalog of the site is the unique beauty of traditional European classical architecture in Istanbul and meeting all the requirements of the modern age. Natural life is given a secondary place, but wide streets, stylish sidewalks, promenades and parks are mentioned with reference to cities such as London, Paris and Milan.

These two examples clearly show that much has changed in the past two decades. While in the first example, a longed for a quiet and rural-urban life is described, in the second example nature is pushed to the background, the scale has grown and the urban is praised.

On the south side of the Şile road, it can be said that the settlements maintain their rural character to a large extent. In accordance with the rural character, the settlement showed an organic development. The settlement is built on a main street and the streets accessed from this street. Ömerli neighborhood administrative units, health center, fire department and public school are located here.

Figure 8. The northern and southern settlements of Ömerli District 2 (2023)

Although the northern and southern parts of the neighborhood are separated from each other by only one road, the lives in both settlements and the places where these lives take place (Fig.8) are quite different from each other. Luxurious housing estates with their high walls in the north of the settlement have minimal contact with the south. These sites, which promise many privileged opportunities to their residents, unfortunately did not make a meaningful contribution to the other side of the road. According to İstif, the fact that the sites in the region were built with the logic of gated communities do not provide any benefit to the rural settlements where they are located, and these luxury settlements divide the region into income groups. Since they increase the land prices in the region, the local people in the region are forced to sell their land to construction companies [4]. Separate lives are led on both sides of the road (different markets, different schools, different lives). On the one hand, there is the Marketplace and small businesses, local producers, and on the other, large chain markets and fast food restaurants (Fig.9).

Figure 9. Social facilities in the northern and southern settlements of Ömerli District (2023)

Omerli district, which is on the periphery of Çekmeköy, has begun to intensify and lose its periphery character with the development of transportation facilities. The city and its features have gradually started to show itself in this place, which has come to get away from the negative features of the city (such as traffic, noise, pollution, chaos). Although the forest areas in the middle of the district limit this process for now, industry and warehouse areas have started to flow into this region with the development of the ring roads. Therefore, the ecology of the region and forest areas are in danger.

4 Conclusion

Istanbul is the city most affected by the rapid urbanization process in Turkey. In line with this process, there is an intense flow towards the urban periphery of Istanbul. An example of these settlements formed on the city periphery with this flow is Çekmeköy.

The region, which was the distant rural living area of Istanbul until 10 years ago, has become one of the favorite settlements of those with middle and upper-middle income levels in recent years, with the opening of the TEM and II. Bosphorus Bridge connection roads, the construction of the Şile highway, its earthquake-resistant ground and nature. Çekmeköy is fringing towards the countryside, the construction is gradually moving towards the forests and water basins and is threatening these protection areas.

The situation is similar in Ömerli district. In recent years, when factors such as pandemics and earthquakes have been added to the increase in transportation opportunities, the demand for Ömerli, which is the periphery of the city, and therefore the building density, has increased rapidly. Agricultural lands in the region are disappearing and forest areas are being suppressed.

The formation process of new settlement areas has a significant impact on the growth and spread of the city. The uncontrolled realization of this process leads to the deterioration of the integrity of the city and puts natural areas in danger.

References

[1] Sezgin, D. and Varol, Ç., The Effects Of Urban Growth And Sprawl On The Misuse Of Fertile Agricultural Lands In Ankara, Ankara'daki Kentsel Büyüme ve Saçaklanmanın Verimli Tarım Topraklarının Amaç Dışı Kullanımına Etkisi, *METU JFA*, (2012) pp. 273-288, 10.4305/METU.JFA.2012.1.15

[2] Karataş, N., The Effects of Urban Sprawl Trends in İzmir on Land Ownership Change Processes in Torbalı-Ayrancılar, İzmir'deki Şehirsel Saçaklanma Eğilimlerinin Torbalı-Ayrancılar'da Arazi Sahipliği El Değişim Süreçlerine Etkileri (1968-2000), *Planlama*, (2007) pp. 3-12.

[3] Çolak, Y. The Spatial Development of Çekmeköy, Çekmeköy'ün Mekansal Gelişimi, in Çekmeköy Symposium, İstanbul, 2006.

[4] İstif, S. Spatial development process of the city of Istanbul, investigation of the Çekmeköy-Ömerli settlement area within the scope of the new urbanism movement, İstanbul Kentinin Mekansal Gelişimi, Çekmeköy-Ömerli Yerleşmesinin Yeni Kentleşme Akımı Kapsamında İncelenmesi, İstanbul, MSGSU Fen Bilimleri Enstitüsü, 2009.

[5] Anonymous, Çekmeköy Municipality, 13 2 2023.

[6] Demirkaya, Y., Cekmekoy's Socio-Economic Structure and Urban Life Quality, Çekmeköy'ün Sosyo-Ekonomik Yapısı ve Kentsel Yaşam Kalitesi, İstanbul, Çekmeköy Belediyesi, 2010.

[7] Özgür, E.F., New housing tendencies within the framework of social segregation and spatial fragmentation: Gated communities, the case of Çekmeköy-İstanbul, Sosyal Ve Mekânsal Ayrışma Çerçevesinde Yeni Konutlaşma Eğilimleri: Kapalı Siteler, İstanbul, Çekmeköy Örneği, *Planlama*, (2006), pp. 79-95.

[8] Ozorhon, I. F. and Ozorhon G., The Metropolis and the Child: Healthy Childhood Spaces for a Healthy City, in 58th ISOCARP World Planning Congress, From Wealthy to Healthy Cities - Urbanism and Planning for the Well-Being of Citizens, Brussels, 2022.

[9] Ekici, T., Examination of Gated Communities in the Framework of Sustainable Urban Development: The Case of Istanbul-Çekmeköy, Sürdürülebilir Kentsel Gelişme Çerçevesinde Kapalı Sitelerin Irdelenmesi: İstanbul-Çekmeköy Örneği, MSGSU Fen Bilimleri Enstitüsü, Istanbul, 2011.

[10] Karagülle, D. The spatial impacts of urban sprawl on natural resouces, an example of Istanbul, Cekmekoy, Kentsel Saçaklanmanın Doğal Eşiklere Mekansal Etkisi, İstanbul Çekmeköy Üzerine Bir Çalışma, İstanbul, MSGSU, Fen Bilimleri Ensitüsü, 2011.

ANNEX TO HISTORICAL BUILDING: THREE CITY, THREE MUSEUM BUILDINGS

Ilker Fatih OZORHON* and Guliz OZORHON

Ozyegin University

Çekmeköy Campus, Nişantepe District, Orman Street, 34794 Çekmeköy, İSTANBUL-TURKEY; ilker.ozorhon@ozyegin.edu.tr, guliz.ozorhon@ozyegin.edu.tr

Abstract

This study examines the subject of annexes of historical buildings. For this purpose, three museum buildings (MAXXI, STEDELIJK, Maritime Museum) located in three different cities (Rome, Amsterdam, Istanbul) were examined. These 3 museum structures were first examined separately (with the titles of history, environment and design), and then a joint evaluation was made together (with their environment, dialogues (images) and programs). In the study, data obtained from national and international publications, books, journals, articles, photographs and observations made by the authors in the field were used. Interventions and additions made in buildings that are important to the city, such as those exemplified here, change and transform not only the building or its immediate surroundings, but also the city and its life. It is also important to examine this relationship, which can make a difference in urban life, and to explain its potential.

Keywords

extensions of historical buildings, museums, transformation

1 Introduction

Historical buildings are important components of urban memory. They both form the identity and memory of the city and mediate the connection with the past. However, the passage of time wears out historical buildings both contextually and physically. Therefore, the survival of the buildings can only be achieved by adapting to the conditions of the time. This adaptation is associated with the preservation and revitalization of buildings. This is sometimes possible by organizing the building with a new/up-to-date function. Sometimes the structure continues its current function, but in this case, it needs to be adapted to current conditions and requirements. In this new situation, a new spatial organization and annexes may be required. With these additions, the building also takes on a new identity. The historical structure changes and transforms. In this case, what is critical is how the relationship between the original state of the structure and the additions/changes is interpreted. This study examines this situation in the example of the museum.

1.1 A brief about the museum:

The International council of museums describes the museum as follows: “A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicately, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing.” [1] As an important part of the social and cultural life, the museums are landmarks of the city. Due to their symbolic values for the entire city and their indispensable position in the cultural and artistic life of the city, museums are considered as culture temples of the centenary [2]. Today's museums are not considered as single-functional buildings that only display what is inside, but as multi-functional ones that present and exhibit themselves as a value together with their contents [3] Museum architecture has undergone a significant change in the world, especially in Europe. The main axis of this change is the transformation of museums, which are a kind of closed conservation space, into open spaces that invite participation in the city and sometimes play a transformative role in the city. [4] The city/museum relationship, like all other forms of relationship, includes a double-sided situation. In this relationship, it can be said that both parties affect each other. [3] Museum is perceived as a building that shows a potential of urban landmark and owing to this potential it represents the city and has the power to transform the surroundings. [5]

1.2 Method of the Study

The annexes can cause functional changes in buildings in line with the needs, as well as helping the buildings to continue to perform their current function. The reintegration of buildings into life with these designs sets an example for the sustainability of buildings.

It is very common to transform historical buildings into museums by renovating or enriching/enlarging them with various additions [6]. One of the best-known examples in this regard is the world's most visited museum, which was established in the Louvre palace. (Fig.1) Although the palace was turned into a museum in 1793, it took its final shape with the addition of the pyramid designed by Pei (1983-89). Although it was the target of various criticisms at the time it was made, it can be said that today Pei's design has become an integral part of the Louvre museum and Paris.

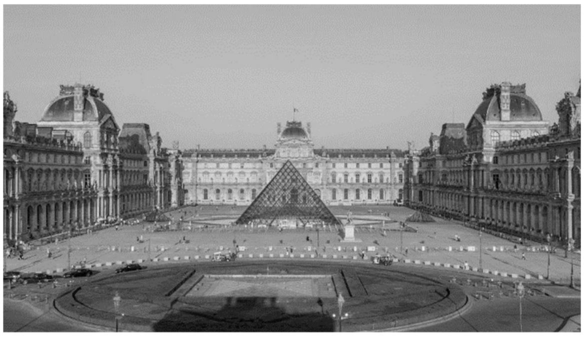
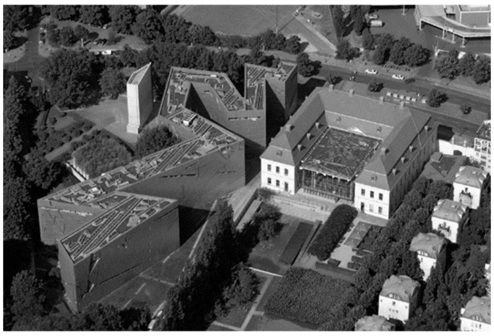



Figure 1 Louvre Museum, Paris (https://www.boutiquesdemusees.fr/en/shop/museum/musee-du-louvre/?par=2)
Figure 2 Jewish Museum, Berlin (https://www.inexhibit.com/case-studies/daniel-libeskind-jewish-museum-berlin/)

A similar example is the Jewish Museum that Daniel Libeskind built in Berlin in 1999 (Fig.2). The project emerged as a result of a competition organized by the Berlin administration in 1987 to expand the existing Jewish Museum in Berlin. Libeskind designed a building located right next to the old building and accessed through it. For him, the Jewish Museum is more about restoring and securing an identity that was lost in Berlin than a competition [7]

In this study, the subject of annexation to historical buildings is examined in the example of the museum. With this new addition, buildings are changing/transforming and often gaining a new identity. Within the scope of the study, three museum buildings (MAXXI, STEDELIJK, Maritime Museum) located in three different cities (Rome, Amsterdam, Istanbul) are examined. With this review, the research seeks answers to the following questions: What kind of a change did the transformations of museum buildings create in terms of their relations with the city and public space? How can the original and changing states of the buildings be evaluated in terms of the identity of the building? How has the spatial organization of the buildings changed?

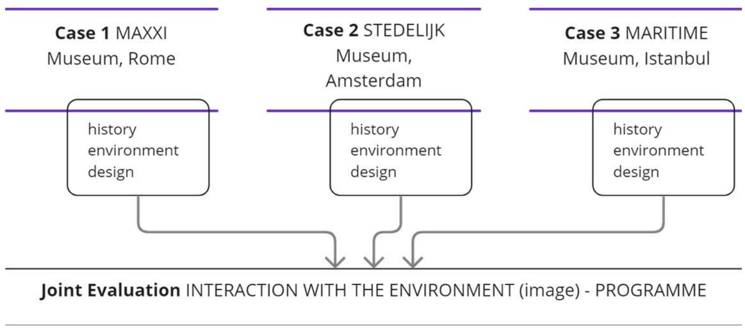


Figure 3 Framework of the study

In the next part of the study, these 3 museum buildings were examined under the titles of history, environment and design, thus revealing their stories, relations with their surroundings and design strategies (Fig. 3). In the third part, a common evaluation was made through the dialogues (images) and programs of the 3 museum buildings with their surroundings. In the study, data obtained from national and international publications, books, journals, articles, photographs taken and observations made by the authors in the field were used.

2 Three Museum Building

The reuse of monumental buildings, which are the heritage of architecture, not only creates a good way for protection, but also contributes to the revival of the region by increasing the spatial quality in line with the needs of the society [6]. In this section, 3 museum buildings that contribute to the region are examined.

2.1 Case 1: MAXXI

Figure 4 MAXXI Museum, Rome (Authors, 2010)

- **History:** MAXXI (Fig.4), Italy's First National Museum of Modern Art, which was designed in 1998 by Zaha Hadid Architects (ZHA) winning the competition for the new Museo Nazionale Delle Arti Del XXI Secolo building [8], is located in the Flaminio district of Rome, MAXXI (Fig.5) was created by partially restoring the devastated Montello military barracks and articulating Hadid's design. The design idea was nourished by the gentrification of Flaminio, which is considered an outdated area, and the discourse of being an alternative cultural space to the center [9].
- **Environment:** What Hadid wanted to do was to design a structure that contrasts with the surrounding high-rise buildings, rather than a museum building added to the site as a pastiche. For this reason, Hadid interpreted the museum as an extension of the low-level urban environment and the second shell of the land, rather than being a building. In some places, the building joins the existing floor to form the new floor, while in some places it rises and combines with other parts to form masses [10]. In MAXXI, Hadid set out from the idea of creating an "urban campus" in harmony with the urban fabric and aimed to become an urban element belonging to that part of the city by creating unique indoor and outdoor spaces. While the two parts of the building, which seem to overlap, separate the functional differences, the pedestrian paths outside provide the transition between the streets of the city throughout the mass of the building [11].

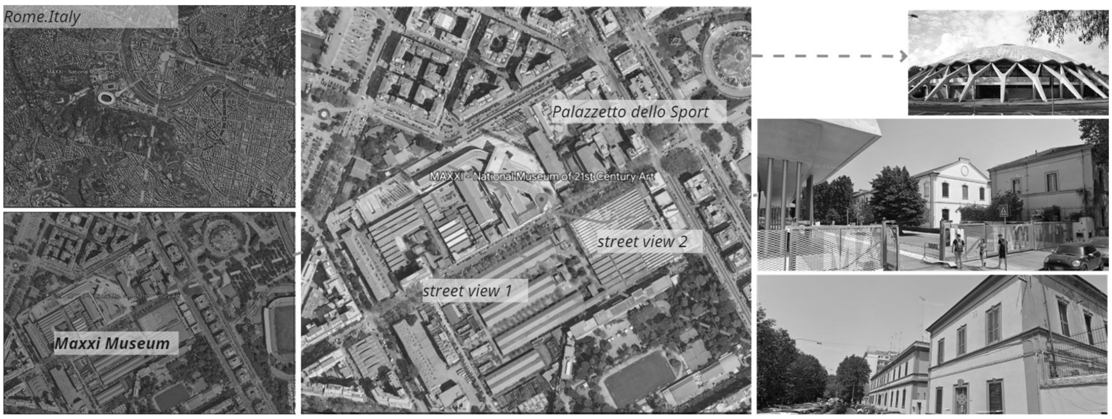


Figure 5 Location and Environment of MAXXI Museum

- **Design:** While planning the museum, Hadid envisioned the building as an art campus. The building has forms that are both innovative and spectacular. In the general form of the building, there are fluid and curvy shapes that Hadid frequently uses in her works. Black and white colors were used predominantly in the building. In addition, in the lighting design of the building, it is aimed to make maximum use of natural sunlight by using a transparent roof and to illuminate the building with natural light. MAXXI addresses the urban context issue by continuing the low-rise urban fabric of the former military barracks, which acts as a barrier against the surrounding high-rise blocks (Fig 6). In this way, the center acts more like an “urban link”, even taking on a second skin for the area [12]. Hadid explains the approach that shaped the design at MAXXI*: “I see MAXXI as an urban-cultural space that feeds the cultural life of the city and where ideas can be exchanged. MAXXI should not be perceived as just a building: While initially only walls separating the exhibition spaces were needed, our design work led us to a concept where lines merge and direct the space. This project brought us from the idea of "museum as an object" to the idea of "collection of buildings". MAXXI is not just a museum building, it is an urban cultural center where interior and exterior spaces are organized with interconnections. While the galleries are surprisingly intertwined inside, their linear surfaces fill a huge space outside.”*

Figure 6 MAXXI Museum, Rome (Authors, 2010)

2.2 Case 2: Stedelijk Museum

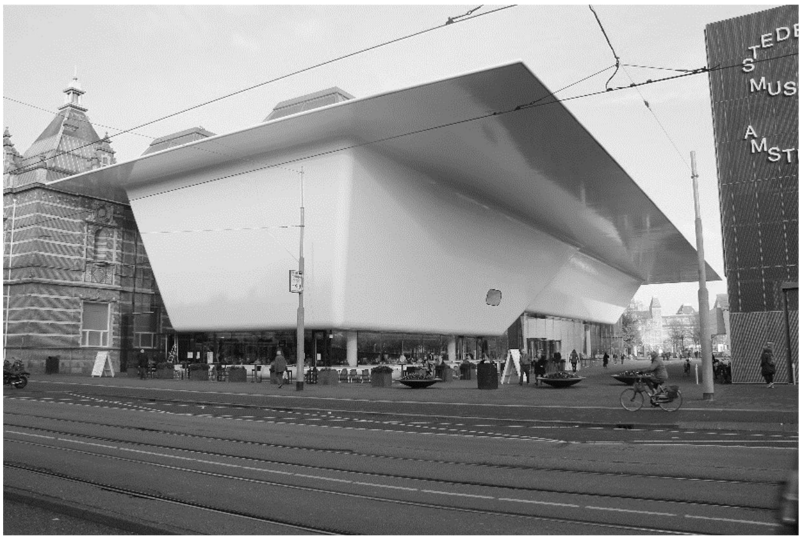


Figure 7 Stedelijk Museum, Amsterdam (Authors, 2013)

- **History:** The Stedelijk Museum was founded in 1874 by a group of private citizens in Amsterdam, who donated funds and their art collections to establish a in the capital of the Netherlands that would be devoted to modern art. Designed by Adriaan Willem Weissman in the 19th century, the Stedelijk Museum was built on the Paulus Potterstraat between 1891 and 1895. The building, whose facade and tower are designed with a combination of stone and red brick, is in the Neo-Renaissance style dominating 16th century Holland [13] The museum took its final form with the design made by Benthem Crouwel Architects as a result of the competition held in 2004 (Fig.7).
- **Environment:** The Stedelijk Museum is located on Amsterdam's Museumplein (Museum square), which also includes the Rijksmuseum and the Van Gogh Museum (Fig 8).

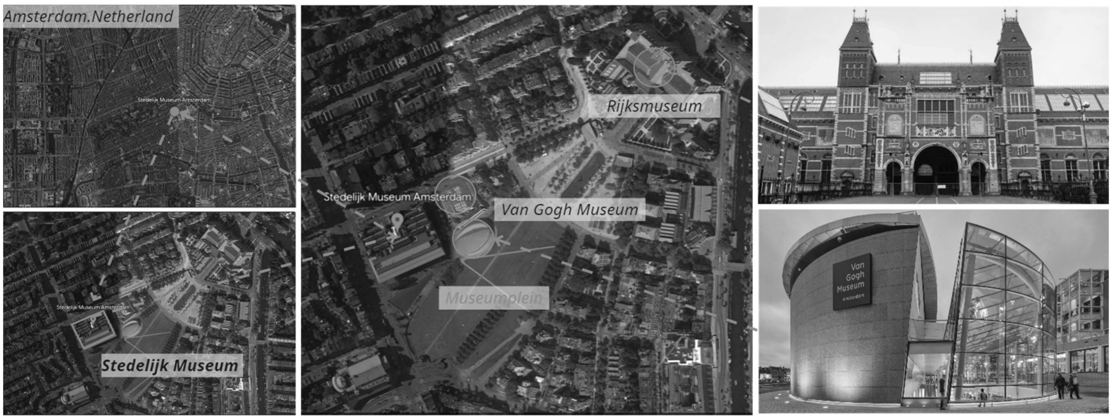


Figure 8 Location and Environment of Stedelijk Museum

- **Design:** In the design by Benthem Crouwel Architects, the building's majestic staircase, grand rooms and natural lighting were preserved, along with the white color used throughout the museum. The annex is planned as an integrated annex alongside the existing building [14]. Although the contrast of the new building to the old building is obvious from the outside; it can be said that there is a continuity (Fig.9) in the interior. With the new arrangement, the entrance of the building has been changed, and the approach to the building has been turned to Museumplein. The new entrance includes all public functions such as counters, library, museum shop and restaurant. The ground floor of the building has a strong relationship with the square, such that the boundary between the building and the square is ambiguous, and the ground of the building is a continuation of the square. The most important part of the building's identity is the large white roof-eaves. The smooth white volume, also known as the "tub", is made of fiber-reinforced composite.

Figure 9 Stedelijk Museum, Amsterdam (Authors, 2013)

2.3 Case 3: Maritime Museum

Figure 10 Istanbul Maritime Museum

- **History:** The Istanbul Maritime Museum was opened to visitors in the Dolmabahçe Mosque Complex in 1948, and in 1961 the museum moved to its current location in Beşiktaş. A new building was needed over time, so a national architectural project competition was opened in 2005. The new building (Fig.10) was opened to visitors in 2013. The task was to propose a new exhibition scheme for the same site, preserving one of the existing buildings, as designated by the Monuments Council. The lot in Beşiktaş, by the Bosphorus aligned with Ottoman Palaces, offered a very limited space with a set of difficulties to design and build (to build a contemporary structure on Bosphorus) [15].
- **Environment:** In the competition report, the architects described the building as "The current Maritime Museum in Beşiktaş is a lost and forgotten complex in the center of Istanbul. The proposal, together with its invaluable content, puts this area on the shore of the Bosphorus into the use of the city" (Fig.11). The fact that the building is located in one of the busiest Bosphorus settlements in Istanbul and that the land is crammed into the center of the settlement has enabled the building to have a form that provides comfort to its surroundings. "One who looks at the structure from the Bosphorus sees a large boathouse with sledges out of his eyes. What the one who looks at the Bosphorus from the museum sees is a quay: it's like a fleet waiting to be sailed."
  Entrance to the building is provided from Beşiktaş-Dolmabahçe Street, after the entrance hall, the building opens to the sea with exhibition halls. The new building is positioned behind the street, so the old (registered) building is brought to the fore. In addition, the space created in the entrance area creates a relaxation area and a meeting point in the dense urban texture.

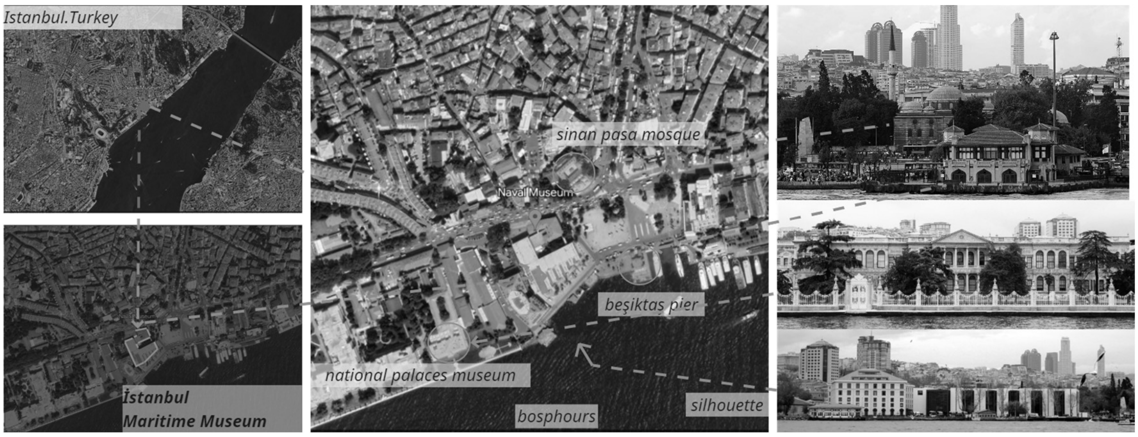


Figure 11 Location and Environment of Istanbul Maritime Museum

- **Design**: This new building was constructed in relation to the existing building, but did not intervene between the old building and the city, on the contrary, it opened the way and made it more visible (Ozorhon and Ozorhon). Proposal featured the boat gallery as the climax of the entire complex, opening it up to the Bosphorus through a fractal interface. Given the fact that the collection is permanent and unchangeable, the design resembles a 'glove' perfectly fitting (Fig.12) [15].

Figure 12. view from the sea Istanbul Maritime Museum
(https://www.arkitera.com/haber/deniz-muzesi-istanbul-siluetindeki-yerini-aldi/)

3 Joint Assessment

3.1 Interaction with the Environment

« *The most important feature to remember about museums is that they are in a constant state of change.* » [16].

Table 1: Brief information about buildings

name	*Stedelijk Museum*	*Maxxi Museum*	*Istanbul Maritime Museum*
architects	Benthem Crouwel Architects	Zaha Hadid Archtects	Teğet Architectural Office
year	*2012*	*2009*	2010
area	**26.500 m²**	**29.000 m²**	**30.000 m²**

The relationship between outside and inside is of paramount importance to the museum as a building typology, as museums exist in such an eclectic assortment of scale, settings, and contents: urban, suburban, and rural locales, public and private institutions, categorical and encyclopedic collections. Such diversity makes it impossible and undesirable to assign the museum a specific style of architecture (Sirefman, 1999)

MAXXI was launched with the motivation of gentrifying the region and adding cultural venues to it. Probably partly for this reason, communication with its environment has been the main element that guides the design. Rather than presenting the building as an object, Hadid proposed a semi-urban space, a world to immerse in. Both external and internal circulation follow an inclined geometry with vertical and horizontal circulation elements [12]. The circulation of the building and the urban context are intertwined and knit together. The internal and external circulation follows the general flow in the form of the building [10].

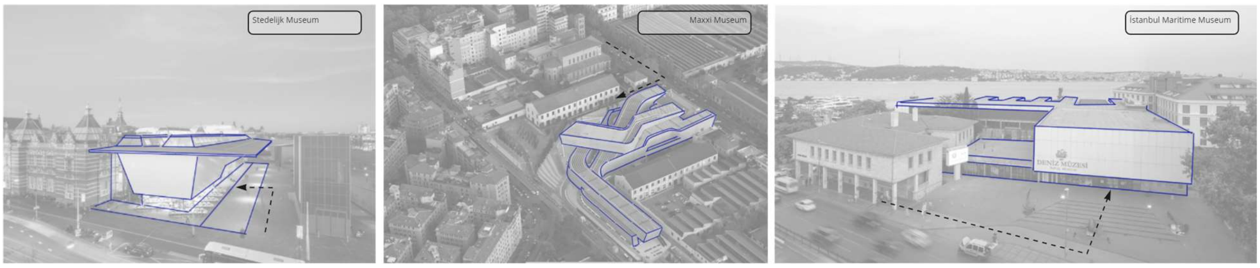


Figure 13 Annexes and Entries

Benthem Crouwel Architects has preserved the important details of the historical building and offered various new opportunities for exhibitions with the additional building they designed next to it. This new additional structure is neither dependent on nor completely separate from the old one; Now the two buildings are integrated with each other. When viewed from the outside, the contrasting stances of the white new building, which resembles a bathtub, and the historical building are very evident, but inside, it is difficult to notice this distinction when moving from the new building to the old one [17]. By taking the entrance of the museum building to the square side, the interaction of the building with its surroundings has been increased. Especially the ground floor of the building is a continuation of the public space here.

The Maritime Museum building has turned its face to one of the most heavily used axes of Istanbul. The building has been pulled back a little from the main road and defined an open public space, a meeting point in front of it. This area is bounded/defined by the old and new building, each a representation of their own time

All three buildings exemplified here have a strong relationship with their immediate surroundings (Fig.13). In other words, the public contents of museums are reflected in the relationship of the buildings with their immediate surroundings. The inviting building entrances, organized by the continuity of the outdoor-indoor space and the building formation, add the buildings to the city life, and the buildings are nourished by the richness of the city life.

Atagök underlines the contribution of the museum architecture, which attracts the attention and curiosity of the visitors, to the increase in the number of visitors [16]. The fact that the number of visitors of the Istanbul Maritime Museum, which also changed its strategy with its new venues, increased by 50% in 2018 compared to the previous year, can be considered as an indication that the Istanbul Maritime Museum has achieved its goal of becoming a meeting center in the Beşiktaş district [18]. Similarly, the Stedelijk has become one of Amsterdam's most popular museums, attracting more than 700,000 visitors each year, MAXXI welcomed 3,328,000 visitors in 2019—more than double the amount in 2010.

3.2 Program

Museums; Along with other cultural facilities such as theatres, libraries or concert halls, they make an important contribution to the cultural infrastructure of a place or region. The MAXXI includes an auditorium, a library and media library, a bookstore and a cafeteria, spaces for temporary exhibitions, outdoor spaces, live events and commercial activities, laboratories, and spaces for study and entertainment. By organizing workshops in certain periods, it is aimed to be a place where visitors can both have a good time and learn new things [11].

Stedelijk's new addition is a superstructure supported by six support points. The additional building, which was completed in 2012, provided an area of 9000m2 for the historical museum building. In addition to the exhibition halls, the museum includes a bookstore, cafe, auditorium and study spaces.

In the Istanbul Maritime Museum, temporary exhibition areas, meeting rooms, a conference hall and a concert area as well as accessible cultural spaces are provided, so book festivals, children's biennials, etc. events are organized and joint programs are carried out with other cultural institutions [18].

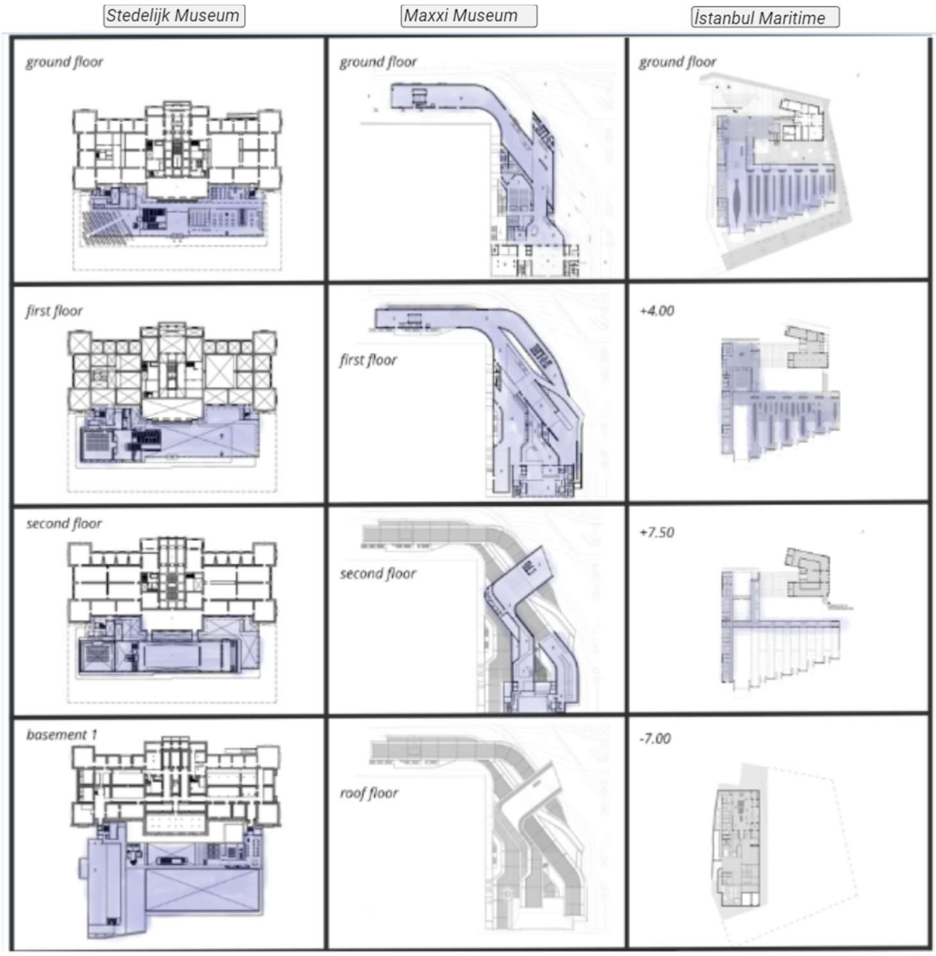


Figure 14 Plans –annexes are highlighted-

4 Conclusion

Cities are made up of parts that are in constant communication/interaction with each other. The change in each of these parts changes both their relations with each other and inevitably the city itself. Changes and additions made to buildings of critical importance to the city, such as the buildings exemplified here, change and transform not only the building or its immediate surroundings, but also the city and its life. It is important to examine this relationship, which can make a difference in urban life, and to explain its potentials.

Today, museum buildings are renewing/changing the image of their surroundings, the city they are in, and even the country, by occupying a position far above the function of being a mere museum, with an architectural identity that is stronger and more prominent than the objects they exhibit.

It can be said that the museum buildings sampled within the scope of the study have established modest relations with the historical buildings to which they are added. With their formation and identity, they reflected the technology and architectural understanding of their time, at the same time they respected the size of the old buildings and did not damage their perceptibility. On the other hand, all three buildings not only supported the program of the old building, but also strengthened the integration of the old building with its surroundings and their participation in urban life.

References

[1] Anonymous, "ICOM," 24 Agust 2022. [Online]. Available: https://icom.museum/en/resources/standards-guidelines/museum-definition/. [Accessed 4 January 2023].

[2] Jenks, C. *The Iconic Building: The Power of Enigma*, Frances Lincoln, 2005.

[3] Ozorhon, I.F. Ozorhon, G. Investigation of the relationship between museums and cities in the context of image: cases from Istanbul, *Journal of Architecture and Urbanism,* vol. 39, no. 3 (2015) pp. 208-217.

[4] Gökmen, H. On Museum and Museum Architecture, Müze ve Müze Mimarlığı Üzerine, *Ege Mimarlık,* july (2010) pp. 22-27,

[5] Güzer, A. The Museum as a Building Reclaiming Its Reputation, İtibarını Geri İsteyen Bir Yapı Olarak Müze, *Ege Mimarlık,* july (2010) pp. 14–15.

[6] S. Balçık, G. Karaoğlu and B. Ayaz, "Evaluation of Additional Space Designs in Architectural Heritage Buildings" "Mimarlık Mirası Yapılarda Ek Mekân Tasarımlarının Değerlendirilmesi," *International Mardin Studies,* pp. 39-53, 2022.

[7] Anonymous, "Arkitektuel," 18 october 2017. [Online]. Available: https://www.arkitektuel.com/berlin-yahudi-muzesi/.

[8] Garcia, M. MAXXI, Rome: Zaha Hadid Architects, *Architectural Design* (2010) pp. 132-135.

[9] Köksal, A. H., Architect's Trick Beats the Museum: MAXXI, the Promises of a Contemporary Art Museum, Mimarın Fendi Müzeyi Yendi: MAXXI, Bir Güncel Sanat Müzesinin Vaatleri, *Yapı Dergisi* (2010).

[10] Balık, D. Interpreting the Museum, Müzeyi Yorumlamak: Üç Yeni YapI, *Ege Mimarlık,* july (2010) pp. 33-35.

[11] Mutlu, N. Hadid in Rome, Roma'da Hadid, 6 july 2011. [Online]. Available: http://mimdap.org/2011/07/65180/.

[12] Merdim, E. arkitera.com, 10 june 2000. [Online]. Available: https://www.arkitera.com/proje/maxxi-museum/.

[13] E. Yıldız and M. Dağgülü, “Amsterdam Stedelijk Museum in Terms of Formation Factors,” *Inonu University Journal of Art and Design,* p. 1309, 2021.

[14] A. Benthem Crouwel , 4 april 2013. [Online]. Available: https://www.archdaily.com/350843/stedelijk-museum-amsterdam-benthem-crouwel-architects?ad_medium=gallery.

[15] . M. Teğet. [Online]. Available: https://teget.com/project/istanbul-maritime-museum/.

[16] T. Atagök, “Museology and Turkish Museology”, “Müzecilik ve Türk Müzeciliği,” *Ege Mimarlık,* pp. 8-13, july 2010.

[17] İ. Sudaş, 18 nowember 2013. [Online]. Available: https://www.arkitera.com/proje/the-new-stedelijk-museum-amsterdam/.

[18] İ. Gültaş, Applications of Museum Competition Projects in Turkey: Evaluation of the Maritime Museum in the Context of Exhibition, Türkiye'de Müze Yarışma Projeleri Uygulamaları: Deniz Müzesi'nin Sergileme Bağlamında Değerlendirilmesi, İstanbul: YTÜ, Sosyal Bilimler Enstitüsü, Master Thesis, Yüksek Lisans Tezi, 2019.

[19] S. Sirefman, “Formed and Forming: Contemporary Museum Architecture,” *Daedalus,* pp. 297-320, 1999.

[20] I. v. Aalst and I. Boogaarts, “From Museum to Mass Entertainment The Evolution of the Role of Museum in Cities,” *European Urban and Regional Studies,* vol. 9, no. 3, pp. 195-209, 2002.

[21] Anonymous, 1 12 2022. [Online]. Available: https://www.stedelijk.nl/en/museum/history.

URBANIZATION ON THE HISTORICAL LANDSCAPE OF BANGKOK'S INNER ORCHARDS: TRANSITIONS THROUGH DETERIORATIONS AND ADAPTATIONS

Vudipong DAVIVONGS*, Sigit Dwiananto ARIFWIDODO

Department of Landscape Architecture, Faculty of Architecture, Kasetsart University
50 Ngamwongwan Road, Lat Yao, Chatuchak, Bangkok 10900, Thailand; archvpd@ku.ac.th

Abstract

Bangkok's inner orchards, located in the present-day peri-urban area of the city, were established at least 350 years ago. They served as a crucial production area for fruits and vegetables to meet the needs of Bangkok's residents. The cultural landscape of this mixed tropical fruit cultivation is characterized by its irrigation system of ditches and dikes, and the manipulation of land to incorporate cultivation with the low-lying land condition of the alluvial floodplain.

However, over the last five decades, these peri-urban orchard lands have been negatively impacted by rapid urbanization. This study traced the urbanization on the orchard lands through historical maps and changes in landscape configuration from 1959 to 2000. Landscape configurations focusing on the fragmentation of the orchard landscape matrix were clarified using Patch Number (PN), Patch Density (PD), and Mean Patch Size (Area_MN) indexes. The results revealed a large expansion of urban areas (+304.88%) while only a small expansion of orchards (+47.92%) during the study period. Additionally, landscape fragmentation indexes have revealed that the orchard lands have become increasingly fragmented over time.

The study concluded that many of these orchards have been abandoned or deteriorated due to urban encroachment. To be able to survive in the urbanized Bangkok, adaptation measures for the orchards were required. Farmers have changed their cultivation methods to suit the harsh environmental changes and to avoid pollution from urbanization. Furthermore, some orchards have transformed their agricultural businesses to serve as potential green areas for recreation and tourism for city dwellers.

Keywords

Urbanization; Agricultural land; Cultural landscape; Adaptation; Bangkok

1 Introduction

Bangkok's inner orchards were established at least 350 years ago as mixed-fruit orchards in a small agricultural village of Bangkok that produced fruits and vegetables to serve Ayudhaya, the former capital city of Thailand (historically known as Siam) [1]. Later, Bangkok was established as the capital city in 1782 [2]. Since then, the orchards become a crucial production area for fresh fruits and vegetables for Bangkok’s residents. This historical landscape of orchards is currently located along the Chaophraya river in the western peri-urban area of Bangkok.

The cultural landscape of Bangkok’s inner orchard is characterized by its irrigation system of ditches and dikes [3] (Figure 1.). The landform has been manipulated to incorporate fruit cultivation in the low-lying land condition of the alluvial floodplain. Soil from the digging ditches was piled up as raised planting beds and dikes. Various tropical fruit trees were planted altogether on these raised planting beds imitating the natural forest [2].

During the late twentieth century, rapid urbanization occurred in Bangkok as a chaotic form of urban sprawl due to fast economic growth [4, 5]. Peri-urban areas have been developed as places for housing estates to serve the inward-migrated population. The road network was laid over these orchard areas as an important infrastructure for development. As a consequence, Bangkok’s inner orchard areas have been negatively affected by the urban sprawl. Deteriorations of the environment due to urban sprawl are harmful to these fruit trees [6].

Due to the urbanization in Bangkok, this study aims to 1) trace the urbanization in the orchard areas through historical maps from different periods, 2) determine landscape configurations focusing on the fragmentation of the orchard landscape matrix, and 3) understand current orchard conditions through case studies and farmers’ interviews.

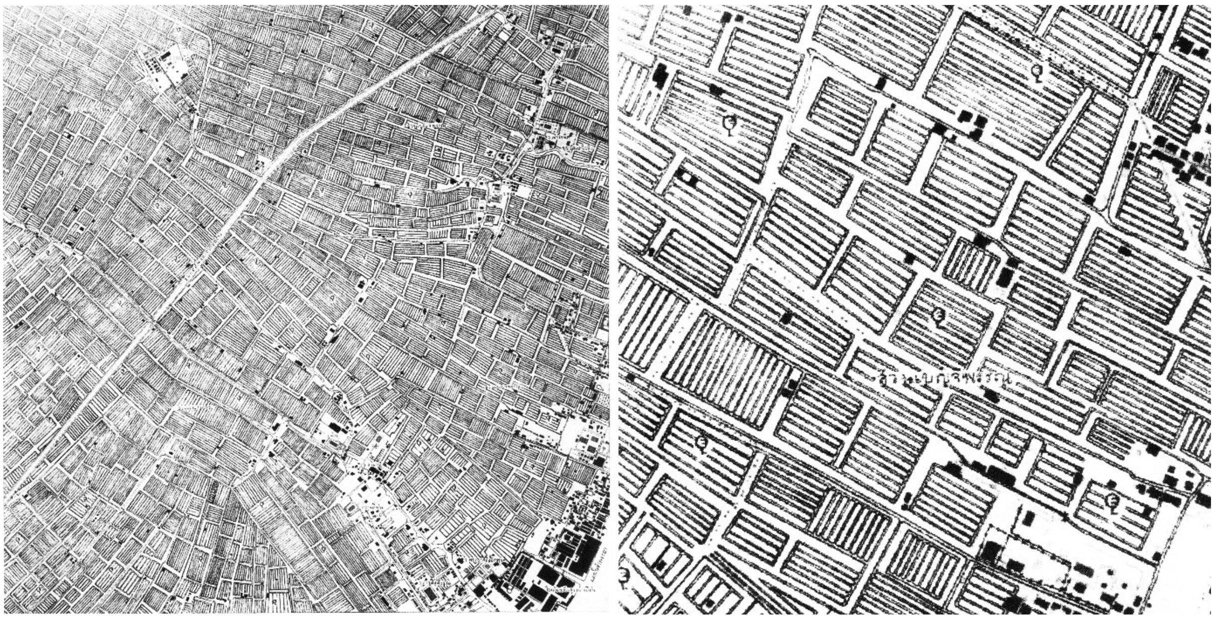


Figure 1. Historical Map of Orchard Areas (Left) with Ditches and Dikes System (Right) [7]

2 Methods

2.1 Land Use Changes

Urbanization over Bangkok's inner orchard areas was studied using land use data from various historical maps. Topographic maps from 1959 and 2000 received from the Royal Thai Survey Department (RTSD) were chosen for comparison. The L708 map series was made from the land survey data in 1959 while the L7018 map series was made from the land survey data in 2000 at a 1:50,000 scale. These map series provided adequate information to identify orchard and urbanized areas. Both orchard areas and urbanized areas were digitized and stored in the geographic information system (GIS). Bangkok's inner orchard areas were identified as mixed-fruit orchards on the original maps.

How much orchard and urbanized areas have changed over time were calculated at the macro-scaled level using the spatial analysis function in ArcGIS 10.3 software. The amount of both land uses in 1959 and 2000 were compared. The area changes were analyzed in square kilometers (A) and percentages.

2.2 Landscape Fragmentation

The fragmentation of orchard and urbanized lands were analyzed using landscape configuration indexes for analysis. These indexes were Patch Number (PN), Patch Density (PD), and Mean Patch Size (Area_Mn) [8].

PN is an index that counts the total number of land patches. A high PN value means more land fragmentation. In contrast, a low PN value means less land fragmentation.

PD is the number of land patches in a square kilometer. PD of orchard and urbanized areas were analyzed using Eq. (1).

$$PD = PN/A \tag{1}$$

Where A is the area in square kilometers, and PN is the Patch Number.

A high PD means more land fragmentation. In contrast, a low PD means less land fragmentation.

Area_MN is the average size of all land patches. The calculation of Area_MN of the orchard areas can be done using Eq. (2).

$$Area\_MN = Total\ A/PN \tag{2}$$

Where Total A is the total study area in square kilometers, and PN is the Patch Number. A high Area_MN means less land fragmentation. In contrast, a low Area_MN means more land fragmentation [9].

2.3 Orchard Conditions

To understand how orchard areas have been affected by urbanization. Ground surveys to identify the current condition of orchards were conducted at a micro-scaled level. Six operational orchards were selected for the surveys. Measurement was made along with photo shooting and the plan and section drawings.

Opinions from the local people are crucial to know how orchards can survive in the urbanization circumstances. Farmers and orchard owners were interviewed with a pre-guided question set that aimed to understand 1) Orchard deterioration from urbanization and 2) Adaptation conducts to keep the orchard continue in operation.

3 Results

3.1 Land Use Changes

The spatial analysis of each land use revealed that orchard areas were 293.06 km^2 in 1959 and 433.75 km^2 in 2000 (Figure 2.). Hence, orchard areas have increased by 140.69 km^2, or 47.92% in total. Urbanized areas have increased enormously from 107.13 km^2 in 1959 to 1,012.07 km2 in 2000. There were 326.62 km^2 of new urbanized areas developed over this period (304.88%).

In addition, some of these emerged urbanized areas have taken over the existing orchards. More than half (157.26 km^2, 53.66%) of the orchard areas in 1959 changed to urbanized areas in 2000.

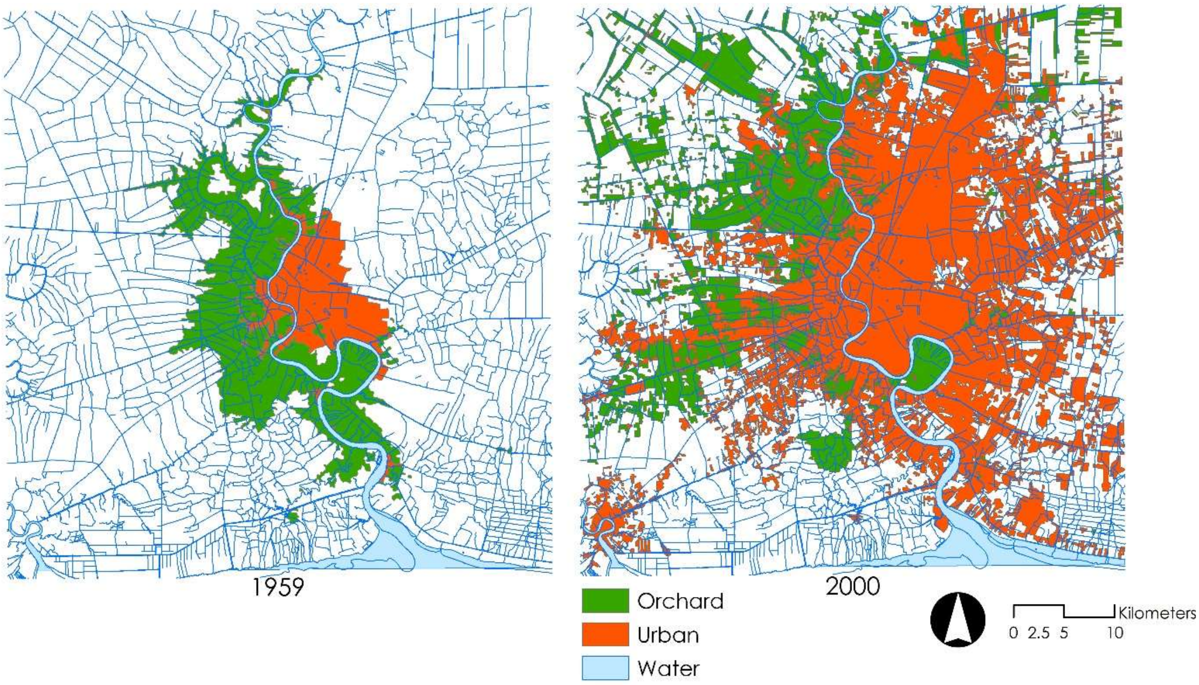


Figure 2. Orchard and Urbanized Areas in 1959 and 2000

3.2 Landscape Fragmentation

Landscape fragmentation of orchard areas from 1959 to 2000 was determined by using 3 indexes which are PN, PD, and Area_Mn. The results revealed that PN of orchard areas has increased from 40 patches in 1959 to 306 patches in 2000. Higher PN in 2000 compared to 1959 indicated a change in more landscape fragmentation of orchard areas. (Table 1)

For PD, the number of orchard patches per km^2 in 1959 was 0.14. PD in 2000 was found to increase to 0.71. A higher PD in 2000 means more landscape fragmentation compared to 1959 which was a lower PD. (Table 1)

Analysis of the orchard's Area_MN revealed that the Mean Patch Size of orchard areas in 1959 was 7.33 km^2 while in 2000 was 1.42 km^2. Smaller Area_MN in 2000 compared to 1959 can be interpreted that the orchard areas changing to be more fragmented. (Table 1)

Results from all these landscape configuration index analyses point out the same direction that landscape fragmentation of orchard areas increased from 1959 to 2000.

Table 1: PN, PD, and Area_MN of Orchard Areas in 1959 and 2000

Year	**Patch Number, PN**	**Patch Density, PD**	**Mean Patch Size, Area_MN**
1959	40	0.14	7.33
2000	306	0.71	1.42

3.3 Orchard Conditions

From the spatial analysis using GIS data to identify the orchards and urbanization, the results indicated that many orchards have converted to urbanized areas. Even though, many of them have been left abandoned. In the field survey of six micro-scaled study orchards and interviews, we found that many orchards are still operational. However, deteriorations of the existing orchard from the effect of urbanization were found. Some orchard owners adapted their orchards to survive in the urban sprawling area. Here, two representative case studies are explained as follows.

The first orchard was "Uncle Kaew Garden" (Figure 3.). This is a mixed-fruit orchard that was still cultivated traditionally. It was currently surrounded by urban sprawling of new housing estate development. A canal that runs right next to the orchard was one of the key factors as a free water source that keep this orchard surviving. However, the farmer had to adapt their traditional cultivation by regulating receiving water from canals to avoid water pollution. The farmer kept the original and rare variety of fruit trees and also allowed the exotic plants to grow as new products in the orchard. Produces from the orchard such as various types of tropical fruits, vegetables, and herbs were distributed to urban customers via close-by flea markets. These were the main income for the farmer.

The second orchard was "Poomjai Garden" (Figure 4.). This is a mixed-fruit orchard type that is dominated by large lychee trees *(Litchi chinensis)*. A private secluded orchard was then open for urban residents to visit and enjoy this green area with some fees. A restaurant and café were added to serve the orchard's unique recipes with the farm-to-table concept in mind. This mixed-fruit orchard incorporated recreational and tourism activities into traditional cultivation practices to comply with adaptation for survival.

Figure 3. Plan, Sections, and Photo of Uncle Kaew Garden

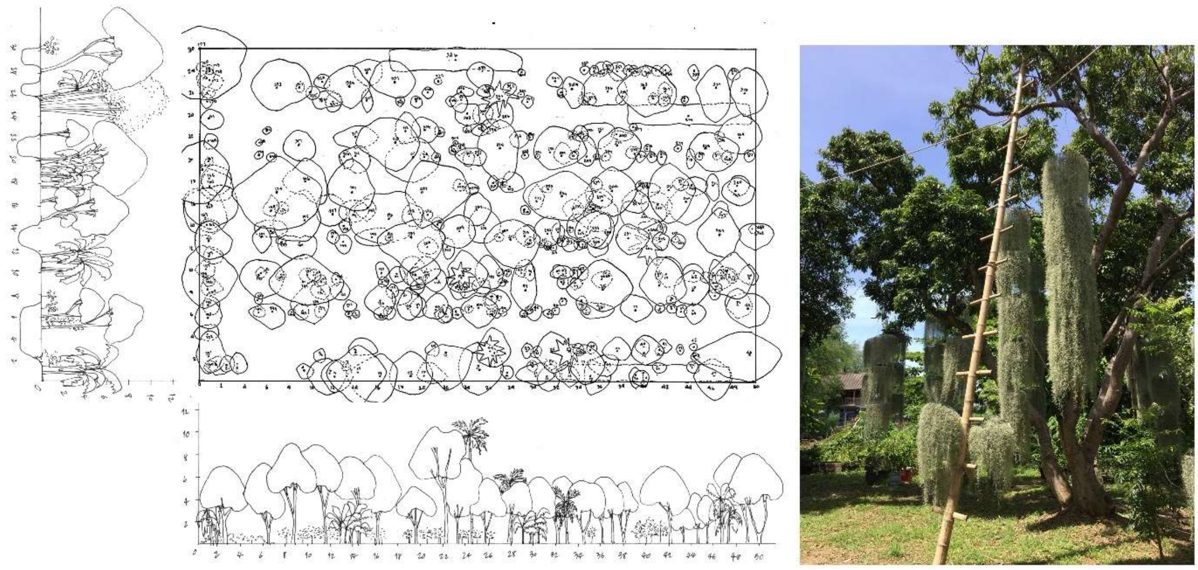


Figure 4. Plan, Sections, and Photo of Poomjai Garden

4 Discussion

Results from the spatial analysis reflected the rural-urban land transition in Bangkok's peri-urban areas. There have been competing expansions between the orchard and urbanized areas. Urbanized areas expanded significantly tripling from the original year in 1959 (+304.88%) while the orchard areas were far less expanded (+47.92%). This can be explained by the rapid economic growth and urbanization of Bangkok during the late twentieth century [4,5]. Especially since the 1980s, urbanization has encroached into high-quality agricultural lands around Bangkok [5, 10].

The original orchard lands were formed as continuous patches concentrated close to the urban areas. Orchards can be defined as market gardening in Von Thünen's Isolated State Model [11]. Perishable products such as fresh fruits, vegetables, and herbs are necessary to locate close to the city to reduce spent time on transportation. From the analysis, all landscape fragmentation indicators – PN, PD, Area_MN – revealed an increasing fragmentation in the orchard areas over time. The urban infrastructure of the road network constructed in the area initiated the roadside urban development [12]. Urban development along the roadside is a form of development in Bangkok that possibly affects to landscape fragmentation of the orchards. Road access with low land prices usually attracts real estate developers to purchase these lands to develop their housing estate projects [13]. The continuous orchard patches were divided by the encroachment of new urban development. Then, the former large orchard patches become fragmented into several small patches.

This roadside urban development can be considered disturbance patches in the orchard landscape matrix. Even though many orchards were deteriorated and left abandoned because of their effects, many orchards were still operational by adapting themselves to suit the harsh environmental changes. Air and water pollution from urban development highly affected the orchards [6]. Water source is a key factor that keeps the cultivation activities continued. The network of irrigation canals in the area has been filled and deteriorated from the urban sprawl [14]. However, the result revealed that farmers can regulate the water to avoid receiving outside polluted water via the existing ditches and dikes system.

These operational orchards were adapted to a certain degree to be multi-functional agricultural lands [15]. In the first case study, the farmer planted a more exotic variety of fruit trees and vegetables to serve the needs of nearby urban residents. Local flea markets become an important product distribution channel that is well-connected with local urban customers. For the second case study, the farmer adapted more to combine recreational and tourism activities into the existing orchard. Therefore, these orchards' adaptations reflected the survival skills and visions of farmers toward urbanization. Mutual benefits between orchard areas to urbanized areas are suggested for future studies.

5 Conclusion

The historical landscape of Bangkok's inner orchards has been affected by rapid urbanization. In the macro-scaled studies, urbanized areas has expanded more prominently compared with the orchard areas. The orchard landscape matrix has been fragmented over time. In the micro-scaled studies, many of these orchards have been found abandoned or deteriorated due to urban encroachment. However, many operational orchards still survive. To be able to survive in the urbanized Bangkok, adaptation measures for the orchards were required. Farmers have changed their cultivation methods to suit the harsh environmental changes and to avoid pollution from urbanization. Furthermore, some orchards have transformed their agricultural businesses to serve as potential green areas for recreation and tourism for city dwellers.

Acknowledgements

The authors gratefully acknowledge financial support in a research grant (Grant No. MRG6080249) from the Thailand Research Fund, Office of the Higher Education Commission, and Kasetsart University. We are grateful to all farmers and orchard owners who gave us information and allowed us to study their orchards.

References

[1] Takaya, Y., *Agricultural Development of a Tropical Delta: A Study of Chao Phraya Delta*, University of Hawaii Press, Honolulu, USA, 1987

[2] Sternstein, L., *Portrait of Bangkok*, Bangkok Metropolitan Administration, Bangkok, Thailand, 1982

[3] Molle, F., Sutthi, C., Kaewlulaya, J., Korpraditskul, R., *Water Management in Polder Raised Bed Systems: A Case Study in Chao Phraya Delta*, Doras Center, Kasetsart University, Bangkok, Thailand, 1998

[4] Bello, W., Cunningham, S., Li, K.P., *A Siamese Tragedy: Development and Disintegration in Modern Thailand*, Food First Books, Oakland, CA, USA, 1998, pp. 95-115

[5] McGee, T.G., Robinson, I.M., *The Mega-Urban Regions of Southeast Asia*, University of British Columbia Press, Vancouver, Canada, 1995, pp. ix–xv

[6] Mekvichai, B., Foster, D., Chomchan, S., Kritiporn, P., Urbanization and Environment: Managing the Conflict, *Research Report of the 1990 TDRI year-end Conference*, Chon Buri, Thailand, 1990

[7] Royal Thai Survey Department and Faculty of Architecture, Chulalongkorn University, *Maps of Bangkok 1931-2002*, Royal Thai Survey Department, Bangkok, Thailand, 2006

[8] Leitao, A. B., Miller, J., Ahern, J., McGarigal, K., *Measuring Landscape: A Planner's Handbook*, Island Press, Washington DC, USA, 2006

[9] Qiu, F., Laliberte, L., Swallow, B., Jeffrey, S., Impacts of Fragmentation and Neighbor Influences on Farmland Conversion: A Case Study of the Edmonton-Calgary Corridor, Canada. *Land Use Polic*y, 48*,* 2015, pp. 482-494

[10] Jones, G.W., The Thoroughgoing Urbanization of East and Southeast Asia, *Asia Pacific Viewpoint*, 38, 1997, 3, pp. 237-249

[11] Rodrique, J.-P., Comtois, C., Slack, B., *The Geography of Transport Systems*, Routledge, New York, USA, 2013

[12] Menakanit, A., Davivongs, V., Naka, P., Pichakum, N., Bangkok's Urban Sprawl: Land Fragmentation and Changes of Peri-urban Vegetable Production Areas in Thawi Watthana District, *Journal of Urban and Regional Analysis*, 14, 2022, 1, pp. 59-78

[13] Rondhi, M., Pratiwi, P. A., Handini, V. T., Sunartomo, A. F., Budiman, S. A., Agricultural Land Conversion, Land Economic Value, and Sustainable Agriculture: A Case Study in East Java, Indonesia, *Land*, 7, 2018, 4, p. 148

[14] Davivongs, V., Yokohari, M., Hara, Y., Neglected Canals: Deterioration of Indigenous Irrigation System by Urbanization in the West Peri-Urban Area of Bangkok Metropolitan Region. *Water*, 4, 2012, 1, pp. 12-27

[15] Lovell, S.T., Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States. *Sustainability*, 2, 2010, pp. 2499-2522.

USING NATURAL LIMESTONE FOR THE ACHIEVEMENT OF GREEN ARCHITECTURE

Architect Dr. Samy Aly Kamel
Emeritus Professor at the Department of architecture
Faculty of Engineering, (Mattaryah), Helwan University/Cairo, Egypt

Abstract

has become one of the priorities all over the globe to take serious actions towards adopting alternative building technologies , to replace the conventional use of the reinforced concrete way of construction which has a negative impact on the environment , starting by the high fossil fuel consumption to provide the processing heat to produce Cement and Steel, which are the main components of the concrete which got so widely spread over the last decade (Hundred years) nearly everywhere on the globe , so that most of the people in nearly all countries of the world , think that it is the sole and only way of construction.

The newly presented alternative ideas to reduce the air pollution vary between using some biological components or additives , or switching to Nano technologies , who by themselves cause different danger to the environment , as using biological components will certainly lead to an over use of those biological components , while they could surely be used either as nutrition elements or replace the agricultural land which becomes a vital importance to feed the humankind in the present and the future . The use of Timber in construction-works must be reduced drastically, as if not, then the lack of production of Oxygen will affect humankind in a very negative way and may lead to, disappear soon.

To produce Nano products will need to be manufactured and thus huge investments for the construction of the industrial buildings as well as the equipment. The production process will also need energy during the process, which will surely have some unhealthy emissions.

The production of the conventional building units (Bricks) will also consume a lot of fossil fuel, and investments, to turn the material into the final form of building units, to produce different sizes and forms, such as Clay or Cement bricks and blocks.

Compacted-earth bricks are not environmentally friendly ones, because of their Clay component, and their weak strength which leads to restricted practical use as walls in skeleton type of buildings and a maximum two floors in the form of load bearing walls.

This paper will focus on the use of natural limestone blocks, who has no Carbon footprint, as its processing needs no heating or burning of the raw material, but they could be directly used in the site, after being cut from the quarries in the form and size which are suitable for the construction of load bearing walls and vaulted ceilings, while only a very tiny amount of carbon emissions is emitted in the quarries due to the generators who depend on burning the fossil fuel, to generate electricity for the electric saws used to cut the limestone in the quarries, who are always far away from the human settlements.

The use of natural limestone, will not hurt or cause any damage to anybody, but at the contrary will have a lot of potentials such as:

• A drastic reduction of air pollution, as no burning of the raw material will be needed.

• A huge decrease in the construction cost, within a radius of 300 Kilometers from the quarries.

• A good saving of energy and water to produce the building material as well.

• A good heat- insulation rate during summer and winter for the interior of those buildings with load bearing walls, due to the physical properties of the building material, and for the thick walls, and the vaulted ceilings, which allow better ventilation in summer, and a bigger storage of heat in winter.

• A better harmony and matching in texture, and color of the exterior walls, with the environment, especially if the façade is left without plastering.

• The creation of an endless number of jobs in the field of construction, as this way of building is classified as intensive labor technique.

• Some spines or roots could be created free of charge, in geographic areas where limestone hills, present a handicap of horizontal extension, as the digging could be for free if the saws are used to cut the stone, in uniformly shaped cubes, which are then sold to clients, as building material.

• Not only housing projects could be designed in the form of load-bearing walls and vaulted ceilings but also service buildings such as (schools, shopping malls, health, and social care facilities, etc..) in the form of three or four floors, on top of ground floors to achieve better environmentally friendly buildings.

1 Introduction

Architecture in many countries suffers unfortunately from the domination of different pollutioncausing manufactured building material among which the most important are reinforced concrete, steel stutters and different types of glass. Woods are destroyed in order to provide timber and wooden structures.

A major reason behind this trend is the interest of design offices and entrepreneurs whose profits are calculated as percentages of the total cost of buildings.

Dealers and Agents for equipment and construction material are also very active in introducing new products and in pushing towards more consumption of their goods.

For the amelioration of environmental conditions, it is important to use the shortest way for the creation of national architecture, which should help in solving the housing problem in an economic way and improve society's sustainability.

The use of local stones would certainly decrease the amount of pollution caused by manufactured building materials and would also preserve woods all over the world.

2 AIM OF THE PAPER

This paper aims to emphasize the main concept of the world's famous architect Hassan Fathy with some development in order to enable people everywhere to realize the construction of multistory buildings as follows:

(A) The flexibility in using available local materials such as lime stone or other kinds of stone (sand stones, basalt, etc.) of which quarries are spread over a wide range of countries around the world.

(B) Encouraging the cooperative systems and organizations to construct buildings with self-motivated persons (almost without interference of entrepreneurs), which should lower the cost of building enormously

(C) Using the same building material for the construction of walls and curved ceilings. The bonding mixture consists of lime stone powder, some lime and cements which reduces the required quantities of the highly polluting traditional cement used for mortar and plastering

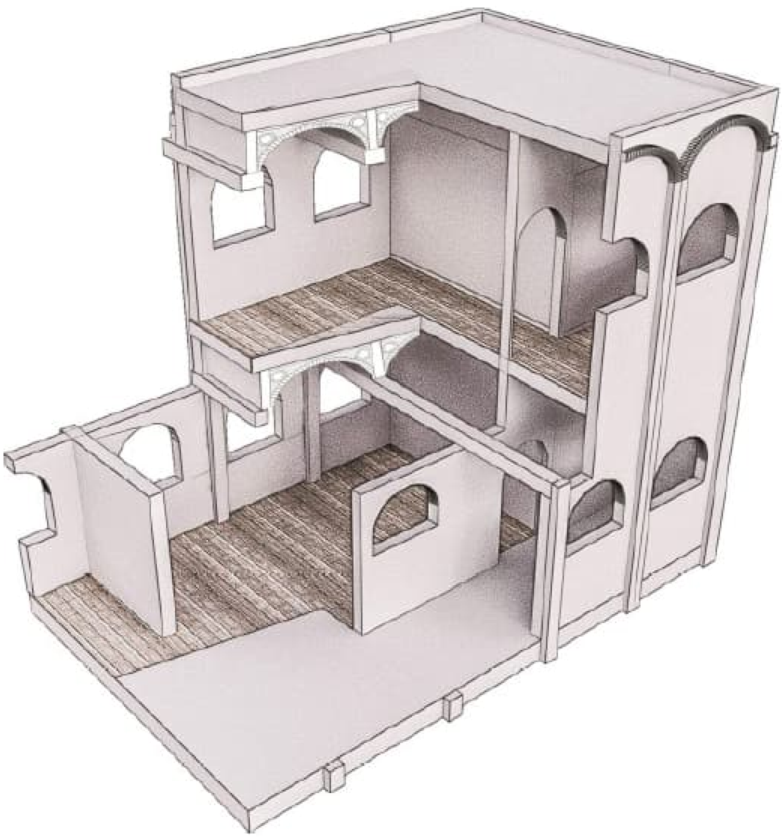


Figure 1. Perspective of the suggested method.

Perspective cross-section in a building designed and supervised by the author in a village in Minya Governorate for a six-class school building showing vaulted ceilings, backfilling and pottery pipes used to reduce heavy loads in the backfilling area that can be used to protect water supply pipes, electric wires or even Sewerage pipes to ensure its isolation from the building.

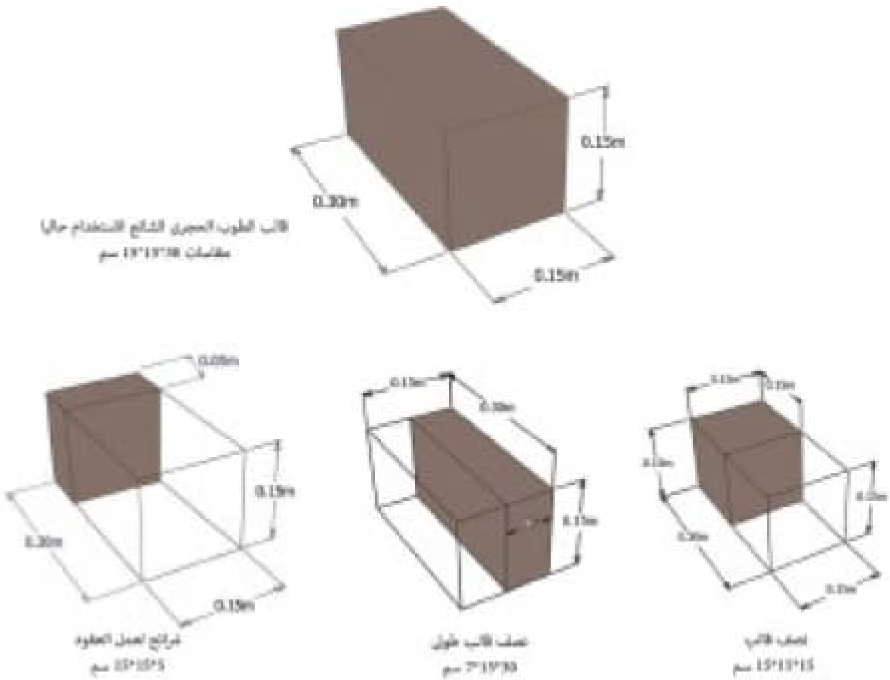


Figure 2. Dimensions of the used Blocks.

The proposed stone briquettes are cut using electric saws in the quarries. The manual cutting method is not used because it is expensive. The powder resulting from electric saws is used as a hundredth material in the mortar.

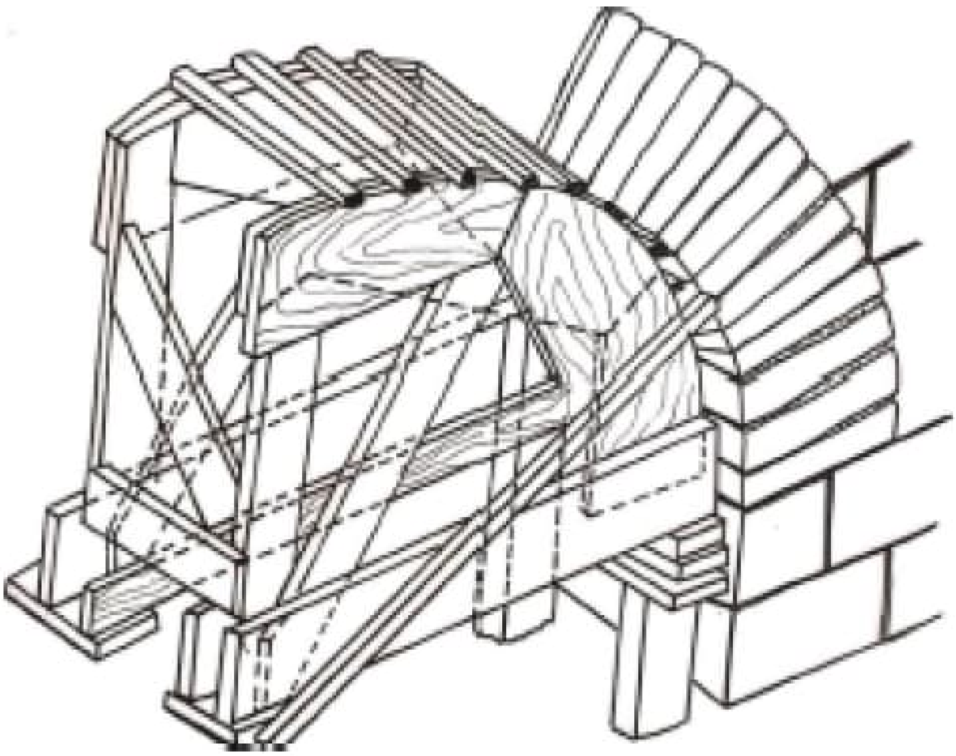


Figure 3. Used formwork for arched vaults.

Limestone slices with a thickness of 7 cm are used after cutting them electrically with saws, and they are stacked on a wooden chopper that is removed after completing the construction of the arch, in order to make the thresholds of doors and windows in a circular shape, and by repeating this arch, we get the vaulted ceiling.

Despite the tremendous development that took place in the field of construction in terms of creating new types and forms of building materials and methods of construction, yet every environment remains rich in many of its primary resources, which has been, for a long time, the main source of construction, which has proven through what has been built its efficiency, durability, and resistance to many climatic conditions, weather factors, and even misuse.

It is currently possible to develop some of these methods that were common before to obtain many advantages, as natural limestone that can be used, after cutting it into stone blocks in the quarries by means of electric saws, in building with a system of load-bearing walls and vaulted ceilings, where this proposed method is characterized by many advantages, for example:

- The widespread use of this proposed construction method leads to a reduction in the cost of construction due to the availability of building materials and the replacement of cement with what it causes of severe pollution to the environment during its manufacture as an adhesive material with an alternative mortar of turmeric, lime and sand (the least harmful to the environment).
- The proposed construction method reduces the cost of furniture, especially on the lower floors, where part of the furniture can be built into the walls.
- Providing high rates of thermal insulation, which in turn leads to the rationalization of energy consumption required for cooling in summer and heating in winter, in addition to good sound insulation, which in turn leads to raising building efficiency.
- Heights of up to three floors above the ground floor is achievable.
- The consistency with the environment increases in shape, color and texture, especially if the external facades are left unfinished.
- Preserving the environment from pollution, as the proposed construction method reduces reliance on reinforced concrete and the severe pollution caused by its components, whether of cement or reinforcing steel, In the form of fumes or waste harmful to the environment, several treatments are required only to reduce this pollution, as well as the energy intensive manufacture of these materials.
- This technology helps to create many job opportunities, as it can be classified as labor-intensive, which is suitable for countries where unemployment rates are high and needs projects that increase the chances of obtaining jobs and income for citizens, which in turn contribute to the revitalization of the national economy instead of resorting to equipment that requires huge investments and results in pollution of the environment due to engines that burn fossil fuels.
- The possibility of building a larger number of residential, administrative and commercial units with the same project budget, which contributes to solving housing problems and reducing the support that the state needs to provide economic housing opportunities, which in turn reduces the burden on the state budget.

- Ease of training in this method of construction, which enables officials to use it in emergency cases or when disasters occur, as those affected by these disasters can contribute to the construction after simple training.

There are also many examples and heritage models of buildings built with a system of load-bearing walls and have proven high efficiency in facing climatic and environmental factors in our world, such as the mud towers in Yemen and parts of the old city of Jeddah and the architecture between the two rivers.

Figure 4. Wooden formwork used in construction

Figure 5. Training of workers on the construction method

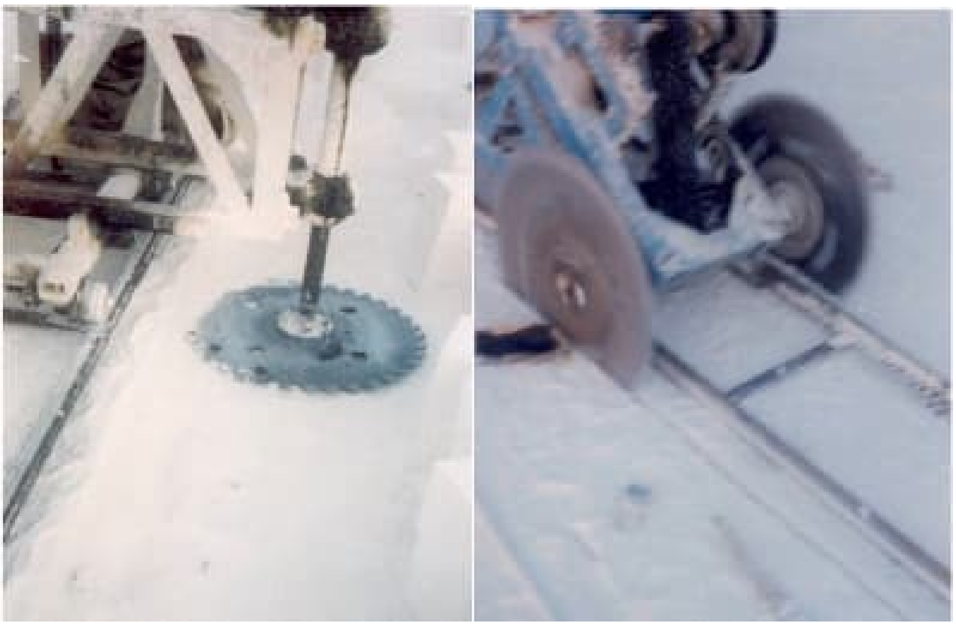


Figure 6. Electric saws used for cutting stones

(7-A)

(7-B)

Figure 7. Pictures showing how harmonious the building with natural stones is with the surrounding environment

And as an example-project of the proposed construction method, A low cost six-classrooms elementary school was designed and supervised by the author of this paper in Beni Khaled village, Minya Governorate in EGYPT as follows:

- The school was designed and implemented by the author in 1999 in a poor and remote area on the east bank of the Nile in Minya, Upper Egypt, about 250 km south of Cairo.
- A suitable site has been provided by the local authorities in cooperation with the National Development Program for Rural Areas (Al Shorouk) under the supervision of the Ministry of Local Development.
- The funds were donated by the Egyptian Swiss Fund office in Cairo.
- The main objective of the project was to test the economy in the proposed technique and the natural materials used compared to other traditional methods used in Egypt at that time.
- Meanwhile, the designer sought to transfer the building technology through the builders themselves to the residents of the area.
- The total cost amounted to approximately 180,000 Egyptian pounds, including the costs of the fence and the main gate, for a built-up area of approximately 350 square meters, or approximately 400 pounds per square meter.
- The shell was finished internally and the outside appearance was left as nature.

- Tiles were laid all over the school and even ceramics were worked to a height of one and a half meters in the sanitary area.
- The cost represents a reduction of at least 25 to 30% compared to traditional methods. There are other positive effects such as harmony with and preservation of the environment, good heat and noise insulation, and the creation of new jobs in the field of construction.

Figure 8. Pictures showing construction works (left) and first day of school after completion (Right)

Figure 9. Perspective of a Multi-Story building using the proposed construction.

STAKEHOLDER RESEARCH IN THE BUILT ENVIRONMENT: ASSESSING EMERGING METHODS FOR A POST-PANDEMIC WORLD

*Alexandra STAUB; Sana AHRAR

The Pennsylvania State University
121 Stuckeman Family Building, University Park, PA 16802, USA
acs11@psu.edu, sxa5735@psu.edu

Abstract

Architecture and urban design represent spatial conceptualizations at different, interlinked scales. Economic and social sustainability as part of the design concept requires user and community-based research to determine stakeholder habits and needs. One of the largest challenges in such research is collecting representative data, a challenge that was exacerbated by the lack of in-person research opportunities during the Covid-19 pandemic.

The pandemic has forced research method adaptions for both qualitative and quantitative community-based research. Our paper examines these adaptations as examples of emerging methods more generally. We first trace both analog and digital stakeholder-focused built-environment research over the past decade. Next, we focus on studies conducted during the COVID-19 pandemic to detail new methods and tools developed during this time. A special focus is on methods developed to access stakeholder groups often overlooked in built-environment research, such as low-income and other vulnerable populations.

We analyze emergent and newly developed methods to determine their applicability, benefits, and limitations for use in a post-pandemic world. In doing so, we contribute to developing methodologies and tools for built-environment stakeholder research where data has typically been harder to access.

Keywords

Emerging Research Methods, Community Engagement, Digital Research Methods, Stakeholder Theory

1 Introduction

The COVID-19 pandemic, with its subsequent lockdowns and lifestyle implications, made conducting community and urban research challenging. Qualitative field studies that required access to specific communities and population groups became difficult, especially with populations not used to operating online. The problem was recognized globally across discipline boundaries. The Nippon Foundation Ocean Nexus Center at the University of

Washington [1] compiled resources on conducting social science-based research during the pandemic, while academic organizations working on spatial research offered workshops on methods that lent themselves to conducting research during lockdowns and travel restrictions [2]. The *International Journal of Urban and Regional Research* published a collection of essays in which scholars pursuing research on urban communities outlined their pandemic challenges and methodological adaptions [3]. One issue highlighted by these studies is that many focused on digital data collection, yet increasing digitalization is distributed unevenly across the world, with poorer communities less likely to have access to digital devices or platforms. Researchers' increasing use of digital methods thus risks skewing data, as qualitative studies omit the input of large numbers of stakeholders.

2 Analog Research Methods

Community engagement has been defined as dialogue and discussion between the general public and the decision-making body [4]. In this process, stakeholders discuss their needs and concerns and negotiate common goals. This engagement may occur at one or multiple stages. The level of engagement of stakeholders varies based on the methods and phase of engagement in a project.

Globally, planning bodies and non-governmental organizations (NGOs) have used community engagement as a tool in urban regeneration, city design, tourism planning, and urban planning processes [5–8]. Lawson and Kearns [7] have called public engagement a means of promoting democracy and empowering communities.

Western countries, including many European countries and the United States, have used community engagement as an essential public policy component since the late 1990s [7]. Governments and NGOs have published a range of toolkits and guides on engaging communities for inclusive and sustainable development [cf. 9–12]. Methods have included interviews, shared comment boards, in-person and online "walk along" or "ride along" tours to identify community needs, vision and design workshops, and dialogue about draft master plans to gain community recommendations and ideas [8].

Oral history has also been used as a data-collection method. Here, researchers access individual and collective memories of historical events or phenomena to develop or assess spatial transformations, indigenous research projects, neighborhood planning, and social justice projects [13–18]. This fine-grained and accessible method has helped researchers gain information about how historical events have impacted minority communities [13–14, 18–20].

A more extensive example of oral history and interviewing is the go-along method, where the researcher accompanies a community member and informally interviews them during their everyday tasks [15, 21–23]. This method has proven useful in gathering data from groups such as children or the elderly, where data collection methods such as surveys or focus groups may be challenging [22, 24].

2.1 The shift from analog to digital methods

Over the past few years, several analog data-collection methods have been adapted to new digital technologies. Surveys are now often administered online, with participants clicking on an emailed link to access survey questions on commonly available platforms such as Qualtrics, Survey Monkey, and Google forms, which in some cases can perform basic data analysis. Video conferencing on a multitude of platforms such as WhatsApp, Skype, or Zoom has allowed researchers to conduct interviews, either with individuals or with groups of people who do not need to share a location. Software, either as part of or separate from the video- or audioconferencing tools, allows researchers to generate captions or transcriptions of spoken text. Such features have revolutionized the laborious transcription process, which only recently had to be conducted by specialists. Even go-along interviews have in some cases shifted online, using virtual-reality technology to present context-specific probes that allow researchers to formulate questions and lead discussions [25].

Camera and video recordings have provided additional sources of qualitative data. While surveillance cameras have become more common in many societies, their use as a data collection tool presents ethical questions about privacy. Researchers seeking data about spatio-temporal changes in public space usage have, nevertheless, used cameras as a data collection tool for decades [26, 27].

3 Digital technologies as data collection tools

With the growing sophistication of digital surveillance and analysis methods, data collection tools have in many cases shifted from analog to digital technologies. While it is beyond the scope of this paper to calculate how much the Covid-19 pandemic might have further accelerated a move to digital data collection tools, it is not unreasonable to suggest that the pandemic and its lockdowns did encourage researchers to examine digital options as a replacement for in-person data collection.

An increasing use of digital technologies brings with it questions of representation. The use of remote data collection tools to engage with a population of interest is contingent on that population's access, financial capacity, and knowledge of the technology. A lack of access to reliable internet and tools such as mobile phones or computer devices thus severely limits data collection [28]. On a global scale, citizens of countries with great power and income disparities, including much of the so-called developing world, frequently do not have universal access to the internet, making digitally based data collection difficult, especially when working with low-income populations. Figure 1 illustrates the problem: As of 2017, only a quarter of the population of India had access to the internet, while many African countries had virtually no access [29]. As researchers increasingly rely on digital data collection methods, the problem of collecting representative data from communities without universal internet access will have to be considered.

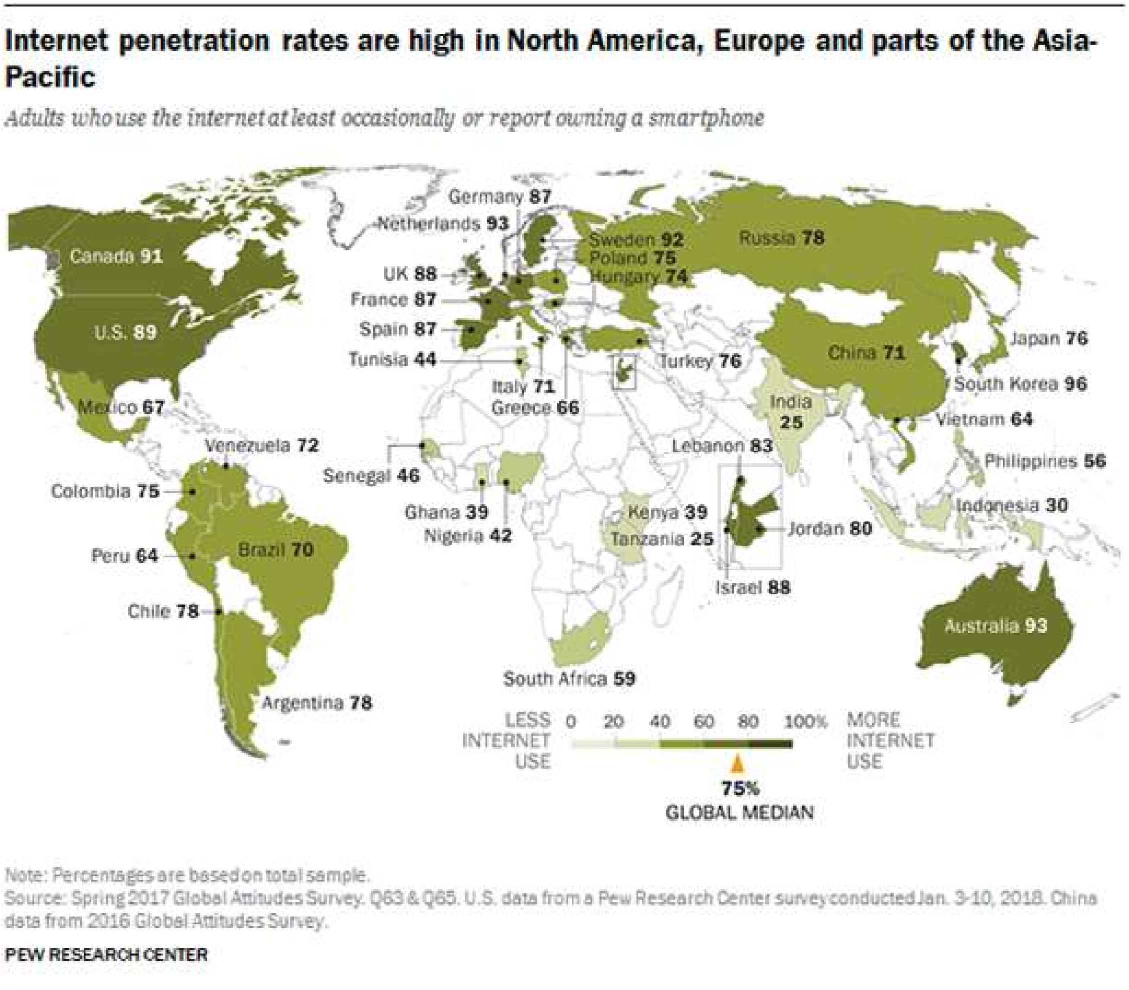


Figure 1. Internet penetration rates by country (2017).

3.1 Covid-19 research challenges

While access to technology can limit digital data collection methods, other factors play an important role in successful data gathering. One such component in ethnographic and other qualitative studies is trust building between the potential participants and the researcher [28]. For researchers working remotely with minority and other vulnerable populations, building trust and motivating potential participants to take part in a study can become more challenging.

The challenge of trust-building through a lack of in-person exposure, as well as the lack of digital access experienced by many vulnerable populations, can ultimately affect a study's inclusivity and predictive accuracy [28]. When some participant groups are harder to reach, there is a risk of selection bias in data collection, a bias that can affect study outcomes.

3.2 A survey of digitally-based research methods

Virtual interviewing methods have become more frequent since the onset of the Covid-19 pandemic. Countering the findings of some earlier studies, Keen et al. [30] note demonstrated advantages, such as better access to some marginalized communities, in part due to being able to conduct focus groups where participants can be united without having to travel to a shared physical space. This is advantageous for participants with restricted mobility, or where travel to a research location is difficult for any number of reasons, such as a lack of transportation. Keen et al. argue that far from being a simple coping strategy during a time of crisis, virtual qualitative research has become an emergent method in its own right, with advantages and disadvantages that are yet to be fully explored.

Part of this development is arguably due to technological advances in general. Whereas a generation ago, synchronous remote contacts were largely conducted via telephone, the ubiquity of personal computers and smart phones in many parts of the world have made video calls an everyday phenomenon for many. Researchers have found that video interviewing platforms such as Zoom can emulate natural conversation and thus help researchers establish rapport with their interview partners [31].

Roberts et al. argue that virtual methods open avenues towards, "research that aims to address structural inequalities in education, health, housing, and general well-being, while also presenting unique challenges," [32]. Working during the pandemic with homeless K-12 students in Houston who were affected by Hurricane Harvey (which hit Texas in 2017), the researchers initially planned to conduct in-person interviews with school personnel, community service providers, and affected families. This changed, as Covid-19 exacerbated the health and wellness problems of already vulnerable families, while drastically changing schooling experiences and making in-person interviews impossible to conduct. The researchers quickly realized that their participants' post-Harvey experiences had been fundamentally altered through the added impact of Covid-19, calling for a new research focus.

Roberts et al. thus turned to technology that would allow them to work remotely, researching several options. A literature review established that videoconferencing did allow researchers to establish rapport with their interview partners, and that technical problems such as dropped calls could even increase the bond between researcher and participant as they worked together to solve the problem. Roberts et al. found that the literature reported privacy and other ethical considerations to be similar in virtual and in-person research, and that virtual methods could even be superior, as participants could, for example, use virtual backgrounds to control the researcher's visual access to participants' homes [32].

In their own study, Roberts et al. found recruiting participants affected by homelessness especially challenging. Their original study plan had called for recruiting families through physically visiting area homeless shelters to get to know the staff, who would then serve as a conduit to homeless families. With the pandemic, the researchers had to approach shelter staff through virtual events, while using analog means such as flyers and posters put up in the shelters to recruit participants. Working with shelter staff allowed the researchers to bring in necessary technology for interviews, such as computers with internet access, cameras, and microphones. This technology, which became especially important for serving vulnerable populations during the pandemic, also allowed the researchers to conduct their interviews with participants served by the shelters. In this way, the researchers were able to address problems of the "digital divide", where low-income study participants do not have access to technology that would allow them to participate in studies remotely. The researchers did note that recruiting or even reaching potential participants who did not live in a homeless shelter with adequate technology would affect how representative the study would ultimately be. As the researchers put it, "[W]e still had to grapple with equity concerns over whose voices would be captured in our research," [32].

In a crowdsourced document provided on the internet and revised in July 2021, sociologist Deborah Lupton collected researchers' experiences with "Doing Fieldwork in a Pandemic" [33]. Lupton's list began with methods, such as videoconferencing, that were well established before the Covid-19 pandemic before turning to "digital native" research methods that did not have an analog version (such as research with online social media accounts). Several methods used approaches designed for participants who do not have reliable digital access or skills, thus increasing possibilities for more inclusive research participation across the digital divide.

Among the methods discussed, many involved the use of smartphones. For example, in a version of self-ethnography, study participants were asked to use their smartphone's camera and voice recording features to provide visual or auditory data in response to prompts issued by the researchers. A further version of this method involved participants keeping diaries or journals, with either written, drawn, or photo-based entries that could be sent to the researchers. If the diaries or journals were kept online, using the internet to transfer data to the researchers became straightforward, although larger document sizes (common for graphic data) did require a more robust internet connection.

In some cases, participants were described taking on roles the researchers had previously played. For example, in researcher-led re-enactment videos, researchers document people's activities by filming them as they go about their everyday lives (often combined with interviews). During the pandemic, researchers reported asking participants to do the filming, either with their phones or with a wearable video camera. Shifting camera control to the participants also allowed researchers to conduct "walk along" or "ride along" interviews remotely. Previously, researchers had accompanied participants on such excursions in person.

Several emerging "digital native" methods were discussed in the list compiled by Lupton [33]. Online discussion platforms, some of which have been developed by marketing research firms, allow researchers to upload their questions for participants to answer. Both researchers and additional participants can, with appropriate settings, see and respond to the answers typed by respondents in real time. This method, which combines survey methods with those typically used in one-on-one interviews or focus group interviews, takes advantage of the fluidity of online work to allow researchers to follow up on findings in real time.

In some cases, existing social media apps, such as Facebook Groups, have been used to provide a discussion or other activity platform for the researcher and participants. The online and decentralized nature of such groups allows people to take part in a study who might have difficulties engaging in analog group activities due to mobility impairment, time constraints (for example, due to being responsible for young children or infirm family members) or lack of access to transportation. Researchers reported that group activities and study content were often similar to studies using in-person meetings. Respondents reported the online group meetings as more convenient than in-person meetings.

A further form of digital data collection involved using computational analysis, for example through using locational traces in online media or through analyzing material readily available on the internet, such as YouTube and other online videos. This type of research, which extracts data from existing material (even human-based material), is different from working with study participants, since the YouTube archive material does not need to be "recruited" and ethical constraints – including in many cases the need for IRB approval – are minimized (although not erased). With an ever-increasing amount of video material available on the internet, opportunities to make use of such data sources will certainly increase.

Finally, one reported method of collecting visual data from participants with little or no internet access was to give participants single-use cameras and ask them to use techniques of self-representation (self-portraiture and auto-ethnography) to collect data for the researcher. Although this required the researcher to recruit and have at least indirect contact with the participant, no internet connection or digital equipment was required by the participant. A project example used was Anthony Luvera's 2020 photo exhibition about homelessness, an ongoing and collaborative project that is perhaps less scholarly than activist research [34].

4 Conclusion

Although digital research methods have been part of the qualitative research arsenal for several decades, the Covid-19 pandemic accelerated their development and use. Increased use of videoconferencing platforms for everyday communication during the pandemic meant that both researchers and their study participants became more familiar with and at ease with their use. Firms providing commonly used videoconferencing platforms developed new features, such as multi-user interfaces and automated transcription services. Such new cost-effective features have greatly helped researchers advance their work. Anecdotal evidence in the literature indicated that researchers had no more problems establishing rapport with participants than they had with in-person interview methods, and videoconferencing tools became a ubiquitous tool for carrying out qualitative research that had been done in person before the pandemic.

In some cases, researchers had participants take on roles they had once adopted. Participants became videographers where researchers had once held the camera, wrote journal entries, or made photos where researchers had once recorded activities. Arguably, this process gave participants more agency over the direction of the research. Even the control functions of many videoconferencing apps allow participants some say over what researchers can visually and acoustically access. More studies are needed to determine how this increased participant agency affects the information participants are willing to share and researchers can access and process.

With the Covid-19 pandemic, researchers increasingly turned to "digital native" research methods, looking to expand the ways in which research can be conducted. Mining existing apps, such as social media platforms or video-sharing platforms, became a further research tool. In some cases, researchers used such apps with participants they had recruited, while in other cases, researchers mined existing data from the apps themselves.

While digital tools became a technical response to pandemic-era research challenges, the Covid-19 pandemic exacerbated social inequities across much of the world and highlighted the need to better understand the lives of vulnerable populations. Some researchers focused on how to give voice to people who are underrepresented in qualitative research, such as the homeless and other marginalized communities who do not have ready access to smartphones or the internet. Although researchers used creative means to gain access to such communities – including working with intermediaries, such as staff at social services centers, working with online platforms to better reach those with a lack of time or mobility, or switching to technologies that do not require the internet, such as single-use cameras – it is clear that more work must be done to develop research methods that will reach the most vulnerable among us.

In assessing digital research methods, the advantages of being able to access study participants with mobility or time challenges must be weighed against the disadvantages of not being able to access populations lacking internet access. More work on these questions is needed. On a global level, the shift to digital research methods must still account for research demands in countries with poor internet saturation, such as India or much of the African continent.

The Covid-19 pandemic has accelerated both the race to develop remote research capacities and an awareness of the social limitations of such methods. Further work on emerging methods will help us better manage these social challenges. The emergent methods developed through the constraints of the pandemic are a good foundation for this work.

Acknowledgements

This project was made possible in part by a Faculty Research Grant from the Penn State Stuckeman School for Architecture and Landscape Architecture, and the Hamer Center for Community Design. Copyright remains with the authors.

References

[1] S. G. Garcia and K. Barclay, “Adapting research methodologies in the COVID-19 pandemic: Resources for researchers,” UTS CRICOS 00099F, Nippon Foundation Ocean Nexus Center, University of Washington, Washington, United States, 2020. Available: https://earthlab.uw.edu/wp-content/uploads/2020/07/uts-adapting-research-methodologies-covid-19-pandemic-resources-researchers.pdf

[2] A. Parikh and K. P. Henrique, “Critical Visual Methods for Fieldwork at a Distance,” Jun. 14, 2021. Accessed: Feb. 14, 2023. [Online]. Available: https://aag-gradresearch-series.secure-platform.com/a/solicitations/11/sessiongallery/216

[3] Liza Weinstein, “Introduction: On Urban Field Research During a Pandemic,” *International Journal of Urban and Regional Research*, (2021), Accessed: Feb. 14, 2023. [Online]. Available: https://www.ijurr.org/spotlight-on/becoming-an-urban-researcher-during-a-pandemic/on-becoming-an-urban-researcher-during-a-pandemic/

[4] J. Cavaye, “Governance and Community Engagement: The Australian Experience,” in *Participatory Governance: Planning, Conflict Mediation and Public Decision Making in Civil Society*, W. R. Lovan, M. Murray, and R. Shaffer, Eds, Ashgate Publishing, London, England, 2004, pp. 85–102.

[5] T. Bahaire and M. Elliott-White, “Community Participation in Tourism Planning and Development in the Historic City of York, England,” *Current Issues in Tourism*, vol. 2, (1999), no. 2–3, pp. 243–276, doi: 10.1080/13683509908667854.

[6] T. L. J. Howard and N. Gaborit, “Using Virtual Environment Technology to Improve Public Participation in Urban Planning Process,” *Journal of Urban Planning and Development*, vol. 133, (2007), no. 4, pp. 233–241, doi: 10.1061/(ASCE)0733-9488(2007)133:4(233).

[7] L. Lawson and A. Kearns, “Community engagement in regeneration: are we getting the point?,” *Journal of Housing and the Built Environment*, vol. 25, (2010), no. 1, pp. 19–36, doi: 10.1007/s10901-009-9168-7.
[8] R. Canesi, C. D’Alpaos, and G. Marella, “A Case of Local Community Engagement for Urban Regeneration: The South Boston Area,” in *Urban Regeneration Through Valuation Systems for Innovation*, F. Abastante, M. Bottero, C. D’Alpaos, L. Ingaramo, A. Oppio, P. Rosato, and F. Salvo, Eds., Springer International Publishing, Cham, Switzerland, 2022, pp. 217–228. doi: 10.1007/978-3-031-12814-1_13.
[9] Futurewise, Interim CDA, OneAmerica, and El Centro de la Raza, “Community Engagement Toolkit: Guidance and Resources for Engaging Community in Planning and Policy Development,” Public Health-Seattle & King County, Futurewise, Interim CDA, OneAmerica and El Centro de la Raza, 2014.
[10] John Sankofa, Hannah Daly, and Elsa Falkenburger, “Community Voice and Power Sharing Guidebook,” Urban Institute, Washington, DC, United States, 2021. Available: https://www.urban.org/research/publication/community-voice-and-power-sharing-guidebook
[11] Queensland Government, “Community engagaement toolkit for planning,” The State of Queensland, Department of Infrastructure, Local Government and Planning, Brisbane, Australia, 2017. Available: https://dilgpprd.blob.core.windows.net/general/Communityengagementtoolkit.pdf
[12] Trans-Urban-EU-China, “A Toolkit for community building for socially integrative cities,” Politecnico di Torino, Tsinghua University, Norges Teknisk-Naturvitenskapelige Universitet, China Academy of Urban Planning and Design, Chinese Academy of Science and Technology for Development, Università di Macerata, 2020. Available: http://transurbaneuchina.eu/fileadmin/user_upload/tuec/files/results/MATERIAL_FOR_AAAS2020_20190722-Booklet_H2020-English_2_.pdf
[13] J. M. Thomas, “Neighborhood Planning: Uses of Oral History,” *Journal of Planning History,* vol. 2, (2004), no. 1, pp. 50–70, doi: 10.1177/1538513203262047.
[14] M. M. Maharawal and E. McElroy, “The Anti-Eviction Mapping Project: Counter Mapping and Oral History toward Bay Area Housing Justice,” *Annals of the American Association of Geographers*, vol. 108, (2018), no. 2, pp. 380–389, doi: 10.1080/24694452.2017.1365583.
[15] S. Ahrar, “Re-Imaging the Public Realm post MRTS operation,” M. Arch Urban Regeneration Thesis, Jamia Millia Islamia University, New Delhi, India, 2018.
[16] N. Stead, J. Gosseye, and D. van der Plaat, *Speaking of Buildings: Oral History in Architectural Research*, Princeton Architectural Press, New York, United States, 2019.
[17] T. Selvi Ünlü, “Urban memory and planning: investigating the use of oral history,” *Eur. Plan. Stud.*, vol. 27, (2019), no. 4, pp. 802–817, doi: 10.1080/09654313.2019.1567696.
[18] A. Ramiller, “Displacement through development? Property turnover and eviction risk in Seattle,” *Urban studies*, vol. 59, (2022), no. 6, pp. 1148–1166, doi: 10.1177/00420980211004214.
[19] P. Virdee, “Remembering partition: women, oral histories and the Partition of 1947,” *Oral Hist.*, vol. 41, (2013), no. 2, pp. 49–62, Available: https://www.jstor.org/stable/23610424
[20] S. Ahmad, “Muslim pasts and presents: Displacement and city-making in a Delhi neighbourhood,” *Modern Asian Studies*, vol. 56, (2022), no. 6, pp. 1872–1900, doi: 10.1017/S0026749X21000512.

[21] M. Kusenbach, “Street Phenomenology: The Go-Along as Ethnographic Research Tool,” *Ethnography*, vol. 4, (2003), no. 3, pp. 455–485, doi: 10.1177/146613810343007.
[22] G. Sun and C. Y. Lau, “Go-along with older people to public transport in high-density cities: Understanding the concerns and walking barriers through their lens,” *Journal of Transport & Health*, vol. 21, (2021), p. 101072, doi: 10.1016/j.jth.2021.101072.
[23] J. Veitch, N. Biggs, B. Deforche, and A. Timperio, “What do adults want in parks? A qualitative study using walk-along interviews,” *BMC Public Health*, vol. 22, (2022), p. 753, doi: 10.1186/s12889-022-13064-5.
[24] M. Oliver *et al.*, “Kids in the city study: research design and methodology,” *BMC Public Health*, vol. 11, (2011), no. 1, p. 587, doi: 10.1186/1471-2458-11-587.
[25] P. Kostakos, P. Alavesa, J. Oppenlaender, and S. Hosio, “VR ethnography: a pilot study on the use of virtual reality ‘go-along’ interviews in Google Street view,” in *MUM 2019: 18th International Conferenceon Mobile and Ubiquitous Multimedia*, Pisa, Italy, 2019. doi: 10.1145/3365610.3368422.
[26] W. H. Whyte, *The social life of small urban spaces*, Conservation Foundation, Washington D.C, United States, 1980.
[27] S. Pink, *Doing Visual Ethnography*. SAGE Publications Ltd, London, England, 2007. doi: 10.4135/9780857025029.
[28] K. Kroese, K. Porter, H. Surridge, and D. Tembo, “Challenges and solutions: surveying researchers on what type of community engagement and involvement activities are feasible in low and middle income countries during the COVID-19 pandemic,” *BMJ Open*, vol. 11, (2021), 10, doi: 10.1136/bmjopen-2021-052135.
[29] J. Poushter, “Social Media Use Continues to Rise in Developing Countries but Plateaus Across Developed Ones,” *Pew Research Center’s Global Attitudes Project*, 2018. https://www.pewresearch.org/global/2018/06/19/social-media-use-continues-to-rise-in-developing-countries-but-plateaus-across-developed-ones/ (accessed Feb. 14, 2023).
[30] S. Keen, M. Lomeli-Rodriguez, and H. Joffe, “From Challenge to Opportunity: Virtual Qualitative Research During COVID-19 and Beyond,” *International Journal of Qualitative Methods*, vol. 21, (2022), pp. 1-11, doi: 10.1177/16094069221105075.
[31] M. M. Archibald, R. C. Ambagtsheer, M. G. Casey, and M. Lawless, “Using Zoom Videoconferencing for Qualitative Data Collection: Perceptions and Experiences of Researchers and Participants,” *International Journal of Qualitative Methods*, vol. 18, (2019), pp. 1-8, doi: 10.1177/1609406919874596.
[32] J. K. Roberts, A. E. Pavlakis, and M. P. Richards, “It’s More Complicated Than It Seems: Virtual Qualitative Research in the COVID-19 Era,” *International Journal of Qualitative Methods*, vol. 20, (2021), pp. 1-13, doi: 10.1177/16094069211002959.
[33] D. Lupton, “Doing Fieldwork in a Pandemic.” (Revised version), 2021. Accessed: Feb. 14, 2023. [Online]. Available: https://docs.google.com/document/d/1clGjGABB2h2qbduTgfqribHmog9B6P0NvMgVuiHZCl8/edit?usp=embed_facebook
[34] M. Warner, “How participatory photography can help shift conversations surrounding homelessness,” *British Journal of Photography*, (2020), Accessed: Feb. 14, 2023. [Online]. Available: https://www.1854.photography/2020/03/how-participatory-photography-can-help-shift-conversations-surrounding-homelessness/

EXTENDED REALITY WORKFLOWS FOR DESIGN TO CONSTRUCTION

Dave Lee

Clemson University
Lee Hall 3-102, Clemson, SC 29634, USA; dlee2@clemson.edu

Abstract

This paper presents research toward the application of Extended Reality technology in the design and construction of physical architectural environments. This research investigates the use of interactive holographic instructions linked to parametric design models that can be viewed and edited by users wearing Head-Mounted Displays (HMD) in real time. The goal of this research is to demonstrate the capability of mixed reality to effectively and meaningfully assist in the production of physical construction at architectural scale.

Several methods of assisting with component fabrication and component registration and tracking are introduced including the use of QR codes and strategies for part recognition in complex assemblies. Additionally, a simplified method of verifying the geometric accuracy of a constructed design with point cloud data is presented.

Applications of these workflows include the ability instantiate, verify, and refine a design in a mixed reality setting. Another application is with fabrication of designed components, in the ability to transfer instructions through holographic projection as procedure, therefore simplifying non-robotic production processes. A third application is with component assembly using a mixed reality environment to register components location in physical space and include head-mounted display instructions. All three applications eliminate otherwise necessary external measuring devices and printed drawings in these phases of a design to construction workflow. Portions of this research were supported by Autodesk[1].

Keywords

Computation, Augmented Reality, Fabrication, Methods

1 Introduction

Now integral to the palette of contemporary data visualization tools, Extended Reality (XR) shows great promise in architectural design and production. The term Extended Reality is typically used as a simple way to refer to the various ways in which we are able to link the digital world with our physical world. Until recently XR has been almost exclusively linked to immersive systems that, in various ways, intend to fully engage a user with a completely digitally crafted environment. Typically referred to as Virtual Reality (VR), this method necessitates a physical disconnect from ones local environment to function properly. As such, they are almost exclusively used for visualization and simulation of user experiences.

By contrast, there are two other forms of XR that intend to maintain a physical connection to a user's physical environment while overlaying digital information. The use of these systems is the focus of this research for the specific reason that integrating physical environments enables potentials for study beyond visualization.

1.1 Mixed Reality, Augmented Reality

Mixed Reality (MR) and Augmented Reality (AR) are used in this research. MR and AR are both methods of virtually projecting digital information, typically geometry, into a physical environment.

The most common use of Mixed Reality - and the method used in this study – is to merge an image of a digital model with a digital camera. This is most commonly done with a smart phone or tablet and there are numerous examples from placing furniture in a room to transforming your phone into a measuring device. MR is very useful for simple visualization where it is useful to integrate a physical environment, however the scaling and placement of digital information as an overlay on a camera image is not as accurate as AR.

AR conceptually works in the same manner, however it used a wearable device (a Head-Mounted Display or HMD) and importantly, uses a holographic projection of the geometric information intended to be virtually integrated into the users environment. The HMD also uses a active-persistent tracking of the users physical environment by creating a 3D scan of the space while in operation. The 3D scanning combined with the holographic project are what make AR far more precise than MR, but an important additional feature for this research is the ability to operate in a hands-free manner.

1.2 How we use XR

These systems are used in three ways in this research. The first is to relay geometry from a computer model to a user interface where it can be integrated with their physical environment. In this way we are able to accurately project geometry that can be combined with the traditional act of making with physical elements. The second way we use XR is related, but specifically regarding the translation of complex operations toward the fabrication of custom architectural components. The third way we use XR is by creating digital geometry through the use of the XR device, either as a design operation or to verify or relay physical data to a virtual environment.

This research began with a goal of using XR as a closed loop of design to fabrication to assembly. XR can be used to remove the 'desktop computer' from the act of digitally making in a design process in a hands-free environment. In previous research I explored this from a pedagogical perspective as well as the psychological changes resulting in an act of making more familiar to physical modelling than traditional computer modelling. In the end, while there are clear connection between design, production and assembly they can (and often do) exist in discrete operations that are not always necessary to link. Therefore, it became more useful to observe them as such. In the following sections the three areas will be presented individually.

2 XR as a Design Tool

As previously mentioned, this research began with an interest in linking design, fabrication, and assembly. As such, the investigation of XR in the design process was initially toward the integration with a broader computational workflow. In the following sections individual aspects will be outlined.

2.1 Measuring spaces

It is normal for architectural constructions to be site specific. One of the most fundamental and necessary sets of information have when beginning an architectural project is regarding the physical properties of a site. This information is normally gathered from an external source and imported into a digital workflow. This can vary with project scale and complexity and may consist of a thorough professional land survey, to a 3D scan of existing conditions, to physically measuring a space with a tape measure. We conducted two experiments with AR to measure spaces. Our experiments were kept at room-scale, but are applicable to a broader range of scales.

In our first experiment we captured geospatial data from an AR headset and directly linked it to a live parametric model to visualize a design in different settings. We accomplished this using the existing hand tracking capabilities of the device, paired with the 3D scan of its own environment. The device tracks the position of the users hands and can project a ray onto the ground plane it approximates from its internal 3D scan. We created a program that would track hand gestures (not unlike clicking a button on a computer) and record the position of the projected ray at each instance as a point that was relayed to our modelling software. The result was a simple set of points in three dimensional space that could easily be used to create a floor plan of the intended build area.

The second experiment used the active 3D scan of the AR headset to create a point cloud map of the physical environment. This generated a point cloud similar to what would be created with a standalone 3D scanner, but with lower resolution. We found the resolution not to be a problem when mapping room-scale spaces. When additional 3D information is required this method may be useful, however for our purposes we found the same shortcomings of 3D scanning to be true. That is, with 3D scanning a highly detailed set of information is created with very little organization. For our purposes it is important to have a simple and straightforward method of mapping a set of data into an existing parametric model. With a point cloud additional steps need to be taken to simplify and clean datasets.

2.2 Verifying Parametric Models

Perhaps the most obvious example of integrating AR workflows into a design process is in the verification of design data in a physical environment. The advantage here, when compared to on-screen or immersive settings is that the accuracy of the model and the physical environment are consistently maintained. Clash Detection is a common use of AR headsets already on construction sites for the ability to see a 3D visualization of a design overlaid on an active construction. This is also important in verifying ongoing designs to check for scale and detail considerations, but also to determine if a computational model is compatible with the physical dimensions of a space. This is particularly useful when considering parametric model simulations.

2.3 Live Simulation Models

Being able to visualize animate data in a physical environment is a useful advantage of integrating a parametric model with an AR headset. We conducted an experiment using a physic simulation of a form-active tensile structure and linked the boundary where it was meant to be attached to its physical environment to spatial information inherited from the AR headset. In short, we were able to actively control the parameters of the tensile structure in the digital model remotely from the headset. The physics simulation would automatically recalibrate with each position change of the boundary inputs. This experiment was also assembled as a sculptural installation using methods that are outlined in section 4 of this paper.

Figure 01. Measuring elastic material lengths with Augmented Reality at left and assembly sequence shown at right.

3 XR for fabrication

An essential part of this research was to investigate the use of AR to assist in the fabrication of architectural components. Moreover, minimizing and/or eliminating the use of CNC tools and even power tools was a priority. The intention of this was to push the limits of AR-assisted fabrication without reliance on other modern technology. While there are also potential benefits of integrating AR with CNC tools[2], it is not the focus of this research. Therefore, the experiments described below are with specific purpose to be integrated with simple tools. This is in line with research that is already being done with the integration of AR with traditional skilled manual labor[3].

3.1 Custom Component Fabrication with Simple Tools

At its most basic level, working with AR and a simple tool is about understanding how to parameterize the function of the manual tool. By understanding how the tool operates and how to translate that operation into a digital function it is possible to integrate its operation into the AR environment. The two examples illustrated in figure 02 and figure 03 show simple machines. One is meant to bend pipe and the other is meant to bend sheet metal. They both have unique aspects, however they fundamentally work in the same way. Each has a pivot point with two main parts. One part is fixed and the other rotates about the pivot. Therefore, we only need to program a few simple aspects of this operation into our model to enable it to work with the physical tool:

- x,y,z coordinates of the physical tool (where material is placed)

- rotation center point
- rotation angle of material (parameter set unique to each part)

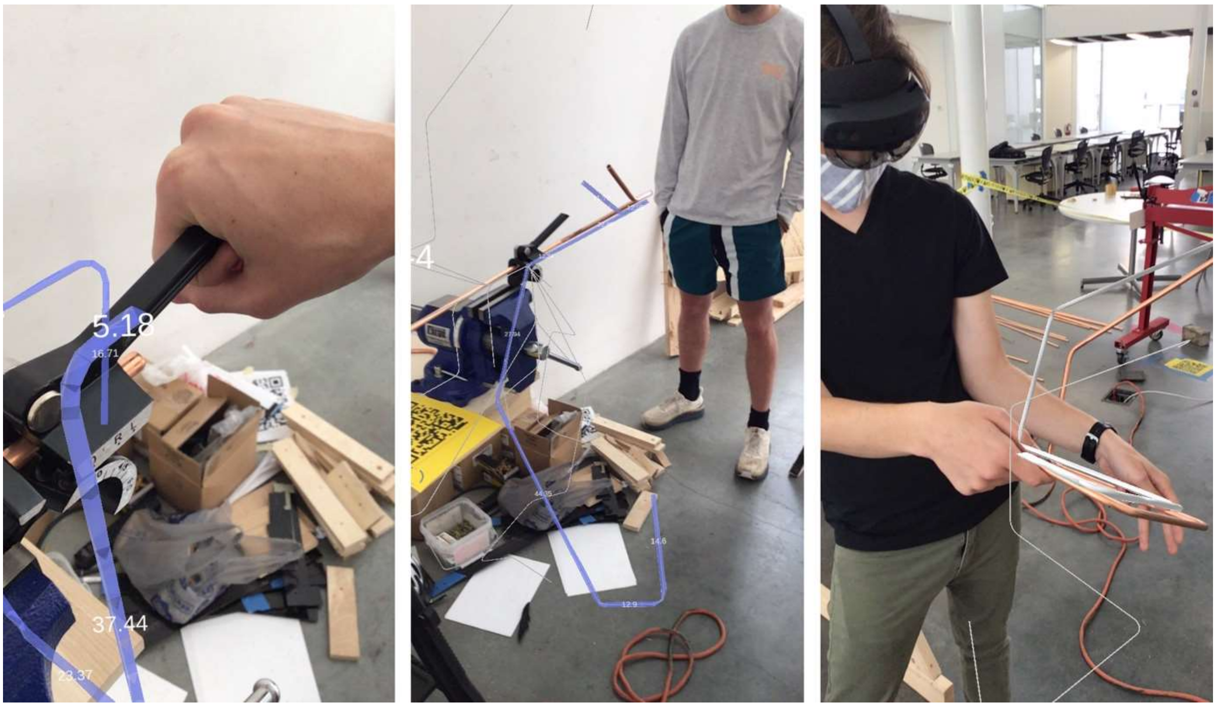


Figure 02. Pipe bending tool used to create parametric bends

Figure 03. Steet metal fabrication with Augmented Reality

The complexity of the parametric model dictates everything else. In the models used in these experiments each part was unique and each part had multiple bends. This made the programming of consecutive bends important, but also is useful to help one understand how difficult it would be to produce these parts without the assistance of AR. If these parts were manually produced without AR it would be necessary to measure them by hand to cut to size. It would also be necessary to mark each individual bend in some way and all are unique so measuring would be very cumbersome. For example, the larger project that we built was made with over 4,000 individual unique bends. Each was done manually, but using AR to holographically project the bend lines and bend angles onto the surface of the material.

It is also always important to understand that one is working with physical materials and to do so will mean that one must understand how to incorporate those behaviors into the AR process. In the case of the two metal bending procedures different strategies had to be used for each. The sheet metal used for one project was high tensile stainless steel strapping. It has a very low ductility and tends to spring back after being bent. This meant it was necessary to create a visualization of the final bend angle and a second, synchronous visualization of the actual position the material needed to bend to before it sprung back. In the case of the pipe project the tool used will actually elongate – or stretch – the pipe during the process of bending. In this case it was necessary to account for the added material length in the computer program to realize each bend at the correct location.

4 XR for Assemblies

This section explains various methods used to integrate AR into the assembly of architectural components. A common goal in all of these experiments was to eliminate the need for any measured drawings or other printed diagrams of how to assemble anything.

4.1 Step-By-Step

The first method investigated was the use of procedural instructions. This is, of course a typical method used in assembling anything with an already fixed set of parts and specific desired configuration. The first impact of moving this to an AR environment was simply to allow ones hands to be free while assembling parts. A second was to be able to see the final construction at full scale. Finally, the ability to use animation sequences and other interactive elements in the AR environment allows for more dynamic features.

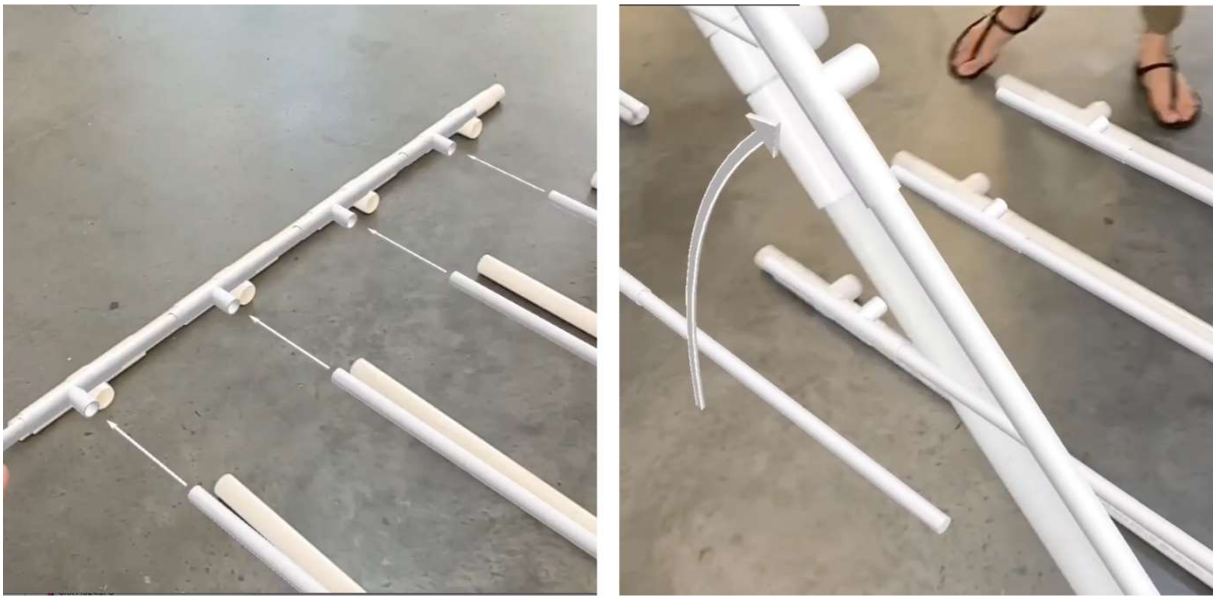


Figure 04. Procedural Instructions for modular assembly communicated through AR

4.2 QR identification for assembly

QR codes are matrix barcodes that carry information which can be detected by the camera of a device such as a phone, tablet, or in this case the AR headset being used. Because the QR can exist in physical space (in this case in the form of a sticker applied to each component) it is possible to embed information in the QR that will be useful to create a line of communication with the digital model being accessed by the AR headset. In the example shown a QR code is applied to each unique part (more than 600) in an assembly. With the embedded information scanned by simply looking at the QR while wearing the AR headset, information regarding the statistics of the part in question as well as the location of the part in the physical model space and its neighbouring parts are all shown to the user. This makes organizing parts very simple. We also used this to register the location of parts during the assembly process.

Figure 05. QR codes applied to unique parts for identification and easy of assembly.

4.3 Verification of Geometric Accuracy

It is sometimes important to verify that an assembly is geometrically accurate to the intended design. Even with carefully controlled CNC operations of exact tolerance, the global structural form is not always accounted for when material properties and structural considerations are taken into account. In an installation that was designed using plywood strips for edges and steel metal straps to resolve joints in the assembly, the total weight of the structure was not taken into consideration in a structural analysis. In the end the final form was not as rigid as desired and it became necessary to compare the built form to the computer model to determine what portions were responsible for the inconsistencies.

Figure 06. Instantiating geometry with AR for testing accuracy of final production.

It is possible to 3D scan the form and compare a point cloud to the original design model, however the geometry if the scan is far too complex for the intentions of this analysis. In our case we knew the problem was with the flexibility of the metal joints and these moments in the model were designed at each vertex of the original geometry. By isolating only those points we could easily reconstruct an as-built digital model of the assembled structure. Using the AR headset, we physically walked around the model and created a point at each vertex/joint in the assembly. This was done by a simple program made to create a point with a hand gesture and the ability to move or edit that point with hand gestures to find its exact location. By doing this we were able to identify the areas most responsible for deflection in the physical construction and modify them to significantly reduce deflection.

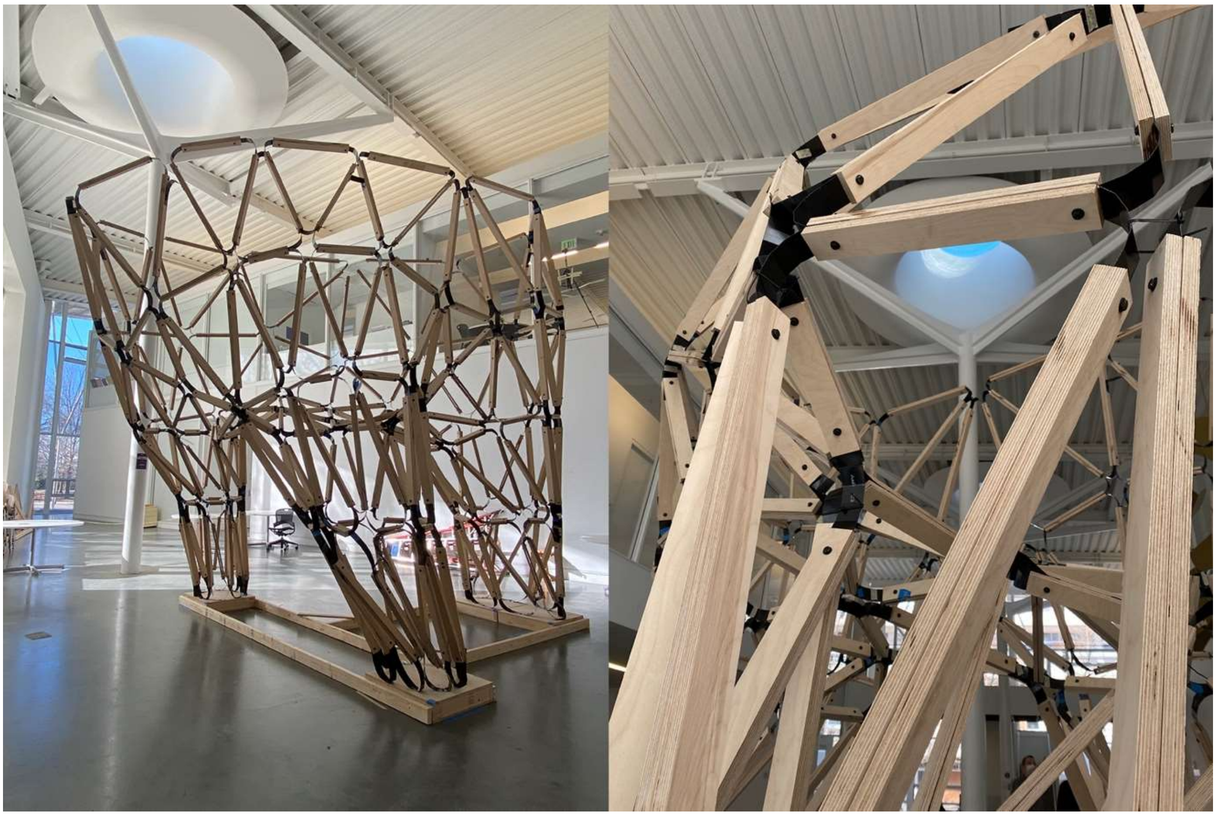


Figure 07. Large scale installation designed, fabricated, and assembled using Augmented Reality

5 Conclusions

When considering the use of AR in a design to construction workflow there are many overlapping processes, and indeed it is important to see them as necessarily related. Nevertheless it is useful to examine at them independent of one another and this paper presents them as such. The aim of this research was to validate the usefulness of AR technology in the design, fabrication, and assembly processes.

In design there is perhaps the most overlap with a conventional workflow. What became apparent as having the greatest benefit was the ability to design digital artifacts in an environment where one is not sitting in front of a computer. Novelty aside, there may be real benefits in the ability to visualize a design at full scale during the act of designing it.

In fabrication there are clearly benefits to integrating AR for component production. In the tests done in this research more extreme examples were used to test the limits of precision and ability to manually produce what is normally thought to only be possible with CNC or industrial tools. Clear benefits emerge with any simple process that requires a large amount of repetition and variation or where consistent measured feedback is required.

With assembly it is easy to see benefits and streamlining of complex procedures to make for more tangible representation of an assembly process. An unintended benefit also emerged in a post-construction analysis. Using an AR headset to create geometry and other feedback for a design that originates in a physical environment and is relayed to a digital one establishes an important and useful feedback loop between digital and physical computational processes. In the case of verifying the position of the large installation it was an essential tool to be able to make in-field alterations.

---

[1] Autodesk generously supported portions of this project in consultation with their Toronto Technology Centre.

[2] Gannon, Madeline. Human-Centered Interfaces for Autonomous Fabrication Machines, Carnegie Mellon University, Pittsburgh, USA, 2018

[3] Franco, Jose Thomas. This is how a Complex Brick Wall is Built Using Augmented Reality, Fologram, https://www.archdaily.com/908618/this-is-how-a-complex-brick-wall-is-built-using-augmented-reality

SUSTAINABLE DESIGN ACCELERATOR: ADVANCING ARCHITECTURE STUDENTS' KNOWLEDGE IN SUSTAINABILITY AND ENTREPRENEURSHIP

Omar Al-Hassawi*, David Drake
Carpenter Hall 118, Washington State University, Pullman, WA 99164, United States;
omar.al-hassawi@wsu.edu, mrdrake@wsu.edu

Abstract

This paper reports outcomes from the second year of the Sustainable Design Accelerator (SDA), a three-year externally funded project within our accredited Master of Architecture program. The SDA addresses three gaps in the curriculum. The first is the limited number of courses covering sustainable design issues and strategies with only one required introductory course offered at the sophomore-level. The second is the high interest in learning entrepreneurial mindset tools, and the third is the lack of opportunities for learning hands-on experimental evaluation methods necessary for the development of commercially viable solutions that mitigate the built environment's impact on climate change. The SDA fills these gaps by stacking two courses, a lab, and a studio, into a semester-long sequence.

The lab course challenges students to develop innovative and marketable building heating and cooling system prototypes. Students in the concurrent studio course are challenged to develop designs for a multi-family housing community that addresses broader sustainability issues while incorporating the systems developed in the lab course. Areas of knowledge covered in the SDA include whole system mapping, life cycle assessment, performance analysis software, entrepreneurial mindset and use of a Lean Canvas Model, and physical prototype construction and evaluation. A proprietary environmental test chamber is used to replicate climate conditions in hot regions and test cooling system prototypes.

Student responses to the exit survey indicated a significant improvement in their level of knowledge before and after the SDA in alignment with results from year one of the Accelerator. Modifications to version 3.0 being delivered this semester include having students in the lab course propose innovations to common enclosure systems and to integrate those systems in their studio design projects.

Keywords

Sustainability, Evidence Based Design, Building Performance Analysis, Business Model Canvas.

1 Introduction

With the rise in urbanization and the projected growth in global building stock square footage, especially in urban centres located in hot and warm climates, there is a need for innovative solutions in the design and construction of the built environment to minimize its impact on the natural environment [1]. Architecture schools in the U.S. are increasingly transitioning to carbon conscious curriculum [2]. The National Architecture Accreditation Board updated its accreditation requirements to emphasize the importance of curricula which incorporate tools and methods that enable future architects in mitigating the built environment's negative impacts [3]. The state of Washington where our program is located and where the majority of our graduates pursue their careers is known for its progressive climate initiatives [4]. These regional, national, and international purposes were the driving forces behind the modifications introduced to our curriculum to provide future graduates with the tools required in facing the challenges of the 21st century.

Our undergraduate and graduate curriculum have two points for introducing content focused on sustainability. The four-year undergraduate architecture program offers only one required course at the sophomore level that provides a broad introduction to the built environment's impact on the natural environment as well as sustainable design strategies that can help mitigate this impact.

No dedicated course on sustainability exists at the graduate level. Out of six studio offerings in the two-year path and four studio offerings in the one-year path, students have the opportunity to take one design studio section with emphasis on sustainability. The course is structured around the framework for design excellence outlined in the American Institute of Architects Committee on the Environment Top Ten Competition [5]. Students submit their work to this competition at the end of the semester and one student team led by one of the authors has been successful in receiving this award [6]. Since gradate studios are typically taught in two sections by different faculty members the introduction of this content fluctuates from year to year based on teaching assignments resulting in the potential that certain cohorts could not have the exposure to sustainability-oriented curriculum at the graduate level.

Developing an entrepreneurial mindset and learning hands-on experimental evaluation methods are critical tools in mitigating the climate crisis through validation of commercially viable design solutions. These skills are actively sought after by our students but only few opportunities are available to limited number of students through direct collaboration with the faculty members conducting research involving these skills. Additionally, curriculum opportunities are limited despite recent experience in this area by the authors [7, 8].

To have a presence of climate conscious design and construction curriculum in our graduate program, we proposed modifying two courses (a lab and a studio) to create a Sustainable Design Accelerator (SDA). The overarching goal of the Accelerator is maximizing students' skills in sustainability, hands-on research methods, and entrepreneurship. In the lab course, student teams design, prototype, and test innovations to common heating and cooling systems for carbon neutral/restorative architecture. Students in the concurrent studio course are asked to design a multi-family housing and integrate the systems developed in the lab course while focusing on broader environmental, social, and economic issues.

In preparation for the launch of the course sequence in January 2021, we sought internal and external funding opportunities and received two awards in summer of 2020. External funding of $30,000 was awarded by the Lemelson Foundation through the VentureWell Faculty Grant and internal seed funding of $10,000 was awarded by Washington State University School of Design and Construction.

Funds were used to cover curriculum design, field trips, and student prototype construction in the lab course. Funds were also used for the design construction, calibration, and characterization of an environmental test chamber that can simulate hot climate conditions for testing innovative cooling systems. Figure 1 is an overall photo of the chamber from the northeast corner. Further details of the chamber have been presented and published by the authors in a conference proceeding [9].

As a consequence of the COVID-19 global pandemic, our university moved to online-only education for the 2020-2021 academic year which coincided with the first year of delivering the SDA. This required significant modification to the accelerator, particularly for the hands-on experimental evaluation component as all instruction, including design critique and workshops, were delivered online synchronously via the Zoom platform, and available asynchronously through recording of the Zoom sessions. Iteration one of the SDA is reported in a conference proceeding by the authors [10] and year two reported in this paper builds on lessons learned from year one, and reflects the SDA design, delivery, and outcomes as it was originally intended.

Figure 1: Test chamber overall construction photo from the northeast corner of the site.

2 Sustainable Design Accelerator Skillsets

A total of five primary skillsets were introduced in the accelerator. *Environmental impact tools* were introduced in the lab and studio courses to help students understand the impacts associated with their design proposals. Specifically, we introduced the following:

- *Whole System Mapping (WSM)*. Architecture education typically focuses on understanding the impacts that the whole building has on its immediate context and limits the system boundaries to the building site. WSM is introduced to expand the understanding of the buildings' impact beyond its site and include the impact that the components arriving to the site have on the environment. WSM is a qualitative method, conceptualizing individual building products as part of a complex system of interactions and energy inputs incorporating resource extraction, manufacturing, interaction with other components, user behaviour, and end-of-life strategies, including disposal or reuse/recycling. In the lab course, students learn the Faludi four-step methodology [11] and apply it to common building heating and cooling household items enabling them to propose sustainability solutions beyond the boundary of the building's site.

- *Life Cycle Assessment (LCA)* was introduced in both courses. In addition to qualitative WSM analysis, students are introduced to quantitative LCA cradle-to-grave analysis tools. This enables them to understand environmental impacts analysis of buildings at multiple scales. In the lab course, students are introduced to the Equalizer Eco Design database, coupled with a Microsoft Excel calculator [12] for evaluating lifetime environmental impacts of building product design alternatives. In the studio course, students are introduced to the Athena Impact Estimator calculator to understand environmental impacts over the lifetime of a whole-building, specifically the enclosure and structural systems [13].
- *Performance analysis software* were introduced in both courses. Students develop preliminary computer models and use performance analysis software to evaluate design performance. This helps students obtain quantitative data of performance parameters quickly and early in the design process for their design iterations when simulated under actual conditions. It enables students to compare several iterations and narrow them down to a single option prior to constructing physical prototypes. Autodesk CFD [14] is used for Computational Fluid Dynamics (CFD) analysis of heating and cooling systems developed in the lab course. This tool simulates air flow and distribution in and around the proposed system as well as temperature changes caused by the proposed heating and cooling mechanisms. Whole-building performance analysis of designs developed in the studio course was done using Solemma ClimateStudio which simulates daylight availability, energy consumption, and external surfaces incident solar radiation levels [15].

Entrepreneurial mindset tools are becoming increasingly important for designers moving into professional practice. To instil in students an entrepreneurial mindset, the Lean Canvas Model (LCM) is introduced in both courses so students can create business and marketing plans for their systems designs in the lab course and building designs in the studio course. This tool reinforced the need for commercially viable solutions to sustainability challenges in the built environment, and required students to clearly articulate value propositions, identify customers, strategic partners, and marketing strategies, while developing quantitative estimates of costs and revenue, as well as a path to profitability.

Hands-on experimental evaluation methods were introduced in the lab course and are necessary to understand system operational issues that would occur in real life and validate design simulation results. This is introduced to students in the lab course through physical prototype fabrication and validation of their heating and cooling systems. After narrowing down their design options to the preferred iteration, students build a scaled prototype in the school's fabrication labs. Fabrication methods and materials prioritized needs for testing and experimentation, and students learned rapid construction methods using readily available locally supplied materials. Depending on the system, physical testing of prototypes performance was conducted either outdoors or indoors using the environmental test chamber described above.

The lab course was delivered in 16 weeks and distributed into four modules whereas the studio course was delivered in 15 weeks and distributed into five modules. Figure 2 outlines the introduction of each skillset within each course and the build-up of student knowledge over the span of a semester.

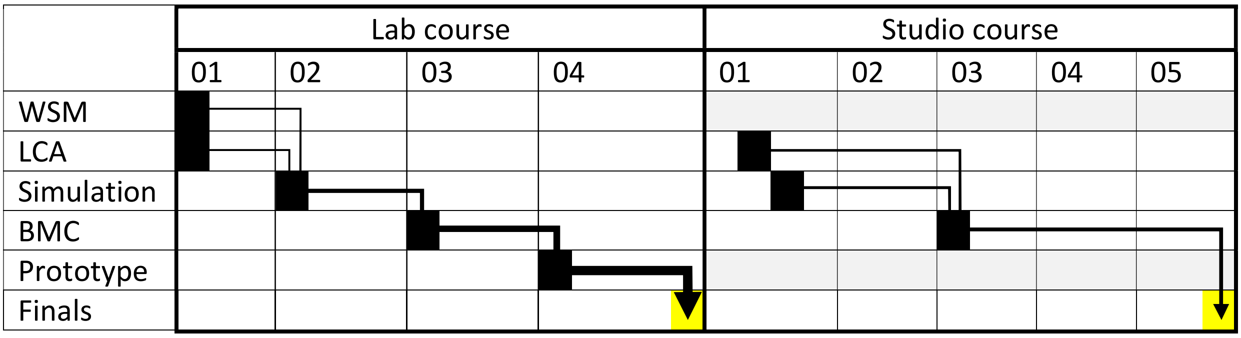


Figure 2: Progression of skillset introduction over the course of a semester in the SDA

3 Modifications to the SDA from Year One to Year Two

The authors cotaught both courses in the first year of the SDA to obtain a better understanding of opportunities and challenges in each course whereas each author delivered one course in second year while considering student feedback from responses to year one exit survey as well as the authors observations. The following adjustments were made to version 2.0:

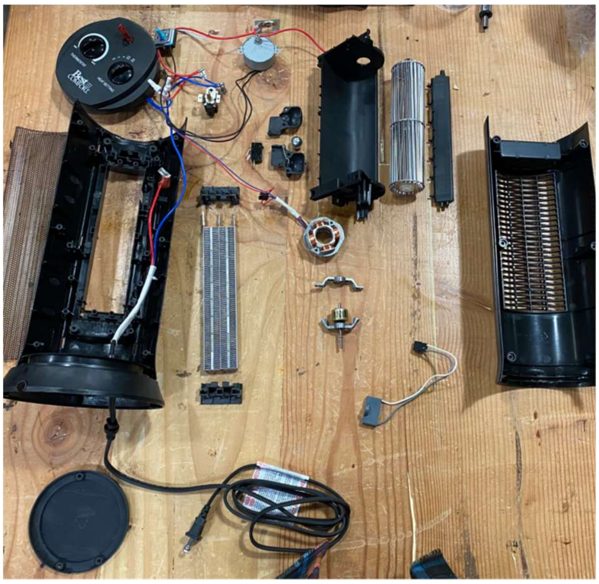
- *Create better integration between the lab course and the studio course:* In the first year of the SDA delivery, each course had a relatively large-scale project and each project was located on a different site with different climate conditions. The students in the studio had a site in Spokane, WA with predominantly cold climate conditions, whereas the students in the lab worked on a site in Tri-cities, WA with mixed climate conditions. To create a more meaningful overlap between the lab and the studio in the second year of the SDA, both courses were assigned smaller project and worked on the same site in Yakima, WA, which faces ongoing challenges with economic, environmental, and social justice. The range of climatic conditions, from hot summers to cold winters, allow for integration of passive heating and cooling design strategies.
- *Refine the delivery of entrepreneurship training*: In the first version of the accelerator, an entrepreneurial expert from the College of Engineering Entrepreneurship Institute was brought into the classroom once during the entire semester. To create a stronger continued impact in version 2.0, an expert from the University's Office of Commercialization was brought into the lab course multiple times. This included a lecture for students, as well as participation in student reviews to strengthen their proposals. Furthermore, students were encouraged to seek other entrepreneurial opportunities outside of the classroom, such as the NSF I-Corp Teams program.
- *Continue to make software training available asynchronously*: Students in version 1.0 appreciated having the software workshops recorded and available outside online

class meetings. Although version 2.0 was entirely in-person, we continued to deliver software workshops as synchronous online sessions, recorded and made available for asynchronous review afterwards.

- *Create continuity between the learning modules in the lab course*: To better introduce the concept of WSM and LCA in the lab course, students analysed heating and cooling household items by breaking them down to individual components, itemizing and weighing the components, and conducting an LCA analysis based on their findings. This addressed feedback from version 1.0 of the SDC where students analysed generic household items not necessarily related to the semester's design challenge and relied on manufacturer's product specifications available online. Additionally, peer-to-peer mentors were introduced where students from version 1.0 helped students in version 2.0 with prototype testing and construction to allow for continuity of knowledge between the cohorts.

4 Example Outcomes from Students in the Lab Course

Each of the four learning modules of the lab course focused on one key skillset. Students worked in teams of three on average to propose innovations to common passive heating or cooling systems. Modules one and two introduced environmental impact tools. Module one lasted three weeks where students developed working knowledge in whole system mapping (WSM) and life cycle assessment (LCA). Environmental impacts of heating and cooling household devices (e.g. box fan, humidifier, heater, etc) were investigated through data collection in a hands-on exercise where students dismantled, inventoried, and weighed the actual components of their selected device (Figure 3). They then developed a WSM for their product and used the Ecolizer Eco Design Database to obtain the Eco-Intensity values of their product's manufacturing, transportation, use, and end of life stages. These values were then inserted into an LCA excel calculator to estimate the product's overall impacts.



Manufacturing	Eco-Intensity (mPts/kg)	Mass per item (kg)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact (mPts)
ABS Plastic	25	0.759	1	20%	Recycled	18.9675
Plastic processing	126	0.759	1	20%	Injection Molded	95.5962
Thermoplastic	25	0.019	1	50%	Recycled	0.47
Thermoplastic processing	126	0.019	1	50%	Injection Molded	2.3688
Ceramic	0	0.032	1	30%	Used Ceramic Tile data	0
Ceramic Processing	124	0.032	1	30%	Used Ceramic Tile data	4.0176
Aluminum	45	0.296	1	30%	Recycled	13.329
Aluminum Processing	382	0.296	1	50%	Casting, Continuous	113.1484
Painted Aluminum	45	0.062	1	50%	Recycled	2.79
Painted Aluminum Processing	382	0.062	1	50%	Casting, Continuous	23.684
Brass	76	0.004	1	10%	Recycled	0.3192
Brass Processing	382	0.004	1	50%	dna for casting - used alum. data	1.6044
Steel	130	0.180	1	30%	Recycled	23.439
Steel Processing	704	0.180	1	50%	Milling	126.9312
Copper	76	0.128	1	10%	Recycled	9.6960986
Copper Processing	209	0.128	1	30%	wire drawing. Not all copper is wire	26.6642712
Rubber	599	0.101	1	30%	Assume Natural Rubber	60.54115
Rubber Processing	0	0.101	1	100%	dna for processing	0
Unk. Insulator	355	0.007	1	70%	Assumed vulcanized EPDM Rubber	2.556
Unk. Insulator Processing	0	0.007	1	100%	dna for processing	0

Transport	Eco-Intensity (mPts/ton-km)	Mass x dist. per item (ton-km)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact (mPts)
Freighter	1.3	14.584	1	20%	Shanghai to Seattle	18.9586346
Truck	12	1.455	1	20%	Seattle to Pullman	17.4602491

Use	Eco-Intensity (mPts/kWh)	Amount per item (kWh)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact (mPts)
Electricity Use (US)	81	3805.62	1	30%	U.S. Energy - lowest value; 5 yr. lifetime, used 5.33 hrs. daily from NOV-FEB, half on low setting and half on high setting	308255.22

End of Life	Eco-Intensity (mPts/kg)	Mass per item (kg)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact (mPts)
EOL of ABS Plastic	45	0.759	1	30%		34.1415
EOL of Thermoplastic	45	0.019	1	30%		0.846
EOL of Ceramic	0	0.032	1	100%	dna	0
EOL of Aluminum	26	0.296	1	10%		7.7012
EOL of Painted Aluminum	26	0.062	1	10%		1.612
EOL of Brass	26	0.004	1	10%		0.1092
EOL of Steel	26	0.180	1	10%		4.6878
EOL of Copper	26	0.128	1	10%		3.31708636
EOL of Rubber	50	0.101	1	10%		5.05351836
EOL of Unk. Insulator	50	0.007	1	50%		0.36

Figure 3: Example household heating device dismantled (left) and example LCA calculation with proposed modifications to the baseline (right). Image credit Ty Hash and Ryan Quinn.

Module two lasted four weeks where students developed working knowledge in system performance analysis using Computational Fluid Dynamics (CFD). Student teams aligned the system they innovated to the type of household item they analysed in module one. Their proposed innovation was designed to be connected to a 100 m^2 community space located on the site in Yakima, WA. Students first reviewed precedents to identify their baseline system and went on a field trip where they visited built projects that incorporate innovative systems. They then used CFD to simulate baseline performance and compare that to the performance of their preliminary design iterations. LCA comparisons between the baseline and the proposed design variations were also conducted. Figure 4 is an example of a team's baseline passive cooling system as well as two variations to the baseline (upper images from left to right) coupled with CFD temperature results through a cross section of their design.

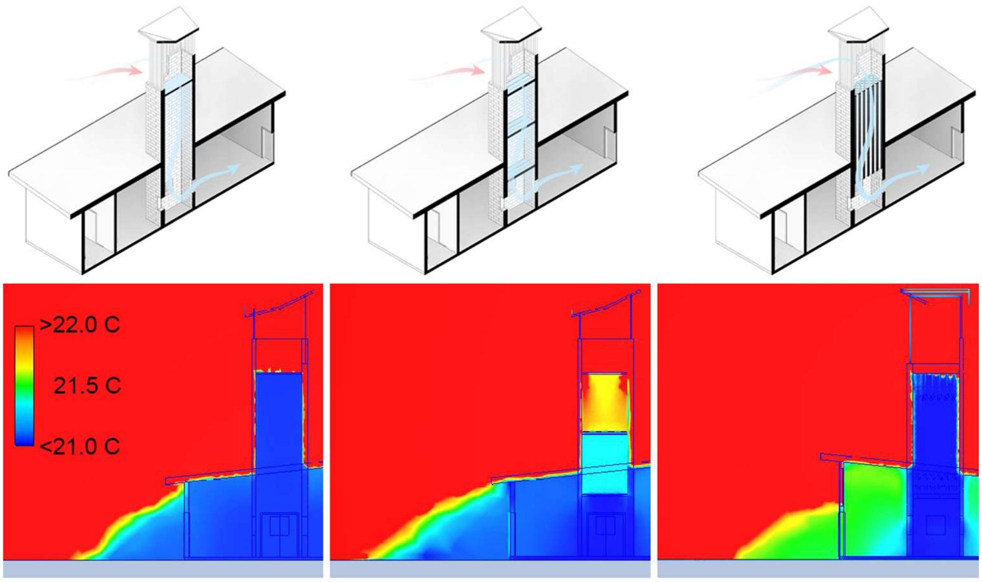


Figure 4: Example student outcomes from module two. Image credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook.

Module three introduced Entrepreneurial Mindset tools and lasted four weeks where students acquired working knowledge of business planning and developing a Business Model Canvas (BMC) to identify commercialization pathways for their proposed systems. In addition, students continued to refine their designs and narrow them down to one iteration informed by ongoing LCA calculations coupled with CFD simulations. As a transition into the final phase of the project, students created prototype fabrication plans, including detailed shop drawings; bill of materials (BOM); and a prototype construction budget.

Module four introduced hands-on experimental evaluation methods and lasted five weeks. Students refined their prototype designs and details, purchased construction materials, and building their prototypes. The last two weeks of the semester were dedicated to testing the and comparing experimental data to simulation results. Teams developed a final presentation covering outcomes from all modules and deliverd it to external reviewers with expertise in product design and commercialization. Figure 6 is a series of construction photos from a passive cooling prototype tested in the chamber (left) and a passive heating prototype tested outdoors (right). Figure 7 represents a portion of the deliverables from the final presentation.

Figure 5: Example passive cooling prototype (left). Images credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook. Example passive heating prototype (right). Images credit Keaton Cox, Theo Clarke, and Jake McCornack

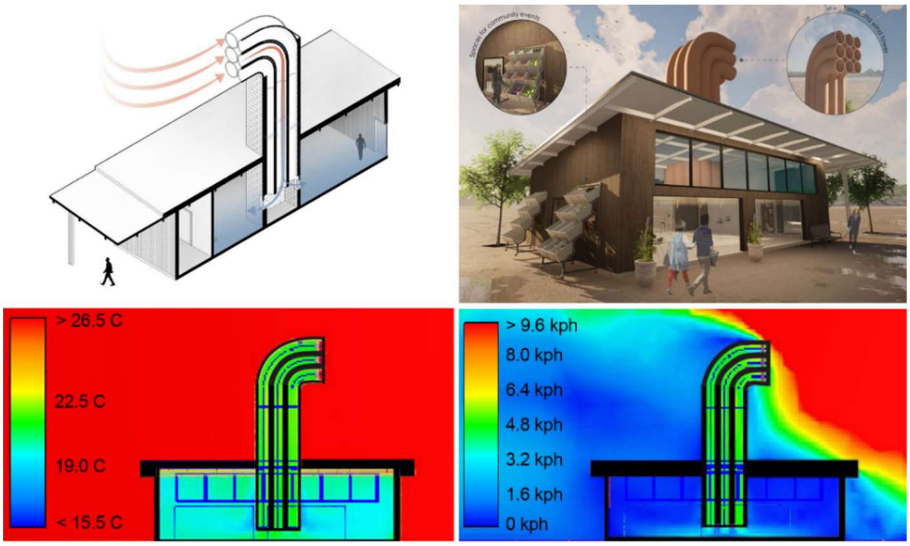


Figure 6: Example student outcomes from module four final presentation. Image credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook.

5 Example Outcomes from Students in the Studio and Lab Courses

Students who were in both courses were in identical teams so they can incorporate their lab systems into their studio designs. The studio course was organized in a traditional format beginning with case study analysis which lasted four weeks followed by three weeks of site analysis and a field trip to the site. The remaining eight weeks were divided into three modules, each representing a primary stage in the design process from preliminary design to design development and final design. Students worked in teams of three or four to design a multi-family housing community in Yakima, WA, with a 2,000 m^2 built-up area.

Module one covered environmental impact tools at the whole building scale giving students the opportunity to practice applying these tools throughout the following modules of the semester. Solemma ClimateStudio was introduced during week two and the Athena Impact Estimator calculator was introduced during week three. Both tools were used as a feedback loop in the iterative design process to meet higher performance measures. Module three introduced students to entrepreneurial mindset tools with the focus in this course being on using the business model canvas for developing a business plan to promote their proposed community considering contextual and environmental factors.

The overlap between the two courses occurred with student teams integrated the system they are developing in the lab course into one or multiple programs in their studio project. Prototype construction reflected the spaces in the studio project to create more synergy and meaningful results from testing the prototype that can then be used to inform design decisions in the studio. Figure 8 is an example project where students proposed an innovation to the inlet of a passive downdraft cooling device and integrated that device into the residential occupancy program of their studio project. The upper images are outcomes from the studio course and the lower images are for the prototype testing of a reduced scale version of one residential unit.

Figure 7: Example studio course outcome (top) and concurrent lab course outcome (bottom). Images credit Trevor Zook, Mikke Wittenberg, Diego Quintana, Assani Kyanza.

6 Exit Survey Results

Analysis of result from version 1.0 exit survey informed modifying the survey questions for version 2.0. In the second iteration, we added four more questions which aim at collecting feedback on the connection between the lab and the studio courses, bringing the total to 14 questions. All 30 students in the accelerator responded to the exit survey. Seven were enrolled in both courses. The primary quantitative outcomes included the following:

- Level of awareness in all five skillsets increased. Results indicated significant improvement in students' awareness of the tools covered in the accelerator as illustrated in Figure 9. A five-point Likert scale was used to ask students about their level of awareness of the five skillsets before and after the SDA with one being the lowest or 'not at all', and five being the highest or 'extremely'. In all five skillsets, students' level of awareness drastically increased before and after the SDA. Scores of one and two were reported by 83 percent of the students before the accelerator (53 percent reported a score of one), whereas 85 percent reported a score of four and five after the accelerator (45 percent reported a score of five). Whole system mapping (WSM) was the most improved skillset where 73 percent were not at all aware of it before taking the lab course. 70 percent became extremely aware of it after completing the lab. Computational Fluid Dynamics (CFD) was the least improved skillset with 77 percent not at all aware of it before the lab course and only 13 percent extremely aware of it after completing the lab course.

- Level of understanding in all five skillsets increased. Using a five-point Likert scale, 80 percent reported a score of four and five. The same pattern noticed in the level of awareness with the individual skillsets existed here. WSM received the highest scores at 96 percent whereas CFD received the lowest at 50 percent.
- Ability to apply all five skillsets increased. Using a five-point Likert scale, 75 percent reported a score of four and five. Prototype construction received the highest score at 90 percent whereas CFD received the lowest at 43 percent aligning with the least improved skillset in the level of awareness category.
- Students preferred prototype construction and experimental evaluation over other activities. 57 percent indicated it as their favourite skillset and 67 percent preferred it over the field trips and the breakdown of the household heating and cooling items. Additionally, 67 percent are extremely likely to use this skillset in future coursework.
- Students in both courses indicated that more crossover is needed. Out of the seven students who were in the lab and the studio, 57 percent reported that the courses were moderately connected, and the remainder either perceived the courses very connected or not at all connected.

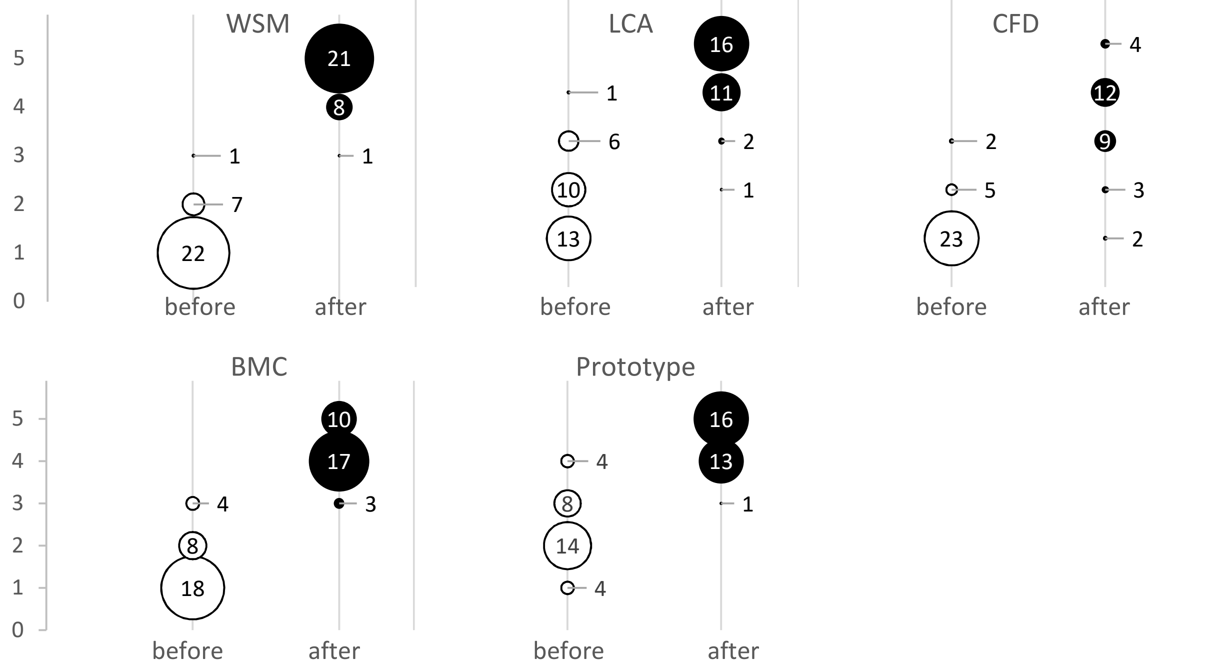


Figure 8: Results of students' level of awareness before and after completing the SDA.

Most of the qualitative feedback we received from the students oriented around course schedule, the continuity of the deliverables between the modules, more software workshops, and the integration between the two courses. Selected comments from the survey are as follows (lightly edited for clarity):

- "I think that getting into the phase of building and testing prototypes much earlier in the semester would have been beneficial and given us a chance to make design changes for the physical model."
- "More focus on developing a product from the start rather than starting out with taking household items apart."
- "More in-depth workshops on how to use some of the software tools and include examples for both heating and cooling rather than having a workshop focusing on cooling systems as the processes are different."
- "I wish the two courses were highly connected because it would have been better to learn how to fully integrate what we learn in Lab to Studio. However, it was a great course and I learned a lot from both tectonic and studio class. Most likely will use this information in the near future."

7 Discussion and Plans for Version 3.0

Survey outcomes demonstrated student satisfaction with the in-person delivery of the course. Moving forward, the following adjustments will be made to version 3.0 of the SDA:

- Continue to create stronger crossover between the two courses. Through student engagement in the whole-system mapping, we realized the need for students to have a firmer grasp of high-performing enclosure systems that will result in lower heating and cooling loads which will in turn enhance the efficiency of the space conditioning systems. Additionally, enclosure systems offer more crossover possibilities since enclosure detailing is typically a required element in studio courses. In year three of the SDA, students taking both courses will design a highly efficient enclosure system in the in the lab course and integrate that system into their studio projects.
- Expand the hands-on experimental evaluation component. Being the most preferred activity among students, year three of the SDA will include a wider variety of testing procedures to incorporate a calibrated hot box apparatus as specified in ASTM C1363. Students will use this to assess heat flow through 1m x 1m full scale mock ups of their high performing assemblies and compare that to a code minimum assembly.

Acknowledgements

The authors are grateful to the Lemelson Foundation who awarded them with the VentureWell Faculty Grant and the School of Design and Construction (SDC) who awarded them with the SDC Seed Grant. The researchers also wish to thank the SDC for donation of materials used in the construction of the environmental test chamber. Finally, we wish to acknowledge input and effort from Colter Nubson, Nathan Albrecht, Anguel Atanassov, Ryan Smith, Tom Jobson, David Thiessen, Miles Pepper, Rabindra Nanda, and Scott Hanson.

References

[1] Architecture 2030. 2022. “Why the Built Environment?” https://architecture2030.org/why-the-building-sector/.

[2] Bernstein, Fred. 2022. “Architecture Schools Begin to Put Embodied Carbon Front and Center.” Architectural Record. https://www.architecturalrecord.com/articles/15823-architecture-schools-begin-to-put-embodied-carbon-front-and-center.

[3] National Architectural Accrediting Board. “NAAB Conditions for Accreditation, 2020”

[4] WA Department of Ecology. “Climate Commitment Act (CCA).” https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act.

[5] Association of Collegiate Schools of Architecture. “2023 COTE Competition Program.” https://www.acsa-arch.org/competitions/2023-cote-competition/program/.

[6] Anderson, Sean, Tobias Jimenez, and Haley Ladenburg. “Wallingford W2E.” Architect Magazine. https://www.architectmagazine.com/project-gallery/wallingford-w2e_o.

[7] Al-Hassawi, Omar. “Design and Evaluation of Passive Downdraft Cooling Systems: Outcomes from Built Prototypes of Single Stage and Hybrid Downdraft Cooling Towers.” *Architectural Science Review 64 (1–2): 17–27*. 2020.

[8] Shaprio, Gideon. “Drywall Waste Block, a Green CMU.” Architect Magazine. https://www.architectmagazine.com/awards/r-d-awards/award-drywall-waste-block-a-green-cmu_o.

[9] Al-Hassawi, Omar, and David Drake. “Design + Construction of a Novel Environmental Test Chamber: A New Method for Evaluating Performance of Passive Downdraft Cooling.” In proceedings of the *36th International Conference on Passive and Low Energy Architecture: Will Cities Survive?* Santiago, Chile. 2022.

[10] Al-Hassawi, Omar, and David Drake. “Sustainable Design Accelerator: Infusing Entrepreneurship and Evidence-Based Design into Architecture Pedagogy.” In proceedings of the *110th Annual Meeting: EMPOWER*. Virtual. https://www.acsa-arch.org/conference/110th-annual-meeting/thursday-schedule/#toggle-id-44-closed.

[11] Faludi, Jeremy. “Whole System Mapping.” VentureWell Tools for Design and Sustainability. https://venturewell.org/tools_for_design/whole-systems-mapping/.

[12] Faludi, Jeremy. “Measuring Sustainability.” VentureWell Tools for Design and Sustainability. https://venturewell.org/tools_for_design/measuring-sustainability/.

[13] Athena Institute. “Overview | Impact Estimator for Buildings.” Athena Sustainable Materials Institute. https://calculatelca.com/software/impact-estimator/overview/.

[14] Autodesk. “Autodesk CFD.” https://www.autodesk.com/products/cfd/overview.

[15] Solemma. “Solemma Climate Studio.” https://www.solemma.com/climatestudio.

PHYTOREMEDIATION LIVING WALLS FOR INDOOR AIR FILTRATION

Mariami Maghlakelidze
Graduate School of Architecture, Planning and Preservation, Columbia University
1172 Amsterdam Ave, #400, 10027, New York, NY, United States;
maglakelidze.mari@gmail.com; mm5755@columbia.edu

Abstract

Today, as a result of urbanization and population growth, air pollution has become a major issue, especially in developing countries. As a result of human behavior, the atmospheric concentration of CO_2 has risen from the preindustrial value of 280 ppm to 421 ppm which is still evolving. Carbon Dioxide have been shown to have a life-treating risk on human health including physiological (e.g., ventilatory stimulation), toxic (e.g., cardiac arrhythmias and seizures), and anesthetic (significantly depressed CNS activity, including reduced productivity and decision making). Increasing greenhouse gas emissions and contaminated air quality is one of the most critical challenges of today which requires immediate attention.

Indoor air quality has become a growing concern of well-being as people spent 90% of their time indoors, which can be 2-5 times more polluted than outdoors. The main contributors to indoor air pollution are volatile organic compounds (VOCs) and Carbon Dioxide from human respiration.

Indoor plants have been found to metabolize toxic compounds and remove the CO_2 through photosynthesis (Phytoremediation), degrade VOCs through the metabolic action of rhizospheric microbes, and improve the air quality. Plants have been further found to create a microclimate and regulate building temperature, decrease noise levels and benefit human well-being. Vertical greening systems, or living walls, are becoming increasingly used indoors for improving the sustainability of buildings, including for the mitigation of excess CO2 levels, derived from human respiration. However, Phytoremediation systems are not sufficiently developed and indoor air pollution removal is still depending on ventilation, chemical purification, and isolation. Synthesized research on phytoremediation living walls is still limited and studies have not been able to fully foresee the ways in which the living walls will filter the polluted air with its full efficiency.

This research aims to find the most effective ways to remove VOCs, CO2, and other pollutants through phytoremediation living wall and improve indoor air quality. This research uses synthesized literature about the capabilities of potted plants for air pollutant removal and identifies the living wall plants with the most air filtration efficiency such as Chlorophytum Comosum, Schefflera Arboricola, Chlorophytum Orchidastrum.

Keywords

Environmental Technology, Air quality, Phytoremediation, Indoor air pollution, Biofiltration.

1 Introduction

Today, as a result of urbanization and population growth, air pollution has become a major issue, especially in densely urbanized places and in the developing countries. CO2 emissions are dramatically increasing every year (Fig 1). In 1950 the world emitted 6 billion tonnes of CO2 which has increased to 36 billion tonnes each year (World data). As a result, the atmospheric concentration of CO2 has risen from the preindustrial value of 280 ppm to 401 ppm in 2015. Built environment has been found to be responsible for 2/3 greenhouse gas emissions. Reducing building CO2 emissions and enhancing air quality has a critical urgency on natural environment and people's public health and well-being.

A growing body of evidence identifies indoor air pollutant exposure as having the greatest health impacts on human well-being today. Indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials which can be 5 -100 times worse than outdoor air quality. Elevated air contaminants may trigger a respiratory, eye and throat irritation. According to (WHO) Indoor air pollution is a leading risk factor which includes approximately 1.6 million deaths each year for premature death (Fig 2). Especially, in low-income countries, 6 % of deaths are attributed to indoor air pollution. As we are dealing with an energy dilemma and prices of cooling and heating are increasing [1] more buildings are built airtight with poor air ventilation. The study [2] has shown that increasing ventilation rates could not fully resolve indoor formaldehyde pollution. Especially in developing countries, where the air quality guidelines aren't properly followed, indoor air pollution is a risk factor for causing death, including heart disease, pneumonia, stroke, diabetes and lung cancer (WHO).

Air pollution is dependent on the following parameters: building orientation, surrounding space, ventilation type (Natural or mechanical), rate of air infiltration, the speed and direction of the speed, indoor and outdoor temperature gradient, and air conditioning system (heating, cooling) [3,4,5].

Plants have been found to have a significant air filtration effect in the interior environments. However, the critical evaluation of phytoremediation systems that incorporate the most efficient plants for pollutant removal is missing.

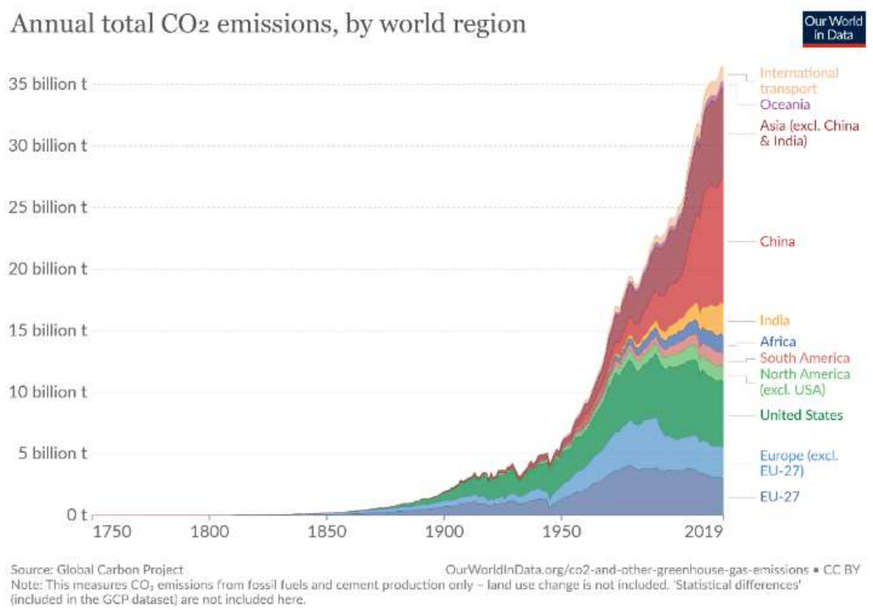


Figure 1. Annual total Co2 emissions, by world region. Our World in Data

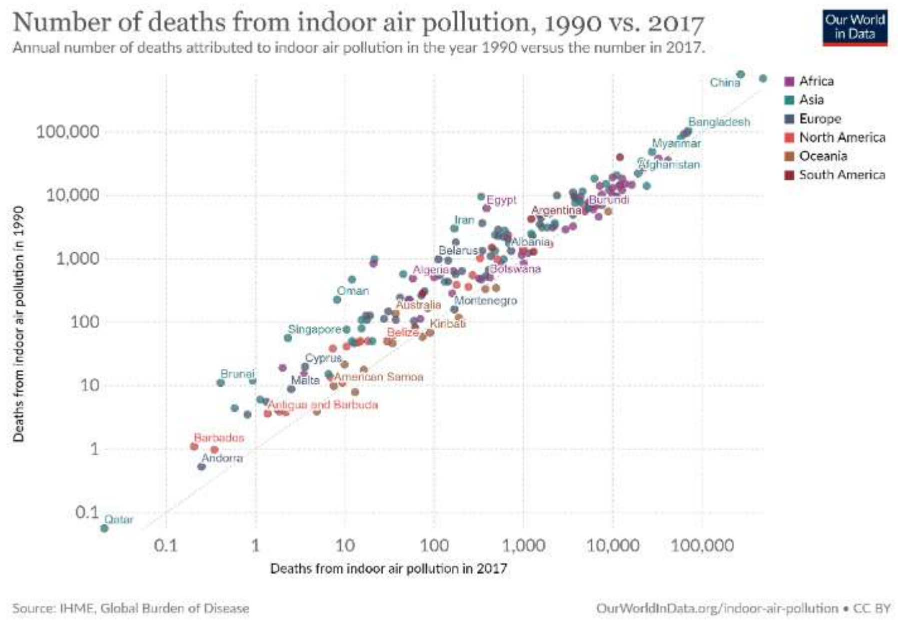


Figure 2. Number of deaths from indoor air pollution. Our World in Data

2 Sick Building Syndrome, effects of Indoor air pollutants on Human's heath

Effects of air contaminants on human's health have been examined in the scientific literature as a possible life-threatening risk assessment. Indoor air pollutants include (CO_2) released from human respiration, particular matter (PM) from occupant activities, Volatile organic compounds (VOCs) [6].

Atmospheric CO_2 exposure affects Human health of normal and sensitive populations (Table 1). The effects of CO_2 in a specific individual depends on the concentration and duration of exposure as well as individual factors, such as age, health, physiologic make-up, physical activity, occupation, and lifestyle. With high-level CO_2 exposure, the displacement of CO_2 by CO_2 significantly contributes to toxicity.

CO_2 levels in the indoor environment have been shown to have a significant effect on the human's well-being. Elevated levels of CO_2 from 350 to 2500pm have been associated with sick building syndrome [7].

A two hours and thirty minutes long study [8] conducted on twenty-two participants, showed that from low to moderate CO_2 levels (1000 and 2500ppm) affects decision-making performance.

the CO2 concentrations from 600 to 2500pm have been further found to be associated with a decreased work place poductivity and task performance [9].

Table 1: Effects of CO_2 [10].

CO_2 Levels	**Effects**
1%	Respiratory rate (RR) ↑ 37%
1.6%	V˙ ↑ ~100%
2%	RR ↑ ~50%; brain blood flow ↑
3%	Exercise tolerance ↓ in workers when breathing against inspiratory & expiratory resistance
5%	Exercise tolerance ↓ in workers when breathing against inspiratory & expiratory resistance
8-10%	Severe HA, dizziness, confusion, dyspnea, sweating, dim vision
10%	Unbearable dyspnea, followed by vomiting, disorientation, hypertension, & loss of consciousness

2.1 Plants role on the removing pollutants

Plants have been found to be the most complex of all photosynthetic organisms [11] and have various benefits on human health and well-being. Photosynthesis ''synthesis with light'' is essential process for all lives on the earth. In the process of photosynthesis light energy is captured and stored by the organism which is utilized for the energy-required cellular processes [12]. The Chloroplast, which is located in the subcellular structure of the leaves, carries out the main process of photosynthesis. Photosynthesis includes four phases beginning with photon absorption, ending with the export of stable carbon products from the chloroplast. First, Light is absorbed and energy is delivered by antenna systems, secondly, primary electron transfers in reaction centers, and lastly, synthesis and conversion of Co2 into carbohydrates (fig.3).

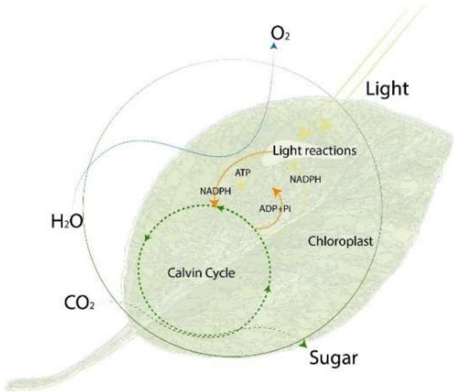


Fig 3. Plant Photosynthesis cycle. Authors Interpretation

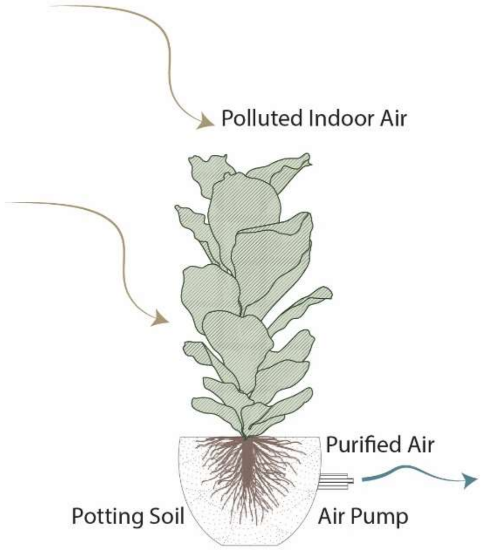


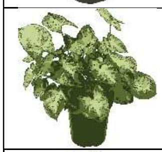
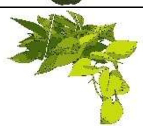
Fig 4. Adapted from NASA's original plant air purifier [16].

Plants consume carbon dioxide and release oxygen [13,14,15]. The studies have shown [16] that soil is playing a critical for plants to remove VOCs efficiently in which the microorganisms within the rhizosphere contribute to VOC removal. Other studies have been conducted on the VOCs removal under the light and dark conditions have shown no significant difference [16]. However, it weas shown [17] that increase in light intensity increases plant metabolic activity.

First, studies on plant air pollution reduction capabilities were coined for NASA [15]. The results of the study showed that potted plants could absorb substantial concentrations of the VOCs formaldehyde, trichloroethylene, and benzene from chamber air [2].

Since the study by NASA, 45 different studies have been conducted on around 200 species for VOC removal capacity. Plants' effect on removing indoor air pollutants has been found in a few studies [18]. Plants can work as natural air filtration, with photosynthesis it can absorb carbon dioxide and release oxygen [13]. Several green wall plants have been shown to have the most significant effect on air filtration (Table 2).

Table 2. Synthesis of studies testing the capabilities of potted plants for air pollutant removal, 2007–2018 [2]. Plants are selected for the living wall and adapted by Maghlakelidze, M

Visual Reference	**Plant Name**	**Green Wall/filter**	**Pollutant**	**Starting concentration**	**Reported air filtration efficiency**	**Author**
	Chlorophytum Comosum	0.5 m2	PM	N/A	53.35% (TSP); 53.51% (PM10); 48.21% (PM2.5)	[2]
	Nematanthus glabra	0.25 m2	PM	PM0.3–0.5 = 19.86 µg/m3; PM5–10 = 8.09 µg/m3; TSP = 142.23 µg/m3	Max PM0.3–0.5 and PM5-10 = 45.78 and 92.46%	[19]
	Chlorophytum orchidastrum					
	Ficus lyrate					
	Nephrolepis exaltata					
	Schefflera arboricola					
	Philodendron	1.5 m2	Methyl ethyl ketone	30 ppbv	56.60%	[6]
	Philodendron scandens 'Brazil'					
	Asplenium antiquum,					
	Syngonium podophyllum					
	Epipremnum aureum	1.08 m2	Formaldehyde and toluene	7.5–10 ppm 250 ppm	0% (leaf); 39.5% (biofilter)	[20]

3 Phytoremediation systems

Plants combined with architectural features and ventilation have been associated with temperature reduction and cooling effect, to control noise disturbance, reduce sound reflection, and reduce carbon dioxide emissions. Vertical greenery can act as a natural air filtration by absorbing dust and cleaning the air [21,22].

Green walls include two types of green facades, passive an active which can be used indoor and outdoor [23,24] (Fig 5). Active living walls incorporate building envelopes such as ventilation, heating, and cooling. An active green wall that cleans indoor air acts as a thermal regulator. The green wall plants absorb CO2 and release clean fresh air in the indoor space through the outlet system [23].

In active living wall systems, there are two types of air pollution removal systems: biofiltration and phytoremediation. A hydroponic biofilter uses a combination of natural plant systems and manufactured air movement systems to move and filter the air for superior indoor air quality. Vertical green wall provides accelerated air filtration as polluted air is mechanically pulled through the plants and substrate.

Active green walls have been found to carry biophilic qualities and be beneficial for improved comfort of the living environment by providing indoor air quality, noise control, thermal comfort and increased productivity and overall well-being. The study has shown that [25] active living wall has reduced temperature by 4-6 C in warm climate, that can lead to possibility for an energy reduction.

In the phytoremediation system, outdoor contaminated air is drawn through the plants, moves through the fan and threated sit enters in the interior space.

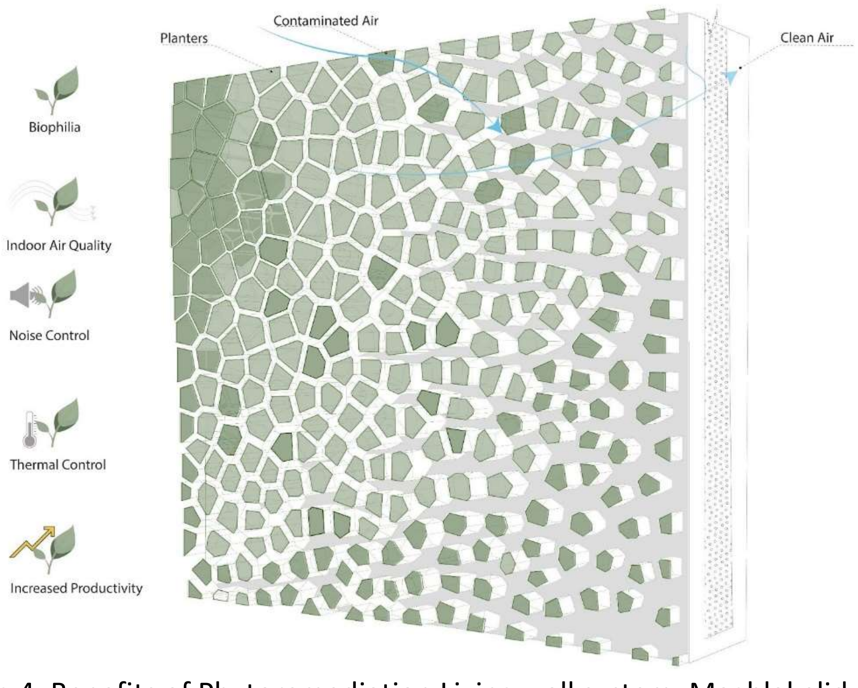


Fig 4. Benefits of Phytoremediation Living wall system. Maghlakelidze, M.

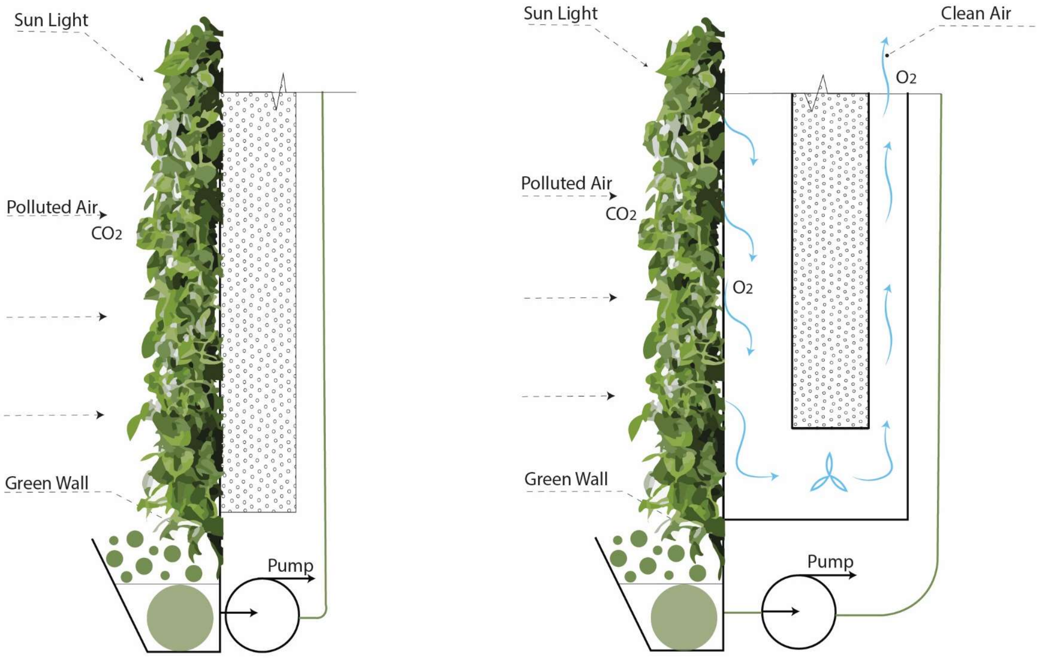


Fig. 5. Passive Living wall, Active Living wall adapted from [26].

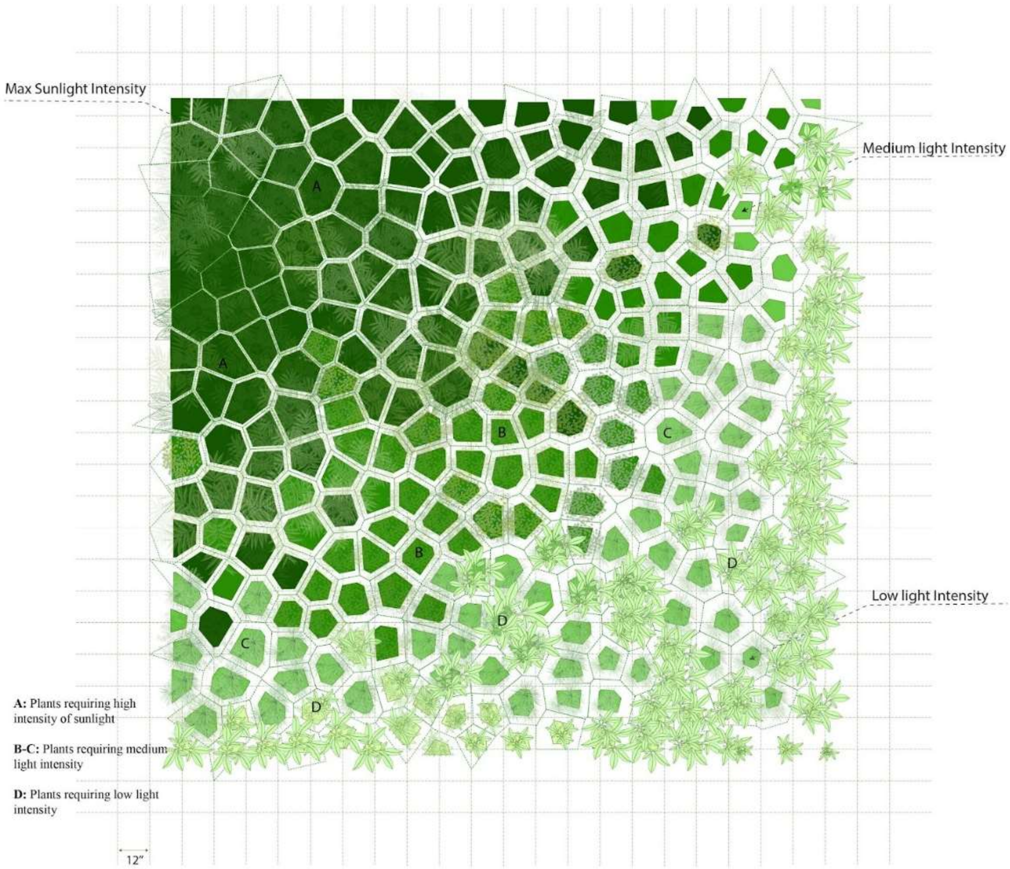


Fig 6. Design of the Phytoremediation living wall system. Maghlakelidze, M.

4 Conclusion and future Outlook

There has been progressive increase in a study of biofiltration systems to potentially enhance the contaminated indoor air quality. Living walls have shown to be beneficial for improving environmental quality, noise control, thermal control, benefit the users with biophilic power of increasing productivity and well-being. However, the effectiveness of the design, in relation to selected plants for the relevant climate zones, and efficiency in air flow velocity, is not sufficiently developed. The buildings still use traditional methods of HVAC systems for air filtrations and living walls are still alienated.

Environmental model analysis can be conducted on the biofiltration systems, in order to quantify the effects of variances in system design in relationship to indoor environment parameters: such as size, orientation, layout, occupancy, climate zone, seasonality, outdoor air quality index and Indoor-outdoor temperature gradient.

References

[1] Pandey, A.K.; Pandey, M.; Tripathi, B. 2015. Air Pollution Tolerance Index of climber plant species to develop Vertical Greenery Systems in a polluted tropical city. Landsc. Urban. Plan.144, 119–127.

[2] Irga, P. J., Pettit, T. J., Torpy, F. R. The phytoremediation of indoor air pollution: a review on the technology development from the potted plant through to functional green wall biofilters. (2018). Rev Environ Sci Biotechnol.17:395–415

[3] Goyal, R.; Khare, M.; Kumar, P, Indoor air quality: Current status, missing links and future road map for India. J. Civ. Environ. Eng. 2, 2–4.

[4] Nazaroff, W.W. 2013.Exploring the consequences of climate change for indoor air quality. Environ. Res. Lett. 8, 015022.

[5] Leung, D. Y. C. 2015 Outdoor-indoor air pollution in urban environment: Challenges and opportunity. Front. Environ. Sci. 2.

[6] Torpy, F.; Irga, P.; Moldovan, D.; Tarran, J.; Burchett, M. Characterization and biostimulation of benzene biodegradation in the potting-mix of indoor plants J. Appl. Hortic., 15 (1) (2013), pp. 10-15

[7] Jafari, M.J.; Khajevandi, A. A.; Najarkola, S.A.M.; Yekaninejad, M. S.; Pourhoseingholi, M. A.; Omidi, L.; Kalantary, S. Association of sick building syndrome with indoor air parameters. Tanaffos, 14 (1) (2015), p. 55

[8] Satish, U.; Mendell, M.J.; Shekhar, K.; Hotchi, T.; Sullivan, D.; Streufert, S.; Fisk, W.J. 2012. Is CO2an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2Concentrations on Human Decision-Making Performance. Environ. Health Perspect. 120, 1671–1677.

[9] Milton, D. K.; Glencross, P. M.; Walters, M. D. Risk of sick leave associated with outdoor air supply rate, humidification, and occupant complaints Indoor Air, 10 (4) (2000), pp. 212-221

[10] Rice, S. A. Health Affects of acute and prolonged Co2 exposure in normal and sensitive populations. Second annual conference eon Carbon Sequestration, Virginia, United States, 2003.

[11] Taiz, L. Zeiger, E. 2010. Plant psychology 5th Edn. Sunderland, Ma: Sinauer Associates.

[12] Blankenship, R. E. 2021.Molecular Mechanisms of Photosynthesis. Third edition. Wiley

[13] Ismail, A., Samad, A, M, Abdul, R, A. Using green roof concept as a passive design technology to minimise the impact of global warming. Second international conference on built environment in developing countries (ICBEDC 2008), 2008. Malaysia; p. 588–98.

[14] Darlington, A. B., Dat, J. F., Dixon, M, A. The biofiltration of indoor air: air flux and temperature influences the removal of toluene, ethylbenzene, and xylene. Environmental science &technology, 35(1), (2001) 240–246. https://doi.org/10.1021/es0010507

[15] Peck, S, W. Greenbacks from green roofs: forging a new industry in Canada. Canada Mortgage and Housing Corporation, Canada, 1999.

[16] Wolverton, B. Foliage plants for improving indoor air quality. National Foliage Foundation Interiorscape Seminar, 19 July, Hollywood, FL (1988)

[17] Porter. J. Toluene removal from air by Dieffenbachia in a closed environment. Adv. Space Res., 14 (11) (1994), pp. 99-103

[18] Wetzel, T.A.; Doucette,W. J. 2015. Plant leaves as indoor air passive samplers for volatile organic compounds (VOCs). Chemosphere 2015, 122, 32–37.

[19] Pettit, T.; Irga, P.J. ; Torpy, F. R. Towards practical indoor air phytoremediation: A review, Chemosphere, Volume 208, 2018, 960-974, ISSN 0045-6535, https://doi.org/10.1016/j.chemosphere.2018.06.048.

[20] Wang Z, Pei J, Zhang JS (2014) Experimental investigation of the formaldehyde removal mechanisms in a dynamic botanical filtration system for indoor air purification. J Hazard Mat 280:235–243

[21] Donahue, j. An empirical anaylisis of the relationship between tree canopy, air quality, and crime in urban areas. United States-District of Columbia: Georgetown University. 2011. ESRL. Trends in Atmospheric Carbon Dioxide.

[22] Amir, A., Yeok, F., Abdullah A, Rahman A, The most effective Malaysian legume plants as biofacade for building wall application, Journal of Sustainable Development, 4 (1), (2011), DOI:10.5539/JSD.V4N1P103

[23] Zhou, J., Chen, Y. 2010. A review on applying ventilated double-skin facade to buildings in hot-summer and cold-winter zone in China. Renew Sustain energy rev; 14:1321-8

[24] Manz, H., Frank, T. 2005. Thermal simulation of buildings zwhich double-skin facades. Energy Build. 37:1114-21

[25] Fernández-Cañero, R.; Urrestarazu, L. P.; Franco Salas, A. Assessment of the cooling potential of an indoor living wall using different substrates in a warm climate. Indoor Built Environ., 21 (5) (2012), pp. 642-650

[26] Pérez-Urrestarazu, L.; Fernández-Cañero, R.; Franco, A.; Egea, G. I. Influence of an active living wall on indoor temperature and humidity conditions, (2016), Ecol. Eng. 90, 120–124.

THE TOPOLOGICAL GRAMMAR OF FORMS

Wonseok Chae*

Design and Representation Methodology Lab., The University of Wuppertal, HC,
Pauluskirchstraße 7, 42119 Wuppertal; wchae@uni-wuppertal.de

Abstract

The purpose of the paper is to explore formal grammars in architectural design. The research examines the changing grammar from pure geometry to complex topology. A couple of architectures from Berlin will be analyzed based on both geometrical and topological principles together with further design developments in complex situations.

On the one hand, geometry has been a dominant principle in architectural design. Particularly in the 20th century, the concept of geometry has been considered as a generic form of language. On the other hand, topology became an alternative principle next to geometry. Since the late 20th century, the concept of topology has been suggested as a specific form of language to overcome the geometrical limit in explaining complex forms.

Today, the formal grammars seem to be shifting to deal with more complexities than simple forms. For example, virtual reality expands to sub-categories such as mixed reality, extended reality, or augmented reality on top of external reality. AI-driven design tools produce a wide variety of aggregated forms. Contemporary architectural media seem to require how to read complexities in which most forms overlap and juxtapose in a less geometrical fashion.

Keywords

Form, Language, Grammar, Geometry, Topology.

1 Introduction

The purpose of the formal grammars is communications by keeping and expanding the design capacity in architectural design. In this sense, the discourse of formal grammars takes the risk of deviating from the authentic or original idea in the linguistic or mathematical fields. The meaning of formal grammars should be conceived neither as linguistics nor as mathematics but as architectural concepts accordingly in this narrative.

The formal grammars have contested one another since the middle of the 20th century. If periodization allows, the contests could cover roughly the spectrum of the classical, modern, postmodern, to contemporary languages in architectural design. The term, formal grammar is conceptualized mainly from Eisenman's life-long-study of "formal language" [1][i] coined from his doctoral thesis "The Formal Basis of Modern Architecture" in 1963. In the study, architecture is primarily understood as a form of "grammar" [1] [ii] for architectural communication for both reading and designing.

Although presenting the concept of "geometry"[1][iii] as a fundamental grammar in the past, Eisenman took another step and expanded the grammatical capacity from geometry to "topology"[2][iv] in "Palladio Virtuel" in 2015 [2]. While the geometry was used to represent a generic quality, the grammar of topology was used to represent a specific quality yet still, communicable as a formal language. The formal grammar of topology is in the parallel opinions since the late 1970s when geometries were seen not enough to understand and design architecture in the complex world [3][4][5].

2 From Geometry to Topology

The formal grammars are connected with a couple of psychological theories in which a form is recognized in a certain cognitive interpretation to tell what is "really there" [6][v] beyond the appearance. The interpretation implies that a form is not just an individual talent but a collective or codified communication which is deeply connected with world reality on a fundamental level. [3][vi] As world reality becomes complicated, formal grammar should be modified accordingly.

2.1 Gestalt of Modern and Classical Grammar

From the classical to modern architecture, the concept of formal language has often been referenced from the geometrical grammar and their stable and absolute forms throughout history. This particular grammar roots in the conceptual foundation of "Gestalt psychology" [1] [vii]. Since the beginning of the 20th century, Gestalt psychology has operated as a framework in which forms are determined as generic and mathematical geometries at a fundamental level such as circle, rectangle, or triangle [1][viii]. The geometrical method of reading and designing has been argued as a legitimate and right way therefore stable [1][7]. Eisenman referenced the linguistic vocation of architecture from John Summerson's linguistic theory of "fundamental solids" [7] [ix] which was theorized in "The Classical Language of Architecture," in 1963 [7]. The concept of "solid geometry" [7][x] or "geometric solid(s)" [1][xi] was considered as constant and absolute throughout history as the fundamental grammar in architecture.

2.2 The Post-Modern and the Post-Post-Modern Language in Schizophrenia

However, a decade later, in "The Modern Language of Architecture" 1973, Bruno Zevi questioned the concept of "geometry" [3][xii] in the modern language. Although the modern language has been successfully settled down after Summerson's classical language, Zevi claimed that the codification of formal language should be eventually done independently and separately from the classical language for its own right [3][xiii]. This tells that Zevi refused to fix the modern language onto the early industrial modernism of abstract forms. On the other hand, modernization is a part of the eternal process of contemporary development where architectural forms evolve apart from the classical codification [3] [xiv]. In addition, Zevi theorized the most visible seven languages as real modern languages: Listing and Design

Methodology, Asymmetry and Dissonance, Antiperspective Three-Dimensionality, The Syntax of Four-dimensional Decomposition, Cantilever, Shell, and Membrane Structures, Space in Time, and Reintegration of Building, city, and Landscape [3].

4 years later, in “The Language of Post-Modern Architecture” 1977, Charles Jencks criticized the previous languages in a similar way to the Zevi’s criticism. Jencks theorized the post-modern language as a schizophrenic combination of classical and modern languages which is constantly changing and deviating in multiple ways [8][xv]. In “Architectural Theory since 1968” (2000) the schizophrenic language of post-modern architecture was recapitulated by Michael Hays as “Rorschach text” [9][xvi]. The meaning of Rorschach text even refers to anything without a generic or common cognitive framework. [9][xvii] Zevi claimed that in the first English version of “The Modern Language of Architecture” that Jencks’s post-modern language theory has a lot in common with his understanding of the real modern language over the pseudo modern language [3][xviii].

2.3 Arbitrariness of the Absolutes or the Situationals

There might be opinions whether the topological grammar is arbitrary compared to the absolute geometry. Whether the Gestalt framework prescribes the formal interpretation within an absolute cognitive structure of geometry, Rorschach’s framework seems to unleash the formal interpretation without a single meaning toward a maximum schizophrenic disorder where everything merges with every other and relates to one another. However, as man-made-artifacts, the level of arbitrariness of stable geometries should be looked at as the same as the level of arbitrariness of unstable topology. [3][xix] In this sense, the formal grammar of topology should not be overlooked as a random concept.

2.4 Topology to fill up the gap between geometries

In “Palladio Virtuel” (2015), Eisenman seems to continue the postmodern language with the concept of topology as an antithesis of geometry. On one hand, geometry was defined as stable; ideal; homogeneous which has been taught and forced to learn since the 15th century’s Albertian ideology [2] [xx] (Figure 1). On the other hand, topology was defined as unstable; virtual; heterogeneous which the 21st century’s architectural discourse should learn [2] [xxi] (Figure 3). The critical difference is that geometries are bounded in a certain context with fixed meanings but topologies break the bondage between form and the previous context in the poststructuralist strategies of language [2] [xxii]. The concept of topology should not be read as a form of disorder or mental illness. It is an opposition strategically to the conventional concept of geometry in a certain measure. Therefore, it can be said that the concept of topology shall be positioned between the gaps created by the classical and modern language of geometry, and the postmodern language of schizophrenia.

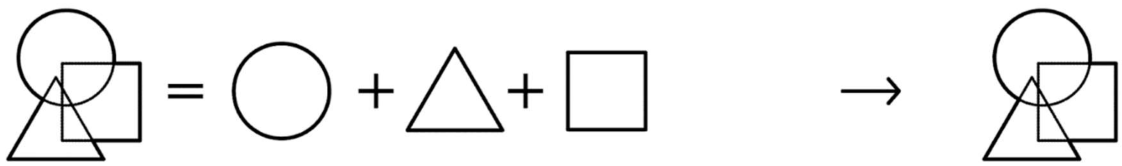


Figure 1. The diagram of geometrical interpretation

3 Definition of Topology

The term, topology, conceptualized by Eisenman could be compared with the same term topology from the computational idea such as “blob” [10] [xxiii] by Greg Lynn’s theory. This is not only because the word is the same but also because Lynn and Eisenman share a certain cultural meaning through the term topology over the difference and blob theory was set up with help of Eisenman in the middle of 1990s [8] [xxiv] (Figure 2) .

The “Blobmeister”, [8] [xxv] Lynn’s definition of topology refers to a smooth surface on which multiple vectors are flowing without a strict collision [10] [xxvi]. It could be said that this concept of topology was fashioned out in architectural discourse during the 1990s to 2000s in so-called the process of computationalization in the architectural design field. It emphasized a topological smoothness as a “single surface” [10] [xxvii]. Lynn exemplified the concept of topology in reference to Italian Baroque architecture such as San Carlo Alle Quattro Fontane which shows the topological principle of smoothness through “topological surfaces” [10] [xxviii]. The concept of topology is considered as an antithesis of the Cartesian doctrine which is fixed and rigid in form [10] [xxix].

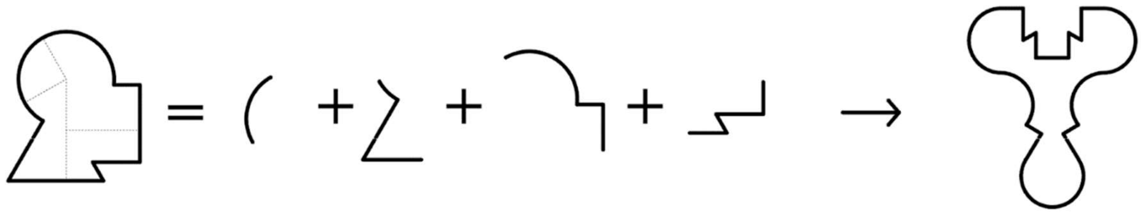


Figure 2. The diagram of topological interpretation: A problem of surface

On the other hand, Eisenman’s definition of topology refers to a form which belongs to multiple geometries at the same time [2] [xxx]. This contradicts Lynn's definition of topology that remained on the surface. In addition, Eisenman’s topology is less related to the physiognomic smoothness. It often addresses an opened or broken form “disaggregated” from “Cartesian geometry” [2] [xxxi]. Therefore, topological forms show a “relational condition” [2] [xxxii] between multiple geometries inside and outside the physiognomic forms. This implies that the concept of topology challenges any idealistic, conventional, traditional, or familiar interpretation of forms [2] [xxxiii]. The topological reading naturally entails not only the idea of form in a priority, but also space, program, and function following the primary concept of form (Eisenman, 2015) (Figure 3). This is where the “conceptual” [2] [xxxiv] framework intervenes.

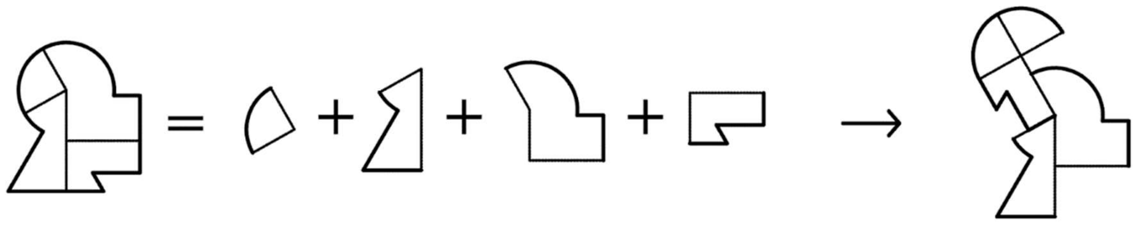


Figure 3. The diagram of topological interpretation: A problem of form

4 Application of Topology

Studio Experimental Design (SEE 22-23) from The University of Wuppertal offers a 1-year-long design research course to the students in the Master degree program. It is a part of 6-year-long research conducted by the author supervised by professor Holger Hoffmann from DME (Design and Representation Methodology Lab.). In the summer of 2022, the studio analyzed buildings from Berlin in topological methodologies. The following two models are parts of the analyzed buildings: a Interbau 57 [xxxv] project in Bartningallee 16, Hansaviertel by Hans Schwippert and a IBA 87 [xxxvi] in Charlottenstraße 97a, Kreuzberg by John Hejduk as following examples. The Interbau 57 project is a high-rise resident building and the IBA 87 project is a residential complex with a studio tower. The base models were firstly constructed in a digital space by a student [xxxvii]. Later, the models were edited and rendered for the following diagrams by the author.

Figure 4. Two building references by Hans Schwippert (left) and John Hejduk (right)

The analysis aims at reading topological forms over the geometrical doctrine which has been fundamental in reading architectural grammar over the decades. The concept of topology will provide unseen, unspoken, or untaught forms to extend the capacity of formal grammar which have been overlooked by the well-known framework of geometrical grammar. A couple of buildings are conceptually chosen from different, otherwise antithetical contexts to test the topological grammars to a certain extent. In addition, the precision of building forms should be acknowledged in as much as the analysis methodology is explained through this research. The building forms are represented in a fictional diorama setting in which formal grammars are recognized without unnecessary interventions of the original environment.

4.1 Geometrical reading

First of all, the Interbau 57 project by Hans Schwippert is a 16-story-high residential tower on Tiergarten of Hansaviertel, Berlin. It consists of four rectangular volume geometries. The main volume occupies the center of the building. The main volume is again divided into four volumes to separate the resident units into three with the central hallway core with stairs and elevator which extrudes in the center of the rooftop.

The other three rectangular geometries surround the main volume facades except the Northern one. The three facade geometries split into deep facade structures which frame and filter the views inside and outside of the building. The joint parts from the main to the facade geometries are tapered or cut-out to accentuate the facade frames and offer terraces not only toward the direction of the frames but also toward the sides. In addition, the facade structure indicates a maisonette configuration in the residential units. On the one side, the joint parts open the facade structure to the side on every second floor for two stories. This provides not only the individual garden terrace (ref) but the extra rooms inside the unopened parts. On the other side, every terrace merges into two floors which provide wider views and more sunlight.

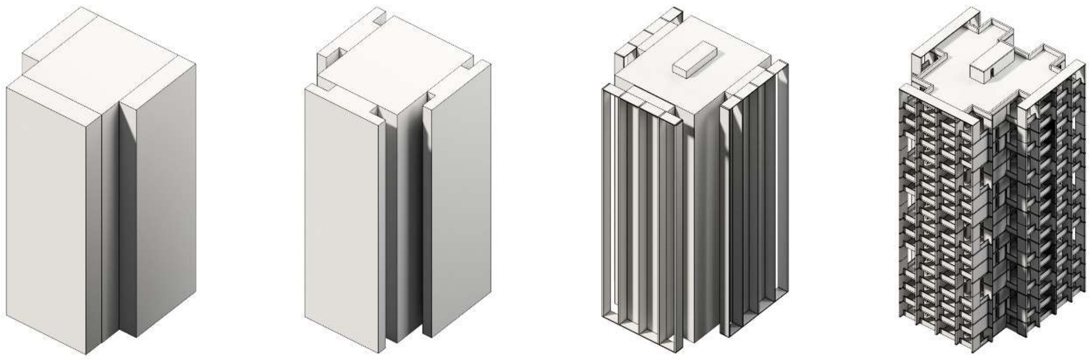


Figure 5. The geometrical grammars: Residential tower by Hans Schwippert

Second, the IBA 87 project by John Hejduk is a residential complex consists of two parts: two low-rise buildings and a studio tower in the center. The buildings represent a human face with a “masque”[11] which is expressed with geometrical forms such as rectangles, triangles, and circles.

The studio tower is a 14-story-high building. It consists of five geometrical volumes. The main volume is for the living room which connects to the maisonette floor. The two small rectangular volumes on the side provide a bed room and a restroom individually. The circular and longitudinal rectangular volume offer the vertical circulations as cores: circular volume for the staircase and rectangular volume for the elevator. On the front facade to the South, each residential floor unit of the main volume has two rectangular window openings with two rectangular balconies under the triangular roofs for the balconies. In the same direction, the facade of the two smaller rectangular volumes on the side has the same triangular roofs for the rectangular window openings on the same floors with the balconies. Eventually, the four triangular volumes are aligned in straight lines on each floor. The two low-rise-buildings are 5-story-high buildings. They consist of five geometrical volumes too. The main volume has a rectangular form and two triangular forms on it. These forms are extruded throughout the site in a longitudinal direction. On the side facades in the Western and Eastern directions, the division of residential units is expressed in a square grid formation overall. On the front facade, three triangular balcony roofs and two balcony units are allocated to express a human face or masque.

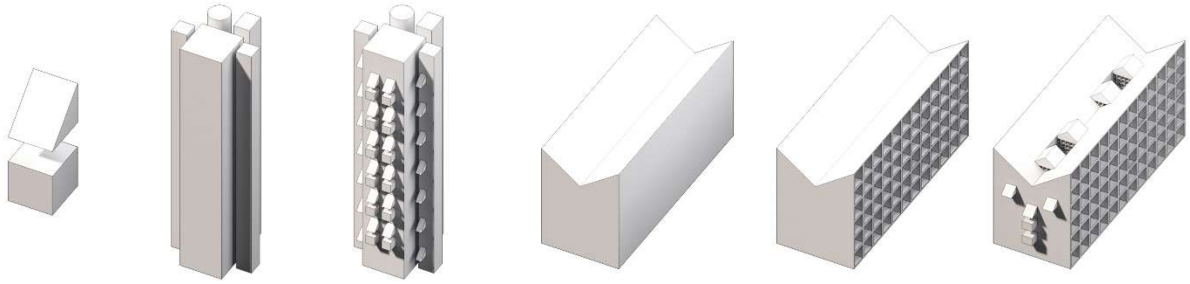


Figure 6. The geometrical grammars: Residential complex by John Hejduk

4.2 Topological reading

First of all, topological reading requires a conceptual framework in identifying specific forms compared to the generic forms from geometrical reading. Each reference building provides four languages under a grammatical coherence. In the case of the Interbau 57 project, the grammar of *extension* is extracted. This is conceptualized in an opposition to the grammar of *enclosure* extracted from the IBA 87 project. In general, different from the geometry's complete look, the topological forms look incomplete, unfinished, or broken. However, they are repetitively shown and considered as adequate or efficient to understand the hidden characters behind the grammar of geometry (Figure 7).

Figure 7. The overview of topological grammars: Residential tower by Hans Schwippert (left) and Residential complex by John Hejduk (right)

In the case of the Interbau 57 project, the grammar of extension is formulated from a distinctive yet, consistent system of extension. The meaning of the extended forms refers to the character of extension which connects structures and spaces in both physical and visual ways. As the forms are extended, the structural configuration and spatial quality are extended and connected in one. (Figure 8)

The first grammar locates in-between roof top, balconies, and rooms under the roof. The vertical structure supports not only the floors but also extends to the horizontal direction. This extension of vertical structure eventually connects and merges spaces from the roof top, to four balconies, and the spaces below it. The second grammar locates in-between vertical core, balcony, and corridor. This unique grammar provides not only the internal circulation but also extends the connection between the internal movement to the external one. The residents must pass through the external space to move in the vertical direction. The third grammar locates in-between internal maisonette and balcony throughout two floors. The wall structure seems to be a part of the internal structure coming through the wall facing the South. However, the wall is separated from the internal structure and distanced from it while extending the view horizontally from the South and East for the residents. The horizontal extension extends once more to the upper floor of maisonette where the two floors share an extended view. The fourth grammar located in-between two balconies within a residential unit. The distanced wall structure from the inside seems to be similar to the previous grammar. The distanced wall structure extends the view together in horizontal directions.

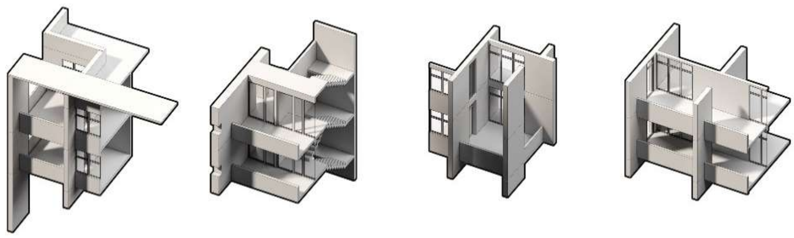


Figure 8. The topological grammars of extension from the residential tower

In the case of the IBA 87 project, the grammar of enclosure is formulated. The meaning of closed forms refers to the character of closeness which expresses the completeness or containment over the diverse connections made between structures and spaces. Different from the Interbau 57 project, the forms of extension are accentuated in the status of being closed or wrapped without loosing geometrical characters completely (Figure 9).

The first grammar locates in-between roof and the façade. The form of masque is complete after a large portion of side facades is removed. The dense grid of openings immaterializes the side facades rather than keeping the forms. The previous reading of a combination from rectangular and triangular extrusions is disaggregated and a seamless assemblage with an irregular edge condition wraps around and closes a frontal part of the building. The second grammar locates on the loft space. The gable roof figure or a combination of triangular and rectangular volumes are dissolved in the opened space. However, the grammar of dissipation is still captured and closed within a geometrical outline. The third and fourth grammar are located in the back façade in the North. Both are breaking the symmetrical character of the main square volume which is even more accentuated with two lateral square volumes in the Western and Eastern façades. The main and the lateral volumes are stationary inside the residential unit. The closed volumes of circular and rectangular volumes [xxxviii] are merged from the back to the main square volume as vertical movements: circular volume of staircase and rectangular volume of elevator core. The geometrical stationary of symmetry from the main and the lateral volumes are balanced with other two vertical yet, asymmetrical volumes.

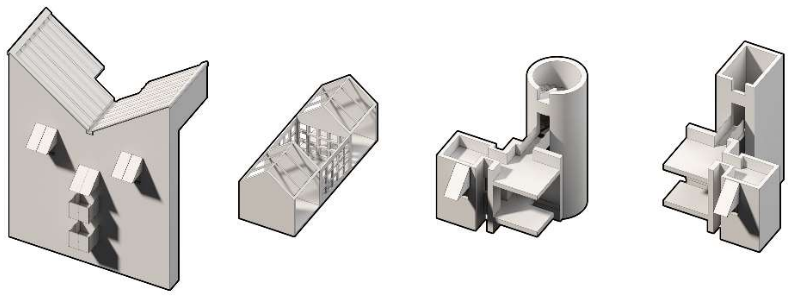


Figure 9. The topological grammars of enclosure from the residential complex

4.3 Grammars of assemblage

The design research proceeded a couple of experimental steps to test how the extracted grammars work in a designing process. The meaning of experiment refers to a new formal methodology beyond the geometrical doctrine inside the given reference buildngs. Instead of repeading the same geometries, the research aimed at merging the two grammars in one to expand the design capacity. The new design grammar contains two antithetical forms of opened and closed in one to control diversity. The merged grammars reveal a dual status of a half closed and a half opened characters in structure and space (Figure 10).

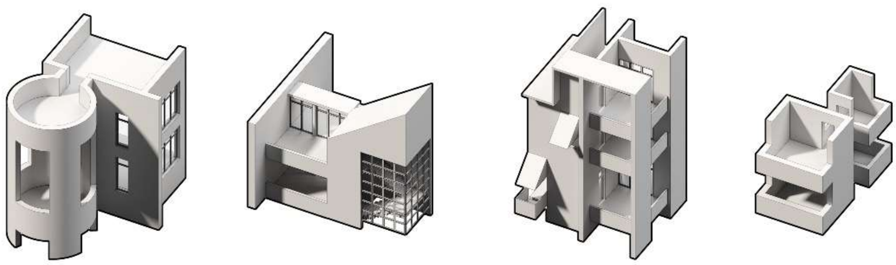


Figure 10. The merged grammars of extension and enclosure

4.4 Grammars in complexity

The analysis continued through an experimental design procedure while pushing the grammatical capacity of the four mixed grammars to the certain complexity in a digital space. This didactic procedure aimed at holding a grip on the complexities in structure and space based on the grammatical principle. The concept of complexity is possible to be communicated through formal principles without reducing the structural and spatial qualities into simple geometry. In a larger perspective, the experimental design has conducted three procedures: making closed forms more closed, making extended forms more extended, and making closed forms more extended (Figure 11).

In the formal representation process of rendering, the materiality crosses over the concept of topology (Figure 12). In an isolated digital space of diorama, architectural forms expand its topological capacity to the environmental element such as ground. The articulated topological forms are not placed on a plateau but intertwined with it. The topological effect is enhanced with interchaning textures between architectural forms and the ground. The dichotomous relationship between architectural form and the ground is virtually recalibrated in a topological whole.

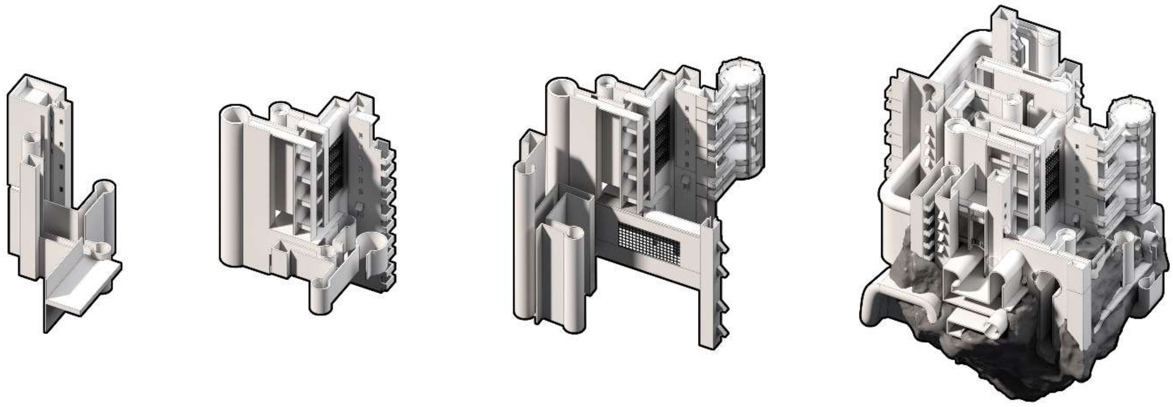


Figure 11. A design possibility with the grammars of extension and enclosure

5 Conclusion

In the 21st century, the problem of unspeakable architectures seems to be growing in digital or urban environments. For example, photogrammetry and AI-driven technology often represents the world with unrecognizably merged forms in digital spaces. This is not only because the grammatical simplicity cannot explain the current situations but also because the current chaotic environments are impossible to explain. This research continues questioning if architectural discourse itself has not been followed up with a new language for today.

The grammatical study in architectural form challenges the problem of reduction by architectural grammars. It attempts to break the common belief that linguistic studies of architecture simplify and regress architectural forms within a limit. At the same time, this study considers that the concept of complexity should not be looked at as a total chaos without a principle. On the contrary, the grammar of topologies is proposed to mediate between the generic grammar of geometries and the specific situations. In other word, our perception of architectural forms is neither saturated by Gestalt theory nor schizophrenic interpretation.

> We are squandering a colossal heritage of expression because we shirk the responsibility of transcribing it and making it transmissible. It may not be very long before we forget how to speak architecture at all. Indeed, most people who are designing and building today can barely mumble [3] [xxxix].

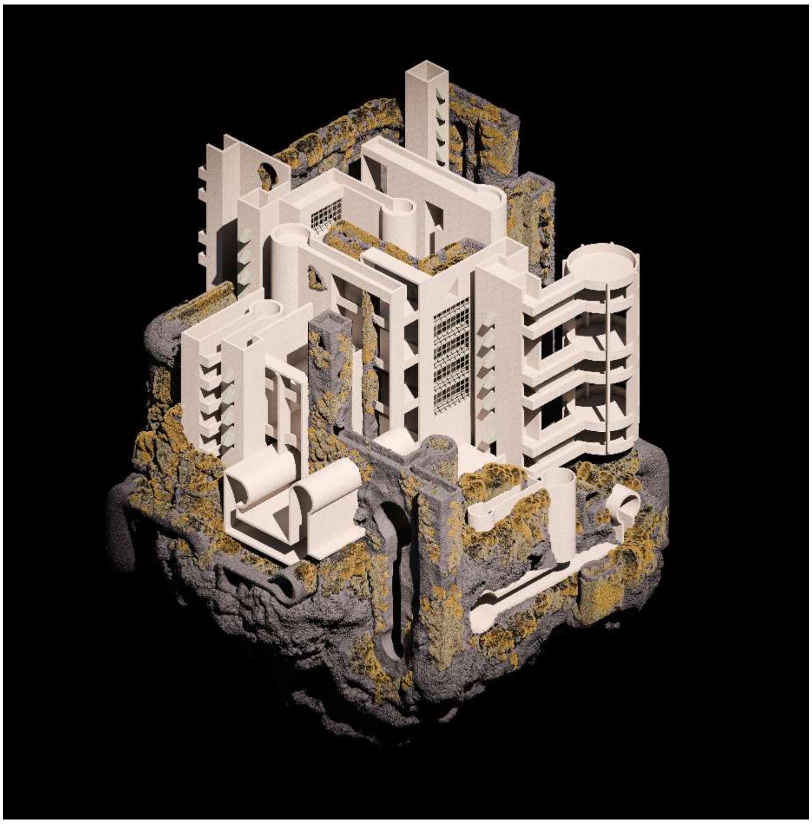


Figure 12. The diorama of extension and enclosure. (Source: Marcus Andrei)

Acknowledgements

The paper is written based on the in-depth communications between the author and the students under the supervision by professor Holger Hoffmann in the University of Wuppertal. The core narrative has been constructed in an immense support from professor Hoffmann together with the funding. In addition, the research project itself in the Studio Experimental Design 22-23 should be acknowledged with the name of student: Marcus Andrei.

References

[1] Eisenman, Peter, *The Formal Basis of Modern Architecture*, Lars Müller Publishers, Zurich, Switzerland, 1963; 2006.

[2] Eisenman, Peter, *Palladio Virtuel*, Yale University Press, New Haven and London, U.S.A. and UK, 2015.

[3] Zevi, Bruno, *The Modern Language of Architecture*, University of Washington Press, Seattle and London, U.S.A. and UK, 1974; 1978.

[4] Colquhoun, Alan, Form and Figure, in *Essays in Architectural Criticism: Modern Architecture and Historical change*, The MIT Press, Cambridge, Massachusetts, and London, UK, 1978; 1981

[5] Jencks, Charles, *The New Paradigm in Architecture, The Language of Post Modernism,* Yale University Press, New Haven and London, U.S.A. and UK, 2002.

[6] Gombrich, E. H., Art and Illusion, Princeton University Press, Princeton and Oxford, UK, 1960; 2000.

[7] Summerson, John, *The Classical Language of Architecture*, The MIT Press, Cambridge and Massachusetts, U.S.A. 1963.

[8] Jencks, Charles, Post-Modern Architecture, in *Architecture Theory since 1968*, The MIT Press, Cambridge, Massachusetts, and London, U.S.A. and UK, 1998. (Originally in *The Language of Post-Modern Architecture, 1977)*

[9] Hays, Michael, Introduction of Post-Modern Architecture, in *Architecture Theory since 1968*, The MIT Press, Cambridge, Massachusetts, and London, U.S.A. and UK, 1998.

[10] Lynn, Greg, Animate form, Princeton Architectural Press, New York, U.S.A., 1999

[11] Koch, Eva, F-IBA, Wohnbebauung mit Atelierturm, http://f-iba.de/wohnbebauung-mit-atelierturm-john-hejduk.

---

[i] Eisenman, *The Formal Basis of Modern Architecture*, 20.
[ii] Ibid, 21.
[iii] Ibid, 17.
[iv] Eisenman and Roman, *Palladio Virtuel*, 10.
[v] Gombrich, 5.
[vi] Zevi, *The Modern Language of Architecture*, 3.
[vii] Eisenman, *The Formal Basis of Modern Architecture*, 17.
[viii] Ibid, 17.
[ix] Summerson, *The Classical Language of Architecture*, 17.
[x] Ibid, 42.
[xi] Eisenman, *The Formal Basis of Modern Architecture*, 19.
[xii] Zevi, *The Modern Language of Architecture*, 12.
[xiii] Ibid, 3.
[xiv] Ibid, 3.
[xv] Jencks, *Post-Modern Architecture*, 313.
[xvi] Hays, *Post-Modern Architecture*, 306.
[xvii] Ibid, 306.
[xviii] Zevi, *The Modern Language of Architecture*, 6.
[xix] Ibid, 6.
[xx] Eisenman and Roman, *Palladio Virtuel*, 10.
[xxi] Ibid, 10.
[xxii] Ibid, 11.
[xxiii] Lynn, *Animate Form*, 30.
[xxiv] Jencks, *Post-Modern Architecture*, 210.
[xxv] Ibid, 210.
[xxvi] Lynn, *Animate Form*, 10.
[xxvii] Ibid, 31.
[xxviii] Ibid, 17.
[xxix] Lynn, *Animate Form*, 11.
[xxx] Eisenman, *Palladio Virtuel*, 16.

[xxxi] Ibid, 11.

[xxxii] Ibid, 10.

[xxxiii] Ibid, 18.

[xxxiv] Ibid, 16.

[xxxv] Interbau 57 is an urban project for luxurious collective housings called “Hansaviertel” constructed from 1957 to 1961. The project was to show off the context of West Germany’s democratic ideology and economic power to the German Democratic Republic. The reconstruction of Hansaviertel was celebrated with a large number of participations of renowned architects in the world followed by a national-scale exhibition event. It was also an answer for a large-scale housing shortage yet, it was only for the wealthy people.

[xxxvi] The International building exhibition (IBA) in Berlin from 1984 to 1987 was a urban living movement / development reaction against the isolated living in the modern lifestyle. The event invited world famous architects to the inner city of Berlin. Each project filled up with mix-use-programs together with residences. The principal design method was to recover and rediscover the history of the city which had been forgotten from the diverse modern movements such as Interbau 57 and gigantic housing estates in the outskirts of Berlin.

[xxxvii] Marcus Andrei

[xxxviii] The rectangular volume was a triangular volume when it was proposed to IBA 87 in 1984 (IBA, Internationale Bauausstellung Berlin ‘84’87, Bauaustellung Berlin GmbH, 1984, 144-145.

[xxxix] Zevi, *The Modern Language of Architecture*, 3.

EXPERIENCE OF AGRICULTURAL BANK OFFICE DESIGN FOR SUSTAINABLE FUTURE

Bilge Başaran Çağlayan, M.Arch, Middle East Technical University

ISBANK (Türkiye İş Bankası)

Mimar Kemalettin cad.no:2 kat:6, 35210, İzmir, Türkiye; bilge.basaran@isbank.com.tr

Abstract

Türkiye's largest institution in the banking sector, ISBANK, made it a top priority to understand the needs of the society correctly and to support the society in terms of sustainability with a vision becoming bank of the future, creating sustainable value with an inclusiveness.

In the beginning of year 2022, Isbank aimed to design a new branch, specialized in Agricultural Banking, in order to support sustainable agriculture, to support the effective use of world resources, and to stand by the farmers.

After long term research including interviews with local customers (farmers, and the people in agricultural sector), design principles are determined for the new consept of design. Creating a meeting point that fullfill togetherness, exchanging and sharing ideas, using biofilic principles with natural materials, warm colors, green plants inside, designing an area for children, comfortable working areas that are both easily accessible and also private, bringing technology and tecnological devices that will increase productivity in agriculture were the main design goals.

The branch was completed in June 2022, and opened in the same month. Since its openning, it has received great interest, satisfaction from the customers who have been included in the design process. This successful design concept will proudly be implemented in other provinces of Türkiye.

Figure 1. Example figure

Keywords

Sustainability, Design Concept, Inclusiveness, Agriculture and Bank Branch.

I Introduction

ISBANK, the first national bank of Türkiye founded on the aspirations of Mustafa Kemal Atatürk, is the largest and most respected institution which has almost 1200 branches spreading all over Türkiye. Its vision is to become the bank of the future, creating sustainable value with an inclusive and participatory approach. Therefore, ISBANK has made it a top priority to understand the needs of society and to support society in terms of sustainability.

It is known that the effects of human activity on the environment and climate are dominant. Since the beginning of the 1990s, it has been discussed that architectural design should be sustainable and support sustainable development. (Sayigh and Trombadore, 2022)

Design for sustainability over the last 30 years has highlighted the design approach inspired by nature, making the elements of nature a part of architecture, using the world's resources efficiently and reducing consumption. (Bhamra, 2019) In other words, Sustainable architectural design aims optimizing the quality of life, energy efficiency, and the use of materials in the design.

Sustainable design is also referred to as environmentally conscious or responsible design. One of the main goals of sustainable design is reducing the overall ecological footprint by not only focusing on saving energy and natural resources, but also on increasing the wellbeing of employees, making them feel comfortable in the workspace and improving the quality of their lives.

Responsible design requires the actions of individual designers and design teams focused on economically responsible behavior, environmental responsibility and social responsibility. (Eppinger and Maier, 2019) These have three aspects which are People, Planet and Profit.

'People' indicates that socially responsible design should create better work conditions. Whereas, 'Planet' focuses environmentaly responsible design that meets the needs of future generations. Beside these two, 'Profit' defines economically responsible design that encourages people and organizations to interact with others in a respectful and sustainable manner. (Zeiler, 2022)
These three aspects can be introduced under the name of sustainable triangle. (Bhamra, 2019)

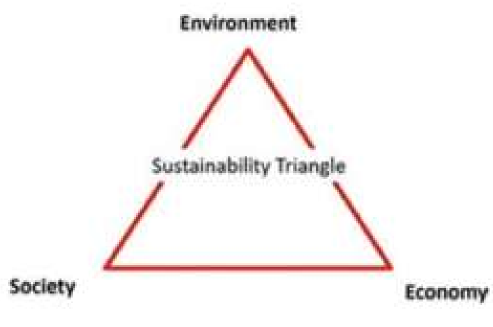


Figure 1. Sustainable Triangle

In this context, ISBANK aimed to design **a new branch**, specialized in Agricultural Banking, in order to support sustainable agriculture, to support the effective use of world resources, and to stand by farmers. After many months of studying and defining the design principles with experts on agricultural banking, branch members and of course farmers, we designed and implemented our new branch.

In this article, we will explain the details of this design, its application and how architecture can contribute to both the world and a sustainable future.

When the idea of a sustainable branch design focused on agriculture emerged, we first wanted to visit and listen to the farmers, who are the main customers, in their villages to understand and assimilate their needs. In almost all meetings with our farmers, we heard that they need places that allow sector specific training, information and conversations, where they can get and share information, and where they can feel that our bank is standing by their side with its guiding vision, both financial and sectoral.

In addition to providing financial support to farmers through banking, we started our architectural design with the aim of using natural resources more efficiently, increasing efficiency by sharing technology and recent developments, expanding the vision of our farmers by providing trainings, and bringing them together with our publications in the field of agriculture.

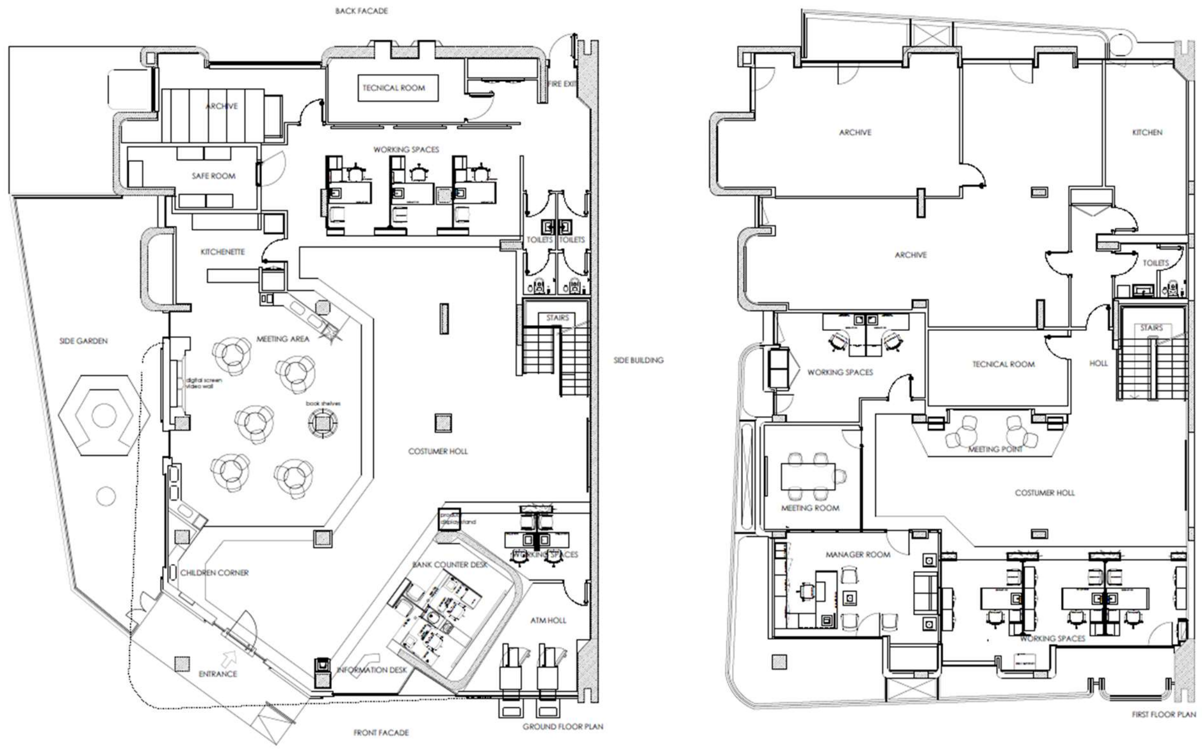


Figure 2. Ground Floor and First Floor plan

The focal point of our design is the 'meeting area', which we created by using design elements that will give the feeling of open space in the warmth of a village cafe, where customers can feel themselves at home.

Figure 2. Digital screen/video wall

By placing our meeting area at the center of our design, we wanted our branch to be used as a meeting point. In this area, we aimed to enable our customers to benefit from library where publications related to agriculture are displayed, to bring the sectoral developments to our farmers instantly with a digital screen, and to exhibit technological products in the agricultural sector with a presentation stand to introduce them to our farmers. We aimed to create an atmosphere that will give a feeling of intimacy and warmth with natural and eco-friendly materials and color tones we used.

Figure 3. Meeting area like a village cafe

Figure 4. Natural Materials-wood panels on walls and ceilings, live plants,

Not forgetting our children, who are the guarantee of our future; we created a corner with wall puzzles containing natural materials, figures related to nature, and books on agriculture and children by IS KULTUR Publications in a way that is visually connected with our meeting area. While our little visitors, who come to our branch with their parents, have a pleasant time, we imagined that they were reading these publications provided for them with care and precision.

Figure 5. Warm color tones

Figure 6. Children's Corner

Again, in line with the feedback we received, we designed an exhibition area together with the presentation stand where our customers can display their products whenever they want. The stand can also be used to display the İş Kültür Publications' books on agriculture. It is positioned at the entrance of our branch so that it can be seen from the outside. We wanted to create an aesthetic integrity with color, material and harmony in all these different functional areas located around our meeting area, which is the focal point of our design.

We designed comfortable working areas and on the walls we used pictures of farmers and products specific to the region.

Figure 8. Local plants specific to region as seperation

Figure 9. Bank counter

Another very important element of our design is our solar energy panels, which we proudly apply within the scope of sustainability. We rearranged the roof area in such a way that we installed 54 solar panels in order to generate electricity. Thus, while providing all the electricity needs of our branch, we have established a system where we can give the energy we produce to the electricity institution in case of excess production, creating added value.

Figure 10. Roof solar panels

By using water purification for drinking water, we reduced the consumption of PET bottles. We are currently working on a system that will collect and reuse rain water.

On the façade, we tried to reflect the dynamic and innovative face of ISBANK. The grafic design we use, includes radial forms that symbolizes ‘entering to a new world’ and invites people. Unlike our other branches, we used the most common local products on our graphic design.

Figure 11. Photo from facade

In conclusion, As ISBANK, Türkiye’s largest and most respected institution, we believe architecture must foster and create changing needs of communities and customers for sustainable and inclusive future. Our design principles are based on the beliefs that sustainability cannot be achieved without collective action. Therefore, from beginning to end of the design we include the needs of all the people related. From now on, we will proudly and continuously develop our design within the scope of sustainability and implement it in other provinces of Turkiye.

Acknowledgements

I would like to thank our Agricultural Banking Team, who participated to the conversations we had with the farmers from the beginning of the design of the concept, and gave all their sincere contributions during the development of the project. And of course, another big thank you to my dear teammates who work side by side with me.

References

[1] Sayigh and Trombadore, Innovative Renewable Energy Series, The importance of Greenery in Sustainable Buildings, Ebook, Springer Nature, Switzerland, 2022,

[2] Zeiler, W., Chapter1:The Added Value of Greenary for Sustainable Building- The Perspective from Netherlands, Ebook: The importance of Greenery in Sustainable Buildings , Springer Nature, Cham, Switzerlend, 2022

[3] Eppinger, S. and Maier, A., Responsible Design: Recognizing The Impact of How We Design, 22nd International Confrence on Engineering Design (ICED19), Delft, Netherlands, 2019

[4] Bhamra,T., Mattson C., Pack A.T., Lofthouse, V., Using a Product's Sustainability Space as a Design Exploration Tool, 2019

REMINDING OF PAST & BUILDING FOR FUTURE:

JUDENPLATZ & FOLEY SQUARE IN 2000

Elif SÜYÜK MAKAKLI*, Nil DÖĞERLİOĞLU

FMV Işık University, Faculty of Art, Design and Architecture, Department of Architecture

FMV Işık University 34980 Şile/İstanbul-Türkiye;

* elif.suyuk@isikun.edu.tr , nil.dogerlioglu@isikun.edu.tr

Abstract

Urban monuments are symbolic elements that reflect the experiences of the city. These works add a new layer to the existing physicality of the city, new meanings to the collective memory, and the city's identity by adding tangible and intangible new values to the space. The Squares, defined by their different physical properties, are perceived as multidimensional and multi-layered. The spatial setup of the squares, which form and reflect the memory of rapidly developing and transforming cities, has been enriched with natural and artificial physical elements, monumental elements, and sculptures. The focus has been enriched with monuments in the squares formed by artificial and natural borders. Monuments create a plastic arrangement as a physical component that defines, shapes, and changes the space they are set in, and the memory of the square, a micro-scale of the city, is redefined with the monument. While monuments are read as a tool to take precautions against forgetting, coding experiences with monuments, make it necessary to be associated with time and space. In this study, two monuments named Holocaust Memorial in Vienna-Judenplatz and Triumph of the Human Spirit in New York City's Foley Square, which opened in 2000 were examined. UNESCO has designated the year 2000 as the International Year for the Culture of Peace, and both monuments represent different historical events. The study reveals the relationship between monuments and architectural transformations in an urban context. The main purpose is to understand the meaning, context, and relation between the selected monuments and the city. The spatial relationship established with the tangible and intangible elements that make up the built environment, building order, building typology, and urban open space, which defines the square where the selected monuments are located, has been evaluated. The method for the demonstration of assessment depends on historical analysis of urban plans, literature review, visual documents, and field observations. The presence of monuments produced with the motto of facing the past in a sense in public spaces is also associated with the claims of different cultural groups on the public space. Significant historical events, social and political developments, changes, and transformations form the political and identity context of the public space with different forms and symbols. Victories, uprisings, and ideological ideas become visible in the public sphere by being symbolized by different elements as a reflection of social memory. The message given by the monuments becomes controversial in the public sphere and how it is perceived is related to the area's features. The relationship between the

monuments and the square has shaped, defined, and customized the square as a physical component while symbolizing it as an architectural element.

Keywords

Urban Square, Monument, City, Transformation, Collective Memory

1 City, Square, Monuments and More

Historically, cities have developed, changed, and transformed, affected by sociological, cultural, and technological developments. As the products of centuries of evolution, cities reflect and create changes. Few cities today are inhabited exclusively by any single ethnic, linguistic, or religious group. A history in which different groups have been in the ascendancy at different times is almost certain to mean that, in the absence of a calculated effort to wipe out traces of one group, a city's landmarks will reflect the identities of more than one group [1]. Certain artifacts become a part of the city's memory, and new ones are added to them throughout history in cities, which are the places of collective memory created by the citizens with daily practices and historical events. The unity between past and future in relation to events and forms is embedded in the idea of the city. The city image is defined by roads, borders, regions, nodes, and landmarks elements [2]. With the experience of the urban environment through cognitive processes, each individual's image of the city is formed in their mind. The boundaries encountered in the city can be physical or perceptual [3]. The physical boundaries determined by architectural or natural elements, stand out as a central balancing element between the voids and the masses in the urban fabric.

Krier defines urban space as "all types of space between buildings in towns and other localities" [4]. The urban environment has various spatial forms, which can be grouped into two broad categories, open and closed spaces. Squares, streets, parks, playgrounds, and gardens are all voids that have been limited to or defined to create an enclosed space [5]. Urban square is the most prominent and conspicuous element of urban structure [6] which relates to city's historical, cultural, social, and physical structures. Urban square is a public space, which functions as a gathering place on certain days for social, cultural, political, and commercial purposes. Thoughts, discourses, and actions are produced and developed in public spaces. The concept of public space first emerged in the squares of the Ancient Greek city-states. Agora was an open space where trade and social activities took place. The public space has been evaluated as a political space where free individuals make political decisions through discussion [7]. Then the "forum", the wide-open space in the cities of the Roman Empire was designed in accordance with the participation of large masses for social, economic and political reasons [8]. Since its medieval beginnings, the square has been defined as the focus of a social concentration specified by the surrounding structures [9]. Sitte [10] stated that the main elements that determine the forms of squares are the nature or structures that limit them. Besides the built environment, the square is also shaped by the period's economic, social, and political conditions.

The built environment is material basis of collective memory by remembering living habits and containing information about historical transformations. Architecture, as an arrangement of material elements, must be understood as a product of memory and physical support [11]. Although urban squares are physical encounter places of people, modernity has saved people from the restrictions of face-to-face relations in the locality of pre-modern societies and led to the stretching of relationships throughout time and space [12]. According to Andreas Huyssen, most national memory projects are organizationally linked to transnational debates in museology, memorial design competitions, human rights activism, and mnemonics [13]. Research on commemoration places emphasizes the participatory roles in developing transnational memory [14]. Memory and commemoration were essential themes in the 1980s and 1990s, and monument practice was reconsidered, and Europe and the United States were called to commemorate the victims from the colonial period to the Cold War [15]. The General Assembly of the United Nations proclaimed International Year for the Culture of Peace 2000 to strengthen respect for cultural diversity, promote tolerance, cooperation, solidarity, dialogue, and reconciliation at the international level and establish a peace culture [16].

This study discusses the spatial and contextual meaning of the Holocaust Memorial in Vienna-Judenplatz and Triumph of the Human Spirit in New York City's Foley Square, which was opened in the same year, 2000. The study aims to understand the meaning, context, and relation between the selected monuments, which have traces that refer to the history and experiences of the city and the squares. Research reveals the relationship between monuments and transformations in spatial and urban contexts. According to Larkham and Jones [17] to evaluate the character of the urban space, townscape analysis should be carried out that studies the main elements such as buildings, open spaces, streets, and site layouts. The research analysis is categorized under three headings: the aspects that determine the square, reminder elements, and perception on the human scale. The method for the demonstration of assessment depends on historical analysis of urban plans, maps, literature reviews, visual documents, and field observations. The spatial relationships between square and monuments and how they perceived are analysed through 2-D plans, elevations, sections and set of views. The perspectives are drawn to represent the visual experience in street level.

2 Judenplatz, Vienna - 2000

One of the selected cases of the research is Judenplatz in Vienna, which has managed to preserve its characteristic silhouette in the historical process. The city's authenticity is mainly due to the overlapping and multi-layered historicity of buildings, structures, and spaces. The Historic Centre of Vienna inscribed in 2001 on the World Heritage List under the following criteria:

> Criterion (ii): *The urban and architectural qualities of the Historic Centre of Vienna bear outstanding witness to a continuing interchange of values throughout the second millennium.* Criterion (iv): *Three key periods of European cultural and political development - the Middle Ages, the Baroque period, and the Gründerzeit - are exceptionally well illustrated by the urban and architectural heritage of the Historic Centre of Vienna.* Criterion (vi): *Since the 16th century Vienna has been universally acknowledged to be the musical capital of Europe.* [18]

The city has important monumental commemorative works designed for a specific purpose and symbolizes past events, people, or a certain conceptuality in urban areas open to public use. Judenplatz is a square in the center of the city that was the center of the Jewish community in the Middle Ages (13th and 14th centuries, first mentioned in documents in 1294). The Jewish name of the square is from the 15th century and this name became official in the 19th century [15]. In this period, against the forced baptism pressure, some Jews committed suicide in the Synagogue, which was located in the square and destroyed after a while. Judenplatz was the centre of what was once the Jewish Town, The Or-Sarua Synagogue, the Jewish School and the Ritual Bath were located. This first Jewish community in Vienna fell victim to a pogrom in 1420/21, in which the inhabitants of the district were expelled or murdered, and the buildings were destroyed [19].

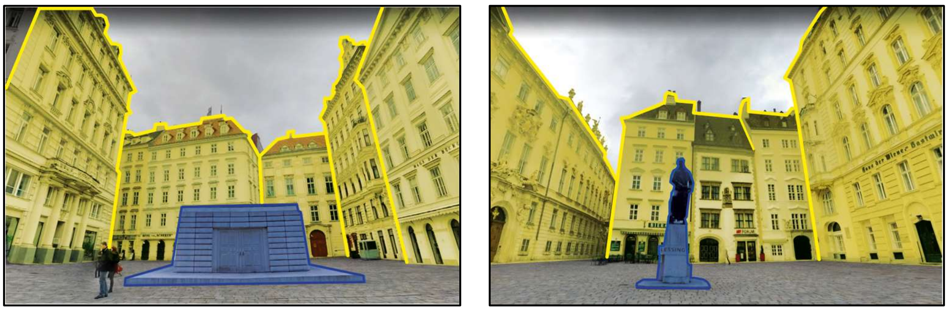


Figure 1. Holocaust Memorial and Lessing Statue in Judenplatz

This baroque square is a unique unit of remembrance with the Holocaust Memorial, the excavations of a medieval synagogue, Misrachi Haus (1693) a museum about medieval Jewry, and the Lessing Statue (Figure 1) [20]. The Holocaust Memorial commemorates the 65,000 Austro-Jewish victims murdered under the Nazis. The buildings, among them one of the city's oldest ones, surrounding the square are primarily for residential use. Mozart lived in 1783 in another building mentioned on the facade on a panel looking to the square.

Before the monument project, archaeological work began in the square, and the foundations of the Synagogue and the bimah were found half a meter below the road level. (a platform where the Torah was read). In the competition specification announced for the monument design, it was not obligatory to associate the monument with the remains [15].

In 1996, the work designed by the British sculptor Rachel Whiteread, later called the Nameless Library, was chosen. The time from the decision to build the monument to its opening took longer. In this work, a visual relationship with the remains was not established at the artist's request. However, the bimah's location effectively determined the monument's location. It has been the scene of various discussions and criticism during the design and implementation phase. However, the ruins not establishing a visual relationship with the square have come to the fore. Finally, the square was pedestrianized, and the monument was unveiled in 2000. Architects Jabornegg & Pálffy designed access to the archaeological excavations via the new exhibition rooms on the ground floor and lower floor in the Misrachi House so the remains' vestiges incorporated with the museum (Figure 2).

Figure 2. Site plan, Holocaust Memorial [19], Section [21],

The layout of the square is rectangular, and the monument stands in the middle of the northern end faces the statue of The Gotthold Ephraim Lessing in the southeast. The square and the streets leading to it form a detached pedestrian zone dominated by the Holocaust memorial and Lessing statue. The monument shaped, defined, and customized the square as a physical component [22]. The nameless library is a concrete block 10x7 m with a height of 3.8 m and consists of books with spines facing inwards and doors with no handles or hinges. The artist imagined that one of the surrounding buildings had a room turned inside out and placed this introverted, non-accessible library in the public space in the middle of the square. Although it is impossible to understand the tragedy experienced with the designed monument, information has been provided with explanations on the pedestal. The names of concentration camps are inscribed on the broad plinth. On the information board, the visitors are asked not to sit on the monument out of respect for victims. Reading the inscriptions, walking around the memorial, and perceiving the bimah create a space and time for contemplation. In a sense, the informative mission of the monument is completed with the Jewish Museum located in the square. On the information board, the visitors are asked not to sit on the monument out of respect for victims. Reading the inscriptions, walking around the memorial, and perceiving the bimah create a space and time for contemplation. In a sense, the informative mission of the monument is completed with the Jewish Museum located in the square.

Figure 3. Buildings in Judenplatz

The elements that define the square shown on the map are buildings, streets, and inner courtyards, and the square with its monuments is the open spaces. The historic square exhibits a great number of significant Baroque buildings (Figure 3). The earliest dated buildings belong to 1683; the youngest is 1184-1918. The 4 to 6-story buildings with impressive facades and attics behave as walls that determine the boundary (Figure 4).

Figure 4. Collage of facades around Judenplatz

The monument gives unique character to the square. The relation between square and sculpture perceived in human scale is explained through different perspectives from different streets approaching towards the square (Figure 5). The roof lines and heights of the buildings surrounding the square, the ratio of the height of to the size of the square, the shape of the space are the factors affecting the perception of the square.

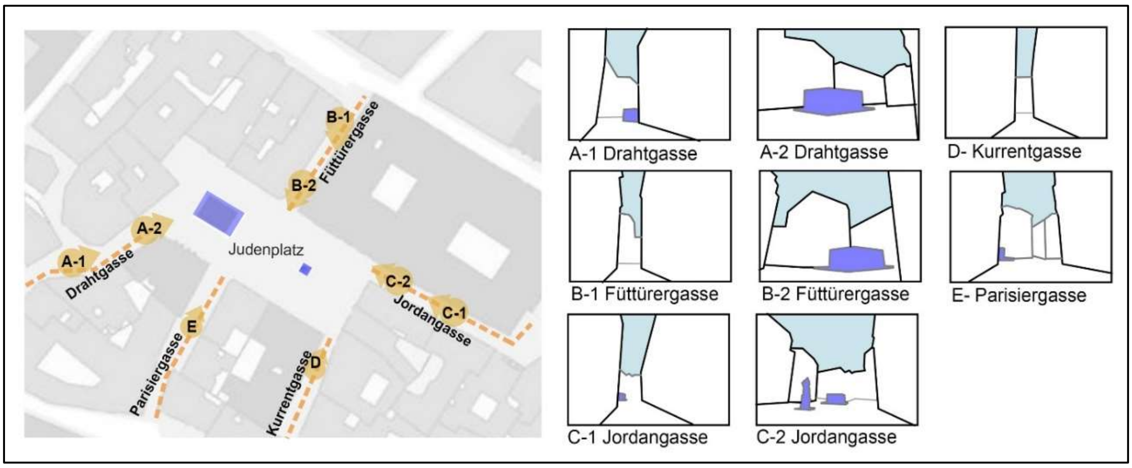


Figure 5. Perception of the monument from the streets in Judenplatz

Different encounters with the monument and visual perceptions are experienced when reaching the square from different city streets. Past and present, existence and non-existence express themselves by being articulated on each other like unseen archaeological remains in the square.

3 Foley Square, New York - 2000

The second case that research focuses on is, Foley Square and The Triumph of the Human Spirit monument relation in the urban context of Manhattan, New York City in the United States. Foley Square is a public open space which is surrounded by court and office buildings.

In the 19th century, the city was transformed by both commercial and residential development relating to its status as a national and international trading center. The city adopted the Commissioners' Plan of 1811, which expanded the city street grid to encompass almost all of Manhattan. Grid-pattern had shaped New York's built environment into an increasingly highwalled maze and squares or plazas offers vistas, open sight lines, or spaces from which to gaze upon the city's architecture or population [23]. The skyscraper, which has shaped Manhattan's distinctive skyline, has been closely associated with New York City's identity since the end of the 19th century. The opening of the subway in 1904, first built as separate private systems, helped bind the new city together [24].

Foley Square was known simply as the "Courthouse Plot" because of its proximity to several State and Federal court buildings at the beginning of 20th century. The area formerly occupied by Five Points was gradually redeveloped through the 20th century. This area was occupied by major federal, state, and city administration buildings and courthouses known collectively as Civic Center. The City acquired the site on August 5, 1913 and transferred title to Parks on March 19, 1930. In 1977 the Council renamed the parcel at New York's center of law and justice Thomas Paine Park. In 2000, several adjacent streets were eliminated to unite the parcels that make up Foley Square. Following this renovation, Thomas Paine Park was officially integrated into Foley Square and rededicated.

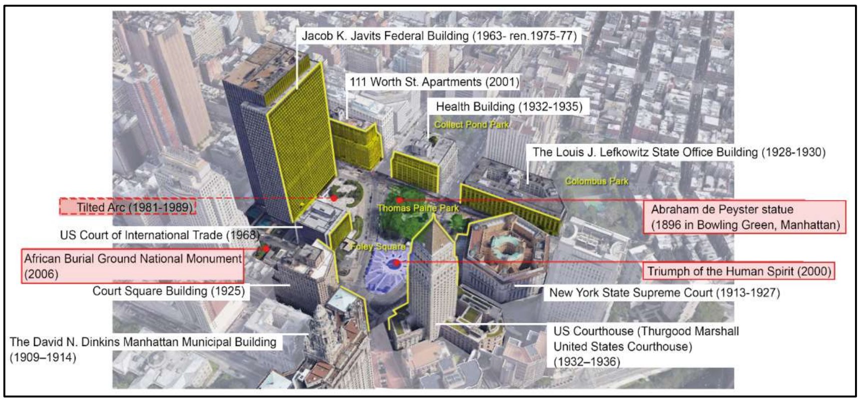


Figure 6: Buildings in Foley Square

Surrounding buildings of Foley Square are mostly built in 1900's but some buildings went through changes in time (Figure 6). The monuments and statues that are in dialogue with the buildings and people in and near the square are Triumph of the Human Spirit, African Burial Ground National Monument, Abraham de Peyster Statue, Tilted Arc (removed).

New York in the early 18th century, was an important trading port and slavery became integrally tied to New York's economy through the labor of slaves. During construction in Foley Square in the 1990s, the African Burial Ground was discovered; the cemetery included more than 10,000 graves of colonial-era Africans. Foley Square is located in northern part of *African Burial Ground & The Commons Historic District*, designated on February 25, 1993 [25].

The African Burial Ground project [26] shows a develop in the transnational memory through collaborative research. The African Burial Ground project and the historical and anthropological resource it represents, can only be enhanced when people with different backgrounds enter in a deeper dialogue [27]. The African Burial Ground was designated a National Historic Landmark in February 1993 [25]. African Burial Ground National Monument (2007) which is dedicated to this archeological site, located near the Square in Duane Street.

Commissioned by the City's Percent for Art program, author & artist Dr. Lorenzo Pace [28] has designed The Triumph of the Human Spirit statue in 2000. Monoblock black granite sculpture weights 300-ton and it is 15-meter-tall is placed inside a large circular fountain. The statue is the abstraction of female antelope '*Chi Wara'*, which symbolizes the successful harvest period and sustaining future generations in West Africa, to keep the historical heritage alive during the founding years of the city during the colonial period. The statue rises on an elongated boat-like structure that symbolizes canoes used by Native Americans, as well as the "middle passage" or overseas journey of enslaved Africans. The monument honors all Africans brought to America, as well as dedicated to all ancestors and future generations, Triumph of Human Spirit sculpture stands for reminding humanitarian side of urban history (Figure 7).

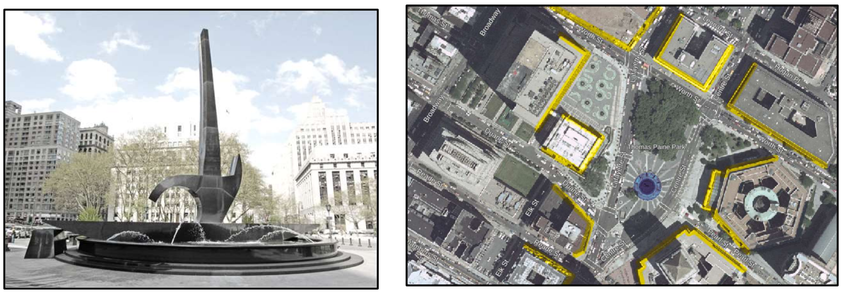


Figure 7: The Triumph of the Human Spirit statue [28]

Radiating from the fountain are five granite paving bands that terminate with large bronze relief medallions (seven feet in diameter), each representing an epoch in the history of Foley Square and its environment. Medallions are designed in 2000 by R.G. Roesch and realized by sculptor Gregg LeFevre [29]. Those monuments and medallions on pavement of Foley Square commemorates African Burial Ground during the 17th and 18th centuries on that site. This place is defined as an avenue leading to spiritual renewal of African American history which is tangible, real, and lives through the dead [27].

The relation between square and sculpture perceived in human scale is explained through different perspectives from different street approaching towards the square (Figure: 2). Road length and building height establishes a narrow frame of the square. The size of the sculpture is perceived dramatically small in comparison with the tall buildings. Sculpture functions as a step or a juncture point between human scale and high-rise architecture. Each street which are approaching to the square have busy vehicle traffic except Saint Andrews Plaza, Pearl Street and Duane Street which are controlled for car traffic and available mainly for pedestrian use.

Figure 8. Collage of facades around Foley Square

Façades act like mirrors, facing each other and reflecting the square repeatedly through their window sequences. The buildings surrounding the square are recently constructed in comparison to Judenplatz in Vienna. The oldest building in Foley Square is David N. Dinkins Manhattan Municipal Building which was constructed in 1909–1914. Foley square showcases many different architectural styles on façades; eclectic, Ancient Roman, Beaux-Arts, Renaissance, Art Deco, Modern (Figure 8).

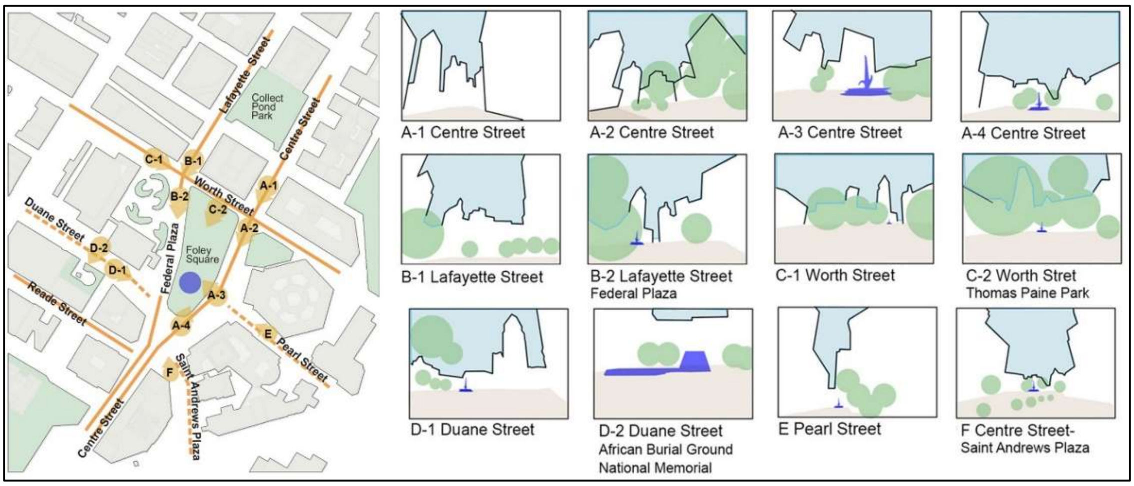


Figure 9. Perception of the monument from the streets in Foley Square

The Sculpture is more visible approaching from South, East, and West directions. The pavement of the square has a radial pattern which is centered in the sculpture and rays diffuse towards the surrounding buildings and streets (Figure 9). Sidewalks are transit zones and a space for social activity, and corners especially are natural gathering places. The grid is not just the physical fabric of the city; the grid also is the systems and people moving through it. Foley square is surrounded by court buildings and has a dynamic texture in everyday life but also, this site allows visitors to reflect on its history and meaning. The memorial structures define the location of the historic remains and artifacts. Soaring high above the square, The Triumph of Human Spirit symbolizes freedom and endurance [28].

Concluding Remarks

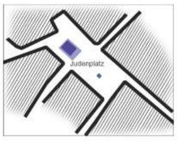
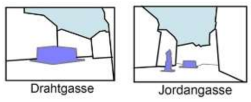
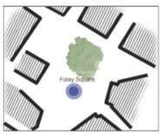
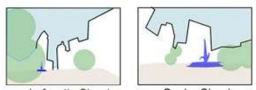
The square is in dialogue with the social and built environment. The effect of the urban squares, whose existence has gone through various stages of construction and destruction from the past to the present, on the urban experience today; It is open to re-evaluation with its monuments aiming to remind the traces of the past, urban furniture that responds to daily practices, and the diversity of structures surrounding the square. While defining the formal features of squares, physicality should be evaluated holistically by examining the coexistence of different elements. There is a strong relation between the square and the facades of the surrounding buildings as they function as walls that give the shape and height of the space.

Both evaluated monuments have a strong presence with a clear narrative and are integrated into the complex urban fabric. They introduce various patterns and emphasize the importance of dialogue between them. In the context of the urban fabric, although they are part of the unity, they are independent. They form a solid and inseparable composition that defines the square regarding the physical, social, and symbolic aspects. What belongs to space and place exists in the sense that the subject attributes to the space. They contribute to the generation of image and identity and also create subspaces. The pedestals of the statues create their spatiality with their subspaces. Although the artist's representation is subjective, they reflect their contextual meaning.

Immediate surroundings of the evaluated squares reveal spatial relations between the architecture and the city. Through the set of views and perspectives, those relations have been analyzed (Table 1). Both squares involve various patterns, directions, and axes, creating frameworks of interconnected spaces and places. Analyses show that monuments in open public spaces provide knowledge of past events and cultural heritage and a continuity of experience throughout the city. The communication of patterns occurs in different layers, with the ruins of the past or the needs of today.

A square needs walls to be defined that give the square a certain shape and height. Opaqueness or transparency of the façade closes or opens the square to other spaces in the city. The facade determines the character with its opening, building materials, colors, rhythm, and tension. Doors, entrances, and windows as openings connect the interior space with the public space in terms of movement, light, and transparency [6]. The relation between the urban space and a building, the square and the façade or a monument illustrates the strong connection between the architectural and urban form and the history with its dark sides. Past tragedies cannot be fully understood with the erected monuments. However, the effort to confront the past becomes physically visible in the city.

Table 1. Elements that determine the square, memorial elements, and background texture

	Elements that determine the square	Memorial elements	Background texture
Judenplatz, Vienna	 Holocaust Memorial Lessing Statue Buildings (Museum) Streets (pedestrianized) Archeological Ruins	 Holocaust Memorial abstraction of library  Lessing Statue	  Drahtgasse, Jordangasse
Foley Square, New York	 Triumph of the Human Spirit Thomas Paine Park Streets (Cars and pedestrian) Buildings (courthouses)	 Triumph of the Human Spirit abstraction of female antelope 'Chi Wara'  Africal Burial Ground Memorial	  Lafayette Street Federal Plaza, Centre Street

Each square has its unique story that forms its shape with a combination of local character features symbolizing universal meanings. Significant past events cannot be separated from the area where they occur and can only be understood when they are seen as living elements of the space. In these two squares where the new meets the old, the act of reminding takes place with an abstraction of architecture or symbols for the past. Although the scales of the squares have changed, the efforts in the 1990s to remind the past have become visible in 2000.

References

[1] Mellon, J., G., Urbanism, Nationalism and the Politics of Place, *Canadian Journal of Urban Research*. Vol. 17, (2008), No. 1 (Summer 2008), pp. 58-77.

[2] Lynch, K., The image of the city. MIT Press, 1960

[3] Borie, A., Pierre M. ve Pierre P. *Form ve Deformasyon Mimari ve Kentsel Nesnelerin Form ve Deformasyonu,* İstanbul: Janus Yayıncılık, 2019

[4] Krier, R., Colin Rowe C., *Urban Space*, Academy, eds.3., 1979

[5] Zevi, B., *Architecture as Space: How to Look at Architecture*, Horizon Press; 1st edition (January 1, 1957), 1957

[6] Norberg-Schulz, C., *Existence, Space and Architecture*, London: Studio Vista, London, 1971

[7] Arendt, H., *The human Condition.* University of Chicago Press, 1958

[8] Mumford, L*., Technics and Civilization*. New York: Harcourt, Brace & Co., 1934

[9] Webb, M., *Die Mitte der Stadt: Städtische Plätze von der Antike bis heute*, Campus Verlag., 1990

[10] Sitte, C., *City Planning According to artistic Principles*, Columbia University Studies in Art History and Archeology, Random House, New York, 1965

[11] Fernandez-Galiano, L., *Fire and memory: On Architecture and Energy* (G. Carino, Trans.). London, England: MIT Press. ISBN 0-262-56133-6, 2000

[12] Giddens, A., *The consequences of modernity*. Polity Press, 1991

[13] Eser, P., 06-29-2018, *State of the art in memory studies: an Interview with Andreas Huyssen*. https://www.politika.io/en/notice/state-of-the-art-in-memory-studies-an-interview-with-andreas-huyssen

[14] Wüstenberg, J., *Locating Transnational Memory*. International Journal of Politics, Culture, and Society, 32(4), (2019), 371-382. https://doi.org/10.1007/s10767-019-09327-6,

[15] Widrich, M., *The Willed and the Unwilled Monument: Judenplatz Vienna and Riegl's Denkmalpflege.* Journal of the Society of Architectural Historians, 72(3), (2013), 382–398. https://doi.org/10.1525/jsah.2013.72.3.382

[16] UNESCO Principal Regional Office for Asia and the Pacific. Regional Unit for Social and Human Sciende in Asia-Pacific. *Launch of the International Year for the Culture of Peace.* Bangkok: UNESCO PROAP., 2000

[17] Larkham, P. & Jones, A., *The character of conservation areas in Great Britain*, Town Planning Review, 64(4), (1993), 395–413.

[18] WHC Nomination Documentation, https://whc.unesco.org/uploads/nominations/1033.pdf

[19] Stadt Wien, https://www.wien.gv.at/stadtentwicklung/veranstaltungen/ausstellungen/unesco/pdf/tafel-16.pdf

[20] Stadt Wien, https://www.wien.gv.at/kulturportal/public/

[21] Jabornegg & Pálffy, https://jabornegg-palffy.at/en/projects/museum_judenplatz/

[22] Young, James E., Memory and Counter-Memory*, Harvard Design Magazine*, 1999

[23] Blake, Angela M., How New York Became American, 1890–1924. Johns Hopkins University Press. pp. 63–66. ISBN 978-0-8018-8874-8, 2006

[24] Cudahy, Brian J., *The New York Subway: Its Construction and Equipment: Interborough Rapid Transit,* 1904. Fordham University Press. p. 2. ISBN 978-0-8232-2401-2., 2004

[25] Gale Harris, Jean Howson, and Betsy Bradley. (1993*). African Burial Ground and The Commons Historic District Designation Report.* (Ed. Marjorie Pearson). New York City Landmarks Preservation Commission.

[26] GSA www.gsa.gov/africanburialground

[27] LaRoche, C.J., Blakey, M.L. Seizing intellectual power: The dialogue at the New York African Burial Ground. *Hist Arch* 31, 84–106 (1997). https://doi.org/10.1007/BF03374233

[28] Triumph of the Human Spirit http://lorenzopace.com/triumph-of-the-human-spirit/

[29] The Graphic History of Manhattan in Five Medallions, 15 July, 2018, https://graphicarts.princeton.edu/2018/07/15/the-graphic-history-of-manhattan-in-five-medallions/

TRANSFORMATIONS AND CONTRASTS: FORMALLY DEVELOPED VS. LIVED CITY: THE CASE OF NOIDA

Sana AHRAR*

Pennsylvania State University,

16803, State College, Pennsylvania, United States, sxa5735@psu.edu

Aqsa RAFI

State University of New York at Buffalo,

14215, Buffalo, United States, aqsarafi@buffalo.edu

Abstract

As an interdisciplinary practice, the state undertakes city planning with a vision to design more liveable cities and plan for future growth directions. In fast-urbanizing countries such as India, planning agencies struggle to cater to the demands and challenges of rapid population growth in metropolitan regions. The unprecedented urbanization rates result in rapid densification and transformation of the built fabric. This research uses Noida, a city established in the late 1970s, as a case study to examine the implications of new urban developments on the pre-existing lived settlements (villages).

For this purpose, we draw on spatial imagery and our fieldwork in Noida, including photographic documentation, urban mapping, and interviews with community representatives. We further draw on planning documents, real estate brochures, and newspaper reports to investigate the transformation of pre-existing villages while being confined within a defined planning boundary due to synergies created by adjacent urban developments.

The study findings draw attention to the morphological transformation of the existing villages in the built environment, public spaces, and land uses post-city planning interventions and development. The research findings provide insights into the challenges experienced by the residents of the urban villages to guide decision-makers in formulating planning guidelines for future city design and planning. It also adds to the understanding of rapid urbanization trends and its implication in the cities of the Global South.

Keywords

Urban transformation; Lived city; Urban planning; Urban morphology; Urbanism.

1 Introduction

In December 2021, an Indian newspaper headline declared, "Soon, Noida to get its own Times Square," adding to the list of visions its town planners have for the city [1]. At the same time, reports show a rise in protests by urban villagers in Noida for necessities such as employment opportunities and access to physical and social amenities [2], [3]. These news reports highlight the differences in the vision of the planning bodies and urban village inhabitants towards the needs of the residents and approach towards city planning. It also suggests an ongoing disparity in the city's resource allocation and distribution of basic service provisions and social infrastructure. This study examines the implications of new urban developments on the pre-existing lived settlements in post-colonial India.

India gained independence from the British in 1947. The partition of India and emerging employment opportunities in urban areas resulted in large-scale in-migration in the subsequent years. The city experienced increased pressure on its existing housing stock and infrastructure. Moreover, the growth of industrial activities in residential areas in the city led to congestion and pollution [4]. To meet the demands of the growing population and decentralize population growth from Delhi, the Indian government developed satellite towns such as Gurgaon, Ghaziabad, Faridabad, and Noida (See figure 1).

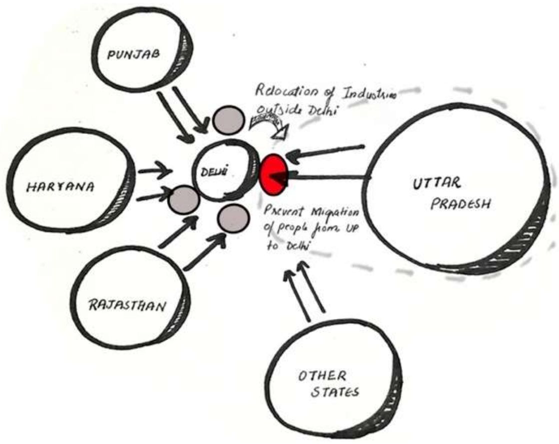


Figure 1. Evolving conurbation and location of Noida.

Among these satellite towns, the planning body developed Noida (an acronym for New Okhla Industrial Authority) under the U.P. Industrial Area Development Act of 1976 on the South-East side of the capital city [5]. The authority developed the city as an integrated Industrial township to decongest, stop speculative investments, and relocate polluting industries from Delhi. With an area of 20,316 hectares, the establishment of Noida also created employment opportunities and provided more housing opportunities beyond Delhi's boundaries [5].

The existing road networks and water bodies shaped the city's physical boundary. Towards the north, the city is bound by the National Highway-24 bypass, the River Hindon on the East, and the River Yamuna on the West. The South determinant of the city's form is the confluence of the rivers Yamuna and Hindon. Figure 2 shows these determinants of the city's form.

The concept of sectors defines the city's organization [6]. As shown in Figure 3, the city is planned on the grid-iron concept and was developed in three phases. The planning authority described the aim of the first Noida Master Plan as to develop sites for small and medium-scale industries and an integrated township for the workers [5]. Hence, the aim was to promote industrial growth in an organized manner while also providing affordable housing and amenities for the workers in proximity to the workplace [5], [7].

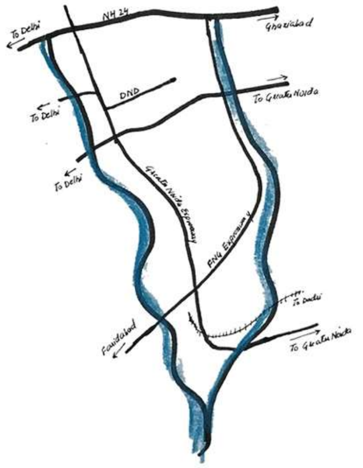


Figure 2. Determinants of the city form.

The planning body developed sites for medium- and large-scale industries in the second phase. Noida Special Economic zone and some industrial sectors of the third phase were developed by 1998. Eventually, the development of the remaining third phase was initiated between 1998-2006 as the industrial sector in Noida grew [8].

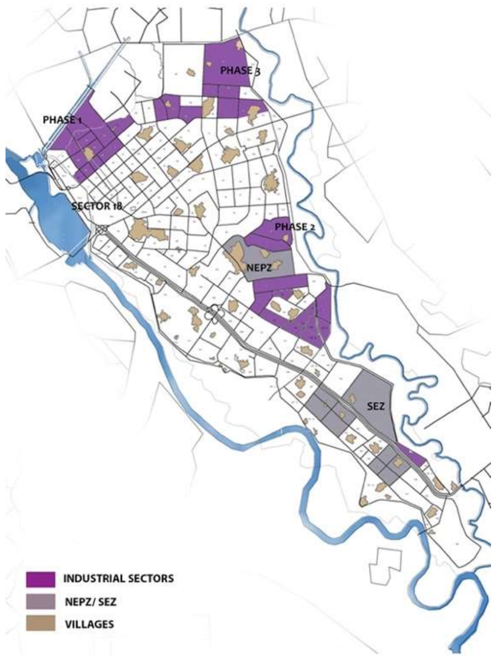


Figure 3. Map showing phases of industrial sector development, NEPZ/SEZ zones, and urban villages in Noida in 2017.

At present, Noida has 163 sectors with different land uses and densities. The recreational areas, commercial districts, and I.T. offices draw people from Noida and Delhi alike [9]. The pro-developer policies post-1994 have allowed private developers to develop group housing on land earmarked for residential development to cater to housing shortages [9]. The government acquired land for residential use and advertised the availability of these land pockets under various schemes to draw private investors to bid and develop housing for faster residential development [9]. However, this approach did not guarantee the timely completion of projects leaving approximately 71 residential communities reported as incomplete in 2020 [9], [10]. In 2020, the Comptroller Auditor General of India reported a shifting interest of the Noida authority from focusing on facilitating industrial development to residential development [10].

The residential developments range from group housing developed for different income brackets by the state under the Noida Housing Scheme, privately developed gated communities, and privately owned farmhouses. Figure 4 map shows the location of the Abadi areas (urban villages) in the context of the residential developments under the Noida Housing Scheme, gated communities, and farmhouses, as noted from government schemes, google earth, and private developer brochures and advertisements.

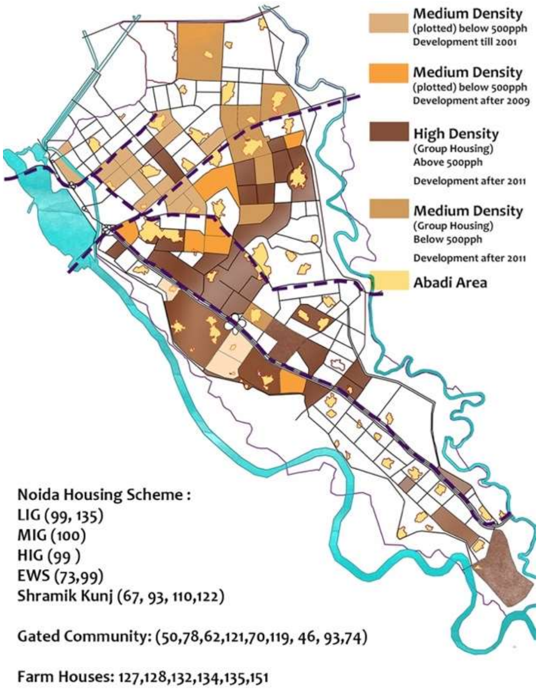


Figure 4. Map showing residential developments in Noida sectors in 2017.

Using the google earth timelapse feature, we note the urban transformation in selected zones of Noida. *Abadi* areas (urban villages) in Noida, as noted from Noida's masterplan 2031 and google earth imagery, are bound by road networks acting as a physical boundary. These physical boundaries include roads, streets, and land uses. We note that villages are densifying with the structured and phase-wise development and even with the shift of the Noida authority's visions. This ingrowth of urban villages is similar to that noted in Delhi [11].

In this paper, we use a case study approach to investigate the implications of urban developments that engulf pre-existing villages to highlight the morphological transformation and the challenges the urban village inhabitants face. We use Atta village and Kondli Bangar as case studies based on their location from the urban center, the land use surrounding them, their access to transportation facilities, and the transforming urban developments in their vicinity.

We draw from journal articles, newspaper articles, and our field observations and interviews conducted for a studio project in 2017. We documented our findings using land use maps, residential typology maps, and context maps, analyzing them based on location, surrounding urban developments, and density. We also use the google earth timelapse feature and street images to observe the morphological changes in the present day in the case study areas.

While the urban village in sector 27 transformed to meet the growing demand for rental housing and commercial developments, the urban village in sector 149 faced challenges in sustaining adjacent to incomplete high-rise residential constructions [12]. The findings from these two cases highlight the morphological changes, disparities in resource distribution, and the unique challenges brought in by urban development around the two urban villages. The findings also provide insights to guide decision-makers in formulating guidelines emphasizing the need to integrate the existing fabric during the initial planning process.

2 Urban Villages in Noida

The geographical area of the present-day city of Noida comprised a network of villages in 1976 with predominantly agrarian-based communities. In 1981, the population of the Noida Urban Area was a 0.037million, and the villages came under the Noida Notified Area [4]. According to the Census of India, by 1991, the population had increased rapidly to approximately 0.167 million. Potter and Kumar note that by 1981 people also began settling in the villages that were previously uninhabited[4].

There was also a significant rise in Noida Urban Area's population in the next two decades. According to the 1991 and 2001 censuses, the urban population increased by approximately 352% from 1981 to 1991 and 82% from 1991 to 2001, making it 0.30 million. The Noida Notified Area, which included villages, also saw a population rise of approximately 170% from 1991 to 2001, making it 0.093 million. This rapid population increase highlights the rapid urbanization rate of the Noida Urban Area and its effect on the villages within the Noida Notified Area. As the city of Noida grew, these villages were engulfed in the formally planned sectors, making them 'urban villages.' Furthermore, in 2011, the population of Noida city increased by approximately 108% from 2001 to 2011, making it 0.637 million[13]–[15].

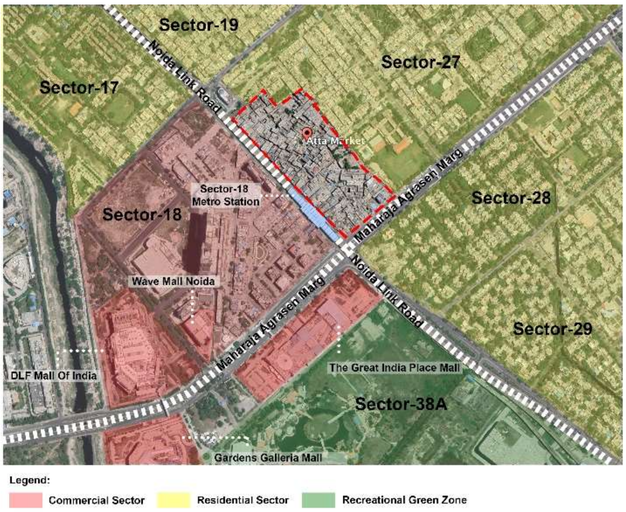
With the growth of the city of Noida, there was a shift in economic activities. In 1991, nearly 11.6% of the people in the Noida Urban Area were involved in agricultural activities, which reduced to 2.6% in 2001 [8]. Moreover, there was a 10.5% decrease in primary economic activities among the village inhabitants of the Noida Notified Area [13], [14]. We can infer this change to be due to the agricultural land acquisition carried out by the governing authority for urban development. As the villagers in the city had no land for agriculture, they adapted to the changes that urbanization brought in and opted for other means of livelihood [12].

The residents of these villages have either found employment in secondary or tertiary sectors or converted their built and unbuilt spaces to supply more affordable rental and commercial spaces for the incoming migrant population to meet the surrounding urban sectors. For instance, inhabitants of villages surrounded by industrial sectors adapted manufacturing and construction activities as livelihoods [13], [14], and inhabitants of villages surrounded by commercial sectors such as Atta near sector 18 incorporated more commercial activities [4]. However, villages around incomplete residential sectors struggle to survive and have adapted to mixed-use activities, such as in the case of Kondli Bangar [12]. We further review these two very distinct cases.

2.1 Atta Village, Sector 27

Clustering economies emerge where economic synergies are in proximity and act as a means of sustenance [16]. The proximity of a commercial sector to Atta village gave its inhabitants the opportunity to adapt and create new forms of economic opportunities for themselves after the state acquired their agricultural lands.

Atta is an urban village located in sector 27 in Noida (See figure 5a). It lies adjacent to sector 18, a commercial district that comprises popular shopping malls such as DLF Mall of India, Wave Mall Noida, high-end retail stores, office spaces, and restaurants. Atta is close to sector 38A, a recreational green zone with malls such as The Great India Place and Gardens Galleria, and residential sectors. The village has emerged as a popular market and eating hub in this setting.



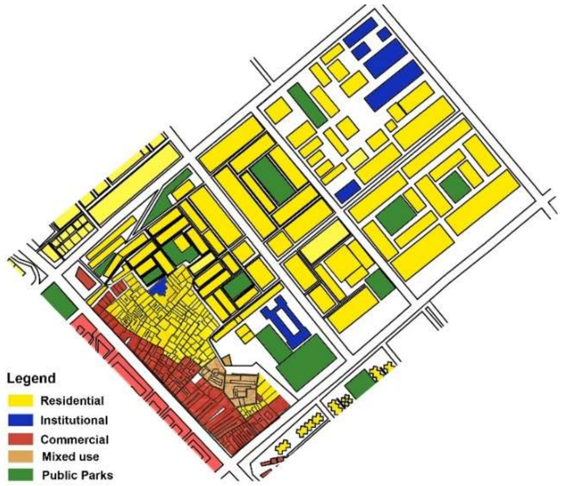


Figure 5a. Atta Market and its context.

Figure 5b. Sector 27 land use map for 2017.

According to Benjamin, an urban area having an interrelated mix of social and economic factors caters to the growth of informal economies in its vicinity[17]. Moreover, access to transportation networks and village inhabitants' adaptability towards change further strengthens the economic mix [16].

Findings from informal interviews conducted in 2017 with community representatives highlighted Atta's proximity to the metro station, bus stop, and Noida link road and the urban development of commercial sector 18 as the key components of the transformation of the village. The community representatives informed that the commercial district brought an influx of low-wage migrant workers from Uttar Pradesh and Bihar. These workers needed cheap housing options and access to affordable food and other amenities. Many residents started renting their homes to cater to the influx of population and search for livelihood. They converted the lower floors of their homes as shops creating an informal commercial belt known as the Atta market along the periphery of the urban village, which has now spread horizontally towards the neighboring planned sector 18.

Figure 5b shows the land use on the ground floor of sector 27 and the difference between Atta village's land use and morphological pattern and the formally planned residential sector 27. The formally planned sector follows regulations that are evident in its urban form. This area is a medium-density plotted development comprising row housing with a 55ha area. A clear road hierarchy of streets varying widths from 7-15m to 18m divides the sector and creates a grid of 500-600m x 550-650m. The heights of buildings vary from 6m-9m. The sector has recreational activities such as clubs, public parks, and institutions such as schools and hospitals to cater to the sector's population. The residential sector has a mix of inhabitants belonging to low-income groups, medium-income groups, and high-income groups that have workspaces in Noida. The arrangement of residences and streets acts like a porous wall that simultaneously restricts the horizontal growth of the village but also offers access to its social infrastructure, such as green spaces, schools, and hospitals.

In contrast, Atta village has densified due to the influx of migrants and its inhabitants' capability to adapt to change. The village has an area of 8ha and comprises a mix of commercial and residential areas arranged in an informal manner creating a high-density mixed-use space. The buildings in the sector vary from 9m to 18m in height. There is no road hierarchy, and the streets are narrow and dark. The residents use streets as parking or storage spaces, reducing the area available for vehicular commutes. The Sector 27 plotted area has a better physical infrastructure than the urban village, where residents complained of localized flooding due to choked drains and limited parking spaces.

Atta village has transformed and is absorbing the excess of the urban growth around it, developing and adapting incrementally to the changes. Despite being physically bound by a formally planned residential development, its inhabitants managed to renew their loss of agrarian land and livelihood by converting the ground floors of their houses into commercial spaces or providing rental options to marginally paid workers. Moreover, the clustering of commercial activities in Atta provides more economic opportunities to marginally paid workers and absorbs the influx of the migrant population. However, the increasing density of the urban village is adding pressure on its infrastructure. The informal discussions with business owners and community representatives revealed that although the urban village shares social infrastructure with the planned area, it lacks proper sewage disposal systems and needs to upgrade or provide the inhabitants with better amenities.

Urbanization creates a "survival circuit" for lived or peri-urban areas such as urban villages through the 'flow of migrants and materials from neighboring areas' [18, p. 12]. Atta village uses this circuit and connects to the economic potential generated by state-planned urban development in its proximity. However, like Atta village, not every peri-urban settlement has transformed and adapted through the synergies created by urban developments in their contexts.

2.2 Kondli Bangar, Sector

According to Bali and Bhatia, the land acquired for development has left many urban village inhabitants without a source of employment [12]. Kondli Bangar, a village located in sector 149, is one such example; where prior to the land acquisition, the major economic activities of the residents of the village constituted farming, cattle rearing, and dairy farming [12].

Kondli Bangar lies adjacent to residential sector 151, comprising group housing projects, agriculture sector 149A, and recreational green zone sectors 150 and 152. The village is connected to the Shafipur road through a service road. It is also close to the Noida Greater Noida expressway, while the sector 148 metro station is more than 800m away. Figure 6 shows the context of Kondli Bangar.

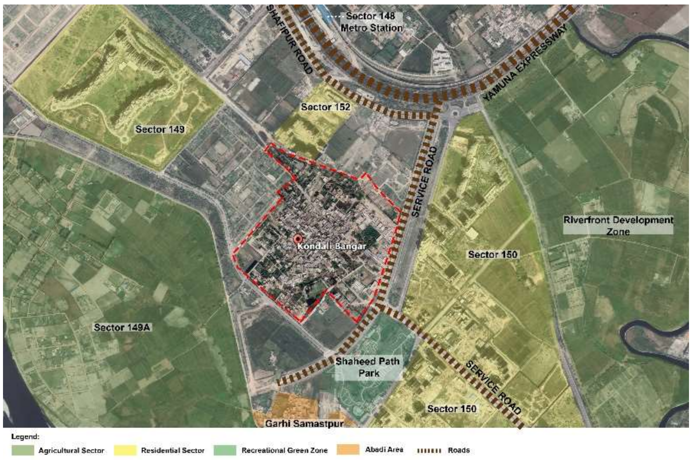


Figure 6. Kondli Bangar and its context.

A comparative analysis of the spatial transformation of the village reveals that the village was surrounded by agricultural lands indicating the economic dependence of its inhabitants on agriculture. However, the land use around it started changing after the development of the Noida Greater Noida expressway, also known as the Yamuna Expressway, which opened in 2012. After 2012, group housing in sectors 151 and 150 started emerging, converting the agricultural land into pockets of residential communities. However, a 2020 report reveals that land acquired from the villagers was sold to private developers, which was against the surrounding sectors' zoning regulations, halting the gated community projects [19].

Figure 7a. Group housing in sector 151. Figure 7b. The village area.

Figure 7b reveals the organic growth of the village, with buildings haphazardly arranged around narrow streets and open spaces. According to Bali and Bhatia, the village's inhabitants are landless laborers or farmers who have resorted to working as watchmen or laborers for construction sites [12]. The master plan 2001 stated that as per the village development scheme of Noida, villages would be incorporated into the urban development by providing them with social and physical infrastructure. However, google earth street views for the year 2021 of the village reveal that vacant lands such as ponds and pastures are used as dumping grounds, highlighting the lack of sewage management within the settlement. Provisions of social amenities such as state-run hospitals are also not present within a 10km radius of the village.

Through the case of Kondli Bangar, we observe that urban developments and changing priorities of the development authority, and court rulings to halt construction have negatively impacted the lives of its inhabitants. The "survival circuit" created in the case of Atta village is not created here as urban development in the village's proximity is incomplete [17]. Moreover, it lacks basic provisions, social infrastructure, and means of connectivity, resulting in a social and economic disconnect between the village inhabitants and their surroundings. An evident spatial fragmentation is arising in the village context with gated communities or group housing lying vacant in the vicinity.

3 Discussion

Cities are a product of time and space that evolve to incorporate socio-cultural values and structures. They also incorporate functionality while striving to keep pace with global advancements. Noida is a city developed post-independence and one of the largest industrial townships in South Asia [12]. According to the Town and Country Planner Jamal H. Ansari, the proximity to Delhi, the growth of Delhi's other satellite towns around it, and the proposals for the development of transportation infrastructure all served as growth potential for Noida's growth and development [6]. However, the planning and developments also face development constraints, such as low-lying areas prone to flooding and dependency on bridges to connect Noida to other cities due to rivers on two sides of the city's triangular shape [6]. Moreover, the pre-existing villages engulfed in the planning of the urban areas transformed morphologically as the city grew around them.

Our study of the two urban villages, Atta and Kondli Bangar, shows differences in morphological patterns and socio-economic transformations based on their location context and adjacent land use and development status. The villages are growing, densifying, and transforming as per their adaptive capacities and evolving broad synergies based on developments around them.

The temporalities in activities and everyday life in these villages are impacted by the demands of the increased migrant population and the needs of adjacent formally planned sectors. Even then, the findings from informal discussions with community leaders of Atta village in 2017 suggest discrepancies in infrastructure provisions, such as a lack of sewage and drainage provisions. These findings support earlier studies on urban villages in Noida which note the absence of piped water supply, higher power cuts, clogged open drains, and use of water bodies as dumping grounds [12], [20]. These are further supported by newspaper articles reporting inadequate drainage networks and sanitary woes of residents of urban villages in Noida [2], [21].

During our fieldwork in 2017, the informal discussions with residents and shopkeepers suggested little engagement of urban village residents and representatives with the planning body. A 2016 newspaper article states that little attention is given to the sanitary problems of urban village residents due to the absence of a formally elected Gram Panchayat, while the sectors have RWAs to represent communities living in other residential sectors of Noida [21]. It also noted that the Noida Village Residents' Association organized a digital protest in 2020 to revive the gram panchayat system for urban villages in Noida that had existed up until 2015 [22].

Since the agrarian communities residing in these villages are no longer employed in the agrarian sector, they depend on alternate livelihood sources, such as providing small shops on the ground floor and rentals on the upper levels for migrants in search of affordable housing options. The increase in population density in the urban villages results in property owners constructing additional floors, housing extensions towards the already narrow streets, and further division of plots. The uncontrolled building development within these urban villages further adds to the demands on the existing drainage network, roads, and sewage systems.

Unfortunately, the absence of community participation in the local model creates a disconnect between the needs for basic amenities in the villages and the development authority's approach toward them [12]. In August 2021, a newspaper report stated that the Noida authority launched a “Noida Aapke Dwar” (translating to Noida at your doorstep) initiative. This initiative was a step to hear the concerns of the residents of urban villages on water, health, and sanitation issues [23]. To better meet the needs of the residents and improve the quality of life in these urban villages caught in the urban development around them, there is a need for more such initiatives to include the voices of local communities. There is also a need to provide alternate livelihood means, skill development programs, and programs that help them understand financial management, helping them adapt to the urban changes around them. Moreover, at the current pace of urbanization in Global South cities, the transformation of urban villages needs an investigation for a more holistic approach toward planning and intervention practices.

Acknowledgements

We conducted the fieldwork for this research as a part of an M. Arch studio exercise in 2017. We are indebted to our studio instructors and classmates for their support and feedback during the studio. We also thank the community groups for their time and input during the fieldwork.

References

[1] S. Srivastava, “Soon, Noida to get its own Times Square,” *Times of India*, Noida, India, Dec. 06, 2021. Available: https://timesofindia.indiatimes.com/city/noida/soon-noida-to-get-its-own-times-square/articleshow/88111417.cms

[2] V. Rajput, “Densely populated urban villages of Noida may affect civic facilities,” *Hindustan Times*, Noida, Jul. 26, 2017. Available: https://www.hindustantimes.com/noida/densely-populated-urban-villages-of-noida-may-affect-civic-facilities/story-zPTVnFZ8nqVPeV6SIb3phN.html

[3] A. Dev, “Model Township? For Now, Villagers Who Relocated For Airport Want The Basics,” *Times of India*, Noida, India, Apr. 07, 2022. Available: https://timesofindia.indiatimes.com/city/noida/model-township-for-now-villagers-who-relocated-for-airport-want-the-basics/articleshow/90694560.cms

[4] R. B. Potter and A. Kumar, “A profile of Noida: A New Town in the National Capitol Region of India.” Geography, University of Reading, Reading, England, 2004.

[5] New Okhla Industrial Area Authority, “Master Plan NOIDA- 2001,” New Okhla Industrial Area Authority, Uttar Pradesh, India, 1983.

[6] J. H. Ansari, “Noida Master Plan-2021,” New Delhi. Available: https://1library.net/document/zk68vd8y-noida-master-plan-jamal-ansari-town-country-planner.html?utm_source=search_v3
[7] R. B. Potter and R. Sinha, “NOIDA: a planned industrial township south-east of Delhi,” *Geography*, vol. 75, (1990), no. 1, pp. 63–65, Accessed: Jun. 14, 2022. Available: http://www.jstor.org/stable/40571933
[8] New Okhla Industrial Development Authority, “Noida Master Plan -2031,” New Okhla Industrial Development Authority, Noida, India, 2011.
[9] D. D. Parashar, N. Thakur, D. M. Dharwal, and S. Singh, “Impact of Land Policies on Housing Markets: Case of Noida, India,” *International Journal of Management*, vol. 11, (2020), no. 6, pp. 65–73, doi: 10.34218/IJM.11.6.2020.006
[10] M. Seth and A. Bhatnagar, “CAG report tears into Noida authority: ‘Lapses of probity, integrity and ethics,’” *The Indian Express*, Dec. 18, 2021. Available: https://indianexpress.com/article/cities/delhi/cag-report-tears-into-noida-authority-7678501/
[11] S. Ahrar and A. Staub, “Top-down planning approaches and urban reality: The case of Delhi, India,” in *EAAE – ARCC International Conference*, Valencia, Spain, 2020, vol. 1, pp. 356–363.
[12] B. Bali and N. Bhatia, “Development, Prosperity and Aspirations: A Narrative from the Peri-Urban Areas of Noida,” *Journal of Land and Rural Studies*, vol. 10, (2022) no. 1, pp. 54–74, doi: 10.1177/23210249211051440.
[13] Directorate of Census Operations, “Census of India, 1991,” Directorate of Census Operations, Uttar Pradesh, India, 1991. [Online].
[14] Directorate of Census Operations, “District Census Handbook Part A & B,” Directorate of Census Operations, Uttar Pradesh, Lucknow, India, 2001.
[15] Directorate of Census Operations, Uttar Pradesh, “District Census Handbook XII-B,” Directorate of Census Operations, Uttar Pradesh, India, 2011.
[16] M. van Oostrum, “Access, density and mix of informal settlement: Comparing urban villages in China and India,” *Cities*, vol. 117, (2021), doi: 10.1016/j.cities.2021.103334.
[17] S. Benjamin, “Urban land transformation for pro-poor economies,” *Geoforum*, vol. 35, (2004) no. 2, pp. 177–187, doi: 10.1016/j.geoforum.2003.08.004.
[18] A. Sood, “The Speculative Frontier: Real Estate, Governance and Occupancy on the Metropolitan Periphery,” *South Asia Multidisciplinary Academic Journal*, (2021), no., doi: 10.4000/samaj.7204.
[19] Comptroller and Auditor General of India, “Performance Audit Report on ‘Land Acquisition and Allotment of Properties in NOIDA’ in Uttar Pradesh,” Audit Report 6, Government of Uttar Pradesh, New Delhi, India, 2021.
[20] S. K. Sinha, “State of Living Condition in Noida City, Uttar Pradesh,” *IJRAR*, vol. 5, (2018) no. 4, pp. 115–119, 2018.
[21] S. Salaria, “Neglect, not representation renders urban villages vulnerable,” *The Times of India*, Noida, India, Aug. 27, 2016. Available: https://timesofindia.indiatimes.com/city/noida/neglect-not-representation-renders-urban-villages-vulnerable/articleshow/53891256.cms
[22] Press Trust of India, “Revive gram panchayats in Noida: Village bodies demand in digital protest,” *India Today*, Noida, India, Aug. 17, 2020. Available: https://www.indiatoday.in/india/story/village-bodies-demand-digital-protest-revive-gram-panchayats-noida-uttar-pradesh-1711933-2020-08-17

[23] Shalabh, “At your doorstep: Noida to hear out urban villagers,” *Times of India*, Noida, India, Aug. 01, 2021. Available: https://timesofindia.indiatimes.com/city/noida/at-your-doorstep-noida-to-hear-out-urban-villagers/articleshow/84936202.cms.

BUILDING WITH BIOLOGY: SYNTHETIC BIOLOGY AND ARCHITECTURE

Alfredo ANDIA

Florida International University
Department of Architecture, PCA 374B, Miami, FL 33199, USA; andia@post.harvard.edu

Abstract

The paper argues that Synthetic Biology (SynBio) has the potential to transform the planet and combat climate change by allowing for the design, editing, and engineering of living organisms. SynBio has already enabled the production of lab-grown meat, bio-grown leather, and novel pharmaceuticals. In the construction industry, lab-grown materials such as bio-bricks and fungal-based materials have emerged. SynBio can also engineer living materials, from synthetic cyanobacteria to programmable bio-matter, with which we could redesign our infrastructures and ecology. The paper presents several growth processes and asserts that this new approach advances a novel imagination and acuity for designing cities, biology, and nature.

Keywords

Synthetic Biology, Bio-Architecture, Climate Change, Biotechnology, Architecture.

1 Introduction: Our Post-Industrial Biosphere

Over the past century and a half, human industrialization has transformed the planet, resulting in a world where human activity dominates most living organisms and ecological systems. Humans and our livestock make up 96% of the world's mammals by weight, with wild mammals having been reduced to 4% and declining every decade. Our industrialized world is now revealing its consequences. Reports from the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Environmental Program (UNEP) warn of approaching points of no return in the Arctic, leading to ocean acidification, sea-level rise, and the thawing of the permafrost, which will unleash one trillion tons of carbon dioxide into the atmosphere. Even if we adhere to the Paris agreement, the natural release of CO2 and methane in the Arctic has created an uncontrollable crisis as the permafrost melts. Reductions in carbon emissions are necessary but insufficient, and we need to focus on developing "negative emissions" strategies to remove carbon from the atmosphere at a massive scale [1, 2].

1.1 Crisis of Imagination

The crisis of climate change is rooted in a fundamental lack of imagination. Architects often suggest solutions to address climate change by relying on slightly improved industrial technologies that contributed to the crisis in the first place. This reflects a deeper crisis of imagination. Instead, this paper argues that biology provides a more sophisticated platform for transforming our planet. The authors outline how our understanding of biology has evolved and how we have entered a new era of biotechnology. However, they also contend that this new era requires a new spatial imagination at the planetary level, not just advancements in material technology.

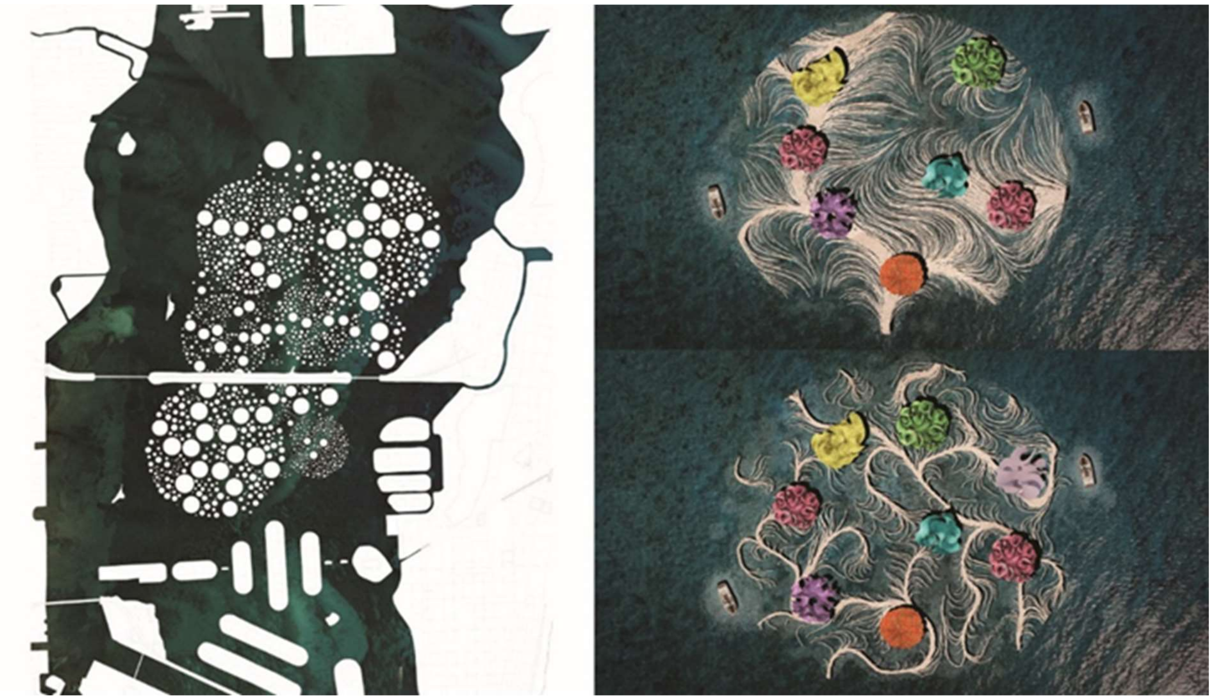


Figure 1. The proposal suggests the creation of islands in Biscayne Bay through the use of reengineered cyanobacteria. Left image: Site plan, Design 7-8 Studio, 2018. Right image: a project by Daniela Romero & Solange Salinas (Alfredo Andia Design 8 Studio, FIU, Fall 2019).

1.2 Nature and The Emergence of Synthetic Biology (SynBio)

The concept of nature has been constantly evolving throughout history. In the 1800s, the field of biology emerged from the voyages of authors such as Charles Darwin and Alfred Wallace, who ventured into largely unexplored natural environments. By the turn of the 20th century, biological studies had transitioned from fieldwork to laboratory research, with a focus on elucidating the fundamental principles of life. The discovery of the DNA structure and function in the 1950s marked a major milestone in lab biology, unlocking a whole new realm of research possibilities. In the late 20th century, genetic biology gained momentum as DNA sequencing and synthesis technologies advanced.

Synthetic Biology (SynBio) is the current field focused on re-engineering biology, succeeding the DNA research developed in the 1950s. SynBio encompasses emerging techniques that enable the design, editing, and engineering of various living organisms. It is now possible to manufacture a wide range of products, such as lab-grown meat, bio-grown leather, milk, wood, fertilizer-free plants, fuels, fragrances, fabrics, novel pharmaceuticals, mRNA vaccines, and even age-reversal techniques, molecule by molecule. SynBio has emerged as the fastest-growing technology in human history. Despite being established officially in 2006, SynBio is growing exponentially, with a factor of ten times per year [3]. In contrast, computer technology has only been increasing by a factor of 1.5 times per year.

2 Bio-Construction

There are two potential approaches for SynBio in construction. The first involves lab-grown products developed by emerging startups to replace existing building materials. However, we believe that the real potential of SynBio lies in the development of engineered living materials that will soon enable the growth of infrastructures locally around the world.

2.1 Generation 1: Bio-Grown Materials

Today, there is a growing number of lab-grown materials being developed. Companies like Ecovative and MycoWorks are utilizing fungal mycelium to produce bricks, walls, and wall insulation materials. Lingrove is using plant-based fibers and resin to create lab-made wood, while Wooddoo is creating transparent wood. Researchers from the University of Maryland have even bio-engineered wood to make it 12 times stronger, comparable to titanium alloys [4, 5].
BioMASON, for example, is using a Bacillus strain to create bricks from sand at room temperature by facilitating the formation of calcium carbonate. SynBio is used to develop self-healing materials, such as concrete that can repair cracks autonomously. By optimizing the microorganisms within buildings, SynBio has the potential to create more energy-efficient structures. Synthetic bacteria, for instance, can produce biofuels or break down organic waste to generate energy [6]. Other examples of SynBio applications in construction include smart coatings, bioluminescent lighting, waste reduction, biodegradable materials, and the development of new plants for green roofs. These approaches have the potential to revolutionize current building processes without significantly altering design and construction delivery. While we see the value in pursuing first-generation projects, we believe that these are temporary visions given the rapid pace of technological advancement.

2.2 Generation 2: Living Buildings

A more sophisticated application of SynBio in the construction industry involves the engineering of novel living materials from cells, bacteria, fungi, biological seeds, or the orchestrated growth of multiple organisms in an accelerated timeframe. This idea gave rise to the development of Engineered Living Materials (ELM), which received funding as a research program at DARPA in 2016. Their vision is to "imagine that instead of shipping finished materials, we can ship precursors and rapidly grow them on site using local resources." And, since the materials will be alive, they will be able to respond to changes in their environment and heal themselves in response to damage” [7]. A number of reviews and taxonomies summarizing projects in this innovative field have been produced by various authors [8, 9, 10].
It is our belief that the upcoming generation of SynBio technologies will revolutionize the way we design human environments. In the near future, it may be possible for SynBio producers

to transport bio-ingredients and ecosystems to a designated location, allowing us to cultivate and construct our own habitats.

3 Carbon Level stabilization by Reengineering Cyanobacteria

In order to explore the potential of Synthetic Biology in Architecture, we initiated a series of design studios. Initially, our focus was on exploring growth techniques that are typically observed in living organisms. However, we soon realized that conventional architectural software and analog models were insufficient for our purposes. Therefore, we transitioned to procedural software that allowed us to conceptualize new design techniques and processes. In the subsequent pages, we elaborate on the various themes we developed in multiple studios.

3.1 Carbon Level stabilization by Reengineering Cyanobacteria

The UNEP and IPPC reports emphasize the importance of new carbon removal methods to combat climate change. One natural organism that removes carbon dioxide from the planet is photosynthetic cyanobacteria, which emerged between 3.5 to 2.5 billion years ago and transforms CO2 and H2O into sugars, releasing O2 into the air as a by-product. Today, all living organisms breathe oxygen produced by cyanobacteria or descendant organisms, such as cyanobacteria in oceans and plants that absorbed cyanobacteria via endosymbiotic evolution. Cyanobacteria in the sea, including Prochlorococcus, algae, and oceanic plankton, are responsible for 50-to-80% of the planet's oxygen production.

Figure 2. Render of self-growing bio-concrete structures using re-engineeredyanobacteria that deposit calcium carbonate on the crest of the structure as it rises, Biscayne Bay, FL.

The University of Colorado Boulder has developed a bio-concrete made from cyanobacteria that grows and reproduces at an exponential rate, allowing it to create "living rocks" like stromatolites [11]. The cyanobacteria can be kept alive for up to 30 days and, if divided, can regrow into new bricks in just hours. By redesigning biological circuitry with cyanobacteria in shallow waters, excess CO2 from the atmosphere could be captured to create new islands and buildings from cyanobacteria bio-cement in just days. An example of this can be seen in figure 1, which shows envisioned islands growing using re-engineered cyanobacteria in the shallow waters of Miami's Biscayne Bay. A detail is seeing in figure 2. All that is required is water and redesigned cyanobacteria.

3.2 Sea-Level Stabilization Sponge-Towers

Our studio envisions the growth of large-scale bio-infrastructures that mimic the water-absorbing abilities of sponges and cacti using synthetic biology. These bio-towers, as shown in figure 3, could be deployed worldwide and serve as desalination towers capable of absorbing excess seawater from melting ice sheets and glaciers, ultimately stabilizing sea level rise. These towers can be designed to contain bioreactors and other infrastructure that can provide locally sourced food, energy, and raw materials. The Miami desalination tower project is an example of this concept, with the ability to absorb 6 million cubic feet of seawater. The design uses voxels of calcium carbonate that arrange in Semper knot structural formations, which are created as a byproduct of cyanobacteria circuitry. These sponge towers could potentially serve as a sea-level stabilization strategy for the planet. With an ocean surface area of approximately 1,680 million square feet and sea-level rise projections of 6 feet by 2100, the earth is expected to gain approximately 10,800 million cubic feet of seawater volume. If we were to gradually grow 1500 of these infrastructures around the world, they could absorb the extra seawater and maintain current sea levels.

Figure 3. Desalinization, absorption, and retention tower proposal for Miami Biscayne Bay proposal. Project by Renzo Lopez (Alfredo Andia Design 8 Studio, FIU, Spring 2018).

3.3 Bio-Fiber infrastructures

Our team has developed a series of habitats with fibrous-based skins, which are designed to capture CO2 from the air. By injecting synthetic micro-fluidics into these fibrous structures, we can increase carbon sequestration by 100 times more than using the same volume of trees. Figure 4 illustrates an example of an island/concert hall that grows from the shallow Biscayne Bay using a metaball structural formation. The surface of the structure is covered by synthetic biological fibrous organisms that not only capture CO2 but also generate energy and provide changing illumination. This fibrous skin is an advanced version of the glowing nanobionics plants previously developed by the Strano Research Group at MIT [12].

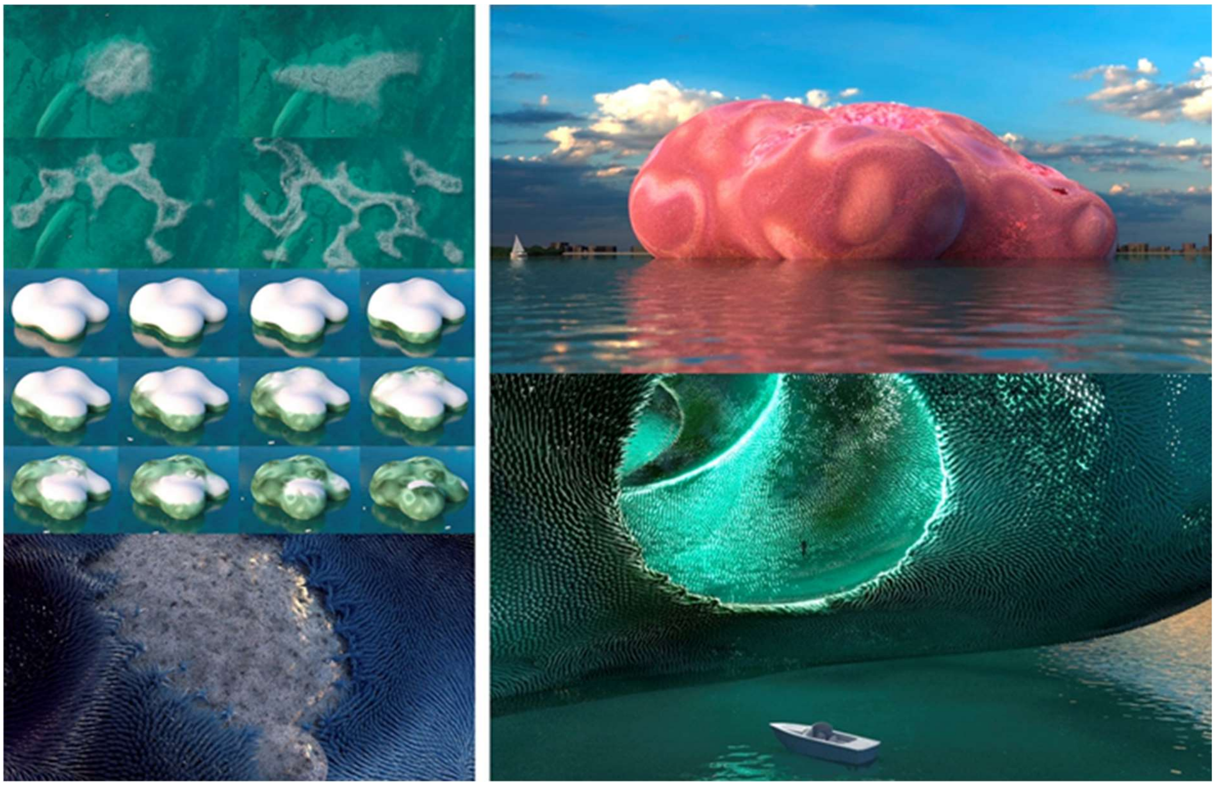


Figure 4. This project is an island/concert hall that grows from the shallow Biscayne Bay. Project by Carmen Alvarez and Steve Rivera (Alfredo Andia Design 8, FIU, Spring 2021).

3.4 Bio-Foods

Synthetic biology has brought early successes in plant-based food and lab-grown meat, with companies like Impossible Foods, the Not Co., and Ecovative creating products that mimic and replace traditional food items. These companies are even developing scaffoldings that replicate the texture of meats such as steak, bacon, and eggs. However, if proteins can be transformed to taste and look like anything, why should food in the future be limited to the appearance of burgers, bacon, or steak? Why can't vegetables have the crispy texture of pizza or the smoothness of marshmallows? As we move into a new era, we must redefine our design boundaries.

Figure 5. Experimental forms of synthetic bio-food for mammals and humans.

A newfound freedom of forms could allow food to take on any shape, texture, or consistency while also addressing its politics as seen in figure 5. In our studio, we have explored the idea of edible buildings with bio-surfaces containing engineered bacteria that can remove dirt, toxins, and detect pathogens. Food is also a critical issue for numerous species, particularly the dwindling number of mammals in the Arctic. We developed a project for Polar Bears in the Arctic, who are experiencing a shortage of food and are increasingly resorting to cannibalism to survive. Our proposal includes habitats for Arctic explorers that incorporate bio-reactors capable of synthetically producing food for the Polar Bears. As we face the impacts of climate change and enter a bio-technological era, a new human-animal relationship will emerge.

3.5 Bio-String Infrastructures

Spider silk is an incredibly durable material that surpasses steel in strength and Kevlar in resistance. Numerous startups, like Spiber Inc., are cultivating synthetic spider silk in their laboratories, which is already being used in products by Adidas and North Face. However, when will synthetic spider silk be integrated into architecture? Historically, art, design, and architecture have had limited exposure to string structures. In our studios, we have investigated synthetic spider silk for piping structures and enclosure/façade systems. Figure 6 illustrates the experiment of string structures, where the growth process generates continuous channels capable of collecting, transporting, and storing nutrients through the structure. The work utilizing reaction-diffusion and noise offset to create string-based forms for architectural applications.

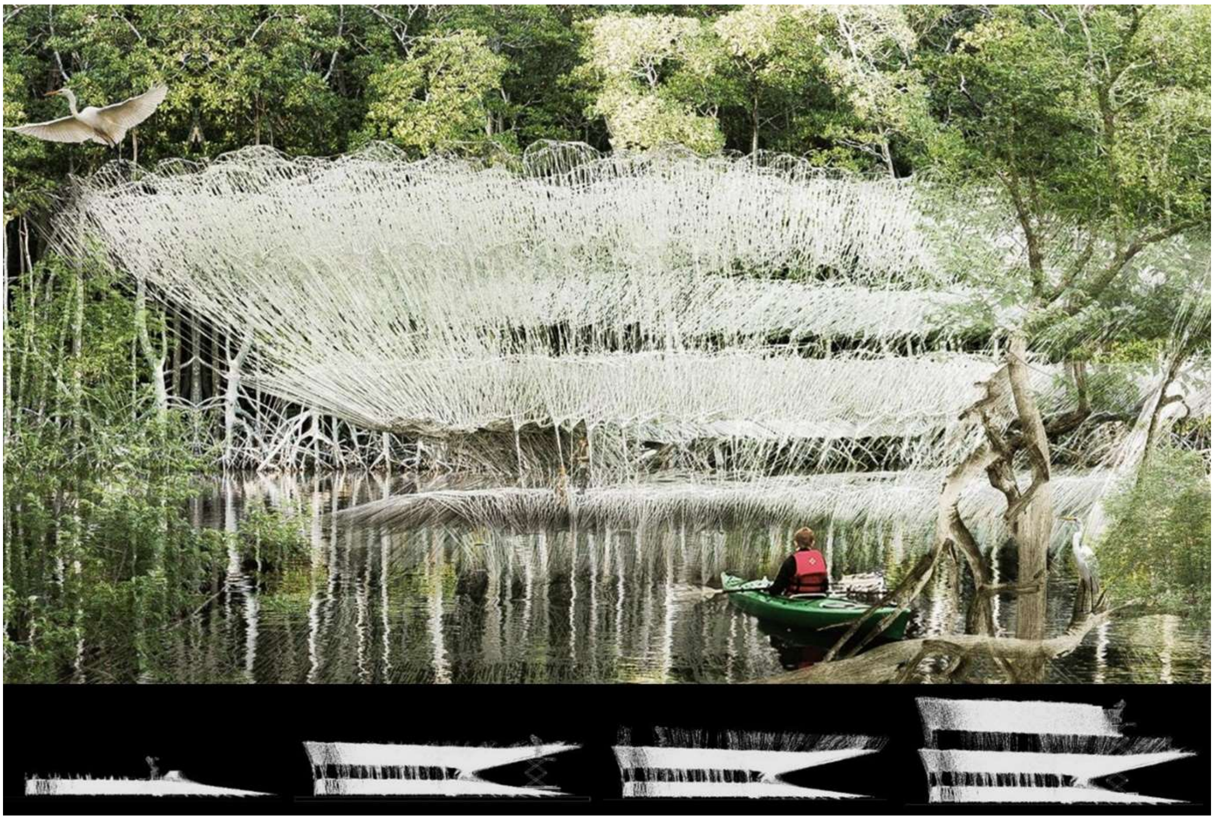


Figure 6. Stages of growth of a string structure using reaction diffusion. Project by Maria Perez and Richard Salinas (Alfredo Andia Master Project Studio, FIU, Spring 2021).

3.6 Bio-matter

The concept of "programmable matter" refers to a material that can be programmed using digital code. It is a highly advanced vision in the field of computer science that could potentially have a profound impact on the analog world. While early versions of this idea, such as Claytronics, M-blocks, and Computronium, involve tiny robots, biology offers a more sophisticated way to manipulate matter than traditional computing. All living organisms consist of programmed biological matter that can perform complex functions, such as the regrowth of antlers in a deer. In our studios, we imagine a future where generic bio-matter is a highly intelligent biological entity made of living cells that can compute, store, retrieve, and process data encoded in its DNA (refer to figure 7). We have experimented with bio-matter designs that utilizes form-finding workflows based on recursive growth. For instance, one group studied facades that use recursive growth bio-matter that propagates through two conditions: solar radiation and structural stiffness (refer to figure 7). Another group used bio-matter to grow skin structures over scaffolding made of fast-growing shrubs that later dissolve. We have also explored a growing bio-matter organism that could develop catenoid formations. Catenoid structures allow bio-matter to develop spatial materialization from a single plane that twists as it grows. This project was based on research on artificially produced cells at The Technical University of Munich, which demonstrated how cells could communicate and potentially lead to shape control in a more advanced version [13].

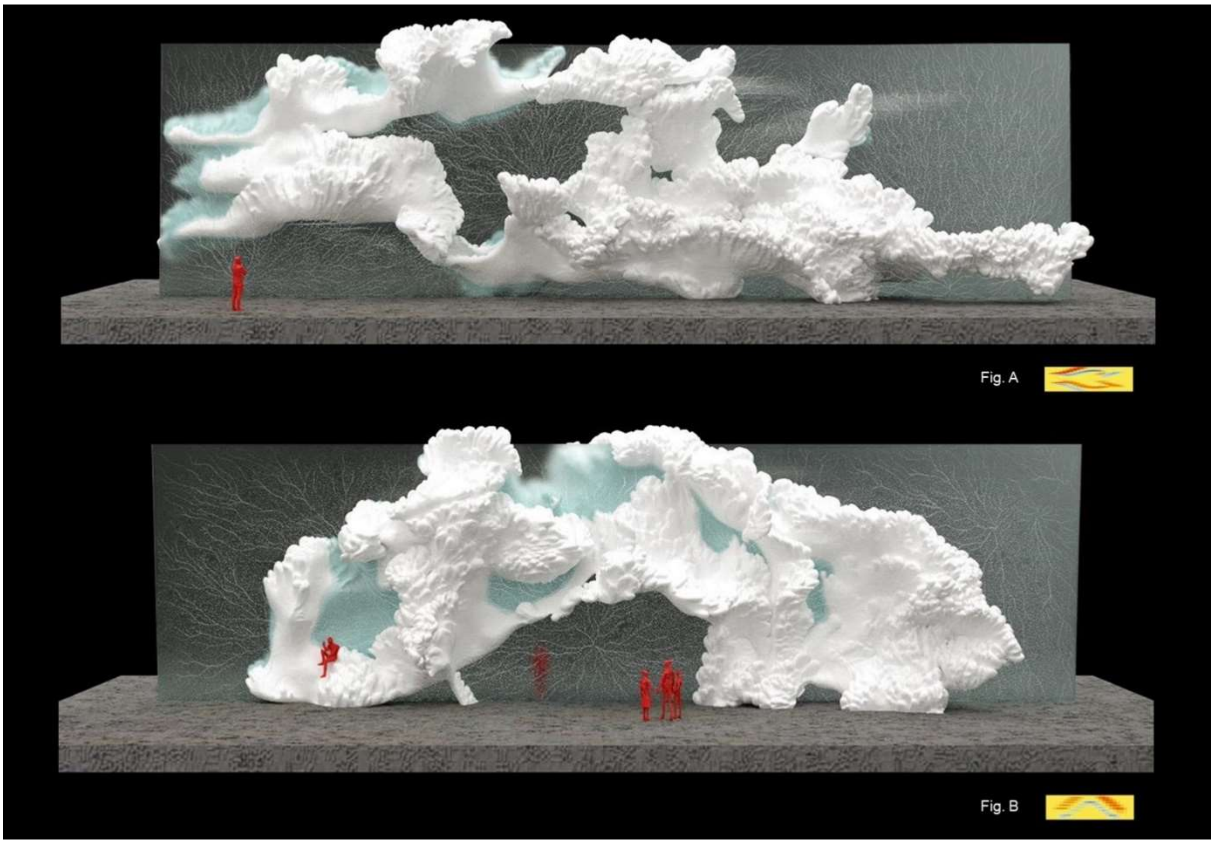


Figure 7. Programmable Bio-Matter. A series of walls designed to react to stiffness and solar radiation levels and wind forces of the site. Project by Maria Perez and Richard Salinas (Alfredo Andia Master Project Studio, FIU, Spring 2021).

4 Conclusion: SynBio Design

Every major period of innovation brings with it a paradox of design. Typically, we struggle to imagine what is new. Instead, the design of the new is often heavily influenced by the immediate past. This was particularly evident when automobiles first emerged - they resembled their predecessor, the horse carriage. However, as time passed, the car evolved and every one or two decades. Similarly, the first generation of SynBio products, from 2006-to-2022, has been focused on developing a viable industrialized biology. However, we must ask ourselves, will we remain stuck in this new biological era eating SynBio foods that simply resemble our old burgers and bacon? Can we redesign our foods beyond that? Architecture is also trapped in this paradox, are we limited to merely replacing the materials for bio-materials for our contemporary buildings and cities. In our work, we propose that the ultimate zeitgeist of the SynBio era will be how we integrate our bodies into "pure experiences" with our biosphere. In the philosophy of life sciences there is a critique to the traditional view of biology as a reductionist and mechanical model that views life as a series of physical and chemical processes. Francisco Varela, Evan Thompson, Eleanor Rosch, Alva Noë, Mark Johnson, Dan Dennett, and Shaun Gallagher are among the scholars who have advanced a new paradigm through their work on neurophenomenology, enactive perception, and the nature of consciousness. These scholars have argued that the traditional view of biology is limited because it does not take into account the subjective experiences of organisms, and the role that these experiences play in shaping the nature or niche of life. By incorporating the principles of mindfulness, the lived experience of organisms, and the embodied nature of consciousness, we can create new forms of life that possess properties that are beyond our current understanding. In that context, architectural imagination is critical.

References

[1] UNEP, Temperature rise is ‘locked-in’ for the coming decades in the Arctic/Press release: Nairobi, March 13, 2019/UN Environment, https://www.unep.org/news-and-stories/press-release/temperature-rise-locked-coming-decades-arctic

[2] Schoolmeester, T., Gjerdi, H. L., Crump, J., Alfthan, B., Fabres, J., Johnsen, K., & Baker, E., *Global linkages—A graphic look at the changing Arctic,* UN Environment and GRIDArendal, Nairobi and Arendal, 2019.

[3] Church, M., George, & Regis, Edward, *Regenesis: how synthetic biology will reinvent nature and ourselves*, Basic Books, 2014.

[4] Song, Jianwei; Chen, Chaoji; Zhu, Shuze; Zhu, Mingwei; Dai, Jiaqi; Ray, Upamanyu & Li, Yiju, Processing bulk natural wood into a high-performance structural material*, Nature, 554,* (2018), no. 7691, pp. 224-228.

[5] Beckwith, L., Ashley; Borenstein, T., Jeffrey & Velásquez-García, F., Luis, Physical, mechanical, and microstructural characterization of novel, 3D-printed, tunable, lab-grown plant materials generated from Zinnia elegans cell cultures, *Materials Today 54* (2022), pp. 27-41.

[6] Zhang, W., Chen; Zhang, W.; Zhang, T., C., & Song, H., Applications of synthetic biology in the construction industry, *Frontiers in Bioengineering and Biotechnology, 8*, (2020), 323, DOI: 10.3389

[7] DARPA, Living Structural Materials Could Open New Horizons for Engineers and Architects/2016/Defense Advanced Research Projects Agency, https://www.darpa.mil/news-events/2016-08-05.

[8] Nguyen, Q., P., Courchesne, N. M. D., Duraj-Thatte, A.; Praveschotinunt, P. & Joshi, N. S, Engineered living materials: prospects and challenges for using biological systems to direct the assembly of smart materials*, Advanced Materials, 30,* (2018), 19, DOI: 1704847.

[9] Gilbert, C., & Ellis, T, Biological engineered living materials: growing functional materials with genetically programmable properties, *ACS synthetic biology, 8,* (2018), 1, pp. 1-15.

[10] Srubar III, V., W., Engineered living materials: taxonomies and emerging trends. Trends in Biotechnology, 39, (2021), 6, pp. 574-583.

[11] Heveran, C., M., Williams, S., L.; Qiu, J., Artier, J., Hubler, M., H., Cook, S., M. & Srubar III, V., W., Biomineralization and successive regeneration of engineered living building materials. Matter, 2, (2020), 2, pp. 481-494.

[12] Lew, Tedrick, Salim, Thomas, Koman, Volodymyr, Gordiichuk, Pavlo, Park, Minkyung & Strano, S., Michael, The emergence of plant nanobionics and living plants as technology, *Advanced Materials Technologies 5,* (2020), 3, DOI: 1900657.

[13] Dupin, A., & Simmel, C., F., Signalling and differentiation in emulsion-based multi-compartmentalized in vitro gene circuits. *Nature chemistry, 11,* (2019), 1, pp. 32-39.

DRONECOTE

Angelos FLOROS

Ionian University
7, Tsirigoti Sq, 49100, Corfu, Greece, angelos.f@ionio.gr

Abstract

This work examines the key role of networks as a symbiotic model of human and robotic culture in common ground. It applies a method that brings together future technology of delivery with current and emerging needs of society into the time present. The *Dronecote* (or the House of Drones) is a realization project, a think tank for applications that applies to Public Sphere (Habermas, 1989), bridging communication and delivery technologies using applications and infrastructure of urban, suburban and regional societies. It is based on pre-internet culture where societies used doves (pigeons) as a centralized or decentralized: node-based communication and information exchange.

Dronecote is a free-standing structure or extending to a structure that hosts drones to serve the community in digital and information era. The structure is located in urban, suburban or countryside areas.

Design method separates the interdisciplinary research in four axes module: a) the construction of *Dronecote* tower and b) the implementation of applications for a drone's node-based network system, c) the urban, suburban and the regional needs of societies, d) local principles of everyday life on a global map.

The *Dronecote* as a practice based research emerges two questions a) how our civilization can capitalize the achievements of the past and b) how does it feel to live today together with the future?

Dronecote project is a part of the research program HAL (Hub of Artistic Laboratories) of the Department of Audio and Visual Arts of the Ionian University which is set ti yield multiple benefits for the Ionian Islands Prefecture.

Keywords: Delivery, Drones, Robotic Age, Services, Adaptable Architecture

1. Introduction

"*Time present and time past/Are both perhaps present in time future/And time future contained in the past./If all time is eternally present/All time is unredeemable*." TS Eliot[i] In these sentences of the poem, Eliot sets the importance of present time in our everyday life. Memories of the past are related to present time and future time linking individuals to timeshape form. This approach is used to describe the role of memory and past time to human existence as a meditation process and how people and societies interact with time. The concept of time embeds a variety of methods that led us to understand the sense of timelessness. Eliot, suggests that the past and the future are contained within all moments. In this project, time gains spatial characteristics helping us to module an evolution process for communities, that evolves robotic technology on society needs and values.

Dronecote project proposes a method to design and develop a house of drones as a flexible delivery method for urban, suburban and regional area. *Dronecote* will to offer tools and gIve to architects, designers and developers opportunities to design the role of networks within the symbiotic model of Robots and Humans in present and future time.

Dronecote is designed as an open platform having as a case study to serve a delivery system for Ionian Islands Prefecture. The Prefecture of the Ionian Islands is located on the west part of Greece and is consisted by the following major islands (Figure 1): Corfu (Kerkyra), Paxos, Lefkas, Ithaca, Kefalonia and Zante (Zakynthos).

Figure 1. Ionian Islands, Wikipedia

The project is running the first phase, which means, it collects data and produce resources for the following phase of Analysis & Design. The Phase 1 is essential to ensure the timely successful delivery of the project, it covers the project management and preparation and includes the following work packages:

- Understand the current environmental and technological criteria
- Prepare detailed project plan
- Defuse project organisation including structure, communication plan, resources and logistics
- Define project management structure, standards and tools.

The research of *Dronecote* project has the initial point on the achievements of the past. This research focuses on the use of pigeons as a method of communication since the ancient years, looking back to the history of cultures and communities. Since then, dovecotes became very popular worldwide and had a distinguished role in regional economy, politics and war.

The *Dronecote* tower, as a docking station, focuses on flexible infrastructure to serve different needs according to UAVs current technology and the services they offer. The design of the tower requires a program that covers facilities for drones, humans, logistic support and delivery service.

The UAV technology has a distance limitation depending on battery size and GPS accuracy. Several technologies appeared the last years and many patents applied from leading companies of the market such as Amazon, Alphabet and many others, covering the urban district, suburban settlements and countryside areas needs.

The major needs of the communities are not related with technological evolution over time. People, as customers, usually, are looking for food, goods, gadgets, tools, medicines and other objects of everyday life for human body, accommodation, work and leisure. Also, small and big size enterprises are using unmanned aerial vehicle (UAV) technology to surveillance areas, to cantilever agricultural fields, etc. Authorities and non-profit organisations are developing their own services to control and protect people as also the natural environment.

In the near future drones will play a leading role in people's daily lives in the era of digital transformation. The smartphone redefined fundamental fixed values in interpersonal relationships, and at work. The UAV comes in turn to revise several constants in the field of transport, delivery and logistics.

The mobile phone has allowed us to respond with ease and speed to the ever-increasing complexity of our daily lives. Drones will soon be an integral tool for every family, perhaps even for every person. Emerging AI services will adequately cover a wide range of 21st century services.

Technology is evolving at a rapid pace, combining advanced materials and complex management systems. The management of urban space from the 70s onwards is gradually passing from the hands of architects and urban planners to the hands of companies and developers.

Already in 2000 we saw the disappearance of urban planning as a research subject in university institutions internationally, since specialized real estate companies took over their work, planning settlements and cities through micro-economic and macro-economic models. The technology of automation is obviously not unknown to architects, but unfortunately the proper ground is not provided for the utilization of the skills and abilities they have developed for the operation of cities and periphery in the 21st century.

The future has come, but societies still don't have proper tools to embed it wisely. Applied policy systems and infrastructures are primitives. There is no common ground to develop a proper vision for humanity by using the tools of automation. A reliable process or method to evaluate the outputs is not yet established. Artificial Intelligence and machine learning technologies occupy a significant position in all aspects of life. Robots in the near future will be everywhere.

Drones recently became very popular to the public, as a flying tool, offering aerial photography, video production, inspection service, mapping areas and activities and many more. Few years ago, Amazon presented the Prime Air service, using drones as an emerging delivery service. Amazon promotes Prime Air as "a future delivery system to safely get packages to customers in 30 minutes or less using unmanned aerial vehicles…" (Amazon, 2018). The flying vehicles vary according to the variety of operating environments. They established development centers in the United States, United Kingdom, Austria, France and Israel. For Amazon, safety and security are as they declare "top priorities''. They are working with regulations and industry to design an air traffic management system.

2. The time and the process of changes

Dronecote project proposes a method to design and develop a house of drones as a flexible transportation and delivery method for urban, suburban and regional area of Ionian Islands. *Dronecote* offer tools to give a proper opportunity to design the role of networks within the symbiotic model of Robots and Humans in present and future time for the Western Periphery of Greece.

Looking back to Past at the beginning of the last century, Modernism introduced to societies a global decentralized economic mass production module, through design, in urban and suburban districts.

One hundred years after the manifest of De Stijl, several methods established as a charter of the Evolution of Humanity for the work and leisure in centralized and decentralized urban environments.

The democratization pattern of Modernism defined the necessary infrastructures for rapid growth of urban cultures, such as mass production, logistics, global economies, policy systems, local and global transportation networks and many others. A plethora of educational, economic, commerce, law, technological and scientific models were developed under the prism of human perspective, focusing on social and liberal changes. The radical changes of modern age required non objective and non-representational methods, an abstract medium to document, analyze and classify data and metadata, transforming them to information in order to form a synchronized consciousness of time connected with the universal.

The transportation service of *Dronecote* is based on a successful approach of Pigeon Post who last from the ancient years up to our days.

Historically, after World War II many questions emerged about the role of Automation as a pioneer augmented tool of the human consciousness for work and the free time in urban cultures. Constant Nieuwenhuys proposes the New Babylon[ii] (Constant, 1953) as a future potentiality for cities and citizens. The ‘evil’ city (Lefebvre 1983) of New Babylon became the figure of good forming 'situations' as alternative life experiences for the city of the future[iii]. Het Nieuwe Instituut, as a commissioner, celebrated the 100 years of Modernism in Venice Biennale 2018, raised the automation and its spatial implication for the built environment under the thematic ‘Body, Work, Leisure’[iv] “to foster new modes of creativity and responsibility within the architectural field in response to emerging technologies of automation”. The harbour of Rotterdam moved on full automation infrastructures and services “from the self-managed logistical infrastructures of the port to the logic and relations that define the physical and social landscapes of the city, and across agricultural clusters in the Netherlands.” as the commissioner declares.

3. Data from the past time: Pigeon post modules

3.1 Training methods

The Pigeon post has its roots in ancient history since man succeeded to train birds. The homing pigeons (Columba livia domestica)[v] were selected to be used as a medium for airmail. Homing pigeons have the ability to return to their nest even 1000 km away. They may cover a distance of 220 km in about 4 hours. Historically, the pigeons were used to carry messages only one way, back to home. For pigeon posts, the nest was the destination spot. In order to reuse them for another transportation they had to return them to base manually. Through all of these years they implement techniques to use homing pigeons as a two way communication. By placing their food at one location far away from home they managed to train the birds to exchange their location between those two poles. Finally, they succeeded in using homing pigeons for round-trip flights up to 160km. New York Times published the article “A Homing Pigeon’s Instinct in 1881 mentioning that these birds managed to return home over 185 miles, four months after their relocation.

3.2 Navigation system

Most researchers tried to answer the question, how these birds can find their way back to home covering such a long distance. Most of them believe that the ‘homing ability’ is based on a model that combines a map and a compass. Birds have the ability to detect and use the Earth’s Magnetic field. The sun acts as a compass mechanism allowing birds to be oriented over the map. The research found a large number of iron particles on the pigeon’s beak, which remain aligned to the north. Exactly the same principle is used by the industry to produce compass. Many others researchers focus their navigation research on trigeminal nerve in magnetoception, a light-mediated mechanism of the eye[vi]. Magnetoception is a sense that allows an organism to detect the magnetic field and collect direction, altitude and location data. Other research shows how pigeons can navigate using the visual memory of the environment, like humans. The technology of infrasound also has been used by pigeons to navigate in low-frequency sound waves. Experiments by John Hagstrum of the US Geological Survey succeeded to disrupt or redirect the birds navigation using 0.1 Hz sound wave frequency.[vii]

3.3 History of pigeon post

It is hard to find the origin of the first use of Pigeon Post. There are several publications mentioning that in Egypt, they used homing pigeons to deliver messages in 3000 BC, but other publications mention the Persians and the Sumerians. In the Classical Era, the Greeks used pigeons to proclaim the winners’ list of the Ancient Olympic Games. Since then, the pigeon post has become a reliable airmail method around the world. Pigeon’s Posts have been documented in Baghdad (1150), Mongol Empire, Syria (1167), Damietta (1436), Republic of Genoa, Mysore (1750), Brussels (1818), Auckland and New Zealand (1897) and many others.[viii]

3.4 Military use

The pigeon post was used during wartime as a reliable communication method. In World War I important messages were sent in northern France and Belgium. Cher Ami, a female pigeon, was awarded the French Croix de guerre for her heroic services during World War I. Cher Ami donated by British to the US Army Signal Post. She was trained by American pigeoners to be used in France in the war. During World War II the British dropped into the Netherlands eighty-two homing pigeons, as part of the Operation Market Garden, to deliver messages back to Britain covering 390km.[ix] The message was attached to the pigeon’s leg, usually written on light paper and rolled into a small tube. After training they manage to send messages up to 75g.

3.5 Adaptive roles

In the beginning of the 19th century, in Germany, they used pigeons to deliver medicines and in England in 1977 they developed a system to exchange laboratory material between two hospitals. 30 homing pigeons were used daily to exchange packages between Plymouth General Hospital and Devonport Hospital.

Many cases mentioned that homing pigeons are used as a smuggling technique to transfer drags across borders. In Sao Paulo pigeons delivered drugs, sim cards and cell phone batteries into prisons.

3.6 Dovecotes across history and time

Dovecote is a special type of building, referred to as a house for pigeons or doves. These structures can be free-standing or embedded to an existing building. Pigeons and doves were important for local economies over time, for food, agriculture, commerce and transportation. Several types of dovecotes were constructed around the world from the ancient years up to the 20th century.

In England it has been very popular since Medieval times. Dovecotes were also a symbol of power in Western Europe.

In Greece dovecotes are known as Peristerones (Figure 2). These structures are very popular in Cyclades islands and particularly in Tinos. More than 1000 peristerones have been documented in the small island of Cyclades. The breeding of the pigeons became very popular because they were used for food and fertiliser. The dovecotes introduced to Greeks by the Venetians in the 15th century. Usually we found dovecotes in the countryside, far away from urban environments helping decentralized cultures in several economic tasks.

The war introduced another typology of dovecote, the mobile carrier pigeons. During World War I they produced the vehicle WWI B Type Bus as a motorized carrier pigeon, a transformed version of Type B troops carrier. They used these motorized dovecotes during the war across Europe because they understood the important role of the homing pigeons in this war.


Figure 2 : Left: Dovecote in Tinos Greece. https://tinostoday.gr/peristeriones-tinos-2/
Figure 3 : Right: An old Dovecote in Doorn, Netherlands
https://en.wikipedia.org/wiki/Dovecote#/media/File:Pigeonhouse.JPG

4. Data from the near future

4.1 Drone Laws

Almost all the countries allows the flight of drones in urban and suburban districts, upon certain and customised circumstances. The non-for-profit NGO "Drones Laws" [x] offers a database, including national drone regulations with several additional resources and many useful links to sources and regulatory agencies. Drones laws are not yet fixed, they change frequently. *Drones Laws* offer useful information to they involved parties and help them to have a local and global view of the regulations and policies. The local and governmental aviation authorities are responsible drone safety. The aviation authority utilise a licensed drone service operator. The Federal USA agency that is responsible for drones regulation and safety is the Federal Aviation Administration (FAA). The US state of Virginia succeed in 2019 to give the authorisation for Drone Delivery and has certified the Alphabet's Wing to operate as an airplane[xi].

4.2 Current application

Many applications on mobility and transportation came to the market giving reliable valuable solutions to communities. Zipline -a US based startup- is using air delivery to transport COVID-19 test samples in remote locations across five African countries such as Rwanda. Zipline send urgent medical aid like blood, vaccines or medicines from the town of Muhanga to the whole country[xii].

In the academic field articles about air transportation and delivery have seen a drastic increase the last decade. The most common debates focus on technical and regulatory issues. The public acceptance is a key element in the further development of drone technologies.

Amazon Prime Air is a delivery service based in flying vehicles. The operations were expected to start in selected cities late 2019, but the service has yet to materialise. Amazon service promises a 30-minute delivery, after the order. The package should be less than 2.25 kg and small enough to fit in a cargo box that the craft can carry. The delivery location should not exceed the 16 km from Amazon fulfilment center. The Federal Aviation Administration selected Amazon, Zipline, Wingcopter and seven (7) other companies to participate in a type certification program for delivery drones.

In our days, a large number of current applications is used by the industry, such as: civil security and defence, emergency response, humanitarian aid and disaster relief, conservation, disease control, healthcare, agriculture, weather forecasting, maritime, waste management, energy, mining, construction planning, infrastructure development, insurance, realty, urban planning, transportation, airlines, telecommunications, internet, outdoors photography, tourism and hospitality, life entertainment, sports, advertising, retail, manufacturing and inventory management, underground economies and fighting crime, food services, education, e.t.c.

4.3 Patents

The rapid development of applications for drones has led companies that want to have a leading role in the global economy to an uncontrolled race to secure technologies through patents. Amazon alone for 2016 has filed over 78 patents in technologies it wants to manage, such as UAV, shipping, vehicle, freight and autonomous, vehicle. It has already received the following approvals: Multi-use unmanned aerial vehicle docking station (2016)[xiii], Multi-Level Fulfillment Center for Unmanned Aerial Vehicles (2017)[xiv], Airborne fulfillment center utilizing unmanned aerial vehicles for item delivery (2017)[xv], Ground-Based Mobile Maintenance Facilities for Unmanned Aerial Vehicles (2017)[xvi], Stabilized Airborne Drop Delivery (2017)[xvii], Aquatic storage facilities (2017)[xviii] and many others[xix]. Ford also hold the patent 'Vehicle moonroof systems for docking and cooling unmanned aerial vehicles' (2019) allowing their vehicles such as Ford F-150 to be used as a UAV docking station[xx].

5. The Dronecote Docking Station

5.1 *Dronecote* site

This project is based on the historical evolution and use of dovecotes and pigeons and transforms the syntactic use of the free-standing structure to serve communities of the Ionian Islands in the digital and information era, through the Dronecotes.

According to the framework of this proposal, Dronecotes can be located in urban centers, suburban areas and in the countryside. Several typologies may be applied according to different characteristics of the built and natural environments. In cities the Dronecotes may be located on patios, parks, or even on building roofs . They can be an adapted structure of an existing building, or an individual and fully autonomous free-standing structure.

5.2 The program

The program of the tower is consisted by the followings: a) individual drones base, b) loading area, c) storage area, d) charging system and e) staff area. Major inhabitants of the *Dronecote* are the drones.

Dronecote structure as an outdoor tower structure cannot be less than 5m height and 3 meters diameter, according to ergonomic design of transportation service. It should have the ability to host at least 6 drones, offering the necessary infrastructure for parking, pick-up, place and store small or large scale packages and charging capability. The tower should offer a safe and functional environment for drones, staff and products.

It is crucial to design a fully automated procedure reducing possible technical failures and human and robotic energy. The purpose of this framework is to give to designers all the necessary data for a functional operation of air transportation using drones.

Each drone should have a base, for departure and rest. Each drone's base must be safe from the outdoor environment and protected from any weather condition. The base must include a charging option during resting time.

The loading area should be in a location that allows each drone to access it easily, without any barrier. The area should not be less than 4 square meters. The size of the area is dependent on the size of the packages. Also, a loading system should be embedded, connecting the storage area to the landing area. This can be vertical, having an upright hydraulic mechanism to bring the package from the lower storage area to the landing area. Another option is to have a horizontal or an angled conveyor that shifts the package to the right position for loading.

Storage areas usually are using shelves to store the packages. The framework of the *Dronecote* focuses to a small scale storage areas that have the capabilities to cover specific needs of the society. It is not addressed to logistic companies to carry large scale packages for private use. These companies have the expertise to use advanced automated systems related to their financial needs. Twenty square meters is the minimum space for the storage area.

The *Dronecote* can be designed only to host drones. Another typology should have the ability to host staff, one or two persons as a minimum number of employees. In suburban and regional editions the staff may have a resting room for 24/7 services. The staff area may not be limited to 20 m^2. The structure should be designed for a zero CO2 trace to the environment.

There are no typological instructions on the design of the structure. Designers are free to invent an environmentally friendly structure and create a sustainable environment that fits in guideline needs. The type of the construction may use printed materials or other digital fabrication technologies. Today, we have the ability to print materials that embed digital circuits and other electronics allowing the implantation of complex systems. Autodesk firm has an extended research on 3D printing technology that allows circuits to be intergraded inside the objects. The latest model of Voxel8 3D electronic printer promises these combinations in one object using a single print job.

The ETH Zurich focus on flying machines enabled construction research. Flight Assembled Architecture[xxi], a collaboration with the architects Gramazio & Kohel was an exploration research on aerial construction using drones. The research program ended by the end of 2019. One of the projects focuses on building a brick tower and another one on aerial assembly of tensile structures. Both techniques can be used for the construction of the *Dronecote*.

6. Outlook

The informational technology which is inspired by spatial and society components plugs the urban citizen as an involved user into an aparallel augmented reality era, combining city infrastructure and desktop interfaces. Which are the spatial components and the community interests and needs that are embedded in informational systems? What is the identity of the contemporary citizen in a futuristic city? Using the scale of linear space as a dynamic element it provides an informational method is provided, analyzing the applets of the design process, morphing AI interfaces, building technology and city infrastructure. What is the role of the networks? How can they be used in order to provide new patterns of interaction in this global era?

In our days AI and Cloud network technologies offer a reliable method to implement complex problems. Machine learning interfaces, architectural design process and the city infrastructure are the applets of an urban network. They help metropolitan and non-metropolitan citizens to gain the experience of living in a global era supporting glocal characteristics. Moreover, they influence the decision in urban planning projects. Crucial remains the method of the scale for keeping the citizen as a part of a system. Otherwise, the citizen prefers to continue a virtual tour in online social communities uploading and downloading urban experience.

The network city morphs the urban user to a symbiotic model in the time of individualism. Metropolitan citizens can easily understand that the contemporary city is a network. They are individual “objects”, parts of a swarm and users of a dynamic infrastructure. The transportation system improves and defines our ability to read the urban structure. Junctions and path-lines can capture the bandwidth of the city aura. In our days, it is more crucial the question of what citizens do we want for our city than what city do we want for our citizens. The major degree of complexity that characterizes the contemporary city demands a well informed citizen that uses external computational power in order to be part of the system. Herbert Simon wrote "*Roughly, by a complex system I mean one made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in a ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole*."

Time is the medium not only to organize the activities, but also to model the life of the urban citizen. Time is the new structure of a living organism, such as city. Time is also a variable to debug the network credibility. The network transportation has to run always properly without any delay or inconvenience; otherwise it has to be repaired. Dronecote project is fitted in 'State of Affairs and Future Visions' track. It uses architectural design process, AI media and network techno"where practicioners and researches meet and exchange knowledge, insights and experience on cross-disciplinary field of architecture and built environment.", as S.ARCH website describes on conference call.

7. Reference

1. *Burnt Norton* (1936), TS Eliot, the first poem of 'Four Quartets' (1943) Harcourt edition
2. Constant Nieuwenhuys (1953) For an Architecture of Situation
3. Lefebvre H., Ross K., Lefebvre on the Situationists: An interview (1997) MIT Press
4. https://work-body-leisure.hetnieuweinstituut.nl/
5. https://en.wikipedia.org/wiki/Domestic_pigeon
6. https://doi.org/10.1098/rsif.2019.0295
7. https://www.livescience.com/26714-how-homing-pigeons-navigate.html
8. https://en.wikipedia.org/wiki/Dovecote
9. https://en.wikipedia.org/wiki/Cher_Ami
10. https://drone-laws.com/
11. National Public Radio (NPR), https://www.npr.org/2019/04/23/716360818/faa-certifies-googles-wing-drone-delivery-company-to-operate-as-an-airline
12. https://blog.flykit.app/zipline-drones-of-rwanda/
13. https://patents.google.com/patent/US9527605B1/en
14. https://patents.google.com/patent/US20170175413A1/en
15. https://patents.google.com/patent/US9305280B1/en
16. https://patents.google.com/patent/US9950814B1/en
17. https://patents.google.com/patent/US9688404B1/en
18. https://patents.google.com/patent/US9624034B1/en
19. https://www.cbinsights.com/research/amazon-warehouse-patent/
20. https://patents.google.com/patent/US11548658B2/en?q=(Vehicle+moonroof+systems+for+docking+and+cooling+unmanned+aerial+vehicles)&oq=Vehicle+moonroof+systems+for+docking+and+cooling+unmanned+aerial+vehicles
21. Augugliaro F., Lupashin S., Hamer L., Male C., Hehn M., Mueller M., Willmann J.S., Gramazio F., Kohler M.,
22. d'Andre R. (2014) The Flight Assembled Architectural Installation, IEEE Control Systems Magazine, August 2014

A SCENARIO BASED DESIGN STUDY AGAINST EARTHQUAKE FOR DOMESTIC INTERIORS

S. Banu GARİP*, Ervin GARİP, Gözde GÖKDEMİR, Uğur Efe UÇAR, Koray GELMEZ

Istanbul Technical University
Taskisla Campus 34347 Istanbul, Turkey;
baseskici@itu.edu.tr*, ervingarip@itu.edu.tr, gokdemirg@itu.edu.tr, ucar15@itu.edu.tr, gelmez@itu.edu.tr

Abstract

Within the scope of studies aimed at detecting and reducing earthquake risks, the most important measures to be taken are the correct placement, to construct earthquake resistant structures and retrofit the existing buildings. Subsequently, the risks can be reduced by the measures taken in the interior spaces of the buildings. This paper presents a research project which aims to determine what the interior design criteria for reducing earthquake risks in residential interiors are, and to search for interior design solutions that define reduced risk areas based on these criteria. As the first stage, an analytical study was conducted, national and international publications related to "earthquake risks and approaches to reducing risks in interior spaces" were searched and systematically analyzed. At this stage, using the content analysis method, the data to define the criteria were collected under the headings of "risks" and "strategies" for "housing interior components".

The design study is conducted for the case of a standart apartment model which can respond to different scenarios focusing on human behaviours during earthquakes and defined earthquake risks. At the final stage, a sustainable furniture family is proposed and the spatial behavior and responses of these furnitures during the earthquake was studied. It is aimed to explore the potentials of furnitures to reduce earthquake risks with different material and design approach.

The process and findings have been presented as a design guide with the title of “Design Guide for Reducing Earthquake Risks in Residential Interiors”. This guide aims to provide a holistic data set for interior architects and designers to be used by users as well as to reduce the indoor risks of the earthquakes.

Keywords

Interior architectural design, residential interiors, furniture design, earthquake, risk reduction

1 Introduction

This study deals with the earthquake phenomenon and earthquake risks in the context of interior design. The aim of the study is to investigate what the design criteria are for reducing earthquake risks in residential interiors by analyzing the existing studies in the literature and how interior designs that define reduced risk areas can be made depending on these criteria. Within the scope of the paper, the final phase of the research project carried out for the defined purpose is presented. In the study, a holistic approach to reduce earthquake risks is followed. A design study is conducted for the case of a standart apartment model which can respond to different scenarios focusing on human behaviours during earthquakes and defined earthquake risks. As the last stage, a sustainable furniture family is proposed, responses of the furnitures during the earthquake is studied.

Considering the analysed studies, it is seen that the they are mostly carried out in the field of civil engineering and on a structural scale, and there are few resources on interior design. When studies and publications in different fields that can be references to this study and where necessary data can be collected are searched, it is seen that these studies are related to furniture design, interior design and precautions to be taken in existing spaces to reduce earthquake risks. Studies on furniture design [1,2,3,4,5] focus on single furniture or combination-assembly details. Studies examining the effects of earthquakes in the interiors of buildings investigate the effects on furniture or non-bearing interior elements [6,7,8,9]

Studies focusing on interior design to prevent earthquake risks generally deals with the topic at a room scale, within the scope of user behavior or general precautions, and in this context, it is seen that there are approaches that deal with the subject from different points of view [4,10,11,12]. Studies on measures to be taken in the existing spaces [13,14,15,16] define principle decisions holistically. AFAD (Ministry of Interior Disaster and Emergency Management Presidency) and similar institutions have extensive publications on the precautions to be taken before an earthquake. These measures, which are explained in line with the experiences, provide important data for the study of design criteria for reducing earthquake risks.

2 Working Through Scenarios

When an earthquake will occur, it is not possible to know in advance or to predict what effects it will have. In cases where the structure is not demolished, especially for the interior spaces, precautions should be taken, considering the worst-case scenario. Under this title, the design phases of the presented study (Figure 1) which are based on the existing literature analysis will be explained.

Figure 1. Phases of the study (source: authors)

2.1 Literature Research Phase

As the first phase of the study, an analytical research was conducted, national and international publications related to "earthquake risks and approaches to reducing risks in interior spaces" were searched and systematically analyzed. Using the content analysis method, the data to define the criteria were collected under the headings of "risks" and "strategies" for "housing interior components". “Risks” are defined as the conditions that may cause damage or danger within interior spaces during an earthquake while “strategies” define the proposed solutions to prevent these damages.

As a result of the literature analysis, the interior components that are involved within the interior architectural design process of residential interiors are grouped as;

- Fixed furniture
- Mobile furniture
- Objects
- Non-structural elements
- Electrical appliances
- Technical equipment
- Lighting fixtures

Collected data related with risks and strategies mentioned in the examined literature is presented within a holistic "design criterion set", which is an output of the study. This presented data set basing on the literature analysis is expected to be a guide on earthquake awareness in residential interior design for designers as well as residential users.

2.2 Developing Scenarios: A Standart Apartment Model and Spatial Behavior During the Event of an Earthquake

A scenario describes a sequence of actions and events that lead to an outcome; these actions and events are related in a usage context that includes the goals, plans, and reactions of the people taking part [17]. Eilouti defines scenario-based design methodology in which scenarios represent essential tools for exercising various role playing and exploring potential “what-if” settings [18]. In line with this approach, a standart apartment model which can respond to different scenarios focusing on human behaviours during earthquakes and defined earthquake risks are developed. On this model, before and after the event of an earthquake scenarios including behavior alternatives for different user types are defined (Figure 2).

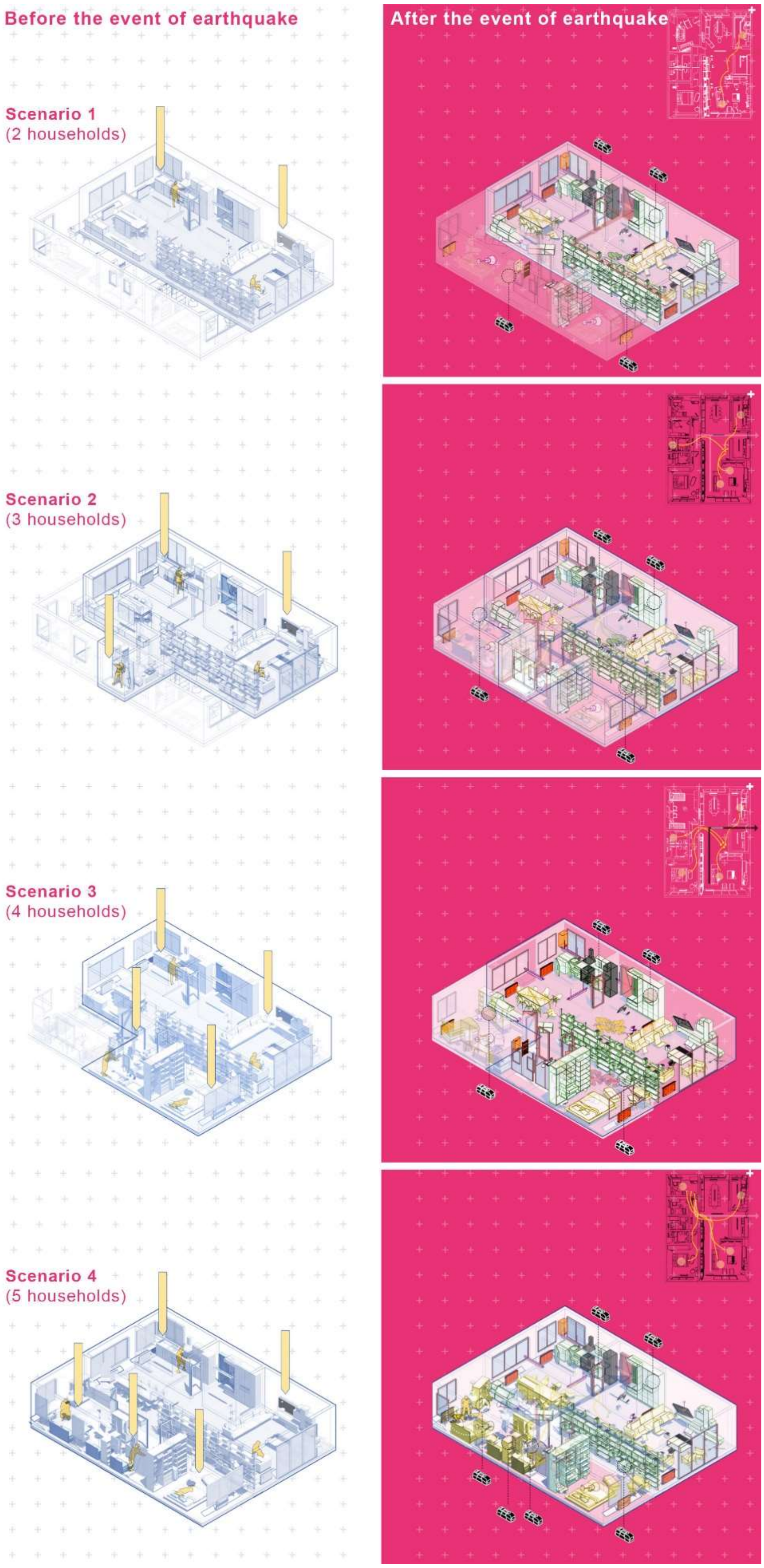


Figure 2. Different scenarios focusing on different user types on the composed model (source: authors)

Parameters which were effective on the determination of the scenarios are defined as below:

- A standart apartment unit that can meet the needs of different family types in Turkey was composed to be used for the representation of different scenarios and later for the Design Model Development phase. The reason why the residential interior to work on is considered as an apartment unit is, the common living units in Istanbul and Turkey are in the form of apartments.
- The first scenario defines a user type which is consist of 2 households, the second scenario defines a 3 households family type, the third scenario is a 4 households family type and the fourth scenario is consist of 5 households.
- The number of bedrooms and the plan layouts differ according to different family types.
- For the selection of family types, 2021 TUİK (Turkish Statistical Institute) data are taken into account [19]. Average household size in Turkey according to 2021 TUIK data has been decreased to 3,23. Istanbul has an average value which is in the range of 3,11-3,39 [19]. Based on these data, the model which is selected for the Design Phase study is defined as 3 households family type.

In line with the purpose of the research, with the development of the scenarios, a base for studying on two main issues that will be focused on during the design phase is composed:

- Definition of “reduced earthquake risk area”,
- Circulation-based human behavior before and after an earthquake event.

Bangate et al., in their study, determined that people during the event of an earthquake tend to reach their family (social attachment theory) [20]. For example, a baby's mother will immediately try to reach him and act with the motivation of protecting him during the earthquake. In this context, it is seen that a safe and continuous circulation for this action they will perform instinctively is needed as well as for reaching to the exit.

2.3 Designing a Sustainable Furniture Family

Furnitures, together with their form and usage styles, have potentials to provide protection against earthquakes, and they can also be a danger in the event of an earthquake. As it is seen in the literature, the potential risks are defined as tumbling, breaking, blocking the escape route, discharge, crushing (human). From the perspective of interior architecture, the study differs from previous studies with the search for optimum solutions to the earthquake's effects on residential interiors and the development of furniture family design with a holistic approach to residential interiors to minimize the problems it may cause.

In this context, at this stage of the study, it is aimed to design an innovative furniture family that will reduce the risks within the residential interiors during an earthquake where structural elements are not damaged (Figure 3). Based on this context, It is aimed to explore the mobility and movement potentials of furnitures to reduce earthquake risks together of with different materials and design approaches. This approach is developed with the use of “auxetic” forms within this study.

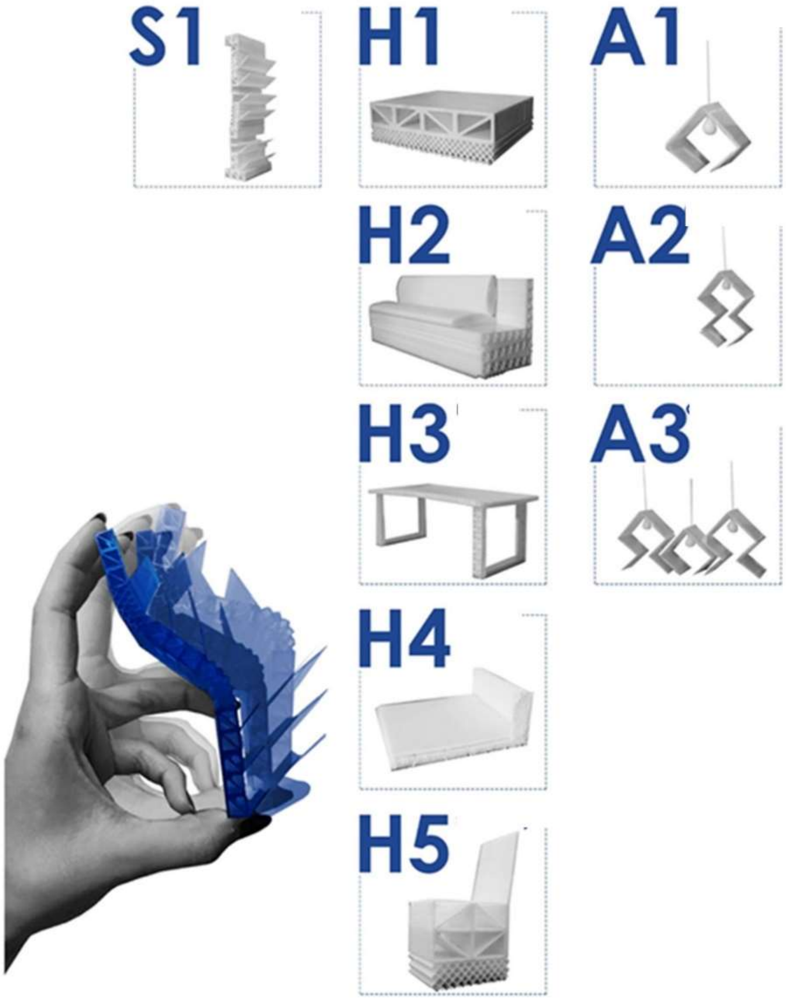


Figure 3. Physical models of the designed furniture family (source: authors)

Auxetic forms are defined as structures or materials with a negative poisson ratio (NPR) [21]. These metamaterials, unlike conventional materials has a structure that can expand in different directions [22]. This structure of the auxetic forms, has the potential for mobility, transformation and adaptation to different loads.

As a strategy for the design of the bookcase, which is considered in the fixed furniture category and coded as S1, the principle of “reduced risk area” for circulation has been accepted. In line with the principle, in the event of a possible earthquake, It is aimed to reduce the area covered in the circulation area with the folding movement of the bookcase. The bookcase structure is designed with flexible and rigid different auxetic pattern systems. Thanks to the two separate flexible auxetic patterns developed, the bookcase can be folded and thus the area it covers reduces 53% when it falls, and safe circulation area increases. In addition, bookcase shelves are considered as an extension of its main structure.

Risks of crushing, tumbling and breaking for the elements considered in the category of mobile furniture, and the risks of falling and breaking for the elements considered in the category of lighting are taken into account as emphasizing the flexibility, lightness and transformation potentials of the auxetic forms. Within the scope of the research, 1:20 and 1:10 scale physical model studies were made by using 3D printing methods. Future studies should test the full operation of the system by 1:1 prototype production and evaluations.

2.4 Working on the Design Guide

Turkey is located in the earthquake zone. The city of Istanbul, with its population of more than 15 million, is defined as a large metropolis with an ever-expanding structure. After the 1999 Marmara and Düzce Earthquakes, there are predictions that a major earthquake will occur in the city of Istanbul. Scientific studies reveal that the probability of a devastating earthquake with a magnitude of “7” and above to occur in the Sea of Marmara in the near future is possible. For this reason, the risks that will occur during the earthquake will affect millions of people.

In line with the data taken from the existing literature the presented “Design Guide for Reducing Earthquake Risks in Residential Interiors” is aimed to be a guide that can be accessed by designers as well as the society, and a resource for social awareness.

3 Conclusion and Discussion

The fact that large number of people use residential interiors during earthquakes and daily life mostly takes place in residential interiors explains the widespread effect of the study. Within the scope of the study, the residential interior design criteria, which consider the risks that may occur during possible earthquakes, were investigated through the analysis of the existing studies in the literature.

Since the magnitude, time and effects of earthquakes cannot be predicted in advance, what can be realized at the interior architectural scale may be "precautionary". With this study, it is discussed that furniture design can be reconsidered with innovative approaches in order to prevent the dangers and damages that may occur in the interior spaces during the event of earthquakes if the buildings are not demolished. However, residential interior designers and occupants should be aware of the issue and take the necessary precautions. In this context, research on the subject gains importance in terms of developing new strategies and different solution proposals.

Acknowledgements

The presented research project titled “Determining Design Criteria for Reducing Earthquake Risks in Housing Interiors and Developing a Design Model Defining Reduced Risk Areas” is funded by TUBITAK (The Scientific and Technological Research Council of Turkey) with project number: 221M188 and run at the Istanbul Technical University Department of Interior Architecture.

The authors would also like to acknowledge the contribution of the whole project team including researchers, scholars and consultants.

References

[1] Aytöre, S. Depolama ve Üretim Biçimleri Açılarından Seri Üretilen Mobilyaların Deprem Karşısında İnsan Üzerindeki Etkileri (The Effects of Mass Produced Furniture on Humans in the Face of Earthquake in terms of Storage and Production Methods. *Proceedings*. Kocaeli Deprem Sempozyumu. Kocaeli, Turkey. 2005 pp. 1251-1260.

[2] Ahmadnejad, M., Darbandi, M. Study of Safe Design Against Earthquake with the Furniture in Kindergarten, Based on the Idea of the Triangle of Life. *Current World Environment Special Issue 1*, 2015. 10(1), pp. 831-834.

[3] Chen, M., Jiang, L., Lui, D., Lyu, J. Furniture Innovative Design with Earthquake Self-rescue Function: From Furniture Form and Structure Perspective. *Proceedings*. International Conference on Informatization in Education, Management and Business (IEMB 2015)., 2015. pp. 35-40.

[4] Kaya, L., Yücedağ, C., Aşıkkutlu, H., Çokyiğit, H. Spatial Design Approaches to Prevent Damages from Earthquake inside the Buildings. *Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 9*(1), 2018. pp. 55-62.

[5] Sweet, T. Furniture Design for Disaster: A Case Study for Psychologically Resilient Objects. *Journal of Interior Design, 43*(1), 2018. pp. 29-27.

[6] Cimellaro, G.P., Domaneschi, M., Qu, B. Overturning risk of furniture in earthquake affected areas. *Journal of Vibration and Control, 26*(5-6), 2020, pp. 362–374.

[7] Yeow, T., MacRae, G., Dhakal, R., Bradley, B. Validatıng The Slidıng Mechanics Of Office Type Furniture Usıng Shake-Table Experiments. *Bulletin of the New Zealand Society for Earthquake Engineering, 51*(1). 2018.

[8] İpek, C., Kuzguncuoğlu, A., Kıstır, M. Yapısal Olmayan Sistemlerin Deprem Etkileri Açısından Değerlendirilmesi (Evaluation of Non-Structural Systems in Terms of Earthquake Effects) *Proceedings*. 7-9 Mayıs, Uluslararası Burdur Deprem ve Çevre Sempozyumu. 2015. Burdur, Türkiye: Mehmet Akif Ersoy University.

[9] Filiatrault, A., Sullivan, T. Performance-based seismic design of nonstructural building components: The next frontier of earthquake engineering. *Earthq Eng & Eng Vib, 13*, 2014. pp. 17-46.

[10] Demiraslan, D. Türk Ve Japon Konut İç Mekanlarında Depremsellik Açısından Konut ve Eşya Kullanim Alişkanliklarinin İrdelenmesi. (Examination of House and Furniture Usage Habits in Terms of Seismicity in Turkish and Japanese House Interiors). *Proceedings.* Deprem Sempozyumu Kocaeli Üniversitesi Güzel Sanatlar Fakültesi İç Mimarlık Bölümü. 2005. pp. 728- 737.

[11] Karamanoğlu, M., Ulay, G. Deprem Riski Yüksek Bölgelerde İç Mekân Düzenlemelerinin İncelenmesi (Investigation of Indoor Arrangements in Areas with High Earthquake Risk) *Journal of Foresty Faculty*, 2017. pp. 186-193.

[12] Doğan, C. Hareketli Mekân Tasarımındaki Ergonomik Faktörlerin Deprem Bölgesi Konutlarına Uygulanması (Application of Ergonomic Factors in Mobile Space Design to Earthquake Zone Housing) *Mimarlık ve Yaşam Dergisi Journal of Architecture and Life*, 5(2), 2020. pp.615-626.

[13] Alıcı, M. The Investigation Of The Furniture Utilization In Terms Of Earthquake Fact. *Internatıonal Anatolian Social Sciences Journal*, 3(1), 2019. pp. 4-15.

[14] Albayrak, Ö. Etkin Afet Yönetim Bilgi Sistemleri: Gerekleri Ve Kullanımı (Effective Disaster Management Information Systems: Requirements and Use). *Proceedings.* Deprem Sempozyumu, Kocaeli, 2005. pp. 1509-1516.

[15] Bernardini, G., D'orazio, M., Quagliarini, E. Towards a ''behavioural design" approach for seismic risk reduction strategies of buildings and their environment. *Safety Science, 86*, 2016. pp. 273–294.

[16] Hürol, Y. On Ethics and the Earthquake Resistant Interior Design of Buildings. *Sci Eng Ethics, 20,* 2014. pp. 171–181.

[17] Rosson, M.B., Carrol, J.M. Scenario-based design, in J. Jacko & A. Sears (Eds.), *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*. Lawrence Erlbaum Associates, 2002. pp. 1032-1050.

[18] Eilouti, H. Scenario-based design: new applications in metamorphic architecture, *Frontiers of Architectural Research*, 7, 2018. pp:530-543.

[19] TUIK, https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Aile-2021-45632

[20] Bangate, J.M., Dugdale, J., Beck, E., Adam, C.A. A Review on the Influence of Social Attachment on Human Mobility During Crises. *Proceedings.* T2-Analytical Modelling and Simulation Proceedings of the 14th ISCRAM Conference – 2017. Albi, France, Tina Comes, Frédérick Bénaben, Chihab Hanachi, Matthieu Lauras.

[21] Mir, M., Ali, M. N., Sami, J., Ansari, U. Review of Mechanics and Applications of Auxetic Structures. *Advances in Materials Science and Engineering*, 2014, pp. 1–17. doi:10.1155/2014/753496

[22] Ou, J., Ma, Z., Peters, J., Dai, S., Vlavianos, N., Ishii, H. KinetiX - designing auxetic inspired deformable material structures. *Computers & Graphics*. 2018. doi:10.1016/j.cag.2018.06.003

DECIPHERING THE INFORMAL:

BORDER TRADE LEFTOVERS AND THE TANDOORI HOUSE

Zeynep ATAS

Mardin Artuklu University
Mardin Artuklu Universitesi, Mimarlik Fakultesi 47100 Artuklu, Mardin, Turkey;
zeynepatas@artuklu.edu.tr

Abstract

Rural settlements on the south-eastern part of Turkey, along the D-400 transnational trade route to Syria and Iraq, are widely characterized by user-built, makeshift additions to the main buildings. With the reuse of left-over materials from border trade trucks, such as fuel tanks, tires, pallets, truck trailer tarps integrated with regular building materials like mud, stone and briquette in certain ways, auxiliary spaces of everyday life such as tandoori houses, poultry houses, garages, storage units, sheep pens, garden fences and walls, some in quiet sophisticated forms, are built by the locals themselves. In this context, this research aims to analyse the architectural knowledge embodied in these additions, just as another form of informal genius involving, in this part of the world, border trade leftovers. An analysis of this kind involves transnational trade politics and economics, circular economy, local socio-economic structure in macro scale, and integration and reuse of materials, formation processes, methods of construction and articulation within the existing environment in micro scale. In order to create a basis for the analysis an inventory of these additions is formed, documenting each on an interactive map with 3D models, plan-section-elevation drawings, construction and material composition diagrams. Such a work is believed to be important to shed light on the informal and to add on to a limited number of research that expands our knowledge on this fluid, unstable and underexplored form of *architectural knowledge*.

Keywords

User-built architecture, Informal architecture, Generative processes, Patterns of self-organization, Material reuse

1 Introduction

Informal/user-built architectural practices take various forms in different parts of the world depending on the geography, climate, socio-economic and political conditions, cultural characteristics, knowhow and material availability. Built by their users and non-professionals, these buildings are mostly makeshift in their constructive nature. Generally through low accumulation processes and scarcity of resources, materials used are commonly upcycled [1]. “Generative processes of self-organization'' are at work in their emergence as in traditional environments [2-4, pp.61][5]. Meaning, they are not *prescribed* but *generated* over time as practical and efficient solutions to immediate daily matters through direct involvement of people who are actively and intimately related to the place in question. Utilizing knowledge accumulated through generations, know-how, and feedback they become *emergences*, dynamic outcomes of living processes [1, pp. 180] Either within an urban or a rural setting, due to their implicit spatial logic, sincere nature, uniqueness, efficiency, and methods of construction these practices are recognized by many researchers including ourselves as ingenious and creative [5]. In this context, our research aims to analyse just another version of these practices; the user-built auxiliary spaces in the rural settlements of the southeast Turkey, to have a deeper understanding on how these practices work and expand the cumulative knowledge on user-built architectures.

Rural settlements along the southeast part of the D-400 transnational border trade route, namely the *Silk Road*, are characterized by user-built makeshift additions constructed with truck leftovers. In some of the villages, buildings of this type have reached such a number that they determine the overall image of the settlement. Auxiliary spaces of everyday life such as tandoori houses, poultry houses, garages, storage units, sheep pens, garden fences and walls are built attached or in some relation to the main buildings, using fuel tanks, tyres, pallets, or truck trailer tarps integrated with regular building materials like mud, stone and briquette (Figure 1). Supporting "different forms of livelihood" [5] humans, goats, sheep, hens and chickens, these spaces have a spatial logic as well as a manner of articulation within the surrounding environment. Following unspoken rules of *material use*, *construction* and *morphology,* often genuine designs are *generated*.

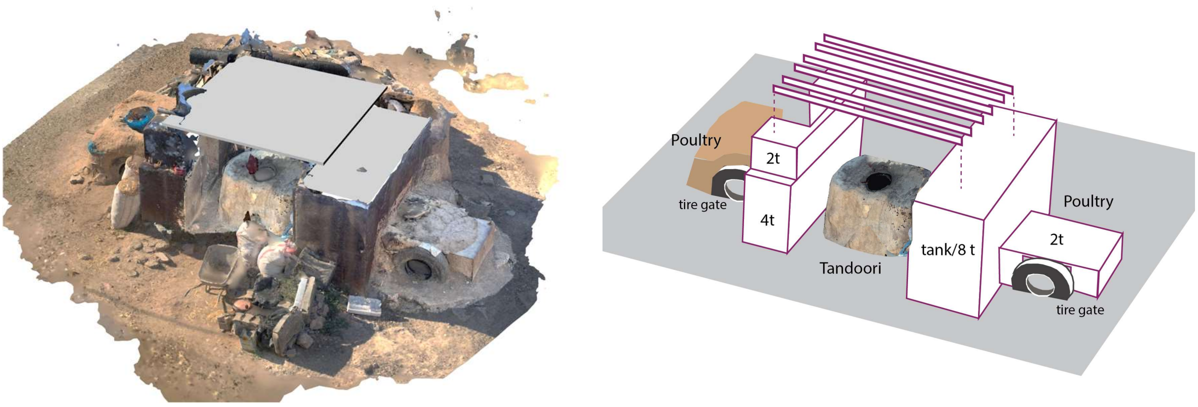


Figure 1. Tandoori and poultry complex from fuel tanks, tyres and mud (model/diagram)

It is the main objective of this research to decipher these implicit rules and methods in order to understand the generative processes underlying the emergence of these spatial practices. In this sense, we engage primarily with three questions: What are the variations of material use? What are the micro-spatial and constructive patterns that underlie the emergence of these spaces? How do these spaces articulate within the existing socio-spatial environment? Through these questions, we aim to conduct a systematic analysis to shed light on the micro-spatial patterns on user-built architectures, which is an underexplored part of our architectural knowledge.

2 Research Setting

Mardin and Sırnak are southeast border provinces of Turkey, home to Nusaybin and Habur border gates to Syria and Iraq. Border trade was initiated in the 1970s, in order to improve socio-economic conditions in the region and made a significant contribution to the economic development and spatial transformation of cities, villages and towns on the border. Official border trade started with Iran, an oil-exporting country, in the 1970s triggered by the worldwide oil crises [6-7]. In this process, in order to take a share from the developing economy, the prominent tribes of the southeast set up truck fleets, and most of the families living in border villages and towns bought trucks [8]. As a result, the socio-economic structure of the region has undergone an enormous transformation from agriculture to transportation. Although oil transportation within the context of border trade was forbidden in 2002, today, in most of the rural settlements located along the D-400 border trade route, transportation and border trade is still the main economic activity [9].

During this process, an unregistered fuel inflow also occurred in an amount much higher than the registered fuel exported into the country. Tons of unregistered fuel carried in *additional tanks* installed on trucks and TIRs during the 1980s and 90s. While the urbanization in the city centres speeded up, rural settlements also became more urbanized and affected in another way as homes to many truck or TIR owners and drivers: Leftovers from these trucks and TIRs, especially accumulated after the prohibition of oil trade, like fuel tanks, tyres and tarpaulins formed the main material stock in these settlements.

Within this network of socio-economic relations, the residual products of one organized system have become the main element of another through an inherent act of making and creative genius. A circular economy has emerged as a result of reusable material surplus, limited access to *regular* building materials, and poverty. Reuse generates a cyclical way of thinking; "taking something that already exists to a different stage of its life, an altered state of usefulness, but without major changes to its physical state [10]. Besides being architecturally creative, it has also been a waste management strategy in these villages, that use of reclaimed materials as close to their original states as possible in order not to require much change.

Our research evolved following these user-built architectural practices; visiting those villages and documenting in order to form an inventory of user-built architectures in border rural settlements for further analysis.

3 Methodology

In this research direct observation, visual recording, 3D photogrammetry and 3D modelling techniques and programs are incorporated to document these user-built architectures. The work is influenced from the author's previous architecture design studio work on vernacular architecture in the region. Field work has been undertaken by the research team between 25 May-24 July 2022. A number of villages on the south and north of the D-400 route were scanned according to the objectives of the research. Case studies have been selected in a range to demonstrate variations on material, building technique and morphology, depending on their authenticity.

An interactive map is created showing the exact location and concentration of the buildings, labelled according to the material use and function (Figure 2). It is used to visualize the geographical distribution of material and spaces. Spaces are modelled in Rhino and Metashape, a photogrammetric modelling program, for micro-spatial analysis and documentation.

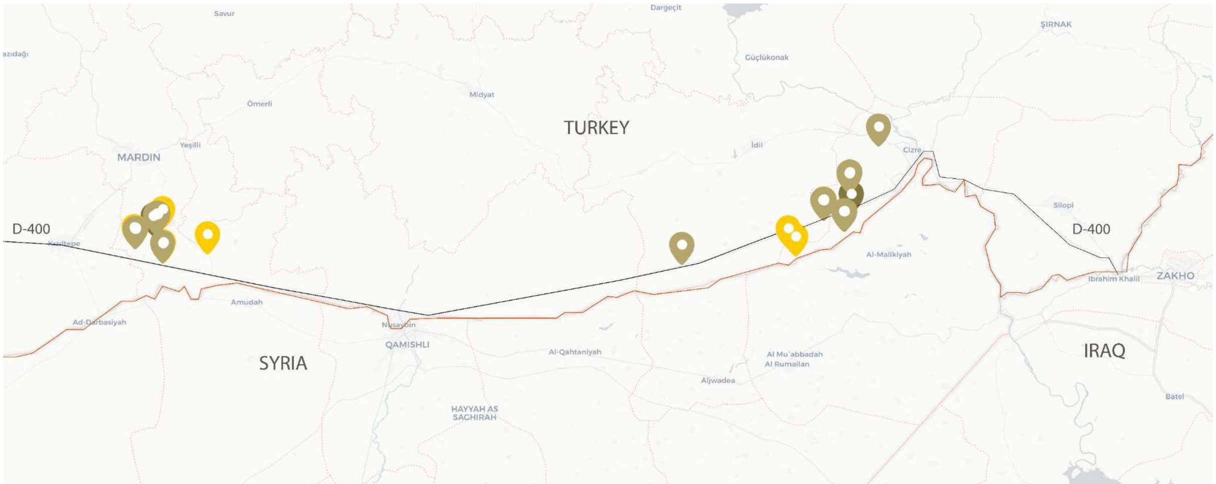


Figure 2. Documented data locations following D-400 and the border. Yellows: Fuel Tank intense; Greens: Pallet-intense

In this context, the inventory consists of a site plan, photograph, 3D Model and a construction and material diagram for each space (Figure 3). Although the auxiliary spaces are modelled isolated from the whole settlement, a part of Boztepe village where a number of these spaces exist in relation to each other, is modelled as a whole in order to analyse and demonstrate their articulation within the existing built environment.

Through documentation, mapping and visualization, in a way, we reconstruct the reality of these spaces to invent new ways of seeing and understanding. In this way “the data that cannot be grasped by the senses becomes visible” [11, pp.6]. Diagrams, as abstractions, also help to make spatial and material relations more legible. The inventory, by putting all the “selected, omitted and recoded” data together in an abstract way creates a base for production of knowledge in itself [11, pp.6] and open ways to decipher and understand the generative process behind the emergence of these user-built auxiliary spaces.

4 User-built Auxiliary Spaces: A Micro-spatial Analysis

Our micro-spatial and constructive analysis is concerned with variations in material use, construction techniques and morphology, aiming to discover unspoken, customary rules and patterns of self-organization. User-built auxiliary spaces in question are tandoori houses, poultry houses, garages, storage units, sheep pens, garden fences and walls. Figure 2 shows the geographical distribution of materials and spaces. Accordingly, while fuel tanks are widely used in all the settlements, they are concentrated in the settlements on the west, especially in one village, Boztepe. Pallet uses noticeably increased driving east on the D-400; villages of Cizre and Okçu village in particular there is a concentration of pallet use.

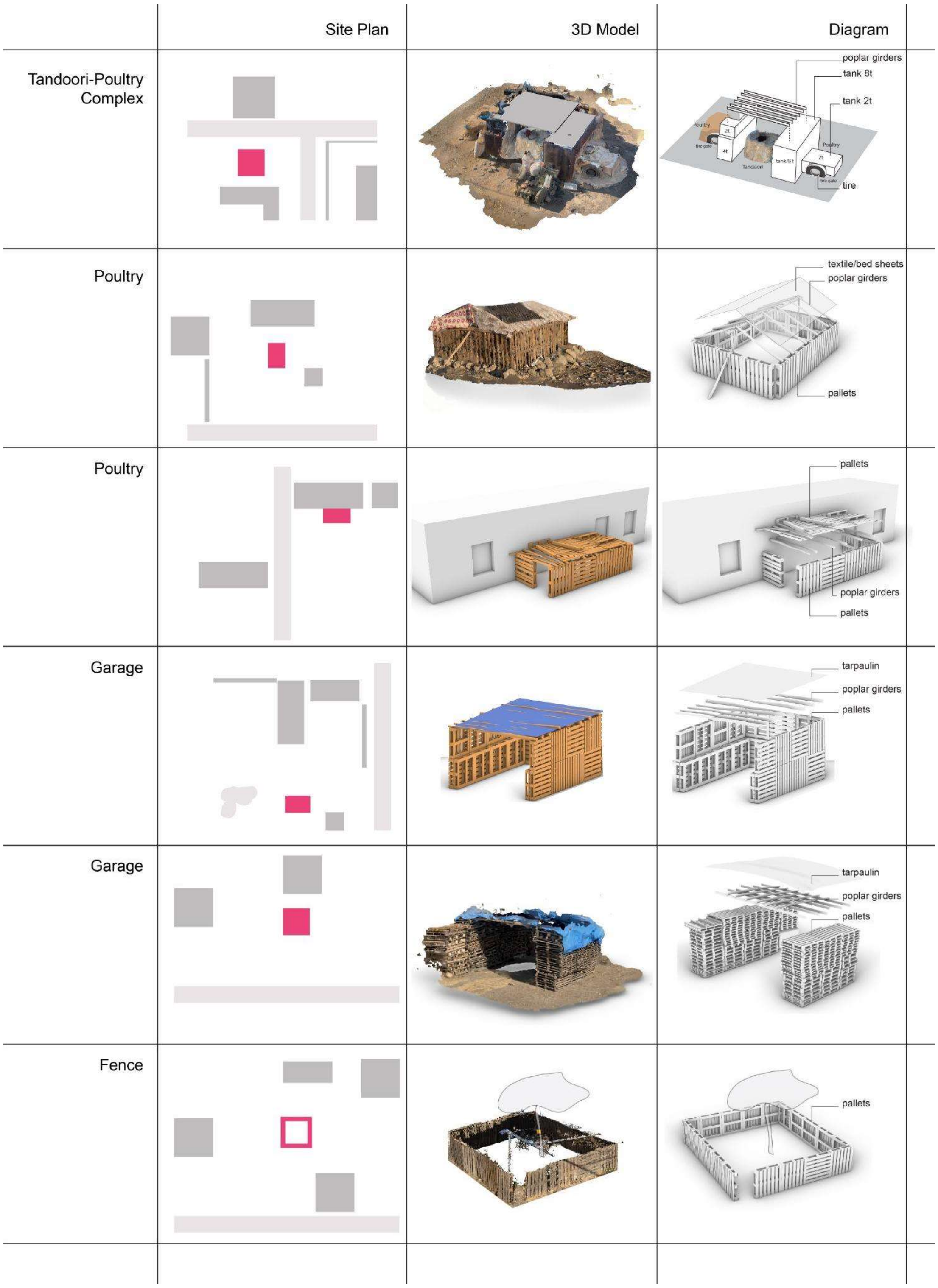


Figure 3. A part of the inventory

Fuel tanks of various sizes are used as load-bearing walls for tandoori houses, and for constructing sheep pens and garden walls. Locals state that fuel tanks are heavy and voluminous enough to not be toppled by the sheep (Sheep can trip over pallets or other fences and get injured). They are also very convenient in casting solid shadows for the sheep to rest under the burning sun. Thus, they are generally built with fuel tanks of various sizes (Figure 4). In most of the cases tyres are used to create a basis for the tanks, separating them from the ground, as a measure for protection. Tyres are also utilized as complimentary building elements for the walls, lined up or stacked on top of the tanks. In general, tyres are stockpiled horizontally on top of each other, lined up or stacked vertically, forming a part or a compound of the whole building.

Figure 4. A sheep pen, Boztepe

Pallets are mostly used singularly in building fences and poultry houses (Figure 5). Due to their uniform size, they form modular buildings, and become the denominator for fences and poultries making them proportional to each other: 3x4 to 2(h) pallets for a garage, 1.5x4 to 1(h) pallet for the poultry, 4.5x5 to 1(h) pallet for a garden fence etc. Pallets are used in two ways, mounted side by side or stacked on top of each other to form a wide load-bearing wall. While in most of the poultries, pallets are braced to each other or conjoined with the help of a piece of wood, in Boztepe a specific detail is observed (Figure 6).

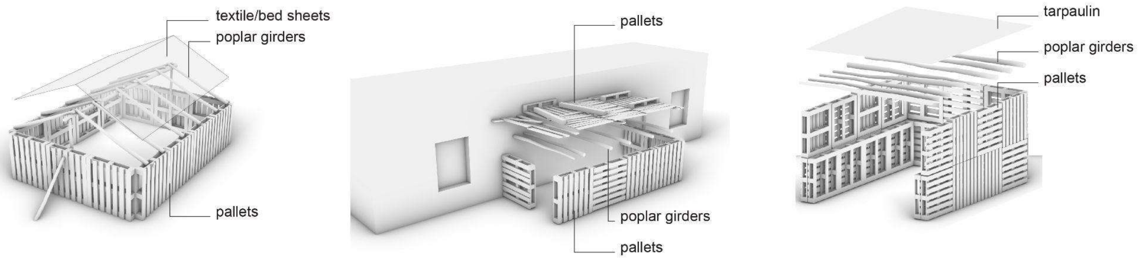


Figure 5. Pallet poultries and a Pallet garage

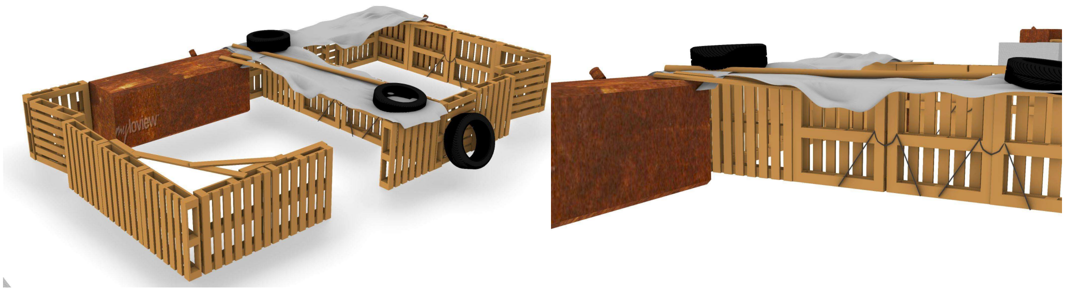


Figure 6. Poultry pallets connection detail, Boztepe

Although reused materials are generally assembled together it is also common to see Integrated use of those with regular building materials such as mud, briquette and poplar girders. Fuel tanks utilized as bricks, together with bricks , as an integrated part of the wall stacked delicately (Figure 7). Mud is another material, traditionally used in the region, that is integrated with reused materials. Any space left in-between turned into a small poultry, generally with mud. Due to its plasticity, mud can fit any form and leftover space and can form a smooth transition between different materials and forms. Other than these attached forms, a local production, mud-dome poultries are commonly independently added to the scene (Figure 8). Poplar girders are also observed to be used in these spaces. Poplar girder construction is a common technique for roof construction, as poplar is grown for commercial use in the region. As seen in Figure 5 poplar girder and tarpaulin is used to construct and cover the roof of the constructions, resembling the common traditional building techniques.

Figure 7. Fuel tanks used as bricks. Left: Boztepe, Right: Okcu

Figure 8. Fuel tanks integrated with mud. Left: Calıslı, Right: Boztepe

Another level of analysis is about the variation of form and material between the settlements; it is observed and documented that similar formation patterns with same material use repeat continuously forming a uniform building character in one settlement. Thus, the development of neighbouring compounds are influenced by each other as one of the characteristics of a self-regulating system. As Hakim notes "the self-regulating aspect is a result of the decisions and actions of specific individuals in starting new compounds...In doing so, they respond to existing conditions on adjacent properties by adjusting their planning and design decisions" [3, pp.35]. All the poultries in the Siyahtepe village are built with the same material (pallets) in the same form, spreading over the village. In just this one village, 16 poultry houses of this kind are found while only one is found in another settlement.

Self-regulative aspect manifests itself in building type, building formation as well as general articulation of various buildings within the village in Boztepe and Okçu villages. As seen in

Figure 9 the positioning of each building refers to the existing building axes and leave the adequate space in between for the circulation of sheep herds, hens and chickens. Boztepe is the only settlement with the largest concentration and number of sheep pens from fuel tanks; they can be encountered almost on every corner (Figure 10).

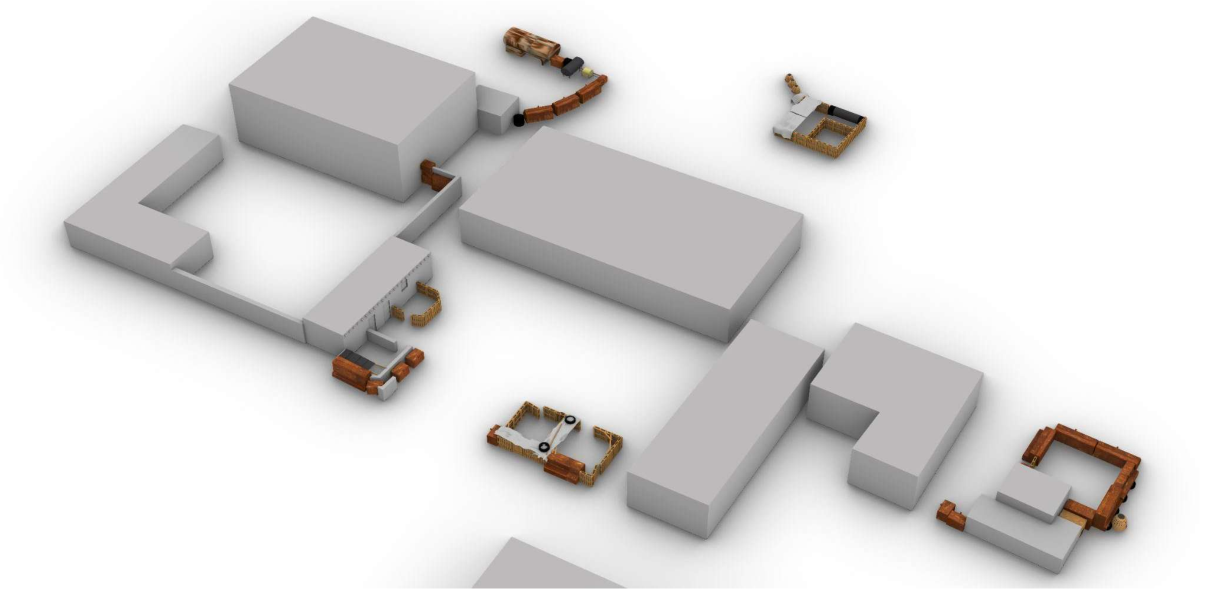


Figure 9. Boztepe village model

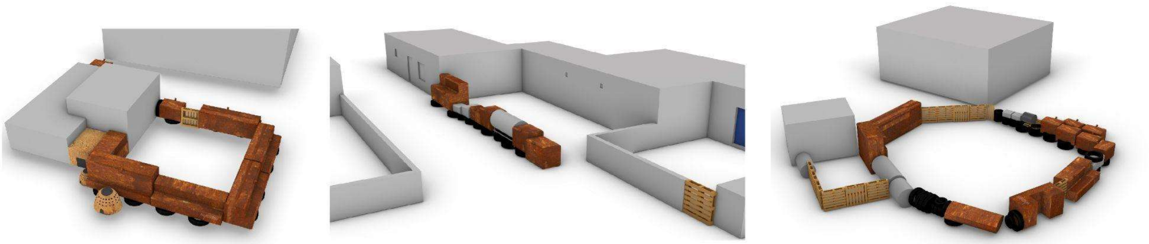


Figure 10. Sheep pens of Boztepe village

While sheep pens are generally built attached to a barn building, garden walls and fences are attached to the main living area. Poultries and garages are generally built independently but in a certain relationship with the house, mostly in the courtyard. Tandoori houses are in general in the common use of a few households in the village. Thus, they are located mostly independent from the house, either one side attached to the street side of a garden wall or in the village square (figure 11). The tandoori house-poultry complex in the Calıslı village requires a specific attention (figure 12). Recalling a scene from the Star Wars series to mind at first sight, this complex is one of a kind and it is not easy to decipher the separate compounds that form the whole structure. At the core there is a tandoori house built by fuel tanks and a roof structure from poplar girders, surrounded by poultry houses. The one on the right is built by a reversed, u-shaped tank covered with mud. Tyres are used as a mould for the mud and form the entrance holes for the poultries. The rest of the construction on the back is also built with the stacking of reused materials like pipes, and bricks and mud with spaces left in between designed as poultries.

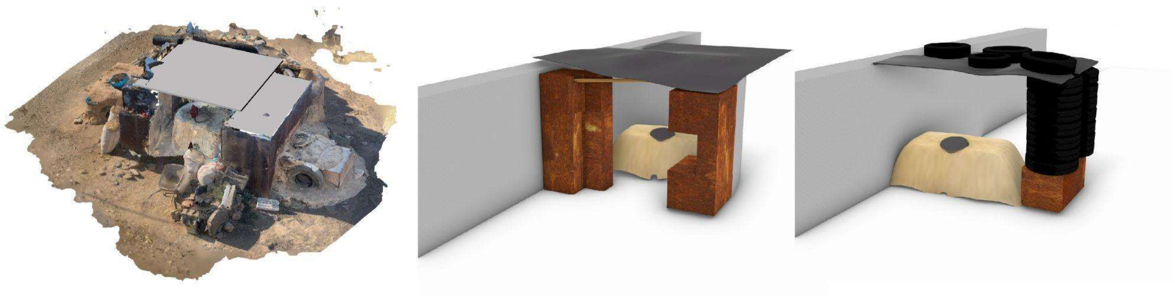


Figure 11. Tandoori houses

Figure 12. Tandoori and poultry complex from fuel tanks, tires and mud (also Figure 1)

5 Discussion and Conclusion

“Even the humblest forms of matter and energy have the potential for self-organization” [12, pp.6]. Patterns of self-organization underlying the formation processes of these user-built auxiliary spaces become more visible looking at the general view. We may identify a few of these unspoken and informal rules, but most we could only intuitively *sense* behind the seeming disorder and messiness; they still stay implicit.

If some of the obvious ones could be phrased it would sound like: Reach for the most available material; Consider the user, be it a sheep or a human; Build sheep pens and tandoori walls with fuel tanks as they are less dangerous for sheep and create isolation from the sun both for humans and sheep; Always elevate fuel tanks from the ground, as they are produced from sheet metal they can rust away exposed to humidity; Tyres and stones or briquette can be used to elevate the fuel tanks and adjust wall heights; Apply to traditional knowledge and materials if necessary…

Whatever these micro-spatial rules are or the material and the construction technique is, the process follows two basic and interconnected rules: *self-regulation* according to environmental conditions and *feedback*. In generative systems these rules construct the main structure upon which unique and various forms emerge in the hands of the people following those implicitly, may be unconsciously. The rest depends on the socio-economic conditions, cultural characteristics, politics, geographical and climatic conditions and material availability. As a result, although the same materials and construction techniques are used, each sheep pen, fence or poultry emerges as a unique form, in a unique position.

These spaces are the diverse results, dynamic temporary outcomes of the process, that are constantly subject to change driven by self-regulation and feedback. As an outcome of the self-regulating aspect, changes and adaptations occur over time in the compounds as the human/user factor “adjust and adapt to changes in neighbouring and contiguous compounds” [3]. *Feedback* is also a massive driving force for change. It is the capacity of the system to learn from the inoperative features over time and adapt itself accordingly. Thus, the form continuously changes with small scale adaptations sometimes over very long periods of time. Modelling one of the sheep pens in Boztepe, small adaptations that happened only within two months were noticed, the motivation of which remains unknown.
The leading agent here is human, who reserves the capacity for unpredictable action: autonomy. It is what drives the emergence of unpredictable results and what is lost by the prescribed processes of formal building act. That is what continues in the user-built environments; the space unfolds in time directly “in the hands of people intimately associated with the needs of the situation” [2]. And probably what evokes our wonder as researchers and creates the urge to decipher the architectural knowledge behind, is the implicit operation of self-organization, and the creative and ingenious nature of forms and structures resulting from these processes.

Acknowledgements

I am grateful for the intellectual contribution of my colleague and friend Yuvacan Atmaca to this research, and for the work of Adnan Orhan, who assisted this research project in documenting and visualizing the data.

References

[1] Dovey, Kim and King, Ross, Forms of Informality: Morphology and Visibility of Informal Settlements, *Built Environment, 37,* (2011), 1, pp. 11-29, DOI: 10.2148/benv.37.1.11

[2] Alexander, Christopher, *The Nature of Order, An Essay on the Art of Building and the Nature of the Universe, Book Two, The Process of Creating Life*, Centre for Environmental Structure, Berkeley, CA, USA, 2002

[3] Hakim, Besim S., Mediterranean Urban and Building Codes, Origins, Content, Impact and Lessons, *Urban Design International, 13,* (2008), pp.21-40

[4] Kamalipour, Hesam, Forms of Informality and Adaptations in Informal Settlements, *Archnet-IJAR, International Journal of Architectural Research, 10,* (2016), 3, pp.60-75

[5] Kamalipour, Hesam and Dovey, Kim, Incremental production of urban space: A typology of informal design, *Habitat International*, *98*, (2020), 102133, https://doi.org/10.1016/j.habitatint.2020.102133

[6] Terzi, Gökhan, Türkiye’de Sınır Ticareti ve Uygulamadaki Sorunlar (Problems of Border Trade and its Implementations in Turkey), *Gümrük ve Ticaret Dergisi, 11*, (2018), pp. 38-49

[7] Öztürk, Nurettin, Türkiye'de Sınır Ticaretinin Gelişimi, Ekonomik Etkileri, Karşılaşılan Sorunlar ve Çözüm Önerileri (The Development of Border Trade in Turkey, Economic Effects, Problems and Solutions), *Zonguldak Karaelmas Üniversitesi Sosyal Bilimler Dergisi,* 2, (2006), 3, pp. 107-127

[8] Özgen, Neşe Sınırda Kaçakçı Olmanın Antropolojik Tarihi (The Anthropologic History of Being a Border Smuggler), *NTV Tarih*, *35,* (2011)

[9] Karademir, Diyar, Cizre İlçesi Yerleşmeleri (The settlements of Cizre), Harran University, Sanliurfa, Turkey, 2014

[10] Gorgolewski, Mark, *Resource Salvation, The Architecture of Reuse*, Wiley Blackwell, Hoboken, NJ, USA, 2018

[11] Dovey, Kim, Ristic, Mirjana and Pafka, Elek, Mapping as Spatial Knowledge, *Mapping Urbanities Morphologies, Flows,Possibilities*, (Kim Dovey, Elek Pafka and Mirjana Ristic), Routledge, New York, USA, 2018, pp. 1-16

[12] De Landa, Manuel, *A Thousand Years of Nonlinear History*, Swerve Editions, New York City, NY, USA, 2000

S.KIT OF PARTS HOMES: DELIVERING CUSTOMIZED, SUSTAINABLE DWELLINGS AT SCALE

Alexander Boucher*, Nancy Clark, Jeff Carney

University of Florida
2411 Lauder Drive, Maitland, FL 32751, United States; aboucher1@ufl.edu

Abstract

The economic and social policies of the post-war era created a twenty-one percent increase in homeownership—the largest in US history—almost exclusively in the suburbs. Today, approximately two-thirds of Americans live in single-family homes. Modern iterations of these homes vary exceptionally little across diverse U.S. climatic zones, necessitating a dependence on active heating and air conditioning systems. This has, in part, led to significantly more carbon emissions in suburban homes than in vernacular or urban dwellings; an occurrence largely due to developers, designers and homeowners ignoring local climatic and geographic conditions. Furthermore, this repetitive reliance on a standardized stick-frame construction produces ubiquitous communities, ill-suited to individualized needs.

Rather than advocate against single-family constructions, this project establishes a new methodology for creating these homes using a predefined kit-of-parts. Intended to mass-produce customized, resilient, sustainable homes, this methodology centers around an interactive interface that allows personalized input to quickly produce a finalized design through an automated, intelligent synthesis of climate data, material proximity and performance, and individual needs.

Contents within the kit-of-parts are based on traditional American homes' spatial compositions, and includes prefabricated subassemblies, designed and developed by analyzing traditional suburban homes, prefabricated housing case studies, and prevailing climatic and geographic conditions throughout the United States. Accelerating the design and construction processes reduces costs. These savings are then reinvested in the home to integrate environmentally responsible systems and materials into the identity of each dwelling. Resultant homes are regulated yet custom; capable of providing a wide range of needs and performance levels with a limited number of components. Completed prototypical homes are evaluated through three lenses: environmental sustainability, social responsibility, and affordability.

Kit components are prefabricated for two main reasons: costs savings and environmental advantages. Cost is a frequently a hurdle to homeowners who want to live more sustainably, so by reducing cost, this strategy is more accessible than typical sustainable design and construction methods. Waste reduction, improved resiliency, and improved performance through tighter tolerances are also expected advantages for the sustainability of the home. Moreover, it creates a path to customization at scale, offering an individualized response to

the environment and the occupant.

Keywords

PREFABRICATION; PASSIVE DESIGN; SINGLE-FAMILY HOME; SUSTAINABILITY; CLIMATE

1 Introduction

Though single-family homes are the preferred living arrangement of most Americans, [1] these homes and surrounding suburbs are fraught with issues, especially when evaluating through an environmentally conscious lens. At the development scale, the increased distance from city centres lengthens commute times, increases household carbon emissions, and creates vehicle dependency. [2] These developments also raze and occupy land that could otherwise remain naturally wild or used productively. At the individual dwelling scale, these homes are ubiquitous in their construction process, mono-cropped lawns, and poor energy performance. [3] The stick-built methodology is the choice of nearly all developers despite the diverse climate regions these homes appear in. [FIGURE 1 & 2] This disregard for local conditions results in homes that are entirely dependent on active heating, cooling, and ventilation to ensure comfort and safety for its occupants. Though this issue persists for one reason: cost. Developers use this strategy because it is inexpensive. Prefabrication technologies, however, offer the potential to disrupt this monotony. Combined with automated, site-responsive decision-making, a new process can emerge and generate competitive, customized, mass-produced homes that are responsive to a given locale.

Figure 1. Sprawling Suburb in Las Vegas   Figure 2. Suburban Sprawl in Central Florida

Through careful planning and development, this prefabricated methodology will produce more-sustainable single-family homes. This method will engage the cost saving benefits of mass production and add a layer of site-specific information to guide the resultant design of the home. This process will not engage an architect or designer; it will be automated based on the aggregation of climate and site data to synthesize relevant passive design features, resiliency strategies and client needs. The design will be the result of arranged, predefined, mass-produced programmatic blocks, and applied, locally-specific site-built components such as roofs, foundations, and landscape components. Furthermore, all portions of the final home will be comprised of locally specific materials. Intended to be a tool for developers and future homeowners alike, this process will ultimately develop an interactive interface that provides constant, relevant feedback to the user as they input their specific information and needs for their new home.

This strategy will reduce costs though the increased speed of construction, reduced labour costs and greater construction accuracy. This resultant cost savings can be reinvested into the house creating the opportunity to integrate sustainable, high-performance technologies, such as photovoltaic arrays, energy efficient appliances, resilient water management utilities and more.

2 Domains of Research

The objective of this project is to quickly produce site-responsive, environmentally conscious customized homes for occupants who would otherwise live in a hot-home community. Considerations about material availability and performance, construction methodologies, prefabrication strategies, local vernacular design strategies, and passive design methods were merged with historical and demographic research on single-family housing in the United States to produce a process that fulfils this goal.

2.1 Single Family Housing

The modern suburb, and its single-family homes, rose to prevalence in the years following World War II [4] and is now home to over half the US population. Financially, the 1934 National Housing Act lowered barriers to homeownership for large segments of the populace. [5] Logistically, this evolution was made possible with the $25 billion allocation within the National Interstate and Defense Act for the construction of the interstate highway system. [6] This development allowed jobs within the city to be available to residents of the periphery area. Additionally, post-depression anxieties led to the rise of the ‘mass-market’ encouraging citizens to engage in the purchasing of goods such as cars, appliances and, most critically, homes as a means of fuelling the economy and preventing future financial downturns. [7] The results of these pressures are single-family developments that encircle every American city and a shared cultural identity of homeownership as part of the American Dream.

The programmatic anatomy of these homes is generally uniform—changing little over the last several decades—with variations relating mostly square footage differences in otherwise equivalent spaces. At its most basic level, a single-family home contains a living room, a kitchen, a bathroom, and a private bedroom. Bedrooms, living rooms, and bathrooms are repeated as required or desired by the occupant. Other spaces such as foyers, laundry rooms, dining rooms and garages are also common in single-family homes. Less common but still frequently occurring spaces are mudrooms, sunrooms and home offices or gyms.

2.2 Prefabrication

Prefabrication refers to the process of constructing portions of, or entire buildings at a location other than the building’s site, often a manufacturing plant or factory. This strategy is used for two main reasons: improved build quality and reduced cost of construction. [8] Additional benefits include waste reduction, and efficiency in the procurement and assembly of building components. [9] This methodology first saw use in America during the Gold Rush of 1849 [10] but is most seen in the form of modular homes.

Though a full volumetric package is commonplace in the realm of single-family housing, variations in strategies and levels of prefabrication exist. Prefabrication delivery can be as simple as a preassembled truss or as complex as an entire dwelling unit. The prefabricated strategy engaged by this project is a panelised delivery system—a system that prefabricates full walls with all necessary structure, insulation, interior and exterior finishes, openings, doors and windows, and MEP components already assembled. This strategy minimizes the need for a crane and other heavy machinery and is more compact, reaching the jobsite with fewer trucks than other methods. However, a panelised system requires more on-site work than volumetric methods.

2.3 Sustainable Design and Construction

Sustainability, in the built environment, refers to the design, construction and operation of a building without compromising the quality of the natural and social environment in which is exists. Minimizing negative impacts on the natural environment requires the building process to be cognizant of embodied carbon costs in materials, waste produced during construction, site impacts, operational resource consumption, potential maintenance concerns and an end-of-life plan.

Buildings, throughout the course of their life, will be produce far more carbon—due to energy consumption from fossil fuel power plants—during their operational lifespan than during the construction process. [11] Therefore, minimizing energy demands within a home is a critical goal for sustainable design. Vernacular methodologies create dwellings that are comfortable for inhabitation through passive strategies that are relevant for a given location. These strategies vary by region but can be largely represented by two main strategies: passive ventilation strategies and solar management strategies. Passive ventilation takes advantage of airs inherent physical properties to either retain or evacuate heat from a structure. Similarly, solar management strategies either reinforce or reduce heat gains from the sun. Building performance, with respect to energy load, also contributes to the operational carbon of a building. High efficiency fixtures and furnishings, a tight envelope, and high-quality insulation all improve building performance.

Though operational carbon emissions outweigh embodied carbon emissions, the construction process is still critical for reducing greenhouse gas emissions. A large source of GHG emissions is from transporting and processing raw and refined building materials. [12] Emissions from this process can be reduced significantly by sourcing local materials that are processed through less carbon intensive methods. Additionally, material waste is a common issue in single family construction practices. A significant reduction of waste during this process can result in not only reduced carbon emissions, but also improved financial performance. All these advantages can be leveraged through a prefabrication design and construction process.

3 Method

Sustainable design decisions are dependent on the synthesis of client/occupant needs and the constraints and opportunities of a given location and site. Given that the project is a single-family home, the required components and spaces become immediately available regardless of the more specific wants and needs of the client. The possible design decisions follow suit and can be further filtered by understanding the climate region and potential threats. To tie these decisions, strategies and needs together, a several stage flowchart [Figure 3] was developed to address the all necessary aspects of sustainable home design and construction. The order of the stages is organized similarly to traditional architectural methods, beginning with site analysis, followed by program design before addressing more specific components of the house. Finishes and certain stylistic choices are available for the client throughout the process. However, the process is intended, much like current single family construction practices, to remove the need for an architect and instead provide a series of options and restrictions, capable of producing a variety of home permutations. The intent of this process is that all resultant configurations are climate and site-responsive homes, created by clients who are given an understanding of relevant factors throughout the process.

Figure 3. Home Design Flow Chart (text removed for sizing purposes)

3.1 Macro Site Analysis

A regional site study is the starting point. This step impacts the following steps by removing and promoting options to guide the finalized design towards environmental sustainability. The most relevant factors are natural hazards and threats, and prevailing climate conditions. A threat analysis creates restrictions on certain products and design methodologies based on the threat type and occurrence rates while promoting strategies that improve the home's resilience. Climate studies determine which passive strategies will be used to increase or regulate solar heat gains and ventilation. Also occurring at this stage: a local residential code review to ensure all possible permutations are legal in each location, and identification of threatened or critical habitat locations to inform site design.

3.2 Micro Site Analysis

Analysing the specific site where the home will be constructed further guides the relevant strategies and components of the home. Identifying the orientation of the site and prevailing wind directions guides the application of the homes solar and passive ventilation strategies. Next, a computer-vision assisted process identifies the presence of invasive and native species on the exact site. This assistance identifies sources of shade from either nearby homes, developments, or vegetation as well. Also in this stage is a GIS-based analysis of site to identify soil conditions, wetlands, watersheds, topography, and floodplains.

Writ large, this step is intended to offer the necessary information for the design process to begin. The relevant passive design strategies will have become apparent, the orientation of the home will dictate how these strategies operate and the necessary and available site strategies will have been determined. Furthermore, the possible programmatic arrangements will have been reduced.

3.3 Program Design

Defined by the spatial anatomy of the typical American single-family home, this step ensures all homes are delivered with a kitchen, living room, and the chosen number of bedrooms and bathrooms. This stage also determines the need for additions to this program such as foyers, dining rooms laundry rooms, and garages. Program, mainly through its organization in plan, controls the effectiveness of passive design strategies. Given each site's unique nature, this arrangement will be determined based on ability to maximize the effectiveness these strategies. The integration of a site-specific vernacular space will aid this process.

To avoid infinite variability and lean on the advantages of prefabrication, the home's program is grouped into blocks, allowing clients to choose their homes based on a series of parameters, not a fully architectural design process. These blocks have some variability in how they can connect to other blocks, resulting in plan designs that facilitate passive strategies without requiring direct input from an architect. The arrangement is automatically completed by the site analysis phase resulting in a home that is reactive to its location. The design of these spaces is based on case study investigation of modern home designs and Frank Lloyd Wright's American System Built Homes. [Figure 4]

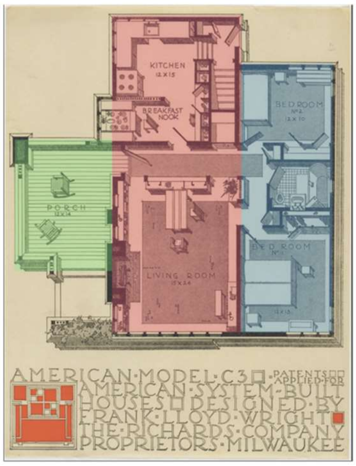


Figure 4. American System Built Home, model C3, with Color Blocking

Live Block

The 'live' block is the main, non-private component of the house. These blocks contain the home's kitchen and living space with options that include dining rooms, additional bathrooms and secondary living rooms. Variations in form and arrangement exist to suit various environments, personal preferences, and budgets. [Figure 5]

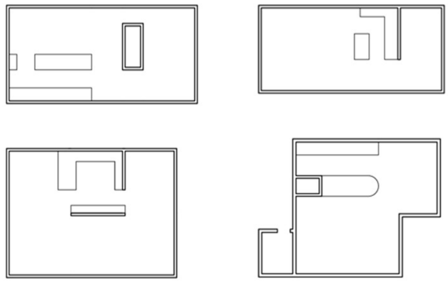


Figure 5. Sample of Live Block Configurations

Rest Block

The ‘rest’ block contains private spaces, namely bedrooms, guest rooms or offices. Variations exist largely to suit a range of client needs. [Figure 6]

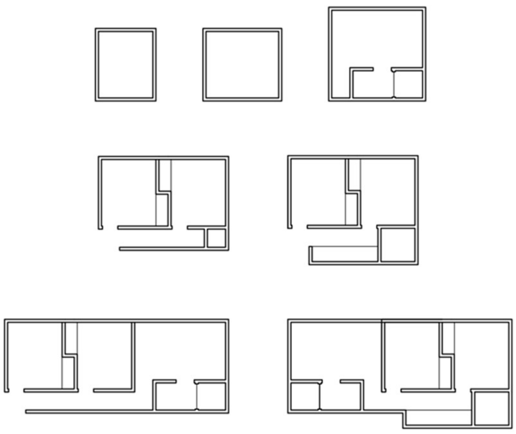


Figure 6. Sample of Rest Block Configurations

Additional Spaces

Garages, extra bathrooms, and a master bedroom—for split plan designs—are options that can be added independently from the main programmatic blocks. These spaces are entirely optional and, again, dependent on client need.

Vernacular Spaces

For these homes to be fully climate reactive, programmatic arrangement will dictate performance. The integration of additional program based on local code, climate concerns and threats will aid in the home’s performance. In heating-load dominated climates, a courtyard or enclosed exterior spaces such as sunrooms and porches will be integrated for cooling purposes. For climates with frost lines below shallow footing depth or tornado threats, a basement will be added. A comprehensive list of these components is not yet complete, however as more climate regions are explored, the number of available spaces here will increase.

3.4 Creating Openings

Once program is satisfactorily arranged, the process of creating wall openings can begin. Doors are automatically populated from site orientation and accessibility constraints, but windows offer a degree of customization. The client will move space by space and indicate the amount of fenestration they want to the interface. Their decision-making will be guided by the live feedback from daylighting and energy modelling. Different programs will be improved by different daylighting schemes, and orientation of openings will guide the success of energy-saving passive strategies. Additionally, site factors such as water bodies and other desirable views may impact this process. Trombe walls and location of thermal mass can also be determined at this point.

3.5 Facades and Treatments

Significant energy reductions can be made, in hot climates, by limiting the amount of direct sunlight that is able to enter the interior of a home. By adding a stage requiring clients to shade windows, these homes add an additional layer of operational sustainability. Options available here are varied for different solar orientations, climatic conditions, and personal preferences.

3.6 Roofing

Overhead enclosure dictates how heat circulates vertically within a home, as well as how exterior conditions interact with the house. While the options available here for roofs are traditional stylings, the availability of each style is dependent on. In locations of high snow fall, steeped roofs are required. In hot, dry climates low flat roofs are available for long shade overhangs and to minimize the volume of home needing to be cooled by HVAC systems. Each roof type has a local availability and use.

3.7 Foundation

The foundation options available at this stage are few and this step is almost entirely automated. Natural hazards dictate the relevance or requirement of different foundation types. Stilted foundations are recommended in locations of heat and humidity for their ability to allow air to cool the underside of the house. They are required in flood-prone areas to ensure the safety of the home and occupant during a flood event. Slab on grade foundations are the ‘default’ options available anywhere a natural hazard doesn’t prevent their use. This option is ideal for mobility-challenged occupants for its proximity to the ground and lack of stairs. Basement foundations are only available in locations where the water table is low enough to accommodate them. They are required in locations where tornados are present, or the frost line is more than a couple feet below grade.

3.8 Sustainable Systems

The home, as it will exist for the occupant, is almost entirely complete at this stage. Now there is an opportunity to further develop the sustainability of the home by offering the integration of sustainable technologies. The relevance of these technologies is also location specific, but will include solar panels, rainwater catchment, heat pumps, solar water heating, and more.

3.9 Site Design

Guided by the vegetation and GIS-based analyses of the site analysis stages, site design is the final step in the process. Here clients arrange the exterior components such as driveways and porches. This stage offers the opportunity to further reduce energy demands by using site shading and evaporative cooling, if relevant. Spaces to consider at this stage are driveways, decks, porches, patios, stoops, detached structures and vegetative landscaping.

4 Testing and Results

To test the viability of this strategy, an initial design was conducted for an outside party, who agreed to act as hypothetical client. The client guided decision making throughout the process to create a home that would best suit their needs. Beginning with location, the client selected a suburb outside of Arizona, across the street from 11505 W Ventura St, El Mirage, AZ 85335. This location is inside of recently developed, planned suburban community so the buildability of the site was already proven. Beginning with an initial site analysis, the site faces west, but offers its longer orientation to the south and north. Arizona climate is intensely hot and dry, with a high temperature variability between night and day. The most relevant passive design strategies in this climate are natural ventilation, minimized east and west facades, treated southern apertures, and large shade overhangs. This climate also necessitates the integration of a courtyard to improve air flow and minimize heat gains. The site itself is devoid of vegetation. Threats that face this location are droughts and flash floods.

The client selected a live block, then expressed the desire for three bedrooms, two bathrooms and a single car garage with mudroom. [Figure 7]

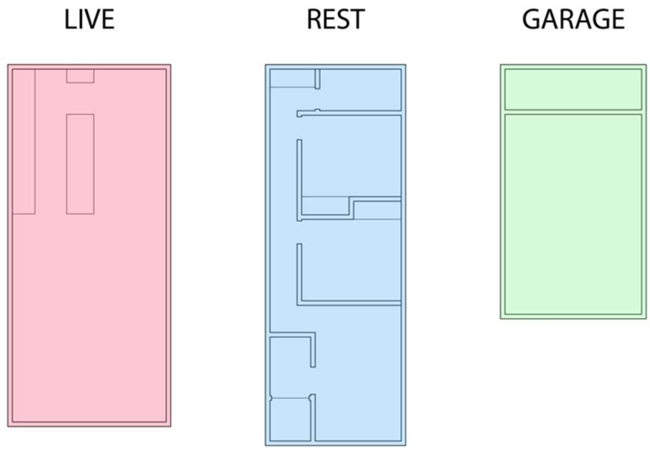


Figure 7. Client-Selected Programmatic Blocks

The program was then arranged to promote passive ventilation, create maximal shade, and orient openings to the north and south. To integrate the courtyard component, additional connective space was added. [Figure 8]

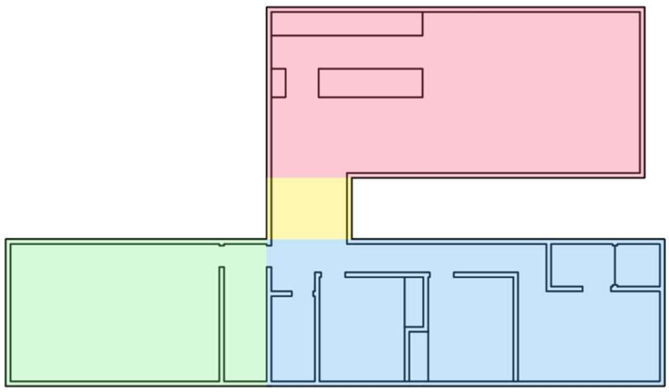


Figure 8. Programmatic Arrangement for Optimized Passive System Operation

This orientation allows the unconditioned garage block to receive the most intense solar heat gain, while shading the living space to the north. Rest spaces located along the southern façade have easily shade-able openings, while the block itself creates shade for the live block. A courtyard visually ties the two components together while promoting exterior air flow.

The roof for this project will be mostly flat with large overhangs to shade the facades. A slight slope in the roof will be added to allow how air to passively ventilate out of the interior. The foundation, since the site is in a floodplain, will be a stilted construction to prevent water inundation. This foundation will also allow for a thermally massive floor to be added, absorbing radiant heat during the day, and allowing moving air to ventilate the heat away at night. The finalized design still needs detailing, material selection, solar analysis and energy modelling, however, initial tests of the program blocking and site-based design strategies proved effective. [Figure 9]

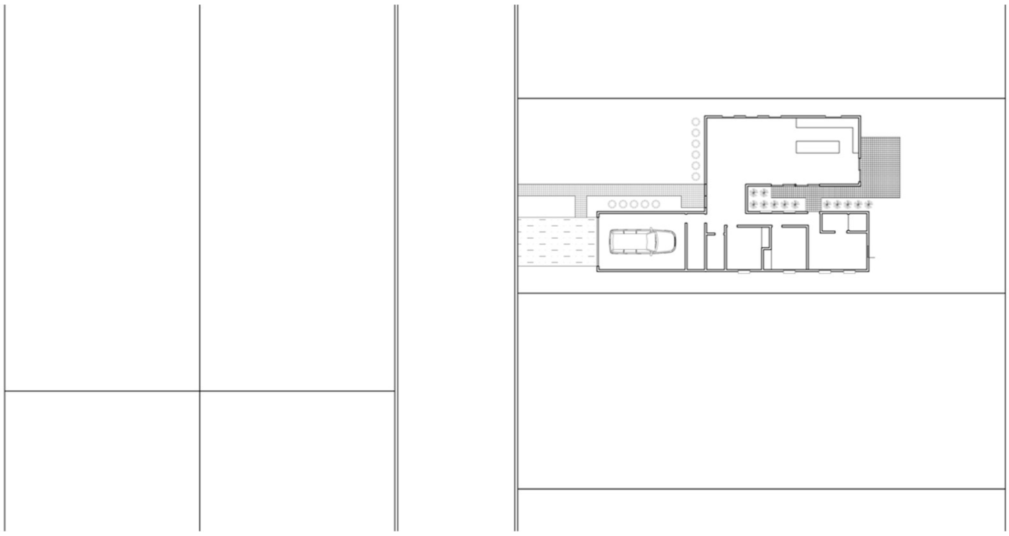


Figure 9. Schematic Design of Client-Driven Home

Acknowledgements

The authors gratefully acknowledge the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2023 for efforts done for the success of this event.

References

[1] Clark, Brian E. “Return to the Suburbs.” www.nar.realtor. National Association of Realtors, October 15, 2020. https://www.nar.realtor/on-common-ground/return-to-the-suburbs.

[2] Sanders, Robert. “Suburban Sprawl Cancels Carbon-Footprint Savings of Dense Urban Cores.” Berkeley News. UCal Berkeley, July 9, 2015. https://news.berkeley.edu/2014/01/06/suburban-sprawl-cancels-carbon-footprint-savings-of-dense-urban-cores/.

[3] Southworth, Michael, and Eran Ben-Joseph. Streets and the Shaping of Towns and Cities. Washington: Island Press, 2013.

[4] Cohen, Lizabeth. 2004. A consumers’ republic: The politics of mass consumption in post-war America. Journal of Consumer Research 31(1): 236-239.

[5] Fritz, Marie Justine. “Federal Housing Administration (FHA).” Encyclopædia Britannica. Encyclopædia Britannica, inc., October 4, 2016. https://www.britannica.com/topic/Federal-Housing-Administration.

[6] Congress.gov. "Titles - H.R.13489 - 85th Congress (1957-1958): An Act making appropriations for military construction for the Department of Defense for the fiscal

year ending June 30, 1959,-and for other purposes." August 28, 1958. https://www.congress.gov/bill/85th-congress/house-bill/13489/titles.

[7] Cohen, Lizabeth. 2004. A consumers' republic: The politics of mass consumption in post-war America. Journal of Consumer Research 31(1): 236-239.

[8] Tam, Vivian W.Y., Ivan W.H. Fung, Michael C.P. Sing, and Stephen O. Ogunlana. "Best Practice of Prefabrication Implementation in the Hong Kong Public and Private Sectors." Journal of Cleaner Production 109 (2015): 216–31. https://doi.org/10.1016/j.jclepro.2014.09.045.

[9] Lu, Weisheng, Ke Chen, Fan Xue, and Wei Pan. "Searching for an Optimal Level of Prefabrication in Construction: An Analytical Framework." Journal of Cleaner Production 201 (2018): 236–45. https://doi.org/10.1016/j.jclepro.2018.07.319.

[10] Peterson, Charles E. "Prefabs in the California Gold Rush, 1849." Journal of the Society of Architectural Historians 24, no. 4 (1965): 318–24. https://doi.org/10.2307/988318.

[11] King, Bruce. New Carbon Architecture: Building to Cool the Climate. Gabriola Island, BC, Canada: New Society Publishers, 2018.

[12] Ibid.

BIOMIMETIC DESIGN EDUCATION: BENEFITS OF IMPLEMENTING COMBINED METHODOLOGIES

Mercedes GARCIA-HOLGUERA*

University of Manitoba
R3T 2N2 Winnipeg, Canada; Mercedes.garciaholguera@umanitoba.ca

Abstract

The development of biomimetic design methods has been central to the advancement of biologically inspired design for the past two decades, with researchers proposing a variety of tools and design approaches to facilitate a wider spread of the discipline in professional and academic environments. This research illustrates that a heterogeneous combination of tools and design methodologies is the preferred option by designers approaching biomimetic design for the first time. It is argued that adopting a flexible combination of resources might be the pathway to increasing the presence of biomimetic design in the professional arena when adequately aligning the design challenge to existing biomimetic methods and tools. In addition, the relevance and complexity of integrating transdisciplinary tools, such as the Energy System Diagrams, and the challenges imposed by time constraints and creative barriers are discussed. Work prepared by four cohorts of graduate-level students over four years and reflections from participants in the course are presented to support these findings.

Keywords

Biomimetics, biomimicry, biologically inspired design, education, Energy System Diagrams

1 Introduction

The field of biomimetic design in architecture has evolved over the past decades in academic and professional environments. Whereas in the academic realm, the focus is greatly on theoretical aspects of the field, professional settings have been more productive in generating applied cases and engaging the public's interest. Biomimetic design as a discipline is now moving from its infancy towards a consolidated state where terminology, methods and tools are being assessed for their capacity to effectively turn biomimetic designs into commercial products. In this context, the existence of a considerable array of design methods and tools serves to strengthen the discipline [1], and opens the question of what method and tool to use in the face of a design challenge. From a pedagogical point of view, the question faced is what method and tool should be taught to students and future biomimeticians to facilitate and consolidate access to biomimetic design. Equally important would be to define how to best adapt these tools to specific learning audiences [2].

Researchers [3, 4] have documented a long list of available tools from the literature, and have reported the obstacles to include some of these tools in biomimetic design exercises. This

document supports the argument already discussed in previous research work [4, 5], that a combination of tools and strategies from several biomimetic methods might be an effective alternative when conducting biomimetic design processes. In particular, this research shows that an heterogenous arrangement of strategies and tools is preferred by graduate-level architecture students and shows the value of implementing the Energy System Diagrams (ESD) as a biomimetic tool.
The ESD is a qualitative tool from the ecological engineering discipline, developed by Odum [6] to graphically represent the organization of ecosystems, and more specifically the energy flows observed in ecological systems. An ESD illustrates the structure and organization of the system under study, classifies components according to their functionality and places these components following an energy hierarchy. ESD have been used in the past outside the ecological engineering field to represent social systems and building systems [7, 8] and in the context of biomimetic design to facilitate the abstraction of biological strategies into a functional model [9].
This document describes the biomimetic course offered to 64 graduate level students over four years and presents results and reflections that endorse a biomimetic pedagogy based on the combination of multiple methods and tools.

2 Course description

This investigation relies on data obtained from the graduate-level course named *Introduction to Biomimetic Design*. This is a 1.5-credit elective course taught over five consecutive weeks during the Fall at the Faculty of Architecture at the University of Manitoba, Canada. The information presented here was gathered during four academic years (2019-2022), and only the Fall 2020 session was imparted remotely (Table 1).

Table 1. General information about registration numbers and teaching formats.

Year	Number of students registered in the course	Teaching mode	Biomimetic approach	Design goal theme	Biologist involved
2019	14	In-person	Top-Down	Resources use optimization	No
2020	16	Remotely	Top-Down	Heat conservation and Indoor Air Quality	No
2021	18	In-person	Bottom-Up	Resources use optimization (Arctic)	Yes
2022	16	In-person	Bottom-Up	Water / Flooding control	Yes

The structure of the course is similar to the one followed by other biomimetic courses [10] and its content covers general history and theory of biomimetic design, analysis of case studies, introduction to biomimetic design methods and tools and exercises that culminate in a biomimetic group project (Table 2). Each class combines lectures, discussions, individual activities, and group activities. Lectures and discussions provide the framework for individual and group work, which concentrates most of the class time. Some classes are designed to work as ‘flipped classrooms’, so students come prepared to discuss and apply the content provided by the instructor beforehand.

Table 2. Course content by week

Week 1	Biomimetic history, terminology, and categorization.
Week 2	Methods and tools. Exercise: Biomimetic case studies

Week 3	Methods and tools. Biomimetic project: Identification phase
Week 4	Methods and tools. Biomimetic project: Abstraction phase
Week 5	Guest speaker. Biomimetic project: Transfer phase

The introduction to biomimetic design methods and tools begins on Week 2 with the presentation of a general set of guidelines that govern the design process followed in the course. These guidelines are common to most biomimetic methodologies, although they can vary depending to the design approaches:

- Most biomimetic design happens as an iterative spiral rather than a closed cycle. This is easily grasped by students at graduate programs who have already design experience, but can be challenging for students coming from Sciences programs.
- There are two pathways that initiate most biomimetic design processes: the bottom-up and top-down approaches [11-13]. In years 2019 and 2020 a top-down approach was implemented, and participants received a general design question that helped frame the research and design process moving forward. The top-down approach is preferred by engineers and designers when the biomimetic exercise begins with a clear design challenge and also when biology knowledge or participation of biologists is limited. On years 2021 and 2022 the bottom-up approach was followed instead, due to the incorporation of a biologist in the instruction and assessment of biological content. Differently to other bottom-up exercises described in the literature [12], the students were offered not one, but several biological systems with relevant characteristics that could be transferred into their designs. Each team was able to choose their biological model and study the macro and micro structure of specimens at 1:1 scale and under the microscope.
- Biomimetic design processes are organized around three fundamental design stages: identification stage, abstraction stage and transfer stage. Some researchers subdivide these phases into more detailed design steps [4, 13, 14] to facilitate access to biomimetic design.
- The outcome of the biomimetic project needs to incorporate environmentally oriented solutions. Sustainable or environmentally friendly designs are not inherent to all biomimetic processes, although this goal is more clear in the case of biomimicry based design [15]. One way of introducing environmental goals in a biomimetic design process requires to define a design question that inevitably will need sustainability principles at the core of the design solution. This goal has been present in the course since the beginning.

After the introduction to this general framework students review and discuss a selection of design methods from the literature: BioTRIZ [16], BioGen [17], the Design Spiral [14, 18], the Ecomimetic method [19] and Ecosystems Processes Biomimicry [20]; and get exposed to a series of biomimetic tools in preparation for the biomimetic project: Asknature [21, 22], DANE [23], IDEA Inspire [24], BioMaps[25], the Engineering-to-Biology thesaurus [26, 27], Energy System Diagrams [6, 9, 28], and Environmental Modeling tools [19, 29].
Although participants get access to extant literature, the biomimetic process is quite controlled and directed by the instructor in terms of biomimetic approach (top-down vs. bottom-up), research question, design method and biomimetic tools. This level of control is required by the number of participants in the course and time limitations, but it reduces the

opportunities for exploration of additional tools that would match best some participants learning modes or some research questions. It has been argued that a more catered selection of methods and tools according to the specifics of the design challenge would be an interesting way to advance the biomimetic discipline [5], and this document adds to that conversation presenting a course that combines biomimetic methods and tools to better serve a specific audience and teaching model.

During Weeks 3, 4 and 5 students work on assignments related to each of the three biomimetic design stages (i.e. identification, abstraction and transfer) and follow instructions that specify: information to gather, tools they need to use, documents to generate and any other aspect that will help participants complete the weekly assignment. In Table 3, a list with the approaches and tools used at each stage is presented.

Table 3. Methods, tools, and outcomes at each biomimetic design stage.

	Identification stage	**Abstraction stage**	**Transfer stage**
Methods used	Design Spiral	Ecomimetic method	Brainstorming
Tools used	AskNature Search engines Scientific literature Interaction with biologist	Energy System Diagrams Biomimicry Resource Notebook	CAD tools Hand drawings Models
Outcomes	Identification and description of biological systems and their strategies	Energy System Diagram of selected biological system Table identifying mechanism, function, strategy, and design principles associated to selected biological system	Drawings of proposed design solution Written description of design solution

2.1 Implementation of heterogeneous methods

A successful biomimetic design method responds to a series of heterogeneous and changing conditions that include, but are not limited to, the type of audience that will be participating in the biomimetic design exercise (e.g. professional practitioners in engineering vs. first year architecture students), the nature of the design challenge (e.g. a broad aspirational design goal vs. marketing driven challenges), the allotted time for the exercise (e.g. a one-day workshop vs. exercises conducted in professional environments or university courses), and the instructor bias based in his/her background and position in the discipline. General biomimetic design approaches, (i.e. bottom-up and top-down) can absorb most of these differences in parameters, but they cannot provide specific answers to more detailed questions (e.g. where to find biological models? How to abstract strategies identified in biological models?). However, most biomimetic design methods listed above and other found in the literature [3] are not comprehensive and can lack tools or procedural design steps to guide all biomimetic exercises.

In the graduate-level course presented here, the author's first attempt when developing the course was to implement the Ecomimetic method which was part of a previous research project [19]. However, it was soon evident that the length of the course would not allow to train participants in some transdisciplinary tools proposed in the Ecomimetic method, and also that databases and search engines developed by other researchers would address better some of the course's needs. For example, the extent and logical organization of the

biomimicry taxonomy in AskNature [22, 30] facilitated enormously the first stage of the biomimetic process, especially during the first two sessions when a biologist was not involved in the course. Similarly, some conceptual approaches and tools described in the Biomimicry Resource Handbook [18] served as useful complements to the graphical analysis of biological models initiated with the Energy System Diagrams (ESD) during the abstraction stage. The Energy System Diagrams is probably the tool that required more preparation and training from the participants because it incorporated terminology and concepts unfamiliar to architecture students. The ESD allowed participants to graphically identified all the components of the biological system under study, their functions and the relationships between the components that explained the strategy being mimicked. Students consistently reported the usefulness of this tool, but also the challenges they faced when using it for the first time (Fig. 3-5). Finally, time constraints also played a critical role in the decision to use group brainstorming sessions during the transfer stage of the biomimetic exercise. Participants were encouraged to focus on design solutions able to capture functions observed on the biological systems to answer the original design questions posed at the beginning of the exercise.
The combination of methods and tools presented here is a living structure that is open to future modifications, and the flexibility of this structure was tested with the integration of a biologist in the course in years 2021 and 2022.

2.2 Incorporating a biologist

From the inception of the course, the involvement of ecologists and biologists was preferred; however, it was only during the third year that a collaboration with a biologist was possible. This collaboration was also requested by students' in surveys conducted in years one and two. The biologist contribution included: offering a focused lecture on pre-selected biological systems, gathering preserved specimens to present to participants, preparing specimens to be examined under the microscope, supporting students to obtain and interpret microscopy images, offering consultation and feedback to students during in-class and out-of-class activities, and attending classes. The biologist had previous experience working in biomimetic courses and was aware of designers' most expected challenges when engaging on a transdisciplinary design process. Opportunities and challenges derived from the participation of a biologist in the course are presented in the Discussion section.

3 Results

This section includes samples of work developed by students registered in the course and data gathered through surveys launched after every class through Socrative [31]. The answers presented here correspond to a likert scale survey, meaning that statements are offered to participants and the survey captures their degree of agreement or disagreement with the statement. The surveys do not have the same number of responses for all questions for several reasons. In some cases, participants missed the class and in other cases participants did not submit a response through Socrative in the required timeframe or did not take the survey. Also, in some cases participants could select more than one response which can be wrongly interpreted as a larger number of participants in the survey. In those cases the number of total responses and the number of participants is indicated in the figure's caption. All the surveys were administered after the students had been trained on the topic associated to the survey, and had tested their learning in one or more exercises (i.e. in-class activities, out-of-class

assignments). The author will share complete surveys for each year (2019-2022) and each class with those interested in having access to more detailed data of the course.
Three major findings have been identified that are relevant to the topic discussed in this document. The first one is that most participants were satisfied with the results of their biomimetic project (Fig. 1) despite all the challenges and struggles encountered during the process and that will be discussed below. 66% of participants expressed that they were satisfied with the results of their work and 31% reported to be somewhat satisfied with the results. Only 2% of the students (1 individual) indicated not to be content with the outcomes achieved.

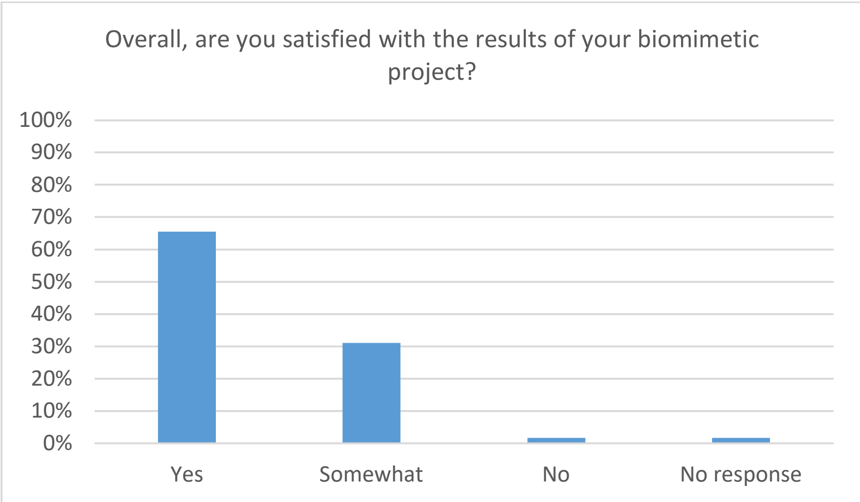


Figure 1 Responses to question: "Overall, are you satisfied with the results of your biomimetic project?". Total number of participants: 58

Second, when asked about their preference regarding biomimetic design methods, participants were more inclined to use a combination of methods rather than a single biomimetic approach (Fig. 2). Nonetheless, the Design Spiral method was also selected by a considerable number of participants (21%) as their desired biomimetic approach. The other biomimetic design methods included in the survey (i.e. BioTriz, BioGen, Ecomimicry for Regenerative Design, and the Ecomimetic method) were selected by 3-7% of responders. More importantly almost half of the participants (48%) expressed their inclination to work with several biomimetic methods. Although they were not given the opportunity to indicate what methods they will include in that mix, participants could choose more than one method when taking the survey and 9% of the responses did include two or three biomimetic methods as the desired approach.

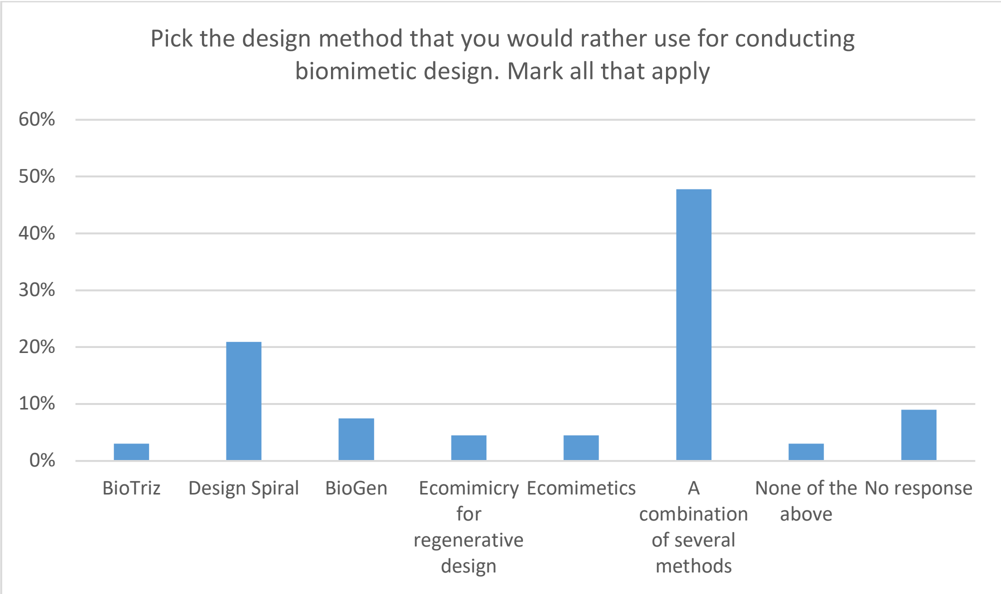
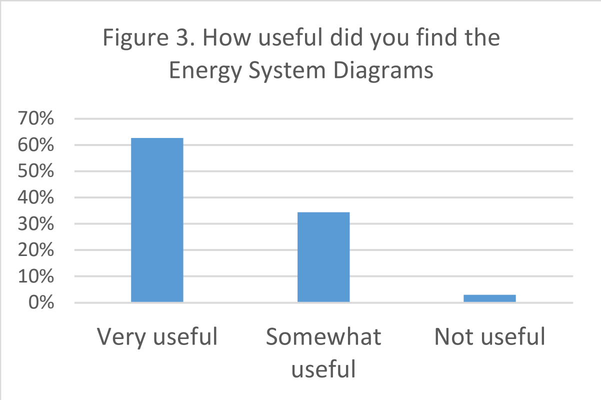
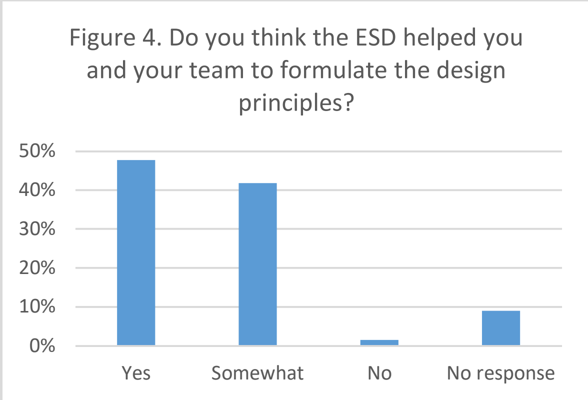
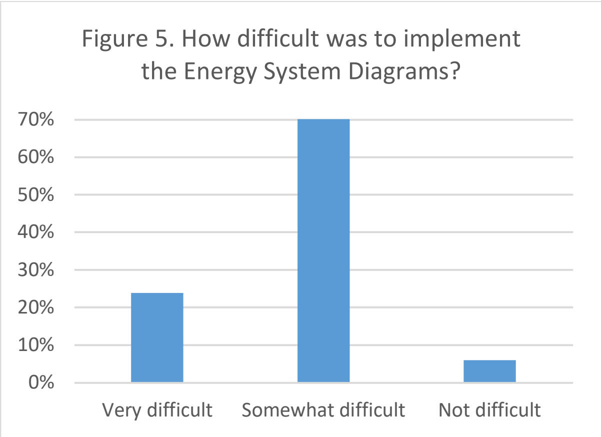


Figure 2. Responses to question: "Pick the design method that you would rather use for conducting biomimetic design. Mark all that apply. Total number of participants: 57. Total number of responses: 67.

Finally, 97% of the participants in the course found the Energy System Diagrams very useful or somewhat useful when developing their biomimetic design projects (Fig. 3). In particular, 90% of the responders judged the ESD a valuable tool to abstract and formulate biomimetic design principles (Fig. 4). Abstraction of biological functions and processes and their reformulation as meaningful design principles is probably one of the cornerstones in biomimetic design, and the ESD have the potential to facilitate that process in a significant way. Nevertheless, 94% of participants stated that implementing the ESD in their biomimetic design process was very difficult or somewhat difficult (Fig. 5), and these results align well with the responses given by students when asked about the three biomimetic design stages in general (i.e. identification, abstraction, transfer). When questioned about the most challenging stage of the biomimetic process, the abstraction stage was voted as the most demanding when compared to the identification and transfer stages (Fig. 6). It is at the abstraction stage when participants are required to isolate design principles that will be used in the transfer stage, and when abstraction tools such as the ESD are needed.







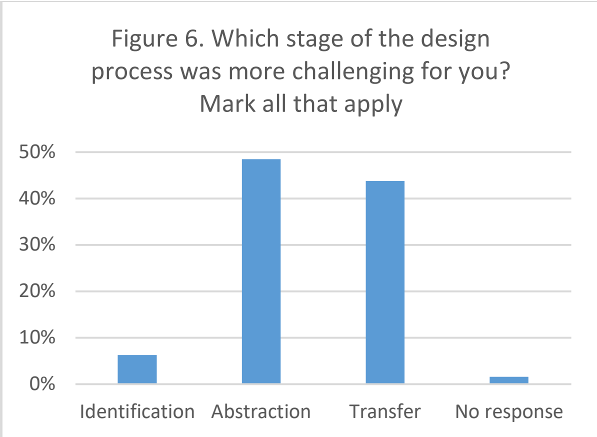


Figure 3. Responses about ESD. Total number of participants: 67. Figure 4. Responses about ESD. Total number of participants: 67. Figure 5. Responses about ESD. Total number of participants: 67. Figure 6. Responses about biomimetic design stages. Total number of participants: 58. Total number of responses: 64.

Next, a selection of Energy System Diagrams developed by participants are presented together with their final design solutions to illustrate some challenges and outcomes of the course. For conciseness purposes only one project from each cohort is shown here, but the author will provide access to more work samples to those interested in learning more about the course. Students worked collaboratively in groups of 4-5 people during the last three weeks of the course in the development of the biomimetic projects.

Team A (Year 2019)

This group had to design a shelter that would optimize resources used in buildings. They identified the musk ox as one potential organism to mimic based on several heat conservation strategies found in databases (i.e. AskNature) and the literature. The group produced several iterations of ESD (Fig. 7) as an attempt to synthesize and correlate all the information gathered. After completing the ESD a table inspired in tables from the Biomimicry Resource Handbook [18] was created to identify one or more design principles (Table 4). Finally, the team developed a series of shelters that mimicked the musk ox strategies by adopting a circular formation to protect inhabitants from prevailing winds and included a removable façade system that would adapt to Winter and Summer conditions similar to the musk ox moulting process (Fig. 8).

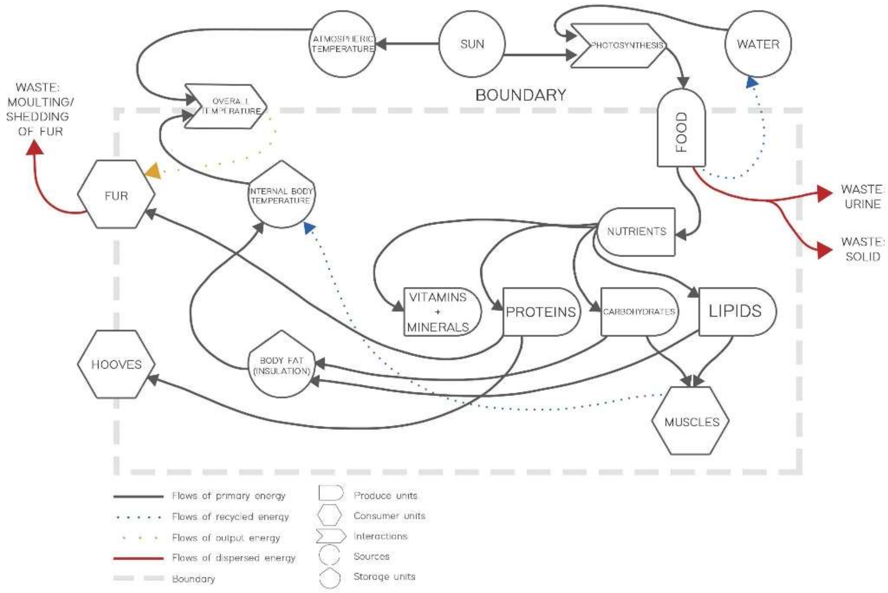


Figure 7. ESD depicting components of a musk ox and the interaction among them according to functions (i.e. production, consumption, interaction, storage, energy sourcing)

Table 4. Identification of mechanism, function and strategy observed in organism, and deduction of design principle.

Organism	Musk Ox
Mechanism	Double fur layer to adapt body temperature to extreme temperatures Moult inner layer during warmer months and grow back for winter months Store and retain heat within body fat
Function	Thermal insulation
Strategy	Retain heat within double exterior layers Utilise inner envelope layers to act as insulating material Utilise envelope material to act as thermal mass
Design principle	Energy (heat) retention utilizing a thermal massing system Multiple envelope layers may be added/removed depending on seasonal needs

Figure 8. Shelters inspired in lessons learned from the musk ox. Winter and Summer conditions

Team B (Year 2020)

The cohort in year 2020 designed wearable devices that addressed issues related to indoor air quality and thermal comfort optimization. Team B studied the properties of the meadow spittlebug larvae, mammals’ eyelashes and behavioural aspects of tree leaves to design a clothing apparatus that would combine design principles from the three organisms. The ESD below corresponds to the group’s study of the spittlebug larvae strategy (Fig. 9).

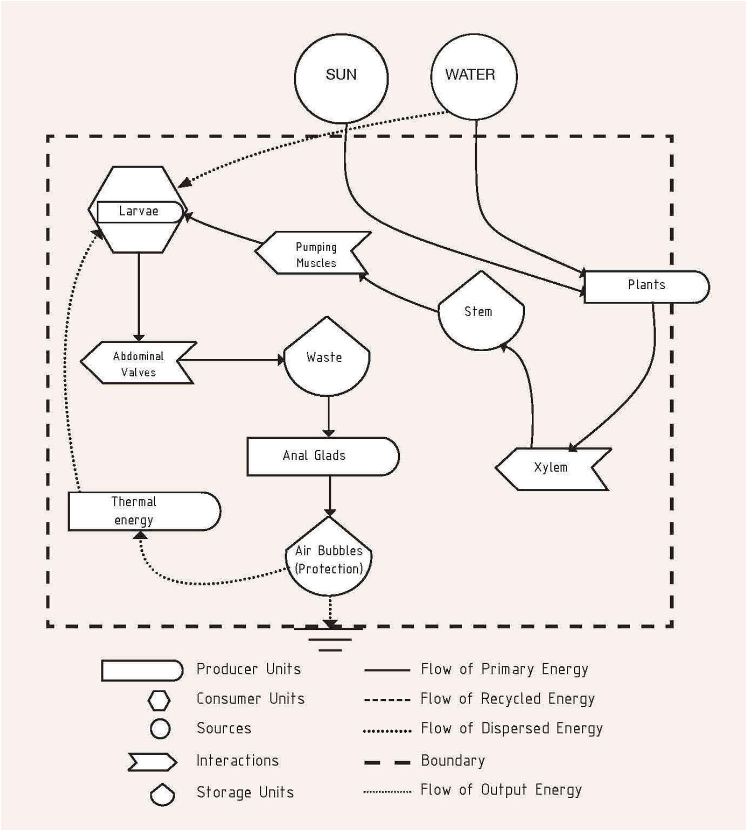


Figure 9. ESD of the meadow spittlebug larvae. Depiction of components related to the strategy under study, their functions and the interactions happening among them.

Team B used the ESD to identify the design principles (Table 5) that would be transferred to the final project through several brainstorming sessions. The final project incorporates an inflatable wearable device inspired on the spittlebug larvae strategy that captures and cleans air that is then redirected to the upper mask. The inflatable device also performs as a thermal protective layer when inflated (Fig. 10)

Table 5. Identification of mechanism, function and strategy observed in the meadow spittlebug larvae, and deduction of design principle.

Organism	Meadow spittlebug larvae
Mechanism	Defense mechanism to secrete large amounts of bubble-shaped fluids. This mechanism deters predators and protects the larvae from harmful UV rays.
Function	Defend against predators and protect from harmful conditions
Strategy	Secrete fluid from anal glad, which interacts with the valve on the abdomen to create spittle bubbles (air bubbles).
Design principle	A rapid deployable protective environment. A device that can fill up of air-like bubbles for physical isolation against germs.

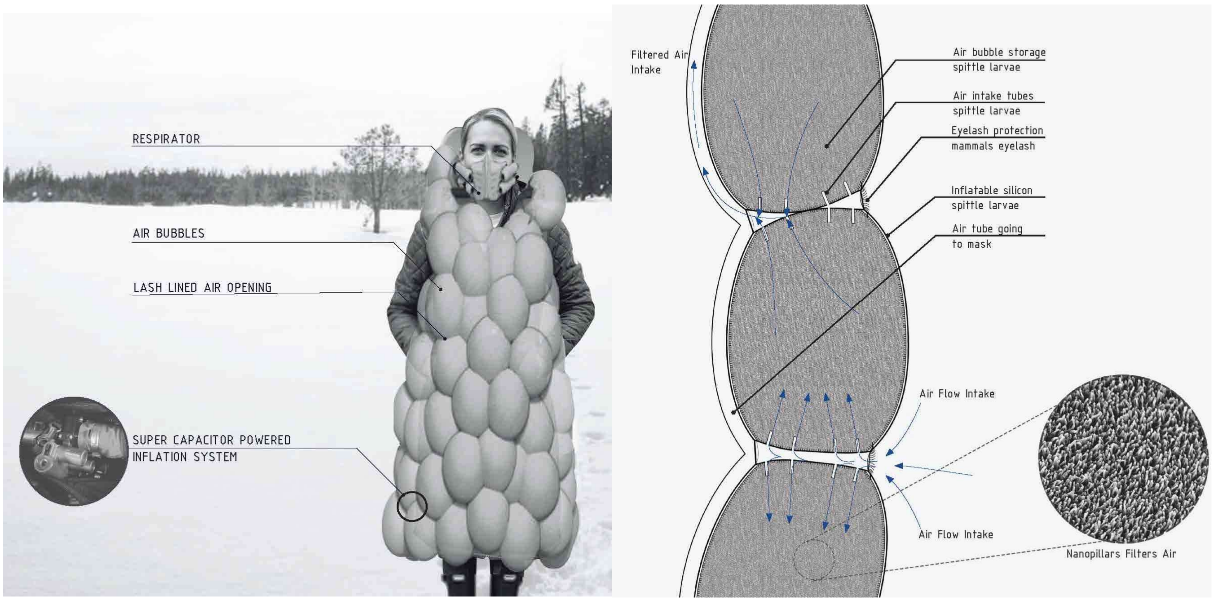


Figure 10. Wearable device inspired by the meadow spittlebug larvae. Elevation and detail section.

<u>Team C (Year 2021)</u>

The design challenge in year 2021 focused on the optimization of resources use in buildings with an emphasis on heating loads and the additional requirement to design for a cold climate. Team C examined a fish's swim bladder and its ability to alter its volume to control buoyancy without using additional energy. The team extrapolated the lessons learned from the fish's manipulation of gas's volumes to regulate the amount of air that would be heated or cooled in a building. The ESD illustrate the first attempt made by the team to understand the elements that played a relevant role in the fish's swim bladder functioning (Fig. 11). Subsequently that understanding was recorded in Table 6 where the team summarized the organism's mechanism, function, strategy and design principles to be transferred to the project.

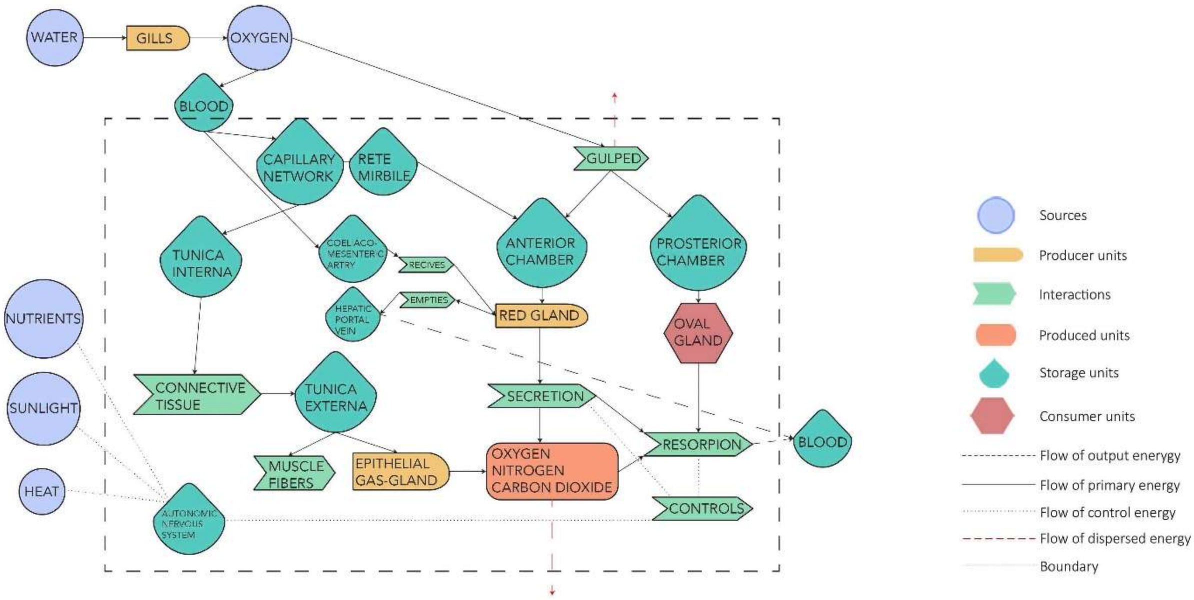


Figure 11. ESD of a fish's swim bladder. Depiction of components related to the strategy under study, their functions and the interactions happening among them.

Table 6. Identification of mechanism, function and strategy observed in the fish's swim bladder, and deduction of design principle.

Organism	Fish's swim bladder
Mechanism	Hydrostatic, gas filled organ that enables a fish to control its buoyancy and depth in water without sinking and without having to exert energy swimming.
Function	Equilibrate the body in relation to surrounding medium by increasing or decreasing the volume of gas content.
Strategy	Hydrostatic organ for buoyancy and depth control in water column
Design principle	Buoyancy control and gas exchange within a medium

The final proposal integrated, among other features, a dynamic façade that would facilitate the expansion and contraction of the building's volume (Fig. 12). Changes in volume would be dictated by increases and decreases in occupancy, and by heating and cooling needs. The end goal was to develop and adaptive skin that would maximize, minimize or maintain the volume of a space while also controlling the diffusion of air between spaces. It was expected that this targeted approach would help reduce energy consumption in buildings.

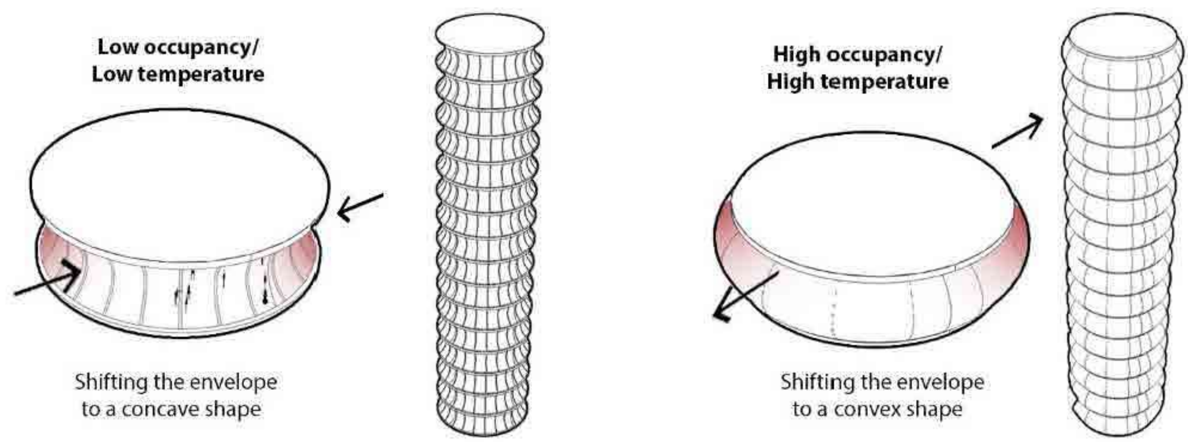


Figure 12. Volume-changing-building inspired by a fish's swim bladder. Depiction of two potential states: deflated (low energy use) and inflated (high energy use)

<u>Team D (Year 2022)</u>

Students in this cohort were instructed to tackle flooding related issues in their biomimetic projects. Team D explored several organisms, one of them being the Antarctic copepod. Figure 13 presents the ESD developed by this group and Table 7 portrays a summary of the abstraction exercise conducted by the participants.

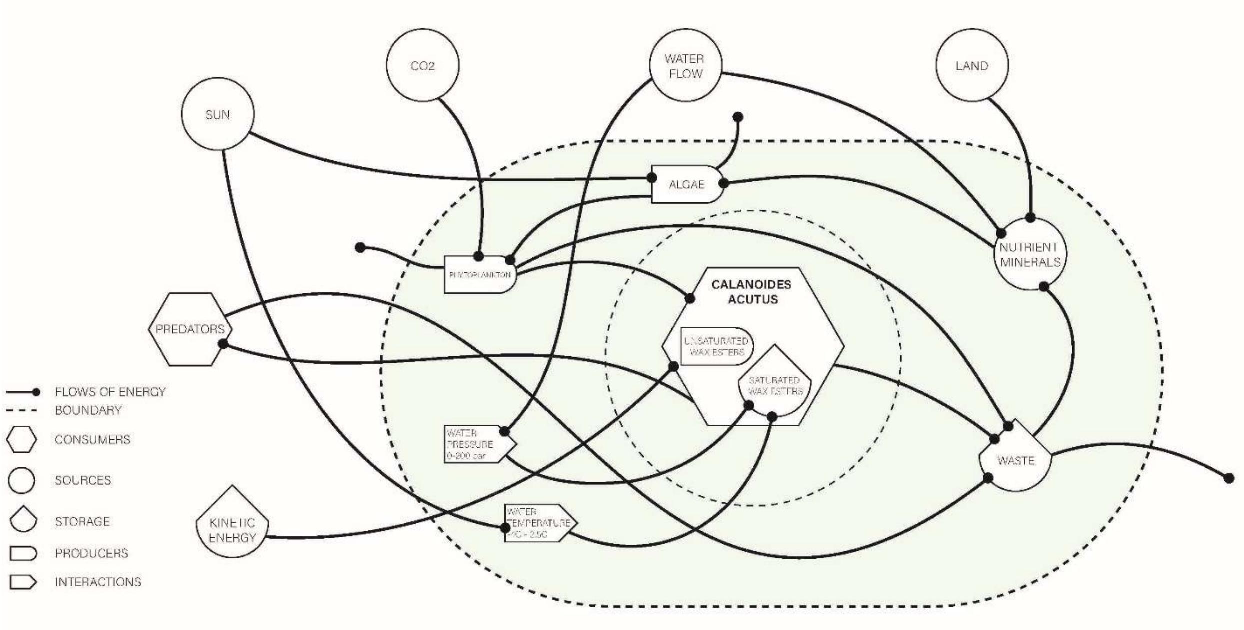


Figure 13.ESD of the Antarctic copepod. Depiction of components related to the strategy under study, their functions and the interactions happening among them.

Table 7. Identification of mechanism, function and strategy observed in the Antarctic copepod, and deduction of design principle.

Organism	Antarctic copepod
Mechanism	In preparation for diapause develops lipid reserves, primarily through the consumption of phytoplankton. Following environmental cues the copepod forms was esters from the lipids and begins to descend. Pressure and water temperature compress the was esters to be a denser mass, reducing the energy needed to descend.
Function	Reduce energy required to reach, maintain and emerge from diapause
Strategy	Onset of diapause: lipids in body become dense solids allowing the organism to sink. End of diapause: was esters become less dense allowing the organism to float up.
Design principle	Buoyancy changes through water pressure and density alterations

The final solution consisted of an emergency power supply system that would be activated by a flood event and took into consideration that, often, during extreme rainfall and flooding events power supply is disrupted. Therefore, the proposed system would store water in vertical underground columns that will use water weight to compress air and generate power. When the compressed air is released, or once the flooding event is over, the water is drained to a deep aquifer (Fig. 14).

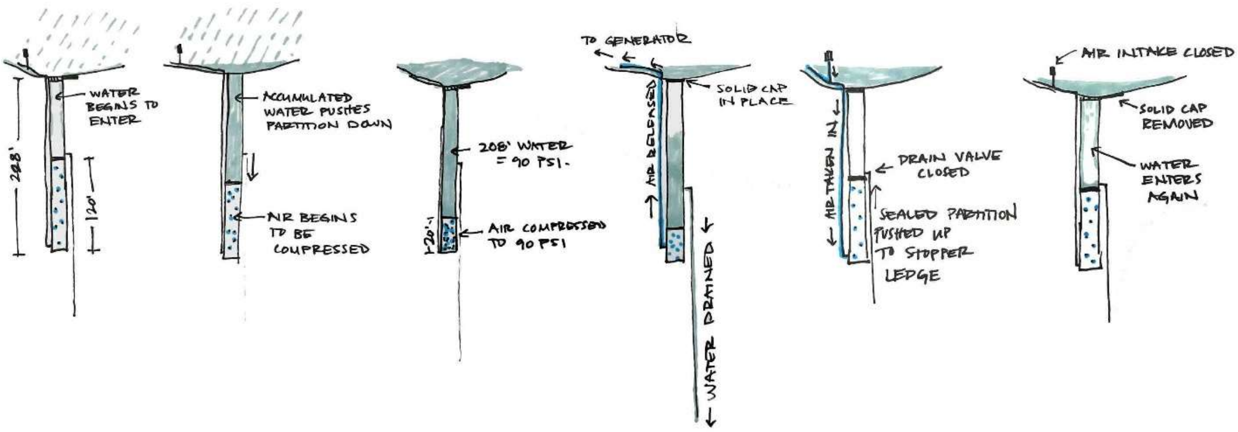


Figure 14. Sketch showing proposed functioning of one energy-generating water column inspired by the Antarctic copepod use of compressed wax to sink passively.

4 Discussion and Conclusion

The work presented here aims to give a brief overview of the potential in using a combination of biomimetic design methods instead of following a single biomimetic approach. In the last two decades a large amount of biomimetic research has focused on developing, improving and illustrating the implementation of design methods that will ease the transition between biological knowledge and design creation, and although some approaches have experienced greater dissemination, most biomimetic methods are still secluded behind academic walls. Creating more accessible and user-friendly tools has been identified as one way of making biomimetic research accessible to professionals and the public, and AskNature is a good example of what a well designed and publicized tool can achieve for the discipline. However, AskNature alone cannot address the knowledge transfer challenge that biomimetic design is facing as a growing field. This author suggests that a blend or combination of methods and tools according to the specifics of each design challenge will help to disseminate biomimetic design to a great extent. The course presented here only offers one possible arrangement of tools and choice of methods, but it gives some light into what others can expect when exposing participants to other similar combination of borrowed pieces. Next is a list of reflections and lessons learned from the course:

- Short term biomimetic exercises require straight forward design instructions to optimize time management. Clear design steps and accessible tools are central to guaranteeing a smooth progress of the design process. In some cases, offering partial completion of some design stages can help focus the attention on some aspect of the biomimetic process. For example, in the two years where a bottom-up approach was followed a previous search and analysis of biological systems was conducted to reduce the time participants would have to spend on the identification stage.
- Participants in the course found interesting aspects in all the methods presented to them, including those they only studied from the literature but did not have a chance to implement. Some of these methods were conceptually inaccessible because of difficulties to comprehend the materials available due to the short duration of the course (i.e., BioTRIZ). Participants amply agreed on their desire to use a combination of methods and tools rather than committing to a single approach. This requires, though, that instructors are trained in a

full array of biomimetic approaches, that in some cases, can be obscure or difficult to master solely from the information found in the literature. Some form of focused training for biomimetic instructors would ease this process. For example, recurrent peer-teaching workshops where researchers and instructors involved in biomimetic design could exchange, teach and share tools and approaches of their preference with other colleagues would greatly increase the number of available resources to teach and disseminate globally.

- In addition, the possibility to choose between several biomimetic methods and tools, offers great flexibility to instructors when developing a course's goals, assignments, and assessment modes. It also helps to address some constraints faced during the course. For instance, when dealing with time limitations some of the more complex methods and tools could be removed from the curriculum and substituted by others. Also, templates and handouts from workshops' activities retrieved from the literature were very useful as in-class activities to explain key concepts and transition to the out-of-class assignments. In addition, having access to a larger array of tools helped to break down the teaching process into smaller and more diverse routes.
- Because the biomimetic project assignment is planned from its conception as a combination of methods and tools it is simpler to add, replace or modify some of the tools used as well as to alter design steps in the biomimetic process. One example of this was the smooth transition from a top-down approach to a bottom-up approach and the incorporation of the biologist in the course. Although adjustments to the course content and assignments took place, the overall structure and objectives remained the same.
- The incorporation of a biologist to the course presented opportunities and challenges. First, more in depth biology knowledge became available to participants when studying biological systems. From a pedagogical point of view adopting a bottom-up approach reduced the time spent searching for biological systems and simplified the first stage of the biomimetic exercise. However, some students reported some frustration for what was perceived as a reduction in freedom of choice (i.e. biological models were provided to participants instead of being selected by the students from the databases) Second, new tools became accessible to participants with the incorporation of a biologist to the course. In particular, students had access to preserved biological specimens and microscopy imagery tools to improve their understanding and analysis of biological systems. This was received positively by most participants and time devoted to this activity was increased per students' request. Finally, what seems to be the strongest benefit from the participation of a biologist in the course is the opportunity to receive feedback and engage in fruitful conversations at each stage of the biomimetic process. Regularly architecture students tend to linger on trivial biological features that do not necessarily address the design question at hand or that misunderstand functions and processes achieved by the organisms. Conversations with the biologist during review sessions were very valuable in dismantling some of these misconceptions, and helped redirecting designs towards more appropriate solutions.
- Regarding the implementation of biomimetic tools in the course, participants encountered various challenges as they moved forward through the biomimetic project. Although the identification stage was perceived as non particularly difficult, students expressed their disappointment when they could not find biological systems to address their design goals in the databases or when information about the biological systems was not

sufficient. They also struggled to unravel the scientific literature and to discern what aspects and pieces of information were relevant to their biomimetic purposes. Having a biologist on board helped considerably to address this issue, but students only had access to the biologist at certain times and had to go through the literature unaided most of the times. To address this disciplinary gap, one potential action would be to open the course to biology students and ensure that every team includes at least one participant from this discipline. However, the major challenge encountered by students was at the abstraction stage. In part, it was at this point where they noticed that some of the information gathered at the identification stage was insufficient, inappropriate or not useful for their purposes. The ESD were particularly valuable in that regard since students had to depict their holistic understanding of the biological strategy and represent all components involved, the functions performed by these components and the relationships existing among them. Not many teams achieved this level of synthesis in their ESD, but all teams identified weaknesses in their biomimetic strategies analysis when using the ESD tool. It has become clear to this author that one of the strengths of the ESD is its role as a thinking and self-assessment tool that can be systematically accessed by novice users. Being a graphic tool, designers felt at ease using the ESD quite rapidly, and it was consistently used to advance the biomimetic project and to discard design solutions. For example, the ESD were effective revealing when participants had misunderstood aspects of the biology data if they could not identify enough components and their functionality to explain the strategy under study. The ESD also revealed when information in the literature was insufficient or not comprehensible to team members if the narrative of the biomimetic strategy could not be fully completed in the ESD. These challenges are reflected in the participants' responses in the surveys and their assessment of the ESD as a very difficult and somewhat difficult tool, but surveys also reveal that the ESD were central to facilitate abstraction of design principles. In most cases teams had to discard several biological systems selected at the identification stage and go through a number of iterations of ESD before conceiving their final diagram. This process was very time consuming and emphasizes the need for more training and implementation time in the course, particularly at the abstraction stage. Several options are being considered to address these limitations. Firstly, converting the course into a 3-credit course would double the in-class and out-of-class time for teaching and applying biomimetic tools. This change has been regularly requested by students in their course evaluation forms, and it would be worth to assess potential benefits and identify new challenges when more in depth, time and complex tools can be integrated in the course curriculum. Secondly, transdisciplinary biomimetic tools (i.e. the ESD) could be modified and adapted to the needs of biomimeticians in training and in practice. The ESD introduced in this course attempts to follow the guidelines established by ecological engineers in the literature, but the biomimetic process could benefit from a ESD tool that embodies and acknowledges all biomimetic design stages. For example, it would be very useful if the ESD could be developed into an online tool capable to link information obtained from AskNature or other search engines to build diagrams. It would also be beneficial if functions associated with the ESD symbols (i.e. producer, consumer, storage, source, etc.) were adapted to display a more transdisciplinary language and functionality aligned with biomimetic design.

Overall, the combination of tools and methods in a graduate level biomimetic course has been a positive experience both for participants and instructors. The projects developed by the participants tend to be very strong in terms of creativity and inventiveness, but it could also be argued that some projects seem to be fall under what has been identified as biologically inspired design inspired rather than being the result of a systematic biomimetic design process. In those cases, lack of design iterations and in depth understanding of biological strategies can explain the results, and relates to the above mentioned challenges (i.e. more time and more involvement of biologists)

There are several aspects in this course that can and will be modified in the future as listed above. Other aspects of the course will remain and will be emphasize further if possible. For example, maintaining a heterogenous biomimetic approach and enlarging the number of biomimetic tools and methods that students can learn and implement in the course will take precedence and will serve to advance pedagogy in biomimetic design. The combination of methods and tools presented here has permitted to introduce a group of graduate-level students to the complexities and possibilities of biomimetic design in a short period of time and maybe the lessons learned will be extrapolated to their academic and professional careers moving forward. The overwhelming enthusiasm and level of engagement and dedication of participants over the past four years speaks to the interest of novice designers in developing skills that are attuned to the workings of the natural world in a responsible way.

Acknowledgements

The author gratefully acknowledges the work done by Prof. Erwin Huebner and the participants in the course.

References

1. Bensaude-Vincent, B., *Bio-Informed Emerging Technologies and Their Relation to the Sustainability Aims of Biomimicry.* Environmental Values, 2019. **28**(5): p. 551-571.
2. Jacobs, S., et al., *The Education Pipeline of Biomimetics and Its Challenges.* Biomimetics, 2022. **7**(3): p. 93.
3. Wanieck, K., et al., *Biomimetics and its tools.* Bioinspired, Biomimetic and Nanobiomaterials, 2017. **6**(2): p. 53-66.
4. Fayemi, P.E., et al., *Biomimetics: process, tools and practice.* Bioinspiration & Biomimetics, 2017. **12**(1): p. 011002.
5. Jacobs, S. and K. Wanieck, *Biom*: On becoming a teachable discipline*, in *Biomimicry for Materials, Design and Habitats : Innovations and Applications*, M. Eggermont, V. Shyam, and A.F. Hepp, Editors. 2022, Elsevier: San Diego, UNITED STATES.
6. Odum, H.T., *Ecological and general systems: an introduction to systems ecology*. 1994: University Press of Colorado.
7. Odum, H.T., *Environment, power, and society for the twenty-first century : the hierarchy of energy*. 2007, New York: Columbia University Press.
8. Srinivasan, R.S. and K. Moe, *The hierarchy of energy in architecture energy analysis*, ed. PocketArchitecture. 2015: Routledge.
9. Garcia-Holguera, M., et al., *Ecosystems Biomimetics: Ecological Systems Diagrams for Characterization of Environmental Performance of Buildings.* The International Journal of the Constructed Environment, 2013. **3**(2): p. 147-164.

10. Wanieck, K., et al., *Biomimetics: teaching the tools of the trade.* FEBS Open Bio, 2020. **10**(11): p. 2250-2267.
11. Gruber, P., *Biomimetics: materials, structures and processes. Examples, ideas and case studies*. 2011, Springer Verlag: Berlin; New York.
12. Pedersen Zari, M., *Biomimetic approaches to architectural design for increased sustainability (paper no. 033)*, in *Sustainable Building Conference*. 2007: Auckland, New Zealand.
13. Helms, M., S.S. Vattam, and A.K. Goel, *Biologically inspired design: process and products.* Design Studies, 2009. **30**(5): p. 606-622.
14. Hastrich, C. *The biomimicry design spiral*. Biomimicry Newsletter, 2006. **4**, 5-6.
15. Benyus, J.M., *Biomimicry : innovation inspired by nature*. 1997, New York: Morrow.
16. Vincent, J., et al., *Biomimetics: its practice and theory.* Journal of The Royal Society Interface, 2006. **3**(9): p. 471-482.
17. Badarnah, L. and U. Kadri, *A methodology for the generation of biomimetic design concepts.* Architectural Science Review, 2015. **58**(2): p. 120-133.
18. Baumeister, D., *Biomimicry resource handbook: A seed bank of best practices*. 2014: Biomimicry 3.8. 280.
19. Garcia-Holguera, M., et al., *Ecosystem biomimetics for resource use optimization in buildings.* Building Research & Information, 2015: p. 1-16.
20. Pedersen Zari, M., *Ecosystem processes for biomimetic architectural and urban design.* Architectural Science Review, 2014: p. 1-14.
21. The Biomimicry 3.8 Institute. *Ask Nature*. 2008 October 2012].
22. Hooker, G. and E. Smith, *AskNature and the biomimicry taxonomy.* INSIGHT, 2016. **19**(1): p. 46-49.
23. Vattam, S., et al., *DANE: Fostering Creativity in and through Biologically Inspired Design*, in *Design creativity 2010*, T. Taura and N. Yukari, Editors. 2011, Springer: London.
24. Chakrabarti, A., et al., *A functional representation for aiding biomimetic and artificial inspiration of new ideas.* Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 2005. **19**(2): p. 113-132.
25. Cheong, H. and L.H. Shu. *Automatic Extraction of Causally Related Functions from Natural-Language Text for Biomimetic Design*. in *ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. 2012. Chicago,IL.
26. Nagel, J.K.S., R.B. Stone, and D.A. McAdams, *An Engineering-to-Biology Thesaurus for Engineering Design.* 2010(44137): p. 117-128.
27. Nagel, J.K.S., *A Thesaurus for Bioinspired Engineering Design*, in *Biologically Inspired Design: Computational Methods and Tools*, A.K. Goel, D.A. McAdams, and R.B. Stone, Editors. 2014, Springer London: London. p. 63-94.
28. Brown, M.T., *A picture is worth a thousand words: energy systems language and simulation.* Ecological Modelling, 2004. **178**(1–2): p. 83-100.
29. Thompson, B.P. and L.C. Bank, *Use of system dynamics as a decision-making tool in building design and operation.* Building and Environment, 2010. **45**(4): p. 1006-1015.
30. Institute, T.B. *AskNature*. 2021 [cited 2023 March 1].
31. Showbie-Inc;. *Socrative*. 2023 [cited 2019 September]; Available from: www.socrative.com.

POTENTIALS OF RURAL-URBAN INTERSECTIONS IN ISTANBUL: THE CASE OF BAŞAKŞEHIR DISTRICT

Ozge KESKIN, Hulya TURGUT*

Ozyegin University,
Nisantepe District, Orman Street, 34794. Istanbul/TURKEY
ozge.keskin@ozu.edu.tr, hulya.turgut@ozyegin.edu.tr

Abstract

The rural lands located on the peripheries of Istanbul entered the process of structuring and transformation, especially with the neoliberalism and industrialization policies increased after 1980. Rural-urban relations have changed and created ambiguous settlements that can neither be defined as urban nor rural have emerged. This rapid urbanization alters the quality of rural areas while reducing natural resources. As a result, social, economic, and ecological vulnerabilities may arise, threatening the city's resilient future. At this point, the urban-rural relations and ecological sustainability of the city should be reconsidered. This study is based on research carried out in the City and Architecture Master's Program at Ozyegin University and the aim is to re-think the city through new perspectives on the rural and urban relationship in Istanbul. In this paper, by revealing the various boundary situations at rural-urban relations, the potentials and vulnerabilities of in-between spaces will be examined. In the method of the research, Başakşehir district will be chosen as the case study. Rural-urban intersections were examined over the Basaksehir district, which is intertwined with the rural area in the urban periphery of Istanbul. Through this district existing vulnerabilities and potentials will be discussed in the socioeconomic and spatial context. The research results will provide a better understanding of the rural-urban intersections in Istanbul, and the findings will be used to develop strategies for a more resilient and sustainable urban future.

Keywords

urban, rural, r-urban, intersection, resilience

1 Introduction

Urban and rural definitions are often perceived as two opposite concepts. According to these definitions, daily social life practices, economic and socio-cultural values differ according to the place, and the uses of the space have changed. The urban and rural dichotomy and its borders gradually weakened with the industrialization, neoliberal, and globalization movements that started in the 1980s. With increased urbanization and reliance on rural peripheries, settlements that spread to rural areas create spatial encounters where the rural and the urban coexist. These spaces can be defined as rural-urban intersections, which serve as an interface where the boundaries between urban and rural become blurred. The rural-urban periphery, in this context, is a dynamic transition zone between rural and urban areas, located on the fringes of the urban built area, where urban and rural uses are blended and sometimes conflicted, and where there are mixed periphery uses[1].

The distinction between rural and urban is rapidly disappearing due to modernization and globalization, with technological developments supporting this shift [2]. Now the urban has come to define where the rural is, because the rapidly expanding city is spreading beyond its borders to the rural peripheries. The industrial revolution and the change of production relations created superiority of the urban over the rural [3]. This triggered intensive migration from rural to urban areas, resulting in the formation of slums in the city and urban settlements that proliferated in the rural areas. Mass housing areas and mega projects rising in the rural areas of Istanbul expose the villages and slums in the region to urban transformation activities. These transformations cause the urbanization of rural areas but reveal places that can be neither urban nor rural. The ambiguity of Istanbul's urban and rural boundaries creates a blur on where the rural ends and the urban begins. These ambiguous areas as the rural-urban (*R-urban*) transition zones, there are life practices in these places where some rural activities and traditions are preserved while adapting to urban life. This is a unique phenomenon that is a result of the rapid modernization and globalization of our world, and it is important to recognize and understand the implications of this shift.

When re-setting the city, it should be rethinking all the systems and relationships. A self-renewing city is a city that can adapt itself to the problems caused by fragility and maintains its resistance to future crises. Fragility is the degree of being sensitive to negative effects of a system and the degree of inability to cope with them and the stress, shock, and adaptation capacity of the system [4]. In this context, when we consider the relationship between the rural-urban, rural practices in Istanbul are weakened and transformed. In the 1970s, 60 %of the population of Istanbul lived in rural areas, while 7% live in the rural in 2020 [5]. In this case, the rate of communities living in the rural and still maintaining production practices has been decreasing. As a metropolis, Istanbul is not self-sufficient, has weakened connections with the rural areas, is inadequate in the use of natural resources and local production activities, and relies on the surrounding provinces' supply of food and water resources. Istanbul has a capacity to produce only 19% of annual herbal food consumption itself and is dependent on the environment in food supply [6]. This affects not only Istanbul but also the resources of the surrounding provinces and villages and its ecological and economic situation. Considering this situation of Istanbul, socioeconomic and ecological fragility emerges that will shake the durability of the city in a future crisis. To eliminate this fragility in the system, socio-economic and ecological systems that renew the city and support the adaptation capacity should be developed. The socio-economic system is defined as a system that includes social and ecological subsystems in mutual interaction [7]. At this point, it is necessary to think about the nature-human relationship in the rural and the urban. Since a fragile (vulnerable) social-economic system loses its elasticity and losing flexibility means loss of adaptation ability [8].

The production-consumption gap and the urbanization situation here may turn Istanbul into a state that does not use its own resources in the future. Therefore, the rural area has great potential for the future. Rural-urban intersections are important in ensuring the ecological resilience of the city with its natural resources, production practices and natural environment. These intermediate spaces are places where urban transformations occur, local cultures and productions are lost, and many ecological vulnerabilities occur where natural areas are destroyed. For this reason, it is important to consider a sustainable rural-urban relationship to ensure the ecological resilience of the city. Ecological resilience can be defined as the system's ability to instantly respond to this situation in times of disruption and disaster, renewing itself and reaching a state of balance. While there may be uncontrollable risks in these unexpected situations, human activities may also shake the ecological balance. Sustainable urbanization is a phenomenon that provides connections between cities and the surrounding rural areas, and between all settlements from the smallest urban centers to metropolitan areas [9]. To create sustainable and ecological rural and urban relations, it can be discussed how effective resource use, healthy social environment, production-consumption network and a symbiotic city-rural relationship will be. At the same time, it is important to reconsider the relationship between the urban and the rural by revealing the characteristics of the rural-urban areas, which accumulate on the peripheries of the city and have a high potential for construction.

This paper is based on the "*Advanced Design Research Laboratory*" studies within the scope of *Ozyegin University, City and Architecture Master's Program*, and continues to be developed. The research aims to provide a new perspective for future urban studies on the change in the rural-urban relationship, to define the socio-economic and spatial qualities of the rural-urban intersections, and to rethink the city to develop strategies for a more resilient and sustainable urban future. The case study explored the blurring of rural and urban areas in Istanbul, examining the rural-urban intersections. The study focused on Başakşehir district, situated on the city's periphery. This region has undergone a transformation in the wake of industrialization, migration, and rural production practices since 1980, becoming increasingly intertwined with urban life. The study recommends interventions to strengthen the rural-urban connection in the region and suggests creating a symbiotic relationship between the rural-urban through small interventions that can have a catalytic effect.

A qualitative methodological process was adopted in the research based on: (1) definitions of rural and urban, explaining concepts related to rural-urban relations and interactions; (2) to understand new approaches on rural-urban described in the literature; (3) a case study for analysing and interpreting rural-urban relations and transformation process in Istanbul.

2 Rural-Urban (*R-Urban*)

A city is defined as a residential area where most of the population is engaged in trade, industry or administrative affairs and there are no agricultural activities. Many definitions and discourses about the city have been made by looking at different approaches in urban sociology. The city has been described in relation to situations such as forms of social relations, individuality, and division of labor. According to Wirth (1938), the city is the place where population size, heterogeneity and density are all three, as the heterogeneity structure increases, the stimuli in the city increase and social differentiation and lifestyles vary [10]. Therefore, the city is a mixed society structure with different lifestyles and population density. Simmel (2012) sees cities as the growth of computational rationality and rationality. He says that the operation in the city is based on the money factor and capitalism. Simmel (2012) states that the individual living in the metropolis develops an individuality type, has a high level of consciousness, and becomes more indifferent by developing an immunity to the intense stimuli of the city [11]. Finally, Tonnies(2012) describes society as a place where social differences, independence of the individual and goals are dominant, where individuals who are far from tradition live [12]. Lefebvre (2013) states that the city and urban society is a structure originating from industrialization [13]. It defines it as a society born after this industrialization process that dominates agricultural production. Therefore, urban society emerges with the changes in the forms of the city and the disappearance of its old form. Capitalism plays an effective role in the reproduction of the city. In this sense, “urban revolution” is defined as the transformation from industrial production to modern capitalist production originating from the city. Looking at these definitions, the city is the place where a dense, variable, heterogeneous society exists as a space reproduced by capitalist relations.

Rural areas are generally seen as agricultural production areas. Wirth (1938) states that cities distance human beings from organic nature and states that the characteristic settlement forms of rural areas are farms, mansions and villages. Urban space, which Harvey (1982) calls the "built environment", is man-made and has different characteristics from the rural area [14]. The rural area, on the other hand, is a much more natural and less complex, homogeneous structural settlement. According to Tönnies (2012), community relations are seen in rural areas and social relations between people are stronger, acquaintance, neighborliness, common values, and beliefs are more common.

In today's, the traditional distinction between urban and rural areas is no longer applicable. The terms urban and rural still have unambiguous connotations, but in a world where it is increasingly difficult to distinguish between urban and rural environments, such definitions are out of date. From a dichotomous binary perspective based on alterity to the urban environment, the terms "rural" and "urban" refer to spatial realities that have frequently been interpreted as opposed, or even antagonistic and divergent [15]. This strategy expresses a nonexistent homogeneity of rural and urban spaces, as if there were only one model for each category. It also represents a simplification in many other ways. The rural-urban dichotomy is now thought to have a more complex relationship and interactive togetherness. The concept of dichotomy is a duality that has lost its boundaries and interacts. Dichotomies are mixed and "joined" realities created through unexpected associations and crossovers, and paradoxically based on principles arising from seemingly impossible mergers [16]. These binary expressions and dichotomy are therefore understandable not only on their own but when considered together with the concept of simultaneous opposite.

The boundaries of the urban and rural dichotomy began to weaken gradually with the industrialization, neoliberal and globalization movements that started in the 1980s. With the increase in the rate of urbanization and their reliance on rural peripheries, settlements that spread over rural areas form a spatial form in which the rural and the urban are together. These spaces reveal a heterogeneous structure where rural and urban practices are mixed. In this sense, the concept of rural-urban (*r-urban*) is places where rural and urban boundaries are blurred, and spatial and daily practices are transformed. Rural-urban is defined as the area between the city and the rural area, where the spatial boundaries are variable, and where urban functions are intertwined with rural functions [17]. In this sense, rural-urban is a transition zone where rural and urban practices are mixed. Being a transition zone also requires examining the concept of "border". Boundary is the line that divides two different things. Boundaries can be sharp or blurred, continuous or discontinuous, natural, or artificial, and sometimes the exact location of the boundary is unclear or disputed [18]. The boundaries to indicate where time or movement begins and ends are vague. Likewise, the boundaries in space become blurred and unclear. It is the weakening of the urban-rural divide, the merging of borders through intermingling. It's a blurry place where the boundaries between the rural areas and the urban cannot be seen. The ambiguity lies only in our ignorance of the exact location of the boundaries because infinite fragments can be found at cross-border transitions [19]. In these ambiguous spaces, where boundaries are blurred, a variety of identities and uses intersect, leading to unexpected encounters, spontaneous activities, creative daily uses, and alternative publicity. This creates a unique time-space experience that is far more valuable than the discontinuities that arise from rigid borders. By creating porous and ambiguous spaces, we can unlock the potential of any given place [20]. For this reason, the blurred boundaries of a phenomenon or space are not clear but are seen as a threshold and a transition zone. Any deterioration or change in the sharp boundaries of space leads to deterioration or transformation of the qualities of the space.

The resulting state of' re-urbanity,' with urban forms and practices reinvented and articulated in a variety of settings, the abandonment of traditional rural-urban dichotomies, and the search for new socio-spatial models [21]. On the one hand, the discovery of a networked space characterized by multiple flows and dependencies connecting urban and rural, suggests that the rural dichotomy is collapsing. To account for this, a set of intermediate classifications, such as 'peri-urban' - areas near cities that often function as extensions of them - have been introduced. This allows for a more complex understanding that exists between urban and rural areas, which no longer lend themselves to simple distinctions. Various recent studies have examined and interpreted the functional territories that result from rural-urban integration or hybridization in the area known as the "rural-urban periphery," which is viewed as a space with its own distinct characteristics. This entity has also been referred to as the "urban-rural interface," and it is composed of urbanized rural areas, intermediate territories, in-between territories, territories of a new modernity, or "hybrid geographies "[22]. Rural-urban (*r-urban*) has formed the intermediate spaces of this duality, which are intertwined, blurred, and a hybrid transition zone. Here, it is a region that is neither urban nor rural, but which has the characteristics of both urban and rural areas on the periphery, which has defined a residential area by leaping from the city, but where practices can be realized mutually.

In-between space is the threshold where two different environments, functions meet, intersect and undergo a constant transformation and change. While the rural areas on the peripheries are included in the city, it is often encountered that the lands in the city are dissolved without foreseeing, and these dissolved areas often turn into a rural appearance. In a sense, these areas can be defined as the lines between the rural and the city becoming blurred and turning into each other, but never turning into a rural or a urban. These transformations form the definition of a new area between rural and urban areas and are referred to as "in-between space"[23]. Also, rural-urban intersections can have permeability. It is a region between urban and rural textures. It is a texture transition between urban-urban or urban-rural adjacent to the undefined areas left by the urban leaps.

Based on conceptual framework (Figure 1) of this research, (1) to explain the conceptual evolution of the rural-urban, (2) to analyze the characteristics of the rural-urban interactions with the concepts of in-betweenness, blur, ambiguity, permeability, and hybridity. (3) re-thinking the city by rural-urban intersections and discussed the potential for resilient future.

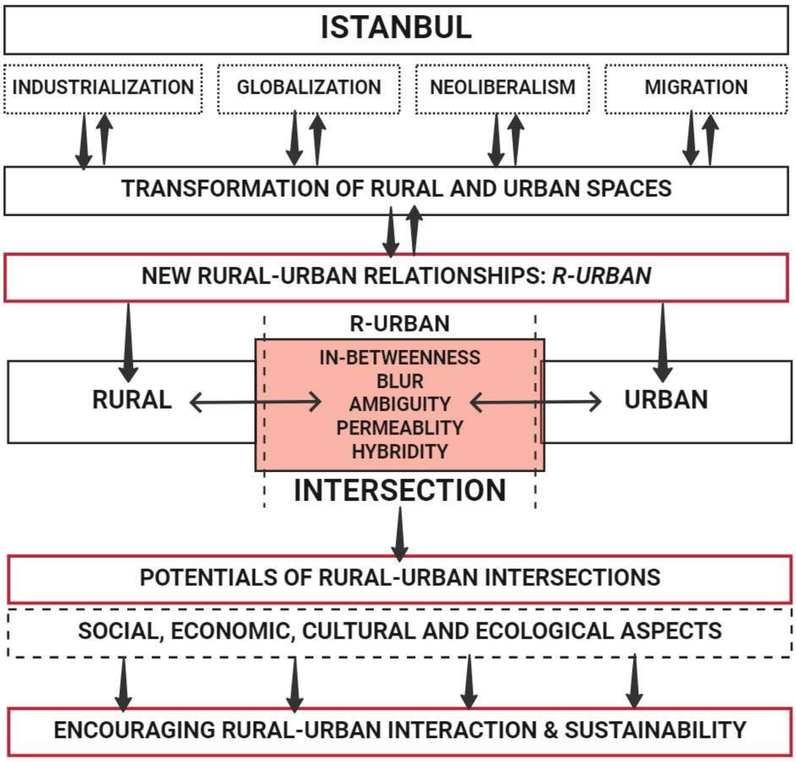


Figure 1. Conceptual framework of the research

3. Rural-Urban Intersections: The Case of Istanbul, Başakşehir District

From the perspective of Istanbul, it is seen that the boundaries between rural and urban spaces are becoming increasingly blurred. The reason for this is the intermediary spaces formed in the city periphery by the transformation of spaces in terms of politics, economy and sociology. It is seen that the necessity of making a different definition from the definitions that limit rural areas to agriculture, animal husbandry and forestry activities, characterize them as undeveloped infrastructure and superstructure, and specify rural dwellings. The most effective situation in the formation of rural-urban intersections can be said to be industrialization of rural areas by changing production practices. In addition, the relocation of some functions within the city to the periphery has also led to a transformation process in the rural. This situation has revealed the blurring of rural-urban borders.

The rural-to-urban migration that has been spurred by industrialization has led to the emergence of squatter settlements, which have grown more quickly than planned areas. Initially, these settlements were established in the empty spaces of city centers, but over time, they have spread to the outskirts of cities due to a lack of space in city centers and the availability of jobs in industrial zones. This phenomenon is not unique to one rural but is seen in many developing countries. The characteristics of these settlements, such as the quality of housing, access to essential services, and infrastructure systems, may differ from rural to rural, yet the process of their development is largely the same (Davis, 2006) [24]. Due to political reasons and amnesties, squatter settlements in Turkey have been recognized and have gradually become urban housing areas where the middle class also resides. Despite the expectation that migrating people would adapt to the lifestyle and cultural texture of a city, they have been unable to fully integrate and have instead developed an "in-between identity neither urbanized nor villager. These squatter areas have become increasing on the urban agenda and have become the new vicious knots of urban peripheries (Keyder,2000) [25]. Despite their precarious existence in the urban space, these settlements remain a significant potential, and are still a topic of discussion in today's urban transformation projects.

The change and transformation of rural and urban peripheries, it is seen that political, economic, social, and urban interventions are effective in the change of visible and invisible borders of Istanbul. It is formed because of factors such as transportation networks providing access to rural areas, unplanned construction, urban transformation and mega projects as factors affecting the formation of rural-urban intersections in Istanbul. Urban transformation and sprawl create rural-urban spaces and create an Istanbul between the local and the global.

The change in the rural and urban borders of Istanbul has been affected by industrialization, migration and globalization movements and the formation of new settlements. Especially in the period between 1970-1990, the factors that caused the change of rural and urban borders are the rapid industrialization of Istanbul and the relocation of industrial zones to the city periphery. In addition, during this period, situations such as the Real Estate and Credit Bank and the Expropriation Law, which strengthened the zoning operations, emerged. In these newly formed industrial zones, zoning activities started with migrations and squatting. The Bosphorus Bridge, which was opened in 1973, and the Fatih Sultan Mehmet Bridge, which was opened in 1988, were built to balance the distribution of workplaces and residences on the European and Anatolian sides and to increase the access between the two continents. Along with these bridges, the construction around them started to gain speed.

The 2000s, as can be seen in Figure 2, it is seen that the change in rural and urban peripheries in Istanbul has been affected by the increase in transportation networks and the mega projects carried out, and the rural area is getting smaller and smaller. In addition, political interventions were also effective in rural and urban borders. With the Disaster Law enacted in 2012, regions and structures deemed risky have led to the emergence of urban transformation and construction-destruction activities, and many slums and rural settlements have undergone spatial transformations in this way [3]. The mega-projects, where the largest interventions on urban and rural borders, seen after 2016, were effective. These are the 3rd Bridge, Istanbul Airport and Northern Marmara Motorway and the planned Canal Istanbul and Canal Riva projects. The common feature of these projects is that they create an urban development direction that will lead to the construction of rural areas in the north of the city. Transformations in the rural, which started near these projects, will change the boundaries of the city, cause the rural areas to be built and the city to grow towards the north.

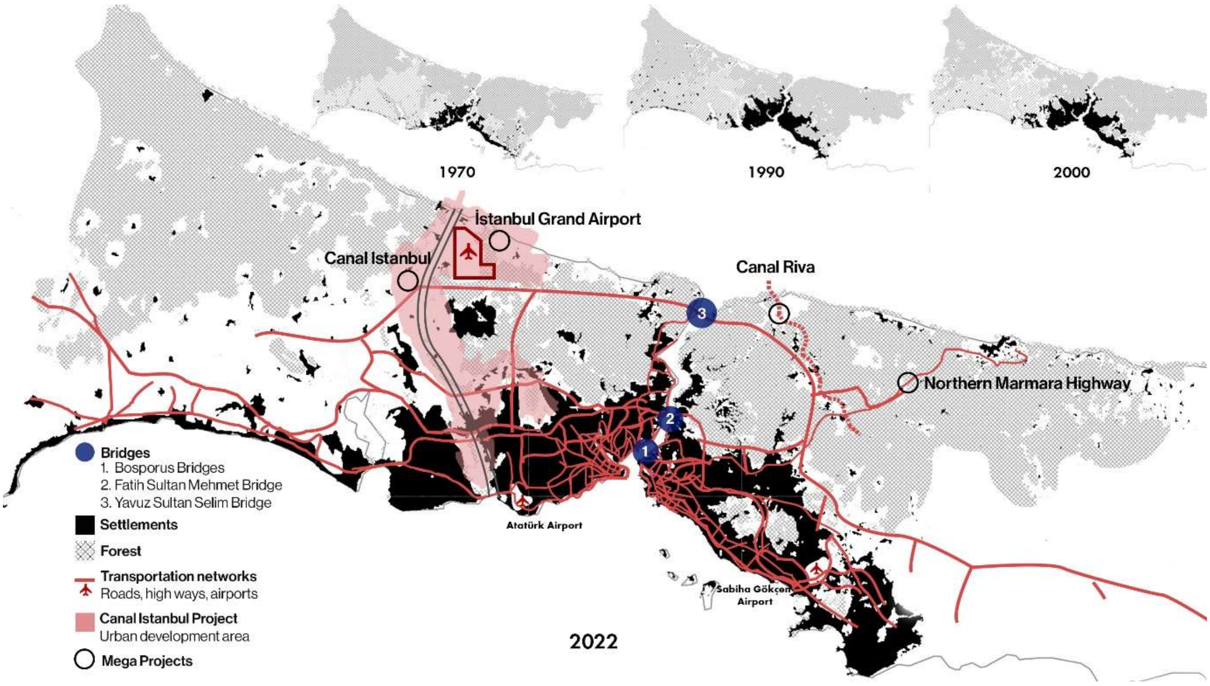


Figure 2 . The impact of urban interventions on the transformation of rural and urban areas through the construction of Istanbul from 1970 to 2022.

The changes in the rural and urban peripheries of Istanbul over the years, it is seen that the development of access networks, mega projects, relocation of industrial areas, mass housing and urban transformation activities transform the rural area and urbanization begins at the points where the city periphery meets the rural area. Urbanization is the beginning of adaptation of rural space or people living in rural areas to urban space and practices. has developed with urban transformation and mass housing.

Figure 3 presents the current status of Istanbul's active and passive green spaces, water resources, and urban and rural settlements, along with the ecologically significant reserves, water resources, and basins. It is clear that urbanization is spreading to the city's northern periphery. Notably, Başakşehir was chosen as the study area due to its location at the intersection of various domains, resulting in hybrid and ambiguous spaces that blend urban and rural areas, industrial and agricultural activities, and diverse lifestyles. The area and land uses in the area are varied. The district exhibits a diverse range of textures and land uses. While looking at the rural-urban intersections, it was seen that Başakşehir also showed an intersection feature within the city and contained different spatial textures from the city to the rural.

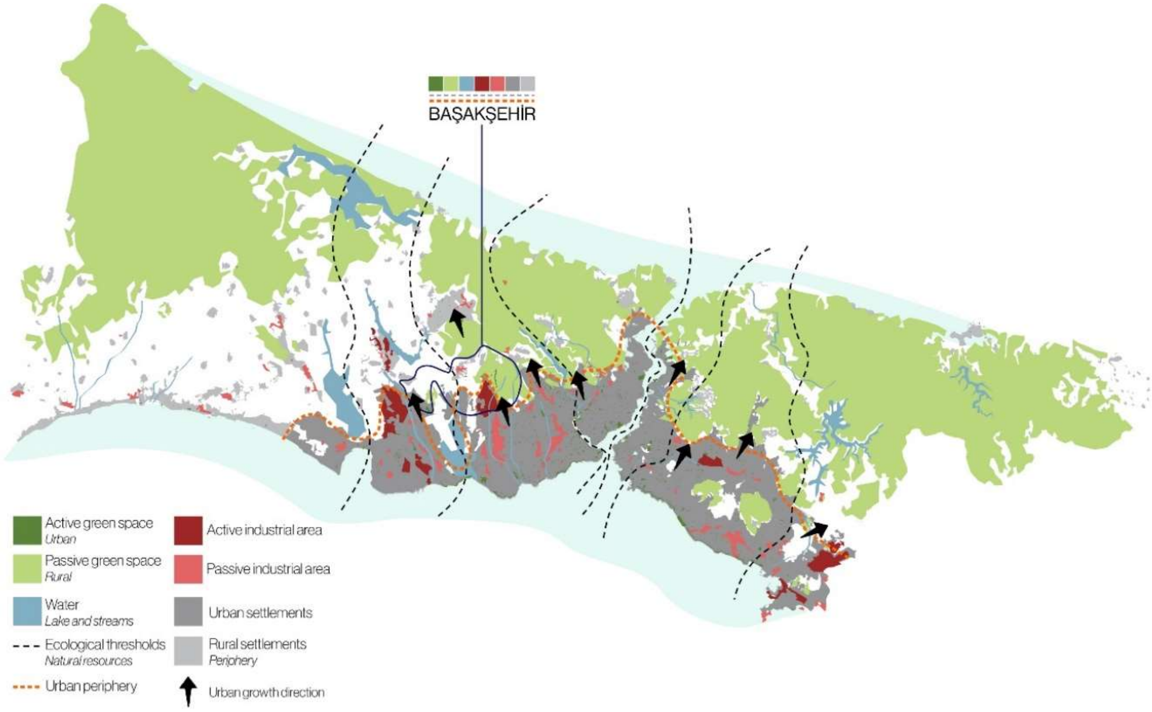


Figure 3. Geographical and urban structure of Istanbul, the location of Başakşehir as an intersection. *(The map was created by the author using the source* [26]*).*

4. Potentials of Rural-Urban Intersections: Başakşehir

Until the 1980s, Başakşehir region was a rural settlement consisting of villages connected to Bakırköy district, where agriculture and livestock production were located. Due to the organized industrial zone established in the 1980s, there were intense migrations to the district, and the number of closed settlements in the region increased rapidly with the "Basaksehir Mass Housing Project" initiated by the Istanbul Metropolitan Municipality (IMM) due to the increasing housing need. With this rapid construction and urbanization dynamics, Başakşehir District was established with the decision taken in 2008. Basaksehir; It consists of 11 neighborhoods. Güvercintepe, Şahintepe, Altınşehir Neighborhoods are the regions where citizens with low economic level reside; Başak, Başakşehir, Kayabaşı and Bahçeşehir Districts are observed as residences of citizens living in protected gated communities. Apart from this, Ziya Gökalp District has a dense urban texture due to its proximity to the organized industrial zone. Başakşehir exhibits a heterogeneous appearance where the rural and the urban coexist. Gated settlements and rural neighborhoods in the region bring border situations in settlement areas. This situation does not allow encounters in rural and urban residential areas within the city. As a result, spatial, social, cultural and economic segregation occurs. Due to the rapid construction process, rapid transformation of rural areas, industrialization, dense closed settlements and green areas in the urban fabric, Başakşehir district was chosen as the study area by considering the rural-urban intersections. The present study critically examines the emergence of textures resulting from the juxtaposition of disparate spatial conditions, namely the rural and the urban, within a singular locale. Drawing on a theoretical framework that foregrounds the concepts of in-between, blurred boundaries, permeability, ambiguity, and hybridity, the study examines five distinct intersections in Başakşehir to illustrate how diverse spatial situations are conjoined (Figure 4). Each intersection is named with a number (I.1, I.2, I.3…) and explained their potentials and vulnerabilities.

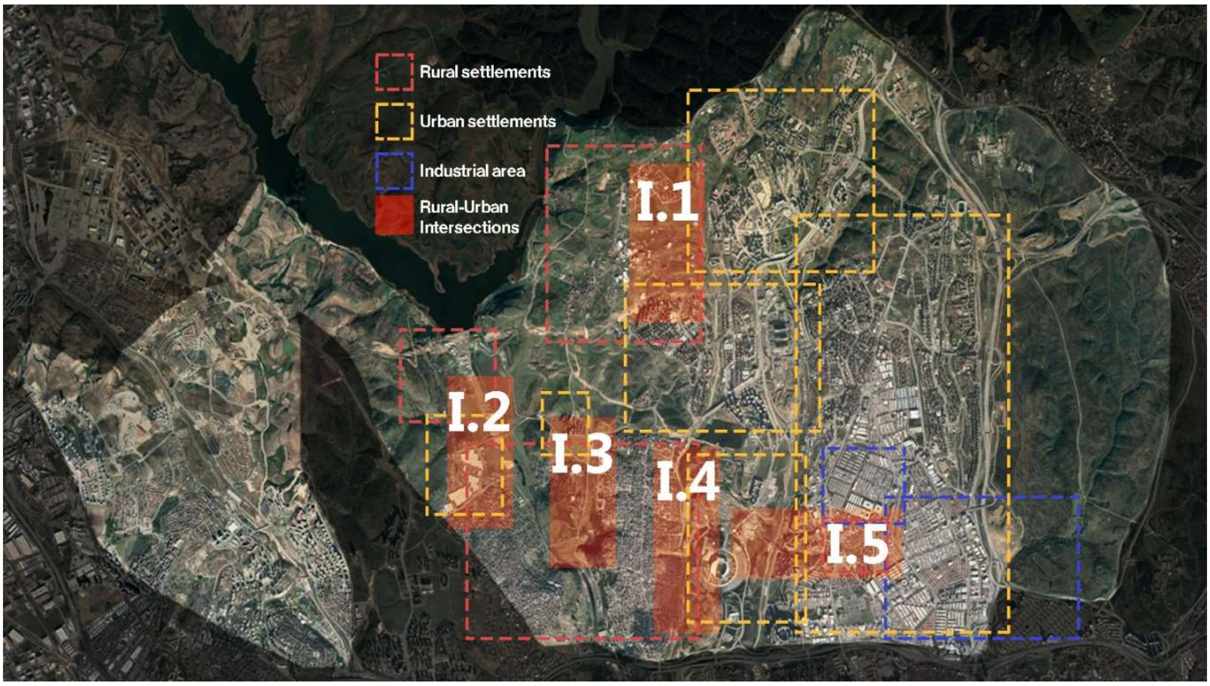


Figure 4. Rural-Urban Intersections in Başakşehir

As seen in Figure 5, the existing rural and urban areas of Başakşehir, its natural physical features and the areas where rural productions are made are mapped. In addition, due to the planned "Canal Istanbul" project, which was announced in 2011 and whose zoning plans continue, it is foreseen that the existing rural settlements will undergo urban transformation and the green areas under protection will be destroyed. With this project, the areas planned as a new urban development zone in Başakşehir were shown and the damage that could occur in the ecological texture was also evaluated.

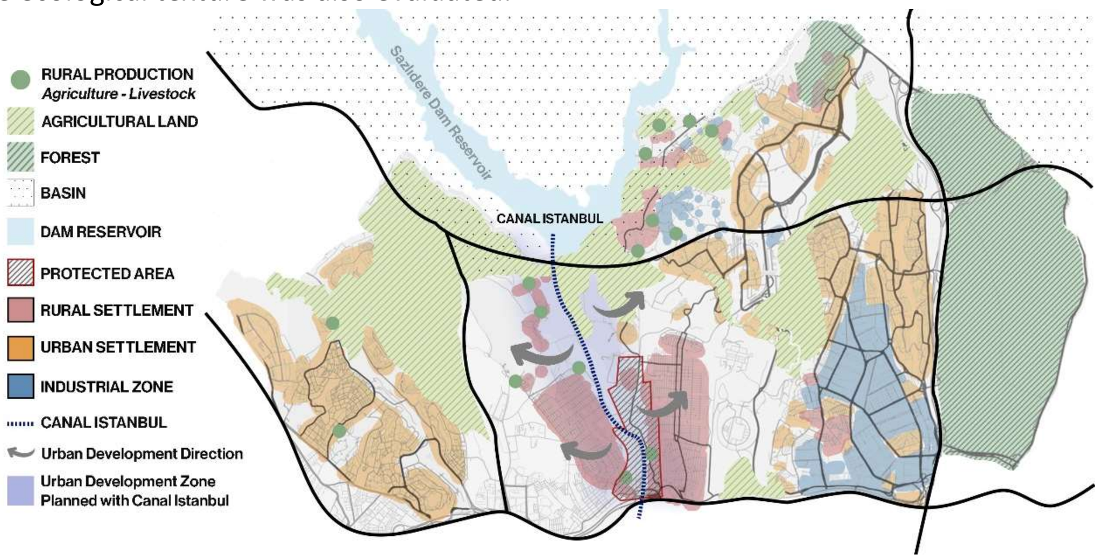


Figure 5. Existing geographical and urban structuring in Başakşehir *(The map was created by the author using the source* [27]*).*

Organized industrial zone and urban transformation activities in Başakşehir have been effective in the development of the region. Developing and transforming housing around the Ikitelli Organized Industrial Zone has brought along mass housing and estates, and some shantytowns have been converted into apartments with the urban transformation. Başakşehir socioeconomic levels were compiled from real estate sites and compared on a neighborhood basis. Socioeconomic analysis has been studied to understand the invisible boundaries between the intersection regions and urban space and their spatial reflections. Neighborhoods with the highest socio-economic level as neighborhoods are seen as areas that have been renovated with urban transformation and have closed sites and are at A/A-levels [28]. In this case, it has been observed that the neighborhoods defined as C at the lowest socioeconomic level are rural settlement areas and shantytowns. In this sense, the socioeconomic situation and the situation of rural-urban intersection areas were tried to be read. The importance of this in the research is to be able to detect not only spatial but also existing social and economic vulnerabilities in the intersections.

Catalyst impact points were determined by considering the existing potential to reduce the fragility factors in the region. These catalysts can help to eliminate the pressure of urban and urban transformation from the exploitation of the urban to the rural by establishing urban and rural ties and creating a symbiotic way of life with small-scale interventions. For this purpose, catalyst points that will strengthen the rural-urban relationship have been proposed (Figure 6). While choosing the focus of influence of these catalyst points, the rural-urban potential, production activities, and cultural and social situation around them were taken into consideration. For this reason, ecological, economic, cultural and social focal that can help to repair these vulnerabilities have been determined in the cross-sectional regions with low socioeconomic level and lack of social and cultural infrastructures on a district basis.

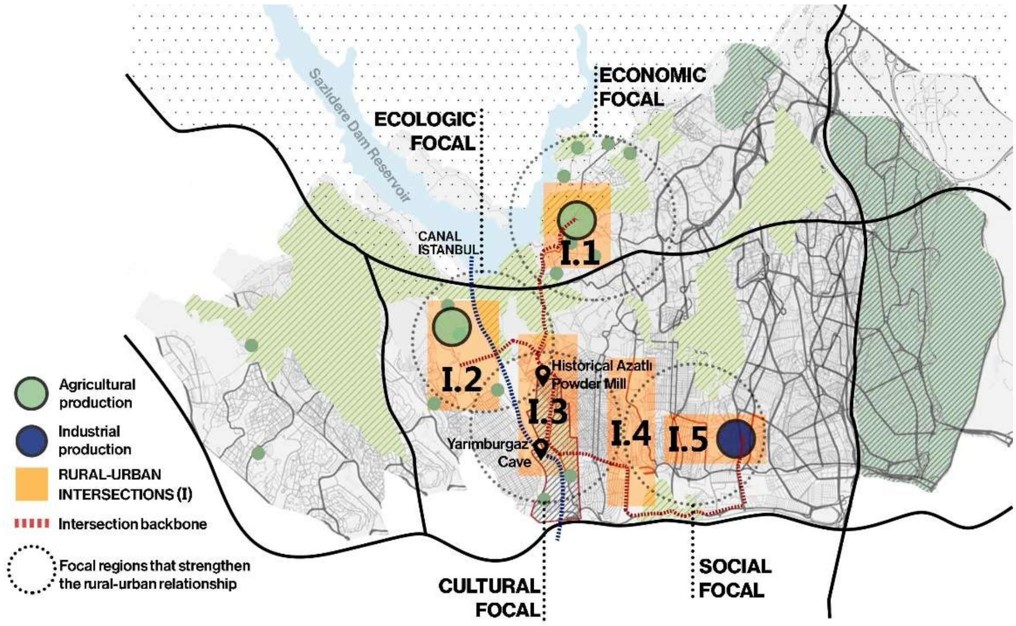


Figure 6. Proposal of creating economic, cultural, ecological and social focal that can act as a catalyst to enhancing rural-urban intersections.

INTERSECTION 1 (I.1) : It is one of the old settlement patterns of Başakşehir before 1980. As an intermediate space, it is a region where two different environments, urban and rural, intersect and open to continuous transformation and change. It is that the lines between the rural and the urban become blurred and begin to transform into each other, but never turn into a rural or a urban. There are factories where both agricultural and livestock activities and industrial production take place. Considering the current situation, the regions where active agriculture is still practiced in the district are shown as the focus of agricultural production. It has been proposed to strengthen agricultural activities as an **economic focal** by supporting the agricultural activities in this region, which has a low socioeconomic level.

INTERSECTION 2 (I.2): There are rural settlements with agricultural production, slums. It is also a rural-urban intersection adjacent to production facilities, industrial enterprises and gated communities. The region is located at an ecologically important point. The rural space where Sazlıdere Dem Reservoir and its surrounding basin areas are located has been taken into consideration as an **ecological focus**. In addition, this region has been defined as one of the new urban development areas within the scope of the Canal Istanbul project and there are many agricultural farms and basins and states in the region. Taking this region as an ecological focus is important for the protection of both the dam lake, biological diversity and natural resources.

INTERSECTION 3 (I.3): It is a section where the rural neighborhood, which is one of the oldest rural settlements of the district, comes side by side with urban structures. The region harbors a tension between the city and the rural, which shows the characteristic of a border. It is the transition area between the settlement showing the urban character and the other settlement showing only the rural character. The stadium, subway, water treatment plants and gated residential areas are next to each other, but they are not texturally intertwined with the urban area. It is also a region with Azatlı Gunpowder House built in the 18th century, which has historical and cultural features, and Yarımburgaz Caves, which are one of the oldest settlements in the world with a history of 400,000 years and were granted the status of *1st Degree Archaeological-Natural Site* in 2001. For this reason, it is recommended to evaluate the **cultural focus** of this place and to strengthen the historical and local identity of the region.

INTERSECTION 4 (I.4): In this region, rural settlements, Başakşehir Fatih Terim Stadium, are located next to closed site settlements and there is an impermeable border with a highway. It is the place where these contrasting rural and urban settlements positioned side by side cannot blend into each other. In determining the region as a **social focus**, it is a region where social interaction is weak except for commercial and production activities.

INTERSECTION 5 (I.5) : The intersection area, as a rural slums, is located between industrial sites and is adjacent to closed sites and apartments. For this reason, it is a hybrid region where the urban and rural dichotomy weakens and becomes blurred by intermingling. It is a blurred place where the rurality stays within the urban. It is a region where social interaction is weak except for commercial and production activities. For this reason, the **social focus** aims to integrate the people living in the slums between the industrial area and the gated communities with the city and to reduce the tension created by the rural-urban dichotomy. Because the relationship of the people living in the region with the city has been limited, and the bond between the rural and the urban has created a border both physically and socially.

6. Conclusion

Rural-urban intersections are important in ensuring the ecological, socioeconomic, and spatial durability of the city with its natural resources, production practices and natural environment. These intermediate spaces are places where urban transformations occur, local cultures and productions are lost, and many ecological vulnerabilities occur where natural areas are destroyed. Therefore, intersections have many potentials. In this study, which is examined on Başakşehir, it is seen that the intersection spaces of the region are the regions at the lowest socioeconomic level and there are spatial vulnerabilities because it is tried to be urbanized as a region where continuous urban transformation activities take place. The most concrete example of this that we can foresee in the future is the Canal Istanbul project located in the region where rural areas and settlements are located and the urban development areas to be developed around it. The common feature of these intersections is that by being side by side with the urbanized region, they never turned into an urban space, but they also lost their rural qualities in a sense. Meanwhile, the remaining regions are the transition zone of the city and the rural. For this reason, the subject of this research in terms of urban life is to rethink the city by looking at the rural-urban intersections and to explore the potential for the future. The fact that rural-urban intersections have natural resources and production practices that can support ecological sustainability can reduce the exploitation of the city to the rural by supporting the provision of urban agricultural production. At the same time, rural-urban intersections contain local culture, and they need to be protected. Conservation of these areas can help restore biodiversity and urban ecology, as areas where rural-urban characteristics often exist in the urban periphery have access to urban forests and natural resources. This situation ensures the adaptation and sustainability of the city against the climate crisis that may exist in the future, lack of natural resources, and food problems. When we reset the city, we can start to rethink the rural-urban relations. In this way, the future city should be resistant to crises and be able to renew itself. By strengthening rural-urban ties, we can reorganize the rural-urban relationship with local interventions. Thus, a sustainable relationship that can create its own production-consumption capacity can be created from these intersection spaces, which are seen as a potential for construction and urban transformation. For this reason, it is important to reconsider the relationship between rural and rural areas by revealing the characteristics of rural-urban regions.

Acknowledgements

This paper is based on the research of the City and Architecture Master's Program at Ozyegin University. It is with great appreciation to the *Advanced Design Research Laboratory* members who have generously shared their knowledge and expertise and esteemed advisor, Prof.Dr.Hülya Turgut, whose invaluable guidance has greatly enriched this study.

References

[1] Hazar, D., Kır-Kent Çeperine Ekolojik Yaklaşım. *Şehir ve Toplum*, (2017), 7, 135-142.

[2] Türk, E., Hızlı Kentleşme Sürecinin Toplumsal Yapıya Etkileri: Batman Örneği, Doctoral Dissertation, Sakarya University, Sakarya, Turkey, 2016.

[3] Kantürer, G., İstanbul Kent Çeperlerinde Kırsal Arazilerin Dönüşümü: Ağaçlı-Yeniköy Yöresi Örneği, Doctoral dissertation, Istanbul Teknik University, Istanbul, Turkey, 2016.

[4] Adger, W. N., Vulnerability. *Global Environmental Change*, *16*, (2006). 3, pp. 268-281, https://doi.org/10.1016/j.gloenvcha.2006.02.006.

[5] Türkiye İstatistik Kurumu, https://data.tuik.gov.tr.

[6] Yerküre Yerel Çalışmalar Kooperatifi., İstanbul Nasıl Beslenir?:Üretici Pazarları Odağında Alternatifler ve Olanaklar, Greenpeace, Istanbul, Turkey, 2020.

[7] Gallopín, G. C., Linkages Between Vulnerability, Resilience, And Adaptive Capacity. *Global Environmental Change*, 16, (2006), 3, pp. 293-303, http://dx.doi.org/10.1016/j.gloenvcha.2006.02.004.

[8] Folke, C., Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses. *Global Environmental Change*, 16, (2006), 3, pp. 253-267. http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002.

[9] Kaya, H. E., & Susan, A. T., Sürdürülebilir Bir Kentleşme Yaklaşımı Olarak, Ekolojik Planlama ve Eko-Kentler. *İDEALKENT*, 11, (2020), 30, pp. 909-937.

[10] Wirth, L., Urbanism as a Way of Life. *American Journal of Sociology*, 44, (1938), 1, pp. 1–24, http://www.jstor.org/stable/2768119.

[11] Simmel, G., The Metropolis and Mental Life. In *The Urban Sociology Reader*, (*Jan Lin, Christopher Mele*), Routledge, (2012), pp. 37-45.

[12] Tönnies, F., Community and Society. In *The Urban Sociology Reader*, (*Jan Lin, Christopher Mele*), Routledge, (2012), pp. 30-36.

[13] Lefebvre, H., *Kentsel Devrim*. *(The Urban Revolution)* Sel Yayıncılık, İstanbul, Turkey, 2013.

[14] Harvey, D., *Limits to Capital*, Basil Blackwell, Oxford, England, 1982.

[15] Champion, T.& Hugo, G., Beyond the Urban–Rural Dichotomy. In *New Forms of Urbanization*, (*Tony Champion, Graeme Hugopp*), Routledge, London, England, 2004, pp. 3–24.

[16] Gausa, M., Guallart, V., Muller, W., & Soriano, F., *The Metapolis Dictionary of Advanced Architecture: City, Technology and Society in the Information Age,* Actar, Barcelona, Spain, 2003.

[17] Avram, Sorin I., The Position of Rural-Urban Fringe in the Framework of Human Settlement System. *Forum Geografic,* 8 (2009), 8, pp. 139-145.

[18] Varzi, A., Boundary, The Stanford Encyclopedia of Philosophy, 2015, https://plato.stanford.edu/archives/win2015/entries/boundary/

[19] Sorensen, R.A. Transitions. Philosophical Studies, 50, (1986), pp. 187–193 https://doi.org/10.1007/BF00354587

[20] Cebir Meral, G.İ., Özsoy, A., The Porosity of Borders: Between Formal and Informal Urban Patterns. In *The Dialectics of Urban and Architectural Boundaries in the Middle East and the Mediterranean*. (*Girginkaya Akdağ, S., Dinçer, M., Vatan, M., Topçu, Ü., Maro Kırış, İ.*) The Urban Book Series, Springer, 2021, https://doi.org/10.1007/978-3-030-71807-7_2

[21] Woods, M., Rural Geography: Blurring Boundaries and Making Connections. *Progress in Human Geography*, 33, (2009), 6, pp. 849-858, https://doi.org/10.1177/0309132508105001

[22] Delgado-Viñas, C., & Gómez-Moreno, M. L., The Interaction between Urban and Rural Areas: An Updated Paradigmatic, Methodological and Bibliographic Review. *Land*, 11(2022), 8, pp. 1-21, https://doi.org/10.3390/land11081298 .

[23] Karadaban, M., & Erkök, F. Delikli Bir Kent Olarak İstanbul'a Bakmak: Kentin Müphem Alanlarına Dair Bir Araştırma, Master's Thesis, Istanbul Technical University, Istanbul, Turkey, 2020.

[24] Davis, M., Gecekondu Gezegeni (*Planet of Slums*), Metis, İstanbul, Turkey, 2006.

[25] Keyder, Ç., Enformel Konut Piyasasından Küresel Konut Piyasasına: Istanbul Küresel ile Yerel Arasında. Metis Press, Istanbul, Turkey, 2000.

[26] 39 KENT Bir İstanbul, Kentsel Vizyon Platformu, Istanbul, Turkey, 2016, https://kentselstrateji.com/proje/39-kent-1-istanbul/

[27] Başakşehir İlçesi. Şehir Planlama Müdürlüğü. https://sehirplanlama.ibb.istanbul/basaksehir-ilcesi/

[28] REIDIN: Veri Analitiği. https://reidin.com/tr/

MULTI-OBJECTIVE OPTIMISATION OF ENERGY RETROFIT IN HOT-HUMID CLIMATES' OFFICE BUILDING

Nissa Aulia ARDIANI*, Steve SHARPLES, Haniyeh MOHAMMADPOURKARBASI

University of Liverpool

25 Abercromby Square, L69 7ZN & Liverpool, United Kingdom; Nissa.Ardiani@liverpool.ac.uk

Abstract

Globally, buildings are responsible for significant amounts of energy consumption and greenhouse gas emissions. Although new buildings can be constructed to higher energy performance standards, around 75% of today's buildings will still be in use in 2050. Therefore, energy retrofitting the existing stock offers significant opportunities to reduce global energy consumption and greenhouse gas emissions. Although building retrofit projects have already been applied in many developed countries, studies in hot-humid climates, like that of Indonesia, are still sparse. Indonesia's hot-humid climate makes developing the right energy retrofit strategies more challenging than in other climates.

This research investigated the multi-objective optimisation of energy retrofitting in Indonesian office buildings using environmental and social criteria to apply the most optimum retrofit strategies. The research methodology utilised environmental monitoring, a questionnaire, and thermal simulation modelling for an office building in Jakarta, Indonesia' that had received a Green Building Council Indonesia (GBCI) Platinum rating.

A post-occupancy evaluation (POE) was carried out to understand the occupants' thermal comfort, actual energy consumption, and the effect of recent retrofitting measures on the occupants' thermal comfort. In addition, the existing building was modelled in a dynamic thermal simulation modelling software, Design Builder (DB) and successful model calibration was achieved using on-site measured data. The calibrated model parametrically tested the suitability of some retrofit strategies for the office building. The results from this and future work will hopefully help Indonesian stakeholders identify the most appropriate retrofit measures based on environmental and social criteria.

Keywords: Multi-objective optimisation, Building retrofit, Energy efficiency, Thermal comfort, hot-humid climate

Nomenclature

NZEB	Net zero energy building	MBE	Mean bias error
ZEB	Zero energy building	N-MBE	Normalised bias error
GA	Genetic algorithm	RMSE	Root mean square error
NSGA	Non-dominated sorting genetic algorithm	CV(RMSE)	Coefficient of the variation of the root mean square error
MOO	Multi-objective optimization		
CFD	Computational fluid dynamic	HVAC	Heating, Ventilation and Air Conditioning
OTTV	Overall thermal transfer value	Low-E	Low Emissivity
BIM	Building information modelling	WWR	Window wall ratio
RBIM	Retrofitting building information modelling	FCU	Fan coil unit
GBCI	Green Building Council Indonesia	VAV	Variable Air Volume
POE	Post-occupancy evaluation	VRF	Variable refrigerant flow
DTSM	Dynamic thermal simulation modelling	BIPV	Building Integrated Photovoltaic
DB	Design Builder	HR	Heat recovery
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers	DOAS	Dedicated Outdoor Air System
		PUPR	Pekerjaan Umum dan Perumahan Rakyat
SHGC	Solar heat gain coefficient		

1 Introduction

Buildings consume significant amounts of energy and are responsible for high levels of carbon emissions worldwide, and so it is essential to formulate sustainable development strategies for buildings [1]. In Indonesia, the building sector (commercial and residential) represented 20% of the average final energy consumption from 2013 to 2019 [2]. It was reported that more than 60% of the total electricity consumption in commercial buildings in Indonesia was used mainly to achieve indoor thermal comfort through air conditioning [3]. According to the Paris Agreement in 2016, the Indonesian government set a target to reduce greenhouse emissions by 26% by 2030. Retrofitting existing buildings offers significant opportunities to reduce global energy consumption and greenhouse gas emissions. Additionally, retrofitting buildings provides excellent opportunities to improve energy efficiency, increase occupants' productivity, reduce maintenance costs, and provide thermal comfort [4].

Building retrofit projects have already been applied over the past decade in many developed countries. Yet, the case studies in hot-humid climates, especially in Indonesia, are minimal. Rating system tools for sustainable building in Indonesia have focused on new buildings and not yet on existing ones. Thus, retrofit could be an opportunity and challenge for Indonesia in the building sector to develop suitable energy retrofit strategies based on geographic location, which is a hot-humid climate. As evidence, a review of Net Zero Energy Buildings (NZEB) in hot and humid climates [5] found that from 34 case studies, only 5 were retrofit projects. Hence, surveys about NZEB in tropical climates with retrofit projects are still limited. Multi-objective optimisation is one of the most robust approaches to assessing different retrofit options because it generates solutions from trade-offs between two or more conflicting sustainable design objectives (i.e. social, environmental, economic) [6].

The recent review recommended a comprehensive and comparative analysis of effective energy-efficient measures in building energy retrofitting by considering different climate conditions for future studies. Developing decision-making tools for improving existing buildings' energy efficiency was also suggested [7]. Furthermore, a study about multi-objective optimisation of energy retrofit recommended future studies on different types of buildings and climates (i.e. hot-humid climate) [8]. A systematic review of the genetic algorithm (GA)-based multi-objective optimisation of building retrofit strategies also highlighted that future studies on this topic could be divided into two groups, which are related to methods or tools, as well as research gaps that need to be explored more including the expansion of objective function concerning occupants behaviour and indoor environmental quality [9].

This study aimed to investigate and test a multi-objective optimisation of energy retrofit in a hot-humid climate office building using environmental and social criteria to apply the optimum retrofit strategies. Hence, the objectives of this study were to investigate a multi-objective optimisation framework for retrofitting office buildings in Indonesia, analyse the most optimum solutions for energy retrofit in hot-humid climates' office buildings based on environmental criteria (minimise energy consumption) and social criteria (maximise thermal comfort), and provide recommendations for energy retrofit projects for office buildings in Indonesia.

2 Building retrofit in hot-humid climates

A study in a hot-humid climate revealed that an electrochromic glazing system with no shading was the most effective and efficient intervention for building retrofit, reducing heat gain by 53%-59% in winter and summer [8]. Several retrofit studies in hot and humid climates use residential buildings as case studies [8-10]. There are also studies about glazing in hot-humid climates [11, 12], shading devices [13] and daylighting [14], as well as radiant cooling or natural ventilation [15, 16]. The relationship between materials and retrofit strategies has also been explored [17]. Many papers discuss retrofit strategies in general [18-20].

A study proposed an optimisation method for retrofitting building information modelling (RBIM) to find the optimum building envelope of an office building in Malaysia with two objectives - minimising OTTV value and minimising retrofit cost. The method required three different software, Autodesk Revit for BIM authoring tools, Dynamo for visual scripting, and MATLAB, to customise a non-dominated sorting genetic algorithm (NSGA-II) for optimisation [21]. Both passive and active state-of-art energy-efficient technologies were implemented in Singapore's Zero Energy Building (ZEB) retrofit demonstration project. The results revealed that active strategies such as energy-efficient lighting and high-performance air-conditioning system were the most energy-efficient retrofit measure for buildings in hot-humid climates. On the other hand, they also concluded that passive design strategies were not preferable because they were not cost-effective and had a more extended payback period [20].

From these previous studies, four different building types were used for multi-objective optimisation case studies: residential buildings [22-25], school or university buildings [20, 26], heritage buildings [15] and office building [21], with office buildings being the least widely. Hence, the author found this as a research gap that should be explored.

3 Methodology

The methodology in this research used a quantitative analysis including a field survey, questionnaire, and software simulation. The selected case study building was the 9th floor of the Main Building of the Ministry of Public Works and Housing, Republic of Indonesia (Pekerjaan Umum dan Perumahan Rakyat - PUPR). The building has received Platinum green certification from the Green Building Council Indonesia. Figure 1 shows the location of the PUPR building, while Figure 2 shows the east view of the PUPR building.

Figure 1. Location of PUPR building in Jakarta

Figure 2. Picture of PUPR building

3.1 Data collection

Data collection was performed to gather building drawings (Figure 3), construction data, materials, occupants' schedules, electricity consumptions, appliances, and HVAC and lighting system details. These were used as resources to make a dynamic thermal simulation digital twin-building model using Design Builder software. A building survey was also conducted to measure indoor temperatures and humidity. HOBO UX100-003 and HOBO MX1101 data loggers were used and installed in several rooms on the 4th, 9th, and 17th floors. The location of the logger installation was decided based on the building manager's approval.

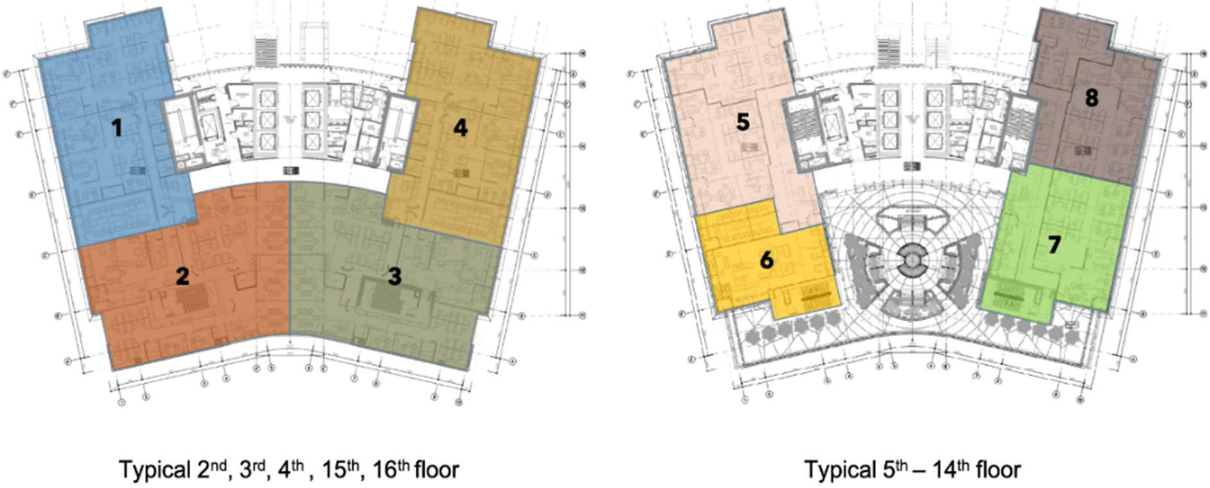


Figure 3. Typical floor plan of PUPR building

Figure 4 shows the location of several loggers installed on the 9th floor. However, in this paper, the simulation will focus on the office rooms where logger number 2 was installed for one month in October 2022. Based on the building manager's information, the building form and orientation were modified to respond to the sun's direction, which can affect thermal comfort. The material of the building uses thermal resistant glass for windows to support the energy efficiency program, which is super silver dark blue 8 mm glass with a U-value of 5.739 W/m^{2}K and a solar heat gain coefficient (SHGC) of 0.423.

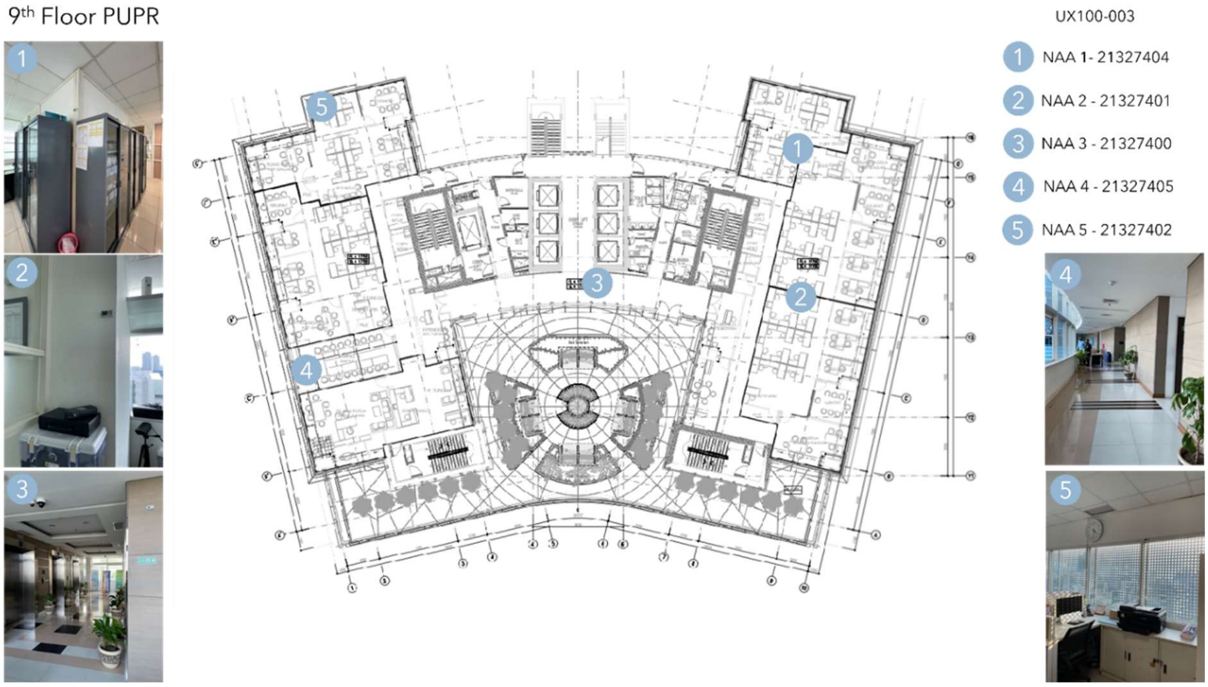


Figure 4. Temperature and humidity data loggers' installation

Insulation was also added on the wall with the configuration of external surface film, cladding aluminium (thermal conductivity k= 211 W/mK), calcium silicate/gypsum (k=0.170 W/mK), and fibreglass insulation internal surface film (k= 0.035 W/mK). Other passive design architecture, such as sun shading on the windows and double skin façade with perforated material on the west side, were installed to decrease solar gain and increase natural lighting.

The temperature in the office area is maintained at 25°C with relative humidity between 60-65%. The office spaces at the PUPR building use a central air conditioning system VAV dual duct water-cooled chiller with refrigerant R-134a. Interestingly, the seventeen-storey building uses natural ventilation in its circulation area, including corridors, the lift's lobby, staircases, and toilets. Types of artificial lighting installed in this building are T5 (52%), LED (4%), PLC (34%), and TL (10%). Illumination is maintained at 350 lux to correspond to the Indonesian National Standard. Furthermore, some strategies related to artificial lighting, such as lux sensors, motion sensors, and scheduling, are applied to obtain energy efficiency.

3.2 Simulation of existing building and model validation

In this study, Dynamic Thermal Simulation Modelling (DTSM) was performed using Design Builder (DB). The building performance analysis process is shown in Figure 5.

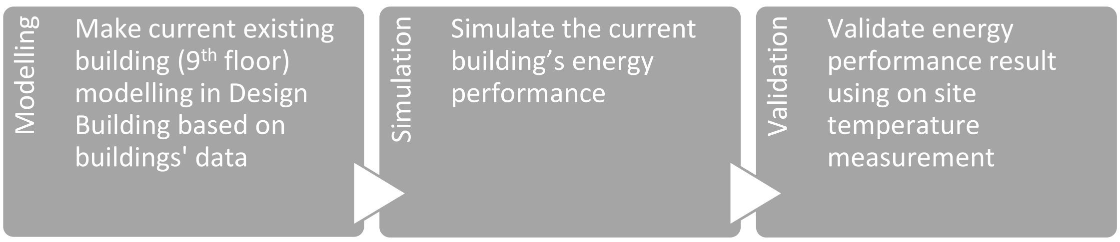


Figure 5. Building Performance Analysis process

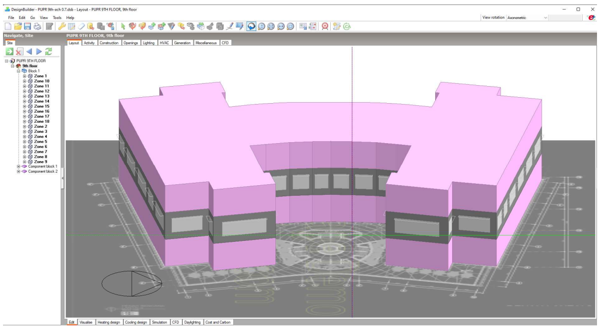


Figure 6. Model of the middle floor of the building

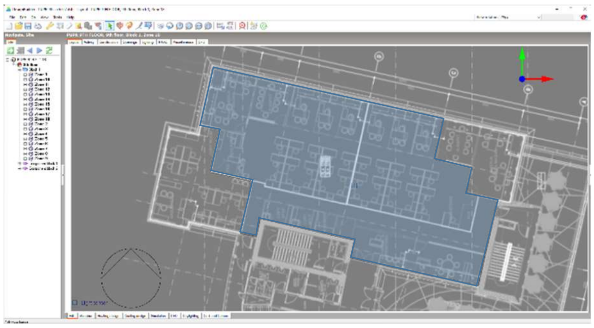


Figure 7. Model of office room as zone

The existing building model was built in DesignBuilder (DB) and based on the as-built drawing provided by the building manager. Figure 6 above shows the DB model of the 9th-floor PUPR building with its upper and lower floor as a component. Figure 7 shows the office room used as the zone for the simulation. The 9th floor was selected because the logger was installed for a whole month without interruption, and the floor itself can be represented as the typical office layout in the PUPR building. The model in DB was then validated using the formula of Normalised Mean Bias Error (NMBE) and Coefficient of the Variation of the Root Mean Square Error (CVRMSE) below:

$$MBE\ (\%) = \frac{\sum_{k=1}^{n} (Y_k - \widehat{Y_k})}{\mathrm{n}} \tag{1}$$

$$Normalised\ MBE\ (\%) = \frac{\sum_{k=1}^{n} (Y_k - \widehat{Y_k})}{(\mathrm{n}-\mathrm{p}) \times \mu} \times 100 \tag{2}$$

p for engineering models to be p=1

$$RMSE = \sqrt{\frac{\sum_{k=1}^{n} (Y_k - \widehat{Y_k})^2}{\mathrm{n}-\mathrm{p}-1}} \tag{3}$$

p= number of variables, in engineering models (Option D) p=0

$$CVRMSE\ (\%) = \frac{\mathrm{RMSE}}{\mu} \times 100 = \frac{\sqrt{\frac{\sum_{k=1}^{n} (Y_k - \widehat{Y_k})^2}{\mathrm{n}-\mathrm{p}-1}}}{\mu} \times 100 \tag{4}$$

According to ASHRAE [48], if using hourly data, the validation accuracy of the model should be +/- 10% for NMBE and <30% for CV(RMSE). The validation results with these formulae are presented in Table 2.

3.3 Multi-objective optimisation of retrofit strategies

This study's multi-objective optimisation process with different retrofit objectives and variables used the Non-dominated Sorting Genetic Algorithm II (NSGA-II) available in the optimisation option built-in DesignBuilder software, as shown in Figure 8. Table 1 shows the selected objectives and variables as the parameter for the optimum retrofit strategies. NSGA-II obtains the optimum result with many parameters that usually contrast with each other. This study's optimisation objectives were to increase thermal comfort (minimise discomfort hours) and minimise the energy needed for cooling. Additionally, six variables were added to the calculation: glazing type, cooling set point temperature (°C), local shading type, window wall ratio (WWR), façade type, and HVAC template.

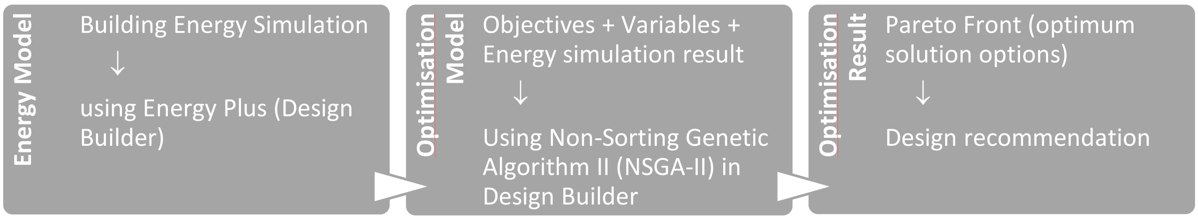


Figure 8. Multi-objective optimisation process

Table 1. Objectives and variables for the optimisation process in DesignBuilder

Objectives		**Variables**					
1	**2**	**Glazing type**	**Cooling setpoint temperature (°C)**	**Local shading type**	**Window Wall Ratio (WWR)**	**Facade type**	**HVAC template**
Discomfort (All Clothing) (hr)	Cooling (Electric) (kWh)	Double Clear 6mm/13mm Air	Min 24 Max 27.5 Step (parametric)2 Step (optimisation) 0.2	0.5m projection Louvre	Min 20 Max 80 Step (parametric) 20 Step (optimisation) 2	Horizontal Strip, 100% glazed	Chilled Ceiling, Air-cooled Chiller
							FCU 4-pipe, Air-cooled Chiller
				1.0m projection Louvre			FCU 4-pipe, Air-cooled Chiller, Parallel Chilled Water Storage
		Double Clear 6mm/13mm Argon				Horizontal Strip, 90% glazed	FCU 4-pipe, Water-cooled Chiller, Parallel Ice Thermal Storage
				1.5m projection Louvre			FCU 4-pipe, Water-cooled Chiller, Waterside Economiser
							FCU with DOAS, Air-cooled Chiller
		Dbl LoE (e2=.1) Clr 6mm/13mm Air		0.5m Overhang		Horizontal Strip, 80% glazed	Fluid Cooler, Generator Heat Recovery
							VAV Reheat, Air-cooled Chiller
				1.0m Overhang			VAV Reheat, Chiller Cooled by Fluid Cooler
		Dbl LoE (e2=.1) Clr 6mm/13mm Argon				Horizontal Strip, 70% glazed	VAV Reheat, Water-cooled Chiller
				1.5m Overhang			VAV Reheat, Water-cooled Chiller with Chilled Water Storage
							VAV Reheat, Water-cooled Chiller, Full Humidity Control
		Project BIPV Window		2.0m Overhang		Horizontal Strip, 60% glazed	VAV with Powered Induction Units
							VAV, Dual Duct, Water-cooled Chiller
		Sgl LoE (e2=.2) Clr 6mm		No Shading		Horizontal Strip, 50% glazed	VRF with HR and DOAS

4 Result and Discussion

The selected zone represents the office room in DesignBuilder and had several setting changes, including the activity schedule, construction details and materials, opening, lighting, and HVAC system. The model in DB was then simulated in fifteen scenarios with infiltration and temperature setting changes to determine the smallest values of N-MBE and CV(RMSE) according to the ASHRAE 14 standard. Table 2 presents the validation result by comparing Jakarta's measured, modelled, and outdoor temperatures from the commercial weather generation software Meteonorm. The results show that the model with an infiltration rate of 3 ac/h and a cooling set point temperature of 20-24°C was closely similar to the temperature the data logger installed in the same room recorded.

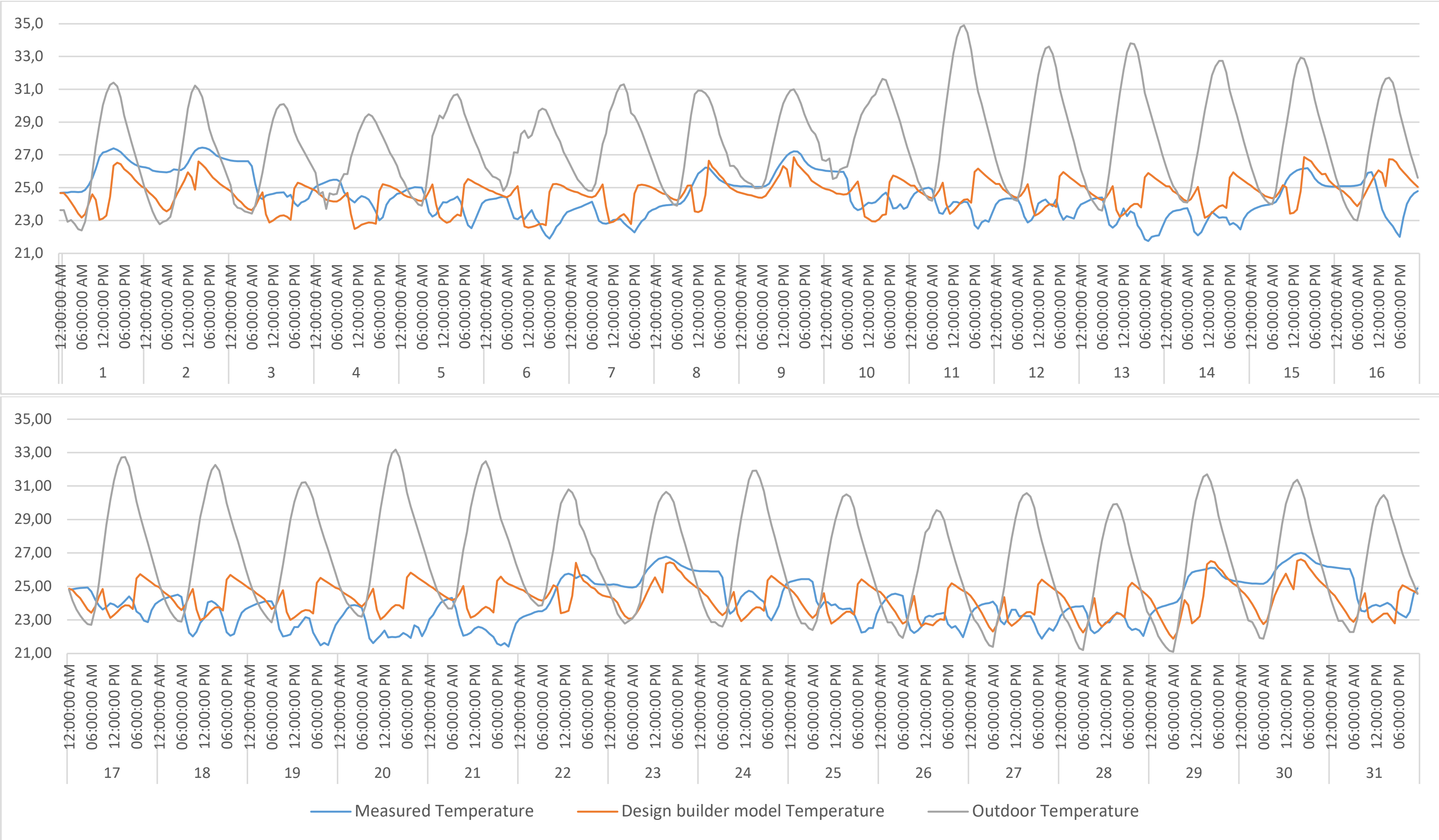


Figure 9. Temperature comparison in 1-16 October 2022 (top) and 17-31 October 2022 (below)

It is shown in Figure 9 that both measured and modelled temperatures inside the office room during office hours in October 2022 were mainly below 25°C, while the outdoor temperature reached more than 30°C in the afternoon. The measured temperatures also showed that on most days in October 2022, the temperature peaked early in the morning before 08.00 and reached its lowest after 17.00 in the afternoon. Meanwhile, the simulation results in DB showed that higher temperatures occurred in the evening and reached the lowest point during working hours. The DB model simulation results shown in Figure 10 indicated discomfort during working hours each day when the temperature was below 24°C because it might be considered uncomfortable or cold.

Table 2. Validation result

Infiltration rate	*Temperature setting*	*MBE*	*N_MBE*	*RMSE*	*CV(RMSE)*
ACH 0.7	T 20-23°C	0.30	1.25	1.46	6.01
	T 20-24°C	-0.23	-0.93	1.50	6.21
	T 20-25°C	-0.70	-2.88	1.77	7.29
ACH 1.5	T 20-23°C	0.30	1.26	1.46	6.03
	T 20-24°C	-0.21	-0.88	1.52	6.25
	T 20-25°C	-0.66	-2.74	1.78	7.33
ACH 2	T 20-23°C	0.31	1.27	1.46	6.04
	T 20-24°C	0.28	1.16	1.43	5.92
	T 20-25°C	-0.65	-2.67	1.78	7.35
ACH 2.5	T 20-23°C	0.31	1.28	1.47	6.05
	T 20-24°C	-0.20	-0.83	1.53	6.29
	T 20-25°C	-0.63	-2.62	1.78	7.36
ACH 3	T 20-23°C	0.31	1.28	1.47	6.06
	T 20-24°C	-0.19	-0.80	1.53	6.30
	T 20-25°C	-0.62	-2.58	1.79	7.37

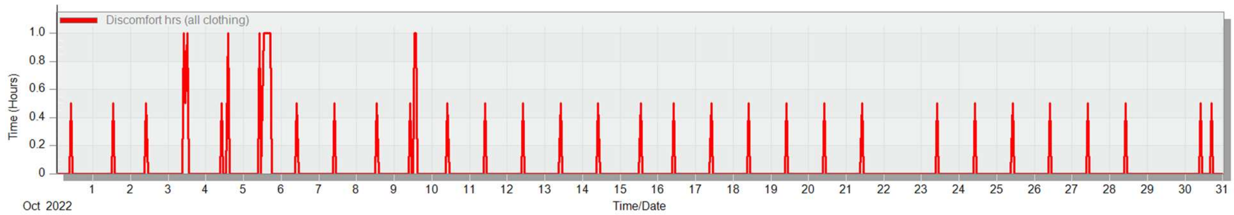


Figure 10. Discomfort hours during October 2022

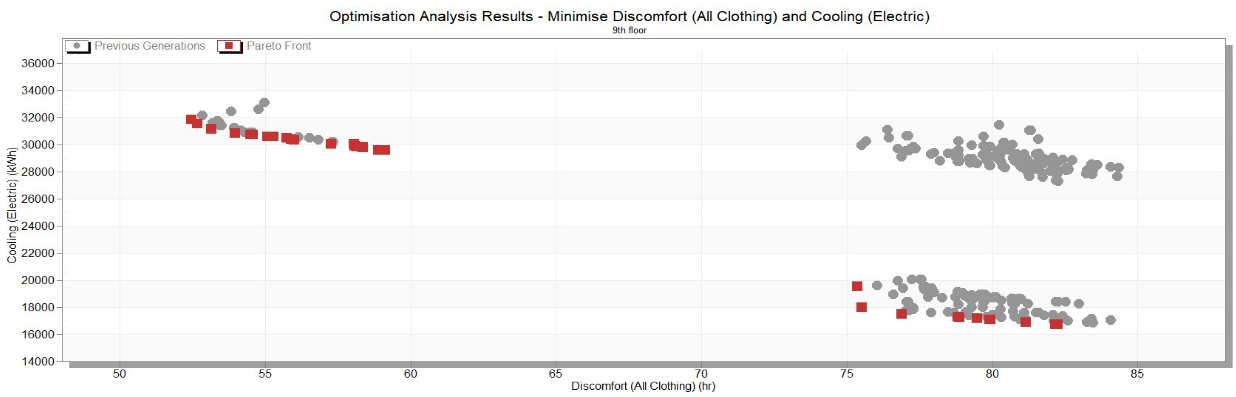


Figure 11. Optimisation analysis results with two objectives

In the optimisation analysis, the setting of maximum generation was 200, while generation for convergence and initial population size were both 20. The results can be seen in Figure 10 and Table 3. In Figure 10, the red points are the Pareto front or the optimum configuration to achieve both objectives with the variables applied. DesignBuilder calculated 1404 iterations with 70 generations until it converged. There are 31 optimal design solutions with a different sets of variables. The configuration with the lowest cooling demand has the most extended discomfort hours. This option uses double low emissivity clear 6mm glass and a cavity filled with Argon, a cooling set temperature of 16.4ºC, a 1.5m projection louvre, a window-to-wall ratio (WWR) of 32%, a façade type as a horizontal strip 100% glazed, and an HVAC template VRF with HR and DOAS.

In contrast, the configuration with the lowest discomfort hours but higher cooling demand used single low emissivity clear 6mm glass, a cooling set temperature of 28.6ºC, a 0.5m projection Louvre, a window-to-wall ratio of 50%, a façade type as a horizontal strip, 60% glazed, and VAV Reheat, water-cooled chiller, full humidity control. From the list of optimum design solutions, double low emissivity glass gave a lower cooling demand than single low emissivity glass. The optimum cooling set temperature was between 20.6-29.2ºC. Shading systems were needed, either a projection louvre or overhang with a range of 0.5-2.0m. A lower WWR was also preferably combined with a horizontal strip façade. As for the HVAC system, the VAV reheat and water-cooled chiller performed well with the other variables, with full humidity control.

5 Conclusions

From the result of the building measurement, simulation, and optimisation in DesignBuilder, it can be concluded that there are 31 sets of optimal retrofit design solutions for the PUPR building in Jakarta, Indonesia. Recommendation of configurations with the lowest cooling demand is using double low emissivity clear 6mm glass and cavity filled with Argon, cooling set temperatures of 16.4ºC, 1.5m projection louvre, window wall ratio (WWR) of 32%, façade type as horizontal strip 100% glazed, and HVAC template VRF with HR and DOAS. Meanwhile, the recommendation of configuration to get the least discomfort hours is using single low emissivity clear 6mm glass, cooling set temperatures of 28.6ºC, 0.5m projection Louvre, window wall ratio (WWR) of 50%, façade type as horizontal strip, 60% glazed, and VAV Reheat, water-cooled chiller, full humidity control. For future studies, testing the performance in other zones and the whole building will be beneficial to see if the solutions are similar. Then further research will apply the exact solutions to the different types of buildings in hot-humid climates.

Acknowledgements

This study was part of one of the authors' (NAA) PhD projects at the University of Liverpool, United Kingdom. We gratefully acknowledge the funding from the Centre for Education Funding Services of the Ministry of Education, Culture, Research, and Technology and the Endowment Fund for Education of the Ministry of Finance, Republic of Indonesia.

References

[1] D. H. W. Li, L. Yang, and J. C. Lam, "Zero energy buildings and sustainable development implications – A review," *Energy,* vol. 54, pp. 1-10, 2013, doi: 10.1016/j.energy.2013.01.070.

[2] D. Arinaldo *et al.*, "Indonesia Energy Transition Outlook 2021," Institute for Essential Services Reform (IESR), Jakarta, 2021.

[3] B. B. T. K. E. B2TKE– BPPT, "LAPORAN BENCHMARKING SPECIFIC ENERGY CONSUMPTION DI BANGUNAN KOMERSIAL," Ministry of Energy and Mineral Resources (MEMR), 2020.

[4] Z. Ma, P. Cooper, D. Daly, and L. Ledo, "Existing building retrofits: Methodology and state-of-the-art," *Energy and Buildings,* vol. 55, pp. 889-902, 2012, doi: 10.1016/j.enbuild.2012.08.018.

[5] W. Feng *et al.*, "A review of net zero energy buildings in hot and humid climates: Experience learned from 34 case study buildings," *Renewable and Sustainable Energy Reviews,* vol. 114, 2019, doi: 10.1016/j.rser.2019.109303.

[6] S. Attia, M. Hamdy, W. O'Brien, and S. Carlucci, "Assessing gaps and needs for integrating building performance optimization tools in net zero energy buildings design," *Energy and Buildings,* vol. 60, pp. 110-124, 2013, doi: 10.1016/j.enbuild.2013.01.016.

[7] N. Hashempour, R. Taherkhani, and M. Mahdikhani, "Energy performance optimization of existing buildings: A literature review," *Sustainable Cities and Society,* vol. 54, 2020, doi: 10.1016/j.scs.2019.101967.

[8] T. T. Ayodele, A. Taki, M. Oyinlola, and B. Subhes, "A review of retrofit interventions for residential buildings in hot humid climates," *International Journal of Environmental Science and Development,* Article vol. 11, no. 5, pp. 251-257, 2020, doi: 10.18178/IJESD.2020.11.5.1258.

[9] A. X. Naves, L. J. Esteller, A. N. Haddad, and D. Boer, "Targeting energy efficiency through air conditioning operational modes for residential buildings in tropical climates, assisted by solar energy and thermal energy storage. Case study Brazil," *Sustainability (Switzerland),* Article vol. 13, no. 22, 2021, Art no. 12831, doi: 10.3390/su132212831.

[10] N. C. Onyenokporo and E. T. Ochedi, "Low-cost retrofit packages for residential buildings in hot-humid Lagos, Nigeria," *International Journal of Building Pathology and Adaptation,* Article vol. 37, no. 3, pp. 250-272, 2019, doi: 10.1108/IJBPA-01-2018-0010.

[11] W. S. Koh *et al.*, "Evaluation of glazing retrofitting solution for the tropics," *Energy and Buildings,* Article vol. 223, 2020, Art no. 110190, doi: 10.1016/j.enbuild.2020.110190.

[12] S. Somasundaram, A. Chong, Z. Wei, and S. R. Thangavelu, "Energy saving potential of low-e coating based retrofit double glazing for tropical climate," *Energy and Buildings,* vol. 206, 2020, doi: 10.1016/j.enbuild.2019.109570.

[13] S. M. Mousavi, T. H. Khan, Y. W. Lim, and A. Mohammadi, "Impact of internal shading controls on efficient daylighting in home-office workspaces in tropical climates," *Jurnal Teknologi,* Article vol. 83, no. 6, pp. 141-156, 2021, doi: 10.11113/JURNALTEKNOLOGI.V83.16635.

[14] J. H. Park, B. Y. Yun, S. J. Chang, S. Wi, J. Jeon, and S. Kim, "Impact of a passive retrofit shading system on educational building to improve thermal comfort and energy consumption," *Energy and Buildings,* vol. 216, 2020, doi: 10.1016/j.enbuild.2020.109930.

[15] E. Bay, A. Martinez-Molina, and W. A. Dupont, "Assessment of natural ventilation strategies in historical buildings in a hot and humid climate using energy and CFD simulations," *Journal of Building Engineering,* vol. 51, 2022, doi: 10.1016/j.jobe.2022.104287.

[16] K. W. Chen, E. Teitelbaum, F. Meggers, J. Pantelic, and A. Rysanek, "Exploring membrane-assisted radiant cooling for designing comfortable naturally ventilated spaces in the tropics," *Building Research and Information,* Article vol. 49, no. 5, pp. 483-495, 2021, doi: 10.1080/09613218.2020.1847025.

[17] H. U. Rehman, "Experimental performance evaluation of solid concrete and dry insulation materials for passive buildings in hot and humid climatic conditions," *Applied Energy,* vol. 185, pp. 1585-1594, 2017, doi: 10.1016/j.apenergy.2016.01.026.

[18] A. T. Balasbaneh, D. Yeoh, M. Z. Ramli, and M. H. T. Valdi, "Different alternative retrofit to improving the sustainability of building in tropical climate: multi-criteria decision-making," *Environmental Science and Pollution Research,* Article 2022, doi: 10.1007/s11356-022-18647-8.

[19] M. Shin, J.-C. Baltazar, J. S. Haberl, E. Frazier, and B. Lynn, "Evaluation of the energy performance of a net zero energy building in a hot and humid climate," *Energy and Buildings,* vol. 204, 2019, doi: 10.1016/j.enbuild.2019.109531.

[20] X. Sun, Z. Gou, and S. S.-Y. Lau, "Cost-effectiveness of active and passive design strategies for existing building retrofits in tropical climate: Case study of a zero energy building," *Journal of Cleaner Production,* vol. 183, pp. 35-45, 2018, doi: 10.1016/j.jclepro.2018.02.137.

[21] T. E. Seghier, Y.-W. Lim, M. F. Harun, M. H. Ahmad, A. A. Samah, and H. A. Majid, "BIM-based retrofit method (RBIM) for building envelope thermal performance optimization," *Energy and Buildings,* vol. 256, 2022, doi: 10.1016/j.enbuild.2021.111693.

[22] A. Jafari and V. Valentin, "Selection of optimization objectives for decision-making in building energy retrofits," *Building and Environment,* vol. 130, pp. 94-103, 2018, doi: 10.1016/j.buildenv.2017.12.027.

[23] P. Penna, A. Prada, F. Cappelletti, and A. Gasparella, "Multi-objectives optimization of Energy Efficiency Measures in existing buildings," *Energy and Buildings,* vol. 95, pp. 57-69, 2015, doi: 10.1016/j.enbuild.2014.11.003.

[24] F. Rosso, V. Ciancio, J. Dell'Olmo, and F. Salata, "Multi-objective optimization of building retrofit in the Mediterranean climate by means of genetic algorithm application," *Energy and Buildings,* vol. 216, 2020, doi: 10.1016/j.enbuild.2020.109945.

[25] M. Tavakolan, F. Mostafazadeh, S. Jalilzadeh Eirdmousa, A. Safari, and K. Mirzaei, "A parallel computing simulation-based multi-objective optimization framework for economic analysis of building energy retrofit: A case study in Iran," *Journal of Building Engineering,* vol. 45, 2022, doi: 10.1016/j.jobe.2021.103485.

[26] J. M. C. Ongpeng, B. I. B. Rabe, L. F. Razon, K. B. Aviso, and R. R. Tan, "A multi-criterion decision analysis framework for sustainable energy retrofit in buildings," *Energy,* vol. 239, 2022, doi: 10.1016/j.energy.2021.122315.

Appendix

Table 3. Optimization result from Design Builder

Iteration	Generation	Objectives		Variables					
		Discomfort (All Clothing) (hr)	Cooling (Electric) (kWh)	Glazing type	Cooling setpoint temperature (°C)	Local shading type	Window Wall Ratio (WWR)	Facade type	HVAC template (Detailed HVAC)
2	0	58.08	29898.49	Dbl LoE (e2=.1) Clr 6mm/13mm Air	26.6	1.0m projection Louvre	24	Horizontal strip, 60% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
22	1	55.73	30488.21	Dbl Clr 6mm/13mm Arg	29	2.0m Overhang	72	Horizontal strip, 90% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
24	1	75.35	19555.88	Sgl LoE (e2=.2) Clr 6mm	28.6	0.5m projection Louvre	58	Horizontal strip, 90% glazed	Fluid Cooler, Generator Heat Recovery
44	2	55.27	30606.75	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	24	0.5m projection Louvre	76	Horizontal strip, 70% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
67	3	75.51	17990.18	Sgl LoE (e2=.2) Clr 6mm	28.8	0.5m projection Louvre	54	Horizontal strip, 80% glazed	VRF with HR and DOAS
78	4	79.92	17078.16	Dbl Clr 6mm/13mm Arg	24	1.5 m projection Louvre	36	Horizontal strip, 70% glazed	VRF with HR and DOAS
86	4	81.16	16905.21	Dbl LoE (e2=.1) Clr 6mm/13mm Air	26.6	1.0m projection Louvre	34	Horizontal strip, 100% glazed	VRF with HR and DOAS
94	4	55.09	30627.60	Project BIPV Window	23.8	1.5m Overhang	24	Horizontal strip, 60% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
97	5	58.37	29822.87	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	25.2	2.0m Overhang	54	Horizontal strip, 90% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
114	5	58.34	29856.62	Dbl LoE (e2=.1) Clr 6mm/13mm Air	20.8	2.0m Overhang	58	Horizontal strip, 90% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
142	7	55.07	30629.71	Dbl LoE (e2=.1) Clr 6mm/13mm Air	21.4	0.5m projection Louvre	42	Horizontal strip, 60% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
147	7	53.15	31160.07	Sgl LoE (e2=.2) Clr 6mm	27.8	1.5m Overhang	34	Horizontal strip, 100% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
149	7	53.95	30871.24	Sgl LoE (e2=.2) Clr 6mm	22.2	2.0m Overhang	30	Horizontal strip, 100% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
160	8	59.12	29585.00	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	23.2	1.5 m projection Louvre	22	Horizontal strip, 60% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
167	8	55.98	30358.17	Project BIPV Window	28.2	2.0m Overhang	22	Horizontal strip, 50% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
194	10	54.49	30766.26	Dbl Clr 6mm/13mm Air	26.4	1.5m Overhang	32	Horizontal strip, 80% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control

198	10	54.58	30762.62	Dbl Clr 6mm/13mm Arg	25.8	1.5m Overhang	28	Horizontal strip, 80% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
203	10	57.28	30057.16	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	21.4	1.5m Overhang	64	Horizontal strip, 50% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
205	10	82.25	16724.07	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	26.4	1.5 m projection Louvre	32	Horizontal strip, 100% glazed	VRF with HR and DOAS
226	11	52.45	31866.06	Sgl LoE (e2=.2) Clr 6mm	28.6	0.5m projection Louvre	50	Horizontal strip, 60% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
257	13	52.66	31573.24	Sgl LoE (e2=.2) Clr 6mm	23.2	1.0m Overhang	22	Horizontal strip, 70% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
276	14	58.89	29626.30	Dbl LoE (e2=.1) Clr 6mm/13mm Air	26.4	1.5 m projection Louvre	52	Horizontal strip, 100% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
295	15	58.16	29859.63	Dbl LoE (e2=.1) Clr 6mm/13mm Arg	25.4	1.0m projection Louvre	34	Horizontal strip, 70% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
326	16	58.05	30046.05	Project BIPV Window	29.2	1.5 m projection Louvre	60	Horizontal strip, 100% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
411	21	78.87	17253.27	Dbl Clr 6mm/13mm Arg	22	1.0m projection Louvre	60	Horizontal strip, 100% glazed	VRF with HR and DOAS
580	29	79.46	17171.76	Project BIPV Window	28.2	1.0m projection Louvre	60	Horizontal strip, 100% glazed	VRF with HR and DOAS
683	34	82.16	16752.87	Dbl LoE (e2=.1) Clr 6mm/13mm Air	23.8	1.5 m projection Louvre	32	Horizontal strip, 100% glazed	VRF with HR and DOAS
698	35	76.89	17468.47	Sgl LoE (e2=.2) Clr 6mm	26	1.0m projection Louvre	34	Horizontal strip, 100% glazed	VRF with HR and DOAS
714	36	55.89	30427.32	Dbl LoE (e2=.1) Clr 6mm/13mm Air	22.2	1.0m Overhang	50	Horizontal strip, 100% glazed	VAV Reheat, Water-cooled Chiller, Full Humidity Control
886	45	78.82	17259.48	Dbl Clr 6mm/13mm Air	29	1.0m projection Louvre	30	Horizontal strip, 100% glazed	VRF with HR and DOAS
989	50	79.91	17085.45	Dbl Clr 6mm/13mm Air	20.6	1.5 m projection Louvre	62	Horizontal strip, 80% glazed	VRF with HR and DOAS

ARCHITECTURAL COMPARISON OF FOUR NEW DEAL COMMUNITIES

Lisa TUCKER*

Virginia Tech

240 Wallace Hall MC 0410

Blacksburg VA 24061 USA

ltucker@vt.edu

Gregory GALFORD

Virginia Tech

240 Wallace Hall MC 0410

Blacksburg VA 24061 USA

ggalford@vt.edu

Abstract

This paper will examine the four Appalachian subsistence homestead communities built as a component of the New Deal in the 1930s. The original town of Arthurdale, WV, was followed by the Tygart Valley Homesteads in WV, the Westmoreland Homesteads in PA, and the Cumberland Homesteads in TN. Together, these four communities are part of the Rural Subsistence Homestead program begun during the early years of the New Deal in the Roosevelt administration. This specific subset was to provide sustainable and affordable housing and a new way of life for out-of-work coal miners. Each of the four developments consisted of a town centre with approximately 200+ single-family homes set on one-to-five-acre plots of land. Residents were encouraged to raise their own food and livestock. Community centres taught canning, other food preservation methods, and life skills such as sewing, weaving, furniture making, welding, and other trades.

The methods used for this research included an archival plan document analysis and photographic analysis of extant houses in each community and the community centre. The overall developments were evaluated using a windshield survey to assess the results as they exist today compared to historical maps of each development.

Understanding the similarities and differences between the small house plans for each development can inform small affordable house designs today. How the original houses were left "as is" versus added to can also provide information on best adapting the original plan ideas to homes.

Figure 1. Sample House—Norvelt [1]

Finally, how the houses relate to the community centre buildings illustrated four examples of how these small towns developed initially and evolved. Using original plat designs and comparing them to the current USGS maps shows where new houses and other amenities were added since the 1930s. Ideally, understanding this historic endeavour can provide essential knowledge to sustainable neighbourhood development in American rural and suburban areas.

Keywords

subsistence housing, New Deal, community, sustainability, historic neighborhoods

1 Introduction

During the 1930s, the Roosevelt Administration sought to address the problem of displaced coal miners and their resulting poor living conditions by creating subsistence housing communities. This focus was initiated after Eleanor Roosevelt experienced the northern West Virginia coal camp's extreme poverty. These communities provided homes and training for families in a new way of life. The philosophy behind these developments was that if coal miners and their families were taught to grow their food and learn new trades, they would successfully transition from poverty into better living conditions, and this was strengthened by incorporating the innovative educational methods of John Dewey that relied on real-world learning. Families had to apply to be a part of these new communities and were selected based on how their skill sets would enable their success. In retrospect, these developments, composed of affordable and sustainable houses, provided residents with the ability to care for themselves and fostered a shared sense of community.

An architectural comparison of the site planning and unique house design demonstrates how sustainability for residential, single-family house design, and land use during the early twentieth century contributes to today's housing crisis in the US. America has a shortage of affordable housing, with little attention paid to sustainability issues in the domestic architecture market, especially in smaller homes. Unlike many European countries, most US housing is designed and built by developers. This has created a schism between commercial and residential design characterized by greater building sector awareness by commercial designers than by residential ones. By tying housing to capitalism, the market is motivated to create larger houses for profit by largely ignoring first-time home buyers who desire smaller sustainable homes.

This paper examines the architectural prototypes designed by architects for New Deal subsistence housing developments. The premise underlying these developments was to make them self-sufficient and sustainable. Although historical, they provide some essential concepts that translate to current single-family housing developments in the USA.

2 The Four Communities

The four New Deal subsistence communities are located in rural Appalachian coal country spanning three states: Pennsylvania, West Virginia, and Tennessee. All four were designed by different architects but followed similar approaches and principles. All four have traditional architectural forms with a focus on community.

As a fundamental premise, each house was located on a lot that allowed for growing food, raising livestock, and storing food. The properties included outbuildings, including a barn or garage, chicken coops, and root cellars. Fruit and nut trees were commonly provided in addition to areas for garden plots.

All the communities included a centre with services for and to assist in the education and training of the residents. These buildings had schools, wood shops, weaving facilities, community centres, and other support buildings. The sites provided easy access to water, along rivers, and transportation routes—highways and, in one case, rail.

The first and best-known community, Arthurdale, WV, sits in Preston County, West Virginia, southeast of Morgantown. Originally comprised of 165 houses and started in 1933, Arthurdale includes a central community area with multiple shared buildings for meetings and training. Each lot consisted of one to five acres for growing food and raising animals. Several properties also had root cellars for food storage. Residents received practical life skills training facilitating the transition from coal mining to other vocations. Decker's Creek runs through the centre of the community, bisected by rural route 92.

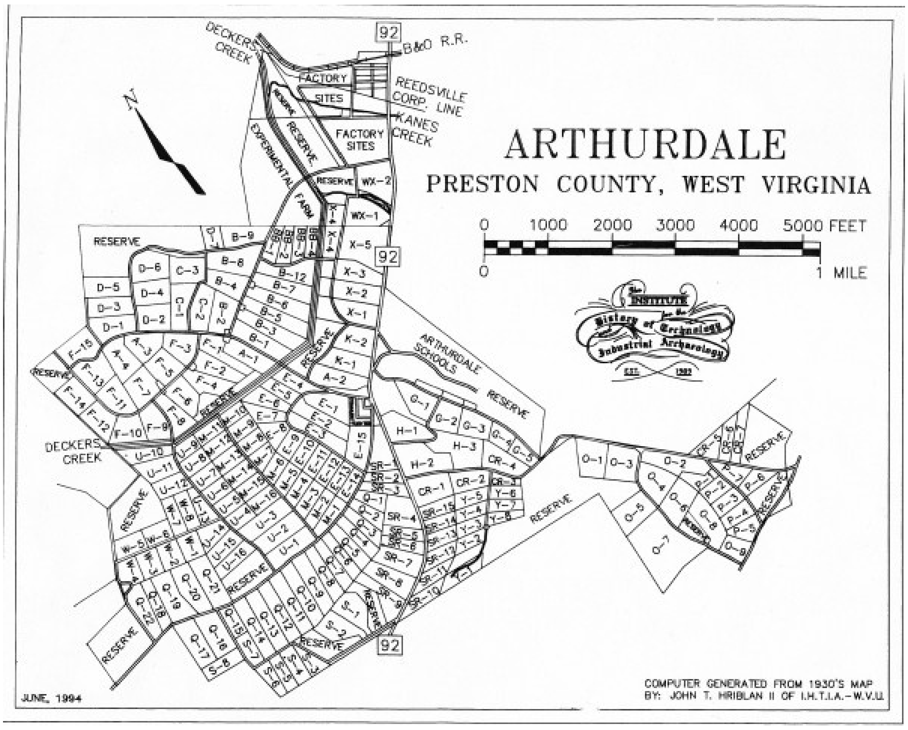


Figure 2. Plat of Arthurdale courtesy of Arthurdale Heritage [2]

The houses, built during three periods, have distinctly different appearances and plans. The first phase consisted of Hodgson Company plan book houses unsuited to the cool and mountainous West Virginia climate. Compounding the problem, the foundations were sized incorrectly, leading to changes and cost overruns. A more traditional, small Colonial Revival style comprised the second phase, and Colonial Revival stone houses populated the third phase. All steps were characterized by small homes with efficient floor plans achieved through small rooms and limited circulation. Amenities such as indoor plumbing were included at Eleanor Roosevelt's insistence, although this contributed to cost overruns.

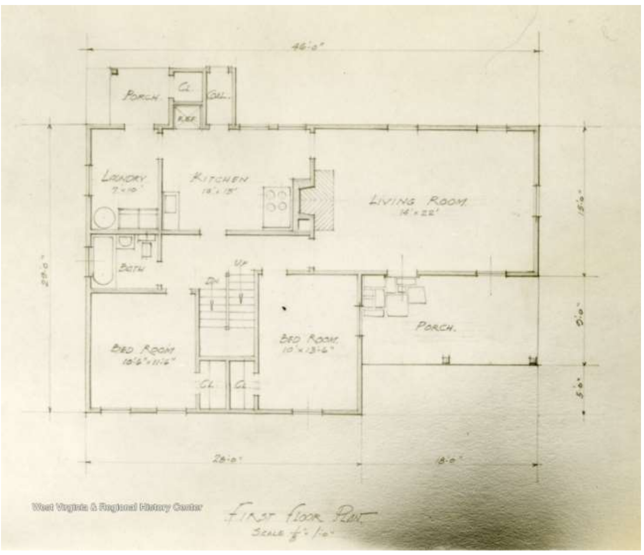


Figure 3. Plan, Phase 2 House, Arthurdale courtesy of West Virginia University archives [3]

The second community constructed (started 1934) was also located in West Virginia in the Tygart Valley near Elkins, WV, and included a plan for 270 houses though only 195 were built. Like Arthurdale, the Tygart Valley was divided by the Tygart River and a road, US Route 250/219. Like Arthurdale, the centre of the community includes a complex of shared buildings. These included “The Trade Centre,” a gas station, a Superintendent’s House, the Homestead School, a Warehouse, a woodworking shop, a weaving studio, a public service office building, and a lumber company headquarters. A community farm was also located near the shared facilities. [4]

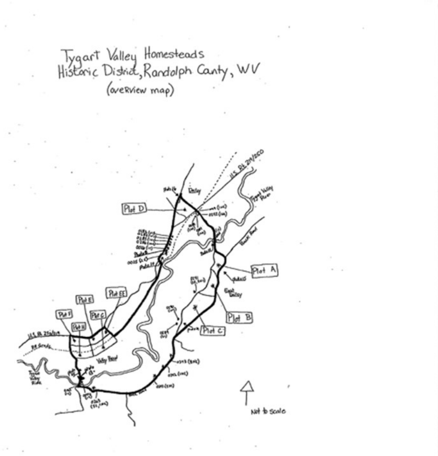


Figure 4. Tygart Valley Site Plan, National Register Nomination OMB Np. 10024-0018 [5]

In 1934, announcements were made for the final two developments—Cumberland Homesteads near Crossville, Tennessee, and the Norvelt community in Pennsylvania. The Cumberland Homestead development was the largest, with 254 houses.[6] Although there were several variations in floor plans, the houses consisted of one-and-a-half-story houses with gable roofs.

Like the other developments, the Norvelt development in Mount Pleasant Township, PA, is bisected by a creek, Sewickley Creek. Of the four communities, the Norvelt development is the only one that does not retain its rural context and is now located in an extended suburb of Pittsburgh.

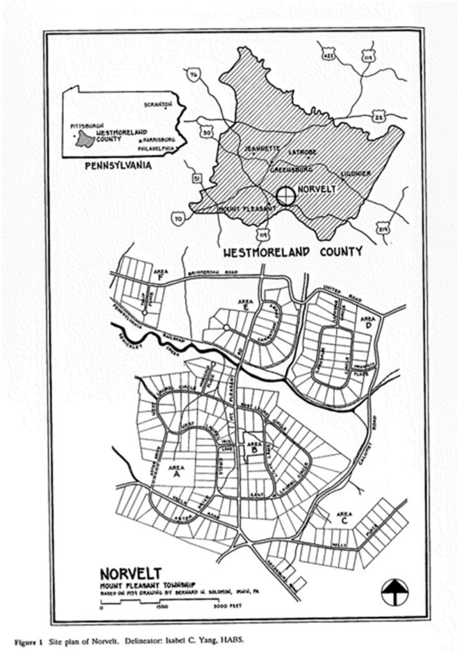


Figure 5. Norvelt Plan, HABS Norvelt and Penn-Craft

Pennsylvania Communities of the 1930s [7]

The houses of Norvelt feature one and a half stories with side-facing gable roofs and a Cape Cod-inspired Colonial Revival style. Like the other communities, the floor plan layouts are compact, and range from four to six principal rooms numbered accordingly, such as 401, 501, and 601. These houses do not have root cellars as in Arthurdale, but all originally had chicken coops and grape arbours.

3 Discussion of House Features

General Features

The Division of Subsistence Homestead's Circular No. 1 outlined the required housing features in these developments. Specific attention to sanitation, conveniences, and aesthetics guided the designs. The houses could vary in size and cost within specific parameters: 3 to 6 primary rooms with prices between $2000 and $3000. Three-room houses had to allow for easy expansion if needed. [8] The Division of Subsistence Homesteads produced a collection called *Homestead Houses* that provided thirty-two possible design solutions ranging from Cape Cod to New England Colonial under architectural advisor Andrew Hepburn. The house form and proportions, with less focus on style and ornamentation, were of primary importance to the designs. [9]

Arthurdale

The project at Arthurdale was the first of the four subsistence homesteads to serve rural Appalachian coal miners. It has three unique house types that showcase attempts at providing sustainable homes for largely unemployed or underemployed families. As it was first, the town contained many of the mistakes in housing that benefited the other communities when they were designed and constructed.

The Roosevelt administration wanted to deliver the housing needs quickly due to the severity of existing living conditions for the former coal miners of Scotts Run, West Virginia. Due to their desire for speed, they used prefabricated housing that could arrive onsite prepared for final installation. The E.F. Hodgson Co. of Massachusetts was contracted to provide the first 50 houses for Arthurdale. The houses were very small by modern standards, with a minimum of dedicated circulation space. They had open ceilings to the roof structure with no attic space, providing spatial height while sacrificing thermal comfort. They were 1-2 bedrooms with an eat-in kitchen and a living room. They did contain a full indoor bathroom. As the Hodgson company primarily built summer cottages for the New England coastline, these homes in the mountainous highland areas of West Virginia were woefully under-constructed. Building insulation and a heating system had to be added to provide an adequate standard of living. Mistakes were also made in coordinating the on-site foundations and the prefabricated homes. Corrections to the foundations and heating and insulation requirements dramatically increased its cost. The lack of economic sustainability for this first phase of Arthurdale was seized upon by the press and was used as a political tool to criticize the entire project.

Seventy-five homes were built during the second phase of Arthurdale; the Wagner house type was not prefabricated and was built on-site. It was frame construction. Mistakes from the previous series of homes were corrected when possible. The Wagner homes were still small but highly efficient with their use of space. It was a two-story house with a cubic form that allowed for efficiency in winter heating. Masonry was on the first floor with clapboard siding above. It was a traditional Colonial Revival architectural style. The living and dining area on the first floor contains the stair to the upper bedroom floor. The living room had ample natural light, a fireplace, and a wall radiator system for heating. Wood parquet floors were used in a slab-on-grade floor construction system. Furniture was built by community members of local woods and was sized for the homes.

The kitchen was light-filled with a large porcelain sink and drainboard. Painted wood-fitted cabinets with glass doors above were standard. The workspace also had a gas-fired stove, an electric refrigerator, and a water heater. This would have been considered luxurious for the former coal mining families living in a 'tar-paper shack.'

The upper floors contained 2-3 bedrooms and a bathroom. The bedroom for parents was slightly larger and would often have a space for a crib. Other bedrooms were small, with just enough room for individual beds and a minimum of furniture. Closets were built into the structure, but they were small. The bathroom had a tub, toilet, and sink in a minimum of space. Radiator heat warmed the rooms in the winter.

An essential feature of the Wagner homes was the outdoor area for food storage. Households were to grow, preserve, and store as much food as possible. An outdoor food storage area was located near the back of the house but independent of the house structure. It was mounded over by dirt covering that insulated the above-ground root cellar.

Forty homes were built on the last version, the Stone house. It was built on the success of the Wagner house but was more significant as it was a full two stories versus the one-and-a-half story of the Wagner home. Some models had a masonry base with clapboard siding above, others were clapboard, and some had stone veneer. The last series of homes were built in the later stages of the Great Depression and are less experimental but more traditional in size and form.

Norvelt

The houses of Norvelt in Westmoreland County, Pennsylvania, were designed by architect Paul Bartholomew. [10] The homes were set on large lots to allow for great gardening. The lots ranged from 1.6 acres to 7 acres. [11]. The homes were very compact, with most houses containing four to six rooms. Entry into the living room was from a side porch without access from the front façade. The exterior style was meant to evoke a Pennsylvania farmhouse, with its traditional form meant to appeal to the new families. The homes had central air heating, plumbing, and cypress siding. [12]. The homes sites in Norvelt contained features that were not always included in the other communities. The lots had several entities beyond the home. Beyond the large vegetable garden area were a single-car garage, a poultry house for chickens, and a grape arbour that usually connected the outbuildings to the house.

The plans varied depending on size but were all two stories. Models were numbered in the 400s, 500s, or 600s. The 400 models contained a living room, kitchen, and bath on the first level, with two bedrooms on the upper floor. The 500 series models included an additional first-floor bedroom; the 600 series had a utility room on the first level. In all three types, circulation was limited to a small stair between classes and little or no square footage for corridors, thus allocating all square footage to usable space. All models contained a central fireplace and used dormer windows to optimize space on the upper levels. Side-facing gable roofs gave the houses an exterior Cape Code appearance.

Figure 6. Photo of Cumberland Homestead house, by author

Cumberland

The houses in the Cumberland homestead were included in the 32 sample designs provided by the Division of Subsistence Homesteads. Although Cumberland had the widest variety of floor plan types, they all had some similarities. The first floor included living and kitchen areas, a first-floor bedroom, and a bathroom. The upper level included two additional bedrooms. The largest of the homes had four bedrooms.

According to the National Register Nomination for Cumberland Homesteads (1988), the development includes fifteen different house models with a few one-of-a-kind houses. They range from four to seven rooms featuring locally quarried stone on the exterior. The nomination labels the house types with letters A-L showing a variety of roof formations. All the variations have side-facing gable roofs, some have shed dormers on the primary façade side (B, D, E, F, G, J, and K), and some have real ells (C, D, E, F, and G) and others have central extensions forming a T (H, I, and K). [13] A large number of houses maintain their original configuration.

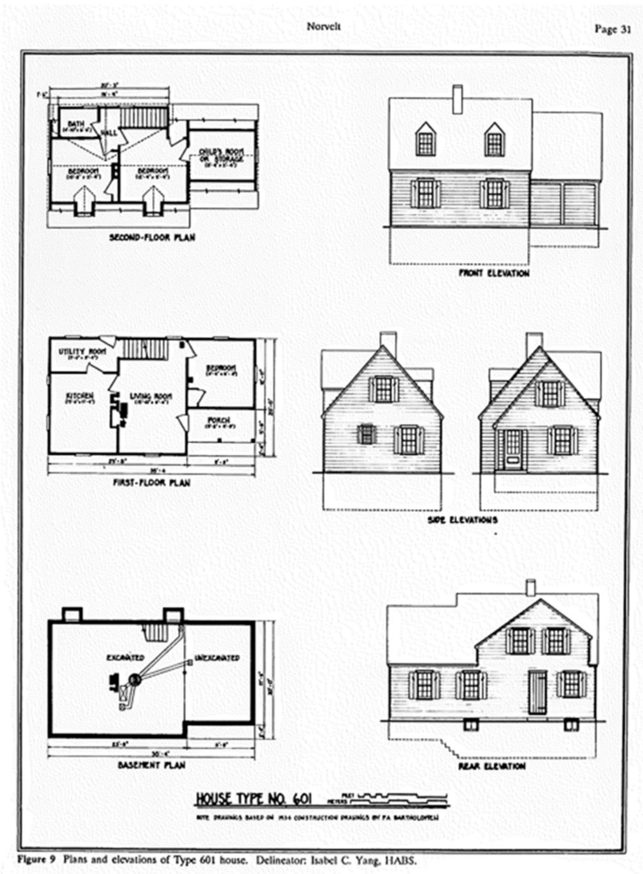


Figure 7. Norvelt House Type 601
HABS Norvelt and Penn-Craft Pennsylvania Communities of the 1930s [14]

Tygart Valley

The Tygart Valley Homesteads, designed by Architect Benjamin Smith, consisted of Cape Cod and Colonial Revival house types with four to six primary rooms. The most miniature version included two bedrooms, while the largest had four. [15] Like the Cumberland Homesteads, the houses were one and a half stories with a side-facing gable roof, and some had dormer windows and a gambrel roof shape. The Tygart Valley Homesteads, unlike Cumberland, were all constructed of wood framing with exterior wood siding.

Each homestead featured outbuildings constructed of wood and earth with metal roofs containing a chicken coop, root cellar, livestock feed storage, and a barn or garage. Like Arthurdale, the lots had a variety of fruit and sometimes nut trees and land upon which to grow food. [16]

Figure 8. Home at Dailey, WV. Tygart Valley homesteads by author

4 Discussion of the Sustainable Features

Many aspects of the subsistence housing development can be applied to today's US single-family housing developments, including neighbourhood layout features and individual house characteristics. The site plans for all four communities are located close to major roadways and are bisected by rivers or creeks, making for easy access to transportation and water. The Norvelt community is also located along a rail line (less common in the USA than in Europe), likely due to its proximity to Pittsburgh, PA. All the developments include community centres with ordinary buildings once used for resident education, essential services and needs, and community events. One of the premises behind the subsistence communities was that neighbours supported one another. A recent research project by the authors confirmed that this experience is still in evidence today, although supportive communities in most parts of the US no longer exist. The social aspects are often overlooked when viewing sustainability through the triple lens of social, economic, and ecological factors. Creating a sense of community that supports all residents is a critical feature that worked in how these 1930s communities were developed and is mainly missing in neighbourhoods built today.

The individual sites for these communities ranged from one to five acres each and included space for growing food, raising animals (chickens most commonly), and storing food. Accessory buildings like root cellars, grape arbours, chicken coops, and small barns were standard in all four developments. The houses were sited on the plot of land to take advantage of the topography.

The house plans in all four communities consisted of efficiently laid out floor plans in either four, five, or six principal room arrangements. Circulation was limited to staircases and very short corridors. Plumbing was stacked between levels, and central fireplaces in many plans helped with heating. Rooms were small while meeting all functional requirements. In Arthurdale, the shop in the community centre produced much of the furniture, where residents could be trained in furniture making. The houses from the four developments range from 750 to 1000 square feet of interior space, accommodating kitchen/dining, living, and bedroom areas with one bathroom. If the site allowed it, some houses included unfinished basements for mechanical equipment. In Arthurdale, some places used basements for food storage without a root cellar.

In addition to the integral elements of sustainability of the houses, house construction used locally available materials such as stone and locally harvested wood. Labour was also provided by local people giving employment to reduce the eventual cost of their homes.

The four New Deal subsistence developments provide a roadmap for communities seeking self-reliance and collaboration. The houses offer examples of efficiently designed small footprints in the Colonial Revival style, which remains popular today. The construction approach using local labour and materials close to water and transportation supports sustainability goals.

Some of today’s sustainable neighbourhood concepts are embodied by these four communities. For example, the idea of the 15-minute neighbourhood promotes quick access to services. Providing places to work close to where people live can decrease commute times and allow residents time to participate in activities such as gardening and growing some of their own food. These concepts are embodied in green building and wellness rating systems such as WELL, LEED, and the Living Building Challenge. These four subsistence communicates provide a historical roadmap for creating significant developments embodying many of these concepts.

One particular feature these community developments embody is that one size does not fit all. The current approach to housing developments in the US is that they are the same in all locations. The New Deal subsistence communities were explicitly adapted to their place. Engaged local workers used locally available materials and building methods and were adapted to specific sites. Although only a few models were designed for each community, the actual houses built on each site were adapted to the landscape and sited to allow for fruit and nut trees, garden plots, and livestock. This customization within a specific framework is what made these houses sustainable. The houses themselves were well-designed and had small, efficient footprints.

Designers and builders can learn from the past. Careful consideration of the principles underlying these four communities has lessons to inform today's construction of subdivisions.

Acknowledgments

We thank the organizers for the opportunity to share this work and the generous residents of Arthurdale and Norvelt for their participation in our research. We would also like to thank Historic Arthurdale for their assistance with organizing our research efforts and architectural historian Tim Kelly for sharing information with us.

References

[1] Hoagland, A. and, M. *Norvelt and Penn-Craft, Pennsylvania—Subsistence-Homestead Communities*, Historic American Building Survey, Washington, DC, US, 1991, cover.

[2] Arthurdale Heritage website, https://arthurdaleheritage.org/

[3] West Virginia University Archives, https://wvhistoryonview.org/catalog/005005

[4] Hoagland, A. and, M. *Norvelt and Penn-Craft, Pennsylvania—Subsistence-Homestead Communities*, Historic American Building Survey, Washington, DC, US, 1991.

[5] Rasmussen B., Riebe, E. and Rowe, A., *National Register Form Tygart Valley Homesteads*, Morgantown, WV, 2003.

[6] Hoagland, A. and Mulroony, p. 9.

[7] Mulrooney, M. *Subsistence Homestead Towns*, HABS No. PA-5919, 1989.

[8] Hoagland, A. and Mulroony, p. 18.

[9] Hoagland, A. and Mulroony, p. 28.

[10] Hoagland, A. and Mulroony, p. 28.

[11] Hoagland, A. and Mulroony, p. 29-30.

[12] Hoagland, A. and Mulroony, p. 31.

[13] Straw, E. *National Register of Historic Places Registration Form: Cumberland Homesteads Historic District,* Tennessee Historical Commission, Nashville, TN, 1988.

[14] Hoagland, A. and Mulroony, pp. 15-16.

[15] Rasmussen, B. Riebe, E. and Rowe, A. *National Register of Historic Places Registration Form: Tygart Valley Homesteads Historic District,* Historic Preservation and Research, Morgantown, WV, 2004.

[16] Rasmussen, B. Riebe, E. and Rowe, A., pp. 3-4.

RECLAIMING A SENSE OF PLACE

WATERFRONT REVITILIZATION THROUGH THE GENERATIONAL LENS

Alexandra KEHOE*, Nancy CLARK, Jeff CARNEY

University of Florida School of Architecture – UF SoA
1137 14th St, Orange City, FL, United States; alliekarma@gmail.com

Abstract

This research uses a notion of looking toward future generations as a driver to investigate the previous and current generational experience of (wo)man's intervention into the existing environment. Through analysing the individual's generational knowledge of the site, and their personal history and experience, it starts to open the door for remediation on specific factors through experience and program. An educational initiative, designed to honour the local heritage, has the potential to rehabilitate the seaside city of Arecibo, Puerto Rico.

This city embodies the global desire for coastal safety, and demonstrates the need for individual community engagement, with a delicate approach of understanding how generational trauma has changed the community's perspective of water. In terms of culture, native Puerto Ricans, the Taino people, used to revere and respect the strength of their waterways; now, they view it with fear and pain. A reminder of a powerful past, and a potential of a sustainable future, focuses the resident's engagement on an intervention that is educational and impactful within a waterfront community - one is not only benefiting the people of the place through engagement, or the history and economy of the place through revitalization, but creating something sustainable with a sense of longevity and purpose for the ecology of the site itself.

This research is categorized by the generational knowledge of the people within the region, the way the water and ecology react within the site, what green infrastructure has already been implemented or can, the actions and program of revitalizing the waterfront, and finally the methods to creating a sense of place for Arecibo. Waterfront communities face challenges due to environmental degradation, poverty, and social inequality. The communities hold the opportunity to benefit from the wealth of natural and human resources, through utilizing their generational understanding of their environment.

To encourage outreach and intentional influence, the proposed solution will be a combination of a permanent structure, as the primary hub of education, while generating a language of learning through fellow temporary structures located among various communities in need throughout the island.

Keywords: generational knowledge, revitalization, education, green infrastructure, community engagement

Introduction

City waterfronts have traditionally served as a hub for trade and shipping rather than entertainment. But because metropolitan areas have lost many of their industrial traits over the course of the last 50 years, many of these aquatic spaces have remained empty and barren.

Due to this underutilization, municipalities all over the world are deindustrializing their waterfronts to put them back to use. Developers transform the docks, warehouses, and other industrial buildings that formerly dominated these areas into residential, recreational, and office buildings that are better adapted to the requirements and patterns of contemporary urban life[1]. In the past, profit-fueled development of waterfronts has disregarded historical place, ecological integrity, and the involvement of an existing community.

The key difference is the terminology; to redevelop is to develop again[2], especially into the consideration of a redesign, a rebuild, or a redo. This is opposed to the term revitalize, which is to instill new life and vitality into an existing factor. To redevelop a site does not necessarily take the preexisting factors of a site into consideration, and often looks fully toward a future design that does not integrate into the cultural identity of the region. The act of revitalization works to uplift and restore, which requires a previous history and culture to expose for future generations to engage with. This research explores the bioclimatic and cultural revitalization of urban waterfronts, with an emphasis on Arecibo, Puerto Rico.

A revitalization process moves chronologically, beginning with the investigation of the site's history, analyzing the present conditions, and designing with the forethought of the site's future – both programmatically and environmentally. The goal is to design an intervention that engages the local population, revitalizes the area's history and economics, and creates a sense of responsibility for the site's ecosystem.

The waterfronts history can be explored through previous generations and the knowledge they hold through their community. Generational knowledge is the foundation for understanding the sense of place within a region. This understanding brings together the ideas of trauma, lore, and chronicle. The trauma can be represented as the financial, environmental, and political hardships the population has experienced over the history of the region. The lore is the cultural stories and traditions that have been engrained into the community, in the case of Puerto Rico, this can best be represented by the Taino culture, and their relationship to the environment. Whereas the lore is the cultural history, the chronicle of the site in the documented and factually passed history. The chronicle offers a transcript of experience for

---

[1] Reonomy. "Urban Waterfront Revival." reonomy.com, June 11, 2018. https://www.reonomy.com/blog/post/urban-waterfront-revival.

[2] Merriam-Webster. Merriam-Webster. https://www.merriam-webster.com/dictionary/redevelop.

the community, as well the environmental footprint. This footprint is significantly more impactful in a waterfront community, as they are directly exposed to a multitude of waterways and more susceptible to the effects of flooding and water based natural disasters. Generational knowledge allows the community to understand the way their water acts and reacts with them.

The Flow of Water is based in understanding the principles of water in the categories of ecology, interface, and interactions. The ecology of the site speaks to the ways a city was developed, and how it was predated. The interface speaks to the first steps (wo)man had made to weave into the ecology, exploring how they first touched the existing environment. The interaction goes into depth of the intent of this touch, and explores the results of the interaction, and how the history of the intervention has shaped the current ecology of the site – weather that be through sea level rise and stormwater flooding. The historical research of a revitalized waterfront design proposed the question: *How can the history and ecology of the site impact the knowledge and actions of its future generations?*

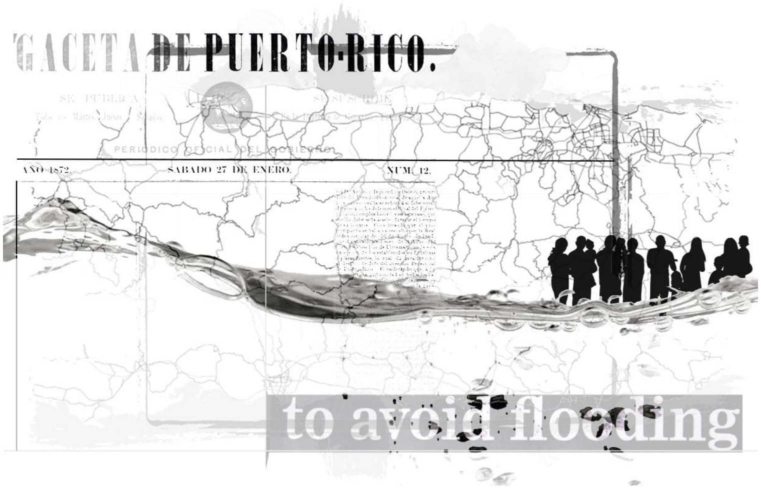


Figure 1 - Flooding in Puerto Rico, (2022)

The present analysis of the site allows the study of successful methods in flood mitigation and preventative development, such as green infrastructures. This theme is broken into the categories of innovation, remediation, and implementation. The innovation of green infrastructures brings to light the designs and discoveries made through decades of research along waterfront communities. Through these innovations, there is evidence of remediation, the way in which damage from ignorance and misinformation with prior interactions (wo)man has made to the ecology has been alleviated and reversed. The methods and materials used in the implementation of these acts of remediation create a base design to improve upon and study. By studying cases of flood mitigation, such as those that utilize wetlands existing in urban infrastructure, and those that employ levee systems for major storm surges, we can begin applying their principles onto bordering public spaces that redirect and filter stormwater along the coastal edge of waterfront cities in Puerto Rico, to ultimately develop a tangible component of resiliency to an implemented program.

The notion of the Revitalized Waterfront is defined by its engagement, development, and economy. The engagement and interaction are the fuel of revitalization, as without the community's presence and involvement, the waterfront remains underutilized. The development of the waterfront is a driver to the longevity and sustainability of a sense of tangible and lasting place, through the utilization of green infrastructure and desires of the surrounding population. As well, success in development leads to the success in economy, and allows a fiscal benefit to a municipality, whether through local interaction and trade, or through tourism. In a location such as Puerto Rico, the human scale interactions with the water are the most coveted and sought of experiences for travelers. As well, the revitalization and interaction will allow for the exposure of rich history and culture woven into site. The analysis of present conditions toward revitalization within the site asks: *How can use and program revitalize community engagement of waterfronts, and honor the history of place?*

The lasting impression of revitalization is through its creation of destination, with desire and intent to be engaged as a true place. A Sense of Place employs the key components of community, education, and inclusivity. Through community, place can be defined purely through emotion and experience. The disconnect of visual benefits to a design[3] and the true tangible experience have left many spaces to feel 'without', as they do not have the driving force of engagement through community-based programming. The educational aspects of programming allow the population to reengage with the water and develop new techniques and solutions of interacting with their respective waterways to feed into the generational knowledge, and trickle down to future inhabitants. The inclusivity is to understand the varying perspectives and experiences of the generations. Through their knowledge, there is a notion of fear toward the water, and somewhere along the passing of stories and traditions of Taino culture, the trauma and experience of the water's power shifted from that of worship and faith, to fear a distrust.

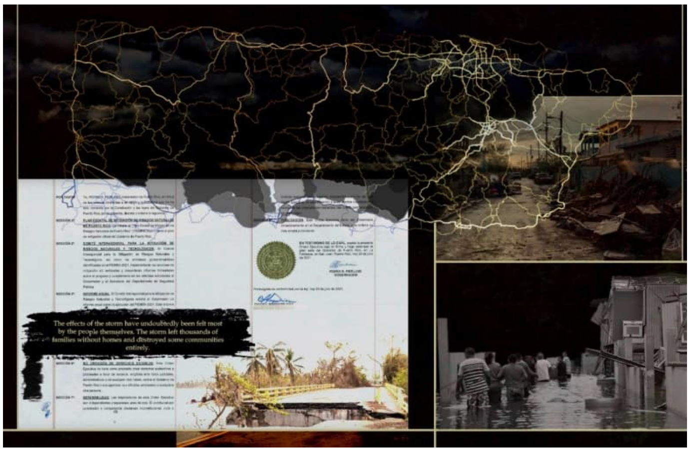


Figure 2 - Declaration of Flood Mitigation, (2022)

The future success of a revitalized waterfront is not only based by the emotions it can evoke for the previous generations, or the memories it can implement for the future ones, but by the sustainable and ecological methods implemented in its design to continue benefiting the surrounding environment. These innovations can be dispersed through educational programs, and feed into future generational knowledge. The design of revitalized waterfront asks: *How can the interventions enhance and react to the natural environment in a positive and sustainable way?*

[3] Pallasama, n.d.

These elements are explored by the construction of investigation and implementation, where the themes of generational knowledge and the way of water fuel the research and questions of the proposal, whereas the following themes of green infrastructure, the revitalized waterfront, and a sense of place cultivate the implementations from the research. The last themes allow exploration of their most successful methods, as opposed to their discovery.

Site Analysis

The chosen site of this proposal is Puerto Rico, as this island has an immediate need for coastal safely, waterfront revitalization, and plethora of generational knowledge to supply an engaging proposal.

In terms of culture, native Puerto Ricans, the Taino people, used to revere and respect the strength of their waterways; now, the native population view it with fear and pain. Taino's named their home Borinquen, which translates as "land of the brave lord." Today, Island residents proudly wear the title of Boricua as a tribute to their ancestors and traditional culture.[4] The indigenous population of the island thrived pre-Columbian era and their community had a strong relationship with nature, specifically water, where they held the goddess Atabey in highest regard. This is because they believed the goddess of flowing water influenced the entire island and surrounding wildlife.

Puerto Rico's extensive network of waterways, particularly the connections between its more than 40 rivers and the ocean that surrounds them, is one of its distinctive features. The Rio Grande de Arecibo, one of Puerto Rico's most potent and intricate rivers, serves as the focal point for the several interconnected minor dams that were originally designed to collect all of the water this watershed created in order to generate energy throughout the island. This river's mouth opens at the seaside city of Arecibo, Puerto Rico.

The city is situated on a small inlet close to the Arecibo River's mouth. It was founded in 1556 and is one of the commonwealth's oldest municipalities, where it was granted authorization by the Spanish monarch in 1537. Arecibo was officially incorporated as a town in 1616, and continues to serve as an official entrance point, manufacturing sporting goods, apparel, paper, plastics, and agricultural equipment. It also has Puerto Rico's largest rum distillery. [5]

As Puerto Rico's third-oldest city, Arecibo is also known by two other names. The city is known as the "Village of Captain Correa" in honour of Antonio de los Reyes Correa, who defended the town from a British invasion in the 16th century. As well, Arecibo is referred to as the city of the Ceti; also known as whitebait, Ceti is a tiny immature transparent fish that lives in the

[4] "The Taíno - Puerto Rico's Indigenous Ancient Culture: Taíno Life, Culture, & Art." Taíno Life, Culture, & Art - The Taíno - Puerto Rico's Indigenous Ancient Culture - LibGuides at LIU Palmer School of Library and Information Services.
https://liupalmer.libguides.com/c.php?g=1133797&p=8275637#:~:text=The%20Ta%C3%ADno%20were%20an%20indigenous,%2C%20Jamaica%2C%20and%20the%20Bahamas.

[5] Britannica, T. Editors of Encyclopaedia. "Arecibo." Encyclopedia Britannica, December 2, 2020. https://www.britannica.com/place/Arecibo.

Río Grande de Arecibo. This begins to entail the city's cultural and historical connection to the water, not just geographical. The coast is littered with multiple monuments and natural landmarks, deeply rooting memories, and experiences of the cities past generations. These names and landmarks are currently honoured by a population of around 90 thousand people, with a median household income of 20 thousand dollars per home.[6]

Along the coastline of Arecibo, sits the municipality of Vista Mar. This city embodies the global desire for coastal safety, and demonstrates the need for individual community engagement, with a delicate approach of understanding how generational trauma has changed the community's perspective of water.

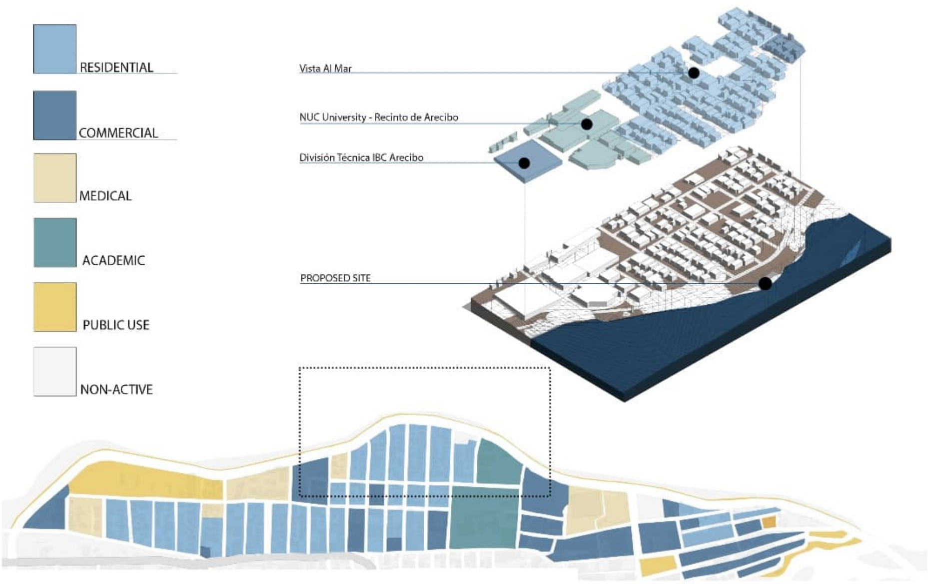


Figure 3 – Zoning Diagram of Vista Mar (2023)

The in-depth zoning analysis of this coastline, shown in Figure [3], reveals a complicated mix of hospitals, office buildings, and even universities dispersed among a sizable residential region. These properties are separated from the coast by an arterial road known as Victor Rojas Avenue, followed by a collapsing walkway that runs between the road and the seawall. Vista Mar's coastline is nearly deserted or decaying - even the existing seawall is disintegrating and plunging into the coast.

The ideal point along the coast to intervene is at the Parquesito Con Vista Al Mar, as the conditions of this site are no longer feasible, and it is a notable space among residents and patrons. This site was once an overlook pavilion, that housed a boardwalk like structure with small shops and eateries. The space was condemned immediately following Hurricane Maria, as the structure is completely unsafe. The former outlook is also the only break in the existing seawall along Vista Mar and has a grade that allows for direct engagement with the water.

[6] Bureau, U.S. Census. "U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates." Explore census data. https://data.census.gov/table?tid=ACSDT5Y2020.B03002&g=1600000US7203368.

Despite the previous popularity of this site, there is no relationship between the structure and the residents.

Figure 4 – Coastal Issues (2023)

One of the main reasons for lack of activity is evident in the immediate needs of Vista Mar's coastline. As examples if Figure [4], the walkway requires repair, the existing residents require a green ribbon or wall to allow a sound barrier from the major road, the seawall needs repair in terms of coastal safety, there is no overhead condition present to provide protection from the sun, and there is no point to cross the arterial road within 1 mile along the coast. Essentially, there is no way to engage with the water - even if the residents expressed a desire to do so.

PROPOSAL

The project proposal is that of a program based in the notion of research, and the accessibility of a cultural and educational experience. The proposal allows for research and development of techniques in flood mitigation, implementation of green infrastructure, and overall coastal safety.

As the site already contains surrounding academic buildings, placing a structure that contains a research facility, an educational hub, and an archive exhibit space of the generational experiences would fit well within the existing urban fabric. This structure would be nestled into a remodelled seawall that touches the coast, which can begin encouraging engagement with the water, and fostering new relationships between the waterways and the community. The project will address the need for coastal safety, the connection of waterways and the relationships with water as an accessible and inviting program.

The physical form of the proposal explores the implied programmatic elements of research and experience, thus begins manifesting a structure within the site lines along the seawall and residential zone. As well, the proposal is placed regarding the existing structure, the Parquesito Con Vista Al Mar, that is nestled directly onto the coast.

The placement of the structure will designate an entry point which allows the eastern portion of the form to hold the most publicly driven program, in which case is the experiential element of the design. Through this language, compartmentalizing the research portion toward the western form creates an opportunity at the northern most point of structure, which sits atop the parquesito, to act as a bridge between the experience, the research, and the coast of the site. This encourages a journey for the individual to move through this displayed exhibit space, into the marriage space of the experience through research, and finally into the educational component.

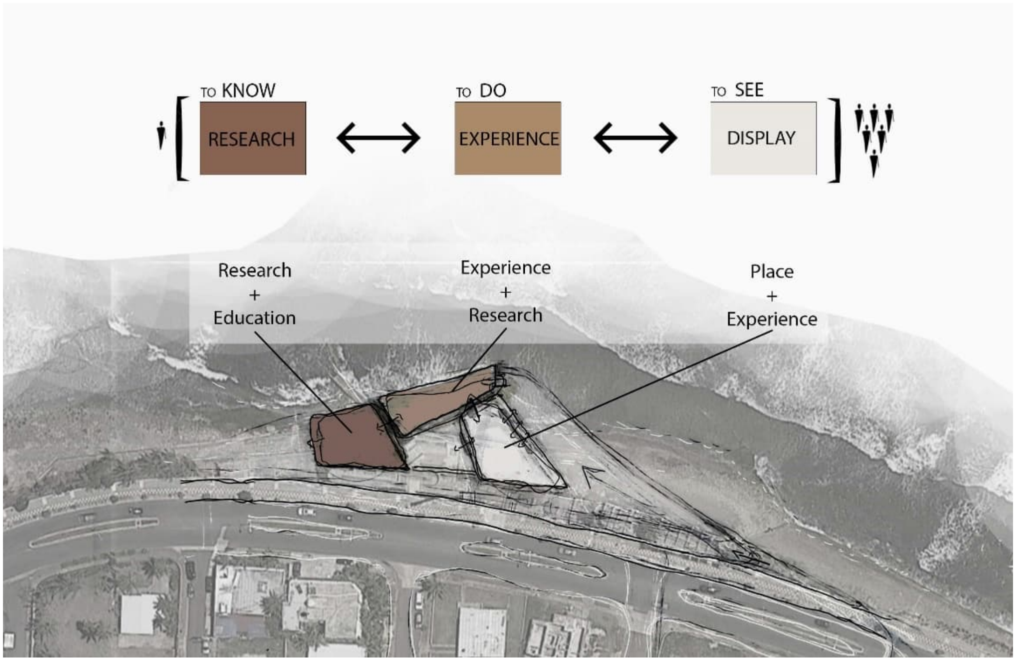


Figure 5 – Form Diagram (2023)

This form and itinerary operate on the notion that if 10 individuals were to see, then 5 individuals can do, and at least 1 individual will know. The communities, as the waterways, are deeply connected and intertwined, and the actions of one lead to the results of many.

The programmatic structure is merely an extension of a larger scale infrastructure designed to protect and revitalize the waterfront. Through the design of surrounding the form, the adapted site and rein visioned seawall begin to aid in the individuals transition of not only programmatic experience to research, but also cultivated a journey of their relationship with the water. The eastern side of the infrastructure – which mirrors the programmatic layout of publicity - is where this sea wall will have a moment of exposure and break open toward the coast. This segment acts as an artificial beach, and utilizes soft-scapes, such as green infrastructure, to encourage engagement and presents the individual with an opportunity to journey toward the water line or the new structure. The seawall connects into the north form and allows the individual to see, almost as an exhibit, the science and research behind this form of coastal safety. The individual can approach the water which flows beneath the northern point of the structure, and learn at a tangible scale, about the hardscape they enjoyed outside. The itinerary of the individual's journey through out the sight holds a hierarchy that allows the experience and archived program to be uplifted, protected, and celebrated along the water.

To encourage outreach and intentional influence, the proposed solution will be a combination of a permanent structure in Vista Mar, as the primary hub of educational and cultural experience, while generating a language of learning through a mobile temporary structure, that will locate itself in rotation among various communities in need throughout the island.

As previously stated, the Rio Grande de Arecibo is One of the island's most potent waterways, joined by minor dams with the goal of collecting all the water this watershed produced to generate electricity. As the city of Arecibo is deeply tied to the river at its connection to the bay, there is a multitude of rural cities dispersed along the riverfront, and various branches of the river that flow directly through entire neighbourhoods. The life of the island is based on connections; not only through its rivers and running water, but through its engrained culture and history passed between generations. To deny the collective and connective power between the coastal and mountainous communities as to deny the power of their waterways. The communities and the waterways are deeply connected and intertwined, and the actions of one lead to the results of many. In example, the actions of the residents in a small neighbourhood such as La Planta will bleed into the Rio Grande de Arecibo, and ultimately run back into the bay. The spine of the river connects these two sites, as shown in Figure [6], as will the project proposal in Vista Mar connect to dozens of other potential locations for the temporary unit to grace.

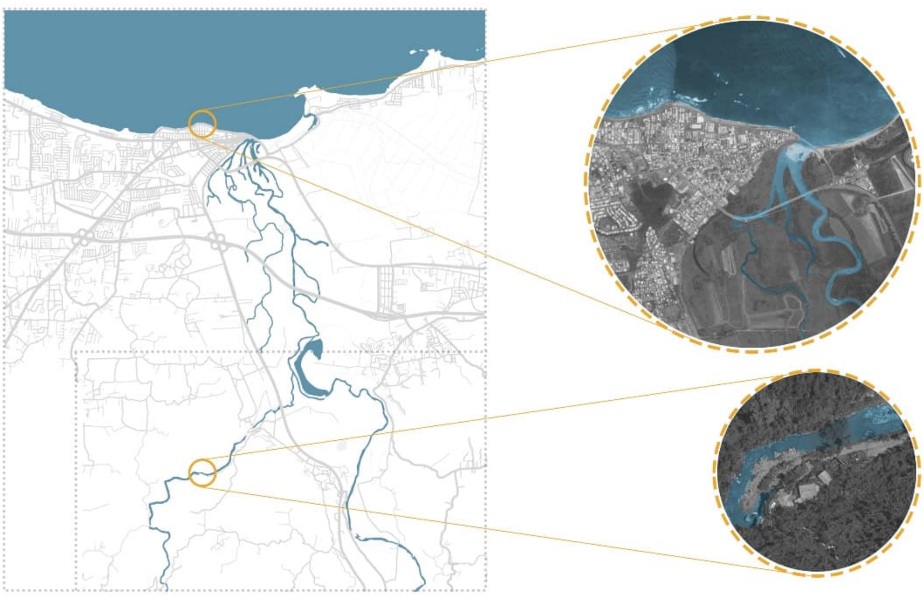


Figure 6 – Rio Grande de Arecibo Adjacency

This temporary unit will continue the notion of a program based on research, and the accessibility of educational and cultural experience through its ability to deploy to various sites along the waterfront of rural communities; this is to offer workshops specific to the communities' waterways and provide flood mitigation techniques at residential level. While this unit would supply resources or history of the cultural relationship to water, it would receive individual experiences and generational knowledge from each site it visits. The satellite unit would foster a relationship of supply and receive between itself and the permanent structure in Vista Mar, between the global population and the local community.

While the unit would be strategically placed in a community of need and expand to outreach into said community providing its resources and workshops, the temporary structure would have a stagnant component, almost like that of a shelter, for the individual to contribute any generational knowledge they would like to offer - whether that be through their trauma, their lore, or their chronicle. This aspect of knowledge could be collected through artifact, photograph, or even that of spoken word; all of which would be archived and housed securely until the temporary unit's return to the permanent structure in Vista Mar.

Once that unit arrives to Vista Mar, the stories, artifacts, photos, any of which pieces of knowledge the unit has obtained from the community it returned from, would be displayed in the educational and cultural experience form of the permanent structure. In theory, this space would be a rotating exhibit that highlights the temporary units last excursion, while the unit itself continues to venture the island to return with further examples of generational knowledge to share with the global population. Through the process of this collection, the permanent structure explores the display of these connections architecturally, as these moments can be displayed through listening rooms, water projections, or archived galleries.

The collection and distribution of generational knowledge is the primary motivation for this proposal. As previously displayed in Figure [5], the component of Place + Experience is tailored to the previous place the temporary unit visited. From this, the component of Experience + Research is the permanent example of the seawall in Vista Mar, and the physical connection to the coast. Which concludes to the component of Research + Education, the element that collects and processes the shared techniques of flood mitigation to create a sustainable solution for coastal safety for the future generations and their knowledge.

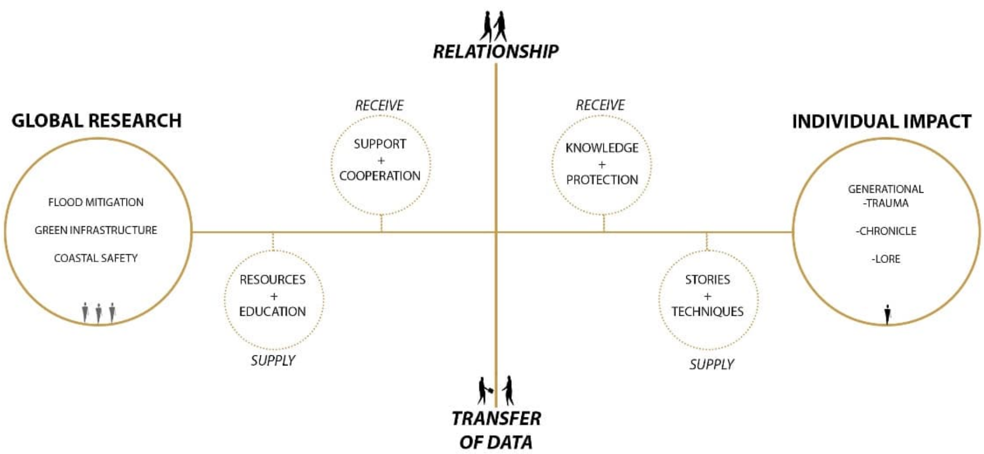


Figure 7 – Data Correlation (2023)

To reinstate, the permanent structure of Vista Mar allows for collection and processing of techniques in flood mitigation, implementation of green infrastructure, and overall coastal safety; this supplies resources and education, as shown in Figure [7]. In comparison, the individual impact acknowledges generational trauma, lore, and chronicle, and supplies stories and techniques.

Through this relationship, the education of many provides knowledge and protection, in exchange for the support and cooperation of one.
Through this transfer of data, this proposal bridges the gap of generational knowledge, geographical distance, and the understanding of complex research through tangible experience.

References

[1] Reonomy. “Urban Waterfront Revival.” reonomy.com, June 11, 2018. https://www.reonomy.com/blog/post/urban-waterfront-revival.

[2] Merriam-Webster. Merriam-Webster. Accessed December 12, 2022. https://www.merriam-webster.com/dictionary/redevelop.

[3] Pallasmaa, Juhani. The Eyes of the Skin. Chichester: Wiley, n.d.

[4] “The Taíno - Puerto Rico's Indigenous Ancient Culture: Taíno Life, Culture, & Art.” Taíno Life, Culture, & Art - The Taíno - Puerto Rico's Indigenous Ancient Culture - LibGuides at LIU Palmer School of Library and Information Services. Accessed December 16, 2022. https://liupalmer.libguides.com/c.php?g=1133797&p=8275637#:~:text=The%20Ta%C3%ADno%20were%20an%20indigenous,%2C%20Jamaica%2C%20and%20the%20Bahamas.

[5] Britannica, T. Editors of Encyclopaedia. "Arecibo." Encyclopedia Britannica, December 2, 2020. https://www.britannica.com/place/Arecibo.

[6] Bureau, U.S. Census. “U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates.” Explore census data. https://data.census.gov/table?tid=ACSDT5Y2020.B03002&g=1600000US7203368.

IDENTITY: PLACE-MAKING WITHIN THE URBAN ENVIRONMENT

Merlina OPERTA*, Nancy CLARK, Jeff CARNEY

University of Florida School of Architecture
85 Reeding Ridge, 32225 & Jacksonville, FL, United States of America;
merlinaoperta@gmail.com

Abstract

Place-making can serve as a driver to regenerate identity with the urban environment. The identity of a city is formed by the shared values of the residents that live within the city boundaries. These values form through frequent connections within their environment. These connections are facilitated through place-making. Cities are formed by historic layers of micro-interactions that come about because of place-making.

There are a variety of scales of identity that weave together communities and the urban fabric. There are some cities that struggle with the consequences of the post-economic growth of the 20th century. The main urban consequence is the lack of civic spaces, which would provide the opportunities for people to interact with one another. Recent contemporary projects often lead to the gentrification and displacement of people and their spaces in favor of projects focused on economic and industrial growth. Cities prefer sustainable urbanism and more urban revitalization projects due to the consistent long-term growth rather than projects that require continuous reinvestments. It is visible in the selected case studies of urban revitalization how place is meaningfully made within the projects. There is also the acknowledgement of how people are treated, and identity is regenerated. Effective projects integrate the different layers of scales for these interactions to occur that connect across the urban fabric. Through interactions overtime, the urban environment becomes a cohesive expression of various identities, and eventually will continue to self-regenerate the urban fabric.

Overall, studying how place-making expresses itself within the city is essential to understanding how the environment is influenced both consciously and unconsciously by the people. By studying these interactions, hopefully buildings and urban interactions build on each other and influence the morphology of the city and return people to civic spaces requiring less conscious intervention in the future. It is important for new proposals to focus on solutions that address the specific needs of the community and site to regenerate activity and use.

Keywords

Identity, community, cities, place-making, revitalization

1 Introduction

Cities are the overall reflection of how people create a tangible relationship to the site. The city is a network of connections between places and spaces, and their ability to interact and establish themselves within the urban fabric and environment. The layering of these different networks creates moments of collision building up layers of micro-interactions. Sometimes districts, towns, or city centers may lack the activity that other cities may have. In American urban morphology, cities begin at an established center. We can see in a few American metropolitan cities today that this center is often replaced in favor of new “modern” buildings, and barely have remnants of the original historic buildings and street layouts. The relationships between architecture and spaces within the city can communicate the way it may be inhabited, altered, or transformed. The urban fabric is not just the building but the way that architecture can shape the urban fabric to continuously generate activity. The American morphology integrates highways along the edge of cities and may cradle the center of the city. The highway, like a railroad, is divorced from people until it reaches a destination. The pedestrian language of a city is much slower than the speed of the highway. The morphology of the American city developed into a much faster spatial experience which conflicts with the slower needs of historically pedestrian urbanism. In doing so they may end up erasing pieces of their history that tie them to their site. When people interact with their environment it is a form of adaptation. They transform the site to suit their needs and the site reacts in response, creating many layers of place-making. The way that people approach the site creates a small-scale relationship that adds to the larger scale of how the city creates a relationship with its site.

2 Identity within the City

A city is a large-scale act of place-making. Place-making embodies the tangible and intangible aspects of the site involving people, site, and culture. [1] According to Edmonds, the significance of a place for humans lies in the ability to occupy a space, there is a need and a purpose that is communicated by the intent of a design. [2] Architecture is a form of place-making that is born out of a need to solve that need. This architecture then generates other forms and place-making to take place around it. Architecture exists as a tangible play between site and need, it is the articulation of idea, of life in the spaces. [3]

Identity is the measure and linkage between place-making and tangible form. [1] Our identity becomes our sense of self and the ability to relate the self to the community. The self-identity of an individual is a way to relate to a larger group and identify with others through shared values. The shared common values find themselves in the creation of a shared space. This space is a social construct that provides a place to create relationships between the self and the community. [4] Public spaces provide the spaces to allow one to build and interact with others based on societal values. [4] The associated identity with a place is expanding, layering, and varying between individuals.

Community is a shared sense of identity, of social values between individuals. A community is often localized to a specific area. It can conceptually exist as something as small as a neighborhood but can exist as large as a group sharing international borders. [2] Community is dependent on small-scale identity interactions through shared spaces that promote societal values. Community is where gathering happens. It is tied to the feeling of being connected and to the ability to connect with others. As long as there is an interactive human scale then the layers of small-scale interactions can occur to build community. [5] The community acts as the middle scale in the city that connects the individual to the larger scale.

The urban fabric (urban morphology) exists in three types that depend on the form of transportation. [6] The walking city relies on walkable access, these cities had a high density, with an organic form that is adapted to the landscape. [6] This form is most often found in the center of Old-World cities. The transit city allowed for the gradual expansion from the walkable center made possible in the 1860s by trams or streetcars. [6] The third form is the automobile city which accelerated post-Second World War. [6] The technology of the time—the automobile and highway system—alongside urban planning ideas, like those of Le Corbusier, allowed for a more rational organization of cities and zoning. This leads to the modern issue of urban sprawl because of the ability to expand the city further.

There seem to be three scales of identity: the individual, the community, and the society. The interactions between individual identities build up the community. When we think of the identity of a city it is a culmination of everything within its boundaries. It is true but can also change due to external influences. The identity of the people within its borders and their values defines the medium-scale identity of the city. The formation of buildings and spaces become overlapping physical expressions of identities. [7] Viewing a building as a photograph is often different than experiencing the space created by it and within it as it evokes a certain feeling. [7] We often see the overarching societal identity lay the groundwork for the development of a place. It is a national identity, regardless of place, that provides the values. The main issue with highways is that they divide the cities' medium-scale identities. Often isolating individual identities, preventing the middle scale to connect to the overarching identity of a city. This leads to the frequency of urban renewal and the city must constantly create a new space that will attract individuals. [8]

3 Case Studies

3.1 Eco-Urbanism

The Cheonggyecheon Stream underwent a revitalization that transformed it from being forgotten into a large-scale urban revitalization for public use. I think about how water is so important to cities, to civilizations, and how cities normally found themselves around a water source. This stream was historically a part of people's everyday lives. There would be houses lining the edge of the river, a path, and a bridge to cross the stream. During Seoul's automobile expansion, the stream was covered up by a highway, as shown in figure 1. After the stream became hidden and forgotten, any spatial or cultural connection to the stream was also lost because of the inability to access it. The surrounding area was paved over, the houses were pushed back to allow for larger streets. It was a complete erasure of centuries of place-making. The stream was hidden away in favor of the economic and population expansion that occurred in Seoul. The restoration and revitalization of the stream re-establish the stream but promotes it further as an experience in people's lives. It is not just a stream that people can only walk by. Trees and plants provide habitats for fauna, insects, and people. These spaces bring people closer to the water, provide shade under the canopies, and provide a moment of pause in a dense and busy urban area. The revitalization reshapes the space as one for the people, not just cars, and allows for micro-interactions that help to further shape this place.

Figure 1. Seoul Cheonggyecheon river. WWF.

Seoul saw a population increase after the Korean war ended in 1953. South Korea was recovering from war and had a historically small population. The existing infrastructure could not handle the sudden growth of the 20th century. Cheonggyecheon stream was part of a constructed water infrastructure of the old city limits which is now the old city center of Seoul. As seen in figure 2, women and children would gather at the banks and do chores like laundry. We see this in many cultures where water intuitively becomes a place of gathering.

Figure 2. Laundry and bathing in the Cheong Gye Cheong.

The stream was a place for micro-interactions between people and was valued mostly for its usefulness but also as a generator of activity and conversation. After the population boom of Seoul, the stream had to serve more people. The river became more of a sewer system than for gathering and chores. The increase in people lead to an increase in housing which lead to slums lining the banks of the stream as well as increased pressure on the sewer system. With such a large population the central stream became heavily polluted. The stream was unable to naturally grow and adapt to the population growth and no changes were made to the existing infrastructure. In a twist, perhaps the population was also unable to adapt to the stream. Rivers and other sources of water can hold some importance in different cultures and societies. When we imagine the city as a gathering of people, there was an influx of new people with different identities and values and how they spend their time. The stream was underdeveloped and required a specific purpose to be there or to pass by there. In the 1960s-70s Seoul began its automobile expansion. The first and most common solution at the time was to cover it up with a highway. A highway system and urban expansion are the 20th-century markers of economic growth, but these can also be considered gentrification. It is debatable if this was intentional gentrification, or if the city thought they were solving a public health issue by removing people from a site with such a poor quality of living.

The Cheonggyecheon stream restoration plan, shown in figure 3, envisions the stream as a corridor of eco-urbanism. Eco-urbanism reintroductions ecology and mimics natural systems. The reintroduction of vegetation increases insect and animal populations by providing habitats, food, and water. The inclusion of vegetation, such as trees, and water helps to create shade and reduce exposed asphalt and sidewalks which contribute to the heat island effect. The project also functions as part of the infrastructure by catching runoff water and redirecting it to a water plant where it is treated and pumped out into the stream which connects to the Han River. Much like wildlife, people also seek to relax under the trees and by the water. The ecosystem is a much-needed relief in a dense urban environment that usually lacks trees.

Figure 3. Conceptual site plan presented in 2002 by the Research Center Director of the Seoul Development Institute. Seoul Metropolitan Government. 2002.

The stream starts from the old city center and connects to the Han River. In figure 3, the river looks like a sea of blue and green bursting at the seams of the urban environment. The bridges almost look like stitches trying to hold the urban landscape together. Rivers can be viewed as links or divisions in the landscape. A river is a place itself, where people gather, where cities gather as seen in Figure 4. This stream was man-made and served as part of the sewage infrastructure. With the tactics implemented by eco-urbanism, the stream is now a beautiful place for the public instead of a public pollution problem. The way the stream served the city, now serves differently and arguably much better than it did before.

Figure 4. Yonhap News. Seoul. 2022.

The stream creates a continuous place through the city that works on a larger scale. It connects neighborhoods across the city. Working backward we can see this river unifies medium-scale communities, such as the high-rise blocks. On a smaller scale, the river also provides space for individuals to connect with each other and create place. Before the highway, the river may have been a spot that few people would willingly venture into the water for. During the highway, the river was inaccessible and only served those with cars. After the revitalization and providing walkable surfaces and shade a way where many more people can comfortably interact with the water. The stream has become more integrated into the city and becomes more than just infrastructural. The stream reclaims its ability to gather people and host interactions between people. It creates interaction between people and the environment.

3.2 Palimpsest

A city is composed of an urban fabric that is consistently growing and changes over time. It is a continuous cycle that is made up of new and repurposing or renewing the old. We can look at the plan of a city and observe what used to be. In this way, architecture becomes a palimpsest. A palimpsest is a manuscript or piece of writing material where the original text has been scraped or washed off so the page can be reused. However, the traces of the original text and ink may remain. Palimpsest in urbanism is an erasure of something that existed before but traces of what existed before remains. An architectural palimpsest can find itself in many forms, bricked up windows, a building whose shape is added onto and changed, an adaptive reuse project, or the footprint of a building that is torn down but becomes a civic space. Figure 5 is a palimpsest analysis of Oslo Harbor.

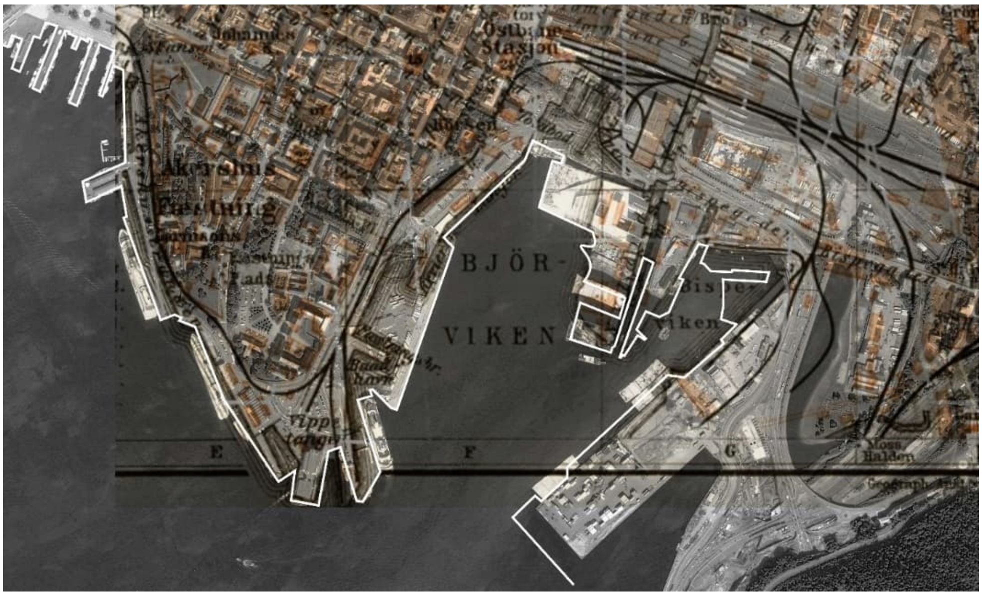


Figure 5. Palimpsest of Oslo Harbor.

The Oslo Opera House by Snøhetta is built on the Bjørvika peninsula as part of the harbor as shown in figure 6. The harbor is what historically connected the city with the rest of the world. The harbor industry carved out the coast and created the docks that jet out into the water. The harbor sits on the threshold between land and water, between the city scale and the international scale, between past and present. In figure 5, we can see the axis leading from the harbor into the city. The harbor was important to the growth of the city internationally and economically. Eventually, the harbor fell out of use. Much like a palimpsest, the harbor was erased but what was left was a vacant lot, the remnants of the harbor boundaries, and the connection to the harbor. The connection of the city that for so many centuries revolved around the water leaves behind a port near a station that is near other public services such as a library. The importance of this era is very much ingrained in the local form. There is an almost rationalized nature of squares that compete with the angles of the harbor and the docks that jet out into the water.

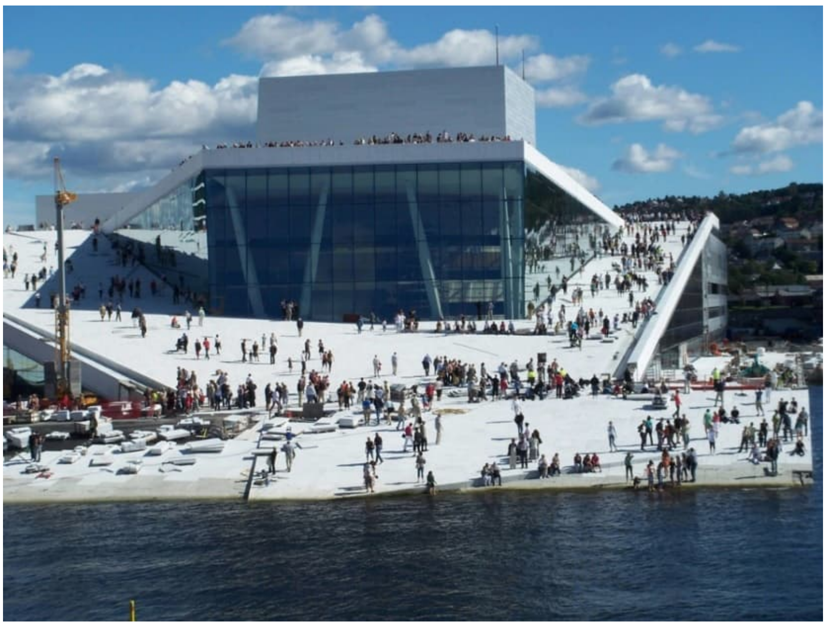


Figure 6. "The Carpet." Oslo Opera House. Snøhetta.

The Northern Scandinavian countries have a historical relationship with water. The first thought is an image of the fjords and their reliance on water for trade and food. This project has a very important job to act as the bridge between the city and the water and to respect the history of the site. The building provides opportunities for people to interact with water. The form seems to almost dip into the water and blurs the edges between land and water. When snow piles up, the sheets of snow and ice slip off and float away in the water. This gives me a sense of nostalgia for the boats that use to float and sail through this harbor and the glaciers during winter. Whether the snow slipping into the water is intentional or unintentional, there is a relationship between architecture, identity, and site which creates a very nostalgic event. The site is a palimpsest of edges, footprints, and water. The site of the building occupies the water's edge but the building itself pulls back. The site is not being on the water, the site is the experience with water. The sloping roof and the path around the opera house create a space for the people to gather in the harbor, as seen in figure 7. Shown in figure 8, some benches are slightly raised from the ground for people to sit. The roof itself is sloped enough so people feel that they can sit. In figure 9, the edges of the roof become the ground that meets the water's edge and blends seamlessly into them. It looks as though it is only where the roof touches the ground, that it people can access the water without a wall. The ground is not steep but looks like a concrete beach with people sitting on the edge and interacting with animals.

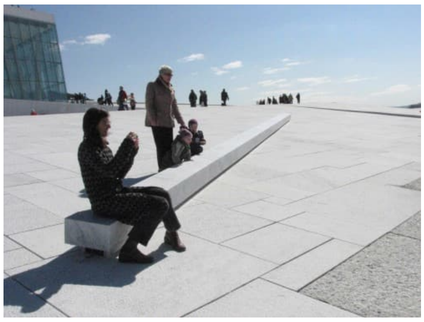




Figure 7. People walking along the water's edge. Snøhetta.; Figure 8. People sitting on the roof of the Opera House. Snøhetta.; Figure 9. Visitors interacting with local wildlife. Snøhetta.

This project is meaningful as it addresses the past of the site with a public program that aids in the activation of the waterfront space. The water and the harbor were considered the lifeblood of the town because of international trade. The opera house still retains this "public" program that everyone is allowed to access either visually or physically, rather than privatizing the space. The harbor is a resource of interactions and reflection. The relationship of the city to the site and the historical importance of this site for the town are still present in this new building. It is about this water connection, people walking across the harbor but now for a different reason. This is the layering of place. The way I think about this space, the original space's purpose was not because of economics, it was a space for interaction, between boats, people, cities, countries, and businesses.

3.3 Ad-Hoc + Tactical Urbanism

This project transforms an abandoned tramline in Turin into an urban park. This park was created as a temporary recreational space during the pandemic but has since become a permanent park. The term Ad Hoc means "as needed" and this project embodies a need. Many cities have some form of vacant lot. There are more vacant lots in some cities than there are in others. However, these vacant lots in the city can be transformed as needed to suit additional needs, as seen in figure 10. During the Covid pandemic, there was a need for more space, and ironically it was so the people could not gather so closely or interact within a certain distance. This led to a search to be able to occupy whatever space there was outside, to take over any lot.

Figure 10. Torino Stratosferica. Procollinear Park. 2021.

The way this project came about speaks to the creative solutions to a problem, that any lot in a city has the potential to become a building or a spot to gather. Although the other case studies are large in scale and examples of buildings, the act of place-making is something that can happen anywhere. Tactical urbanism is the approach towards neighborhood building using short-term, low-cost interventions to catalyze change. These can be innovative solutions that are a direct reflection of the people who are making the space. We see in figure 10 and figure 11, how the lot is now occupied by pedestrians, bicyclists, and even a restaurant with seats for anyone who decides to stop in the middle of the street.

Figure 11.Torino Stratosferica. Procollinear Park. 2021.

Historically city streets were walkable and were meant for people and carriages. There was not much change to the streets when trams and electric cars were introduced. There was still the ability to walk in streets and trams only moved at a slightly faster pace than people. With the introduction of cars, people were displaced from the streets and moved to the sidewalks. Cars were faster, changing the pace of the streets and changing the language of the streets. The site was originally a tramline that was conveniently located in the middle of the street. After the popularity of cars, the essential tram line became a vacant green lot in the middle of traffic. Finally, it became a recreational island, a moment of pause in the middle of traffic. Through ad hoc and tactical urbanism, this vacant green lot was reclaimed as part of the urban fabric, rather than a remnant of what used to be there. Perhaps this transformation of the site begins to inspire other green lots to take this form. Hopefully, these small intimate pauses in the middle of heavy traffic that is being reclaimed will become popular with the community. Does this area become a noticeable embodiment of values?

3.4 Temporal + Reprogramming

One of the events that occur under the Fuller Warren Bridge on the West Bank in Jacksonville, Florida as shown in figure 12. This is temporal urbanism combined with reprogramming. Temporal urbanism is the short-term use of vacant or public spaces, such as festivals or markets. Reprogramming is the repurposing of existing infrastructure or public space for contemporary needs. This temporary reprogramming allows people to reclaim the space and use it as they see fit, the ability to unite under what used to divide.

Figure 12. Jacksonville Arts Market. 2021.

This event is the Riverside Arts Market. Another example of unintended place-making, like the previous example. In this case, an event, a bustling art market is located under the highway. On other days of the week, there may be a variety of different events that vary from the market or even an enjoyable sitting area for locals. The highway creates shelter and boundaries that set the rhythm for the stalls, for the paths. One of the main arguments for removing highways is that they take up valuable urban plots that can be necessary for the continuity of the urban fabric. The effects of the first introduction of highways were the division of communities through racial and social status. The Arts Market is not permanent and disappears during weekdays. However, the spatial organization is flexible and communicates how the space can adapt and change and reflect the interaction between people. This event as well as others occur in this space adapting it to their use, a constant reshaping of spaces.

Why would something like temporary reprogramming need to happen? Reprogramming in urbanism is a natural cycle that adapts a program to newer contemporary cultural values. The city develops and reflects the values of the people that live within it. This growth builds upon a site adding layers of historical interactions. The urban fabric is a generator for the continuous use of space. In downtown Jacksonville, there are many parking lots, green lots, vacant lots, and some abandoned buildings. These open spaces can cause fragmentation in what should be a continuous stream of activity and interactions between people. Reprogramming allows for the urban fabric to continue serving the needs of the people and adapts to the constantly changing social values. In places where it might be difficult to propose a long-term plan or where there are many open lots, locals can adapt the space to suit their needs temporarily, as seen in figure 13 and 14. By using temporal urbanism one site can serve many purposes and allow for that site to continuously add to the layers of interaction in the city.

Figure 13. Produce stands at the Market. Carrie McLaren. 2022.; Figure 14. Live Music at the Market. Claudia Garcia. 2016.

Highways are seen as divisive as they erase a strip of the urban fabric that connects the city. The urban fabric is connective and communicative at the small and middle scale, and at a much slower speed than the highway. The highway is on a larger scale and at a higher speed than people. Then there may become a North and South, or East and West, side to the highway. Immediately there is fragmentation. However, the occupation of the space under the highway re-establishes the connection and treats the highway as part of the architecture, rather than a wall. This is why it might seem odd that space under a highway is the perfect location for markets and festivals. However, in this climate, the highway provides shade from the sun, shelter from the rain, and breezes and views from the nearby river. From an architectural standpoint, there are two swaths of uninterrupted lots under the highway that are cut by a street that allows attendees to load up immediately next to stalls and either deliver items or take them home.

Acknowledgements

The organizer gratefully acknowledges the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2022 for efforts done for the success of this event.

References

[1] Eckler, James F., Subway Urbanism, Masters Thesis, University of Florida, Gainesville, United States, 2008.

[2] Edmonds, Angelique, *Connecting People, Place and Design,* Intellect Ltd, Bristol, Australia, 2020.

[3] Zumthor, Peter, *Thinking Architecture,* Birkhäuser, Basel, Switzerland, 2010.

[4] Knox, Paul and Pinch, Steven, *Urban Social Geography: An Introduction,* Taylor & Francis Group, London, United Kingdom, 2009.

[5] Burke, Stephen, Placemaking and the Human Scale City/Project for Public Spaces, https://www.pps.org/article/placemaking-and-the-human-scale-city.

[6] Newman, Peter, and Kenworth, Jeffrey, *Sustainability and Cities: Overcoming Automobile Dependence*, Island Press, Washington D.C., United States, 1999.

[7] Davis, Diane E., and Libertun de Duren, Nora, Cities and Sovereignty: Identity Politics in Urban Spaces, Indiana University Press, Bloomington, United States, 2011.

[8] Marris, Peter, A Report on Urban Renewal in the United States Part Two: Renewal and Relocation – Urbs and Suburbs: Section 10, *Urban Condition: People and Policy in the Metropolis*, *1,* (1963), 113-34.

THE LIVING BRIDGE

Fernando DE AGUIAR*, Albertus WANG, Lisa HUANG

University of Florida School of Architecture – UF SoA
95 E Magnolia St, Oviedo FL, 32765; deaguiar2705@gmail.com

Abstract

This research is an exploration of how the bridge can be reimagined as an architectural typology to create new urban spaces and to take back pedestrian connective spaces through a symbiosis with the automobile as well as expand the programmatic activity of the city. The aim of this project is to investigate the historical use of bridges and how they can be designed as an extension of the activity of the city. The bridge can be used as a spatial form that initiates deeper connections within or around the city in areas which lack a connective layer to improve the pedestrian interaction. This brings about connections that link sectors of the city which otherwise had little dialogue in the human-scale. In order to further diffuse the overcrowding in the inner city the bridge would incorporate commercial elements of its own.

The bridge as a typology has always been defined by one program; circulation. The idea of a bridge is to connect between two points usually above the ground which facilitates the fast travel between these points. Historically, bridges like the Ponte Vecchio in Italy had been built specifically for pedestrian access with shops and vendors along it. These bridges were imbued with a dual-functionality and in this way gave greater importance to the usage of it. This proposal begins a dialogue about how architects can reimagine the purely engineered structure of the bridge and establish a proposal for an inhabited bridge within an urban setting.

This inhabited infrastructure project would bring about new layers within the context of Philadelphia to enable a catalyst for activity and further urban growth in the Central City neighbourhood. Many of the inhabited bridge precedents had their structures built over a river, but with this site being within the urban fabric of the city, there is a deeper dialogue to understand what is underneath and around this elevated bridge element. A key theme of this project is the spatial reaction to the bridge, an elevated street, and the elements which inhabit the suspended program. This proposal would be both a physical and social connection within the urban context to serve as not only a transitional space but also a destination in order to further stitch the community together.

Keywords: circulation, inhabited-bridge, dual-functionality, infrastructure, linkage Topic: T6 Urban Ecology and Climate

1 Introduction

As cities grow and populations increase many bridges become an element detached from the activity of the city solely for the purpose of automobile traffic. The pedestrian interaction has been set to the peripheral and the vehicular interaction has become the prominent source of circulation through cities. The task is to inject human occupation to a city dominated by the vehicle while addressing aspects of the inhabited bridge that bring commercial programs to a city in need of usable space. The goal is to look to the reinvention of the historical inhabited bridge to inform a new understanding of what a bridge can be and accomplish in cities. The inhabited bridge as defined by Jean Dethier is a structure which "in addition to its primary function of surmounting natural or man-made obstacles, be they rivers or canals, railways or motorways- serves as an organic link between two urban areas by connecting them to each other with a development of buildings erected on the bridge deck to form permanent accommodation for various social and economic activities"[1]. This thesis thus asks the question; How can the bridge be designed to extend the communication at the human scale through pedestrian interaction and public programs?

About 80% of the U.S. lives in urban areas and this continues to grow every year[2]. The growing numbers of activity place a greater burden on available space within urban environments. This dwindling buildable space in urban cities puts a burden on the architect to design taller or to begin expanding outwards from the periphery of the city. Density in the urban setting is crucial in the way that it keeps the activity at the city center. As new elements of the city begin expanding outwards this diminishes the activity of the inner city. This diminished activity affects the city economically by initiating a decline in the use of city center programs, thus it is crucial to analyze the inhabited bridge as a typology that can create a structure for new programmed public spaces in the inner city.

Another key element to the city is its pedestrian interaction. There are many factors in cities that have led to the diminished use of pedestrian space in cities including factors caused by the automobile, urban sprawl, and urban density. Urban sprawl has been characterized as "the lack of continuity in expansion" and is inefficient because "it increases transportation costs, consumes excessive amounts of land, and adds to the cost of providing and operating public utilities and public services"[3]. This has led to cities being designed to prioritize the car at the expense of the pedestrian. The continuous polluting of our ecosystem is driven by the use of the automobile, which has been shown to be one of the largest contributors of pollution. By encouraging the idea of a walkable city, inhabitants can begin to have a positive impact on the environment as well as create an active lifestyle. In order to address these issues, taking a deeper look at the connective infrastructure of cities is necessary. Before the integration of the vehicle, bridges were seen in historic civilizations as an extension of the city.

---

[1] Peter Murray et al., eds., *Living Bridges: The Inhabited Bridge, Past, Present and Future* (London : New York: Royal Academy of Arts ; Prestel, 1996).

[2] Stephen Malpezzi, "Population Density: Some Facts and Some Predictions," *Cityscape* 15, no. 3 (2013): 183–202.

[3] Richard B. Peiser, "Density and Urban Sprawl," *Land Economics* 65, no. 3 (1989): 193–204, https://doi.org/10.2307/3146665.

2 Literature Review

The Bridge as a Structure

Bridges are defined as structures with the single function of supporting loads across an obstacle which could be a river or even another land mass. The Greeks built the first recorded bridges dating back to the 13th century. The Romans improved on the engineering and infrastructure that the Greeks created for the bridge, even using these techniques for the aqueduct. As engineers began specializing in the construction of bridges, they were challenged to design these structures across larger and larger spans. The carrying capacity later increased rapidly with the need for horse drawn carts and later automobiles to transverse the bridge which later led to its evolution into other structural forms including the arch, truss, suspension, cantilever, and even cable-stayed bridge.

The Bridge as an Idea

The bridge revolves around the concept of connecting two sides which lack a dialogue. The concept of the bridge, as written by Thomas Harrison, illustrates that a bridge is a "meeting place which paradoxically highlights the distance and difference between that which cannot ever be fully united."[4] Differences enrich human life and through connection, these differences are understood. An idea of a bridge can thus be interpreted as language which bridges the thoughts of mankind to an understanding. In this way, the bridge is thus a powerful liminal space which is capable of not only transversal but also connection and understanding. Thomas further points out that a bridge "does not neutralize the differences between the shores and peoples that it links. It creates no synthesis …."[5] This forms the thought of being "separate but united" depicting the bridge as being capable of easing the divide in thought among people while not forcing any one homogeneous outcome. Thomas's writings of the bridge can be understood metaphorically as an outstretched hand, joining communities together. The translation of concept to structure is the inevitable outcome for this proposal. This idea begins to inform how the city and its communities can be stitched together. The bridge using these metaphors, is seen as an extension of the city, not merely an object on its landscape. The dilemma, as depicted by Harrison, is one which resolves the question of "how to respect the eternal apartness of things while making them dance together."[6] In the same way walking over a bridge is like walking above the flowing power of water, "life itself is a bridge over death." This space above water is thus a profoundly symbolic spatial entity that can become the interstitial space that weaves communities together.[7]

The Walkable City

In the past decade, numerous environmental, social lifestyle, and economic effects have resulted from widespread vehicle ownership. As a result, the pattern of movement has shifted

[4] Thomas J. Harrison, *Of Bridges: A Poetic and Philosophical Account* (Chicago: The University of Chicago Press, 2021).

[5] Harrison.

[6] Harrison.

[7] Harrison.

from a mode of transportation that is focused on moving people to one that is focused on moving vehicles. Walking is a people-centered method of transportation that is the least harmful to the environment. It also has a significant impact on the creation of urban settings that effectively promote social contact. There are several issues in relation to the importance of walkability in cities, including the following: “rapid urbanization results in city designs that give pedestrians little priority; pedestrians are denied access to pedestrian friendly streets; and lack of awareness of the factors that impact walkability.”[8] New York City has already taken steps to bring pedestrian interaction back to the city with their program called “pavement to plazas” where they temporarily “used a section of a mostly underused street or square as public space, while making it inaccessible to motorized traffic.”[9] As a direct result of this program, the importance of public pedestrian connection spaces was understood leading to more plazas being added to different sections of New York City. After these public spaces opened, the city immediately saw a surge of new economic development in the surrounding area.[10] In this way, when cities create spaces for the encouragement of walking this strengthens the community and economic expansion, making public spaces a direct catalyst for these outcomes.

Along with these issues it is understood that with the prominence of the vehicle, much of urban life has become dependent on the machine leading to a passive lifestyle and higher cases of obesity across developed areas. Being part of a walkable city has many economic advantages but a key element of this initiative is encouraging an active lifestyle. The creation of a walkable weaving of the city thus promotes not only an increase in business activity resulting in increased capital for the city, but also improves the quality of life for the entire community.

OMA designed a project called the 11th Street Bridge Park directly correlating to the idea of weaving two districts of a city together thru a connective tissue and promoting the increase of business activity. Located in Washington D.C., this project works to connect a long-divided city by encouraging residents from both sides of the Anacostia River to begin a dialogue where two communities become one. Based on previous studies found by the city, access to green spaces such as parks and green spaces have a direct impact on promoting a healthy lifestyle but also increasing social capital. By bringing commerce to this space, the surrounding commercial centers like shops and small businesses also begin to see increased support and commerce, further building the surrounding community. This inhabited bridge thus becomes the catalyst for the improvement of the city.

Automobile vs. Pedestrian

Individual motorized transportation is dominating urban areas bringing with it problems including traffic accidents, noise pollution, and air pollution. Cities were initially designed for the use of pedestrians, but through the decades the vehicle has become intertwined in the

[8] Siti Fatimah Ilani Bilyamin, Mohammad Hussaini Wahab, and Khairul Hisyam Kamarudin, “The Key to Be a Walkable City,” n.d., 8.

[9] Luca Bertolini, “From ‘Streets for Traffic’ to ‘Streets for People’: Can Street Experiments Transform Urban Mobility?,” *Transport Reviews* 40, no. 6 (November 1, 2020): 734–53, https://doi.org/10.1080/01441647.2020.1761907.

[10] Bertolini.

fabric of the city in a way pushing out the regular pedestrian. The automobile has displaced the pedestrian as a means of experiencing the city. After the introduction of the automobile some cities like Phoenix, Arizona even began to design solely for the use of vehicle. Urban cities have now come to an understanding that expanding spaces for the encouragement of pedestrian interaction is beneficial in many aspects of the urban city. City planners and politicians from all around the world struggle with the challenge of separating the need for mobility from calls for more livable communities. Based on studies done by Delbosc and Currie, it was found that the percentage of people with driving permits was declining in several developed nations, increasing the possibility of a reduction in young adults' commitment to their cars.[11] These studies show that pedestrian travel will become more prominent in years to come.

Much of the transportation infrastructure in almost all cities is dedicated to the automobile. This is an issue because the "private car is the most space-intense transport mode."[12] Even with this understanding, "city planners are advised never to argue against the car."[13] Rather than create disadvantages to the automobile, cities can create ways of making pedestrian travel more advantageous. Bauman analyzed that "SUV number growth in the USA reflected fears of an outside environment perceived as dangerous"[14]. Based on this reflection, when advances have been made against the vehicle it has been seen as a personal threat as they interfere with psychological needs of feeling safe and secure. Therefore, the first guideline of any communication plan is to never argue against the car—directly or indirectly. Based on this understanding, Copenhagen has found a successful transformation into a bike city based on a positive advertising plan that never referenced automobiles or environmental concerns such climate change. It instead emphasized the advantages of bicycling, such as faster average speeds and improved health. Another positive example is Barcelona's car-free superblocks. The fundamental concept is to designate a 3 × 3 grid of nine city blocks and limit vehicular traffic to the streets surrounding the grid. The inside roadways free up public space for riding, walking, and creating more green space. In high traffic urban cities like New York, which are already dominated by car traffic, it is obviously counterintuitive to simply start "carving up" roads for pedestrian connections. The key is to find a solution that is "transformative, yet not socially disruptive."[15] The increased pressure applied to urban spaces created from expansion of automobile infrastructure is the main issue. In order to reintroduce a positive pedestrian interaction and connection of these spaces, urban cities must find ways to release this pressure.

The Pont Jean Jacques Bosc Bridge is an example of a bridge which intends to solve the issue of automobile dependency by beginning a dialogue where the automobile and pedestrian are in symbiosis. This project revolves around the idea of creating a space where the pedestrian and automobile experience work in connection without one dominating the other. The 11th

[11] Alexa Delbosc and Graham Currie, "Causes of Youth Licensing Decline: A Synthesis of Evidence," *Transport Reviews* 33, no. 3 (May 1, 2013): 271–90, https://doi.org/10.1080/01441647.2013.801929.

[12] Sean Scanlan, "Zygmunt Bauman, Liquid Times: Living in an Age of Uncertainty," *Journal of American Studies* 43, no. 1 (April 2009): E19, https://doi.org/10.1017/S0021875809006513.

[13] Scanlan.

[14] Scanlan.

[15] Stefan Gössling, "Why Cities Need to Take Road Space from Cars - and How This Could Be Done," *Journal of Urban Design* 25, no. 4 (July 3, 2020): 443–48, https://doi.org/10.1080/13574809.2020.1727318.

Street Bridge Park in contrast being designed next to an existing automobile bridge values the pedestrian interaction with public gardens and commercial programs like the Ponte Vecchio in a modern form to create a link between two communities in Washington D.C. which had very little pedestrian interaction.

Urban Density Issue

Cities are becoming denser with less room for new public and community programmatic elements. The previous solution seemed to be to simply build higher to incorporate more programmatic elements in the city. From an article by Stephen Malpezzi, he analyzes a statement that “in 40 years, the average person will live closer to her neighbors and farther from the ground than she does today.[16]” Studies from U.S. Census found that “about 81 percent of the U.S. population is currently urbanized compared with 74 percent 40 years ago”[17]. Malpezzi further states that “during the past 40 years, the total U.S. population has grown about 1.1 percent per year, the urban population has grown about 1.3 percent per year, and the rural population has grown slightly more than 0.2 percent per year”[18]. It can be inferred based on this data that the U.S. is becoming more urban. With an average density of 50 pph (people per hectare) and a center density of 200 pph or more, New York City is the densest city. After 20 kilometers from midtown Manhattan, the density rapidly drops to 50 pph or less. [19] This data leads to an understanding that an expansion in cities is needed in some form. An ineffective way of doing this would be to expand the city outwards since this leads to urban sprawl which decentralizes the activity in the city. The goal is then to find a way of expanding pedestrian and programmatic spaces in the urban context without reducing the activity away from the core city.

The Inhabited Bridge

In his 1997 book, Peter Murray writes about the typology of the inhabited bridge by analysing its historical identity while depicting the importance it has for the urban context. Murray defines the inhabited bridge as follows;

> *In addition to its primary function of surmounting natural or man-made obstacles, be they rivers or canals, railways or motorways- [the inhabited bridge] serves as an organic link between two urban areas by connecting them to each other with a development of buildings erected on the bridge deck to form a permanent accommodation for various social and economic activities.*[20]

The typology of the inhabited bridge had its prominence in many European countries starting in the eleventh or twelfth centuries. These bridges were found in many regions but predominantly in England, Italy, and France. France has been recorded to have had more than 35 bridges of this type. In ancient times, many towns and cities were founded on river banks

---

16 Malpezzi, “Population Density.”

17 Malpezzi.

18 Malpezzi.

19 Malpezzi.

20 Murray et al., *Living Bridges*.

because being near water was essential to life and the spreading of goods and trade. When towns began to grow beyond their capacity, they would expand out onto the periphery areas, but the disadvantage to this was that they would be built far from the city centre so commercial access was limited. Located over a flowing river meant that this was a prime location for mills and local shops. Any vacant land was premium including the area above a bridge linking a town's river banks, thus the creation of the inhabited bridge emerged due to urbanization. Murray states that the inhabited bridge is different form a regular bridge in that it can "extend the intensity of activity generated on each bank, and become a destination in its own right."[21] Instead of being simply infrastructure, these bridges had a variety of commercial programs built on them like grocers, butchers, or even blacksmiths.[22] The inhabited bridge was built in ancient cities as an extension of the city but also for defensive purposes. In the case of a river siege, these bridges would be heavily guarded along its structure becoming a barrier.

Another key element of the inhabited bridge is its ability to self-finance. The Old London Bridge for example generated enough money from rent and tolls that it was able to leave an inheritance called the Bridge House Fund. The income produced totals more than $10 million annually for this bridge alone. These funds were kept in order to be spent on repairs, but the amount was enough to support many other charitable organizations as well.

Around the eighteenth century, changes in military strategy, along with the rapid growth of the economy and urban centers, not only exerted pressure upon cities to spread beyond their perimeter walls but also increased the volume of traffic passing through their roads, creating constrictions on free-flowing traffic. This later led to the disappearance of the inhabited bridge from common town-planning practice among historic cities. Bridges after this time began to have little to no commercial or residential component.

The inhabited bridge can create an organic connection between two existing communities, this relationship can spark growth of the other less developed community which would otherwise be isolated by the rest of the city by a physical barrier[23]. Modern bridges have had only one purpose, to carry traffic. This has become an increasing waste of resources in that land has become a premium for the city.

3 Precedent Review

This Precedent review will analyze some historical as well as current examples of the inhabited bridge. These case studies work to inform how these bridges were able to impact the city context.

The Old London Bridge

The Old London Bridge was historically the only bridge that connected the City of London to the south-east of England over the River Thames. There have been many historical bridges at this site since the time of the Romans with the first inhabited bridge dating back to 1201. The bridge later contained wooden housing, commercial shops, warehouses, and even a chapel. After the Great Fire of London of 1666, the bridge was destroyed and rebuilt with an array of

---

[21] Murray et al.

[22] Murray et al.

[23] Murray et al.

taller four-story homes erected with a causeway in between that stretched for 5-6m across. The bridge was then in use for over six hundred years until the year 1823 when it was demolished due to constraints within the city. The Old London Bridge encouraged “high density development” in its north bank and in the south bank had lighter style buildings.

Analysis

The creation of the Old London Bridge was established as a symbolic and triumphant figure for the city of London. Like inhabited bridges of the time, the form of the bridge follows the architectural style of the city surrounding it. Instead of having a fully connected row of housing and commercial elements, this bridge has areas of pause along its path where views can be experienced without the housing elements fully obstructing the view. These areas of pause are described by the architect as being defined as squares in the same way as the inner city established the condition of squares to encourage pedestrian interaction along busy streets.

Ponte Vecchio

The Ponte Vecchio (‘Old Bridge’) was designed and constructed by Taddeo Gaddi in 1345 to create a connection that spans the Arno River from the historic Roman Forum to the city of Oltrarno by extending the ancient *cardo* (Roman north-south oriented street) to the south bank of the river. These commercial elements along the bridge extend the activity of the city to the river. In this example, the bridge is no longer an independent element from the city, rather an extension of the fabric of the city. Within the city of Florence, the Ponte Vecchio is the best-maintained and most ideal illustration of the application of trecento logical architectural principles. Neoplatonic Boethian principles guided the idea of the plan for the bridge, which were familiar to all Florentine merchants of the time. This established order was essential to add to the city's pride and beauty, which the bridge's architect considered essential to maintain order within the city landscape. At the centre of the bridge is the piazza which spans the entire width of the bridge (19.1 m) giving unobstructed views of the Arno River. All measurements that make up the design of the bridge equal the ratio of 1:2 In ancient times. This would have been one of the few locations in Florence's small, magnificent centre where such a panoramic perspective would have been feasible due to the city's dense urban fabric. [24]

Analysis

The Ponte Vecchio bridge connects directly to the colonnade that continues along the river bank and seamlessly into the Uffizi galleries. The bridge acts as a distributor directing the passage of the pedestrian into the key elements of the city further bringing the interaction created at the bridge level into the city. In doing so, the Ponte Vecchio works to pull both sides of the river together expanding the public realm. Like the way the roots of a tree are anchored into the landscape, the Ponte Vecchio roots itself into the surrounded city. This connection establishes this bridge as an architectural structure no different from the many historic Roman buildings on either side of the river.

Ponte Di Rialto

[24] Theresa Flanigan, “The Ponte Vecchio and the Art of Urban Planning in Late Medieval Florence,” *Gesta* 47, no. 1 (2008): 1–15, https://doi.org/10.2307/20648957.

The Ponte Di Rialto or Rialto Bridge was first constructed between 1588 and 1591. The primary material used for the first iteration of the bridge was wood but based on the risk of the wooden bridge being destroyed by fire, the city decided to begin a proposal for a design of the Ponte Di Rialto built out of stone instead. After many years of proposals from the likes of Palladio, Sansovino, Vignola, and Marastoni, the Senate of Venice decided to appoint the building to the new bridge which would span the Grand Canal to Antonio dal Ponte. The design that the Senate envisioned was based on a proposal from Vincenzo Scamozzi, one of a bridge with a central passage of travel between rows of commercial shops with walkways along the back of the shops towards either side of the river with a portico built in the middle. This would allow for views to both ends of the river while still having a commercial aspect of activity at the bridges centre.

Analysis

The Rialto Bridge has three primary traffic lanes; one pathway through the centre of the bridge to encourage the use of the commercial shops, and two other pathways on the left and right of the bridge primarily for pedestrian circulation. This spatial understanding poses the idea of separating the usage of the bridge into pure circulation and programmed elements. The user decides whether they would experience the bridge as an urban public square or as a pathway connection into the city. When experiencing the bridge through its inner pathway, the bridge can thus be seen as an element completely removed from the fact that it is a suspended structure over the Grand Canal, defining its usage ethe same as any other local street in Venice. The circulation from the bridge extends directly into the public square of the Campo San Giacomo di Rialto which brings the usage of the bridge into experiencing more of the inner city weaving the interaction to the surrounding area.

Comparison

The Rialto Bridge, unlike the Ponte Vecchio bridge, allows pedestrians to circulate the bridge on either side of the shops. This is done through walkways on the sides of the bridge giving unobstructed views of the city form the Grand Canal, which is something only available in the Ponte Vecchio within the central piazza.

Project Proposal

Philadelphia, Pennsylvania

One of the core themes of this proposal is the reuse of obsolete urban infrastructures to create an extension of the traditional street. A further theme is the spatial reaction to the bridge, an elevated street, and the elements which inhabit the suspended program of the project. The bridge will be inhabited, like the case studies researched thus far, containing building programs along an extended bridge element. The building-bridge will be designed in harmony with relation to the activation of the pedestrian level in the green corridor. Connection is one of the key themes in this research which carries into this site, specifically an elevated horizontal connection between three urban nodes. These nodes are identified as the Pennsylvania Convention Centre in addition to the Philadelphia City Hall at its south end, and a warehouse at its north end. The railway currently terminates in the north end at the existing warehouse, of which will be designed to be more than just a static storage place. It will transform into a multi-use facility containing programs such as stationary retail and rotating

markets. Not only will this be a hub for commercial activities and a public destination, but also a starting point to further connect to other urban nodes on the northern side of 676. Interstate 676 is currently dissecting the bridge from the north to south in between the convention centre and the abandoned railway line. The city-roads penetrate the interstate on the ground, but only for vehicular usage. The bridge will require a new connective layer that will begin at the warehouse, reaching to the convention centre and terminating at the Philadelphia City Hall. This connection will follow the original path of the railway, bridging these three nodes with elevated program as the main link between each, producing new layers of information above the existing history of the site. Many of the analysed precedents had their structures built over a river, but with this site being within the urban fabric of the city, there is a deeper dialogue to understand what is underneath and around this elevated bridge element.
This inhabited infrastructure project would bring about new layers within the context of Philadelphia to enable a catalyst for activity and further urban growth in the Central City neighbourhood. This proposal would be both a physical and social connection within the urban context to serve as not only a transitional space but also a destination in order to further stitch the community together.

The existing railway track is currently in disrepair from years of weathering and not being maintained properly. Aside from its abandoned nature, it is currently not doing anything for the city of Philadelphia except taking up viable building space. By activating this unused infrastructure element, the city can take back one of its important historical structures and adapt it to relate to the future as well as the past. Guided by this notion of adaptive-reuse, the bridge can begin to relate back to its history of connection by once more being a connective tissue for the Central City district. The idea to activate an abandoned railway network is not about the focus of speed in circulation, but rather a focus on creating spatial conditions that provide a pause within this historic infrastructure network.

References

A. Balasubramanian. “Bridges and Their Types,” 2017. https://doi.org/10.13140/RG.2.2.18109.46566.

Bertolini, Luca. “From ‘Streets for Traffic’ to ‘Streets for People’: Can Street Experiments Transform Urban Mobility?” *Transport Reviews* 40, no. 6 (November 1, 2020): 734–53. https://doi.org/10.1080/01441647.2020.1761907.

Bilyamin, Siti Fatimah Ilani, Mohammad Hussaini Wahab, and Khairul Hisyam Kamarudin. “The Key to Be a Walkable City,” n.d., 8.

Delbosc, Alexa, and Graham Currie. “Causes of Youth Licensing Decline: A Synthesis of Evidence.” *Transport Reviews* 33, no. 3 (May 1, 2013): 271–90. https://doi.org/10.1080/01441647.2013.801929.

Flanigan, Theresa. “The Ponte Vecchio and the Art of Urban Planning in Late Medieval Florence.” *Gesta* 47, no. 1 (2008): 1–15. https://doi.org/10.2307/20648957.

Gössling, Stefan. “Why Cities Need to Take Road Space from Cars - and How This Could Be Done.” *Journal of Urban Design* 25, no. 4 (July 3, 2020): 443–48. https://doi.org/10.1080/13574809.2020.1727318.

Harrison, Thomas J. *Of Bridges: A Poetic and Philosophical Account*. Chicago: The University of Chicago Press, 2021.

Kemp, Emory L., and Jet Lowe. "The Fabric of Historic Bridges." *IA. The Journal of the Society for Industrial Archeology* 15, no. 2 (1989): 3–22.

Malpezzi, Stephen. "Population Density: Some Facts and Some Predictions." *Cityscape* 15, no. 3 (2013): 183–202.

Murray, Peter, Mary Anne Stevens, David Cadman, and Royal Academy of Arts (Great Britain), eds. *Living Bridges: The Inhabited Bridge, Past, Present and Future*. London : New York: Royal Academy of Arts ; Prestel, 1996.

Peiser, Richard B. "Density and Urban Sprawl." *Land Economics* 65, no. 3 (1989): 193–204. https://doi.org/10.2307/3146665.

Scanlan, Sean. "Zygmunt Bauman, Liquid Times: Living in an Age of Uncertainty." *Journal of American Studies* 43, no. 1 (April 2009): E19. https://doi.org/10.1017/S0021875809006513.

COASTAL THRESHOLDS

DESIGNING THE CITY-SEA BOUNDARIES IN MEDITERRANEAN ENVIRONMENTS

Dimitra Chatzisavva, Alexios Tzompanakis
School of Architecture, TUC (Greece) Akrotiri, 73600 Chania, Crete
dchatzisavva@isc.tuc.gr, atzompanakis@arch.tuc.gr*

Abstract

The redefinition of the role of both deactivated port areas and waterfronts, are issues that have considerably evolved over several decades and have pushed the research towards new models of urban development.

The activation of abandoned port facilities, the recovery of the often impeded connection between the city and the sea, the interconnection of linear coastal systems are research fields that regard urban development policies and strategies which give great importance to both identity and tourist attractiveness, as well as to the environmental restructuring of contemporary cities.

The interaction between urban and aquatic ecosystems, starting with the issue of the port-city regeneration and continuing with the issues of the linear coastal dispersion, littoralization etc., define complex urban landscapes that require strategies capable of following complex urban dynamics but also of responding to the demand of identity. All these procedures move on the common borders of politics, social sphere and spatial organization, defining interventions related to place, landscape and memory, within the vulnerable, «long-term», dense historical cityscape of Mediterranean cities.

The coastal Mediterranean areas can define a network of wider interventions that can trigger urban systems capable of overcoming the traditionally conflicting relationships between the city and the sea. Within this frame, the medium-sized port cities can pursue development strategies based on a flexible vision able to combine several levels of complexity: from the organization of the urban public space to the management of tourist flows, from the promotion of cultural heritage to the avoidance of processes of gentrification, from the management of urban dynamics to the micro-geography of the everyday life of the Mediterranean City.

Within this theoretical frame, the results of the Urban Design Workshop «Coastal Thresholds-Designing the boundaries between city and sea» held at TUC in May 2018 (The workshop was organized by the Postgraduate Program «Tourism, Culture and Mediterranean Space», School of Architecture, Technical University of Crete, under the scientific responsibility of D. Chatzisavva and A. Tzompanakis) will be presented as strategy tools towards the analysis of peculiar urban dynamics and qualities, as well as the spatial rhythms of the city-water relationship in a Mediterranean tourism enclave.

Keywords
Urban design, coastal regeneration, littoralization, tourism, city branding

01 Aquatic ecosystems

The interactions between terrestrial and aquatic ecosystems, as well as the city's contact with the water, define territorial and urban landscapes that require intervention strategies capable of relating to complex urban dynamics as well as to the demand for new forms of spatial appropriation and identification. Today, these strategies face locally emerging ecologies that try to oppose to the static and generalizing arrangements of the diffuse city as we know it, dotted with static and monofunctional "objects". The character of the Mediterranean landscape is precisely the urban culture, the space of the interconnection, of differences that meet each other, of hybridization, of boundaries destabilization. Much has been written about these transforming and shifting boundaries, from Braudel's [1] poetic modern narrative of systems, to Matvejević's [2] postmodern fragments, to Cacciari's [3] scattered archipelago. The Mediterranean is always a topological space, a network with multiple thresholds, the points of which are constantly in a state of entropy and change, unable to belong to a distinct whole.

Contemporary regeneration strategies aim, this way, at a broader role linked to a framework where social, environmental and economic sustainability are intertwined, in order, for cities, to be able to stand in the context of global city competition. This fact raises questions regarding the scale and the correlation of the interventions with the existing dense historical landscape of the Mediterranean cities: the large-scale interventions push to rapid modification of the life and character of the city and to major alterations of the Mediterranean model of social coexistence in the urban space. Coastal areas are thus transformed into tourist products that often have, as a result, the radical reformulation of the identity of the place, since its historical, cultural and natural landscape is transformed in goods with exchange and use values focused on consumption.

Thus, the coastal areas of the Mediterranean environments are the pretext for a network of wider interventions that activate urban systems capable of transcending the traditional conflicting relationship between city and port, aiming at the regeneration of degraded urban tissues, the provision of public spatial networks and infrastructures and the rehabilitation of the existing building stock. These interventions also aim at the reconnection with an urban identity hidden in the folds of the modern city through the re-appropriation of the urban space through identity.

02 Coastal thresholds

The workshop "COASTAL THRESHOLDS", held at the School of Architecture of Chania, is inscribed within this frame, examining the peculiar dynamics, rhythms and qualities of the relationship between the city and the sea in a Mediterranean tourist enclave.

The workshop was about the urban regeneration of an area that is activated exclusively during the tourist season, creating an urban setting that changes periodically according to the season and the needs. Specifically, the workshop was focused the coastal littorialized linear residential tissue located to west of the city of Chania (on the borders of the municipalities of Chania and Platanias), which defines a seafront characterized by purely touristic or tourism-supportive uses. In this zone do coexist those characteristics that define the modern diffused Euro-Mediterranean city of tourism: the coastline and the morphological outcrops, the historical nuclei of the settlements, the urban diffusion, the pockets of agricultural production within a tissue whose evolution becomes "typical " in regard to the hotel units (characterized by density, seriality, uniformity and a certain degree of enclavization) but "informal" in in regard to the rest of the building stock.

A continuous urban system is thus created, which is dense and apparently uniform (which consists of the urban tissues of Kato Stalos, Agia Marina, Platanias, Neo Gerani, Pyrgos Psilonerou, Maleme) and is made up of individual sub-units (hotel units) lined up as delimited but serially arranged spatial enclaves. These fenced monofunctional islets not only do not participate in the activation of the urban condition, but also make it difficult for both visual contact and public connection between the tissue and the sea, consuming insatiably the natural coastline and causing a significant ecological burden. Thus, this dense and apparently uniform tissue seems to be in constant search for balance within the oxymoron of "repetition" and "difference": that is, while on the urban scale the obsession with the repetitive seriality of hotel units is evident, on the architectural scale dominates the absolute morphological, more or less sophisticated, search for exotic diversification with the aim of consumption.

In particular, the workshop focused on the area of Platanias, whose main spatial characteristics are: the linear dependence on the street which is clearly supplied with recreational uses and hotel facilities on both sides (or with uses that support them), the obstructed contact with the sea due to the unplanned urban development, the lack of permanent housing or uses that support permanent housing, the inexistence of public spaces able to define urban centralities as well as collective spatial references and thus residential cohesion through a sense of identification with the place.

This area is an ecosystem where the characteristics of the modern diffused city appear with the phenomenon of Mediterranean littoralization, linked here to the ongoing abandonment process of inland settlements and with the corresponding massive exploitation of the coastline. Consequences of this trend are the radical alteration of ecosystem factors, the depletion of the hydrological and soil reserve due to the overexploitation of resources (in this case the silted adjacent streams), the degradation of the landscape, the abrupt change of the urban microscale along with those transition zones that usually allow mild and controlled environmental processes, the destabilization of social and anthropogeographic balances.

Furthermore, the abandonment of traditional economic activities and the "seasonality" of facilities and services, along with the monofunctionality of noisy leisure without basic public-oriented daily services, produces a strong change in the social structure, a pressure on these coastal zones and in the contact between the city with the sea. It is worth noting that in this particular area, due to the proximity to the center of Chania and the exclusive presence of tourism facilities, there are only a few family homes, creating an even more difficult relationship in the identification between the residents and the specific place.

Unevenly distributed and developed concentrations and densities, informal urban tissues, spontaneous urbanization, low-quality neighbourhoods of temporary housing supporting the tourist infrastructure, residual rural enclaves and a landscape where only the streams and the rural pattern ground set limits to rampant tourism, compose an explosive scene that needs understanding and the research on containment strategies and creative proposals for its alternative management.

03 Wet traces: Workshop proposals and aims

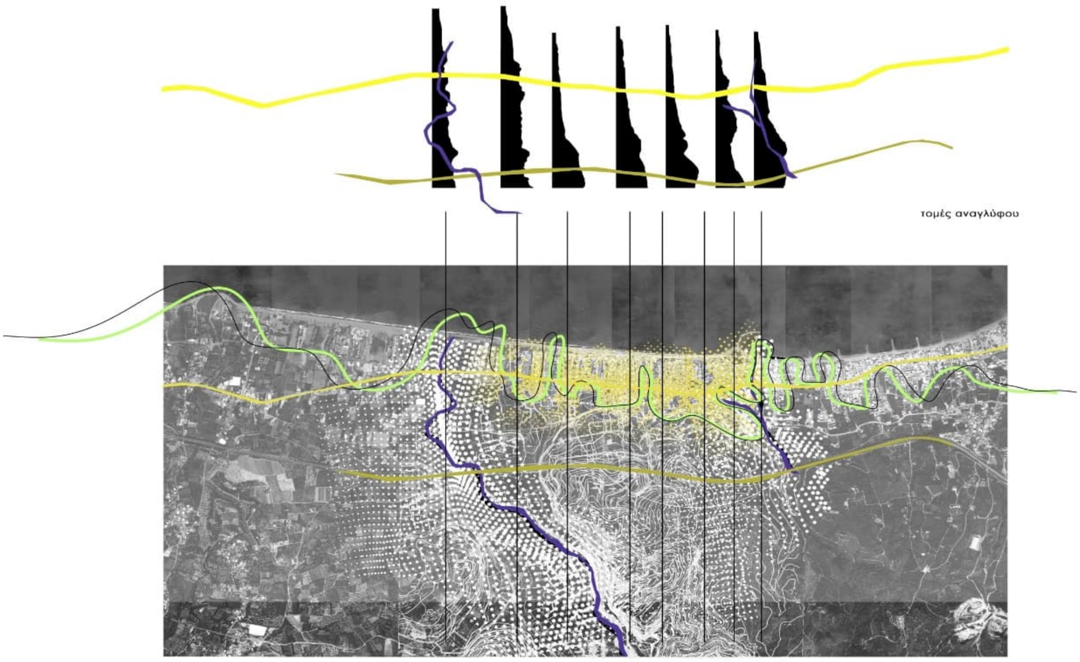
According to Indian landscape architects Anuradha Mathur & Dilip Da Cunha "The water is everywhere before it is somewhere, it is rain before it is rivers, it soaks before it flows, it spreads before it gathers, it blurs before it clarifies" [4]. These Landscape architects observe, record and map previous water conditions before it is placed somewhere. They face the problems of coastal ecosystems, studying the relationship between the coastline and the aquatic element by recording the traces of its wider flows. This ecological approach does not only focus on landscape and urban issues but examines also the cultural, geological, mnemonic and urban conditions in their interdependence.
The academic framework of the workshop emphasized, this way, the observation of the territory, decoding and diagramizing the elements that define the place, collecting both its macro and micro-scale features.
Furthermore, the urban approach of the workshop did not focus on generalizing morphological and functional spatial organizations but on the recognition and activation of specific, although scattered, strategic areas that are considered suitable for highlighting the complex issues of the place. The priority and the unifying common ground of the proposals is the public space that works as a structural mechanism for any new intervention connected with what pre-exists. Guiding in this direction is the thought of the Catalan urban designer Manuel de Solà Morales [5], for whom, in these urban systems based on punctual interventions, astonishment and intuition are considered as important as coherence and understanding of the study area.
Within this reasoning, punctual sub-areas suitable for analysis were selected by the teachers. These strategic punctual sub-areas describe the dysfunctions of a general intervention area that summarizes all the characteristics of a typical tourist coastline in the Mediterranean area.
Each sub-area therefore highlights urban issues and conditions that different groups of students worked on in a short period of five days.

04 Sub-Areas

The street
The inelastic linearity of the central road defines the façade of the typical touristic seriality of seaside resorts. It is a non-place, a route for buses and cars that you can find everywhere in the touristic Greek territory, a scene of chaotic provision of tourist services, a mirror of the homogenization and the loss of memory and identity.
In this case, this uncanny corridor has minimal visual escapes towards the sea, pointing out the violence exerted on the territory, a violence that modifies the fundamental features of the Mediterranean landscape, such as the theatricality of the gaze from and towards the sea. Here there are only a few, moreover obstructed, visual connections between the tissue and the sea. The complexity and the informal experience of the public space that

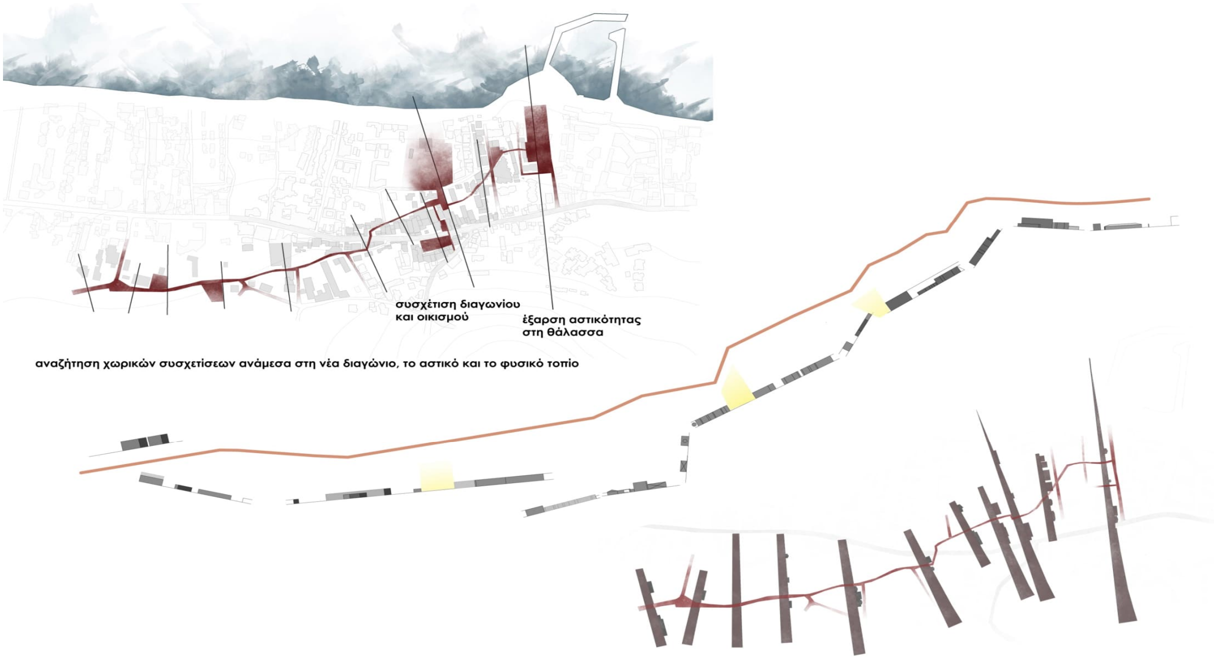
characterizes the Mediterranean environments based on the “long duration” are replaced, in this particular case, by the indifferent homogenization, as a mandatory condition for the needs of tourism.

The student proposals critically identify these situations by proposing elements that redefine the visual connections from and towards the sea, redefine the character of the transversal routes, obtain coherence in the rhythm of the street fronts on both sides, defining an accessible and coherent sidewalk able to erode tourist monofunctionality.



A structural network of public spaces

The student proposal attempted to establish a structural and organizational network of public spaces (a condition that is completely absent due to the linear and shallow layout of the settlement), in order to interconnect and overcome the established dividing boundaries of the area. The proposal rearranges a diagonal network of public spaces capable of entangling the strong oppositions and boundaries of the area (natural/artificial, density/rarefaction) reorganizing new syntactic hierarchies. The network of public spaces defines an alternative structural narrative with transversal connection spaces (green spaces and small squares) that cross the border of the residential fronts as well as the main street itself in order to interface with public reference spaces of the wider tissue. This organizational network of public spaces ends with and is reinforced by the student proposal located in the area near the small port (The Port).

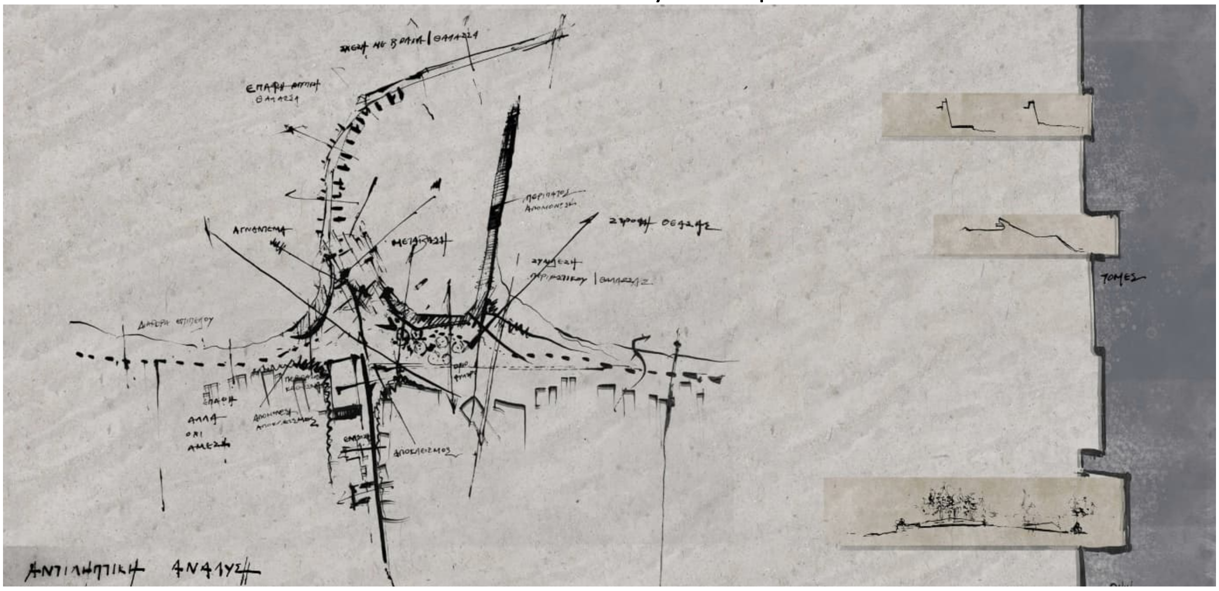


Bridging the natural and the artificial

This specific area encounters major problems regarding the infrastructure of the large-scale hotel facilities and the stadium as well, since it stretches out on the edges of the sea, blocking the exit to it. The student proposal removes the specific land use and attempts to restore the cultural and urban centrality of the area, focusing on the church and the school, which have been enclosed until now, giving them public places of transition as well as a visual exit to the sea. At the same time, the proposal restores the coastal space intervening on the ground relief, rearranging the balance between urban and natural spaces.

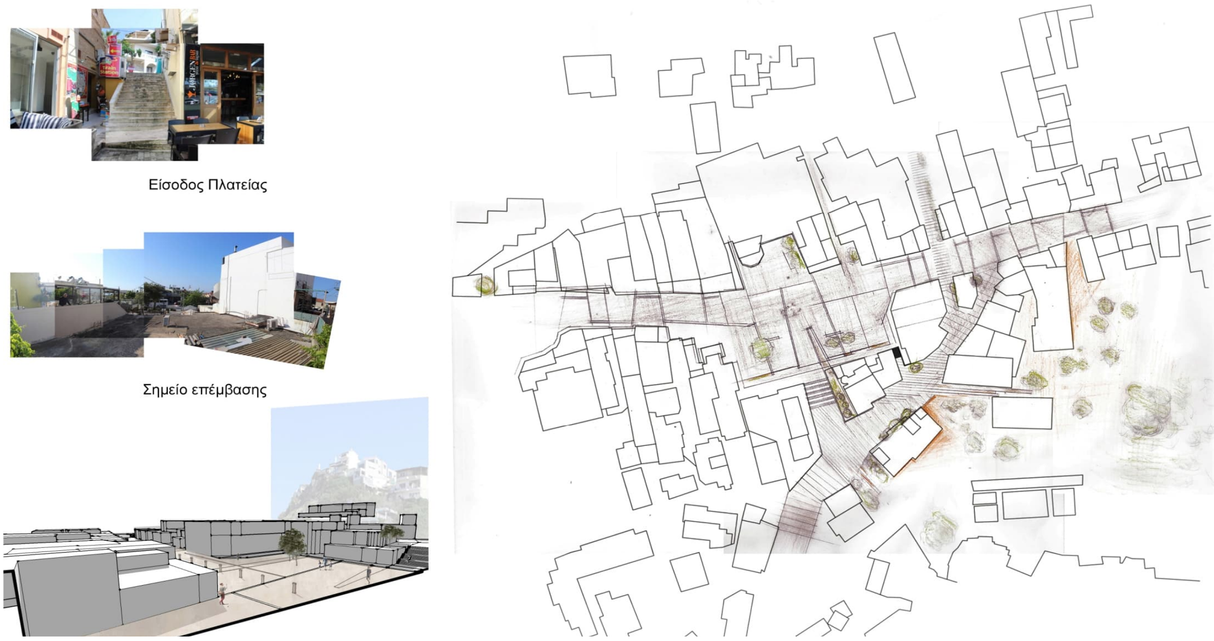
The Port

The student proposal removes the stadium with the aim of bringing back the atmosphere of a small port with micro-scale uses. It proposes to restore the beach along with a unifying landscape intervention with coherent textures, materials and land uses as fishing boats, small shops, small piers, in order to propose a spatial experience based on micro-environments that are connected with the memory of the place.



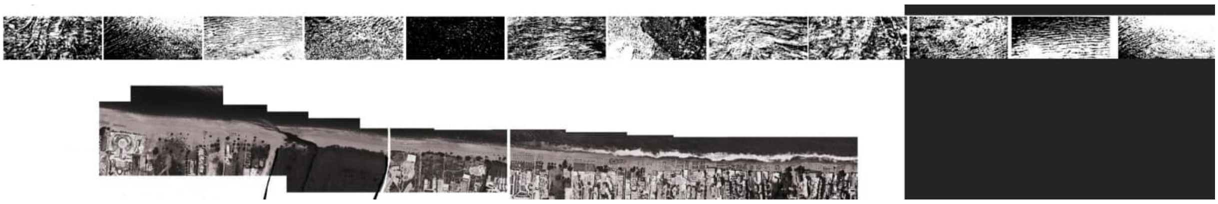
The central square

It is difficult to perceive the current central square of Platanias as it is a small plateau crossed by the flow and noise of the traffic of the main street. Its isolation is enhanced by the altimetric differences of the tissues around it as well as the lack of complexity in the ground floor uses. The student proposal attempts to extend the square's boundary and restore its centrality, using the altimetric difference as a pretext in order to connect the square with the surrounding tissue.

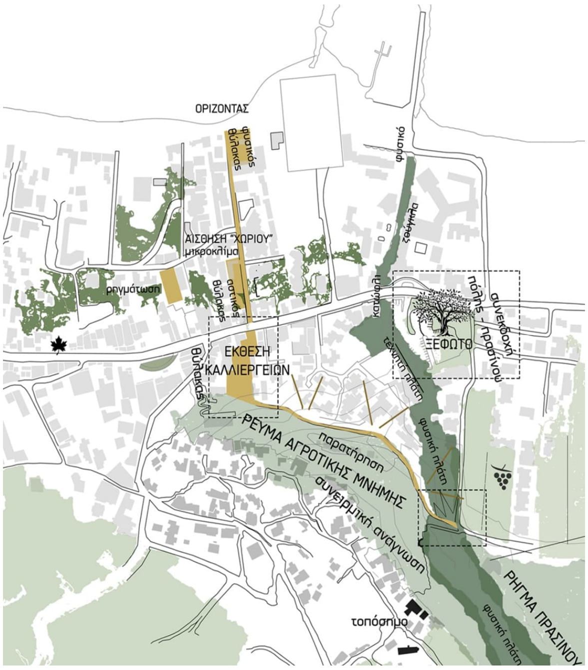


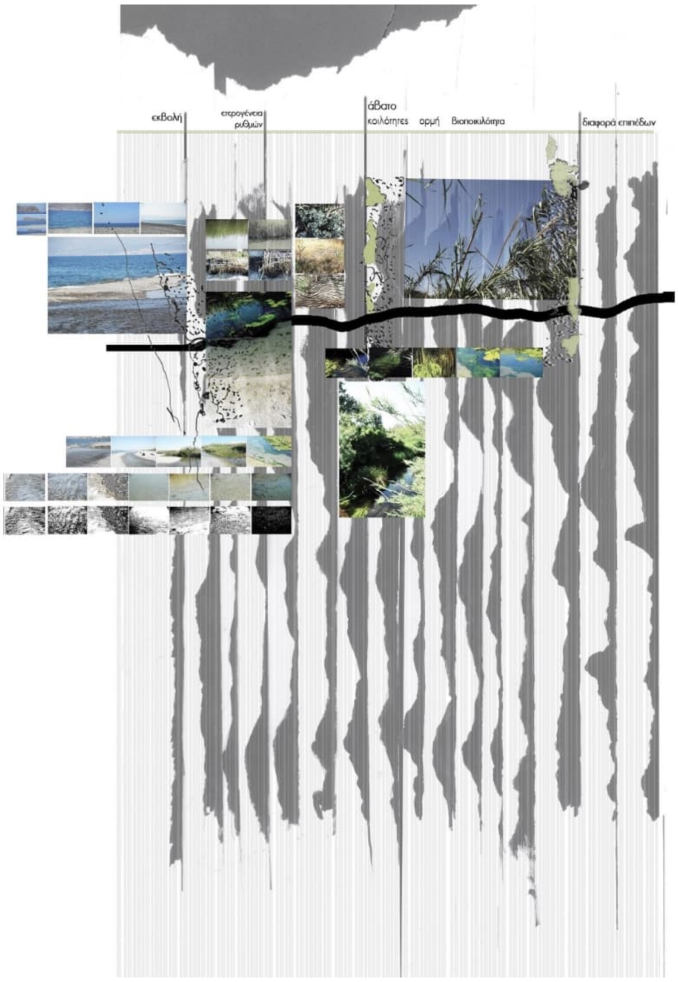
Rifts-streams

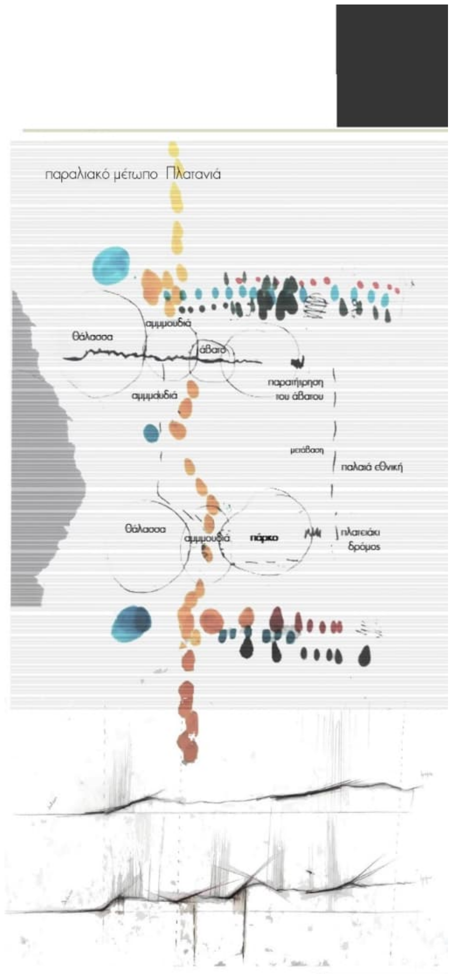
At the boundaries of the study area to the east and west, there are dammed streams with obstructed exits to the sea. This deactivation of the ecosystem is made more ironic as the name “Platanias” derives from the pale trees of the area.



This area was divided in two sub-areas. The first student proposal examines the eastern side streams at the entrance from the city of Chania, where the buried stream leave its residual traces on the relief and the rural landscape as a reminder and a promise of restoring the relationship between the upper city (the old settlement of Platanias), and shoreline life.
The second student proposal deals with the western stream near the protected wetland. This wetland is nowadays partially active, with tragic consequences for both the fauna and the flora of the area mainly for the flood risk. The team examines the ecological corridors, the potential connections with the irrigation system, the relief and the sandy shore, proposing micro-scale transitions connected to the landscape in order to coexist with the river ecosystem.

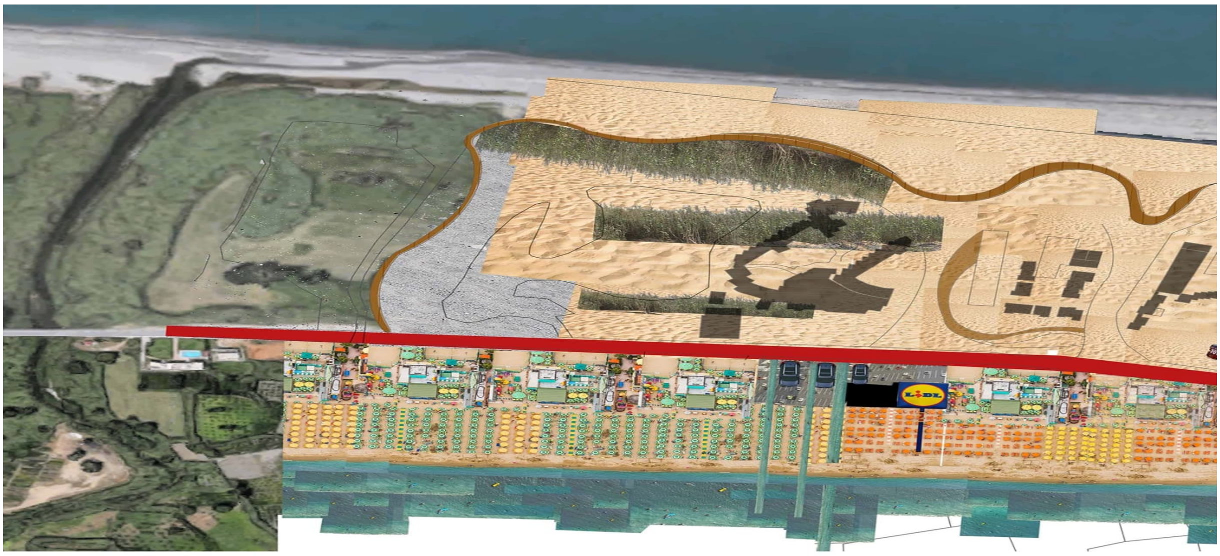




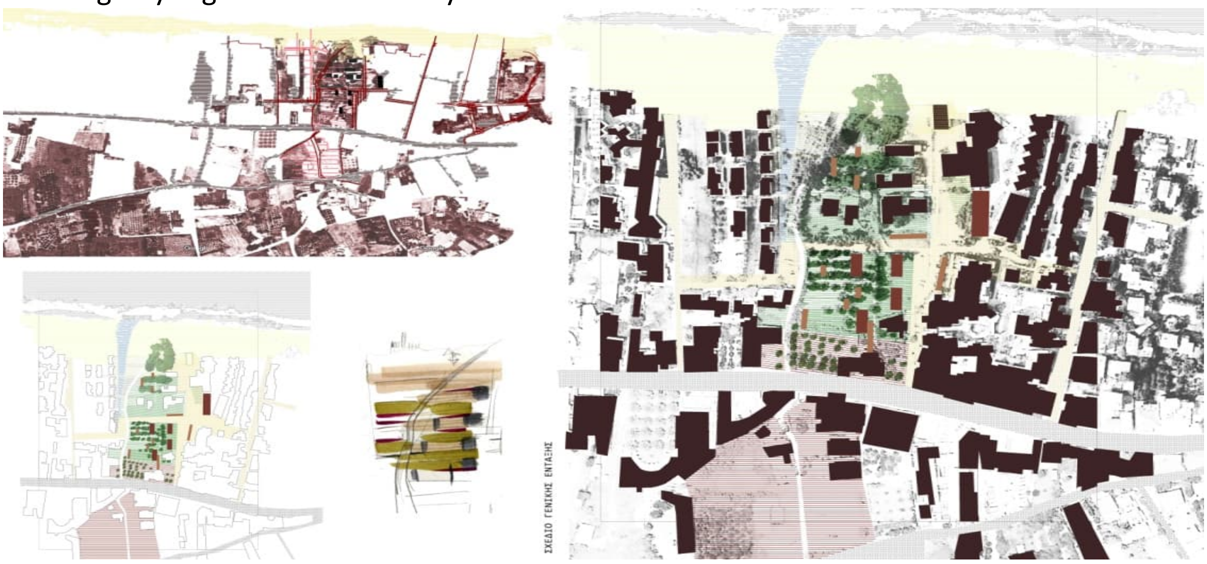


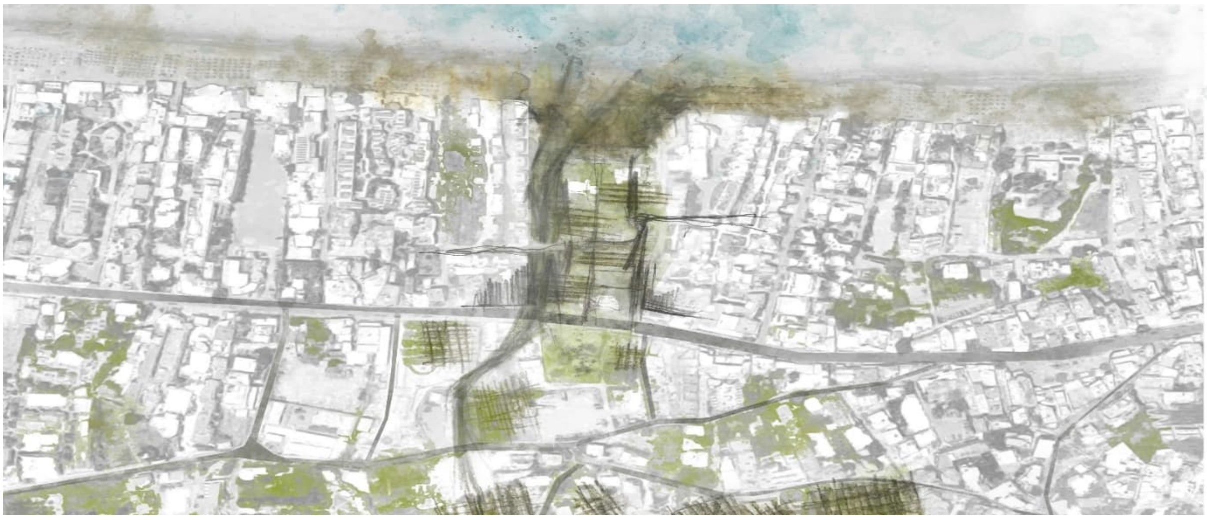
Mirroring asphalt infrastructures with beaches

The student proposal ironically comments on the uncritical transfer of urban consumption imagery and symbolism into the natural landscape. Tourism demand for swimming pools nearby the sea, the regression of sand in favour of arrangements that recall urban quality and materiality, the use of the lawn instead of that of tamarisk, etc., all these dualities are inverted. In particular, the proposal comments on the scale and layout of a well-known super market chain with a large paved parking area that is located nearby the protected wetland and natural landscape. The proposal comments on this condition by inverting the terms involved, proposing the transfer of sand and beach facilities to this area. An ironic counterpoint and a commentary on the degradation of the coastline that is based on a serialized experience of sun and lounger.



Relationship with the historical settlement – urban farming
Two student proposals comment on the touristic monofunctionality of the area by proposing different touristic and productive behaviours that have their origins in the agricultural tradition of the area. One proposal proposes rural gardens and rural tourism residential facilities located among the exclusive monothematic areas of the tourist facilities. The other proposal proposes urban operations with programmatic ecological actions (ecological routes, paths, neighbourhoods) in order to create a sustainable micro-scale, with an alternation of rhythms referred to different levels of identification with the place, able to be meaningfully registered in the daily life of the inhabitants.

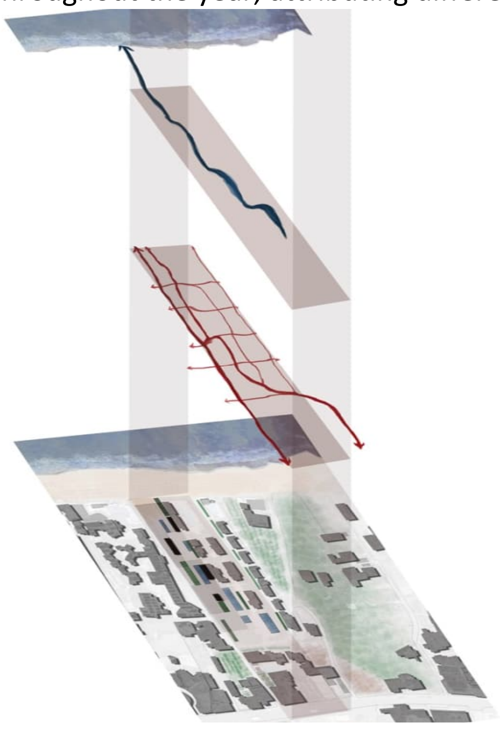




Alternative tourism and human geography - public baths

The proposal comments on the enrichment of the study area with other types of tourist facilities for different users. Public baths are proposed as a typology that deviates from the dominant seasonal hotel model of the area by offering a different spatial typology.

The linear arrangement of this typology inverts the relationship with the coastline, since it does not produce the introverted and isolated inner lawns referred only to the hotels, but, on the contrary, creates a complex inner connection between the main road and the sea through an introverted urban spatiality that rearranges the current typologies as well as the urban layout by providing only public spaces in different scales. The proposal does not claim or opportunistically consume the view and the beach, but provides alternative services throughout the year, attributing different experiences of the place.



Conclusions

The climate change and the consequent erosion of the coasts with the rise of the sea level, the constructions within the coastal zone, the disappearance of the sand and the beach itself, make it necessary to take strategic positions and decisions for tourism management in the coastal areas. Both the alternative forms of hospitality and the urban and local management of the coastal ecosystems which derives from them, seem to be a one-way street, if we aim at the reconnection of the settlements with both their memory (related to the rural area and with the condition of the linear city of tourism) and its coastal infrastructures. The proposals presented seek processes that evolve from locally emerging conditions (urban, ecological, or related to landscape) versus the generalizing arrangement of serialized urban “objects”. Processes that move on the common fringes of the cultural, social and natural realm, proposing interventions related to the place, the landscape and the inhabitants in the sensitive, 'long-term' Mediterranean environments.

References

[1] Braudel, F. *Lo spazio, la storia, gli uomini, le tradizioni,* Bompiani, Milano, 1987.
[2] Cacciari, M. *L’Arcipelago*, Adelphi, Milano, 1997.
[3] Matvejević, P. *Breviario Mediterraneo,* Garzanti, Milano 2004.
[4] Mathur A. & da Cunha D. *Design in the terrain of water,* Applied Research & Design, 2014.
[5] De Sola Morales, M. *A Matter of Things*, NAi Publishers, Rotterdam, 2008.

VACANT GAPS IN SHRINKING CITIES: THE LETHARGY, THE PROBLEM AND THE OPPORTUNITY

Jiří MIKA*

Faculty of Architecture, Czech Technical University in Prague
Thákurova 9, 160 00 Praha 6, Czechia; jiri.mika@fa.cvut.cz

Abstract

The existence of temporarily vacant lots (gaps) is a frequent manifestation of the shrinking cities phenomenon, which offers opportunities to add missing elements to the city's fabric. The paper clarifies the options for the temporary use of these gaps within the central urban areas, what they can provide to their surroundings in the short term, and what hinders their use. I address how to provide qualitative improvements in conditions of quantitative non-growth through the flexibility and adaptability of temporary arrangements and describe it using the examples of Ostrava (CZE) and Leipzig (GER) analysing the selected neighbourhoods with gaps on two levels: on the one hand its existing structure and on the other hand its missing part (gaps). In the case of gaps, I examine their position in the neighbourhood, size, infrastructural coverage, ownership, physical form (surface, boundaries) or status in the land use plan. By combining these analyses, I identify „spatial supply and demand“ and try to find out why they are not currently saturated, even though they largely overlap. The current use of the gaps is dominated by parking and fallowing, but conversely, there is demand for other uses besides parking: community gardens, sports facilities, playgrounds and more. The intersection of supply and demand is hampered by waiting for the ideal solution, ownership, legislation, and the fear of petrifying the temporary use. In shrinking cities, it is not always possible to target a final solution, but it is also necessary to explore interim measures that can open the door to a long-term settlement.

Figure 1. Vacant gap in Leipzig

Keywords: shrinking; temporary design; adaptive planning;

1 Introduction

This paper is concerned with what is described in the literature as "TOADS" (temporarily obsolete, abandoned, and derelict sites) [1], [2]. The broader phenomenon within which TOADS exist are so-called "shrinking cities", i.e. cities affected by large population declines, and as a consequence they may experience a local reduction in their physical structure. Scholars distinguish between elastic cities (expanding or shrinking), inelastic cities (staying the same), which can have both growing and shrinking populations, thus creating four categories of cities in relation to spatial and population change: inflating, compressing, diluting, deflating [3], and this paper is focused on diluting and deflating cities. The response to the situation of these cities is so-called "smart decline," sometimes criticized as succumbing to decline but in fact attempting to use quantitative decline for qualitative growth, as shown by the projects and plans of cities such as Buffalo, Philadelphia, Youngstown, Flint, or Cleveland [4]. Smart decline often takes advantage of temporarily vacant space to accomplish these goals. Ray M. Northam divides vacant parcels into three categories: remnant parcels, reserve parcels, and the aforementioned TOADS [1]. In terms of origin, vacant parcels are most often post-industrial, derelict, unattended with vegetation, natural or transportation-related [4]. TOADS usage is defined primarily due to two aspects: their ownership and developability [5]. The term "left-over" is used for vacant parcels and their uncertain nature, as opposed to the functioning and productive substance of the city [6]. These areas are a manifestation of the city's transition from a past state to a new one, in which there is obvious potential allowing the temporary land uses (TLU) to use parcels of the city in an unconventional way [2]. The alternative term 'interim reuse' then captures well the essence of this process embedded in space and time (interim) and in function (reuse) [7]. Transition and its associated temporary uses are an important part of city life, in which we have probably all participated at some point, for example by visiting circuses, markets, flea markets [7]. Thus TOADS are not just "terrain vague" but instead they allow for a certain freedom and non-mainstream uses that would be unthinkable in other circumstances [5], [8], [9].

2 Background

TOADS are either empty or temporarily used as parking lots, temporary sports fields, playgrounds, or landfill, but they can also be integrated into the ecological network of the city through community gardens, etc [5]. Their lack of use and maintenance creates a negative image of the neighbourhood [6]; for example apartments or houses next to vacant lots can be worth up to 20% less than those further away, but this is completely compensated if the vacant lots are maintained [10]. The maintenance of TOADS plays a larger role than their function in the eyes of residents, as research by Victoria Morckel in Columbus (Ohio) shows that while using a vacant lot as a community garden is more popular than not using one, a poorly maintained community garden is perceived worse than an unused but well-maintained vacant lot [11]. While the presence of TOADS itself complicates redevelopment as they symbolize decline, conversely their restoration or temporary use leads to increased property values in the neighbourhood and support for neighbourhood shops and services [12]. Interim reuse has many benefits, for example it allows for quick change if it proves dysfunctional, it is an economic opportunity (the space is already there and does not need to be expensively created), and it can serve to compensate for environmental or social deficits in an area [13], [14]. Interim reuse also activates a positive process in a neighbourhood, the community can come together for a common goal and show interest in the neighbourhood [5]. The ability to accentuate ecological or cultural values allows to compensate a normative economic view of cities where these values are only perceived as externalities [6]. The economic side is also significant, creating low-threshold base for entrepreneurs, turning vacant lots into a desirable resource [15]. The social potential of temporary land uses lies in the use of parcels to flexibly support vulnerable populations [5], [16]; they can enable "aging in place" to provide facilities for older people so they do not have to move out of their neighbourhoods [17]. In terms of ecology, the value of the TLU lies in its potential to supplement the city's missing natural ecosystem. This happens spontaneously when a parcel is abandoned, with the area gradually becoming overgrown by succession. Full restoration of the site to a natural species composition is a long-term issue [18]. Green uses can help to mitigate the problem of urban overheating. Although demolition of abandoned properties will rather exacerbate the problem, according to researchers, the subsequent greening of vacant lots already has a significantly positive effect [19]. TLUs also have the advantage of being easier to enforce through the community than permanent large-scale projects. Researchers questioned the residents of Barreiro (Portugal) about the options of using the TOADS first as final, then as temporary uses. The survey showed that the temporary solutions had higher support than the permanent ones [7]. The absence of the need to design permanent solutions frees up hands for alternative approaches to planning, such as urban acupuncture, based on the selection of a small number of minimalist interventions, but with (if chosen correctly) a large impact [20].

The literature suggests that local authorities should play a role in mediating and countering the negative consequences of temporary uses [2] for top-down policies to support bottom-up initiatives [7]. Large top-down projects are expensive, whereas bottom-up projects are more certain, more rooted in the community, and cheaper [21], but are harder to implement without support from above [7]. To initiate interim reuse a city needs to understand the TOADS and their characteristics, which is rare, but once an overview is established, it can provide citizens with practical information about what uses are possible and under what conditions [16]. The literature suggests three steps a city can take to promote TLU: to educate about the potential of the gaps, to connect owners and residents for building a consensus, and to publicise what is being done. In post-2000 Berlin temporary land uses were also seen as an economic stimulus, and a way to reduce crime. The city did not invest directly in TLUs but made them possible by relaxing spatial and functional regulations for temporary uses [22]. The creative class attracted by TLUs to Berlin is important for urban regeneration, but it needs a base on which to operate, which TOADS can provide [23].

Few potential problems emerge: The communities that want to undertake the TLUs usually do not own the plots, so their use may be unaffordable, either financially or administratively [5]. For example, 77% of vacant lots in NYC in 2013 were in private hands [24]. It can be difficult to get permission for TLU in certain legal systems but for making it work it should be as simple as possible [2]. There might be a risk of gentrification of a neighbourhood when TLUs are successful [22], or people may become accustomed to the temporary use, wanting to keep it permanently, blocking other development options [2].

3 Methodology

This paper is focused mainly on the spatial and functional aspects of interim reuse of TOADS. It briefly presents the procedure of spatial analysis of a neighbourhood affected by the existence of numerous gaps in a case study of the district around Stodolní street in Ostrava (Czech Republic). In order to have the whole picture, it is necessary to analyse the neighbourhood in two levels, namely its standing structure and its seemingly missing structure. In the standing structure I measure the density of population, the functional use and accessibility of necessary public and commercial amenities, the open spaces and the built environment in terms of the perceived intimacy of the environment, or the capacity of the transport infrastructure (the need and condition of parking lots). In the TOADS part of the structure, I observe the ownership, the way of possible temporary use, the spatial characteristics and functional possibilities of the gaps (area, spatial characteristics of the edges of the gaps, surface of the gaps, utility connections, stability, maintenance). By comparing the two parts of the analysis, an obvious 'demand and supply' of functional and spatial use emerges, some of which meet each other and some of which do not. The following discussion looks at the reasons why the ratio of supply and demand saturation is as it is. To illustrate the options, we use reference examples from Leipzig as well as analysis of city planning documents and other legally binding documents.

4 Ostrava-Stodolní Case Study

The case study is focused on the central part of Ostrava, an industrial city in the east of the Czech Republic near the Polish border. Until the 19th century, Ostrava was a small, virtually insignificant town, but after the beginning of coal mining and the emergence of the metallurgy industry, it has grown from a population of a few thousand over the last 150 years to 331,466 in 1990. After 1991, the population gradually began to decline to 279,791 in 2021 [25], while economic transformation was taking place and Ostrava became a post-industrial city. The district around Stodolní street was created at the turn of the 19th and 20th centuries as a direct extension of the historic core of Ostrava. Structurally, it is a typical representative of a Central European compact block city of its time. A small number of gaps have always been present in this district, as some individual plots were never built on, and a larger number appeared after the World War II, when damaged buildings were demolished. The resulting gaps were not built over at first, as this part of the town was intended for demolition due to undermining [26]. When the plans changed, Ostrava had already entered its epoch of a shrinking city and did not have the economic power or demand to fill them.

4.1 Standing Urban Structure

In terms of access to public and commercial amenities, the district is served by most of the necessary functions. The majority of local houses are typical urban mixed-use buildings which allow for variable use of commercial space on the ground floor and therefore if there is a potential unmet need, its fulfilment is not limited in spatial or functional terms. Structurally, the neighbourhood lacks small and medium scale green space (ranging from semi-private gardens and community allotments to small public parks) and a supermarket or market, a spatial typology that differs from mainstream commercial amenity and therefore cannot be saturated in existing spaces. The area of the district is 26 ha. The local type of urban structure corresponds to a potential population density of 118 inhabitants/ha, plus 55 jobs/ha [27], so the total capacity of the whole district, if complete, would be 3,068 inhabitants and 1,430 workers. The spatial potential of the district is approximately 58% fulfilled, with the remaining 42% being TOADS (Figure 2), which makes the potential of the now standing part of the district approximately 1,776 residents and 828 jobs. However, the actual number of permanent residents is slightly over 800, which indicates a significantly higher use of the neighbourhood for employment opportunities. There are 850 parking lots in the neighbourhood’s public spaces outside of the TOADS and an additional 1,096 spaces in the TOADS. This indicates that the number of public parking lots is more than adequate for the permanent residents of the district, which is also visually verified by the large number of empty parking spaces out of working hours. It is not possible to determine the real need for parking lots for the people working here, due to the lack of data on the structure of these jobs, but the public parking lots are completely exhausted during working hours, and the parking lots in the TOADS have a high occupancy rate during working hours too, but almost always offer some vacant reserve. There are no religious buildings in the area, but this need is satisfied by the large number of churches in the immediately adjacent neighbourhood. The area of Stodolní district has several important cultural institutions, which in turn covers the need of other parts of the city.

Figure 2. Stodolní District in Ostrava (orthophoto by mapy.cz)

4.2 Missing Urban Structure

The TOADS occupy a total area of 6.6 ha, of which 1.2 ha is not used in any way. The area of 4.3 ha is occupied by temporary parking lots (with a capacity of 1,096 positions), 0.7 ha is used for creative industries, specifically the space of the former hobby market is used for a gallery and one of the TOADS for a gastronomic market. A very minor use are the short cuts through the development (0.3 ha) and a maintained green spaces (0.1 ha), which is not accessible to the public as it serves as a nursery school. The ownership structure according to the land register shows that of the total area of the gaps, 3 ha are owned by the city, a negligible area is owned by municipal organisations and churches (one parcel each) and the remaining 3.6 ha are owned by various private companies and individuals (Figure 4). The vast majority of the privately and church-owned plots are used as temporary car parks, the only significant exception being a set of plots in the north of the area, which is grassed over and unused. Of the municipal land, 1/3 (1 ha) is temporarily used for parking, and 2 parcels (0.7 ha) are temporarily used for the aforementioned gallery and gastro-market. The type of surface of the TOADS does not depend on the type of ownership (there is no significant correlation), but on their function, with the unused plots being grassed and the parking areas paved. The level of maintenance is higher on unused (grassed) plots, but practically the whole area is maintained in a basic sense and there is no illegal dumping or similar negative regression. If this neighbourhood was 'complete' without the gaps, it would have a very poor range of spaces with varying perceived space intimacy, but the gaps compensate successfully for this thanks to their varied positions and dimensions (Figure 4).

Figure 3. TOADS Spatial Analysis

4.3 Comparison and Consequences

Comparing the analyses of the two parts of the district, several conclusions emerge. The area is dominated by the issue of parking. The parking needs of the residents can be covered in the public parking, the parking capacity for those working there cannot be precisely determined, however, given the calculated capacity of the area and the overcrowding of parking spaces, we can assume that people from the wider area, not only from the district itself, also park in here, thus transmitting the negative externalities (noise, pollution, destruction of visual identity) of this phenomenon. Most of the parking lots in the gaps are on those in private ownership, as it is a way of earning money with low operating costs. Some lots are used for cultural purposes, which appropriately complements the important cultural institutions located there. On the other hand, the TOADS do not currently provide a solution of the large deficit in green infrastructure. There is a single park in the area, but it is relatively inaccessible from most of the neighbourhood, and there is no district-scale or small-scale green space (neighbourhood community gardens, small-scale crop production). Temporary TOADS uses also do not help vulnerable populations in any way. The poor spectrum of spaces based on perceived intimacy is indeed supplemented by TOADS, but these are mostly haphazard solutions that saturate this need rather unconsciously and un-conceptually. Therefore, the spatial and functional supply and demand of the built and demolished part of the neighbourhood is for the most part only saturated where it is an externality of something else.

The logical question is why this is so. The city's land use plan does not deal with TOADS, a few mentions can be found in the strategic plan. The latter emphasises the development of the TOADS with architecturally valuable stable buildings, and only marginally mentions the possibility of using the gaps temporarily for green infrastructure or new connections (shortcuts). Temporary solutions are not seen as sufficiently valuable; the aim is at the final state of the territory, which is not always achievable in shrinking cities. The few existing projects in this vein in other parts of the city are individual actions, as are the cultural and food market uses within our area. In contrast, the subject of parking occupies the public debate, yet it partially saturates the needed parking capacity and is economically advantageous for the owners at least in the short term. Apart from a general top-down policy that would initiate a more diverse use of the spaces, there is also a lack of an information base that would provide the necessary basis for bottom-up initiatives on how TOADS can be used. Based on the examples of TOADS in Ostrava and others, this paper compiles a list of necessary parameters (Table 1) that give a comprehensive set of information on each TOADS for its interim use. The selected parameters focus mainly on the spatial and functional characteristics of individual TOADS, which are essential for the suitability and options of their use. In contrast, some existing city projects (participatory part of the strategic plan, participatory budget) can also be used as a basis for a top-down policy, although they are not explicitly focused on TOADS.

Table 1: Selected variables that determine possible uses of TOADS

Parameter	Values	Information source
Maintenance	Maintained, unmaintained	Observation
Interim reuse	None, sports field, playground, parking, markets, park, front yard, community garden, creative industry, passage, waste containers, etc	Observation
Land use plan	Usage according to the local plan	Land use plan
Stability	None, provisional, temporary, long-term	Observation
Ownership	State, municipal, municipal companies, cooperatives, church, private	Cadastre
Perceived level of intimacy	Private, semi-private, semi-public, public	Observation
Area	X m^2	Cadastre
Surface	Grass, trees, gravel, screed, threshing, paving, etc	Observation
Side facades	Unimproved, plastered, green, mural, etc	Observation
Front edge	None, trees, hedge, fence, wall, low wall	Observation
Rear edge	Passable, non-passable	Observation
Spatial context	Separate gap, part of a group, corner gap	Cadastre
Utilities	Water, sewage, electricity, gas	Utilities maps

5 Discussion

Indeed, the gaps form the "terrain vague" mentioned in the beginning of the article [5], [8], [9] in most of the Stodolní district and they do not provide much basis for non-mainstream uses. The potential to accentuate ecological, cultural, or social values in contrast to the normative economic perspective as discussed by Kim and collective [6] is not fulfilled completely. I do not want to deny the importance of the economic factor, but the potential of the TOADS to support its creative form is, with few exceptions, not exploited. The conclusions of this paper are in line with the findings of other authors, who stress the need for data on vacant lots as a starting point for most solutions, as well as the subsequent potential for initiation by the city and its role as an additional mediator [16]. A certain obstacle in the management of vacant lots is also confirmed in the form of a high proportion of private ownership, which creates a communication, financial and administrative barrier [5], although it is lower here than in the aforementioned New York City [24]. On the other hand, the fears of a general decline of the area affected by vacant lots due to lack of maintenance are not very much fulfilled in the territory. Neither is the "hipsterisation" or "gentrification" of the neighbourhood, as some authors warn of [22]. Other warnings, for example, about the petrification of temporary solutions where people get used to them and can thus block the overall development of the area [2], have yet to be verified in the future, as they have not yet existed for a long enough period of time.

The potential for temporary use is wide in concrete terms. Examples from Leipzig can be seen in the photos below (Figure 4), however, there are many more variations than the scope of this article can bear. The examples show that, in addition to the functional content, a spatial solution is also essential, which can at least limit the negative effects of gaps on the image of the city and, on a more ambitious level, greatly enhance it. Some of the solutions chosen thus confirm the importance of the spatial parameters in the table above, such as the treatment of the street edge, the blank facades of neighbouring houses or the type of surface of the gap.

LEIPZIG - EISENBAHNSTRASSE LEIPZIG - ENDERSSTRASSE LEIPZIG - WURZNER STRASSE

Figure 4. Examples From Leipzig

6 Conclusion

By analysing both components of the neighbourhood structure it was verified that spatially and functionally there is potential within TOADS and their interim uses to saturate the inherent problems of this urban district. However, this potential is not being fulfilled as the quality of the interim solutions is drowned out in the debate by the focus on the final permanent state of the area, although it is now unattainable and although most of the area has some interim use, it is overwhelmingly a parking use, which of course carries many negative externalities at this scale and transfers the need of other neighbourhoods to the district. There is a lack of an information base that would form the basis for both top-down and bottom-up decision making about TOADS. The paper also proposes a sum of basic spatial-functional data that would be essential for this decision making. In conclusion, although the analysis concludes that there is untapped potential, several individual recent projects can serve as positive examples for other similar projects in the future, although overall coordination will be necessary.

Acknowledgements

I would like to thank FA CTU for their support in the preparation of this paper, and for their financial support of the research in the form of the SGS grant.

References

[1] Northam R. M., Vacant Urban Land in the American City, *Land Economics, 47* (1971), Issue 4, pp. 345-355, doi.org/10.2307/3145071.

[2] Carruthers A., Tretter E., Creative re-uses: The promises and challenges of temporary land use in Calgary, *Cities, 123* (2022), doi.org/10.1016/j.cities.2022.103562.

[3] Newman G.D., Bowman A. O'M., Lee R. J., Kim B., A current inventory of vacant urban land in America, *Journal of Urban Design, 21* (2016), 3, pp. 302-319, doi.org/10.1080/13574809.2016.1167589.

[4] Newman G., Hollander J. B., Lee J., Gu D., Kim B., Lee R. J., Horney J. A., Bearfield D., Li Y., Smarter Shrinkage: a Neighborhood Scaled Rightsizing Strategy Based on Land Use Dynamics, *Journal of Geovisualization and Spatial Analysis, 2* (2018), Issue, doi.org/10.1007/s41651-018-0018-6.

[5] Neméth J., Langhorst J., Rethinking urban transformation: Temporary uses for vacant land, *Cities, 40* (2014), pp. 143-150, doi.org/10.1016/j.cities.2013.04.007.

[6] Kim G., Miller P. A., Nowak D. J., Urban vacant land typology: A tool for managing urban vacant land, *Sustainable Cities and Society, 36* (2018), pp. 144-156, doi.org/10.1016/j.scs.2017.09.014.

[7] Costa P., Brito-Henriques E., Cavaco C., Interim reuse in urban derelicts: Uncovering the community's attitudes and preferences through scenario-elicitation, *Cities, 111* (2021), doi.org/10.1016/j.cities.2021.103103.

[8] Foster J., Hiding in plain view: Vacancy and prospect in Paris' Petite Ceinture, *Cities, 40 part B* (2019), pp. 124-132, doi.org/10.1016/j.cities.2013.09.002.

[9] Lopez-Pineiro S., *A Glossary of Urban Voids*, jovis, Berlin, Germany, 2020

[10] Wachter S. M., Gillen K. C., Public Investment Strategies: How They Matter for Neighborhoods in Philadelphia, The Wharton School University of Pennsylvania (2006)

[11] Morckel V., Community gardens or vacant lots? Rethinking the attractiveness and seasonality of green land uses in distressed neighbourhoods, *Urban Forestry & Urban Greening, 14* (2015), pp. 714-721, doi.org/10.1016/j.ufug.2015.07.001.

[12] Accordino J., Johnson G. T., Addressing the Vacant and Abandoned Property Problem, *Journal of Urban Affairs, 22* (2000), pp. 301-315, doi.org/10.1111/0735-2166.00058.

[13] Pearsall H., Lucas S., Vacant land: The new urban green? *Cities, 40* (2014), pp. 121-123, doi.org/10.1016/j.cities.2013.10.001.

[14] Anderson E. C., Minor E. S., Vacant lots: An underexplored resource for ecological and social benefits in cities, *Urban Forestry & Urban Greening, 21* (2017), pp. 146-152, doi.org/10.1016/j.ufug.2016.11.015.

[15] Oswalt P., Misselwitzz P., Overmeyer K., Patterns of the unplanned, *Loose space : possibility and diversity in urban life / Karen Franck and Quentin Stevens* (2007), pp. 271-288.

[16] Kim G., Newman G. Jiang B., Urban regeneration: Community engagement process for vacant land in declining cities, *Cities, 102* (2020), doi.org/10.1016/j.cities.2020.102730.

[17] Naghibi M., Faizi M., Temporary reuse in leftover spaces through the preferences of the elderly, *Cities, 127* (2022), doi.org/10.1016/j.cities.2022.103769.

[18] Albrecht H., Eder E., Langbehn T., Tschiersch C., The soil seed bank and its relationship to the established vegetation in urban wastelands, *Landscape and Urban Planning, 100* (2011), Issues 1-2, pp. 87-97, doi.org/10.1016/j.landurbplan.2010.11.011.

[19] Jang G., Kim S., Are decline-oriented strategies thermally sustainable in shrinking cities?, *Urban Climate, 39* (2021), doi.org/10.1016/j.uclim.2021.100924.

[20] Enia M., Martella F., Reducing architecture: Doing almost nothing as a city-making strategy in 21st century architecture, *Frontiers of Architectural Research, 8* (2019), Issue 2, pp. 154-163, doi.org/10.1016/j.foar.2019.01.006.

[21] Florida R., The Creative Class and Economic Development, *Economic Development Quarterly, 28* (2014), Issue 3, pp. 196-205, doi.org/10.1177/08912424145416.

[22] Colomb C., Pushing the urban frontier: Temporary uses of space, city marketing, and the creative city discourse in 2000s Berlin, *Journal of Urban Affairs, 34* (2012), Issue 2, pp. 131-152, doi.org/10.1111/j.1467-9906.2012.00607.x.

[23] Ponzini D., Rossi U., Becoming a Creative City: The Entrepreneurial Mayor, Network Politics and the Promise of an Urban Renaissance, *Urban Studies, 47* (2010), Issue 5, pp. 1037-1057, doi.org/10.1177/0042098009353073.

[24] Kremer P., Hamstead Z. A., McPhearson T., A social-ecological assessment of vacant lots in New York City, *Landscape and Urban Planning, 120* (2013), pp. 218-233, doi.org/10.1016/j.landurbplan.2013.05.003.

[25] CZSO, Database of Demographic Indicators for Selected Towns of the Czech Republic, Prague Czechia Czechia, 2022

[26] Strakoš M., Nová Ostrava a její satelity (New Ostrava and its satellites), NPÚ, Ostrava, Czechia, 2010

[27] Hudeček T., Martin Dlouhý M., Hnilička P., Leňo Cutáková L., Leňo M., *Hustota a ekonomika měst (Density and economics of cities)*, České vysoké učení technické v Praze, Masarykův ústav vyšších studií, Prague, Czechia, 2018

LIVING SELF-UPGRADING SHELTER: A BIODESIGN APPROACH FOR FUTURE OF SUSTAINABLE DISASTER RELIEF

Sara Ghanbarzadeh Ghomi[*a,1], Dr James Charlton[b,1], Dr Meng Zhang[c,2]

[1]Department of Architecture and Built Environment, and [2]Department of Applied Science, Northumbria University
NE1 8ST, Newcastle Upon Tyne, United Kingdome.
[*a]sara.ghomi@northumbria.ac.uk, [b]j.charlton@northumbria.ac.uk,
[c]meng.zhang@northumbria.ac.uk

Abstract

This research investigates the application of the proposed "Living Self-TransForming Disaster Relief shelter" (LTF DR-shelter) approach to provide sustainable self-upgrading post-disaster shelters. When disaster hits in countries where beneficiaries have limited access to resources, (i.e., construction material, labour, financial support) quickly, existing post-disaster shelter approaches frequently lead to economically and environmentally unsustainable implemented solutions that fail to meet the needs of those seeking shelter. Solutions are therefore needed to provide new and innovative approaches to providing disaster relief.

Intriguingly, looking forward, emerging Living Technology offers the potential for existing and future Engineered Living Materials to provide novel approaches to providing disaster relief. Such living materials, in which growth is incremental, self-upgrading and utilises living transformation mechanisms, whereby shelters could be grown on-site with living materials that offer features such as self-assembly, self-repair, resilience, etc. promising cost and energy-efficiency, and being environmentally friendly in the next 50 years. Through this future vision, the research explores the success factors of the conceptual approach of the self-upgrading LTF DR-shelter. The LTF DR-shelter concept proposed employs Biodesign and living technology potentials to envision integrating the separate emergency and temporary shelter into one initial ten-kit (living-textile). It self-transforms into a monolithic self-sustaining structure on-site while beneficiaries reside in it with disassembly and reassembly features for relocation.

Furthermore, contrary to conventional design approaches that use materials already developed, the emerging Biodesign methods initiate the material and shelter design simultaneously and even co-designing with microorganisms. Moreover, the applicable biocomposite for LTF DR-shelter is visioned to be designed in the future (next 10-50 years). Hence, while multiple studies are investigating Biodesign methods and DR-shelters separately, there is a dearth of research regarding applying living materials in DR-shelters through Biodesign. Therefore, to address this knowledge gap, this research aims to envision potential future alternative success factors, and challenges of LTF Dr-shelter Biodesign.

Keywords

Future, Shelter, Living material, Self-upgrade, Disaster-relief.

1 Introduction

Disasters occur frequently worldwide, causing significant damage to people's lives and displace millions of people every year, leaving them without adequate shelter, food, and basic necessities [1]. As sustainable architects, we are acutely aware of the urgent need for innovative and sustainable solutions for post-disaster shelter. The current approaches to post-disaster shelter solutions are often focused on providing quick, temporary shelter using conventional materials, such as plastic or metal. However, often, disaster-hit countries and communities have limited access to resources such as construction materials, labor, and financial support [2]. As a result, existing post-disaster shelter approaches frequently lead to economically and environmentally unsustainable solutions that fail to meet the needs of those seeking shelter [3]

Hence, there is a need for new, innovative approaches to provide sustainable, long-lasting satisfactory shelter solutions in disaster-stricken regions. Fortunately, emerging technologies such as living materials and biodesign offer the potential for novel approaches to disaster relief. One such approach is the Living Self-Transforming Disaster Relief Shelter (LTF DR-shelter) [4], which utilises biodesign and living technology to create a self-upgrading shelter that can be grown on-site with living materials. This innovative shelter has the potential to be cost and energy-efficient, environmentally friendly, and easily adaptable to the specific needs of disaster-stricken communities.

The application of living technology and biodesign in architecture provides a promising opportunity for the development of sustainable post-disaster shelters. Engineered living materials have potentials to be designed to have self-assembly, self-repair, and resilience features, which can provide a cost-effective, environmentally friendly, and self-upgrading alternative to conventional building materials [5]. The proposed LTF DR-shelter approach utilises the potential of biodesign and living technology to integrate emergency and temporary shelters into one initial ten-kit that self-transforms into a monolithic self-sustaining structure on-site with disassembly and reassembly features for relocation. This approach could potentially provide an effective and sustainable solution to disaster relief challenges.

While there is a growing body of research on biodesign and disaster relief shelters, there is a lack of research on the application of living materials to disaster relief shelter through biodesign. To address this knowledge gap, this paper explores the conceptual approach of the LTF DR-shelter, which envisions the potential of living materials in the next 50 years. The research aims to envision potential future alternative success factors, challenges, and ethical concerns of LTF DR-shelter biodesign. This paper contributes to the understanding of the integration of living technology and biodesign in disaster relief, offering a new perspective on the sustainable development of post-disaster shelters. By exploring the potential of living materials and self-upgrading technology, this research offers a promising vision for the future of disaster relief shelters. This future vision is a proactive approach fascilitating co-biodesign between interdisciplinary experts, hence, accelerating the successful living technologies application in disaster relief.

2 Literature review

2.1 Biodesign in architecture

Biodesign in architecture is a rapidly growing area of research that combines biology, design, and engineering principles to create sustainable and innovative solutions in the built environment. One of the key focuses of biodesign in architecture is the development of living materials and textiles that are capable of self-regeneration, growth, and adaptation to their environment [6]. These materials have the potential to transform the way buildings are constructed, offering greater sustainability, efficiency, and resilience to natural disasters. The goal of the living construction vision, according to Hub for Biotechnology and the Built Environment (HBBE) [7], is "to develop a new generation of living structures that are sensitive to their surroundings, grown with living engineered materials to replace inefficient industrial construction methods, metabolise their own waste to reduce pollution, produce high-value products and energy, and control their microbiomes to promote the health and wellbeing of both people and the environment".

Such future visions and the consequent architectural speculations offer the What and sometimes Why, but the How lies within the field of synthetic biology fascilitating creating engineering living materials that has gained significant attention in recent years. By thinking of materials not as matter to be harvested after the death of the organism which created them but by controlling the process of material creation while the organism is alive, synthetic biology offers an opportunity in which we might begin to harness a much greater range of biological materials, many of which do not yet exist [8]. Such living materials can be engineered to gain the ability to self-heal, respond to changes in the environment, and regenerate damaged parts [9]. One example of engineered living materials applied in living construction is self-healing concrete, which is embedded with bacteria that produce calcium carbonate when activated by moisture. This process helps to repair cracks in the concrete, extending its lifespan and reducing the need for maintenance [10]. Some examples of recent non-engineered living materials already applied in architecture already are shown in Figure 1 including Mycelium (the vegetative part of fungi) and Bacterial Cellulose. Overall, Biodesign application in architecture has initiated, representing a promising avenue for future emerging sustainable and innovative design solutions.

Figure 1. Hy-Fi Tower- Mycelium-bricks (left), Growing Pavilion Mycelium-panels (middle), Aguahoja Biopolymer Pavilion- Bacterial cellulose (right)

Some novel Biodesign solutions are the development of living textiles incorporated with mycelium and engineered living materials, with the potential to revolutionise how buildings are constructed and maintained, offering greater sustainability and resilience to natural disasters and beneficial in such contexts. Living textile architecture is a field of Biodesign that explores the use of living materials and textiles in architecture. These materials are typically made from living organisms such as bacteria and fungi and are designed to perform specific functions within the built environment [11]. One example of living textile architecture is using mycelium, the vegetative part of a fungus, as a building material. Mycelium can be grown into various shapes and sizes and has been used to create everything from furniture to building panels.

One of the most recent novel examples of living textile architecture is BioKnit Prototype. BioKnit is a project by a team of designers and scientists from the HBBE that explores using 3D knitted fabric structurally at the architectural scale. The prototype is a monolithic, free-standing biohybrid structure made of mycelium, bacterial cellulose, and 3D knitting (knitted from wool and linen) and was not grown in the lab but in "The OME," an experimental test bed in Newcastle. The materials used have a lower environmental impact than conventional construction materials, making it a sustainable and innovative approach to building with living textiles (Figure 2) [12].

Figure 2. BioKnit Prototype, biofabrication and construction process [12].

Recent research in Biodesign in architecture has shown promising results for developing sustainable and innovative building materials. Living materials and textiles have the potential to transform the way buildings are designed, constructed, and maintained, offering greater sustainability, efficiency, and resilience to natural disasters and the design of emergency shelters (tents-kits). However, further research is needed to fully understand the properties and limitations of these materials through experiments and prototyping and to develop scalable and cost-effective production methods.

2.2 Disaster-relief shelters

In the aftermath of natural disasters, providing shelter is a critical aspect of emergency response efforts. Affected populations in post-disaster contexts tend to move between different settlement options [13]. However, in this research target population is nonlocally displaced affected populations after a natural hazard-induced disaster living in a grouped settlement in tents (planned camp). The provision of shelter has traditionally been divided into three main phases: relief, rehabilitation, and reconstruction [14]. During the relief phase, emergency shelters such as tents are typically provided to those affected by the disaster to provide immediate and temporary accommodation until more durable solutions can be found. The rehabilitation phase involves the provision of more durable temporary shelters that can last for several months up to two years, while the reconstruction phase involves rebuilding permanent housing for those affected by the disaster.

One approach to sustainable post-disaster sheltering is transitional shelter (TS) approach, which involve incrementally upgrading existing emergency shelters to more durable temporary shelters by reusing materials or incremental external resource allocation. However, the rush to provide shelter and the subsequent delays in the process have often led to low-quality shelter and reconstruction efforts. Furthermore, the reuse of materials for the next phase is often done with inevitable degraded quality, leading to additional costs and a lack of sustainability in the long run [15]. (Figure 3).

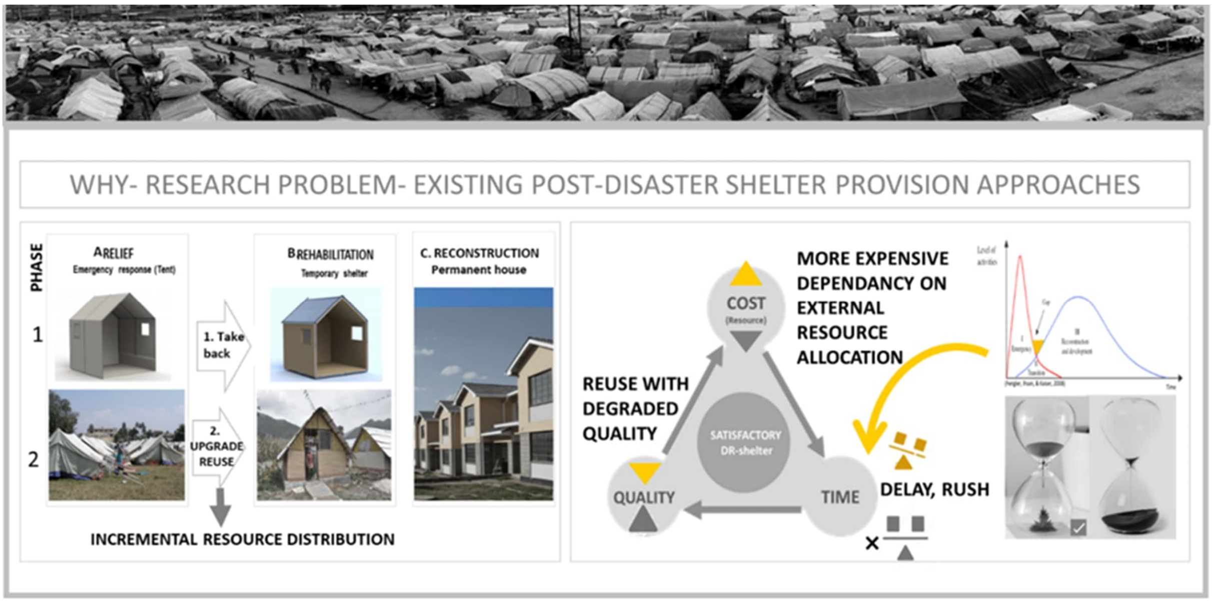


Figure 3. Research Problem in existing post-disaster shelter approaches

Dependency on external resources is another major challenge in sustainable post-disaster sheltering. External cash and material allocations are often required to provide adequate shelter upgrades. Various factors can affect this dependency, including difficulty in accessing the location, limited budgets and resources, and pre-existing or disaster-related lack of infrastructure [13]. In some cases, the cost of providing Transitional shelter can be up to three times more than that of permanent housing reconstruction, highlighting the need for more sustainable and cost-effective solutions [16].

Furthermore, according to [17], supporting shelter self-recovery is encouraged to promote equitable support for all affected populations and facilitate participation; the survivor-led process of recovering adequate living conditions and re-establishing a sense of home is what [17] refers to as self-recovery. Using living materials and technologies is one innovative approach to facilitate self-recovery through sustainable post-disaster sheltering. For example, living textiles are incorporated with engineered living organisms, such as bacteria or fungi, to create on-demand functional living materials that adapt to changing environmental conditions [18].

In summary, sustainable post-disaster sheltering requires a holistic and innovative approach considering the unique challenges of providing shelter in emergencies and post-disaster contexts. Through the use of transitional shelters, sustainable characteristics, living materials and technologies, and a focus on cost-effective and sustainable solutions, it may be possible to improve the quality and long-term sustainability and, accordingly user satisfaction rate of post-disaster sheltering efforts.

3 Methodology

The LTF DR-shelter concept relies on the Technology Readiness Level (TRL) of ELMs (Figure 4). Overall, living materials' TRL is now at level one, two, or three [10], with the anticipation of the next 20-50 years improving to higher levels. Hence methodology adopted for this study involves future forecasting and strategic foresight combined with the Biodesign approach to design. The design process was divided into *Ideation, Validation,* and *Application*.

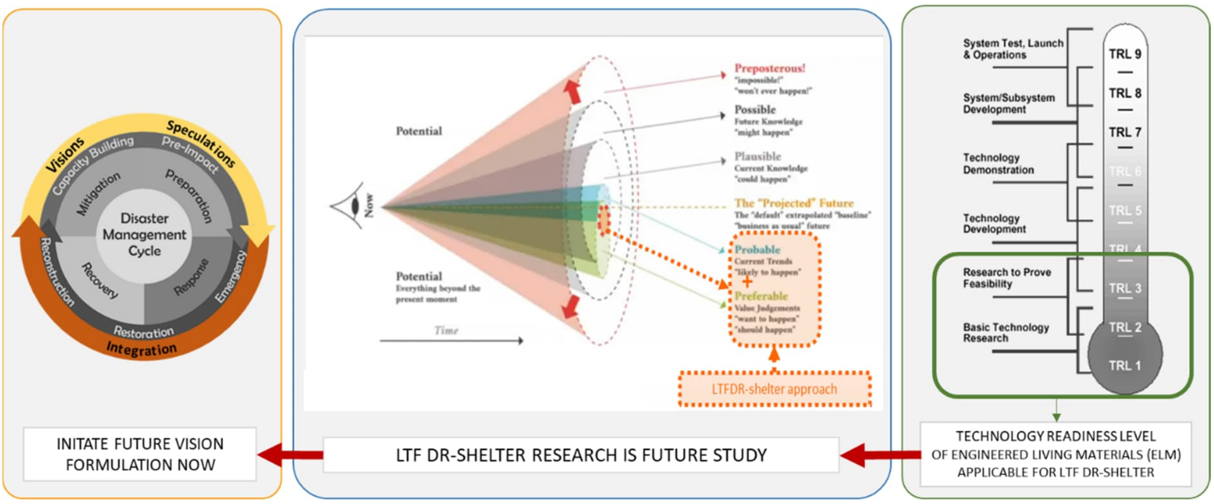


Figure 4. Research Design based on TRL of ELMs

The Ideation phase involved formulating alternative future preferred visions of LTF DR-shelter success factors based on the findings of a SWOT analysis of the literature for existing post-disaster shelters and the opportunities presented by living technology, Biodesign, and living textiles. This phase resulted in developing a framework for the future preferred success factors of LTF DR-shelters.

The Validation phase involved conducting a workshop with eight interdisciplinary experts, including two participants from each expertise, including post-disaster shelter, industrial, living material, and living architecture Biodesign. The purpose of this phase was to validate the framework developed in the Ideation phase and make necessary modifications. In addition, visual speculations of the future LTF DR-shelters were developed using AI tools such as Midjourney.

This methodology aligns with the current trend in architecture and Biodesign, which emphasises the need for sustainable and innovative solutions to address societal challenges such as natural disasters and climate change. Adopting a Biodesign approach in this study provides a new perspective on the design of disaster relief shelters, emphasising the use of living materials and technology to create sustainable and self-adaptable solutions.

4 Results and Discussion

This section presents the research findings, categorised into three themes: *Time, Quality*, and *Cost* related Success Factors. Based on these themes, the user and technology success factor visions are formulated and further divided into two sub-categories: project and product-level visions. The product level visions are categorised into Shelter, Material, and Microorganism Biodesign, with LTF DR-Shelter focusing on Architectural Biodesign, living material Biodesign, and Microbial Biodesign. This approach enables a comprehensive understanding of the various factors contributing to the success of LTF DR-project, including innovative materials, organism design, and engineered living materials with programmable functions.

4.1 Time-related Success Factor visions

The findings from the workshop discussion revealed that time is a crucial factor for the success of LTF DR-shelter implementation. The time-related success factors were classified into two main categories, namely, user and technology. For user-related success, the workshop participants highlighted the importance of cohabiting with the living shelter throughout its growth process. This factor is critical in facilitating the desired integration of relief, rehabilitation, and reconstruction phases in a new way that decreases the workload required for material fabrication and shelter upgrade compared to existing approaches due to shelter and material's natural growth over time (Figure 5). It was also noted that trauma and the need for resilience building should be considered, and the acceptance of the shelter solution and its benefits in relation to other alternatives are key factors for success.

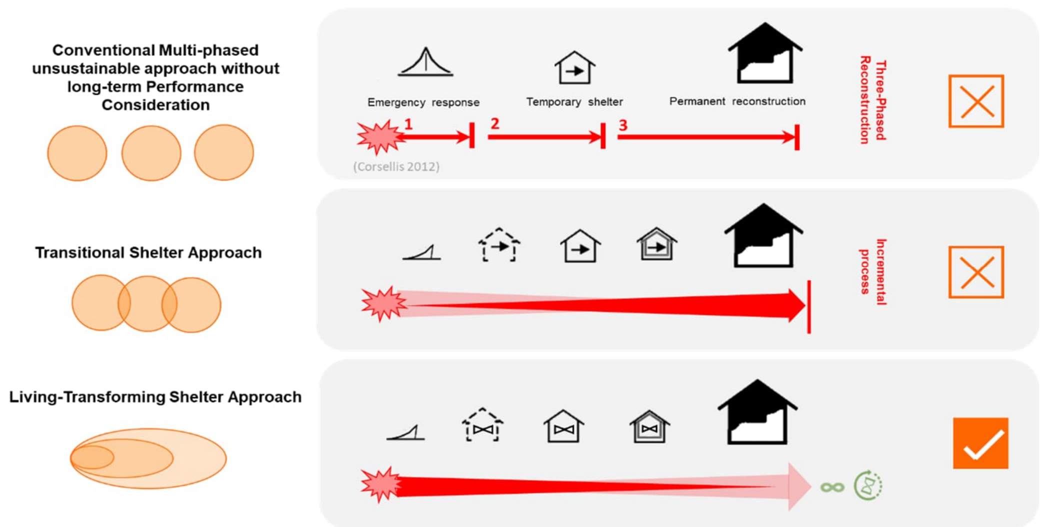


Figure 5. *Integration* of post-disaster shelter phases; A comparison of between LTF DR-shelter vision and existing approaches

The literature supports the importance of time in post-disaster sheltering. Studies have shown that providing temporary shelter in a timely and efficient manner can help alleviate displacement's negative impacts on affected populations [19]. Additionally, the literature emphasises the importance of user-centred approaches in post-disaster sheltering to ensure that the needs and preferences of affected populations are considered [20].

Regarding technology-related success factors, the workshop participants highlighted the importance of biofabrication and architectural Biodesign, living material Biodesign, and microbial Biodesign. These factors are critical in facilitating the self-upgrading of the living shelter and making it more sustainable and acceptable as a new space by the occupants. However, the challenge here is the time that this requires, and the nature of the self-upgrading living shelter will mean that ideally, over time, the shelters will get more durable and more suitable for the occupants growing needs through post-disaster phases.

The challenges identified by the workshop participants were mainly related to the length of stay, person-to-person variation, and the resources required for care activities. These challenges should be considered in designing and implementing LTF DR-shelter to ensure they are user-centred and meet the growing needs of affected populations at all stages.

In conclusion, time is a crucial factor for the success of LTF DR-shelter implementation. The workshop findings highlighted the importance of user-centered approaches and innovative technologies such as biofabrication and biodesign in ensuring the shelter's success. The challenges identified should be considered in the design and implementation of LTF DR-shelter to ensure that they are user-centred and meet the needs of affected populations.

4.2 Quality-related Success Factor visions

The workshop discussions revealed that quality is crucial in designing and implementing post-disaster shelters. The participants suggested that the success of the LTF DR-shelter would depend on the implementation of quality self-adaptation on-site, which includes self-management and self-recovery. User involvement and agency were emphasised as necessary for increasing the users' sense of belonging, satisfaction, and mental health. The findings suggest that user-centric approaches, such as participatory design and co-creation, should be considered to facilitate user involvement and ownership. The participants also highlighted the importance of technological aspects, such as structural stability, self-optimisation, and biotechnology solutions, in ensuring the quality of post-disaster shelters. The maintenance of LTFDR-shelters would be perceived in the middle of classical materials maintenance and gardening activities, suggesting that the shelter's design should consider the users' daily activities and lifestyles. The participants also identified some materials, such as bio-silicon, bacterial cellulose, and mycelium, which have potential for genetic manipulation and self-optimisation in terms of shelter properties. In conclusion, the thematic analysis of the workshop discussions suggests that the quality of post-disaster shelters depends on user involvement, agency, ownership, and technological aspects such as structural stability, self-optimisation, and biotechnology solutions.

4.3 Cost-related Success Factor visions

The thematic category of findings from the workshop discussion on the cost considerations for implementing the LTFDR-shelter concept revealed four key themes. The first theme, dependence on external support, emphasises the need to reduce reliance on external resources for successful implementation. This finding is consistent with the research problem that identified existing approaches as expensive and dependent on external resource allocation for upgrades. The second theme, efficiency and cost reduction, highlights the potential for LTFDR-shelters to eliminate inefficient shelter construction processes and associated costs. This finding aligns with the user cost-related preferred success factor vision related to cost, which emphasises less dependency on external resource allocation and less required incremental cash and material distribution for upgrades (Figure 6).

The third theme, circular economy and biomaterials, supports the formulated preferred and likely cost-related future success factor vision for the LTF DR-shelter, which includes using on-site local and grown materials. The use of biomaterials and a circular waste economy could contribute to reducing costs and improving sustainability [21]. However, it was noted that this would require significant pre-planning and setup and could potentially compete for resources in the local economy.

The fourth theme, DNA modification, aligns with the main success factor to contribute to the preferred success factor vision, which is material on-site biofabrication. DNA modification may become more accessible and cost-effective in the next 50 years and could lead to the development of new materials and building systems. However, it was noted that some level of expertise would still be required to fully utilise this technology, highlighting the significance of associated training provision.

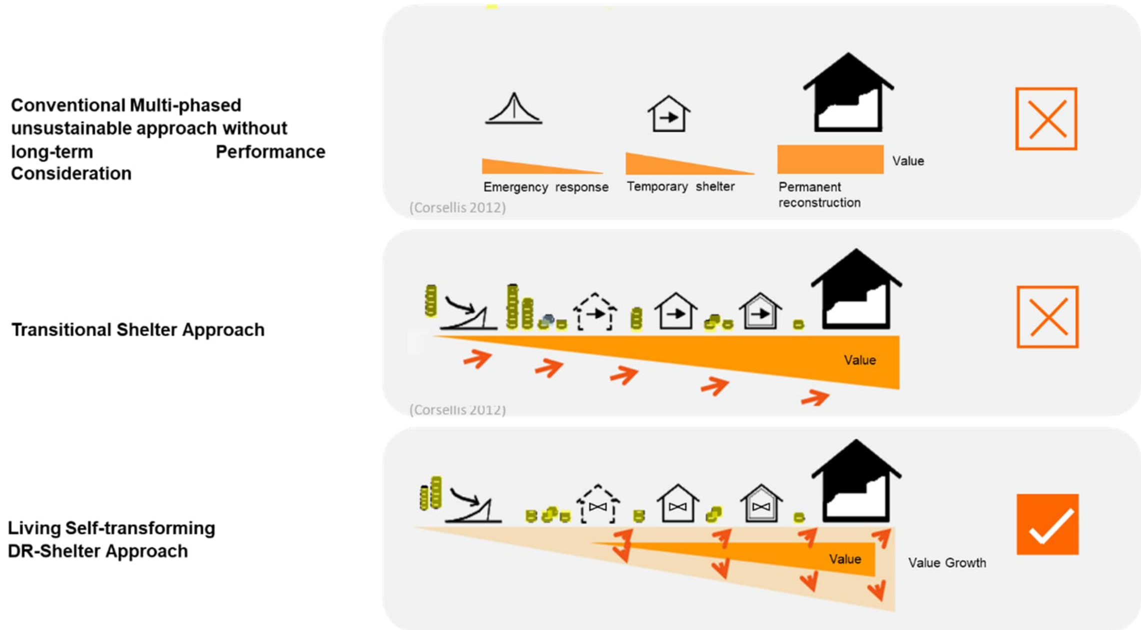


Figure 6. Shelter-related resource (Cash, Material) distribution strategies of existing post-disaster shelter approaches in comparison to LTF DR-shelter vision for values proposition and resource self-development with decrease in required distribution.

Overall, the primary data suggests that the successful implementation of LTF DR-shelters in the real world will depend on careful consideration of the costs and challenges related to both the user and technology aspects, along with a focus on reducing dependence on external support, increasing efficiency, and exploring innovative solutions such as circular waste economies and DNA modification of the microorganism that provides the on demand specification for the proper ELMs. The proposed preferred and likely cost-related future success factor vision for the LTF DR-shelter, which includes on-site local and grown materials, aligns with the third theme of circular economy and biomaterials [21]. To facilitate this, the shelter should generate free additional quantities of material to help with livelihood on-site. This approach's success depends on the level of DNA modification cost and accessibility, which aligns with the fourth theme of DNA modification. Future research could focus on developing sustainable and affordable building materials and exploring new technologies to reduce costs and improve the sustainability of LTF DR-shelters.

Overall, Biodesigning LTF DR-shelter while considering the significance and impact of the success factors mentioned above not only facilitates the balanced relationship between them to tackling the associated problems in the disaster relief shelter provision but also enables thriving through quality upgrade and transformation independent of external support towards more sustainability (Figure 7).

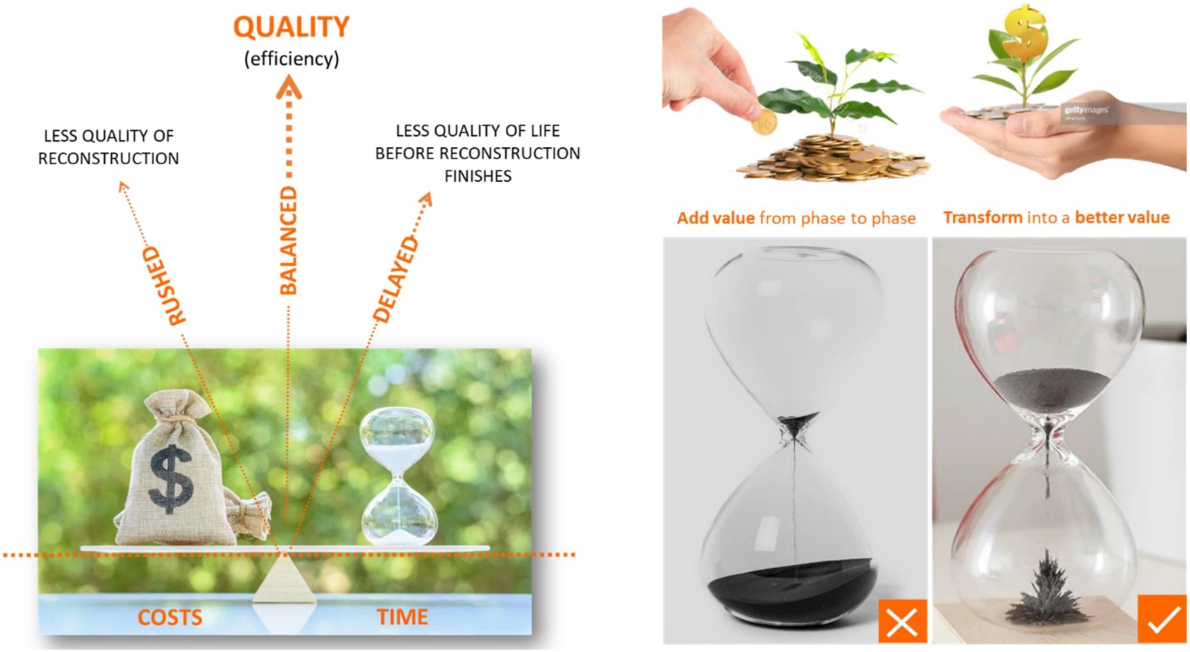


Figure 7. The significance of balance between LTF DR-shelter success factors *Time, Quality, Cost* to tackle existing problems through Biodesign and consequent LTF DR-shelter philosophy of thrive vs survive.

4.4 LTF DR-shelter Visions and Speculations

Finally, the LTF DR-shelters' vision was devised, signifying its main characteristics and alternative future visual speculations (Figure 8). This vision is based on five main characteristics of the Transitional-shelter (TS) approach: reuse, upgrade, relocate, recycle, and resell. The engineered living materials'(ELMs) existing and future potentials, on the other hand, provide the "How" to deliver TS characteristics in a novel way that would elevate the post-disaster philosophy from SURVIVE to THRIVE and encourage more self-recovery going beyond sustainability. Figure 9 is a conceptual illustration of how the Elms' potentials can be utilised to enhance one specification of shelter namely insulation. It signifies the importance of context-specific specifications, e.g., climate-related shelter Bidesign speculations and initiation with local experts that should take place in the preparation phase of the post-disaster management cycle.

Figure 8. LTF DR-shelters' vision, signifying its main characteristics and alternative future visual speculations.

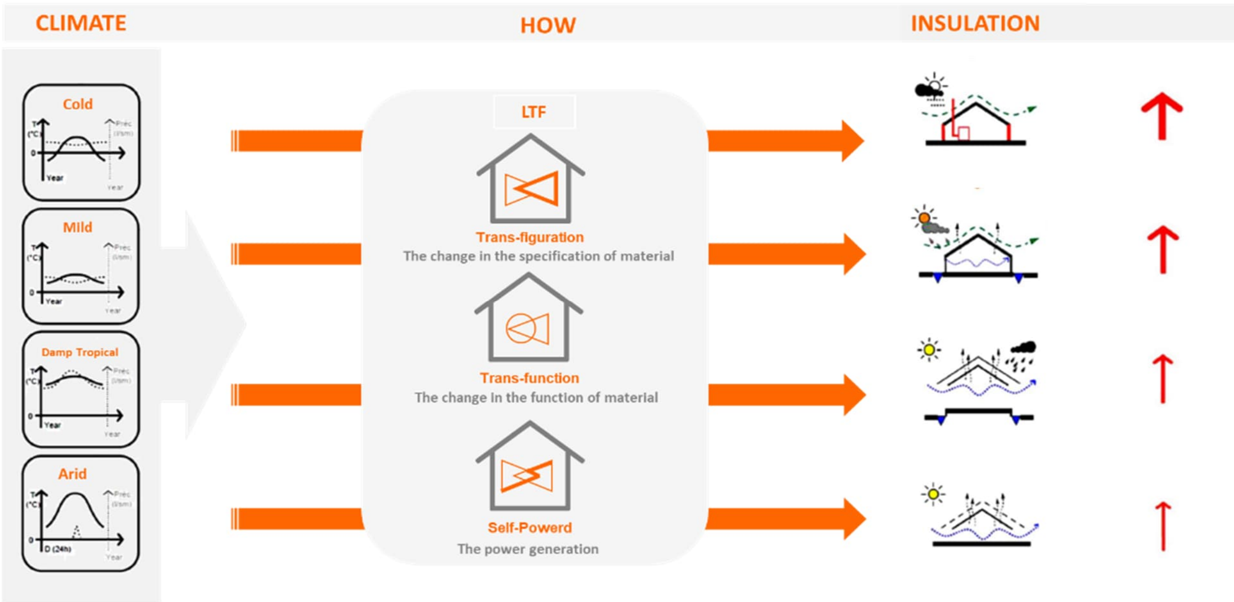


Figure 9. Conceptual illustration of how the Elms' potentials can be utilised to enhance one specification of shelter namely insulation.

5 Conclusion

In conclusion, disasters leave millions of people displaced and in need of adequate shelter, food, and basic necessities. However, the current approaches to post-disaster shelter design solutions often lead to economically and environmentally unsustainable solutions. This paper explores the conceptual approach of the Living Self-Transforming Disaster Relief Shelter (LTF DR-shelter) that utilises Biodesign and living technology to create a self-upgrading shelter that can be grown on-site with living materials. The methodology adopted for this study involved future forecasting and strategic foresight combined with the Biodesign approach to design. The results indicate that time, quality, and cost-related success factors are crucial for the success of LTF DR-shelter implementation. Future research in this field should focus on the development of living materials with self-assembly, self-repair, and resilience features, which can provide a cost-effective, environmentally friendly, and self-upgrading alternative to conventional building materials. The LTF DR-shelter approach offers a promising vision for the future of disaster relief shelters, and its successful implementation requires co-biodesign between interdisciplinary experts, accelerating the successful living technologies application in disaster relief.

References

[1] Rieger, Kerstin, Multi-hazards, displaced people's vulnerability and resettlement: Post-earthquake experiences from Rasuwa district in Nepal and their connections to policy loopholes and reconstruction practices, *Progress in Disaster Science, 11,* (2021), 100187.

[2] Rouhanizadeh, B, Sharareh Kermanshachi, and Thahomina Jahan Nipa, Exploratory analysis of barriers to effective post-disaster recovery, *International Journal of Disaster Risk Reduction, 50,* (2020), 101735.

[3] Alshawawreh, Lara, Francesco Pomponi, Bernardino D'Amico, Susan Snaddon, and Peter Guthrie, Qualifying the sustainability of novel designs and existing solutions for post-disaster and post-conflict sheltering, *Sustainability, 12,* (2020), no. 3.

[4] Ghanbarzadeh Ghomi, S., Wedawatta, G., Ginige, K. and Ingirige, B., Living-transforming disaster relief shelter: A conceptual approach for sustainable post-disaster housing, *Built Environment Project and Asset Managemen*t, 11, (2021), 4, pp.687-704, https://doi.org/10.1108/BEPAM-04-2020-0076

[5] Nguyen, Peter Q., Noémie-Manuelle Dorval Courchesne, Anna Duraj-Thatte, Pichet Praveschotinunt, and Neel S. Joshi, Engineered living materials: prospects and challenges for using biological systems to direct the assembly of smart materials, *Advanced Materials, 30*, (2018), no. 19, 1704847.

[6] Ahlquist, Sean, and Achim Menges, Materiality and computational design: emerging material systems and the role of design computation and digital fabrication, In The Routledge Companion for Architecture Design and Practice, *Routledge*, (2018), pp. 181-200.

[7] Biotechnology in the Built Environment (HBBE), http://bbe.ac.uk/living-construction/

[8] Dade-Robertson, Martyn, *Living construction*, Routledge, United Kingdome, 2020

[9] Jonkers, H. M, Self-healing concrete: A biological approach, *Bioinspired and biomimetic materials systems*, *4(1),* (2011), 034002.

[10] Haneef, M., & Rana, M. A, Mycelium: A Potential Building Material in Sustainable Architecture. *Journal of Building Engineering*, *36*, (2021). 102223.

[11] Attias, Noam, Ofer Danai, Tiffany Abitbol, Ezri Tarazi, Nirit Ezov, Idan Pereman, and Yasha J. Grobman, Mycelium bio-composites in industrial design and architecture: Comparative review and experimental analysis, *Journal of Cleaner Production, 246* (2020), 119037.

[12] Biotechnology in the Built Environment (HBBE), http://bbe.ac.uk/bioknit-prototype/

[13] Corsellis, Tom, *Transitional Shelter Guidelines*, Shelter Centre, Switzerland, 2012

[14] Sutley, Elaina J., and Sara Hamideh, Postdisaster housing stages: A Markov chain approach to model sequences and duration based on social vulnerability, *Risk Analysis, 40*, (2020), *no.* 12, 2675-2695.

[15] Celentano, Giulia, Edwin Zea Escamilla, Verena Göswein, and Guillaume Habert, A matter of speed: The impact of material choice in post-disaster reconstruction, *International Journal of Disaster Risk Reduction, 34*, (2019), 34-44.

[16] Hadafi, Farzaneh, and Alireza Fallahi, Temporary housing respond to disasters in developing countries-case study: Iran-Ardabil and Lorestan Province Earthquakes, *International Journal of Humanities and Social Sciences, 4,* (2010), no. 6 1326-1332.

[17] Twigg, John, The evolution of shelter "self-recovery, Adapting thinking and practice for post-disaster resilience, *Journal of the British Academy, 9,* (2021), no. s8 5-22.

[18] Srubar, Wil V, Engineered living materials: taxonomies and emerging trends, *Trends in Biotechnology, 39,* (2021), no. 6 574-583.

[19] Kruger, E., & van Niekerk, D, The Importance of User Agency in Post-Disaster Shelter, *Sustainable Cities and Society, 57,* (2020), 102113.

[20] Van Niekerk, D., & Kruger, E, Co-creation in Post-Disaster Shelter: Towards a User-Centric Approach, *International Journal of Disaster Risk Reduction, 35,* (2019), 101084.

[21] Tokazhanov, Galym, Olzhas Galiyev, Artyom Lukyanenko, Aslan Nauyryzbay, Rassul Ismagulov, Serdar Durdyev, Ali Turkyilmaz, and Ferhat Karaca, Circularity assessment tool development for construction projects in emerging economies*, Journal of Cleaner Production, 362* (2022), 132293.

EVALUATION OF DESIGN STRATEGIES OF SUSTAINABILITY TO ARCHITECTURAL DESIGNS FROM 1970 TO THE PRESENT

Mehmet Arif AKTOG*, Rosa URBANO GUTIÉRREZ, Haniyeh MOHAMMADPOURKARBASI

University of Liverpool
L69 7ZN, Liverpool, United Kingdom; M.Aktog@liverpool.ac.uk

Abstract

The built environment plays a significant role in global energy consumption and carbon emissions, thus making sustainability an increasingly important concern for architects and designers. As energy efficiency and reducing carbon emissions have become key design objectives, various strategies and methods have been developed to integrate sustainability into architectural design. These strategies have evolved over time, influenced by changes in policies and technological advancements. Furthermore, sustainability certifications such as BREEAM and LEED were introduced to evaluate and score the sustainability performance of buildings.

This study aims to investigate the evolution of sustainable strategies and methods in architectural design from the 1970 oil crisis to the present day. The paper will analyse the definition and comparison of these strategies and explore how they have been influenced by historical and contemporary factors. Additionally, the study will examine the advantages and disadvantages of sustainability certifications and compare their effectiveness in evaluating and promoting sustainable building design. Through this analysis, the paper aims to provide a comprehensive understanding of the current state of sustainability in architectural design practice and the potential for future advancements in this field.

Keywords:

Sustainability, Green buildings guidelines, Office Buildings, Sustainable Certification system, Energy Efficiency

1 Introduction

The building sector has long been identified as a significant contributor to energy consumption and greenhouse gas emissions. Furthermore, it has been acknowledged that improving the energy efficiency of buildings can play a crucial role in mitigating the impacts of global warming. The World Green Building Council (WorldGBC) annually computes the percentage of CO_2 emissions and energy consumption of the Architecture, Engineering, and Construction (AEC) sectors. According to the Global Status report published in 2020, buildings account for 36% of global energy consumption, which constitutes the largest share of energy use. In addition, buildings are responsible for 37% of CO_2 emissions [1] The total energy consumption percentage of the building sector continues to rise, though it experienced a temporary decrease in 2020, dropping to levels last seen in 2007. This decline can largely be attributed to the closure or reduced operations of buildings resulting from the COVID-19 pandemic rather than improved energy policies or regulations [2]. Nonetheless, it is clear that addressing energy efficiency and reducing emissions in the construction sector is imperative for addressing the climate crisis. Additionally, to achieve the carbon reduction targets that governments have set for 2030 and 2050, the implementation of sustainable building practices that significantly lower the carbon footprint of buildings is essential [3]

The United Kingdom has set ambitious targets for reducing greenhouse gas emissions, aiming for an 80% reduction by 2050, as outlined in the 2008 Climate Change Act. Additionally, the country's ratification of the 2015 Paris Climate Agreement has committed the UK to efforts to prevent climate change and limit global warming to below 2°C. To achieve these goals, significant reductions in CO2 emissions will be necessary, with a target of at least a 50% reduction by 2030 [4].

In the UK, as in many other countries, government regulations promoting sustainable building practices have been implemented to raise awareness among employers, designers, and end-users. These policies, agreements, and actions have aimed to reduce the construction industry's energy consumption and carbon emissions. However, to achieve further reductions in energy use, it is necessary to develop new design guidelines and technologies [5].

The decisions made throughout the life cycle of a building, including the selection of energy systems and resources, and the consideration of energy efficiency and gas emissions, are crucial in terms of energy and the environment. As interest in this field has grown, many studies have been undertaken to develop methods to promote sustainability at the design stage. However, these methods only sometimes serve as practical tools, techniques, guides, or strategies for designers at the conceptual design stage and may not meet the needs of designers. Passive design strategies such as orientation, insulation, and shading can significantly reduce a building's energy demand, and incorporating renewable energy technologies such as solar panels and geothermal systems can help reduce reliance on fossil fuels [6]. Furthermore, sustainable building design not only reduces carbon emissions but also improves the health and well-being of building occupants. Poor indoor air quality, as identified by the World Health Organization (WHO), is a significant contributor to health issues such as respiratory diseases and allergies [7]. By incorporating design features that improve indoor air quality, such as natural ventilation and lighting, sustainable buildings can help to mitigate these health risks [6].

Additionally, sustainable building design can also help to reduce operating costs for businesses. Energy-efficient technologies and designs can significantly reduce a building's energy consumption, resulting in lower utility bills and a more financially viable transition to a low-carbon economy [6].

1.1 Problem Statement

According to the existing literature and the energy reports published in recent years, the construction sector is still responsible for approximately 37% of the total global energy in the last 20 years. Although many agreements, contracts and meeting decisions have been made on sustainability, energy consumption and CO_2 emissions have not decreased to the targeted levels. [8] Actions taken are insufficient because the future human population and energy needs will increase. In multiple reports on the climate crisis published in recent years, it is recommended to take urgent action and change the plans and methods of all countries on sustainability. In addition, many developed countries, such as the UK, have 2030 and 2050 targets, and the UK has committed to achieving net zero carbon emissions by 2050 [9]. In the UK, the construction industry is the main source of emissions and is an integral part of emission reduction programs.

Many stakeholders participate in the design process of complex buildings, such as office buildings. Therefore, it is difficult for many stakeholders or designers to coordinate and focus on sustainable building design. At this stage, it has become necessary to use strategies and methods for more effective coordination and, sustainable decision-making [10]. Thus, it is aimed to implement sustainability in design and increase efficiency. However, only some available strategies and methods effectively reduce energy consumption and carbon emissions. In addition, the construction sector still has the highest percentage of energy consumption, and carbon emissions are proof of this. However, having many strategies to implement design sustainability in new office structures could be clearer[11]. Therefore, creating a new standard guideline by analysing effective, sustainable office structures will lead to the design of more effective strategies.

1.2 Research Question

The integration of sustainability into the architectural design and construction process of buildings is a critical issue that requires attention to ensure that buildings are constructed in a manner that promotes sustainability.

This research seeks to address the main research question of identifying the challenges that exist in integrating sustainability into the architectural design and construction process of office buildings.

To achieve this objective, the research will explore five sub-questions:

- How has sustainability affected architectural design practices since 1970?
- Evaluating the role of different design stages in achieving sustainability outcomes.
- How current certification systems and standards can be improved to guide design methodologies and lead to sustainable results.

1.3 Research Objective

The research objective of this study is to analyse sustainable practices and strategies that can be used to integrate sustainability into the architectural design and construction process of office buildings. The research aims to explore how the concept of sustainability and environmental issues is interpreted and turned into an environment from the beginning of the design process to achieve sustainable outcomes. The study will evaluate the critical factors that can be used during the conceptual design phase, identify core priorities and deficiencies, and develop conceptual guidelines for sustainable design. The research will also compare different office design strategies and methodologies with high rates of BREEAM and analyse their positive and negative effects. The study will be conducted through theoretical and experimental means, using case studies and post-occupancy assessments to compare original targets with actual results. The research findings will be used to develop an expanded guideline and user requirement specifications to support the sustainability criteria optimization process in the early design stages.

The study will present a new guideline that can guide all kinds of office buildings to be built sustainably and provide benefits in terms of sustainability. Background studies are presented in Section 2, and methodology is given in Section 3. Information about sustainability and sustainable architecture will be presented in section 4.

2 Concept of Sustainability

Sustainability as an idea has a long history, but it emerged as a word in the 18th century [12]. The starting point of the concept focuses on the prevention of environmental problems that arise with the development of the economy and technology and the protection of natural life at the maximum level [13]. The concept of sustainability is to be used in many different fields, from agriculture to finance, architecture to sociology, and handled in different ways. Since the essential concepts for each discipline vary, the definitions of sustainability have emerged in different ways. The main sustainability definitions are as follows:

- Sustainability, according to the Brundtland Report, the definition of "meeting the needs of today without risking the possibilities of meeting the needs of future generations" is widely used. In the Brundtland Report, the concept of sustainability was used together with development for the first time, and its scope was expanded. [14]

-According to Bossel, sustainability is "various human activities that nourish and ensure the continuity of the historical conduct of all social life" [15].

-In the Dictionary of Urban Sciences, sustainability is explained as an "environmental worldview aiming at ensuring economic development without sacrificing the principle of using environmental values and natural resources with rational methods in a way that does not lead to wastefulness, taking into account the rights and benefits of present and future generations" [16]

-Sustainability is the continuation of life that works in harmony with the environment and does not exceed the consumption limits set by nature [17].

-The main goal of sustainability is rebalancing by repairing the deteriorations in the natural balance, taking precautions for possible damages and minimising the human impact [18].

At the World Summit held in 2005, the United Nations defined sustainability under three sub-titles: economic development, social development and environmental protection (Figure 1). Ensuring sustainability in economic development requires the efficient use of natural resources necessary for economic activities. Social development is achieved by the dominance of dominant consumption instead of unconscious consumption in society. Sustainability is an approach that leaves nature in its most natural state and aims to recover ecological parts that have been left with minimum damage and waste due to human activities or that have been damaged when evaluated in terms of environmental protection [19]. According to this understanding, if coordination between economic and environmental policies is achieved, positive progress can be expected in social learning. Sustainable development is becoming an interdisciplinary concept related to almost all fields of study in its three dimensions (environmental, economic and social). In addition, sustainability has utilitarian and political aspects with a solution approach to problems.

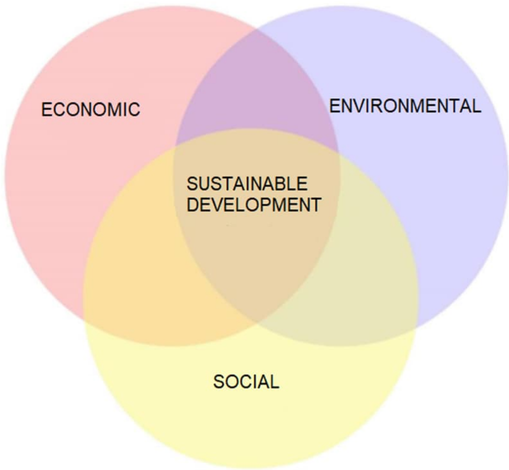


Figure 1: The relationship between sustainable development and economic, environmental and social dimensions [18].

Sustainability, generally understood as the relationship between environmental protection and the economy and where studies are concentrated has included social, cultural and political issues over time. Therefore, five basic principles accepted in sustainable approaches have emerged: thinking of future generations, protecting nature, equality, providing quality living conditions and increasing participation [19]. Sustainability, which examines many components, develops from various perspectives and deepens with the discussion of opposing claims. It has become the common point of all different fields of work, which are located on other planes, and operate in different fields.

The concept of sustainability has also influenced the urban design agenda along with architecture. In the existing literature, definitions have been made for sustainable urbanisation as "the city that meets the needs of the users better than the existing cities and where the city systems are developed to meet their needs" and the "city where socio-economic interests are aligned with environmental and energy concerns in order to ensure continuous change [17]. When the definitions of sustainable urbanisation are examined, three factors stand out. The first is the necessity of increasing the quality of user-city interaction, common areas and public services. The second is to ensure the continuity of the existence of the city as a living space. The third factor is the change in production and consumption habits due to the use of resources above the city's capacity.

2.1 Sustainability of Architecture

Sustainable architecture is a holistic approach to designing and constructing buildings that takes into consideration the entire lifecycle of the building and its impact on the environment [20]. This approach goes beyond just the energy efficiency of the building but also focuses on the use of sustainable materials, water conservation, indoor air quality, and the integration of the building into the surrounding ecosystem [21]. Throughout the building life cycle, sustainable construction presents multiple advantages. It has a positive impact on the environment through energy conservation, saving water and other resources, use of reusable, natural and local materials, reducing pollutant emissions, recycling life cycle waste of the constructions and increasing building durability. It also has positive social effects: guaranteeing users' health and comfort through indoor air quality and acoustics comfort, as well as accessibility, security, and preservation of cultural heritage. Moreover, sustainable construction also provides economic benefits in the long term[22].

One key aspect of sustainable architecture is the use of renewable resources. This includes using natural resources such as solar and wind power to provide energy for the building, as well as designing buildings to take advantage of natural light and ventilation to reduce the need for artificial lighting and heating [20]. Additionally, sustainable architecture also considers the use of water, both in terms of conserving water through efficient fixtures and also in utilizing rainwater harvesting or greywater recycling systems [21].

Another key aspect of sustainable architecture is the use of sustainable materials. This includes the use of environmentally friendly and non-toxic building materials, as well as the use of locally sourced materials to reduce the embodied energy associated with transportation [20]. Additionally, sustainable architecture also considers the entire lifecycle of the building materials, including sourcing, construction, use, and end-of-life disposal. This can include materials that are reusable or easily recyclable, as well as the use of materials that have low toxicity and low embodied energy [21].

In addition to the aspects of energy efficiency and material use, sustainable architecture also considers the social and cultural context of the building and its impact on the community [20]. This can include designing buildings that are accessible and inclusive to all users, as well as incorporating community spaces and green spaces that promote social interaction and well-being [21]. It also includes the environmental impact of the building and its surrounding ecosystem, such as preserving existing vegetation or creating habitats for wildlife [20].

The technological phenomenon in sustainable architecture can be explained as the reduction of the energy consumed by the building with new technological systems in order to reduce the damage it will cause to nature throughout its life cycle. Technology is encouraged to serve the environmentalist architectural approach rather than form concerns. The environmental phenomenon is the creation of a building design that is fully compatible with the environment by using the natural data (climate, material, etc.) of the environment in which the building will be designed. On the other hand, the social phenomenon is to ensure the continuity of social life and culture without ignoring the users while fulfilling its responsibility toward the environment. It is possible to define this situation as the obligation of architecture toward people and culture [23].

A building, together with its users, affects its environment and common areas and also the ecological balance in the long run. Effects such as the destruction of forests, use of resources, pollution of clean water resources and damage to the ozone layer can be observed in the ecological balance [24]. Sustainable architecture is a building process that incorporates local environmental factors, such as natural resources and climate characteristics, into the design and construction of a building. By utilizing this information, sustainable architecture aims to promote resource conservation through the use of energy-efficient systems, effectively manage waste, and ensure that all elements of the building work in harmony. The integration of information systems into sustainable architecture also allows for greater information sharing, storage, and access, which can lead to the implementation of alternative building methods and a departure from traditional techniques over time [24]. In short, it can be said that the concept of sustainability aims to remember basic knowledge in architecture and to bring together new technologies and natural conditions.

In the 1990s, Thomas Fisher explained the five main principles of sustainable architecture as follows:

-Healthy indoor environment (harmful gas emission, filter systems, plant use, etc.)

-Effective energy (heating, cooling, lighting, ventilation, etc.)

-Ecological material

-Environmental form (compatibility with terrain, region, climate and users)

-Good design (effective and long-lasting solutions)[25].

In summary, sustainable architecture aims at harmony with the natural environment. In order to achieve harmony, it collects the data of nature and adapts it to the design—the climate of the natural environment. Geographical structure, topography, underground and surface waters; The data of the artificial environment such as transportation, infrastructure systems, and surrounding structures should be collected and evaluated for the building design to be designed [26].

Due to the above-described scope of sustainable architecture, various sustainable architectural design strategies have been developed. With the development of technology and materials, sustainable architectural design strategies have also changed over time.

2.2 Sustainable Buildings and Sustainable Design Criteria

The role of sustainable construction is also reinforced by Sustainability Assessment and Certification Systems that allow estimations of the level of efficiency and sustainability achieved by improving the quality and performance of buildings. These systems evaluate environmental, economic, and social dimensions of sustainability and are greatly increasing the attention towards sustainable assessment of buildings[22].

As the demand for 'sustainable' or 'green' buildings increases, so does the need to understand better how these structures should be designed [27]. Integrated design approaches for complex design analysis, energy modelling and system optimizations are often required in sustainable building projects [28]. The design process for sustainable buildings is mainly undefined and is being reinvented on a project-by-project basis. This causes a waste of time and money for designers. In addition, since there is no single certificate, guide or framework to be followed by the designers, the effectiveness of the designed structure varies according to the strategy followed. A new design process emerges as highly specialized and fragmented teams are formed for a particular project. As a result, design teams that have challenged collaboration and integration efforts have evolved into highly sequential and specialized business practices. Current sustainable building practice recognizes the critical roles of early stakeholder engagement, collaboration and integration in sustainable building design [15].

Many countries create various certification systems to measure the impact of buildings on the environment and convert them into concrete data. Although it was initially aimed to create special systems in which local production techniques were encouraged for each country, LEED and BREEAM systems have been effective internationally and have been used in various countries for some years. BREEAM was prepared by BRE in 1990 and is the first green building rating system [29]. The American Green Building Council created LEED in 1994[30].

A distinct design process is required for the successful implementation of complex projects. The design process for sustainable buildings, on the other hand, is mainly undefined and is reinvented with each new project. In the green building market, metrics and standards for the final building product, such as the BREEAM and LEED rating systems, are standard [31]. These green building rating systems primarily evaluate building characteristics such as energy performance and material use; however, they offer little guidance in the design and construction processes to assist project teams in meeting these standards. Despite calls for more process-oriented sustainable building evaluation, few methods are available to assess the sustainable building design process[11]. Failure to systematically evaluate the sustainable building design process can result in design process waste, leading to suboptimal building performance.

2.3 Certification Systems of Buildings

Today, developments in construction technologies facilitate the implementation of large-scale projects. Considering the increasing construction activities in recent years, the environmental effects of the construction and operation processes of buildings have become a matter of discussion. Globally, 50% of the energy used, 42% of the water, 25% of the wood production and 40% of the fossil fuels are used for construction activities. However, 50% of the total production of CO2 and other gases that cause the greenhouse effect, 40% of drinking water pollution and 24% of air pollution occur as waste in construction activities [32]. The negative effects of construction activities on nature and the atmosphere are quite high. However, energy use, fossil fuel consumption and gas emissions continue after the completion of the construction process. Therefore, buildings designed as sustainable should be evaluated by a certain certification or assessment institutions and how sustainable they are should be determined by the evaluated organization. Although this evaluation varies according to the institution or the evaluator certificate, it provides information about energy consumption and carbon emissions.

More than 70 various certification systems have been developed worldwide to measure the sustainability level of architectural products. These certification systems are generally called “Green Building Certification” systems. Acting for the same purpose, these certification systems may vary from country to country. There are many certification bodies operating in many countries of the world [33] .

Name	**BREEAM**	**LEED**	**Green Star**	**CASBEE**	**SBTool**
Date	1990	1998	2003	2001	1998
Country	United Kingdom	United States	Australia	Japan	Canada
Criteria	✓ Energy	✓ Energy and Atmosphere	✓ Energy	✓ Energy	✓ Energy and Resource Consumption

	✓ Health and Wellbeing	✓ Indoor Environmental Quality	✓ Indoor Environment Quality	✓ Indoor Environment	✓ Indoor Environmental Quality
	✓ Land Use	✓ Sustainable Sites	✓ Land Use and Ecology	✓ Off-Site Environment	✓ Site Registration and Development
	✓ Water	✓ Water Efficiency	✓ Water	✓ Outdoor Environment on Site	✓ Environmental Loadings
	✓ Materials	✓ Materials and Resources	✓ Materials	✓ Materials and Resources	✓ Cost and Economic Principles
	✓ Management	✓ Innovation and Design	✓ Management	✓ Quality of Service	✓ Social, Cultural and Perceptual Principles
	✓ Transport	✓ Location and Transportation	✓ Transport	x	x
	✓ Pollution	x	✓ Emissions	x	x
	✓ Innovation	x	✓ Innovation	x	x
	✓ Waste	x	x	x	x
Certification Levels	Pass (1 Star)	LEED Certificate (40-49 points)	Average Practice (2 Star)	C (Poor)	-1 (Negative)
	Good (2 Star)	Silver (50-59 points)	Good Practice (3 Star)	B-	0 (Acceptable)
	Very Good (3 Star)	Gold (60-79 points)	Best Practice (4 Star)	B+	3 (Good Practice)
	Excellent (4 Star)	Platinum (80 points and above)	Australian Excellence (5 Star)	A	5 (Best Practice)

	Outstanding (5 Star)	x	World Leadership (6 star)	S (Excellent)	x

Figure 2: Some of the Green Building Certification Systems

The main ones of most well-known and relatively more advanced certification systems are as seen in (Figure 2): BREAM (Building Research Establishment Environmental Assessment Method) in the UK, LEED (Leadership in Energy and Environmental Design) in the USA, GREEN STAR in Australia, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) in Japan and SBTOOL (Sustainable Building Tool) in Canada can be listed according to the year of establishment[33]. Green building certification systems save the building from the relativity of the level of being "green" on the basis of the product, bring reality to the product, make it measurable and evaluable, and make it easily understandable and identifiable for the construction industry and relevant people[27]. Thus, (green) buildings can come to the point where they can represent an embodied example of the concept of sustainable architecture. Today, certification systems operating in many parts of the world have unique evaluation criteria independent of each other. The BREEAM and LEED certification system, which gives great importance to the energy criteria in the scoring system, was found worthy of examination within the scope of the research.

BREEAM is the first worldwide certification system to evaluate buildings in terms of sustainability [33]. In the BREEAM system, under the title of "better buildings, better environment", an evaluation method in which the sustainability of the building is determined with precise criteria has been determined, and a clear comparison of the sustainability of the buildings has been provided. In the evaluation method, not only the structure of the building and its impact on its environment, but also criteria such as material, transportation, energy consumption and even soft effects such as public transportation, building service, and environmental protection programs of users have been added. The aim of the BREEAM system is to make the building sustainability criterion accepted as one of the standards that determine building quality in the real estate sector[31]. The Building Research Establishment Environmental Assessment Method (BREEAM), developed by the Building Research Establishment (BRE) in England and put into practice in 1990, is the first of the green building valuation systems. The BREEAM system evaluates by collecting points for criteria such as management, health and satisfaction, energy, transportation, water, waste, land use and ecology, materials and pollution. A building evaluated according to BREEAM must collect at least 30% of the indicator scores in order to certify its environmental performance. Builds that perform above this are progressively graded as Pass (30-45 points), Good (45-55 points), Very Good (55-70 points), Excellent (70-85 points), and Outstanding (over 85 points) [34]. The project collects points for the criteria it provides. These criteria are; management, health and well-being, energy, transportation, water, materials, waste, pollution, land use and ecology [35].

LEED (Leadership in Energy and Environmental Design program) was developed by the American Green Building Council (USGBC) in 1998 to accelerate the development and production of green buildings and ensure environmental sustainability. In the LEED system, completely transparent technical evaluation and certification processes are carried out [31]. In order for the building to be evaluated, the prerequisites defined in each performance category must be fulfilled. The main targets; are to minimise the impact on the environment in the choice of building location, to support green competition, and to raise awareness about green buildings. For this, evaluation is made in five areas. These; include sustainable site planning, efficient use of water, energy efficiency and use of renewable energy, use of materials and resources, and indoor quality. As a result of the valuation before 2009, Certificates could be obtained in 4 different degrees: Certificate (26-32), Silver (33-38), Gold (39-51) and Platinum (52-69). After 2009, Certificates (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80 points and above) are awarded[27].

These sustainable certification systems standardize design boundaries as they evaluate architectural designs in very different categories. This can be seen as an advantage, but since each certification system evaluates buildings and collects data based on the energy model[33], it does not reflect real energy consumption. The reason for this is that during the usage phase of the buildings, it is necessary to record energy consumption data for at least one year and calculate the energy consumption in this way. Since this takes time, the data can be calculated over the energy model.

2.4 Development Stage From 1970 To Present

The concept of sustainable design is evaluated by considering the performance of the product throughout its life cycle. In this sense, sustainable design should ensure its own continuity, save energy, minimise waste, even create recyclable wastes, and show the ease of assembly and maintenance during production and use. Design explorations for sustainability is an approach to making the transition from obsolete products to using objects of aesthetic interest by recontextualising them. This approach seeks to unite the various poles of old and new, valuable and worthless, craft and mass production, diversity and unity. Sustainability by design is an approach that criticises traditional design and production tools and the existing concept of aesthetics through design explorations [36].

A structure has a variety of short- and long-term effects on nature from its manufacture to the end of its useful life. In order to reduce these effects and to ensure the continuity of the ecosystem in a healthy way, it is of great importance to prefer sustainable methods in architectural designs. Sustainable design is based on three basic conceptual principles:

- Conservation of resources
- Life cycle design
- Humanistic design

Resource conservation; includes topics such as renewable resource preference, efficient use of materials, effective design methods, recycling and environmental compatibility. Ensuring the life cycle; It covers the analysis of the effects of buildings on nature during the design, construction, use and demolition stages. Human-centred design is; It includes subjects such as transportation, urban planning, infrastructure, and unity with the natural environment necessary to increase user comfort [26]

Alternative measures should be taken for energy conservation in buildings organised on the basis of these principles, healthy space conditions should be provided, and reusable and harmless to human health materials should be used. Since the biggest concern in sustainable designs is the protection of nature, care should be taken to obtain energy from renewable sources and to analyse and develop this using new technologies. The main purpose of sustainable designs is to provide physical and psychological benefits to users. This benefit can only be achieved as a result of arranging the relations of the building with its interior, exterior and close environment, thanks to the application areas of the three conceptual principles mentioned above [26].

Energy conservation studies address sustainability in architecture with its environmental, economic and aesthetic aspects. It encourages designers to work in which interdisciplinary relations are established and aims to inform people about energy conservation. As a result of the studies, many products have been developed with the developing technology, and these products have started to shape sustainable architectural designs. The methods and materials using renewable resources have become the basic components of sustainable architecture over time [37].

At EXPO 2000, held in Hannover, Germany 2000, the principles that can be taken as a basis for sustainable design were determined by William McDonough with the Declaration of the Rights of the Planet:

- Ensuring the continuity of human life and nature together,
- Determining the relationship between design and the natural environment and its effects on the environment,
- Carefully establishing the relationship between cultural values and materials,
- Being aware of the responsibility that may arise from the effects of the decisions taken at the design stage on healthy life and nature,
- The designed structure is valuable and suitable for use even after a long time,
- Preventing waste generation with maximum recyclable preferences for the building and the materials used,
- Using natural resources and natural energy transformations in energy analysis,
- Ensuring the harmony of the design with the natural environment, giving direction to the design within the boundaries created by nature,
- Improving the idea by sharing information between individuals and institutions involved in the design and production process [38].

Considering all processes, in terms of sustainability, the design stage is the stage where functionality, cost and effects on natural life are determined. The reason for this situation can be cited as the fact that more than 70% of the decisions that will be valid throughout the life cycle of the structure to be designed are made at this stage. In addition, most of the stages after the design proceed in line with the decisions taken at the design stage. While making decisions at the design stage, three goals should be focused on: maximising the benefit of the building to the user and the environment during the life cycle process, maximising the use of recyclable materials, and minimising the amount of waste[39].

While it is aimed to meet the user's needs at the maximum level in sustainable building design, it is also aimed to save materials, energy and water. In the selection of materials, low cost, high performance and compliance with aesthetic criteria come to the fore. As a renewable resource, water is insufficient due to population growth and needs to be reused. The fact that the building uses energy continuously throughout its life cycle necessitates the selection of energy sources that are compatible with the environment. Nowadays, energy-efficient systems are being developed to ensure energy conservation.

Development of the concept of sustainable architecture and sustainable building, as studies on energy sources, use and alternative energy production methods have gained momentum. As a result of energy use and conservation evaluations, a large part of the energy used in the building is spent on providing lighting.

Since the certification systems developed today restrict sustainable design strategies, the design strategies aim to reach the certification systems criteria.

3 Conclusion

Humanity wanted to dominate nature, which is the main source of all its activities and made changes in nature with various methods they developed. However, over time, the changes made in nature have reached the level of harm. Sustainability considerations have been put forward with the idea that resources can also be exhausted and nature will be insufficient, especially in the age of consumption, which has passed with the industrial age. Although it is thought to date back to the first ages as an idea, it took the 18th century to be created as a concept. Initially, it focused on reducing environmental problems and maintaining natural life. However, over time, it has turned into a multi-disciplinary concept that covers many areas and aims to solve problems through joint studies.

The concept of sustainability, which has been the subject of many national and international studies, has been defined in different ways. With this definition, it started to be considered together with the concept of development and its scope was expanded. Sustainable development aims at the common solution to three basic problems: the protection of the natural environment, the continuity of economic development and the sustainability of social life. Along with various national and international sustainability studies and decisions are taken, the definition of the concept of sustainability in the field of architecture and its effects on architecture has been evaluated.

Sustainable design ideas, criteria and benefits that emerged with all sustainability definitions and studies carried out in this direction were examined. As sustainable design principles; It has been determined that the common continuity of the human-nature relationship, the regular establishment of the relationship of the design with the existing environment, the long-term use of the design, the prevention of waste generation with the use of recycled materials, the creation of a design in accordance with the limits determined by nature, the communication of the individuals involved in the process have been determined. The design phase is the phase where decisions are made for the construction, use and post-use phases of the building. For this reason, it is the process by which the economic, social and environmental effects of the building are determined. The decisions made in the design are the first steps toward the sustainability of the building.

Today, according to the research made by international institutions and international meeting reports, it has been explained that the techniques and methodologies made on behalf of all sustainability architecture are still not sufficient. Therefore, it has been suggested that countries reconsider their plans for sustainable and zero-carbon goals. As a result, sustainable architecture needs new techniques and methodologies. Decisions in sustainable architecture are not always implemented effectively.

4 References

[1] Green Building Council, *2020 Global Status Report for Buildings and Construction*. 2020.

[2] International Energy Agency, 'Global Energy Review: CO2 Emissions in 2021 – Analysis - IEA', *Global Energy Review: CO2 Emissions in 2021*, 2022. www.iea.org/t&c/ (accessed Jul. 23, 2022).

[3] United Nations, '70/1. Transforming our world: the 2030 Agenda for Sustainable Development Transforming our world: the 2030 Agenda for Sustainable Development Preamble', 2015.

[4] BEIS, K. M. Kwarteng, A. M. Sharma, and B. M. Johnson, 'UK enshrines new target in law to slash emissions by 78% by 2035 - GOV.UK', *Gov.Uk*. 2021.

[5] L. Pérez-Lombard, J. Ortiz, and C. Pout, 'A review on buildings energy consumption information', *Energy Build*, vol. 40, no. 3, pp. 394–398, 2008, doi: 10.1016/j.enbuild.2007.03.007.

[6] C. J. Kibert, 'Sustainable construction : green building design and delivery', p. 634, 2022.

[7] WHO, 'World Health Organization Regional Office for Europe SELECTED POLLUTANTS', 2016, Accessed: Jan. 11, 2023. [Online]. Available: www.euro.who.int

[8] 'EXECUTIVE SUMMARY 2021 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION Towards a zero-emissions, efficient and resilient buildings and construction sector'.

[9] UNCCC, 'COP2: The Glasgow Climate Pact', in *UNCCC (2021) 'COP2: The Glasgow Climate Pact'*, 2021, p. 28.

[10] A. A. E. Othman and N. M. A. Abdelwahab, 'Achieving sustainability through integrating risk management into the architectural design process', *Journal of Engineering, Design and Technology*, vol. 16, no. 1, pp. 25–43, 2018, doi: 10.1108/JEDT-09-2017-0087.

[11] M. Landgren and L. B. Jensen, 'How does sustainability certification affect the design process? Mapping final design projects at an architectural office', *Architectural Engineering and Design Management*, vol. 14, no. 4, pp. 292–305, 2018, doi: 10.1080/17452007.2017.1397496.

[12] M. Robertson, 'A Brief History of Sustainability', in *Sustainability Principles and Practice*, 2018, pp. 9–25. doi: 10.9774/gleaf.9781315625478_3.

[13] World Energy, 'A Brief History of Sustainability – The World Energy Foundation', *The World Energy Foundation*, 2014. https://theworldenergyfoundation.org/a-brief-history-of-sustainability/ (accessed Oct. 13, 2021).

[14] R. H. Cassen, 'Our common future: report of the World Commission on Environment and Development', 1987. doi: 10.2307/2621529.

[15] M. Reed, E. D. G. Fraser, S. Morse, and A. J. Dougill, 'Integrating methods for developing sustainability indicators to facilitate learning and action', *Ecology and Society*, vol. 10, no. 1, 2005, doi: 10.5751/ES-01296-1001r03.

[16] 'Sustainability - What Is It? Definition, Principles and Examples [2021]'. https://youmatter.world/en/definition/definitions-sustainability-definition-examples-principles/ (accessed Sep. 27, 2021).

[17] W. A. Salas-Zapata and S. M. Ortiz-Muñoz, 'Analysis of meanings of the concept of sustainability', *Sustainable Development*, vol. 27, no. 1, pp. 153–161, Jan. 2019, doi: 10.1002/sd.1885.

[18] International Organization for Standardization, 'Sustainability, Sustainable Development and Social Responsibility - ISO Definitions and Terminology', pp. 1–10, 2005.
[19] United Nations Environment Programme, 'Executive summary of the 2020 global status report for buildings and construction - Towards a zero-emissions, efficient and resilient buildings and construction sector', 2020.
[20] C. Owen and K. Dovey, 'Fields of sustainable architecture', *Journal of Architecture*, vol. 13, no. 1, pp. 9–21, 2008, doi: 10.1080/13602360701865373.
[21] T. Prudon, 'The Modern Movement and Sustainability: Yesterday, Today and in the Future', *Modern and Sustainable*, no. 44, pp. 4–7, 2011, doi: 10.52200/44.a.tlama8zj.
[22] M. Hegger, M. Fuchs, T. Stark, and M. Zeumer, *Energy Manual : Sustainable Architecture*. Basel/Berlin/Boston, SWITZERLAND: Walter de Gruyter GmbH, 2008. [Online]. Available: http://ebookcentral.proquest.com/lib/liverpool/detail.action?docID=1075583
[23] L. G. Kryder, *United Nations Environment Programme (UNEP)*. 2012. doi: 10.4135/9781412956260.n827.
[24] M. Keitsch, 'Sustainable Architecture, Design and Housing', *Sustainable Development*, vol. 20, no. 3. pp. 141–145, May 2012. doi: 10.1002/sd.1530.
[25] R. Urbano Gutiérrez and L. de la Plaza Hidalgo, *Elements of Sustainable Architecture*. Routledge, 2019. doi: 10.4324/9781351256445.
[26] T. Bhamra and V. Lofthouse, *Design for sustainability: A practical approach*. Routledge, 2016. doi: 10.4324/9781315576664.
[27] 'LEED certification for neighborhood development | U.S. Green Building Council'. https://www.usgbc.org/leed/rating-systems/neighborhood-development?CMSPageID=222 (accessed Jan. 14, 2022).
[28] C. S. Magent, S. Korkmaz, L. E. Klotz, and D. R. Riley, 'A design process evaluation method for sustainable buildings', *Architectural Engineering and Design Management*, vol. 5, no. 1–2, pp. 62–74, 2009, doi: 10.3763/aedm.2009.0907.
[29] BRE Group, 'About us | BRE Group', 2021. https://bregroup.com/about-us/?cn-reloaded=1 (accessed May 16, 2022).
[30] US Green Building Council, 'LEED: Past, present and future | U.S. Green Building Council'. https://www.usgbc.org/articles/leed-past-present-and-future (accessed May 16, 2022).
[31] T. Saunders, 'A discussion document comparing international environmental assessment methods for buildings', *Bre*, p. 46, 2008.
[32] K. Iyengar, *Sustainable architectural design: An overview*. Taylor and Francis, 2015. doi: 10.4324/9781315758473.
[33] C. J. Kibert, *Sustainable construction : green building design and delivery*, Fifth edition. Hoboken, New Jersey: Wiley, 2022.
[34] BRE Global Limited, 'BREEAM - Sustainability Assessment Method', 2018. https://www.breeam.com/ (accessed Jan. 14, 2022).
[35] M. Feria and M. Amado, 'Architectural design: Sustainability in the decision-making process', *Buildings*, vol. 9, no. 5, 2019, doi: 10.3390/buildings9050135.
[36] E. Manzini, 'Design, Environment and Social Quality: From "Existenzminimum" to "Quality Maximum"', *Source: Design Issues*, vol. 10, no. 1, pp. 37–43, 1994.
[37] I. Energy Agency, 'World Outlook Energy 2015 Together Secure Sustainable', 2015.
[38] W. McDonough and B. Michael, *The Hannover Principles*. 2003.

[39] 'RIBA Sustainable Outcomes Guide 2'.

CARACAS RESILIENTE
An Avant Garde Regeneration of the Rio Guaire

Gabriel GONZALEZ DEPALO, Nancy CLARK*, Adeline HOFER*

University of Florida School of Architecture – UF SoA
1480 Inner Rd, Gainesville, FL 32611, United States;
gabriel.gonzalez@ufl.edu nmclark@ufl.edu*, adeline@ufl.edu*

Abstract

A state epistemologically prone to intense shifts in power, the adaptability of Venezuela is a lesson many South American countries are familiar with. However, for a matrix of reasons and influences, the state of Venezuela has been radically different compared to the perseverance of neighbouring countries. The question then, remains: can Venezuela, a petroleum juggernaut, fuel their own initiatives to address their crumbling urban and environmental systems? The country's industrialization came at the perfect time and place in history to supply global powers with their desired resources, which in turn fuelled their modernization throughout the twentieth century. Infamously dependent on global economic fluctuations, the world has bear witness to the country's radical prosperity and demise. The ebbs and flows of these extractive businesses are reflected in the declining quality of Venezuela's protected and unprotected ecosystems as well as the physicality of the country's most important city: Caracas. The patterns of urbanism can be categorized into formal and informal settlements that occur across four distinct time periods: Colonial Caracas [1567-1820], Progressive Caracas [1821-1930], Modern Caracas [1931-1988], and Contemporary Caracas [1989-present]. These periods track the physical evolution of Caracas with explicit reference to the overhead paradigms/powers that motivated the urban innovations. It is within the 'modern' period of Caracas where the influx of people, ideas, and technologies rapidly revolutionized the social, economic, and spatial fabric of the Valley of Caracas. 'Monumental and Modern' efforts of design such as the introduction of social housing, the construction of the highways/tunnels, and the channelling of the Rio Guaire began transforming the city and its natural systems by exacerbating periodic flooding, weakening soil security, and increasing seismic risk for large portions of the metropolitan area. However, there does exist a conflict amongst the origins and language employed to educate and celebrate these advancements. The term 'modern' accurately associates the movement at the broadest scale yet fails to pin-point the radical influences and resynthesis behind the Avant-Garde methodologies prominent figures of the Venezuelan movement were employing in their works.

The research's significance lies in its provision of knowledge regarding the Venezuelan Avant-Garde movement's specific contribution onto the physical and metaphysical infrastructure of the country's Capitol. It also provides a critical context for the theoretical and formal generation of a personal Avant-Garde that references this foundational knowledge and Caracas' environmentalist an urbanist history. The personalized Avant-Garde ensures an authentic connection to site so that a resilient spatial response to the river's exponential threats may be developed. The creation of public space through this Avant-Garde architectural and infrastructural proposal intends to filtrate modes of circulation and phenomena, desegregate the urban environment, and suture the open wound that is *el Rio Guaire*.

Keywords

Urbanity, Environmentalism, Avant-Garde, Resiliency, Publicity

1 Introduction

Pleasantly bound by the seventy fifth and sixty fifth meridians to the west, the fifteenth parallel in the north, and the equator to its south, Venezuela has historically cemented itself as a pioneer of social, economic, political, infrastructural, technological, and artistic progress within the Hispanic context. From leading revolutions and movements to securing the peace and prosperity of her fellow burgeoning nations, there has always been shared revery for Venezuela.

Up until the turn of the millennia. The abduction of federal power in 1998 catalysed an exodus of Venezuelans, albeit unperceivable till it was too late. [1] For the overwhelming majority, their only options in response to their changing environment were to risk their lives staying or risk their lives leaving and forging something new. According to the data collected by the Regional Inter-Agency Coordination Platform (R4V) it is estimated that the forced exodus of Venezuelans already exceeds 7.1 million. [2] Eighty five percent would transit/settle in surrounding countries in Latin America as well as North American and Eastern European countries. Although, even when they settle-in to their new environments they are ostracized for contributing to the pressures their presence places on the host country's infrastructural systems. The subsequential eradication of the middle class and the growing dissent amongst the other two ends of the spectrum made it impossible for the country to finance infrastructural management, resulting in their present state of crisis. The added strains of the climate crisis and the COVID-19 pandemic have only exacerbated matters. [3] Nonetheless, these are only the most contemporary issues, most of which are the direct result of a rich heritage of tyrannical regimes.

Eighty-three years after the birth of this agrarian nation, the discovery of petroleum in Lake Maracaibo in 1914 sparked an industrial revolution that cemented Venezuela's international legacy. [4] Their role as oil producer and supplier has fuelled peaceful and violent global endeavours. Inciting consistent waves of immigration that integrated cultures from around the world into the country's urban areas, diversifying their ethnic, social, and spatial composition. Venezuela's present population of 28.7 million is distributed unevenly considering its landmass. Its north accounts for ninety percent of this population across six major cities that control the mountainous half of the country punctured by the Andes Mountain Range. [5] While the southern half remains comparatively unsettled accounting for only seven percent of this population due to the Amazon Rain Forest's treacherous and fragile topographies and ecosystems. Defining this border, the country's preeminent river, the Rio Orinoco, supplies the country with a majority of its power via the hydroelectric plants in Ciudad Bolivar. The nation's reliance and glorification of rivers and their power can be traced all the way back to its name being a derivative of the Venetian Republic.

Given the complexities of this cultural landscape, the necessity for an organizational document mapping the consciousness of the people of Venezuela was apparent. By re-depicting the entire history of Venezuela, so to truly understand the sequences of events, their influences, and impacts, a brochure of the paradigms and dogmas of Venezuela was curated. It organizes published manifestos, global/national events, government/national shifts, national GDP/inflation, population growth, and artistic/architectural movements. This theoretical framework elucidated the three primary research themes: *Ambientalismo, Urbanismo, and Vanguardismo*. Presented in Spanish, these themes can be defined as:

Ambientalismo: [environmentalism] the movement where concerns about and action aimed at protecting the environment and/or advocacy to limit negative human impacts on the environment.

Urbanismo: [urbanity] the study of how inhabitants of urban areas, such as towns and cities, interact with the built environment.

Vanguardismo: [Avant Garde] the global creative movement from the early twentieth century, under the umbrella of Modernism, that saw artists promoting progressive and/or radical politics to advocate for societal reform through their unusual/experimental works. This thesis establishes a foundation of knowledge regarding precedents so to ensure an authentic synthesis of a 'personal avant garde' that generates an architectural methodology.

These definitions provide a critical context for establishing this thesis. The creation of public space through this Avant-Garde architectural and infrastructural proposal intends to filtrate modes of circulation and phenomena, desegregate the urban environment, and suture the open wound that is *el Rio Guaire*.

1.1 Ambientalismo

Environmentalism grounds the thesis and its responsibility to provide a resilient response that respects and integrates into the site's natural context. The interpretation of Latin American Environmentalism is unique in that it focuses on urban environmental issues rather than the more holistic perspectives North America and Europe employ. [6] This refines the scope and location of the project to urban rivers within Venezuela.

The country's contradictory ethics regarding its treatment of its diverse landscapes and non/renewable resources are exposed through the nodes of illegal mining that occur near and/or within protected boundaries. [7] Since 90% of all environmentalist groups function out of the capitol, they are physically distant from the environmental issues the rest of the country experiences. These groups use the poor infrastructure that defines the southern half of the country occupied by the Amazon Rain Forest, as an excuse for their inability to police these areas. In reality, their main obstacle is the fiscal reliance the nation has on these vulnerable ecosystems. [8] Hesitating to disrupt their localized urban prosperity while acknowledging the economic/political benefits of the systemic exploitation of indigenous peoples and their reservations. Thus, mapping the century of environmental vulnerabilities and damage, hydrological systems, and the constitutionally protected territories, at both national and regional scales, introduces the site's hypocritical consciousness, in an effort to improve the architecture's connection to Caracas' *genus loci.* [Figures 1 + 2]

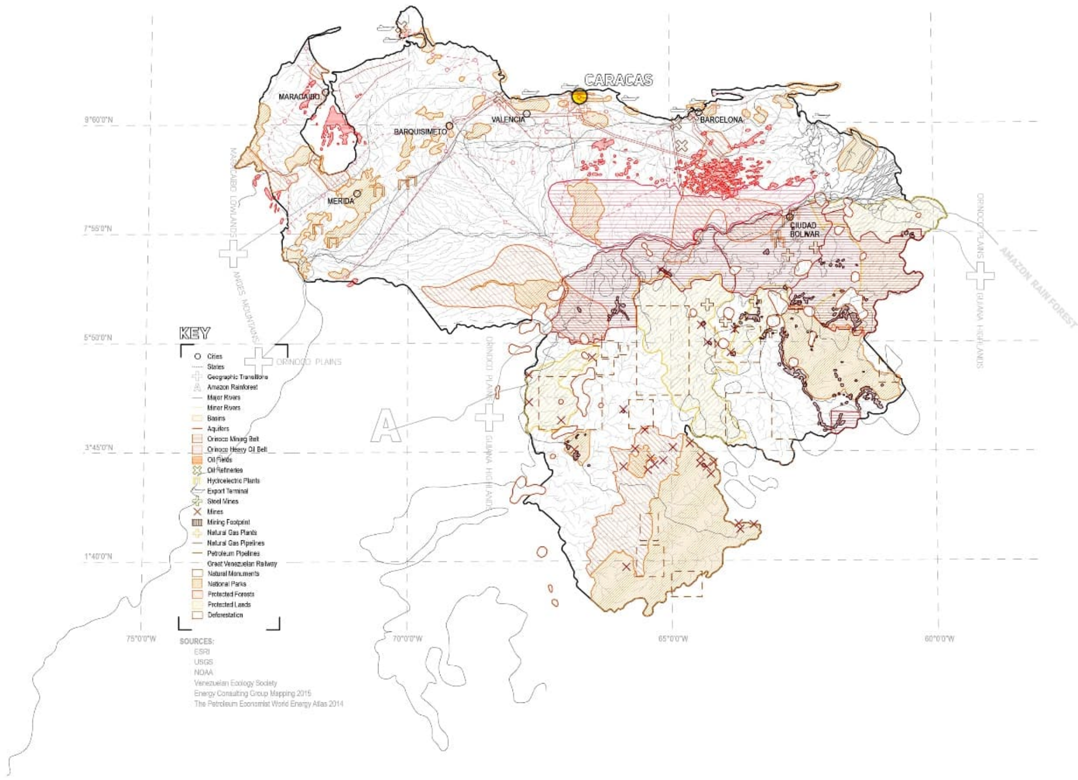


Figure 1. Composite map of the economic, infrastructural, hydrological, and anthropological layers of Venezuela.

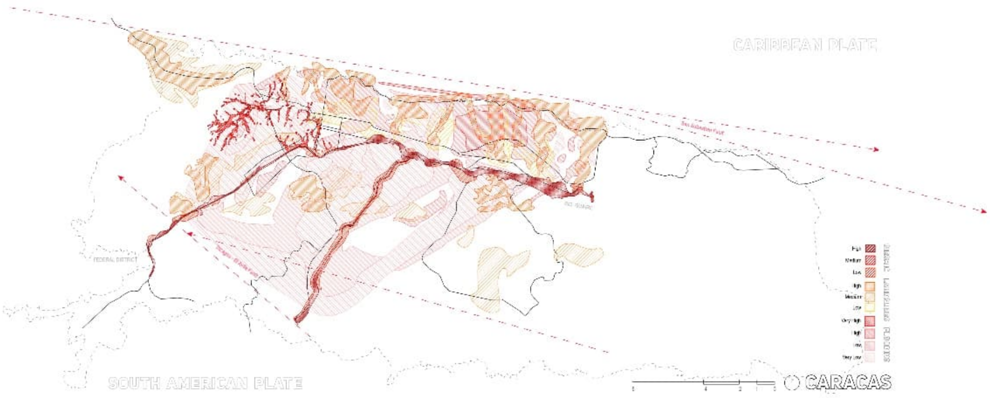


Figure 2. Composite map of the environmental vulnerabilities of Caracas.

The Rio Guaire is Venezuela's most seen river. [9][10] The accepted image of the country's most powerful city describes a contaminated river with degrees of outdated and poorly maintained channelization and infrastructural systems that prioritized improving vehicular connectivity throughout the city over maintaining a healthy river. The Guaire is intrinsically linked to the capitol's present seismic, alluvial, and flooding vulnerabilities, just as much as it is linked with the tumultuous history of the city's economic and cultural development. Comparing the Guaire to similar urban rivers such as: the Medellin River in Medellin, Colombia, the St. Johns River in Jacksonville, Florida, or the Cheonggyecheon River in Seoul, South Korea; divulges the reality of the river in that it is not the strongest, widest, fastest, or deepest. [11] Although historic attempts have been made to program it into a utilitarian fixture for the city, the Guaire river quickly outgrew its capacity and was socially stigmatized as insignificant in the metropolis' masterplan, resulting in its negligence for over seventy years. Of the 72 kilometres of the river's length, it interacts with Caracas proper for only 30 kilometres, where it normally maintains an average speed of 1-3 km/h, and up to 13 km/h during the city's wet season [May-December]. Fifteen main tributaries, presently culverted, transporting fresh mountain water/sediments feed into the river throughout the city, yet their gradual influxes cannot begin to fix the issues of anthropogenic and industrial contamination that primarily occurs before the river even reaches the city. Before the twentieth century, the river was not polluted, especially considering it was a source of water for all inhabitants. However, during the Guzmán Blanco administration, federal investments on infrastructure initiated and with his decree that the Guaire River be used as the main route of the city's sewage, he mobilized his citizens for over a century to dispose of anything and everything into this poor river. [12] The urban environmental issues remain as crucial consequences even though considerable efforts to counter this mentality + methodology have occurred. [Figure 3]

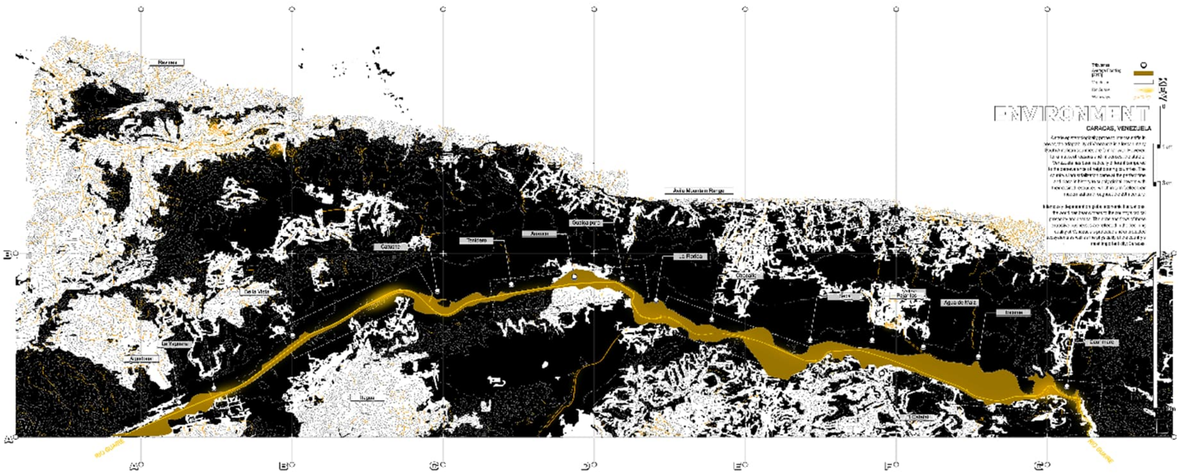


Figure 3. Map of Caracas' environment.

Explicitly, Caracas maintains a successful image rooted in a close nit relationship with its environment, evident of the sprawling green areas and the revery for the mountain ranges that surround it. Implicitly, Caracas' urban fabric and long-term prosperity is constrained by its original infrastructural sins and its ongoing extractive and harmful relationship with its environment. If the city intends to secure any semblance of resiliency, it must redress the harmful urban systems publicly criminalizing its natural river.

1.2 Urbanismo

Urbanism scales the thesis' analysis of the city and the duality within its relationship between the built and its environment. It guides the architecture's audience and intentions: the urbanites of Caracas and their history of spatial successes and failures that must be respectively referenced. The first plan of Caracas [Figure 4] served as a pivotal reference for the research, wherein the depiction of the settlement's foundation, one can recognize the urban boundaries: The Avila Mountain Range, the Valley, and the Guaire river. [13] The map's use of double proportionality references ancient roman surveying techniques to depict the first plan of Caracas at both urban and geographic scales. [14] The twenty-five prescribed and programmed blocks reflect the Spanish Crown's: *Law of the Indies*, and its intention to establish effective and universal colonies through design principles that ensured their 'sustainable' growth. [15]

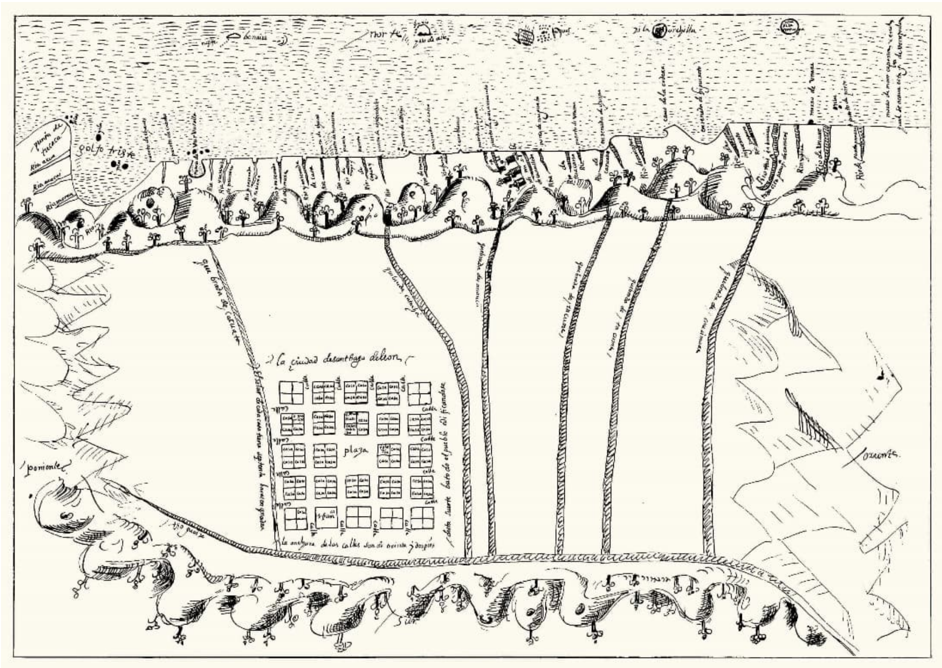


Figure 4. The first drawing of *Santiago de Leon de Caracas*, 1578.

At the core of *Santiago de Leon de Caracas*, was its *Plaza Mayor*, operating as a fulcrum for the social, economic, religious, and political development of the colony. The prosperity of Caracas has aways relied on its people's ownership and activation of their public spaces. This gradual [re]generation of public spaces inevitably proves to be the only consistent connection between people and place and democracy where its socio-spatial benefits can evolve and prosper. These spaces have commanded and connected the infrastructure of the city, including the vehicular and public transportational systems that run under, throughout, and above the urban fabric. Categorizing the public spaces of Caracas into: Boulevards, Plazas, Parks, Malls, Theatres, Sports Facilities, and Universities, reveals the spatial diversity that persists throughout the city with a radical emphasis on accessibility and ingenuity. This progressive network of public spaces developed iteratively and successfully, reflecting the government's clever understanding of the power these spaces hold. Each categorical precedent represents spaces and structures used as political tools, by both authoritarian and democratic administrations, to promote their agendas through the physical makeup of the city. Leaders and planners capitalized on their opportunity to garner support from the masses by investing into this spatial network through innovative and provocative solutions that were proving their efficacy globally. Modernism's introduction into the vernacular and colonial fabric of the city would prove to dominate its visual aesthetic for the formal city throughout its most prosperous era. The installation of the *Nuevo Ideal Nacional* (New National Ideal) would "discharge modernity…" and provide "undeniable proof of progress that justified the rupture from democratic rule…" in a way that kept the nation "up to date." [16] Many of the foreign ideologies influencing these designs stemmed from the vigorous and diverse waves of immigration, particularly from Europe, after economic prosperity became palpable after the World Wars. [17] These modern interventions and strategies would proliferate nationally, inevitably joining a burgeoning architectural family known as Tropical Modernism. This movement required the tedious adaptation of its predecessor’s burgeoning design principles to the tropical context, an effort that time would demonstrate to be insufficient in producing a truly resilient response to its surroundings. Decades of systematic negligence and mismanagement has exposed the reality of how unsustainable these imported solutions were, and more importantly, how damaging they can be for the physical and social wellbeing of an urban environment. The failure of these solutions under the stresses of contemporary political and environmental change have rendered Caracas’ infrastructural systems incapable of supporting its present urbanity.

Caracas’ urbanity historically referred solely to the formal settlements officially planned and included within the masterplans of the city that consumed the vast valley, leaving the mountainous and ravenous edges of the city to be settled informally. [18] The country’s drastic economic upheaval after the industrialization of its extractive markets, disrupted the lives of agrarian Venezuelans, encouraging them to migrate towards the capitol. Urbanization and modernization promised them a better quality of life. The reality for most would be a strict socio-spatial subjugation to segregation. These informal communities represented racial and ethnic minority groups barred from participating in the development of the city’s urban fabric. “The stigmatization of these dynamic urban areas impedes the implementation of visions, strategies, and programs that would help informal areas attain similar living conditions and opportunities to those of the formal city.” [19] Straining the city and its social disparities even further, the Francisco Fajardo highway system callously burrows through mountains, culverts/constrains waterways, and severs the city in two. This monumental effort to integrate vehicular circulation has only further proven to disconnect the informal communities from the formal ones. [Figure 5] The highway physically defines social and environmental boundaries via a universally harmful articulation that is only half of the city’s predominate urban infrastructural issue.

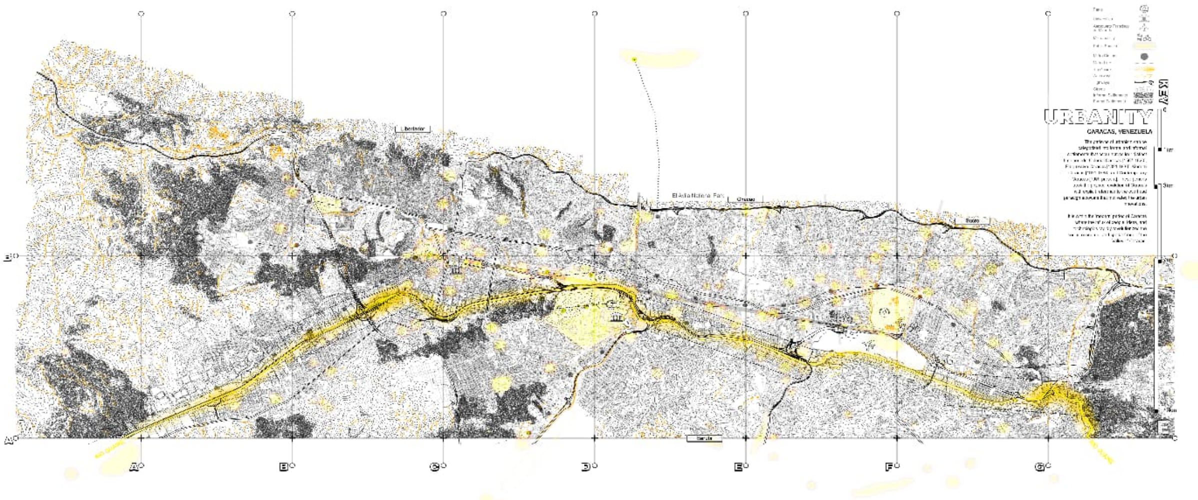


Figure 5. Map of Caracas’ spatial infrastructure and its formal + informal urbanities.

The channelization of the Rio Guaire throughout the 1950s stands to be Caracas' original sin with regards to its urbanization. Egregious and engineered attacks onto the river and its natural systems would reveal the limitations of monumental modern solutions to issues like mobility and flooding. The city shamefully cloaks this wound with the highway's violent presence above or beside the river's newly cemented path. Periodically and exponentially flooding, the Guaire river has only responded negatively to these constraints, posing serious threats to Caracas' urbanity and the infrastructural systems supporting it. [20]

The people of Caracas have adapted physically and socially to a milieu of crises due to socio-economic and political instabilities. This has developed a residual mentality perceiving progress as intrinsically linked with authoritarianism as well as the Avant Garde. This puts into perspective the democratic and environmental sacrifices this society is willing to accept for the sake of tangible prosperity and its accompanying opportunities. Although this prosperity can now be understood for its manipulative intentions, the residual mentality will persist, as it nevertheless produced the lavish public realm the city celebrates today. In order to foster and develop this public realm, it is clear that Caracas must take inspiration from cities like Medellin, Madrid, Paris, and Seoul, and make fundamental modifications to the physical makeup of the city's highways and main river. [21] As complex as the procedures required to regenerate the river will be, paradigmatic evolution is desperately needed for the public socio-spatial realm to be regenerated as well. Caracas' true urbanity must be publicly retold. Considering Venezuela's present bureaucratic priorities, the urban issues presented in this section will continue holding Caracas and its people back from authentic and physical resiliency. However, the following analysis of the integration of Modernism into the city's social and aspatial consciousness will shine a light on the Avant Garde's hopeful and resilient dialogue between the systems/parties. Ultimately, the rigor and quantifiable success of this thesis and its architecture lies in its ability to reference, redress, and reconnect the city's urbanity.

1.3 Vanguardismo

The Avant Garde movement serves as the theoretical context for the research and design's methodology due to the infinite and intimate regenerative opportunities found in its history. While 'Modernism' is an accurate umbrella movement to attribute the spatial revolution Caracas experienced throughout last century, it does not authentically account for the radical concepts, influences, and creations its authors were employing. Avant Garde creations have always been predicated on the celebration of the new through reinventive methods. El Lissitzky and Kazimir Malevich's spatial revolution in the 1910s changed the Soviet Union forever, and, through their pedagogy, sparked a global phenomenon based on reinvention/recreation as a form of rebellion. [22]

Upon their exile in Europe, Venezuelan artists/groups resonated deeply with these rebellious sentiments and reinterpreted the Avant-Garde, exporting it across the Atlantic, back to their country to spread awareness. [23] Occurring simultaneous to Venezuela's preliminary stages of authoritative industrialization, the manifestos/poetic publications, paintings, and sculptures were publicly demonized for their criticism of the regime's treatment of its people and environments. Although its arrival was controversial, the movement proliferated secretly and began inspiring regenerations of the movement so to perfect its relationship to the context.

The Venezuelan Avant Garde movement went from being despised to adored as it began radicalizing the public realm of art and architecture. The citizens of Caracas were enchanted with the country's newly sponsored aesthetic innovations that inspired resounding pride and "propelled Venezuela into the global echelons of the artistic Avant Garde…" [16] Importing these new movements that promoted revolutionary universal mentalities and solutions was always going to be a difficult physical and metaphysical introduction without a proper integrative device. Seeing the opportunities within some of their shared principles, autocrats and urban planners united their urbanization efforts with the use of Avant Garde creations as a marketing device to promote and associate progress with oppression. A familiar hypocrisy wherein the vernacular, rebellious, and anti-government sentiments of the Venezuelan Avant Garde were at odds with the universal, domineering, and tyrannical administration. This degree of public manipulation would prove to be extremely successful because it shattered traditionally inaccessible notions and pedagogies of art while positively reframing the regime for providing the infrastructure to do so. Evident by the oversaturation of work done by the contemporary masters, who were typically commissioned by the government across the decades. Artists like Carlos Cruz-Diez, Alejandro Otero, Jesús Rafael Soto, and Gertrud Goldschmidt reinvented many of the same methods [Op Art, Kinetic Art, Chromatic Art] and ideas they inherited, securing their legacy within the physical makeup of Venezuelan cities. [24] Considered to be country's greatest architect, Carlos Raul Villanueva, whom was just as inspired by the movement and the prominent figures leading it, invited the artists and designers to collaborate on the master planning and development of Caracas' primary institution, Central University of Venezuela (UCV). [25] The product was a marvellously innovative and accessible fixture within the city's fabric that synthesized spaces that blended education and art with the urban environment, and thus, was declared a World Heritage Site by UNESCO in 2000. [26] Villanueva's work contributed immensely to the reality of a progressive and prosperous Hispanic City. Interventions like these delineated a resilient public realm by positively activating spaces through their new and radical art that raised the social/creative sensitivity of all urbanites, which went hand in hand with the growing wealthy elite's programmatic desires for their city. Regardless, Modernism and the Avant Garde have effectively garnered the country's international economic, political, and artistic validity. Thus, the modernization – the term used at the time to denote the parallel industrialization and beautification efforts - of Caracas illuminates the layered intentions and approaches necessary to authentically design within the urban fabric using the Avant Garde as method.

2 *Gromatici* Series

Responding to the established historical context and the Avant Garde movement's tendency to rebel and regenerate itself, the synthesis of a personal avant garde derived from the strategies used to analyse the urban environment by both the contemporary masters and ancient roman land surveyors: *Gromatici*. This series of explorations diagrams the city using double proportionality via ten spatial terms: universal, vernacular, publicity, infrastructure, heterogeneous, homogeneous, flow, ebb, chaos, and order. Five *Groma* plates were generated for each term and then assembled into layered compositions that underwent iterations that would improve their geographic + spatial legibility. This process of reconstructing the city and its spatial + environmental issues via the spatial diagrams eventually generated the *Gromatici Map of Caracas* [Figure 6]. An avant garde respatialization of the city at both the geographic and urban scales, this map becomes a new landscape from where to derive spatial strategies and forms. The usage of the layers: chaos, flow, heterogenous, homogenous, universal, and vernacular weave together in a way that balances the author's subjectivity and the city's objectivity. Framing moments within this weaving that exhibit all the identified spatial concepts in a scaleless manner, the *Groma Joints* enrichen the potential strategies and spatial concepts with new terms like enthalpy and entropy. The discovery of new terms and the visual and theoretical success of the explorations were based on their ability to reference the issues and methods used by the Avant Garde precedents while adapting them to the context's present state of crisis. Three-dimensional studies of the *Groma Joints* translated fields of chaos and order into spatial volumes and logics while beginning to simulate Caracas' urban fabric explicitly or implicitly in moments. Once the *Groma Joint Models* were arranged respective to geography, it effectively regenerated the city + river in such a provocative way that inspired and informed the following proposal and its programming [Figure 7]. While spatial memory and tradition are present in this series' diagrammatic languages, their historical significance never serve as weights making it impossible for new experiences to be born. With that, using the *Gromatici*, the geographic, and contextual theoretical lessons, the formal generation of architecture commences with the *Parque del Guaire*, the Guaire River's Park.

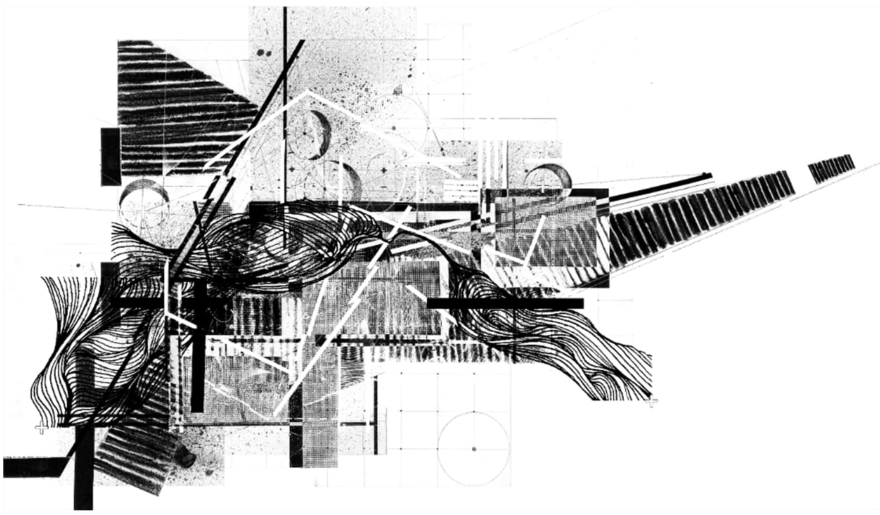


Figure 6. *Gromatici Map of Caracas.*

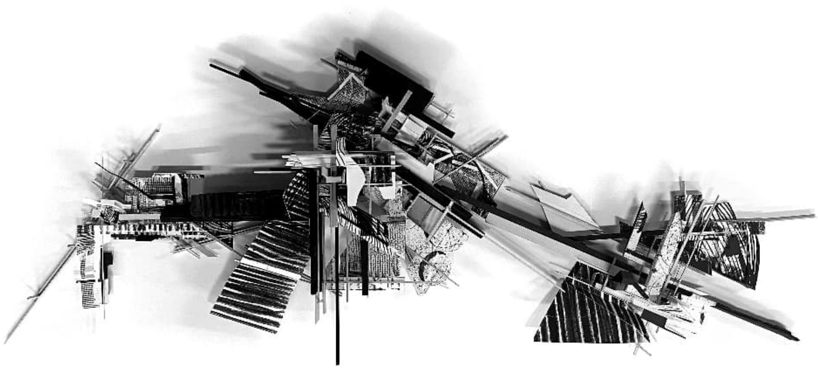


Figure 7. *Gromatici Joint Model* assemblage of the *Rio Guaire.*

3 Parque del Guaire

Weaving west to east throughout the heart of Caracas, the *Parque del Guaire* effectively reunites the metropolis with its long-forgotten river. After over a century, the river's pristine waters meander along the newly developed riverbank wherein architecture and infrastructure support the city's preeminent public environmental datum. The *Parque del Guaire* proposes a comprehensive city resiliency strategy guiding policies, phases, and programs for regenerating the Guaire's socio-spatial image. Connecting and reconnecting urban fragments through its diverse programmatic systems, this park authentically synthesises long term resiliency for Caracas. The park's goals and parameters that coordinated the research's translation into the design were a direct result of a series of site mappings. These maps frame the Guaire river and its immediate urban environmental issues. Assembling the *Groma Joint models* so to reference these maps and the river's geography produced a methodological armature that initiated the strategies for the architecture's urban integration and localization.

The utilitarian and spatial presence of the highway needs to be replaced in a way that reconnects the urban context to the river. While the thesis acknowledges the necessity of redressing the highway system, it offers three options at varying degrees of intensities: downsizing, shallow burial, or deep burial, whose designs can be easily inferred given their successful application in similar contexts. [27] This allows the thesis to prioritize the intensive design of the river's physical infrastructural and social programmatic regeneration. Suturing the wound of the Rio Guaire by appeasing its flooding, improving seismic/soil/water security, and addressing anthropogenic contamination. Desegregating the urban environment of Caracas by integrating an armature of public spaces along the river that remediate its divisive edges and reconnects the formal and informal urbanities. Filtering modes of circulation and phenomena by rearranging the city's highways/vehicular connections and facilitating and improving the pedestrian socio-spatial experience through its architecture. Accepting these priorities and their commonalities, it was evident the largest hurdle needed to be dealt with immediately. Imagining this context without its overwhelmingly intrusive highway presents the river and its edges to the matrix of spatial possibilities and relationships which lays the foundation for the *Parque del Gauire*.

Parque del Guaire relies on the regeneration of the physical river just as much as it relies on the regeneration of its image to be an accessible, authentic, and safe datum of public space for Venezuelans to reconnect with their urban environment though the programmatic transactions they are familiar with. To achieve this, the programme is divided into two spatial systems that organize programmatic typologies that can be designed and built by either the author or locals.

The first design system, the Corridors, deploy multifunctional spaces that play an important and active role in structuring the public ream. Corridors extend across the landscape, channelling the ebbs and flow of the city and its river. Arranged in an elongated fashion on the raised riverbank, Corridors utilize Attractors and Protectors to diversify the urbanization schemes and their infrastructure. Attractors concentrate occupation through diverse, and accessible program typologies that can be self-constructed to immediately and effectively respond to their context. Commerce, Education, Recreation, and Health programmatic modules populate the armature's parcels and intensify the urban activity through attractive and collaborative approaches. The network of attractors along the act as magnets throughout the river armature's itinerary that serve their neighbourhoods and balance the broader urban systems. This provides to a sense of welcome and safety for the surrounding communities, which attracts further public financial, cultural, and emotional investments. The Protectors preserve the areas along the river that are particularly fragile, environmentally sensitive, or better left unoccupied. Protective typologies reference open/unsettled public and private institutional areas so to illuminate the reciprocity within the systems. The primary Protectors for this river are the tributary zones and the naturalized riverbank areas.

The second design system, the Patches, deploy points or fields of infrastructural programs that service the park and the immediate communities surrounding it. Patches are categorized into Receptors and Transformers. Receptors account for the system of parcels embedded within the armature's masterplan that is available for localized management/ ownership. The parcels vary in size defining the pedestrian scale of the park by measuring their proximity and accessibility to surrounding public spaces, contextual programs, and communal services. The configuration of the parcels explicitly references their surroundings and the programmatic potential. Anchoring the programmatic vessels to the parcels physically and theoretically via the usage of pragmatic foundations that receive the programs effortlessly. Transformers are specialized patches of productive activities that facilitate the corridors and receptors. Their programs represent important structural and economic drivers of the park's gradual regeneration and development. Program typologies include sewage management areas, providers of safe water, providers of electricity and communications, and waste/recycling areas. Transformers decentralize the informal and formal urban systems and facilitate consistent investments from both public and private sectors. Gathered trash from the river's regeneration provides the recycling centres copious potential markets including the localized manufacturing of sustainable materials that can immediately be offered to people for their construction endeavours. Transformers and Receptors work hand in hand to configure the armature's integrative potential over time.

Each system has a strong influence on the spatial organization, performance, permanence of the host urban systems/context. Through iteration, these systems will naturally accumulate a complexity that will inevitably characterize its urban value and its ability to support the river's new physical and performative relationships. The deployment of these systems encourages: engagements with the natural and cultural landscape, working with organically evolving modules and networks, as well as healthy and authentic localized urban renewal. United, these architectural and infrastructural systems define *Parque del Guaire's* procedures towards a securing long-term resiliency for the city and its river.

3.1 Groma Vessels

The *Groma Vessels* are the programmatic modules serving the design systems for the *Parque del Guaire*. This avant garde 'kit of parts' curates a variety of structures directly derived from the *Gromatici* series and the wealth of material it produced. Designed to be grafted onto the Guaire's regenerated riverbank, these vessels provide permanent or temporary programmatic options for locals to construct, own, and activate. Over time, the vessels form a network of localized socio-economic growth and new circulatory paths that reconnects the people with its rebirthed river. Additionally, their gradual proliferation along the river's extent contributes to the larger social and ecological goals: the regeneration of the river and the city's public realm, as well as ensuring long term flood protection and resiliency for Caracas. Intimate, provocative, and adaptable, the *Groma Vessels* dive right into the inhabitable scale so to physically investigate, through pragmatic and poetic articulations, the spatial reciprocity between the vessels and their designated parcel upon the armature.

3.2 Simulations

Isolating the frame of analysis and design to a scale where the specificity of the context establishes a demonstrable environment for the systems of design to prove their social, spatial, and ecological efficacy. Drawing the river as a datum in an isometry organizes the contextual and scalar relationships between communities and highlights the connective opportunities between the north and south. The programme instructs how the armature, and its parcels are partitioned at this scale according to local socio-spatial capabilities. Leveraging these programmed zones, a system of accessible green spaces re-naturalizes the edges of this urban river, formalizing a public longitudinal environmental datum for Caracas.

The entire or proportioned removal of the river's channelization reconnects the river to its natural ground, restoring preindustrial water cycles and diminishing the impact of flooding. Articulating the riverbank with vegetated microcosms filter the river and city's contaminants further while contributing to a comfortable and healthy spatial atmosphere. Additionally, mechanical systems designed into the park's armature are reserved for Caracas' wet season and or unusually dangerous hydrological events to defend the city as climate change continues to pose its threats. During low tide, the park invites the city to interact with the Guaire as it did long ago. During high tide, the park's resiliency relies on its mechanical and natural infrastructures for its recoverable capabilities. The occupiable programs invite the city to interact and invest in their future via the programmatic vessels safely anchored onto the river's armature.

Given the park's dedication to accessibility, the selected materials reflect widely available sustainable resources and strategies seen across the city. Brick, wood, steel, and glass define the city's inhabitant's intimate role in shaping their environment through the materials directly around them. Introducing Hempcrete as a foundational material adds to the pedagogical applications as well as jump starts a recycling system to procure the material's ingredients. [28] Reusability, durability, and versatility were the key deciding factors for the materials and their systems of assembly. Masonry and timber (CLT) construction allows anyone interested in participating, or learning how, to contribute to park's construction. [29] This promotes localized ownership and agency towards their spaces, ensuring their proper activation and maintenance. [19]

Simulating the design's scope and sequences through qualitative and quantitative visual measurements has proven the project's social, spatial, and ecological efficacy within the isolated site. Thus, the following hypothesis stands to affirm that the creation of public space through this Avant-Garde architectural and infrastructural proposal filtrates modes of circulation and phenomena, desegregates the urban environment, and sutures the open wound that is *el Rio Guaire*.

Acknowledgements

I would like to thank my co-authors and project advisors: Nancy Clark and Adeline Hofer for supporting the development of this thesis and its architecture. Their guidance and rigor have fundamentally shaped my professional and pedagogical perspective. This work could not be developed without the published insights of experienced urbanist and a previous Venezuelan Director of Urban Planning, David Gouverneur, whose analysis of informal and formal urbanity framed this architecture from its inception. I would like to thank my biological and chosen families, who have unconditionally celebrated and challenged me, formalizing my patriotism and responsibility as a designer to help others. Finally, I wish to extend my gratitude towards my inspirational students and colleagues, and the faculty and staff at the University of Florida working tirelessly to support us all in our mission to contribute to the heritage of architectural education.

References

[1] Trinkunas, Harold A. "The Transformation of Venezuela." (2010): 239-247.

[2] Agency created under the instructions of the secretary general of the United Nations, António Guterres in 2018. https://www.r4v.info/en/aboutus.

[3] Stetz, Amanda. "The Humanitarian Crisis in Venezuela." (2022).

[4] Lieuwen, Edwin. *Petroleum in Venezuela: A History*. Vol. 47. Univ of California Press, (1955).

[5] United Nations, DESA, Population Division. Venezuela Population Prospects (2022). http://population.un.org/wpp/

[6] CAREY, MARK. "Latin American Environmental History: Current Trends, Interdisciplinary Insights, and Future Directions." *Environmental History* 14, no. 2 (2009): 221–52. http://www.jstor.org/stable/40608469.

[7] "Venezuela: Illegal Mining and the Resurgence of Malaria." The Guardian. Guardian News and Media, (December 2, 2014). https://www.theguardian.com/global-development-professionals-network/2014/dec/02/valuing-amazonian-land-voices-tackling-malaria-venezuela.

[8] Hausmann, Ricardo. "Can Venezuela Resurrect Its Economy?" Council on Foreign Relations. Council on Foreign Relations, July 26, 2017. https://www.cfr.org/interview/can-venezuela-resurrect-its-economy.

[9] Morales Tovar, Mirelis. "A Stinking River That Has Played a Role in Anti-Government Protests in Venezuela Is Reminder of Government's Inefficiency." Univision, (April 26, 2017). https://www.univision.com/univision-news/latin-america/a-stinking-river-that-has-played-a-role-in-anti-government-protests-in-venezuela-is-reminder-of-governments-inefficiency.

[10] Lopez, JM. "Scavenging to Survive in Venezuela." Poverty and Development | Al Jazeera. Al Jazeera, (October 16, 2017). https://www.aljazeera.com/gallery/2017/10/16/scavenging-to-survive-in-venezuela.

[11] Stratthaus Cordova, Christian Eleazar, Ochoa Iturbe, Jose, *Recopilacion y Analisis de Informacion de la Cuenca del Rio Guaire* (Recopulation and Analysis regarding the Information oof the Guaire River), *Universidad Catolica Andres Bello, Esceula de Ingenieia Civil* (School of Civil Engineering), Caracas, Venezuela, (2000).

[12] Ramírez, Ricardo. "El Guaire, El Río Que No Quisimos (The Guaire, the River We Neglected)." Rio Guaire, (2021). https://www.rioguaire.org/articulos/ricardo-ramirez.

[13] The First Drawing of Santiago De Leon De Caracas, (1578). Guia Caracas. (Accessed March 2, 2023). http://guiaccs.com/en/.

[14] Ferrar, M J., (2004), ‘Agrimensorial Texts; Practice or Theory’, see N M R, Swindon, Archive.

[15] Mundigo, Axel I., and Dora P. Crouch. “The City Planning Ordinances of the Laws of the Indies Revisited. Part I: Their Philosophy and Implications.” *The Town Planning Review* 48, no. 3 (1977): 247–68. http://www.jstor.org/stable/40103542.

[16] Blackmore, Lisa. Spectacular Modernity: Dictatorship, Space and Visuality in Venezuela, 1948-1958. Pittsburgh, PA: University of Pittsburgh Press, (2017).

[17] Marte, Arturo Almandoz. *European Urbanism in Caracas (1870s–1930s)*. Open University (United Kingdom), (1996).

[18] “Caba - Cartography of the Caracas Barrios 1966-2014.” *Enlacearquitectura.net*, (2016) http://www.enlacearquitectura.net/work/2015/12/caba/.

[19] Gouverneur, David. Planning and Design for Future Informal Settlements: Shaping the Self-Constructed City. London: Routledge, (2018).

[20] Davies, Richard. “Venezuela – Floods Affect Thousands as Major Rivers Overflow.” FloodList, (August 8, 2017). https://floodlist.com/america/venezuela-floods-august-2017.

[21] Popovich, Nadja, Josh Williams, and Denise Lu. “Can Removing Highways Fix America's Cities?” The New York Times. The New York Times, (May 27, 2021). https://www.nytimes.com/interactive/2021/05/27/climate/us-cities-highway-removal.html?utm_medium=website&utm_source=archdaily.com.

[22] Lissitzky, El. *Russia: An Architecture for World Revolution*. Massachusetts Institute of Technology, (1989).

[23] Gaztambide María C. *El Techo De La Ballena: Retro-Modernity in Venezuela*. Gainesville, FL: University of Florida Press, (2019).

[24] Ramirez, Mari Carmen. *Inverted Utopias: Avant-Garde Art in Latin America*. Londres: Yale University Press, (2004).

[25] Posani, Juan Pedro., William. Niño Araque, Luis Pérez Oramas, Paolo. Gasparini, Paola. Bertorelli, and Mirko. Melis. Carlos Raúl Villanueva: un Moderno en Sudamérica. Caracas: Fundación Galería de Arte Nacional, (1999).

[26] “Ciudad Universitaria De Caracas.” UNESCO World Heritage Centre, (2000). Accessed September 1, 2022. https://whc.unesco.org/en/list/986/.

[27] Bcrowther. “Four Principles for a Federal Highways to Boulevards Program.” Congress for the New Urbanism, (November 28, 2022). https://www.cnu.org/our-projects/highways-boulevards/principles?utm_medium=website&utm_source=archdaily.com.

[28] “Hempcrete: Hemp Concrete.” Hempitecture Inc. (Accessed March 2, 2023). https://www.hempitecture.com/hempcrete.

[29] Braungart, Michael, and William McDonough. *Cradle to Cradle: Remaking the Way We Make Things*. London: Vintage, (2019).

BIO-INSPIRED LEARNING ENVIRONMENTS AS PEDAGOGICAL INSTRUMENTS FOR ELEMENTARY SCHOOL DESIGN

Gabriel FERNANDEZ*, Nancy CLARK, Jeff CARNEY

University of Florida School of Architecture – UF SoA
2330 SW Williston Rd, Apt 2913, Gainesville, FL 32608;
gfernandez98@ufl.edu*, nmclark@ufl.edu, j.carney@ufl.edu

Abstract

The umbrella of bio-inspired design, which includes philosophies of biophilia, arcology, biomimicry, and more, is driven by the concept that humans have an innate desire to be surrounded by nature. The application of these principles can be used as a design strategy to advance and improve the educational building typology by presenting a new prototype for elementary schools. The foundational skills that children learn while they are in elementary school are critical to their early development. The spaces in which these students of K-5 education learn in, should foster and enrich their explorative and curious minds.

This new prototype would apply biophilic principles and patterns of design into the overall architecture of the school, its programmatic and circulatory layout, and the atmosphere of the classrooms which will be instrumental in the student's educational experience. Building off Frank Lloyd Wright's organic architectural movement and re-examining outdoor learning spaces that were so prevalent in mid-century elementary school prototypes, this project will propose a classroom prototype that implements various concepts of bio-design that have evolved over the course of decades.

Involving students in the observation and understanding of their school's sustainability systems and how it coexists with its site to create a sustainable ecosystem, allows for a more immersive learning environment for their studies and improves their educational experience. This research focuses on discovering that pedagogical potential of bio-inspired design in elementary schools and how the application of biophilia in and outside the classroom can enhance the learning environment for children in K-5 education. It also seeks to discover the didactic potential of the integration of nature into the built environment and how it can serve as a pedagogical instrument of ecological concepts for the students who inhabit and learn in those spaces.

Keywords

Biophilia, Early-learning spaces, Nature-based design, Bioclimatic architecture.

1 Introduction

A new educational building typology should learn from the shortcomings of past school prototypes and implement the practices and principles of bio-inspired design to become the new standard for sustainable elementary schools. These guiding principles should be woven holistically at all scales of interaction and occupation between student, building, and site. In the application of these spatial scenarios, the typical definitive boundaries between in and out can be obscured. The potential of this liminal space opens the door of opportunity to create an ideal pedagogical learning environment for students that enhances their educational experience and brings them closer to nature.

2 Sustainable Design Methodologies

Since the turn of the 20th century, sustainable design has evolved and developed a vast catalogue of design methodologies that are rooted in nature-oriented philosophies and principles. Here are some of the architectural movements that have placed a great emphasis on resolving the contested relationship between the natural and built environment:

- *Organic*: To form a whole with a systematic arrangement or coordination of parts.
- *Arcology*: To create a comprehensive form through the fusion of architecture and ecology.
- *Ecological*: To restore the previous environmental conditions that existed before.
- *Biophilic*: From the Greek, “life and love of”, To affiliate with nature.
- *Bioclimatic*: From the Greek, “life and imitation”, To emulate the function of nature.
- *Biomimetic*: From the Greek, “life and climate”, To respect the environment.

2.1 Organic Architecture

Frank Lloyd Wright may have introduced the term organic into his architectural style as early as 1914, but the philosophy behind it can be traced back to French architect, Eugene-Emmanuel Viollet-le-Duc. In “My Father Who Is On Earth”, John Lloyd Wright confirms that “Viollet-le-Duc was a teacher of what [Wright] now calls organic architecture as early as 1860. His influence upon [Wright] was marked.” [1] The term “organic architecture” promotes a design ideology that seeks to harmonize the interaction between humans and natural environment. Wright loosely defined the notion of organic “as the character of a thing, living and active as an intrinsic quality that emerges in varied forms responsive to the surrounding environment.” [2] This idea that organic architecture is an attempt to integrate the built and natural environments as one functioning whole, became Wright’s essential philosophy for design. With this perspective, buildings should strive to be responsive to the environment they occupy and “appear to grow easily from its site and be shaped to harmonize with its surroundings.” [3] The union between building and site creates a sustainable ecosystem for nature, the building, and humans to coexist and thrive off one another. Each component is an integral piece to the whole, allowing the entire collective to function as a living system.

The key element in organic architecture is this notion of the sustainable ecosystem. The term "ecosystem" was defined by British botanist Arthur Tansley as "a particular category of physical systems, consisting of organisms and inorganic components in a relatively stable equilibrium." [2] Therefore, a building's design should be thought of as the unifying language that seamlessly integrates the built structure into the natural environment. For a building to be organic, there should be a mutual exchange in the relationship between it and nature. The building should serve purpose to its site, with an intent to replenish the resources that were taken for construction or function in a manner that does not further erode the natural systems it has interrupted. In return, "nature should serve a building as ornament." [4] This interdependent ecosystem between the built and natural environment that encompasses Wright's philosophy towards architecture, can be seen as the catalyst that spawned other similar methods of sustainability that all employ a holistic and often pedagogical approach to design. Every resulting sustainable design method aims to find that harmony between the built and the natural, to serve human's innate desire to be near nature. Ultimately, the central concept of Wright's organic architecture is that humans should be able to witness a thriving relationship between the buildings that grow and adapt from the landscapes they occupy.

Frank Lloyd Wright's desert laboratory for organic architecture, Taliesin West, is an ideal example of how a building that promotes a design ideology creates a seamless intervention with the landscape it occupies. Wright made a conscious effort to design and build this structure with natural materials in mind so that it could appear as a unified whole with its surrounding environment. To Frank Lloyd Wright, "a building needed to grow from its immediate surroundings and environment, to appear as one continuous unit." [5] He also designed the drafting studios so that the interior spaces would visually and sectionally flow and engage with the outdoors. These principles of Wright's organic architecture can be applied to a building or space of any scale. For an elementary school, it's vernacular should be reminiscent of its site and the community it serves. The language of unity and established sense of place that a school can embody with an organic design could create a sustainable learning ecosystem between the students and nature. The School of Architecture at Taliesin demonstrates how an intimate learning environment with nature fosters an enriched educational experience that allows students to learn from the building, its surrounding landscape, and the harmonious connection between the two.

2.2 Arcology

In "The City in the Image of Man", Paolo Soleri describes arcology as "the fusion of architecture with ecology, a comprehensive urban perspective." [6] This concept proposes a compact urban form that is highly integrated with the natural world to give its inhabitants a direct proximity to rural spaces as well as allowing agriculture to be situated near the city. In his first prototype, Paolo Soleri designed an experimental city, Arcosanti, that functions as a living system and research tool for a new "lean alternative" to modern urban sprawl. One of the founding principles that Soleri built Arcosanti upon was the idea that humans need to rebuild their connection with the natural environment, and his way of doing that was through arcology. From these principles, it can be said that in an arcology, the built environment and its occupants interact with their accompanying natural environment on a living scale. [7] This means that, like organisms and ecosystems, multiple systems are at work becoming integrated with each other to become coexistent and environmentally efficient. This hybrid living system between the built and natural, functions as a research tool and pedagogical vessel that attempts to encourage an environmentally coherent context through a more holistic approach to issues of sustainability. [8]

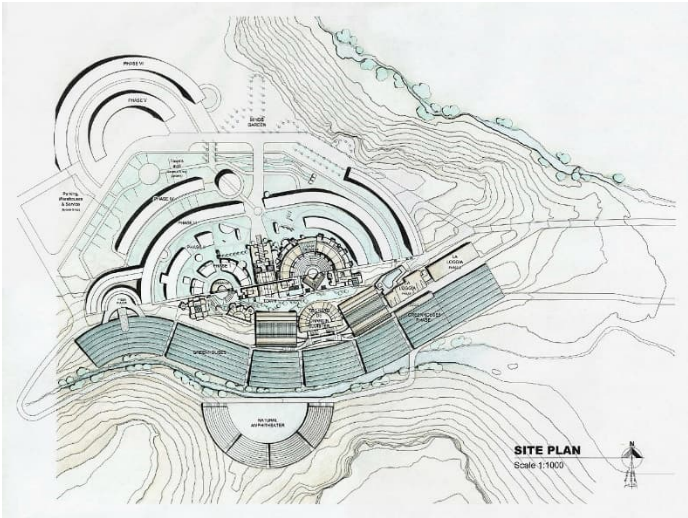


Figure 1. Site Plan of Arcosanti, illustrating its holistic site design and organic form.

One of Soleri's inspirations for creating a city like Arcosanti comes from Constantine Doxiadis' *Map of Despair*. [6] It paints a picture of two different ways that humans can choose to live with nature; one of an ecumemopoly and one of an arcology. In an ecumemopoly, the built environment has used the resources of the natural environment, created cities, and left separate pockets of isolated natural spaces within and around it. In this scenario, tremendous loss of biodiversity and ecological systems is expected and there will be little to no opportunities for interactions or connections with nature in developed areas. On the contrary, in an arcology, the built environment has weaved itself within nature and blurred the lines between the two. In that scenario, biodiversity and ecological systems are protected and preserved by maintaining a balance in the way we develop the built environment. Structures that house spaces for learning should demonstrate this important ecological cautionary tale through the fusion of the built and natural, like Soleri achieved.

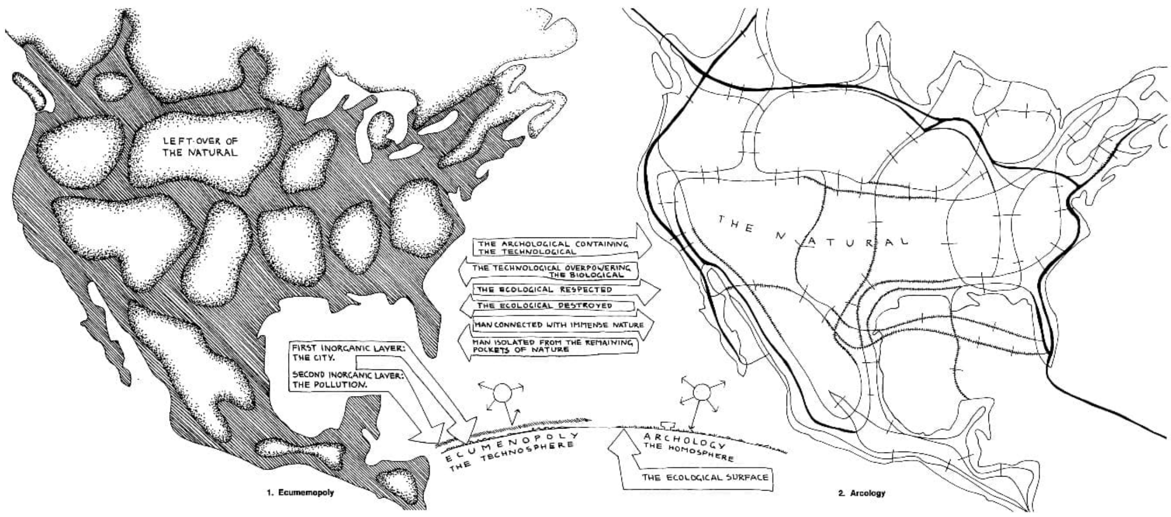


Figure 2. *The Map of Despair* by Constantine Doxiadis, an illustration of two maps that tell opposing stories of human-nature relationships.

One of Arcosanti's primary objectives is a pedagogical one. Members of the community and visitors alike, learn from the city and its structures through its ecologically conscious design. Originally conceived as a self-sustaining community, Arcosanti's reliance on integrated sustainable methods in its design paired with appropriate building technologies, create an instructive learning environment that can teach about ecological concepts. The philosophy or arcology strives to educate through its architectural design about the benefits of a built environment that respects and embodies nature's principles and landscapes. Applying this large-scale concept to the curriculum of elementary education, allows nature to serve as the pedagogical vessel for students. Incorporating lessons involving students in observations and activities that take place outdoors can create a more immersive experience for them. Nature inspired design tools and teaching methods are the perfect tools and learning conditions for children in K-5 because that is the time when they are most curious and explorative. Giving children the opportunity to participate in outdoor learning spaces enriches their education in an optimized learning atmosphere that utilizes naturally occurring pedagogical systems.

2.3 Biophilic Design

Dating back to 1984, the biophilia hypothesis was first introduced by Edward O. Wilson who popularized the theory in his book, Biophilia. He defined biophilia as "the urge to affiliate with other life forms." [9] Theorized to be the result of biological evolution, this human desire to around nature has been incorporated in architecture as a sustainable design strategy that emphasizes reconnecting people with nature in interior spaces. This is typically accomplished through naturalistic elements and forms, passive design strategies, and introducing nature in the space through one or more of the five senses. Using this evolutionary trait that seeks out places that are beneficial to our health and wellbeing, we can improve the quality of our interior spaces by making them reminiscent of nature. This practice is known as biophilic design, which Dr. Stephen Kellert defines as "the deliberate attempt to translate an understanding of the inherent human affinity to affiliate with natural systems and processes – known as biophilia – into the design of the built environment." [10] Biophilic design focuses on the aspects of nature that have contributed to human's physical health and mental prosperity throughout time. When natural elements are introduced into the built environment, it connects us to the landscape and provides a renewed sense of place. Children in K-5 education have a lot to benefit from biophilic design since it has been shown to increase productivity and happiness and improve health and test scores. [11]

Like the design philosophy of arcology, biophilic design functions most effectively when it is implemented as a holistic integrated system throughout a project, like a pocket ecosystem. In Biophilic Cities: Integrating Nature into Urban Design and Planning, Dr. Timothy Beatley elaborates on how nature-integrated design has the power to "heal broken human landscapes and to humanize and reinvigorate distressed built environments." [12] With the ability to uplift the human spirit and promote physical, visual, and mental connections with the natural environment within the built environment, there are certain principles and fundamental conditions for the effective implementation of biophilic design. Kellert defines these five principles for the successful application of biophilic design, describing that it should: [13]

I. Require repeated and sustained engagement with nature.
II. Focus on human adaptations to the natural world that over evolutionary time have advanced people's health, fitness, and wellbeing.

III. Encourage an emotional attachment to particular settings and places.
IV. Promote positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for the human and natural communities.
V. Encourage mutual reinforcing, interconnected, and integrated architectural solutions.

With all its benefits, it’s a wonder why more schools have not implemented these changes or additions to their facilities so that their young students may strive in programs that emphasize natural systems learning. This innovative learning method could also be paired with the advantages of outdoor learning and biophilic classrooms. The power of biophilia suggests that it is essential for people to reconnect with nature on a pedagogical level and that every school designed and built in the future should be incorporating natural systems learning in their indoor and outdoor environments. [12] The Kendeda Building for Innovative Sustainable Design shows how learning facilities can successfully create biophilic learning environments that celebrate a renewed connection to nature through design. To achieve this, the design of the building recognizes that the boundary between interior and exterior should be ambiguous to create a sense of immersion in nature no matter where you are in the project. In and around the Kendeda Building are elements of biophilic design education, biomimicry integration, nature-immersion, and place-based relationships. [14] It has accomplished to demonstrate how biophilic design initiatives can enhance the learning environment for students, nurture human’s evolutionary desire to be around nature, and create environmentally responsible buildings that also function as educational instruments of ecological and sustainable concepts.

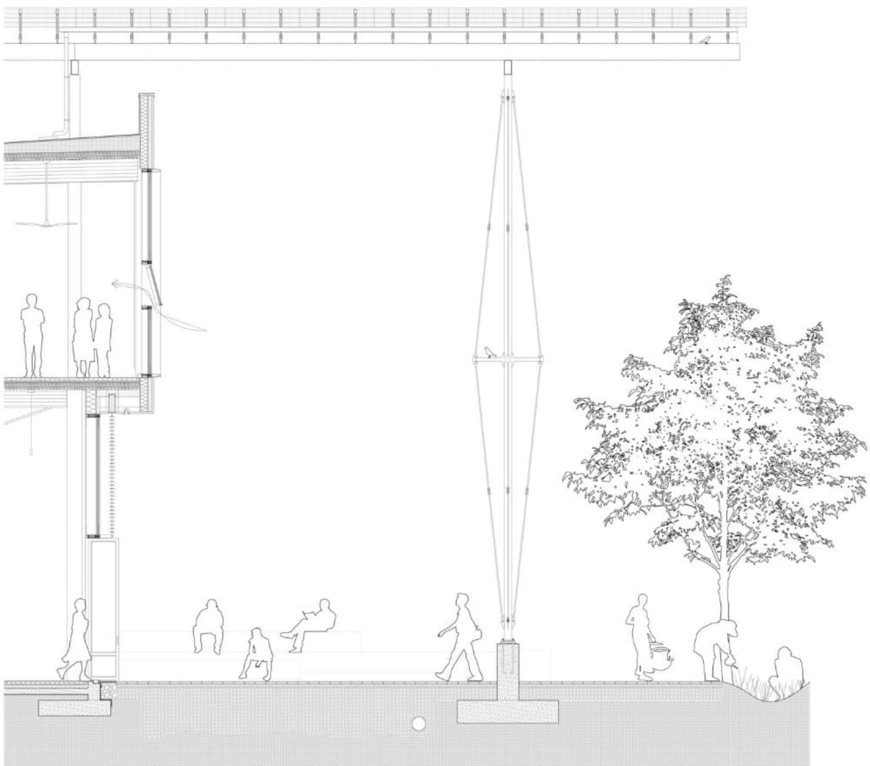


Figure 3. Section Drawing of the Kendeda Building for Innovative Sustainable Design, illustrating a transitional gathering space between indoors and outdoors.

3 Outdoor Learning Spaces

Currently, the majority of schools adhere to a “cells and bells” model of design that impedes the potential for effective learning experiences. The design forces students to spend most of the school day indoors, confined to their classrooms (cells), waiting for the “bells” that indicate the end of the class period. In this cyclical process, there are few opportunities for students to engage with the natural environment and it doesn’t give children the chance to learn in an environment that will foster their growth and develop their young minds. Simply put, the current school prototype of an architecture that limits student’s exposure to the outdoors is not the most effective methodology for design. In the past, schools were more inclined to embrace outdoor learning and some even recognized the important role green spaces play in student’s education. An example of this design approach was the popular school prototype used in the early to mid-20th century that featured classrooms arranged along a central covered outdoor corridor. This axial approach to classroom distribution enabled teachers and students to take advantage of the natural spaces between the building branches. These schools lacked traditional interior hallways and instead used these outdoor esplanades to link students with the surrounding natural environment, giving them the opportunity to enjoy lessons outside the confines of their “cells”.

“The school is where we hear of facts new to us, where we recreate ourselves, shape our mentalities, our outlooks and social attitudes…We can either enjoy friendly openings into green outdoors or suffer uncontrolled uncanny corners behind cramped furniture…and a thousand other psychologically tinged ingredients.” [15] – Richard Neutra.

In the 1930s, Richard Neutra challenged the standard for school design by introducing a new building typology that blurred the boundaries between the classroom and the outdoors. His architectural style, which was influenced by Wright’s organic architectural movement, was characterized by an immersive engagement with nature and landscape through its use of expansive glass thresholds that merged indoor and outdoor spaces. [16] The Corona Avenue Elementary School, with its “glass and grass” classrooms that featured sliding glass-and-steel walls and operable clerestory windows that opened the atmosphere of the outdoors, was the epitome of his vision for nature-oriented classroom design. His bio-centric spatial scenarios created an interstitial space between the inside and outside, transforming traditional indoor learning into explorative outdoor natural learning. Neutra’s experimental school became an early innovative example of bio-inspired open air elementary school design, demonstrating the potential for a new school typology that creates engaging learning spaces for young students to flourish.

The best way to learn from nature is to be in nature. Learning in outdoor spaces plays a critical role in the development of a child’s creativity, problem-solving, and mental health. A study conducted by the American Institutes for Research showed that children in elementary schools who had classes in outdoor spaces had higher test scores, increased self-esteem, and improved behavior in class. [17] With an overall improvement on childhood development, it becomes clear that outdoor learning spaces should be the new standard in all elementary schools.

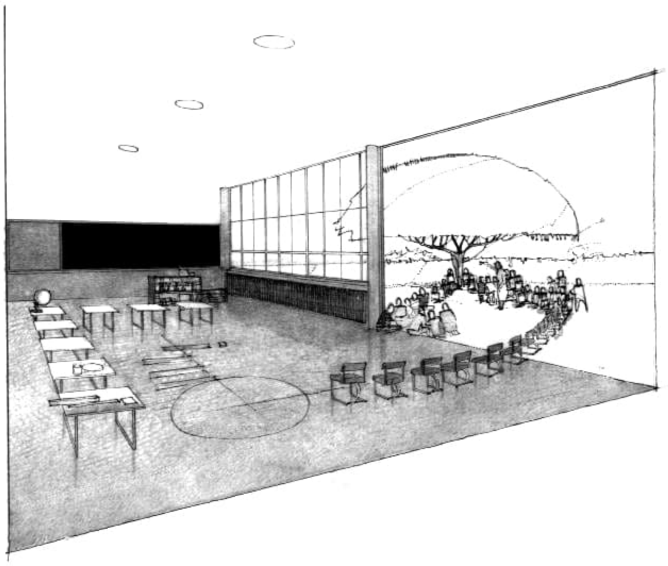


Figure 4. Perspective Drawing of Richard Neutra’s Corona Avenue Elementary School that illustrates the seamless transition between indoor and outdoor classroom.

4 Nature-Inspired Spatial Scenarios

Above all, a biophilic school should foster the same nurturing sense of place in its approach to site design, as it would in its more intimate learning spaces in and out of the classroom. At the scale of the site, a school should achieve harmony and an integrated connection with the landscape. Every element in the site, natural or built, should function as connected systems that are part of a greater whole, like a living organism or ecosystem. In “Biomimicry: Innovation Inspired by Nature”, Janine Benyus describes biomimicry as “a practice that learns from and mimics the strategies found in nature to solve human design challenges.” [18] An important factor that differentiates biomimicry from other bio-inspired design philosophies is its emphasis on emulating and learning from the regenerative characteristics that can be found in nature. Through the lens of biomimicry, there are architectural lessons to be learned from the flow of water in nature. Characterized by its tendency to follow the path of least resistance, the gentle and fluid nature of a stream should be a quality of the circulation between buildings in the site. For the circulation to be fluid like water, the buildings should be distributed in an organic, non-rectilinear form. A design with a central node for classrooms to encircle, creates a nature-oriented circulatory experience that provides students intimate walking experiences through open multi-purpose green spaces.

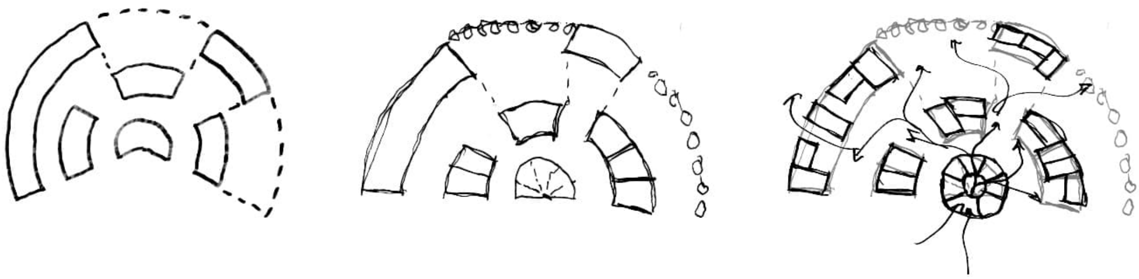


Figure 5. Conceptual school site design with fluid circulation through outdoor spaces around classrooms.

In dealing with shade, natural and built systems must be incorporated to the overall design to ensure student comfortability and sensory immersion into their environment. When possible, creating an extensive tree canopy to provide natural shade for outdoor learning spaces can evoke the sense of security that comes with being sheltered from the natural elements. This proposal fits the criteria of Florida vernacular architecture, having been designed to operate in a subtropical climate. Therefore, shade plays a critical role in ensuring that outdoor learning is an achieving activity for long periods of time. An abundant tree canopy and a comprehensive architectural canopy that can also serve as a pedagogical instrument for ecological concepts are integral elements of the design.

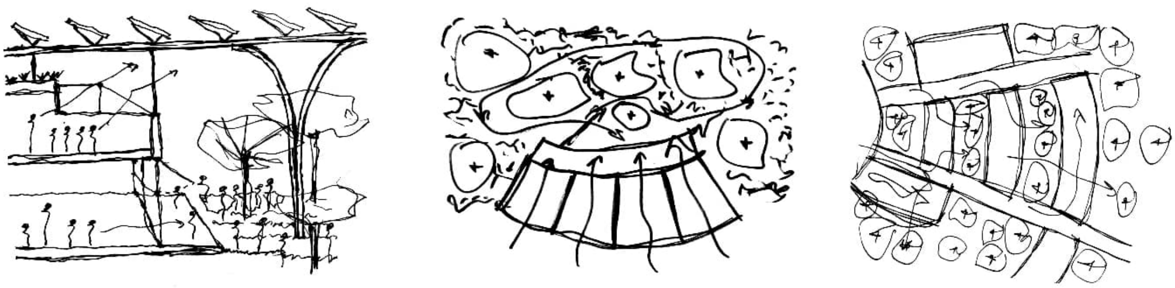


Figure 6. Conceptual school design emphasizing the importance of a constructed or natural tree canopy that provides shade to students in their outdoor learning spaces.

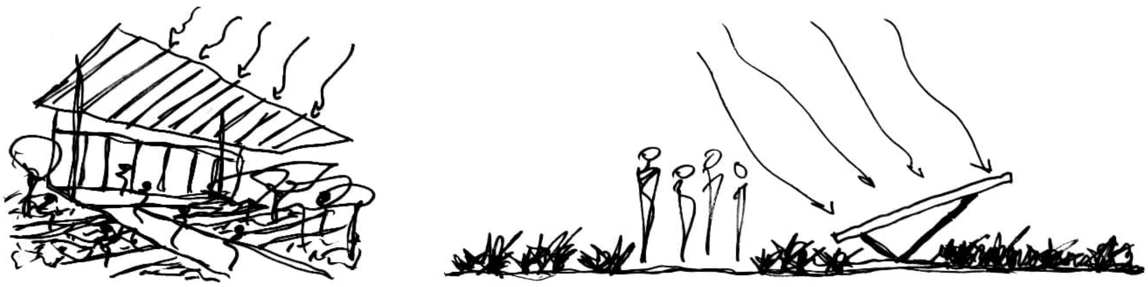


Figure 7. Conceptual school design demonstrating the potential for a pedagogical architecture that teaches students about ecological concepts.

5 Conclusion

This research and project proposal documents the history of nature-centric sustainable design methodologies and assesses their potential for creating a new bio-inspired elementary school prototype design. With the research to support Richard Neutra's concept for open-air schools and outdoor classrooms, this innovation is ready to redefine the educational building typology. Addressing best practices and proposing ideal spatial scenarios for the execution of a pedagogical and ecological educational architecture, this bio-inspired school prototype would foster a healthier and more sustainable for children.

Acknowledgements

I would like to thank my professors at the University of Florida, Nancy Clark and Jeff Carney, for guiding me in my research and serving as my mentors as I explored this research topic I am very passionate about.

References

[1] Wright, L, John, *My Father Who Is On Earth*, G.P. Putnam's sons, New York, New York, 1946.

[2] Graff, Stuart, Organic Architecture and the Sustaining Ecosystem, Frank Lloyd Wright Foundation, July 11, 2018, https://franklloydwright.org/organic-architecture-and-the-sustaining-ecosystem/.

[3] Wright, L, Frank and Deyane, Andrew and Gutheim, A, Frederick, *In the Cause of Architecture: Essays by Frank Lloyd Wright for Architectural Record, 1908-1952*, Architectural Record, New York, New York, 1975.

[4] Hoffmann, Donald, *Frank Lloyd Wright: Architecture and Nature*, Dover Publications, New York, New York, 1986.

[5] Architecture And Nature I: Taliesin West – Organic Architecture, DAS Studio, November 16, 2016, https://www.das-studio.us/design-solutions/2016/11/architecture-and-nature-i-taliesin-west.html.

[6] Soleri, Paolo, *Arcology: The City in the Image of Man*, The MIT Press, Cambridge, Massachusetts, 1969.

[7] Soleri, Paolo and McCullough, Lissa, *Conversations with Paolo Soleri*, Princeton Architectural Press, New York, New York, 2012.

[8] Design Principles, Cosanti Foundation, http://legacy.arcosanti.org/node/8628.

[9] Wilson, O, Edward, *Biophilia*, Harvard University Press, Cambridge, Massachusetts, 1984.

[10] Mador, Martin and Heerwagen, Judith and Kellert, R, Stephen, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, Wiley, Hoboken, New Jersey, 2008.

[11] Scott, Sarah, Learning Spaces: Biophilic Design in Schools, Teacher Magazine, August 24, 2020, https://www.teachermagazine.com/au_en/articles/learning-spaces-biophilic-design-in-schools.

[12] Beatley, Timothy, *Biophilic Cities: Integrating Nature into Urban Design and Planning*, Island Press, Washington, DC, 2011.

[13] Kellert, R, Stephen, *Nature by Design: The Practice of Biophilic Design*, Yale University Press, New Haven, Connecticut, 2018.

[14] The Kendeda Building for Innovative Sustainable Design – Health & Happiness Petal (LBC 3.1), Georgia Institute of Technology, https://livingbuilding.gatech.edu/health-happiness-petal.

[15] Lamprecht, M, Barbara, *Richard Neutra, 1892-1970: Survival Through Design*. Taschen, Cologne, Germany, 2004.

[16] Frith, Kellee and Whitehouse, Denise, Designing Learning Spaces That Work: A Case For The Importance of History, *History of Education Review*, *Vol. 38*, 2009, No. 2, pp. 94-108.

[17] Effects of Outdoor Education Programs for Children in California, American Institutes for Research, Palo Alto, California, 2005.

[18] Benyus, Janine, *Biomimicry: Innovation Inspired by Nature*, Perennial, New York, New York, 2002.

HOUSING + FOOD PRODUCTION: GROWING COMMUNITY AND SUSTAINABLE URBAN LIVING IN JACKSONVILLE, FL

Mariana OLIVEIRA CAPUCHINHO*, Nancy CLARK, Jeff CARNEY
University of Florida School of Architecture- UF SoA
1480 Inner Rd, Gainesville, FL, United States 32611, attn.: to Nancy Clark;
m.capuchinho@ufl.edu *, nmclark@ufl.edu, j.carney@ufl.edu

Abstract

Urban food deserts and a severe lack of affordable housing are two current and intertwined problems facing cities across the globe. Due to ever increasing urban growth rates, combined strategies for local food production and affordable urban habitation can have a substantial impact on the wellbeing of people. This research focuses on inequity, the quality of the environment, food production, and the lack of affordable housing, specifically observed in Jacksonville, Florida.

This paper is divided into three main topics, including case studies and research in food production methods, affordable housing research, and nature in the city to understand better the role that community-based agriculture and affordable housing can play together. The study analyses an area of downtown Jacksonville, on environmental and societal aspects, to see how the current situation of the city. The primary site for the study is a 1-block area near downtown Jacksonville where a speculative design combining the three previous topics will demonstrate the benefit of a combined approach to community-based agriculture and affordable housing.

Around the world, many cities in transition- like Jacksonville- have opportunities for interventions in urban space to develop a more sustainable environment with quality of life for the residents. The lack of affordable housing in the downtown area, the large number of vacant lots, and the food desert present in the city offer an excellent opportunity to incorporate urban gardening and housing, to help the city to achieve a more equitable and sustainable environment.

Keywords

urban food production, affordable housing, inequity, nature in cities, food desert.

1 Introduction

Access to a balanced diet and affordable home spaces is a problem worldwide, and it is similar in Jacksonville, Florida. This big city faces a downtown area laking people interaction, affordability, and life. Helping Jacksonville reinvent the Downtown area will allow the city to succeed and connect more. Food production is a problem that has been mentioned for a while worldwide, we have an increasing population, and food production is growing in a different ratio than the population. We already have a severe distribution problem, and the population increase will worsen the scenario. The distribution and the considerable distance that the food has to travel is another issue to be addressed since the pollution caused by the transportation of products can be lowered, having less impact on the earth and reducing the loss of fresh produce too. Since the world is in constant change and humans have to adapt accordingly, the creation of more methods to feed the population needs to be implemented, and it's essential to be more sustainable since we have observed that the human's impact on earth are devastating the ecosystems.

2 Methodology

With the constant change in society and its impact on the earth, a current problem that increases housing and nutrition, the subject had to be more investigated and combine diverse solutions to develop a more sustainable and resilient society. The paper is divided into research and Jacksonville analysis. The study breaks down into three main topics: Urban food production, Affordable housing in cities, and Nature in the city. It is showing on each of the topics the justification, benefits, and case studies to support the research. For the Jacksonville Analysis, selecting the area and analyzing the city's data to understand more if the proposal of a building mixing food production and affordable housing would benefit the town—the site selection for a speculative design and how it could fit in the city parameters.

3 Domains of Research

Three main topics were addressed to break down the complex topic of access to adequate housing and a balanced diet. The main goal is to demonstrate how affordable housing and food production in cities can help the community achieve a more sustainable and equitable way of living.

The main topics are urban food production, affordable housing, and nature work in the city. A mind map illustrates the topics, subtopics, and the relations between them, Figure 1. The main topics are bigger in the image, the smaller ones are subtopics, and the grey ones, the SDGs and inequity, are two matters connected to a significant part of the themes.

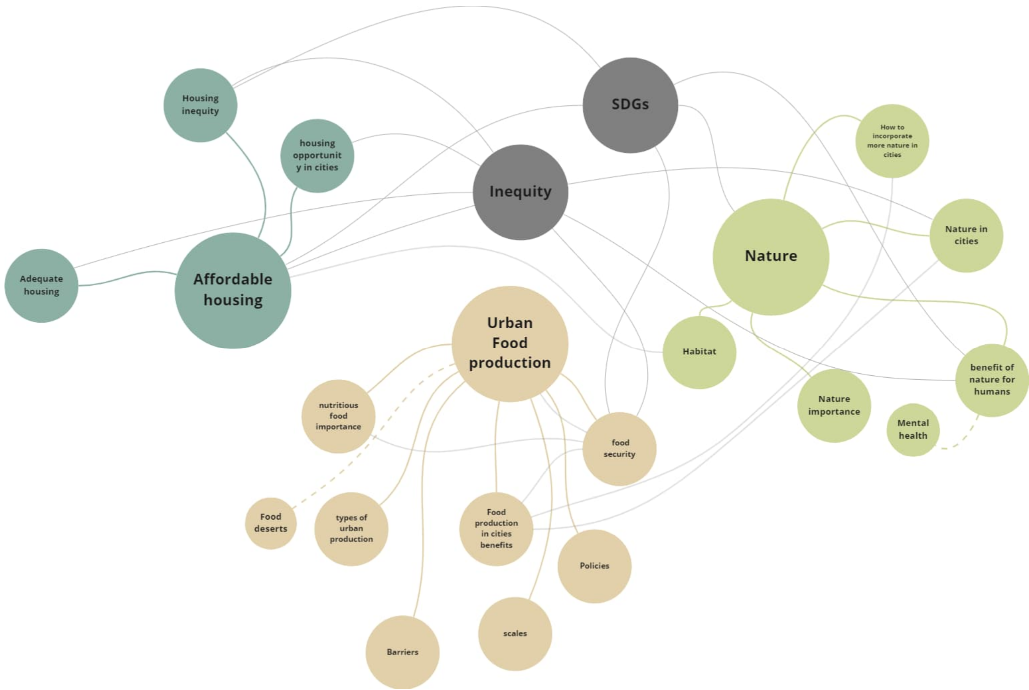


Figure 1. Mind map of the research

3.1 Urban food production

3.1.1 Nutritious food and Human being

Food is essential for human existence; not only is access to food necessary, but quality and a balanced diet are also crucial. A healthy diet is directly linked to human health, the primary determinant of obesity, and it is a factor in risks of diseases such as diabetes and cardiovascular problems [1]. Access to nutritious food also makes a difference in its consumption; healthier food consumption tends to increase when it is easier to find and promote in stores [2]. Adequate nutrition can fight the cycles of poverty and hunger since nurtured people are more productive and can create more opportunities [3]. The benefits of healthy food consumption are vast, and architectural design can make a difference in how the population eats.

The food culture of the United States is unhealthy, and the government and capitalism, together with the business, do not help the population make good diet decisions. A wide variety of unhealthy products is available and cheaper to the public. People should have the option of fresh produce at an accessible price.

3.1.2 Food Security

The earth's population is expected to increase to 9.7 billion by 2050. The urbanization ratio is foreseen to be 70:30 from urban to rural populations in 2050; food production needs to adapt because of the change in the relationship between food demand and population growth.

[1] Michele Ver Ploeg et al., "Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences," n.d. p.51

[2] Ploeg et al., "Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences." P.53

[3] "Nutrition," accessed October 26, 2022, https://www.who.int/health-topics/nutrition.

However, there is a severe threat of resource depletion. [4] Globally, humans are extending the cultivation area. Much of the agricultural expansion is related to achieving global food security that comes at the expense of forest ecosystems, which are essential for biodiversity and the provision of ecosystem services[5]. Despite the food production rising, the proportion of our global population's hunger has increased in the past years. At the same time, almost 2 billion humans are over-nourished, and almost one-third of the world's food production is wasted [6] ,attesting that the current global food system is deficient along with significant environmental degradation.

According to USDA, food insecurity is:

The condition assessed in the food security survey and represented in USDA food security reports—is a household-level economic and social condition of limited or uncertain access to adequate food.[7]

3.1.3 Food production in cities

Food production inside cities can combat a lot of urban issues, like access to healthy food in the local community, shortening the path of food from farm to plate, and leading to lower greenhouse gas emissions; in addition, it can add value to real estate and support other components of development projects[8], but has its disadvantages too, because of the space it competes with other urban needs and with the rural professional sector.[9]

One of the problems that urban food production fights are the food deserts, and the USDA defines it as:

It is an area in the United States with limited access to affordable and nutritious food, particularly an area composed of predominantly low-income neighborhoods and communities.[10]

So the food deserts problem must be fought to have a more equitable society since the lack of food triggers many more problems, like lack of productivity, health issues, and problems for children's development, among other issues. The Urban Oasis project is one successful case study that fights against the food deserts in south Florida; near the Miami area, it started as a volunteer-based group for two years and became a Florida not-for-profit organization. They produce food for low-income families, Figure 2, helping them to create their own gardens, Figure 3, and support local producers managing local markets.

---

[4] Joo Hwa P. Bay and Steffen Lehmann, *Growing Compact*.

[5] Katila et al., *Sustainable Development Goals*.

[6] Katila et al., *Sustainable Development Goals*.p.49

[7] "USDA ERS - Definitions of Food Security," accessed December 17, 2022, https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/definitions-of-food-security/.

[8] "Food and Real Estate | ULI Americas," accessed December 17, 2022, https://americas.uli.org/research/centers-initiatives/building-healthy-places-initiative/food-real-estate/.

[9] Craig Verzone, *Food Urbanism: Typologies, Strategies, Case Studies* (Basel: Birkhauser, 2021).p.9

[10] "Urban Oasis Project," Urban Oasis Project, accessed December 17, 2022, http://www.urbanoasisproject.org/.

Figure 2 - Urban Oasis project , Free Food Boxes to Neighbors in Need

Figure 3 - Urban Oasis Project, G.I.V.E gardens, helping a family to start a garden

The Eagle Street Rooftop farm is another project that combats the food desert, an urban farm in Brooklyn, New York, producing food locally for the community. It is composed of a green rooftop organic vegetable farm with 6,000 square feet. In addition to bringing fresh food to the community, the site is used to educate environmentally, as a venue for events, films, and photo shoots, bringing more quality of life for the locals. The pictures below show the farm with its view in Figure 4.

Figure 4 - The eagle Street Rooftop farm, website roftopfarms.com

3.1.4 Technologies and options

There are multiple ways to grow food in an urban environment, and they can be produced individually, collectively, or professionally and in different formats too. The options are vast, but the implementation must be analyzed since investment, maintenance, and time consumption can vary greatly.

The case study The Farmhouse is an excellent example of producing in the middle of the city, combining housing and food production. The project is a concept proposal made up of wooden modules that creates a residential building with food production between the residential modules, as can be seen in Figure 5, the proposal was made in 2019 by Studio Precht [11], The Architect Chris Precht said this about the project:

"We can create different city centers—that are not defined by banks, or corporations, but rather by health and vitality." - Chris Precht[12]

It can be seen that the architect was worried about fighting the city's current problems, and food was the main one for him, making it a perfect match for this research.

Figure 5 - The farmhouse, modules, and building proposal - studio precht website

[11] "Precht's The Farmhouse Concept Combines Modular Homes with Vertical Farms," Dezeen, February 22, 2019, https://www.dezeen.com/2019/02/22/precht-farmhouse-modular-vertical-farms/.

[12] "Chris Precht on Architecture Driven by Fictional Stories," reSITE, accessed December 17, 2022, https://www.resite.org/stories/chris-precht-on-architecture-driven-by-fictional-stories.

3.2 Affordable housing In cities

3.2.1 Adequate housing

According to the Universal Declaration of Human Rights, adequate housing is one of the Human Rights.[13] It is defined by UDHR as a secure residence to not worry about being removed, having the home taken away, and having access to appropriate services. Adequate housing provides a dignified life and more tranquility to care for the family, pursue dreams, and achieve more.

One good case study to show adequate housing for low-income families is the Villa Verde Housing, an Elemental Architects project located in Chile. The project uses the concept of half a house to deliver to low-income families a home that can be expanded and adapted to the family's necessities. Since they deliver half of the house, the family can construct the other half based on their necessities. On figures below can be seen more about this project. The figure 6 shows how the house is when delivered to the owners, the figure 7 shows one house completed by the owner, making it unique.

Figure 6- Villa Verde Housing,finished construction, source: archdaily

Figure 7- Villa Verde Housing,family unit adapted, source: archdaily

[13] United Nations, "Universal Declaration of Human Rights," United Nations (United Nations), accessed October 26, 2022, https://www.un.org/en/about-us/universal-declaration-of-human-rights.

3.2.2 Affordable housing

Affordable housing, according to Florida Housing Coalition, is generally a residence where no more than 30% of the household income is spent either on rent or mortgage payments.[14] In consideration of that, affordable housing can include different incomes in the same building and incorporate the benefits of mixed-income communities to fight inequity. "The overall goal of mixed-income housing is to establish a better quality of life and adequate living conditions for all residents."[15], blending different social classes can bring more equity to society, create more opportunities, and fight discrimination.

Downtown cities and the lack of affordable housing are other issues many cities are facing. The revival of downtown areas in cities is occurring all over the US, such as Baltimore, St. Louis, and Pittsburgh, which were abandoned and now are being chosen again to be home for young people; however, these areas are growing social inequality and segregation. The cities have more affluent and poor neighborhoods but lack middle ones.[16]. The need for affordable housing and quality of life for the population is rising and essential.

The project of Tent city, located in Boston, MA, is a successful case study of affordable housing in the middle of the city. The area of the project was cleared of existing low-income housing and transformed into a large-scale commercial development. However, the community fought against it and protested, which is how tent city could be built; it is a successful project with affordable mixed-income on it.[17] The project was constructed in 1988 and is still fulfilling its role. The project is a large residential complex with many trees in the middle of the blocks. In figure 8, it can be seen too that they have gathering places between the buildings to engage the community on it.

Figure 8 - Tent city, aerial view, and gathering space, source: Goodyglancy architects

[14] "Affordable Housing Publications," Florida Housing Coalition (blog), accessed December 17, 2022, https://flhousing.org/publications/.p.3

[15] S. Tsenkova, Cities and Affordable Housing: Planning, Design and Policy Nexus (New York: Routledge, 2022).p.3

[16] [16] Mallach, Alan, The divided city : poverty and prosperity in urban America , Island Press, Washington, DC, United States, 2018

[17] "Tent City," Goody Clancy, accessed December 17, 2022, https://www.goodyclancy.com/projects/tent-city/.

3.3 Nature in the city

3.3.1 Importance of nature

Nature is essential for the planet's health, and the balance of ecosystems and the preservation of the environment are becoming increasingly important due to global warming and the greenhouse effect. Accordingly with the World Wildlife Fund (WWF):

Our forests, rivers, oceans and soils provide us with the food we eat, the air we breathe, the water we irrigate our crops with. We also rely on them for numerous other goods and services we depend on for our health, happiness and prosperity.[18]

So our life relies on nature, and the effort being made is not enough to help the environment. Nature can bring countless benefits to human life, and on top of that, we cannot exist without nature because it provides all the resources humans need to survive.

3.3.2 Benefits of nature for humans

According to Sue Stuart-Smith, a psychotherapist, "Spending time in nature, and not necessarily very much time, twenty minutes can suffice, restores our mental energy and strengthens the brain's ability to focus. This unconscious interaction between mind and nature has far-reaching effects with important implications for our mental and physical health"[19].

Nature can be used to make medicines can provide food, and now the benefits for mental health are being studied; since humans are part of nature and part of the ecosystem, it is vital to be in contact with it.

3.3.3 Cities and nature

When analyzing cities, it is clear that when nature is more present, the environment quality is higher, and the space is more pleasant and comfortable. Social inequity is not only current in the economic sphere but also occurs in the environmental sphere, with access to open spaces, parks, and vegetation in general; in addition to the unequal distribution of biodiversity, wealthier people live in areas with higher plant species richness.

The benefits of nature in the middle of the city are extensive, and plants can fight urban environmental challenges such as pollution reduction, temperature regulation, climate resiliency, and stormwater management in a natural way, bringing more quality of life and pleasure to the community.

A case study that shows how the city is implementing more plants to improve the life of the residents is the City of Poznań: social gardens exemplar, located in Poland. The case study started in 2017 and sought to improve the quality of life in areas of the city that does not have equitable access to green space because of higher population densities. The Figure 9 below shows the areas where the project is acting.

[18] "Why It's Important That We Value Nature," WWF, accessed December 17, 2022, https://www.wwf.org.uk/what-we-do/valuing-nature.

[19] Sue Suart-Smith, *The Well-Gadered Mind* (Scribner, n.d.).p.91

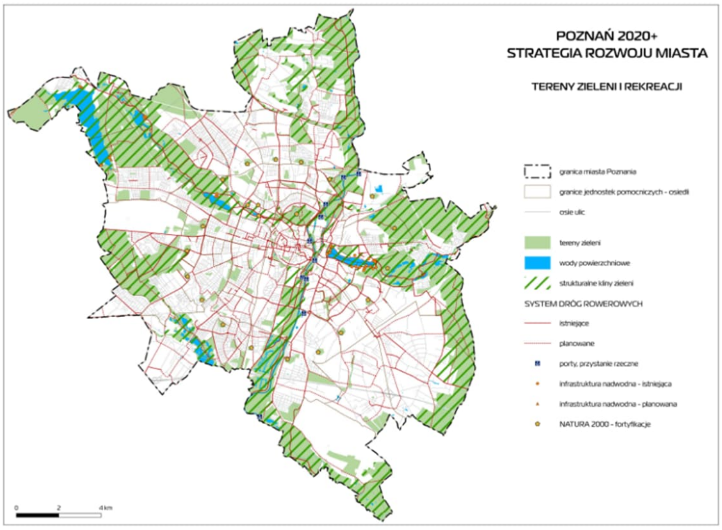


Figure 9 - Areas of greenery and recreation in Poznań, Source: Development Strategy for the City of Poznań 2020+

They plan to implement more nature all over the city, with social gardens, as shown in Figure 10. Creating attractive nature-based solutions in the city center (close to the city's historical center) is also expected to increase tourist attraction attractiveness. The project embraces different interventions, such as natural playgrounds (made with natural resources and with natural shade), open gardens, and floating gardens to treat the water in certain areas [20].

Figure 10 - Natural playgrounds and eco-demonstrators in Poznań's preschools (© Miasto Poznan)

[20] "City of Poznań: Social Gardens Exemplar | Connecting Nature," accessed December 17, 2022, https://connectingnature.eu/city-pozna%C5%84-social-gardens-exemplar.

4 Jacksonville

4.1 Jacksonville Background

Jacksonville downtown is the research site, and it is crucial to understand the site and the context to have a better response and outcome for the research. The city was founded in 1822, but its history is older than that; even before the Europeans arrived in the 1500s, it was home to the Timucua indigenous people that were explored and extinguished by Europeans until 1752.[21] The city has changed and faced many challenges over the years. Moreover, some of the current challenges are the number of vacant lots and the inequity in this area.

The sprawl of the city and the deterioration of the Downtown area occurred after World War II, when the desire of the population changed from living in the city to having a house with a garden and white fence in the suburb area, with people similar to them; the racial integration that occurred on the 1960s and 1970s made the changes faster. With this change, the companies have taken place, and the downtown area became a business district with many offices. Making the city desert on weekends and evenings.[22]

Below is a map, Figure 11, that shows the vacant lots in Jacksonville Downtown are, more recently, made by Groundwork Jacksonville. With the map, we can see the number of vacant lots that exist in the area, and it is worrisome for the future of the downtown city; it needs to be studied what happened and how it can be changed to restore the area.

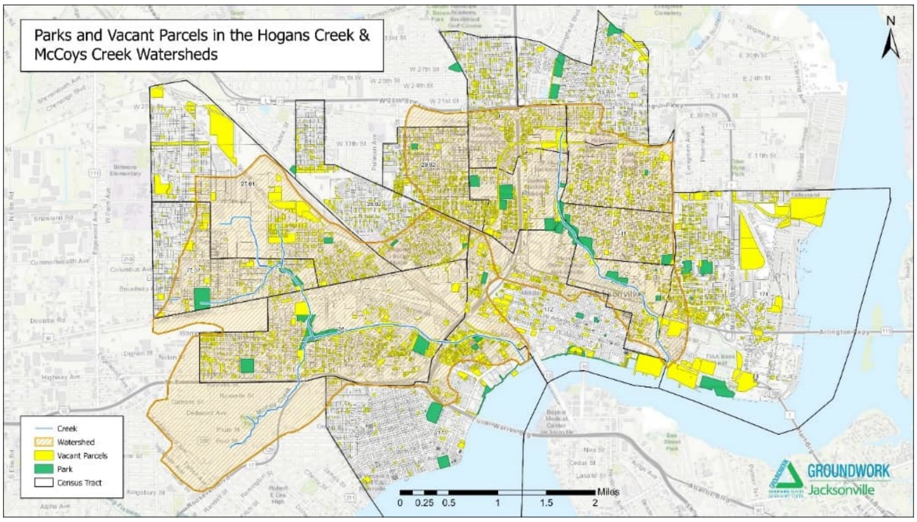


Figure 11 - Parks and Vacant lots Jacksonville - Groundwork Jacksonville

4.2 Jacksonville Analysis

The analysis of Jacksonville Downtown measure the quality of the city environmentally and for the socially. An area of 47 Census block groups of Jacksonville was selected to develop the

[21] "Downtown History," Downtown Jacksonville, accessed December 16, 2022, https://downtownjacksonville.org/downtown-history/.

[22] Frank Denton, "Downtown Jax: It's Time to Fix It," The Florida Times-Union, accessed December 16, 2022, https://www.jacksonville.com/story/lifestyle/magazine/2017/06/16/downtown-jax-it-s-time-fix-it/15372566007/.

map in the Figure 12, it can be seen the area, with the area selected the parameters were selected to apply to the areas.

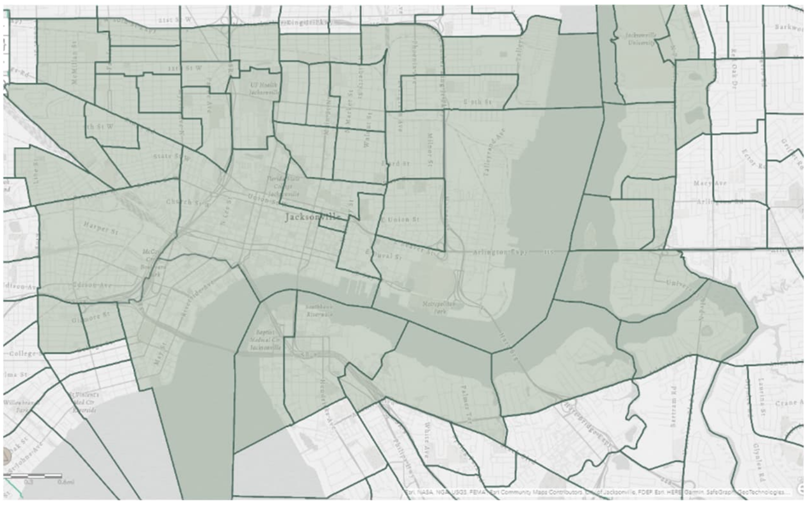


Figure 12 - Map with the 47 Census block groups to analyze

The parameters of the Census[23], that were collected from the website Tree equity score, to analyse the area are:

Tree equity score - Each area's tree equity score is measured on a scale of 30 to 100, with 30 being the worst and 100 being equitable.

Temperature - that is measured by the average temperature of the area.

Canopy cover - that is measured by the percentage of the coverage area. The higher the percentage more shade the site has.

Unemployment - is measured by the percentage of unemployed people, so when it is higher, the situation in the area worsens.

Health index - that parameter goes on a scale of 0- 100 when 0 is healthy and 100 unhealthy.

People in poverty - that is measured in percentage. The higher the percentage higher is the poverty in the place.

With the parameters defined, a rank was made with the selected areas, going first – 47th place; three ranks were made, one with the overall parameters, one with just the environmental parameters, and the last with the society parameters. The overall map below in Figure 13, shows the overall rank first, the environmental rank second, and the social rank at the bottom of each area. The areas highlighted are the higher and lower ranked areas on the map.

[23] Tree equity score, National Explorer, https://www.treeequityscore.org/map/#12.97/30.32593/-81.63637

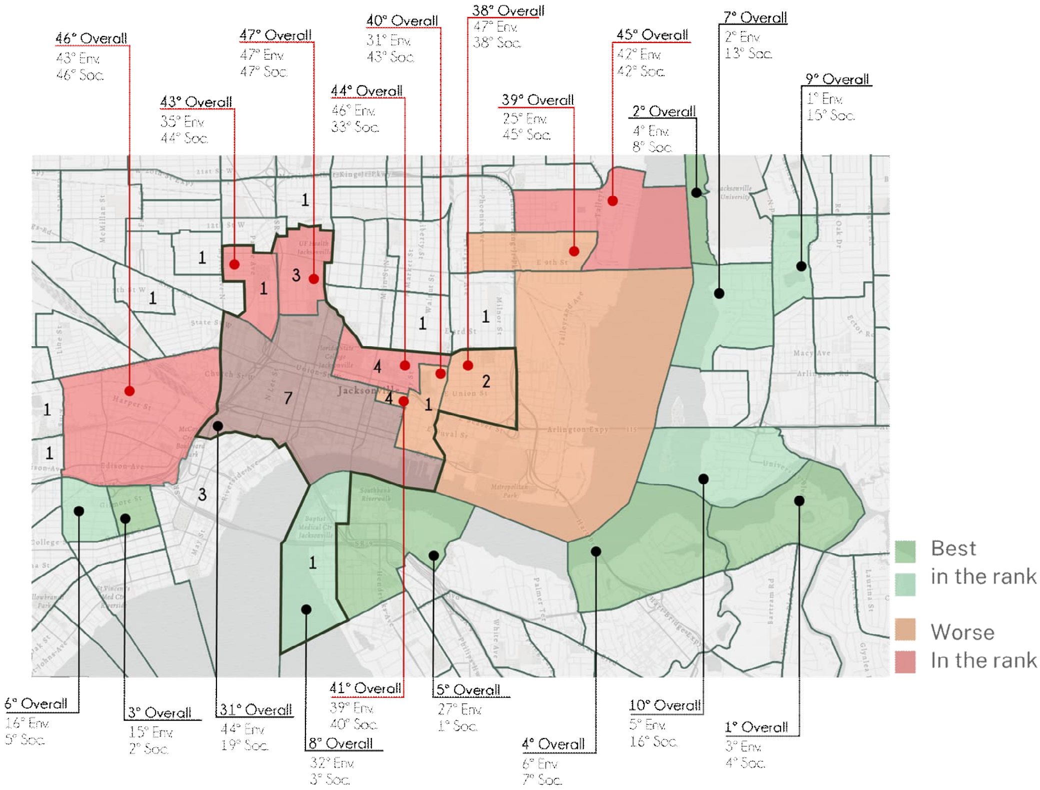


Figure 13 – Jacksonville map-Environmental and Social Analysis

4.3 Site

The selection of a site to have a speculative design to study the viability of the proposal to the city is crucial for the research since the viability, and the benefits for the city are being tested.

Looking closely at Downtown Jacksonville, the Lavilla region stood out due to the number of vacant lots and the lack of housing and grocery stores in the area, Figure 14. The neighborhood currently has just last than a thousand residents, and the government is trying to encourage the revitalization and growth of the whole downtown area of Jacksonville with an overlay zone.

Figure 14 – Lavilla neighborhood, vacant lots, and grocery stores

The site selected is a city block with around 70 000sqft of area, with a considerable amount of vacant lots around it, and very near to a new Groundwork, implementation for the population, 30 miles of trails, greenways, and parks that connects more the city. In the image below, Figure 15, it can be seen that it is near to public transportation bus stop and metro station, making it accessible.

Figure 15 - Site's djacent land use and context

The site is adequate for the proposition of affordable housing with food production; the city and the local community need all the benefits this can bring to the area.

5 Conclusion

Analyzing the situation of the Downtown area of Jacksonville, the implementation of an affordable building with food production to support the local community would improve the quality of life and help the city to succeed. Putting together urban food production with housing lower the costs of grocery expenses, not just that if the building is efficient, makes all the utilities costs lower and makes it more affordable to have a home. In this way, it makes it easier for people to spend more on housing since it balances out with other expenses. In downtown cities, it could be beneficial to implement more buildings combining the garden with affordable housing since it helps the sustainability of the community and the town by shortening the path of the food to the plate and giving all the benefits of contact with nature for the residents.

References

[1] Michele Ver Ploeg et al [1], Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences, 036, United Stated department of Agriculture, United States, 2009

[2] Michele Ver Ploeg et al [1], Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences, 036, United States department of Agriculture, United States, 2009

[3] World health Organization, Nutrition, https://www.who.int/health-topics/nutrition#tab=tab_1

[4] Joo Hwa P. Bay, Steffen Lehmann[1], *Growing Compact : Urban Form, Density and Sustainability*[3], Routledge, New York, United States, 2017

[5] Katila et al., *Sustainable development goals: their impacts on forests and people*, University Press, Cambridge, England, 2020

[6] Katila et al., Sustainable development goals: their impacts on forests and people, University Press, Cambridge, England, 2020

[7] USDA ERS - Definitions of Food Security, https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/definitions-of-food-security/

[8] Food and Real Estate | ULI Americas, https://americas.uli.org/research/centers-initiatives/building-healthy-places-initiative/food-real-estate/

[9] Craig Verzone at al., *Food urbanism: typologies, strategies, case studies*, Birkhauser, Basel, Swizerland, 2021

[10] Urban Oasis Project, http://www.urbanoasisproject.org/

[11] "Precht's The Farmhouse Concept Combines Modular Homes with Vertical Farms," Dezeen, February 22, 2019, https://www.dezeen.com/2019/02/22/precht-farmhouse-modular-vertical-farms/.

[12] "Chris Precht on Architecture Driven by Fictional Stories," reSITE, https://www.resite.org/stories/chris-precht-on-architecture-driven-by-fictional-stories.

[13] United Nations, "Universal Declaration of Human Rights," United Nations (United Nations), https://www.un.org/en/about-us/universal-declaration-of-human-rights.

[14] "Affordable Housing Publications," Florida Housing Coalition, https://flhousing.org/publications/.p.3

[15] S. Tsenkova , Cities and affordable housing: planning, design and policy nexus, Publisher, New York, United States, 2022

[16] Mallach, Alan, *The divided city : poverty and prosperity in urban America* , Island Press, Washington, DC, United States, 2018

[17] "Tent City," Goody Clancy, https://www.goodyclancy.com/projects/tent-city/.

[18] "Why It's Important That We Value Nature," WWF, https://www.wwf.org.uk/what-we-do/valuing-nature.

[19] Stuart-Smith, Sue , The well-gardened mind : the restorative power of nature, Scribner, New York, United States, 2021

[20] "City of Poznań: Social Gardens Exemplar | Connecting Nature," https://connectingnature.eu/city-pozna%C5%84-social-gardens-exemplar.

[21] "Downtown History," Downtown Jacksonville, https://downtownjacksonville.org/downtown-history/.

[22] Frank Denton, "Downtown Jax: It's Time to Fix It," The Florida Times-Union, https://www.jacksonville.com/story/lifestyle/magazine/2017/06/16/downtown-jax-it-s-time-fix-it/15372566007/.

[23] Tree equity score, National Explorer, https://www.treeequityscore.org/map/#12.97/30.32593/-81.63637

RECIPES FOR BAKING BREAD: ARCHITECTURE AND FILM

Sara NESTERUK

University of Huddersfield
Queensgate, Huddersfield, HD1 3DH, UK. S.Nesteruk@hud.ac.uk

Abstract

An analysis of physical structure and film. This work explores Holodomor. Holodomor means death by starvation, and is a Ukrainian term for collectivisation of farms in 1932 and 1933. In working with historical materials I refer to theories by Eisenstein. Eisenstein declared buildings of Acropolis to be ancient forms of cinema (1991, p. 60). Examples of cinematography in physical form. My work is five short films exploring histories from Ukraine. These are interviews with prominent historians and experts in this field. This is practice-based research from my recent PhD. I completed these films in September 2021.

This work builds upon literary theories. Tolstoy describes 'architecture' in his written work. "The cohesion of the structure does not lie in the plot or in the relations (the meetings) of the characters, it is an internal cohesion… look well and you will find it." (Tolstoy, quoted by Pevear, 2000, p. xv). I present my literature reviews. These are maps connecting sources from literature, film theory and visual practice. I also include my project storyboards. These represent film and cinematography in structural form. These production materials show a build up of physical structure, and how this appears in film.

Outcomes for this work include publicity and press at film festivals. These include national and international screenings in 2022 and an award for best experimental short film from Intershort Festival. This is work building upon research to decolonise Ukrainian histories and separate Ukrainian culture from Russian and Soviet stories. I use in particular short cinematic conventions in 25 frame wipes. This is small units of cinematic materials, navigating viewers in both time and space.

This project connects theories and practice based research. I present collections of visual bibliographies, documentation of my research and letters from an engineer working in Ukraine during Holodomor, Jerry Berman. These are parts of my original contribution to research for my PhD. I also include maps using methods of cartographic regression to re-present stories from diaries by a Welsh journalist, Gareth Jones. Included in my presentation is a screening of my final films.

Keywords: Holodomor, Film, Motion graphics, Ukraine.

Figure 1. *Recipes for Baking Bread*: Film Still, 2021.
Source: Author.

Introduction

An analysis of physical structure and film. This paper presents research in three parts. Holodomor, or The Great Famine in Ukraine, drawing upon historical research from Robert Conquest [1], Anne Applebaum [2], and Serhii Plokhy [3]. Architectural theories and practice, with specific reference to Soviet and Ukrainian film-making. Film production in motion graphics and animation. Contexts of this practice investigate areas between traditional animated forms and contemporary TV production.

Holodomor

My research is practice-based investigations exploring Ukrainian histories from 1932 and 1933. The Holodomor Research and Education Consortium give definitions of this term: “The term *Holodomor* (death by hunger, in Ukrainian) refers to the starvation of millions of Ukrainians in 1932–33 as a result of Soviet policies.” [4]. This concerned collectivisation of farmland in Ukraine and requisition of grain by Communist authorities. 24 countries recognise Holodomor as genocide. Recognition from 2022–23 includes Bulgaria, Czech

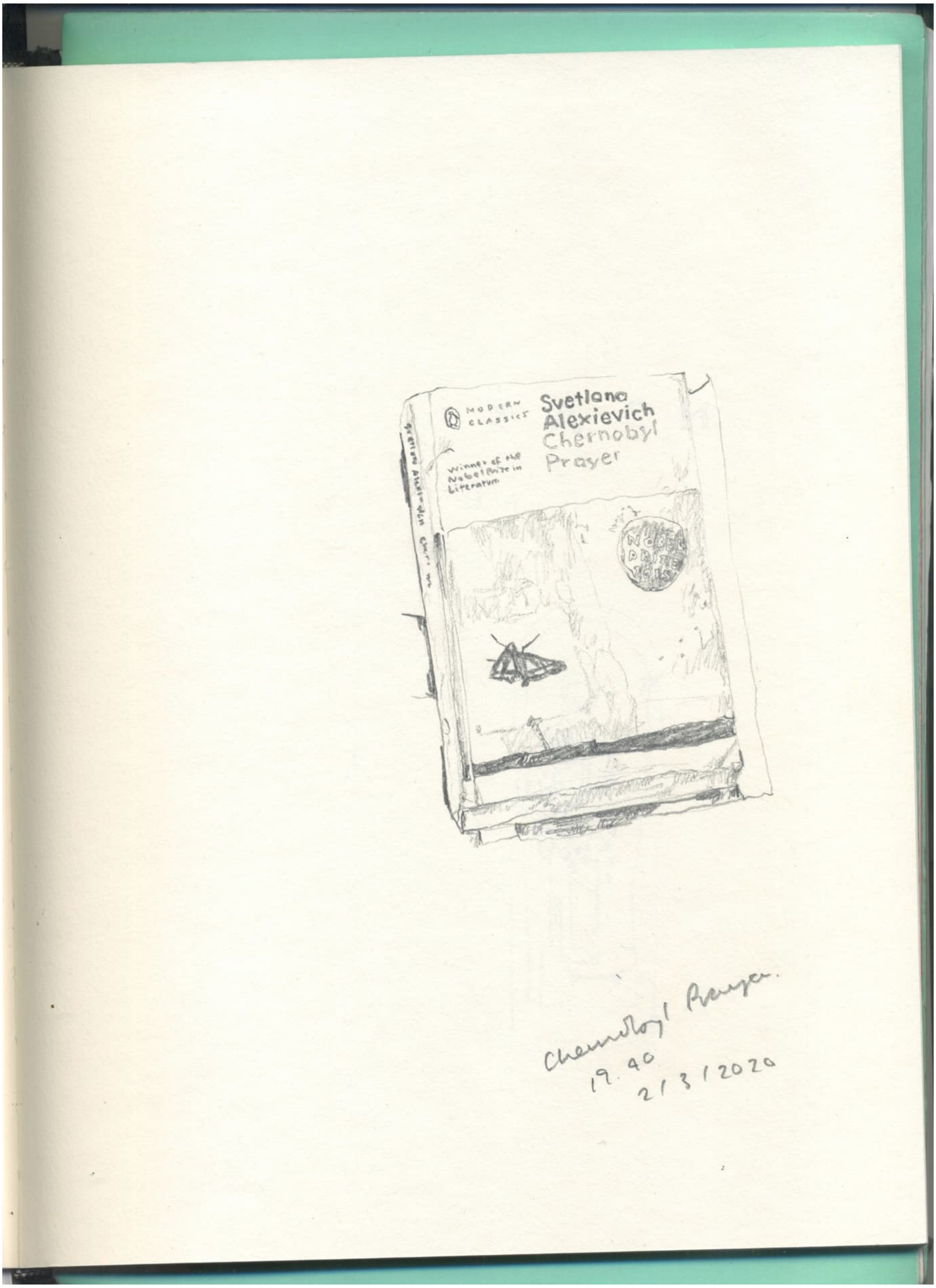


Figure 2. *Draw Bibliographies: Chernobyl Prayer*. Source: Author, 2020.

Republic and Germany. This project is a result of my practice-based PhD research. I work with methodologies including auto-ethnographic research, taking inspiration from author Svetlana Alexievich [5]. I draw upon historical materials, representations of Holodomor in fiction. For example, Vasily Grossman's novel *Everything Flows* [6]. I use comparisons between fiction and non-fiction in Soviet histories. For example, *Life and Fate* by Vasily Grossman [7] and *Second-Hand Time* by Svetlana Alexievich [8]. Both of these works explore 20th century stories from Russia and former Soviet countries, one in fiction and one in non-fiction. I also draw upon literary sources from poetry, literature, artistic practice, architecture and visual arts. For example, writings by David Shields [9]. Drawings form part of my PhD submission (figure 2). I drew and collected bibliographic sources and presented these as a component of my PhD study: *Draw Bibliographies*. My project uses in-depth interviews. My interviews are with historians, academics and experts in this field. My first is Jaroslaw Prytulak, a former British-Ukrainian baker. I also have interviews with Professor Serhii Plokhy, a historian from the Ukrainian Research Institute at Harvard University. Philip Colley, great nephew of Gareth Jones, Jones was a Welsh journalist who reported from Holodomor in British press. Scholar Daria Mattingly from Cambridge University. Letters from Jerry Berman. Berman was an engineer working in Ukraine during Holodomor. His letters provide testimonies to events taking place in 1932 and 1933. These materials are courtesy of Alison Marshall. My final interview is with a Ukrainian priest in Manchester, Reverend Volodymyr Sampara. This work explores my own family histories and background, and my grandparents' stories. My grandparents were Ukrainian.

Architecture

This paper explores relationships and theories of physical environments and film. asking questions of structure, juxtaposition, montage, physical environment and how built forms relate to filmic practice. In particular, I am referencing writing by Soviet filmmaker Sergei Eisenstein. Eisenstein was an early pioneer in uses of editing and montage. This is in contrast to earlier film production using long linear sequences. These radical ideas still appear in film-making today. Eisenstein's text from 1937–40, *Montage and Architecture*, explores these ideas in depth. Relating physical structure and juxtaposition in film with juxtapositions and contrasts in visuals in architecture. Eisenstein compares this with a viewer experiencing buildings by walking from position to position, their view, perspective and standpoint, and a director's role and responsibility presenting these images to viewers on screen. "The Acropolis of Athens could just as well be called the perfect example of one of the most ancient films." [10]. This concerns space, relationships and editing.

I also explore architectural structures, form and composition in literary works. In 1878 Leo Tolstoy referred to 'architecture' of his novels, in response to criticism of his work on novel *Anna Karenina*. "The cohesion of the structure does not lie in the plot or in the relations (the meetings) of the characters, it is an internal cohesion… look well and you will find it." [11]. This is structural form relating to narrative. Editing and juxtaposition of characters, plots and thematic ideas. I relate these ideas to film production. Figure 3 is an image from an interactive component of my PhD research. This is a map of literary sources. It is possible for a viewer to click on one source to connect to another. This builds a unique journey and story of this project through literature, film theory, architecture and historical sources. My storyboards reveal early visual responses and structure to my short film (figure 4). Taking reference from

Japanese poetry, each film is either 50 or 70 seconds long. These films can appear as independent, stand alone pieces of work. They also appear as one composite version. A linking device, a short 25 frame wipe connects these projects together and appears on conclusion of each film. A star shot, a moment of blackness appears two thirds through this film. This is a memorial shot to pay tribute to millions of people who died during Holodomor. Current estimates are between four and seven million Ukrainian people who died during Holodomor [12] [13]. This is a moment of silence and reflection. Work is appearing from demographers working with Harvard University's MAPA: Digital Atlas of Ukraine project who estimate figures around 3.9 million. Early historians in Ukrainian studies admitted it was difficult to estimate numbers due to lack of reliable Soviet archives during Holodomor "the figures for the suppressed 1937 census, which I deduced from various sources, are now confirmed (showing, of course, the huge population deficit that could not then be admitted." [14]. I use short filmic wipes, 25 frames in length as a narrative device. These link individual stories together and navigate viewers through time and in space. Hito Steyerl describes wipes as a political tool. "Wipes as a filmic means are a powerful political symbol. They show displacement by erasure, or more precisely, replacement. They clear one image by shoving in another and pushing the old one out of sight." [15]. These drawings are from architecture in Kyiv during my first visit in 2017. In television, this language has become an almost invisible narrative device. My previous work in industry was as a designer at BBC Sport. In sports broadcasting short, graphic wipes intersperse past and present time. Wipes navigate viewers in a football match between current action and replays. This is now a common production language in television and film.

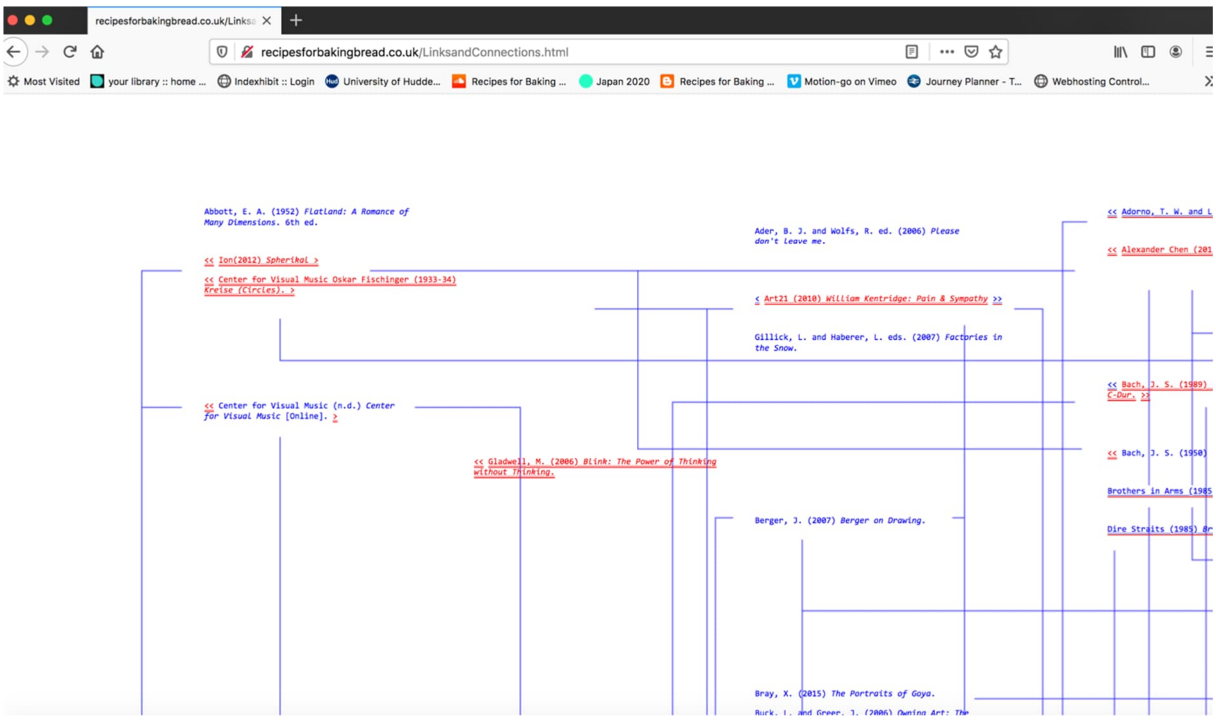


Figure 3. Links and Connections. Source: Author, 2021.

Figure 4. *Recipes for Baking Bread* Storyboards. Source: Author, 2021.

Film

Figures 5–8. *Recipes for Baking Bread*: Film Festivals. Source: Author, 2022.

My final outcome for my project is five short films. These aim to disseminate my research to academic and non-academic audiences. I completed my practical work in September 2021. This is practice-based research from Leeds Beckett University conferred in May 2022. My project, *Recipes for Baking Bread*, explores stories from Holodomor in Ukraine in 1932 and 1933. Screenings for my work in 2022 include festival screenings in Ukraine, Edinburgh, Berlin and Split. Recipes for Baking Bread won best experimental short at Intershort Festival 2022. I received an Artists' International Development Award from Arts Council England for this project in 2017. Screenings in 2023 include a cinema screening at HOME in Manchester and a solo exhibition at Bury Art Museum from February – May 2023. Part of my original contributions to research for this project was my work with Jerry Berman's letters.

Figure 9. Former UK Foreign Secretary Liz Truss and Minister of Foreign Affairs of Ukraine Dmytro Kuleba at the Holodomor Museum Exhibition of Jerry Berman's Letters. Source: Twitter @DmyroKuleba, 2022.

These are first hand witness accounts from Holodomor now in public realms. These letters were to Berman's friends, Meyer and Sonia Fortes. I worked with Fortes' granddaughter, Alison Marshall to digitise and archive these collection. As a result of this study this work now appears in public archives at the Holodomor Museum Kyiv and online. Press and visitors to this exhibit include a visit by former UK Foreign Minister Liz Truss and Ukrainian Foreign Minister of Affairs Dmytro Kuleba in 2022. My fifth film I created first in response to these letters. Music for this project is by Yoni Collier. Production executive is an industry partner, Richard Gort. My project includes practice approaches using cartographic regression. I take reference from British design group Forensic Architecture. "Cartographic regressions refers to the process of using historic surveys, maps and aerial photographs overlaid on contemporary imagery" [16]. Forensic Architecture use this approach in studies from Louisiana in a recent exhibition from the Whitworth Gallery, *Cloud Studies*. I use these approaches in my practice, mapping routes and stories in Ukraine. As part of my research I interviewed Philip Colley in 2019, great nephew of journalist Gareth Jones. Jones, along with British journalist Malcolm Muggeridge reported from Holodomor, and these reports appeared in British newspapers. In his interview, Colley questioned whether Jones was reporting from Russia or from Ukraine during his visits. As Jones only spoke Russian, Colley's question was if Jones was speaking Russian to Russian peasants, or Russian to Ukrainian peasants [17]. Using information from my interview with Colley and Jones' diaries, I mapped this journalist's probable route from Russia into Ukraine. It is known from his diaries, Jones started in Belgorod and travelled along train lines towards Ukrainian borders for about 40 km. I took information from existing train routes on google maps and mapped his probable journey using average walking distances and times (figures 10 and 11). From this information it is possible to see it is almost certain Jones was reporting from Ukraine. I also map my own journey and project routes (figure 12). This is from a drawing from a residency at the Holodomor Museum in Ukraine in 2017. I include production materials in response to Harvard University's MAPA: Digital Atlas of Ukraine project. These form part of my work in progress.

Figure 10. Gareth Jones' Walking Route. Source: Author, 2021.

Figure 11. Gareth Jones’ Walking Route. Source: Author, 2021.

Figure 12. *Recipes for Baking Bread* Project Maps. Source: Author, 2017.

I present my final films:
https://recipesforbakingbread2021.cargo.site/

Acknowledgements

With thanks to: S.ARCH 2023 Programme Committee and Conference Organisers, University of Huddersfield, Leeds Beckett University, Holodomor Museum Kyiv, and all project participants.

References

[1] Conquest, R. *The Harvest of Sorrow: Soviet Collecitivization and the Terror-Famine*, 2nd ed, Pimlico, London, UK, 2002.

[2] Applebaum, A. *Red Famine: Stalin's War on Ukraine*, Allen Lane, London, UK, 2017.

[3] Plokhy, S. *The Frontline: Essays on Ukraine's Past and Present*, Harvard University Press, Cambridge, Massachusetts, 2021.

[4] Holodomor Research and Education Consortium, *Holodomor Basic Facts*. [Online] Edmonton, Alberta: Canadian Institute of Ukrainian Studies University of Alberta. https://holodomor.ca/, n.d.

[5] Alexievich, S. *Chernobyl Prayer*, Translated by A. Gunin and A. Tait. Penguin Books, London, UK, 2016.

[6] Grossman, V. *Everything Flows*, Translated by R. Chandler and E. Chandler, with A. Aslanyan, Vintage Books, London, UK, 2011.

[7] Grossman, V. *Life and Fate*, Translated by R. Chandler. Vintage Books, London, UK, 2011.

[8] Alexievich, S. *Second-Hand Time*, Translated by B. Shayevich. Fitcarraldo Editions, London, UK, 2016.

[9] Shields, D. *Reality Hunger*, Penguin Books, London, UK, 2010.

[10] Eisenstein, S. *Selected Works: Volume II Towards a Theory of Montage*, 2nd Ed. (Edited by M. Glenny and R. Taylor), Translated by M. Glenny, BFI Publishing, London, UK. 1994.

[11] Pevear, R. Introduction, in Tolstoy, L. *Anna Karenina: A Novel in Eight Parts*, Penguin Books, London, UK, 2001, pp. vii–xvi.

[12] Ukrainian Research Institute Harvard University, *Demographic Research*. [Online] Cambridge, Massachusetts. https://gis.harvard.edu/demographic-research, n.d.

[13] Holodomor Museum, *Holodomor History*. [Online] Kyiv, Ukraine. https://holodomormuseum.org.ua/en/the-history-of-the-holodomor/

[14] Conquest, R. *The Harvest of Sorrow: Soviet Collecitivization and the Terror-Famine*, 2nd ed, Pimlico, London, UK, 2002.

[15] Steyerl, H. *Duty Free Art*, Verso, London, UK, 2017.

[16] Forensic Architecture, *Forensic Architecture by Methodology Cartographic Regression*. [Online] London, UK. https://forensic-architecture.org/methodology/cartographic-regression, n.d.

[17] Colley, P. *Interview by Author*, Hastings, UK, 2019.

LEARNING TO DOWNSIZE FROM TINY HOUSE OCCUPANTS: A CASE FROM A DISASTER RELIEF SETTLEMENT IN LUMAJANG, INDONESIA

Setiamurti RAHARDJO*[1,2] & Ganesha Puspa NABILA[2]

[1]The University of Sheffield
Geography Building, Winter St, Sheffield S3 7ND, UK; srahardjo1@sheffield.ac.uk

[2]Telkom University, Indonesia

Abstract

Academic research has provided a wide range of studies about Tiny House discussing the definition, typology, and evaluation. Although there are many interpretations about how tiny it should be, most studies agree that the floor area should be less than 400 square feet or 37 square meters, and we can find it as a house on a wheel, a detached permanent house, or as a micro-village. The last form of the tiny house is similar to what is found in Lumajang, East Java, Indonesia, where small permanent houses exist as a disaster relief settlement. The volcanic eruption of Mount Semeru in December 2021 destroyed at least 5,205 houses and several public facilities, leaving some of the housing areas in the red zone and unsafe for living. At that time, 6,586 people were displaced and the Indonesian government planned to relocate around 2,000 households from the red zone to permanent housing in a safer location, compensated with 6 x 6 meters individual houses.

Besides sharing a similarity in housing typology, both groups of tiny house occupants and the displaced people in Lumajang also experienced a life event that makes them downsize to live in smaller dwellings. However, being forced to downsize requires a huge ability to adapt to a new space. In this case, the tiny house occupants in the Global North seem to have gone through this process earlier, so this paper aims to find the evaluation of their experience of living in the tiny house and discover things that can be implemented in Lumajang to make them live better. In order to further understand the success factors of downsizing to apply in Lumajang, this study reviews the literature on tiny house focusing on the evaluation from the occupants' perspective, observation to the research field, and performs a semi-structured interview with displaced people in Lumajang. It is found that space limitation is not a significant issue in downsizing, but the situations of the neighborhood have a greater role in determining living satisfaction in small dwellings. Moreover, the implementation of the result shown is not limited to displaced people in Lumajang, but also to other groups of forced downsizers in different areas where living in small homes becomes the only option due to demographic movement, financial affordability, or any other cause.

Keywords: displaced people, downsizing, resettlement, tiny house

1 Introduction

Tiny House (TH) has gained popularity with the rising Tiny House Movement in America [1]. Filling the niche of housing market with an extremely small size, TH has reported its success in tackling homelessness [2], solving the rarity of housing land [3], [4], giving an alternate housing typology for those who live alone [5], giving means to people who want to trade-off their dwelling size for more secure financial planning in the future [6], and promoting a lifestyle that supports the environmental concerns through sustainability and self-sufficiency [6]. Reducing the size of a housing unit helps save space, especially in the high density urban areas that need to facilitate a large number of inhabitants [7]. By living in a very small dwelling, people will have to adapt to a simple lifestyle. As a result, there will be less waste and footprint produced by the households [8]. When it is consistently practiced, it will give a positive contribution to environmental sustainability [1], [6].

The volcanic eruption of Mount Semeru in December 2021 destroyed at least 5,205 houses and turned 6,586 people of Lumajang, East Java, Indonesia homeless. Their homes were either destroyed or considered unsafe if located in the red zone. Since then, the government has provided 2,100 units of small houses as a post-disaster resettlement. The displaced persons were compensated with 6 x 6 meters individual houses, which forced them to downsize to a dwelling equal to the size of a Tiny House. Since these people did not initially plan to downsize, we aim to seek the knowledge from the evaluation of the success of the Tiny House to apply to the case in Lumajang.

1.1 Defining the Context of Tiny House

Studies on Tiny House (TH) have been generally discussed in several countries. The dominant evidence is found in North American and Australian context, but there are some studies in European countries and East Asia to define the context of a TH. To learn further about the segment of this house, we will part the sections into the physical features of TH's architectural design and the process of moving into a TH.

Architectural design of a Tiny House.

Technically, TH refers to a dwelling that looks smaller than other dwellings in the same region or country. The largest benchmark to classify a TH is if the floor area is less than 1,000 square feet or 93 square meters [9], [10]. This may be relevant in the Australian context where the average floor area per dwelling is 214 square meters [11] and losing more than half the size of the average dwelling is a significant space reduction. However, there are numerous TH enthusiasts who live in much smaller dwelling sizes. So, many suggest that a TH should not exceed 500 square feet or 56 square meters [12], [13], 40 square meters [4] or even less than 400 square feet or 37.2 square meters [11], [14]. Mangold & Zschau [15] suggested a distinction between the term "small" and "tiny" as they mentioned the true tiny houses are smaller than 400 square feet.

We can find THs in many types of housing design. Shearer and Burton [16] classify TH based on its movability. It can be a house on wheels or a detached permanent house in the rural area or in somebody else's backyard. In another case, a group of THs can appear in a micro-village [17]. Moreover, in the urban area with higher density population, there are more types of TH found in forms of compact housing [18], the grow home, narrow rowhouse, modular housing [12], or micro-apartments [4], [5], [19], [20]. Appearing as a simple and affordable housing, TH's constructions are kept simple, economical, and possible to transport [21], which allow the occupants to be involved in the construction of their own houses [22].

The process of moving into a Tiny House

Culturally, THs are seen not only as a physical construction of small dwellings, but also as an activity popularly known as Tiny House Movement where people downsize [20]. The main idea here is the process of transition to a smaller space to dwell. Usually this movement involves giving up consumptive behavior [23] and decluttering accumulated material possessions to embrace minimalist lifestyle [8]. In several countries, this movement occurs as an expression of disagreement to the existing norms. For example, there is a view in America that the bigger the better [15], or Australia where houses are generally big [24]. In those countries, this movement works as a rejection to the countries' pride of a big space and believe that a better life is achievable through downsizing their living spaces. With so much reduction in the physical stuff, people are finally able to live in extremely smaller dwellings than the average and match the categorization of “tiny” homes.

Many TH enthusiasts started to look at this movement because of a major life event that brought them into life reflections, such as feeling weighed-down by accumulative stuff in their homes or experiencing a personal financial collapse, and moving to a smaller dwelling is seen as a solution to their obstacles and a means to what they perceive as a “good life” [15]. Demographically, this movement attracts groups of people younger than 30 years old or older than 55 years old who live alone or together with a partner [14]. However, what drives them to downsize to a TH can come from different aspects which can be voluntarily or involuntarily [20]. So, we would see the process from both perspectives.

People who downsize voluntarily have a desire that comes naturally as they get into a different stage of life. When some of the family members leave the house, people can feel less at home as they lose connection to their space that is too big for them, and deliberately they think of downsizing [9], [20]. Older people also prefer to downsize [25] because it is easier for them to manage a house with a small size.

Regardless of the age, reasons to live in a TH can be personal depending on the experience of the occupants. In one case, the exposure of various TH designs in the media that look “appealing and cute” [13], [26] encourages architects, interior designers and artistic craftsmen to create an appealing look of tiny homes that sets the trend in this housing typology. As a result, people grow interested in the design of tiny homes and want to have or live in one of their own [1], [27]. People also move to a TH influenced by the ideas of minimalism that are intersected with environmental concerns [6], [15]. Another internal factor that drives people to move to a TH is the flexibility offered by the tiny house on wheels (THOWs). In the Netherlands, this type gets a distinctive interest from young male under 35 years old [27]. Whether as a camper van, an RV or a portable DIY-house, THOWs allow people to travel with their homes and give an experience of freedom of living anywhere [28].

The other reasons for downsizing come from the involuntary process where there are necessities to trade-off housing size for other life priorities [20]. For example in London where people want to obtain an ownership of a house, they need to be willing to get a small property [29] or in America where people want to avoid a long term mortgage [30], they need to reduce their belongings to fit in a portable tiny house or a small accessory unit in somebody else's backyard. When financial reasons become the main concerns, people downsize their dwelling and cut off their unnecessary living cost through simplified lifestyle [31], but there are other trade-offs for other reasons, too. In Serbia and Hong Kong, people prefer to live in a micro-apartment as long as they can stay in the urban area to get the location they want and get comfortable access for their daily commutes [4], [32]. Especially for people who live alone, such as young professionals and new arrivals to the city, the existence of a micro-apartment comes as a solution to make their life more efficient in general [33] even though sometimes it means they have to pay a higher price for their desired comfort [34].

Another trade-off for a TH is because of the situation of the neighborhood. A study in Australia shows that the average rental cost of micro-apartments is higher than the rental cost of studio apartments, but some people consider the distance to desired places and the situations of the neighborhood more important than the dwelling size [5]. There are also groups of tiny house enthusiasts in Germany and Australia who are more interested in rural areas rather than living in the urban area. [6], [14]. These groups of people want to have more freedom and connections to the neighborhood that they cannot obtain in the urban area. Especially those who work remotely and not having a specific office where they can meet and have interaction with other people in person, they can experience loneliness or stress due to massive usage of digital devices [35]. Getting connections from the neighborhood or from a community that shares likewise interest about a TH will be beneficial for their social needs as human beings. It is reported that community is often mentioned as one of the influential factors that drives this movement [1], [15], [22], [36].

1.2 Displacement in Lumajang

When Mount Semeru erupted in December 2021, many people in that area lost their majority of incomes because their land became infertile due to the disaster. Their lives heavily relied on the livestock and the farming activities that were affected by a great loss. Although there were groups of humanitarian community nearby who were familiar with the volcanic activities and able to quickly respond to disaster, many residents around Semeru were still incapable of handling disaster risk management on their own [37].

According to the United Nations High Commissioner for Refugees (UNHCR), a planned relocation is needed to get a thorough evaluation with existing risk and future disaster risk management [38]. A post-disaster resettlement project has been carried out by various parties around the world, such as 2010 Merapi Eruption resettlement [39], 2013 Haiyan super typhoon in Philippines [40], 2006 Sidoarjo mud-flow [41] and many more. From those projects, it is found that the government provides housing for post-disaster resettlement with size limitation. In Lumajang, the housing is provided with the size of 36 square meters (6x6 meters) which is the same as the size of a Tiny House and makes the dwellers be the involuntary downsizers because their previous dwelling space was bigger with the land availability to produce farming and livestock.

The UNHCR (2014) states that planned relocation should be the last resort and based on the consent of the displaced persons. However, the damage in Lumajang was significant and many housing areas were categorized into red zones. Based on the risk analysis, a relocation was considered the best solution to evacuate the people. Learning from the post-disaster project '2010 Merapi Eruption resettlement', the disaster handling and restoring neighborhood programs were deemed successful because the evacuated people were involved in the making of the new settlement that increased the post occupancy housing satisfaction [39]. It is strengthened by a study by Lyons [42] that concludes that directly involving displaced persons as a community member in construction have a positive effect on achieving a higher sense of ownership and sense of belonging. Unfortunately, the post-disaster resettlement program in Lumajang did not involve the occupants in the restoration of their neighborhood and community. Therefore, we need to explore other factors that may help the displaced people gain satisfaction towards their new settlement even though they are not involved in the construction.

1.3 Framework

Learning from the studies of Tiny House (TH) and the post-disaster resettlement program, there are similarities found. First, the settlement consists of small housing units with floor area less than 400 square meters. By architectural design, the houses in Lumajang's resettlement program are categorized as one of the TH typology. Second, the dwellers of the house are downsizers. More specifically, the displaced people in Lumajang are examples of the involuntary downsizers who were not prepared to reduce their dwelling size, but had no choice other than accepting the size provided by the government. With those similarities and the urgency to find factors that may help people in Lumajang gain satisfaction towards their smaller homes, we would like to explore the evaluation of living in the TH as well as the living experience as a displaced person in Lumajang to find out the possible outcomes that create housing satisfaction after involuntary downsizing.

2 Methods

This study is performed in a qualitative approach, using literature review as the basis to understand the context of Tiny House, followed by observation of the research field and semi-structured interview to the displaced people in Lumajang.

The literature is gathered from the study of Tiny House (TH) and the Tiny House movements focusing on the definition of the housing typology, the movements, and the evaluation of the TH. An observation to the research field was performed in July 2022 where the post-disaster resettlement program was just launched and several people started to dwell in the new homes. The visit took 4 days, which included having conversations with the displaced people who were still in the refuge and a site visit to the new settlement to observe the physical condition of the housing and interact with a few numbers of displaced people who had been relocated.

In order to allow the displaced people to experience living in their new homes, the semi-structured interview was conducted in February 2023, approximately 7 months after the first move in early July 2022. Based on the research framework that seeks to explore the living experiences of small housing, the best suited method to use is semi-structured interview (Addams, 2015). There were 30 interview participants who were representatives of the dwellers in the post-disaster resettlement in Lumajang. The interview was conducted with open ended questions that cover several topics including their first impressions of the resettlement house, their perceptions towards the dwellings space, and the physical intervention of the building they have made or they plan to make as a part of their adaptation process.

Since the displaced people mostly communicate in a tribal traditional language, an interpreter was involved in describing the question topics and transcribing the result. Therefore, we also evaluate the participants' intonations from the audio recording to get the full context of their answers. As a part of the ethics, the data keep the anonymity of the participants. Thus, we classify them by codes, where F indicates the female gender, M indicates the male gender, and the number indicates the order of the interview participants.

3 Discussions

3.1 Evaluation from the Tiny House Occupants

With a substandard dwelling size, space adequacy can be the main concern of living in a TH, whether the available space is sufficient to accommodate the residents' needs, or not. Even if the space is sufficient, the reduced proximity between occupants make tiny homes prone to overcrowding [12]. The number of occupants who share the space with, difference in age, gender, and relationship between the occupants also influence the overcrowding of a house [43]. Evaluating the success of TH cannot rely only on the size sufficiency because it is also influenced by housing conditions, neighborhood, and overall expectations [44]. Moreover, Foye [44] explains that expectations toward dwelling size are shaped by past experiences and the size of living space of other people in the surrounding. People tend to feel satisfied with a tiny home if they used to live in a smaller house but may be dissatisfied when their previous house was bigger. On the other hand, the size of other dwellings of those around them also influences the perception of space sufficiency.

Gathering from the literature studies, there are numerous positive reports about TH. Its compact size brings a tangible financial advantage by lowering energy bills and maintenance costs, which also contributes to the sustainable environment [45]–[47]. Nevertheless, a TH can provide sufficient energy that is needed for daily living like in the conventional dwelling with enough electric supply for modern lifestyle equipment such as laptop, TV screen, cell phone charger, cooktop, coffee maker, and other kitchen and cooking utensils [48]. Through the process of downsizing, the TH occupants adapt to the minimum lifestyle and see it as normal or appropriate [26]. They often begin with struggles, but then their expectations shrink together with the shrinking size of the dwelling and reframe their portrayal of ideal homes [49] that can make them feel positive about their homes. They see this experience as a freedom rather than a restriction, so they willingly decide to live this lifestyle and be a part of the "tiny housers" [26]. When they face challenging situations in their domestic space, the dwellers are willing to be cooperative with other occupants by sharing their spaces [17]. As a tiny houser, Foreman [50] testifies about the joy of the decluttering process and enjoys the freedom of living with too much stuff at home.

Planning a TH carefully on the design of the limited space can make tiny homes sufficient to contain everything needed by the occupants [20], such as implementing the concept of open space and integrating several functions or areas together in the same room.–Challenges related to amenities for space limitation can be the triggers of creative solutions, such as using space saving furniture to make their homes look bigger [29]. Regarding the integration of several areas, TH dwellers show positive responses when the kitchen and the living room are joined together, but prefer to keep the bedroom separated for privacy and accept the idea of a bedroom loft [51]. With a size limitation, usually a unit of TH can only fit one bedroom and is ideal for single occupancy or maximum 2 persons [11]. To avoid the sense of overcrowding inside the dwelling, detached THs are often found to be surrounded by natural environments and sometimes are found to be close with other tiny homes. Through the similarities of interest in micro-living, TH dwellers and enthusiasts are often part of communities where they can get social benefits [45] or build connections or the neighborhood they need for their social life.

Other positive reports about living in a TH are also found related to personal growth that brings a sense of pride in the experience of the dwellers, especially those who are involved in the construction work of the house [52]. In Switzerland and Germany, older “tiny housers” are motivated to take care of their space independently because the small space enables them to do so [46]. Because of many opportunities of personal experiences that a TH can offer, those who are satisfied with this lifestyle can find their lives more oriented to get closer to their version of happiness [15]. On the other hand, the existence of THs also brings positive ideas to facilitate the homeless who are actually employed [30]. Even if what they earn is not much, they can still get the chance to obtain a decent living property.

Despite the benefits offered by the tiny homes, the consequences of living in an extremely small dwelling are also inevitable. A study in Hongkong shows that the majority of the occupants feel dissatisfied and 70% of them admit not having enough space in their homes [4]. The lack of space also brings concerns of not having enough space to have guests at home and attachment to previous homes that influences their expectations regarding housing size [45], especially if their previous homes are bigger. Anthropometric standards are also negotiated that may reduce the convenience of mobility when households are doing their activities inside their homes. Shearer [14] reports some occupants complain about the ceiling clearance that is too low in the loft bedroom, the difficulty and lack of safety for accessing the loft because the stairs are not designed accordingly to an ideal safety standard, the smells of the cooking on the entire house because the concept of open space that integrates the kitchen with other rooms, the unpracticality of using composting toilet, and the lack of storage for kitchen equipment, tools, and other basic housing items. Occupants who finally have a baby are often found leaving their tiny homes. It is impossible to block the sound of a crying baby in a very small dwelling and they urge themselves to find a bigger space for living. Micro-apartments are also considered too small to hold a bed and a couch at the same time. Even though a customized design of foldable furniture can be a technical solution, this type of furniture requires an amount of space before it is expanded to serve its function [53]. Constructing retractable furniture also requires more cost than the conventional one [54].

Lastly, folding furniture everyday can be exhausting and people can eventually stop doing it and it makes the space feel more constrained [55].

In the study about THs for the homeless [56]–[59], functionality and the amount of amenities of the house are compromised to suppress the price of the property and make sure that there are affordability benefits offered to occupants [5] with low purchasing power [52]. In America, THs are used to facilitate the homeless that have rapidly emerged all across the nation in forms of villages [2], and as of July 2019, there were 115 tiny house villages with different sizes and amenities, but a few number of housing units were reported having no electricity or neither heating nor air conditioning [2]. Living in a TH can also be lonely for a single occupant, but involving a sense of community creates another concern over privacy [36] especially when they share everything with another household or stay in a communal place with other TH dwellers. And with the small size, this type of housing is often associated with low-quality housing for the poor. As a result, there is a fear of problems related to low community housing, such as poverty, crime, and a creation of unwanted slums in the neighborhood [3], [30].

Lastly, not every downsizer who lives in a TH is satisfied with their choice. An online real estate poll in the United States shows an irony that 44% of the participants express housing regrets and one third of homeowners wish they had chosen a larger home. It is a bigger population than those who wish that they had downsized [60]. It means TH still needs improvements to become comfortable dwelling places and size definitely matters in creating the satisfaction of living in a dwelling [11]. A better plan of furniture and amenities layout can help improve the spaciousness of the room [61] and prevent occupants from feeling overcrowded, but technical guidance is also required to ensure the building does not interfere with the occupants' wellbeing.

3.2 Downsizing for the Displaced People in Lumajang

Besides sharing a similarity in housing typology, both groups of tiny house occupants and the displaced people in Lumajang also experienced a life event that makes them downsize to live in smaller dwellings. However, being forced to downsize requires a huge ability to adapt to a new space. In the Semeru Eruption case, most post-disaster resettlement dwellers were involuntary downsizers. The semi-structured interview data state that only 3 out of 30 participants claimed their old houses were smaller than the new one provided by the resettlement program, and 1 participant lived in the same size as his previous house. Alternatively, the first impression of resettlement viewed by participant F1 was good due to no other choices than living in the resettlement. In contrast, participant F8 was happy because the provision of the resettlement provided had stopped them from being refugees. We found that participant F3 mentioned "very comfortable, very grateful, and the house is sufficient to dwell in," about the resettlement, regardless of the involuntary downsizing situations.

The first impression of living as a downsizer is generally positive, with participant F20 feeling happy and fulfilled and accepting the transition while preparing for future renovation. Participant F7 was grateful for living in the resettlement and had already modified a part of the house to accommodate a car garage. Another point of view was given by participant F12 who planned to renovate gradually in several stages based on her family's financial capacity. It is similar to participant F15 who planned to renovate their house after gaining a legal clarity of the house ownership. Seven out of 30 participants (participants M6, F7, F8, M9, M18, M25, M29) had already built an additional construction separated from the original layout plan, such as adding a garage, a terrace in front of the house, expanding the kitchen area to plan to build a separate room for extended family in the backyard, all of which indicate the lack of space of the main building. The results of this interview show that participants were showing words of gratitude for getting the house provided by the government (participants M28, F27, M23, F17 and F20), so it is an obligation for them to appreciate what has been given regardless of the size of the house. For example, Participant F17 stated clearly, “Because it has been given to displaced persons, so it must be used.” Moreover, participants M18, M19, and M22 said that there was no other option for living other than in the resettlement provided by the government.

On the other hand, an obstacle faced by participants F2 and M6 who had a difficulty feeling at home in the resettlement because of the damaged land that had lost the opportunity for livestock farming. If previously they relied on the land availability in their surrounding for breeding livestock and farming, now they can creatively use their outdoor area or backyard for home farming. Their new property now may not fit for breeding livestock anymore, but they have enough space for building a kiosk and changing their livelihood as food sellers.

Displaced persons’ belongings were mostly gone during the disaster or remained in their inaccessible homes due to the red zones. So, the housing provision includes several basic pieces of furniture, such as beds, cupboards, a three-seater wooden chair, a coffee table, and several kitchen items. However, a positive attitude was shown by participant M11 who was happy to accept the small house and could find a solution by selecting minimalist furniture and being innovative in arranging limited space.

Even though the first impressions of dwelling size and the overall resettlement experiences were positive, eight out of 30 participants (participants F1, F2, M11, F12, F15, M16, M18 and M29) stated that they were still in grief followed by trauma from the disastrous event. Participant F1 was still traumatic during the bad weather, while participant F12 felt scared because the current resettlement location was closer to the top of Mount Semeru than their older house. We found that 18 out of 30 participants mentioned neighborhood as a factor that made them feel at home in the new environment (participants F1, F2, F3, F4, F5, F7, F8, M9, F12, F13, M14, F15, F20, F21, F24, F26, F28, F29 and F30). Besides that, participants M23 and M25 stated that environmental security helped them feel comfortable when living in a new environment.

Furthermore, the neighborhood played a role as a social benefit during the adaptation process. Participant F1 mentioned that being surrounded by the same group of people in the neighborhood in the resettlement could accelerate the adaptation phase. Almost all participants agreed on enjoying group activities such as gatherings and public projects. This confirmed the early observation where it was found that the displaced people helped each other to clean the house before occupancy. In contrast, participant M14 admitted his dislike towards his neighborhood because he was a minority and it was challenging for him to settle in a new environment. Thus, we can see the importance of the neighborhood situation in the adaptation process of resettlement.

3.3 Housing Satisfaction after Involuntary Downsizing

Despite experiencing downsizing, involuntary downsizers in Lumajang were happy and grateful to get a permanent settlement. Looking back from their past experiences, many of them used to live in a bigger house, but then experienced months of living as refugees in the evacuation tents or other designated refuges. It indicates that spatial satisfaction is not only formed by past experiences in general [44], but by the closest or the most influential past experiences. Positioning themselves as a group of homeless people with low purchasing power [52], they were delighted with the given house rather than thinking about the size of the house. The absence of ideas of downsizing helps them reach satisfaction towards their new dwellings because their expectations of the house eventually shrink [49].

Generally, participants in Lumajang show positive feedback as shown as the advantages of living in a Tiny House. Regarding the floor area of the house, participants have different perceptions of spatial sufficiency. The typology of the TH that comes as a detached building allows them to expand their activities outdoors and visualize a future renovation for adding some more rooms in the backyard. Without mentioning explicitly their dissatisfaction towards the size of the house, a metrical measurement of spatial adequacy is still important and the renovation plan is seen as both a disapproval to downsizing and a means to adaptation of living in a smaller dwelling. Although they lost many of their material belongings in the past, they can now adapt by practicing a simplistic lifestyle by utilizing the house and several basic furniture that have been given to them.

The difference between the downsizers in Lumajang and the downsizers in other THs is that people in Lumajang have no stuff to reduce for downsizing. While other TH downsizers selectively reduce their belongings to fit the smaller house and feel a sense of freedom by their detachment to material stuff, people in Lumajang still have plenty of space in their nearly empty homes and get their sense of freedom of starting anew by consciously accumulate items that fit for their small homes. By starting anew, it also means they have to deal with any of the technicality of the house that does not function well as a result of uneven quality of the construction, which was also reported in the TH program for the homeless in North America [2].

On top of everything, the neighborhood is seen as the ultimate factor that creates housing satisfaction. Some of them have lost everything including their livelihood that was attached to the destroyed land, but living in a TH with neighborhood gives them opportunity to get some help from the closest society and they can slowly build their lives supported by the surrounding people. Otherwise, if they dislike their neighbors, it appears as the factor that they wish they could change about their house.

4 Conclusion

Involuntary downsizing for the homeless seems to show the advantages of living in a Tiny House rather than its disadvantages. The position of the homeless as a group of people with less financial power eventually places them to see a house as a positive value despites of its size and quality. Regardless of the size of their past homes, they perceive satisfaction from being homeless to being settled in a house. Although it makes them feel positive about their homes, they replace the conscious process of downsizing through decluttering stuff with the plan to accumulate new stuff.

Since they start their lives in a new house of the government's program, we recommend that a set of knowledge on the benefits of living in a TH is given prior to their settlement so that they can optimize their lives and bring a good contribution to their environment. As mentioned earlier that TH requires a thoughtful spatial planning [20], occupants need to anticipate their consumptive behavior to avoid excessive material accumulation and not solely rely on the architectural forms of the building, given by the housing developers.

References

[1] A. Mutter, "Growing Tiny Houses. Motivations and Opportunities for Expansion Through Niche Markets," *IIIEE Theses*, no. 2013:01, p. 55, 2013, [Online]. Available: https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=4196241&fileOId=4196242

[2] K. Evans, "Tackling Homelessness with Tiny Houses: An Inventory of Tiny House Villages in the United States," *Prof. Geogr.*, vol. 72, no. 3, pp. 360–370, 2020, doi: 10.1080/00330124.2020.1744170.

[3] K. Evans, "Integrating tiny and small homes into the urban landscape: History, land use barriers and potential solutions," *J. Geogr. Reg. Plan.*, vol. 11, no. 3, pp. 34–45, 2018, doi: 10.5897/jgrp2017.0679.

[4] M. H. M. Lau and X. Wei, "Housing size and housing market dynamics: The case of micro-flats in Hong Kong," *Land use policy*, vol. 78, no. June, pp. 278–286, 2018, doi: 10.1016/j.landusepol.2018.06.039.

[5] E. Clinton, "Micro-living: why occupants choose to live in very small dwellings?*," *Aust. Plan.*, vol. 55, no. 3–4, pp. 189–197, 2018, doi: 10.1080/07293682.2019.1632363.

[6] V. Vasseur, J. Sing, and S. W. Short, "Determinants of the adoption of tiny houses and their role in alleviating housing shortages in Germany," *Clean Technol. Recycl.*, vol. 2, no. 4, pp. 199–224, 2022, doi: 10.3934/ctr.2022011.

[7] L. Batista and H. Farias, "Čan Micro-Housing Policies Enable Higher Liveability Standard in Urban Areas? Čase Study of Čascais Historical Čentre, Lisbon, Portugal," *Archit. Urban Plan.*, vol. 17, no. 1, pp. 1–15, 2021, doi: 10.2478/aup-2021-0001.

[8] J. Ford and L. Gomez-Lanier, "Are Tiny Homes Here to Stay? A Review of Literature on the Tiny House Movement," *Fam. Consum. Sci. Res. J.*, vol. 45, no. 4, pp. 394–405, 2017, doi: 10.1111/fcsr.12205.

[9] S. Riegler, "Under 1 , 000 Square Feet the Tiny House Movement," vol. 153, no. Jul, pp. 1–6, 2011.

[10] L. Trambley, "The Affordable Housing Crisis: Tiny Homes & Single-Family Zoning," *Hastings Law J.*, vol. 72, no. 3, pp. 919–958, 2021.

[11] J. Wotton, H. Skates, and L. Shutter, "Tiny House–when size matters," *Aust. Plan.*, vol. 55, no. 3–4, pp. 209–220, 2018, doi: 10.1080/07293682.2019.1634112.

[12] A. Friedman, "DESIGN PRINCIPLES OF SMALL HOMES," in *American architects and the single-family home : lessons learned from the Architects' Small House Service Bureau*,

ROUTLEDGE, 2015, pp. 192–199.

[13] A. Wyatt, "Tiny houses: Niche or noteworthy?," *Planning*, vol. 82, no. 2, pp. 39–42, 2016.

[14] H. Shearer, "Tiny Houses: Love, Live or Leave? What factors Influence the Decision?," *Griffith Univ. Cities Res. Inst.*, 2019.

[15] S. Mangold and T. Zschau, "In search of the 'Good Life': The appeal of the tiny house lifestyle in the USA," *Soc. Sci.*, vol. 8, no. 1, 2019, doi: 10.3390/socsci8010026.

[16] H. Shearer and P. Burton, "Towards a Typology of Tiny Houses," *Housing, Theory Soc.*, vol. 36, no. 3, pp. 298–318, 2019, doi: 10.1080/14036096.2018.1487879.

[17] R. Tucker *et al.*, "Microvillage: assessing the viability of increasing supply of affordable, sustainable and socially integrated small homes," *Hous. Stud.*, vol. 0, no. 0, pp. 1–23, 2021, doi: 10.1080/02673037.2021.2014418.

[18] M. S. Khan, "Compact housing for demographic change," vol. 2, no. July, pp. 52–63, 2014.

[19] L. Armitage, "Micro Houses : Trends and Implications on the Gold Coast Micro Houses : Trends and Implications on the Gold Coast Lynne Armitage PhD Associate Professor of Urban Development Faculty of Society and Design Bond University E : Lynne_Armitage@bond.edu.au Isar," *Aust. Reg. Dev. Conf. Coffs Harb.*, no. October, 2017.

[20] M. Sandberg, "Downsizing of Housing: Negotiating Sufficiency and Spatial Norms," *J. Macromarketing*, vol. 38, no. 2, pp. 154–167, 2018, doi: 10.1177/0276146717748355.

[21] V. Sforzini, B. D. L. Vollaro, and A. D. Angelo, "Tiny House : micro case per un macro progetto," no. July, 2019.

[22] H. Shearer and P. Burton, "Tiny houses: movement or moment?," *Hous. Stud.*, vol. 0, no. 0, pp. 1–23, 2021, doi: 10.1080/02673037.2021.1884203.

[23] R. Roy, "Tiny House, A Big Movement?," *Perform. Improv.*, vol. 58, no. 4, pp. 28–30, 2019, doi: 10.1002/pfi.21862.

[24] H. Penfold, G. Waitt, and P. McGuirk, "Portrayals of the tiny house in electronic media: challenging or reproducing the Australian dream home," *Aust. Plan.*, vol. 55, no. 3–4, pp. 164–173, 2018, doi: 10.1080/07293682.2019.1632360.

[25] A. Doteuchi, "'Downsizing' of Housing and Lifestyles for a Low-Carbon Aging Society," no. 2003, pp. 1–6, 2008.

[26] M. E. Carras, "'TINY HOUSE, BIG IMPACT?': AN INVESTIGATION INTO THE 'RISE' OF THE TINY HOME LIFESTYLE (THL) IN THE UNITED STATES," University of St Andrews, 2019.

[27] B. Glumac, "Tiny portable home: Measuring the rental preferences," *Cities*, vol. 116, no.

June, p. 103279, 2021, doi: 10.1016/j.cities.2021.103279.

[28] N. Summers, “The socioeconomic concentration of intensive production interest: Lessons from the tiny home community,” *J. Consum. Cult.*, vol. 22, no. 2, pp. 476–494, 2022, doi: 10.1177/1469540520982360.

[29] J. Preece, K. McKee, J. Flint, and D. Robinson, “Living in a small home: expectations, impression management, and compensatory practices,” *Hous. Stud.*, 2021, doi: 10.1080/02673037.2021.1988066.

[30] L. Cumberbatch-Pearson, “EXPLORING THE NEED FOR TINY HOUSES IN URBAN CITIES,” The State University of New Jersey, 2020.

[31] L. M. Boeckermann, A. T. Kaczynski, and S. B. King, “Dreaming big and living small: examining motivations and satisfaction in tiny house living,” *J. Hous. Built Environ.*, vol. 34, no. 1, pp. 61–71, 2019, doi: 10.1007/s10901-018-9616-3.

[32] Đ. Alfirević and S. Simonović-Alfirević, “Micro-apartments: Achieving spatial comfort in substandard housing conditions,” *Arhit. i Urban.*, no. 55, pp. 5–23, 2022, doi: 10.5937/a-u0-36566.

[33] Z. Shore, “The Case for Micro-Apartment Housing in Growing Urban Centers,” Massachusetts Institute of Technology, 2014.

[34] J. Infranca, “HOUSING CHANGING HOUSEHOLDS : REGULATORY CHALLENGES FOR MICRO- UNITS AND ACCESSORY DWELLING UNITS,” *Stanford Law Pol. Rev.*, vol. 25, no. 1, pp. 53–90, 2014.

[35] D. Taser, E. Aydin, A. Ozer, and Y. Rofcanin, “Computers in Human Behavior An examination of remote e-working and flow experience : The role of technostress and loneliness,” *Comput. Human Behav.*, vol. 127, no. September 2021, p. 107020, 2022, doi: 10.1016/j.chb.2021.107020.

[36] C. Willoughby, S. Mangold, and T. Zschau, “Small houses, big community: Tiny housers’ desire for more cohesive and collaborative communities,” *Soc. Sci.*, vol. 9, no. 2, 2020, doi: 10.3390/socsci9020016.

[37] A. Purba, S. H. Sumantri, A. Kurniadi, and D. R. K. Putra, “Analisis Kapasitas Masyarakat Terdampak Erupsi Gunung Semeru,” *PENDIPA J. Sci. Educ.*, vol. 6, no. 2, pp. 599–608, 2022, doi: 10.33369/pendipa.6.2.599-608.

[38] UNHCR, “Planned Relocation, Disasters and Climate Change: Consolidating Good Practices and Preparing for the Future,” 2014. [Online]. Available: https://www.unhcr.org/54082cc69.pdf

[39] A. Setiadi, A. Andriessen, and R. Anisa, “Post-occupancy evaluation of Pagerjurang permanent housing after the Merapi volcanic eruption,” *J. Archit. Urban.*, vol. 44, no. 2, pp. 145–151, 2020, doi: 10.3846/jau.2020.11265.

[40] G. P. Cuaton, “Ginbert Permejo Cuaton | Post-Disaster Relocation of Urban Coastal

Communities in the Post-Disaster Relocation of Urban Coastal Communities in the Philippines Ginbert Permejo Cuaton | Post-Disaster Relocation of Urban Coastal Communities in the Philippine," vol. VIII, no. 2, pp. 143–153, 2019.

[41] G. P. Nabila, T. R. Deanda, and A. Akhmadi, "What makes it home: An assessment of place attachment in displaced persons with case study of Sidoarjo Mud-Flow victims," *Embrac. Futur. Creat. Ind. Environ. Adv. Soc. 5.0 a Post-Pandemic Era*, pp. 71–75, 2022, doi: 10.1201/9781003263135-14.

[42] M. Lyons, "Building Back Better: The Large-Scale Impact of Small-Scale Approaches to Reconstruction," *World Dev.*, vol. 37, no. 2, pp. 385–398, 2009, doi: 10.1016/j.worlddev.2008.01.006.

[43] D. D'alessandro *et al.*, "COVID-19 and living space challenge. Well-being and public health recommendations for a healthy, safe, and sustainable housing," *Acta Biomed.*, vol. 91, no. July, pp. 61–75, 2020, doi: 10.23750/abm.v91i9-S.10115.

[44] C. Foye, "Social construction of house size expectations: testing the positional good theory and aspiration spiral theory using UK and German panel data," *Hous. Stud.*, vol. 36, no. 9, pp. 1–20, 2021, doi: 10.1080/02673037.2020.1795086.

[45] G. M. Huebner and D. Shipworth, "All about size ? – The potential of downsizing in reducing energy demand," *Appl. Energy*, vol. 186, no. 2017, pp. 226–233, 2017, doi: 10.1016/j.apenergy.2016.02.066.

[46] I. Stieß, A. Umbach-daniel, and C. Fischer, "Smart small living ? Social innovations for saving energy in senior citizens ' households by reducing living space," *Energy Policy*, vol. 133, no. December 2018, p. 110906, 2019, doi: 10.1016/j.enpol.2019.110906.

[47] C. Nezzi, L. Ruiz-Pastor, S. Altavilla, A. Berni, and Y. Borgianni, "How Sustainability-Related Information Affects the Evaluation of Designs: A Case Study of a Locally Manufactured Mobile Tiny House," *Designs*, vol. 6, no. 3, 2022, doi: 10.3390/designs6030057.

[48] B. A. Rock, "Tiny Houses , Big HVAC?," *ASHRAE J.*, vol. 60, no. 1, pp. 20–28, 2018.

[49] E. Harris and M. Nowicki, "'GET SMALLER'? Emerging geographies of micro-living," *Area*, vol. 52, no. 3, pp. 591–599, 2020, doi: 10.1111/area.12625.

[50] P. Foreman, "My Tiny House Life.pdf," *Mother Earth News*, pp. 20–24, 2021. [Online]. Available: https://www.motherearthnews.com/sustainable-living/green-homes/tiny-house-life-zm0z21fmzbut/

[51] N. M. H. Soub and İ. Memikoğlu, "Exploring the Preferences for Micro-Apartments," *Online J. Art Des.*, vol. 8, no. 2, pp. 88–99, 2020, [Online]. Available: http://www.adjournal.net/articles/82/827.pdf

[52] C. Murillo and C. Bianchi, "The experience and well-being outcomes of tiny house owners in Latin America," *Hous. Stud.*, vol. 0, no. 0, pp. 1–25, 2022, doi:

10.1080/02673037.2022.2091116.

[53] Z. Li and J. Wu, "Research on the design of small interior space," *E3S Web Conf.*, vol. 308, p. 01002, 2021, doi: 10.1051/e3sconf/202130801002.

[54] B. E. Gronostajska and A. Szczegielniak, "Inside a microapartment: Design solutions to support future sustainable lifestyles," *Buildings*, vol. 11, no. 12, 2021, doi: 10.3390/buildings11120654.

[55] J. Urist, "The Health Risks of Small Apartments," *Atl.*, no. December, p. 4, 2013, [Online]. Available: https://www.theatlantic.com/health/archive/2013/12/the-health-risks-of-small-

[56] C. Mingoya, "Building together. Tiny house villages for the homeless: A comparative case study. Massachusetts Institute of Technology," 2016.

[57] C. Turner, "It Takes a Village: Designating 'Tiny House' Villages as Transitional Housing Campgrounds," *Univ. Michigan J. Law Reform*, vol. 50, no. 50.4, p. 931, 2017, doi: 10.36646/mjlr.50.4.it.

[58] C. Greene, "Food, shelter, hope: Examining the possibilities of agricultural tiny home communities for the homeless," *Georg. J. Poverty Law Policy*, vol. XXVII, no. 1, pp. 3–30, 2019.

[59] A. Jackson, B. Callea, N. Stampar, A. Sanders, A. De Los Rios, and J. Pierce, "Exploring tiny homes as an affordable housing strategy to ameliorate homelessness: A case study of the dwellings in Tallahassee, FL," *Int. J. Environ. Res. Public Health*, vol. 17, no. 2, 2020, doi: 10.3390/ijerph17020661.

[60] T. Murtaugh, "People Are Seriously Regretting Buying Tiny Houses," 2022. https://finance.yahoo.com/news/people-seriously-regretting-buying-tiny-160000769.html?guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAC5RG0o7PBFLSnjTiSbGQ-n4LiQ1fZ4wi-53pzn6CQLmqABipzh-dBlGJOB757iZ3U1eAWlOz0fmp89-b5L8AvrCSrqGiETRkvUDH (accessed Feb. 20, 2023).

[61] W. Gong, T. Bai, and D. He, "Talking about Problems and Countermeasures of Small-sized Apartments Design," vol. 5085, pp. 2015–2018, 2017.

ARCHITECTURAL ACTIVISM OF HISTORICAL AFRICAN AMERICAN COMMUNITIES THROUGH MEMORY

T'Quion C. Smith

University of Florida School of Architecture
7547 Park Promenade Drive, Apt. 1514, Winter Park, Fl, 32792
tquionsmith@ufl.edu, nmclark@ufl.edu, j.carney@ufl.edu

Abstract:

African American culture in the United States is a rich and diverse cultural tradition that has developed over the centuries. It reflects the experiences and contributions of Black Americans who have faced socio-spatial challenges and obstacles due to the legacy of racial discrimination and slavery. Despite these challenges, the African American culture has played a significant role in shaping American Culture, while demonstrating resilience and a keen sense of "place" for many generations. Rooted with struggle and resistance these communities have been targeted by many political leaders due to a variety of factors that include, systemic racism, discrimination, and lack of representation from government institutions. These issues have led to socio-economic disparities and mistrust in the government leading to disparities in areas such as education, healthcare, and economic opportunities. The cycles of poverty, inequality and depletion has caused drastic changes in many African American communities leaving many disinvested cities left to disappear in the shadows. Communities across the nation are experiencing gentrification practices to revitalize older neighborhoods into new urban developments. Although these efforts are a helpful, the challenges they bring to these neighborhoods are erasing the historic cultural infrastructure in which these places were built upon. Today with increased gentrification, many African American communities are at risk of losing their history This paper proposes to confront the current limitations in the historical African American community of Durkeeville. Located in Jacksonville Florida this community acts as a primal case study for exploring and refining the current architectural practice of gentrification while employing opportunities to keep the cultural heritage in which these neighborhoods derived from. The goal of this study aims to encourage growth within the urban fabric of historical communities without the loss of cultural investment. Additionally, creating a spatial corridor that promotes a connection between the past, present, and future of historical African American neighborhoods through community education, cultural appreciation, and historic preservation.

KeyWords:

Gentrification, Cultural Heritage, Revitalization, Memory, Generational Wealth

1. Introduction

African American culture in the United States is a rich and diverse cultural tradition that has developed over the centuries. It reflects the experiences and contributions of Black Americans who have faced many challenges and obstacles due to the legacy of racial discrimination and slavery. With these challenges, the African American culture has played a major role in shaping American Culture as a whole, demonstrating resilience and a strong sense of place for many generations to follow. Rooted with struggle and resistance these communities have been overlooked by many political leaders due to a variety of factors that include, systemic racism, discrimination, and lack of representation from government institutions. These issues have led to socio-economic disparities and mistrust in the government leading to disparities in areas such as education, healthcare, and economic opportunities. The cycles of poverty, inequality and depletion has caused drastic changes in many African American communities leaving many disinvested cities left to disappear in the shadows. As the economy continues to grow, residents of these neighborhood are unable to maintain a sustainable living, ultimately forcing them to leave their family homes, or continue to live in run-down places with no opportunities for improvement. Without proper investment, these communities will continue to fail resutling in the erasure of the rich history they possess.

The erasure of the African American communities is a significant issue that has affected the culltural landscape in th Unites States. Through a combination of disciminary policies, urban renewal pojects ands gentrification, many historically African American neighbohoods have been demolished or transformed beyond recognition, leading to the loss of cultural landmarks, traditions and heritage. This erasure is especially harmful because many Black communities have made significant contributions to American culture through their music, literature, and community development. The importance to recognize these attributes helped form the question of how do we continue to improve the infrasturcture of historical African American communities through the process of gentrification while preserving and educating the cultural history of the place. This research will localise itself to Jacksonville, Florida, in a historical African Amrican community name Durkeeville. The value of this unseen community is important for the renovation and restoration of this place and through a series of different approaches to analyze the missing legacy of the African American Culture aids in the redevelopment of the main corridor of Durkeeville, Myrtle Avenue.

2. History of African American Communities

African Americans have undergone many hardships in the United States emerging from early practices of racism and segregation. Following the Civil War and Great Depression, African Americans had a newfound freedom but still faced discrimination and racism, particularly in the South. During the Great Depression, many African Americas struggled to find work to support their families. According to the National Museum of African American History and Culture, "The years immediately following the Civil War were filled with challenges and hardships for African Americans, who were struggling to build new lives in a society that was deeply divided along racial lines." As Richard Rothstein describes in his book "The Color of Law," "Segregation has meant that African American have not had access to the same opportunities, the same amenities, the same jobs, the same safety, the good schools that whites have had given access to (Rothstein, 2017). As the economy continued to fail, African Americans who were already disproportionally affect by poverty cold not find well-paying jobs to support their families. Noted by Jeffrey D. Anderson, the Business of Reforming American Cities: urban Renewal and the Origins of a New Liberal Order, "The depression hit the African American community especially hard. Unemployment among blacks was more than double that of whites, and African Americans were generally the first to be laid off and the last to be rehired." To escape the blatant discriminatory practices place against them in the South, blacks migrated north establishing middle class communities where they developed businesses, newspapers, churches, and literary societies (Rothstein, 2017). African Americans now had the opportunity to have good paying jobs and enroll their children into school for higher education. Unfortunately, the newfound success of black Americans ignited fear in White Americans who felt threatened by their achievements, disrupting the foundation of societal class the white society benefitted on for many years.

2.1 The New Deal

Following the Great Depression, which lasted from 1929 to 1939, newly appointed president, Franklin D. Roosevelt, introduced "The New Deal" programs that offered some relief for Americans as they faced hardships recovering from the previous economic downpour. Stated by the president himself, "We are trying to construct a more inclusive society. We are going to make a country in which no one is left out." "The New Deal was a remarkable achievement. It created jobs, restored confidence, and set the stage for the economic growth of the post-war period" stated by Alan Brinkley, "The End of Reform: New Deal Liberalism in Recession and War." While these programs aimed to help support people from their economic hardships, these policies often overlooked the African American people. "The New Deal failed to provide equal opportunities and protections to African Americans, who were often discriminated against in employment, housing, and other areas." - Carol Anderson, "White Rage: The Unspoken Truth of Our Racial Divide."

2.2 Injurious Public Policies: Redlining

As the economy began to settle, White Americans began to move away from urban areas into the suburbs which were newly developed in the postwar period. This migration, also known as, suburbanization was fueled by the availability of affordable housing, automobile industries and the desire to move into a more suburban lifestyle. "Suburbanization was a way for white Americans to escape the perceived problems of the city and create a new, more homogeneous community in the suburbs." Robert D. Bullard, "The Black Metropolis in the Twenty-First Century: Race, Power, and the Politics of Place." While suburbanization offered economic opportunities for white Americans, it also reinforced racial divides and other practices to exclude African Americans from these opportunities that continue to exist today.

"Suburbanization was not just a matter of personal preference or lifestyle choice, it was a deliberate strategy to exclude African Americans and other minorities from access to housing, jobs, and other opportunities." (Rothstein, 2017). For most African Americans, affordable housing did not come easy. Unlike white Americans, African Americans faced the act of redlining, which is the practice in which banks and government agencies refused to invest in neighborhoods that were predominantly black. This resulted in disinvestment, blight, and lack of economic opportunities in the neighborhoods unlike white neighborhoods. According to a report by the National Community Reinvestment Coalition, Jacksonville is one of the most segregated cities in the united States with a high concentration of poverty in black neighborhoods.

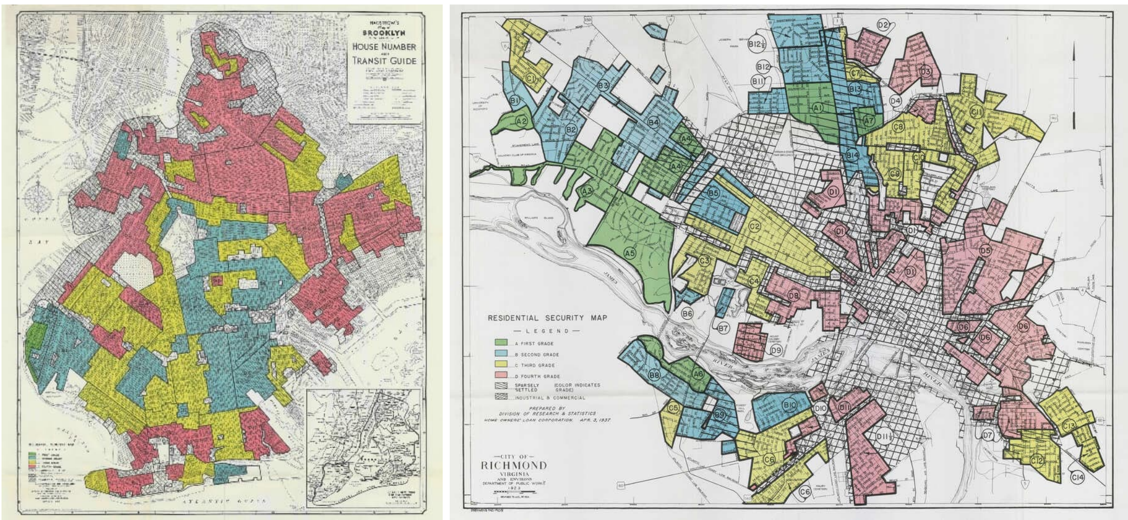


Figure 1. Examples of Redlining Maps from HOLC

3. Method

In this study, a developed series of different approaches that analyze the missing legacy of the place of Jacksonville and Durkeeville, Florida, as it pertains to the renovation and restoration of the main street corridor Myrtle Avenue. Understanding the place through the lens of many scales, including the city, local and street level, provides great insight on the historical attributes and endurance African Americans created throughout the country.

4. Findings

4.1 Jacksonville, Florida

Jacksonville, Florida, is populated by predominately African American communities that have endured the many issues mentioned earlier in this paper. Jacksonville's African American history is a powerful testament of resilience and creativity of its black resident's. One of the most notable African American communities was Lavilla, which was once the epicenter of black culture during segregation. Home to thriving businesses, social clubs, and entertainment, LaVilla was known as the "Harlem of the South" due to its vibrant music and social scene. Another historical community is the community of Durkeeville, which was established in the early 20th century as a common black for middle class African American families who owned homes and businesses. Home to several important institutions, such as Edward Waters College, the oldest black college in Florida. There are many more communities that have made great strides for the city of Jacksonville which includes preserving and helped the growth and development of Jacksonville.

4.2 Jacksonville Cultural Mapping

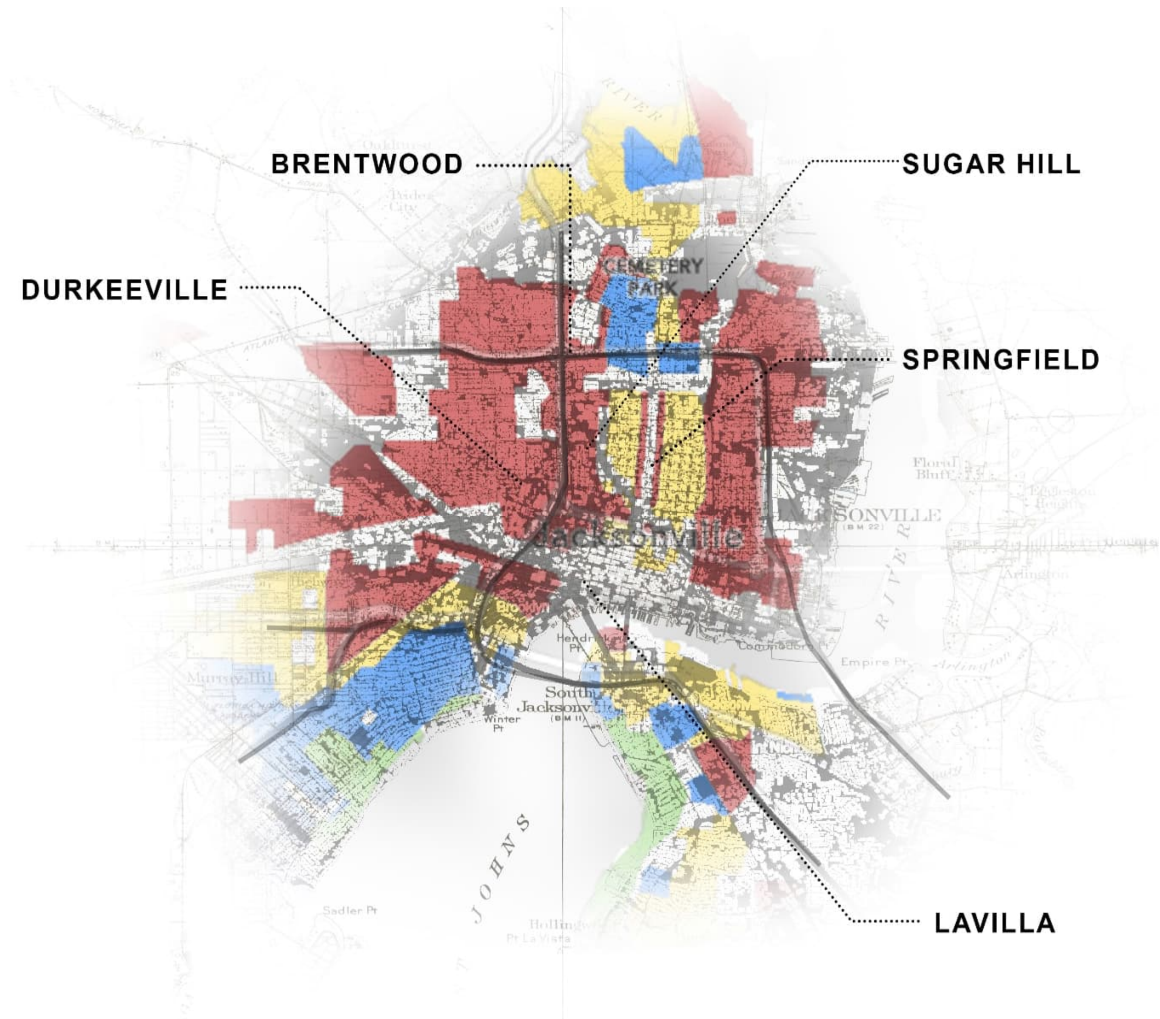


Figure 2. Redlining Mapping of downtown African American communities.

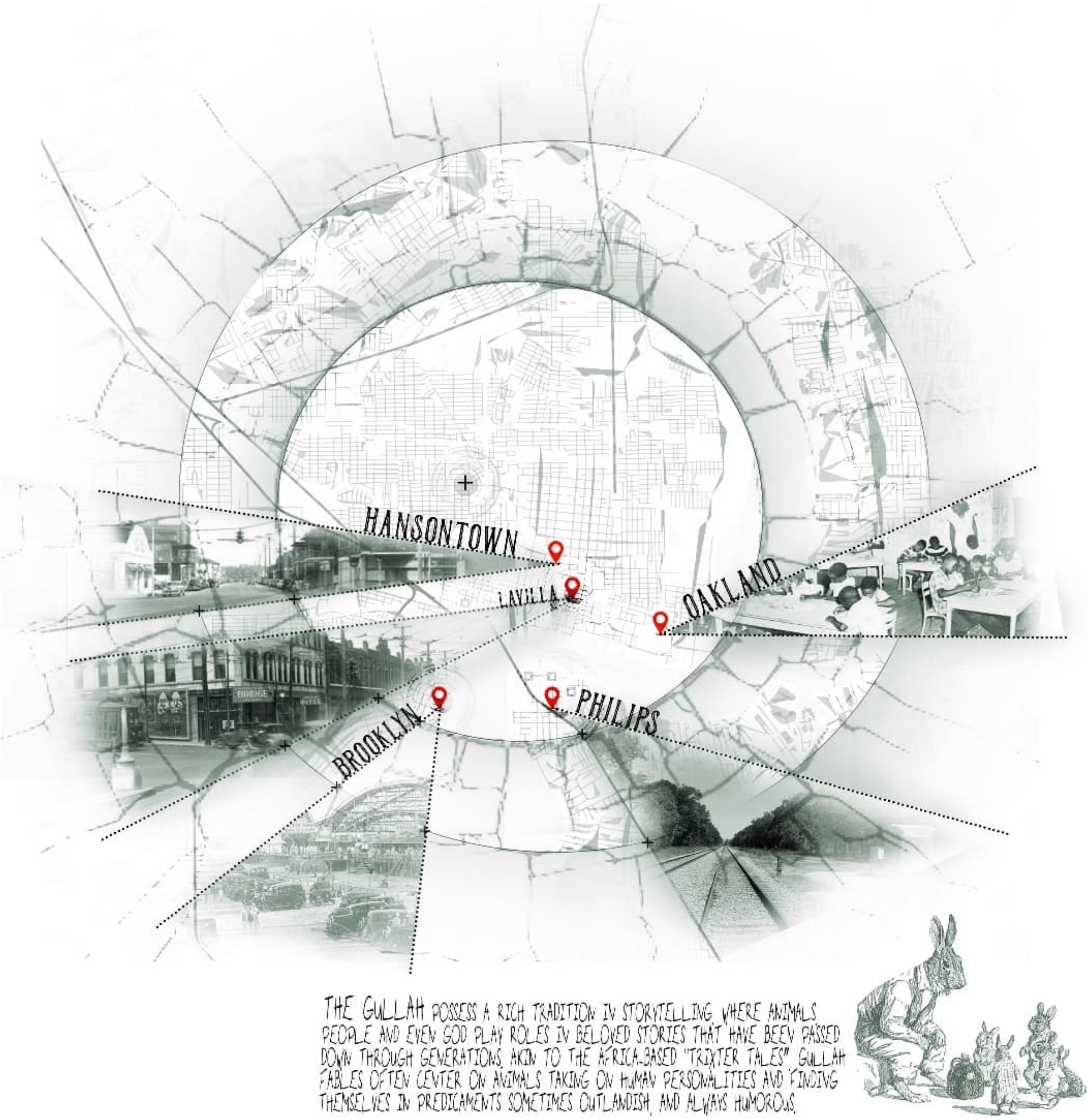


Figure 3. Mapping of Gullah Geechee influence in razed African American communities.

The Gullah Geechee people, who were descendants of enslaved African Americans who settled in coastal areas in the United States have had a significant influence on the black communities of Jacksonville. As artist and activist James Weldon Johnson wrote, “The Gullah people have a rich and unique culture that has been shaped by their experiences as descendants of enslaved Africans. It is important that we preserve and celebrate their contributions to our community.”

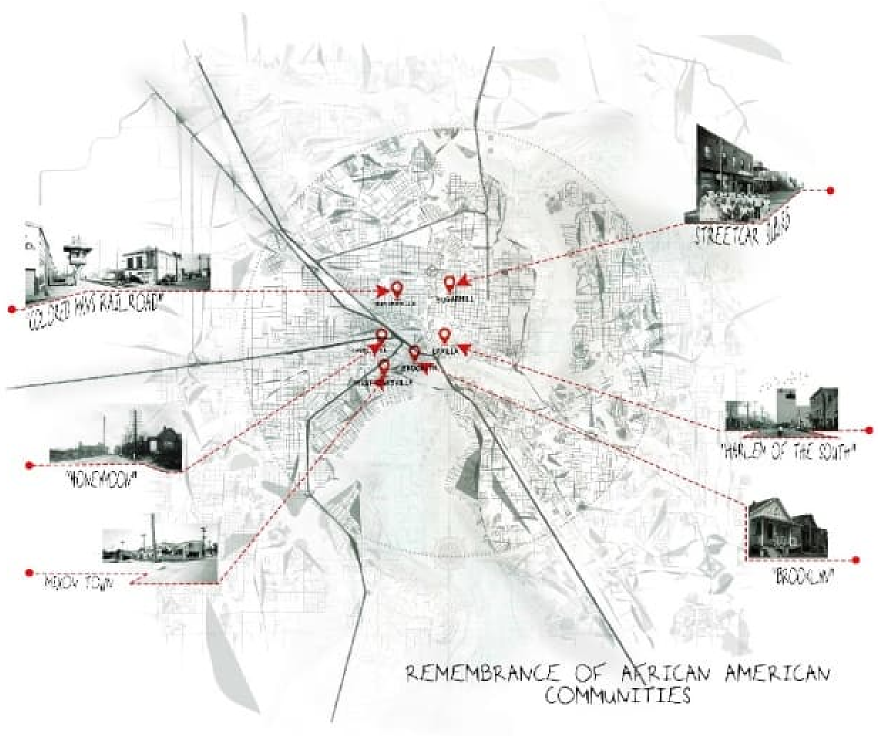


Figure 4. Mapping of remembrance of lost African American communities

Figure 5. Mapping of influence of Churches in downtown Jacksonville.

4.3 Durkeeville, Florida

Durkeeville is a historic neighborhood in Jacksonville, Florida that was founded in the late 1800s by African American entrepreneurs and professionals. According to the Jacksonville Historical Society, the neighborhood was named after the Dukes family, who were prominent African American landowners in the area. Over the years, Durkeeville became a hub of African American culture and community life, with thriving businesses, churches, and social organizations. The neighborhood is also home to several notable landmarks, including the Stanton College Preparatory School and the A. Philip Randolph Career and Technical Center. Despite facing disinvestment and neglect in recent decades, Durkeeville remains an important symbol of African American resilience and community pride in Jacksonville. As community activist Ben Frazier notes, "Durkeeville is a testament to the strength and resilience of African American communities in the face of systemic injustices and discrimination."

Figure 6. Historical Images of Durkeeville.

4.4 Myrtle Avenue Mapping and Collage

Mrytle Avenue is a historic commercial corridor in the Durkeeville neighborhood of Jacksonville that was once a vibrant hub for middle class black business owners. Known as the colored man’s railroad, the use of the streetcar made Myrtle Avenue on the most interconnected places in Jacksonville. As historian and community activist Rodney L. Hurst Sr. notes, "Myrtle Avenue has played a significant role in the history of the African American community in

Jacksonville...[it] represents the fortitude of the African American community to not only survive but to thrive in the face of oppression and discrimination."

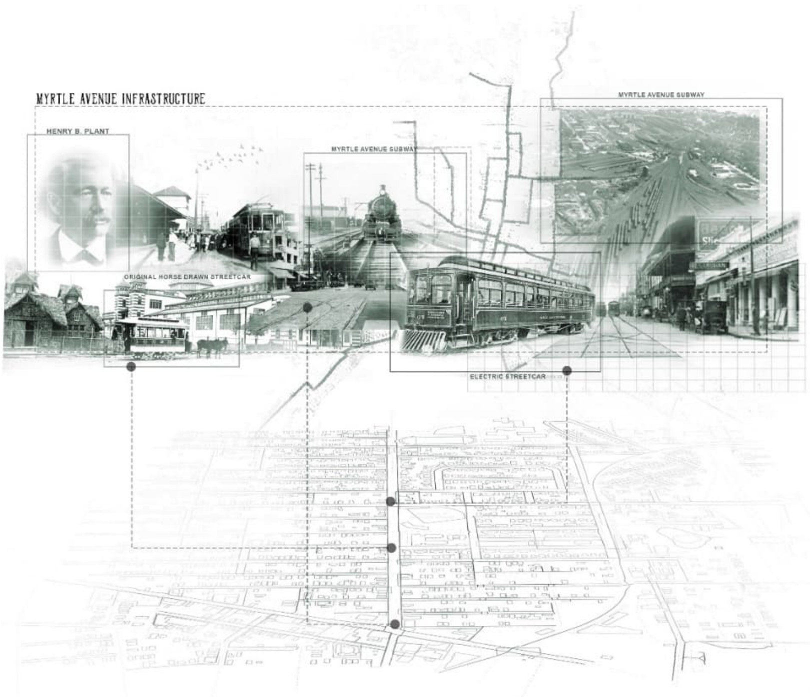


Figure 7. Collage of Infrastructure that helped with the development of Durkeeville.

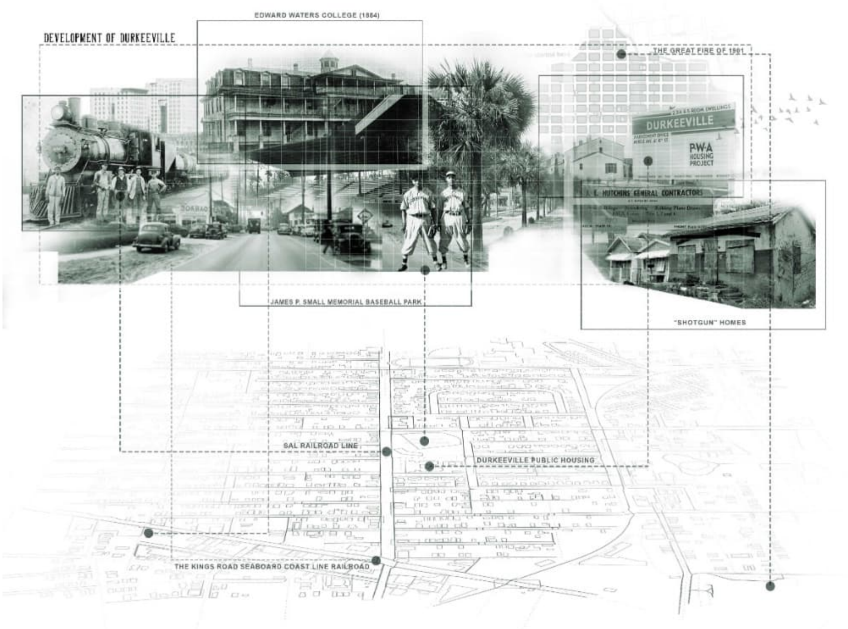


Figure 8. Collage of Important Historical Events in Durkeeville

5. Conclusion

Cultural preservation is relevant as historical communities face the challenges of urban renewal and gentrification. African American culture has deep roots in the evolution of American culture but is often overlooked by many in the broader society including people of power. Although there are new efforts to help reinvest into these underdeveloped communities, the goal for this project is find a cohesive way to invest into these communities without damaging or erasing the historical attributes the communities were found on. Developing the methodology of mapping and collaging was a crucial step to understanding the importance of the past for African American communities to use these findings to aid in the development and programming of the street of Myrtle Avenue. By recognizing and preserving African American culture, we can have a better understanding and appreciation to the diverse tapestry of American society and move toward a more inclusive, equitable future.

References

[1] Jacksonville Historical Society. "Durkeeville: A Community Profile." https://www.jaxhistory.org/wp-content/uploads/2013/12/Durkeeville-A-Community-Profile.pdf

[2] Brown, J. and Patton, D. "Durkeeville: A Jacksonville Story." WJCT News. https://news.wjct.org/post/durkeeville-jacksonville-story

[3] Frazier, B. "Durkeeville's legacy." Florida Times-Union. https://www.jacksonville.com/story/opinion/columns/guest/2020/02/15/guest-column-durkeevillersquos-legacy/112263640/

[4] https://www.jacksonville.com/story/news/columns/2021/02/06/rodney-hurst-looking-back-history-myrtle-avenue-jacksonville/4389998001/

[5] Johnson, T.M. "Revitalizing Myrtle Avenue: Historic corridor has rich past, bright future." The Florida Times-Union. https://www.jacksonville.com/story/news/local/2021/02/14/revitalizing-myrtle-avenue-jacksonville-historic-corridor-has-rich-past-bright-future/4332886001/

[6] Rothstein, Richard. *The Color of Law: A Forgotten History of How Our Government Segregated America.* First edition. New York; London, Liveright Publishing Corporation, a division of W.W. Norton & Company, 2017.

[7] Brinkley, A. (1996). The End of Reform: New deal liberalism in recession and war. Vintage Books.

LOUIS KAHN: FINDING DAYLIGHT IN LUANDA

Martin SCHWARTZ
Lawrence Technological University
21000 West Ten Mile Road, Southfield, Michigan USA 48075
mschwartz@ltu.edu

Abstract

The stature of Louis I. Kahn as one of the great architects of the twentieth century rests, to a substantial degree, on his observations about daylight and how he employed it in his buildings. His spoken observations were often poetic, leaning toward the mystical. But his key insight into daylight was derived from the very pragmatic need to respond to a real condition, that of intense solar glare in Luanda, Angola, for which he prepared a design for a United States Consulate in 1961. In fact, his solution was inspired by Luandans themselves. Kahn saw that Luandans avoided looking at the glare of the bright sky, preferring to look toward blank walls, which diffused the intense sunlight. Kahn's design solution located walls with simple, geometrical openings in the path of light so that inhabitants would experience daylight but only after it was softened by architectural surfaces. Kahn referred to this strategy as "wrapping buildings in ruins" and he employed it, in more advanced ways, in later, better known buildings. In this regard, Luanda is the seminal building in Kahn's use of daylight.

A reexamination of the consulate design and a consideration of Kahn's later buildings encourages us to rethink Kahn's intentions and achievements with daylight. Interestingly, a review of the unbuilt consulate suggests that the solar orientation of the Consulate is less than ideal—a 90-degree rotation of the building in plan offers better daylighting control. But this is not to denigrate Kahn's insights or achievements: Kahn's purpose, his interest in daylight, was never about the achievement of target illumination levels nor on clever lighting effects. His interest was in how his understanding of daylight might organize space for human purposes. Kahn realized that his knowledge of daylight could be deployed—not just for the sake of lighting—but as a fundamental generator of architectural design from the very beginning of the process. In doing so, his buildings reveal the spatial implications of the performance of daylight, based on orientation to sun and sky and with reference to climate, but aimed at human needs.

The architectural results of his lighting strategies enabled Kahn to satisfy his other interests (those that may have competed with his Luandan daylight strategy) such as the need to honor the social aspirations of common people and how then to establish a new monumentality that commemorated these desires. In producing his daylight-generated designs, beginning with Luanda and into his later career, Kahn also revealed much about himself, his own aspirations and persona, his sense of himself. In his architecture and through the incorporation of the requirements of daylighting, Louis Kahn presented a resolution of sorts: first, between the

inner lives of working people and their greater collective aspirations; and second, between the conflicts of the inner man (Kahn) and his own public persona. Louis Kahn's buildings represent the highest aspirations of the people he built for and the best versions he could present of himself.

Keywords

daylight, architecture, Kahn, glare, design process

Introduction: The Thought of a Wall

In 1961, Louis I. Kahn described his visit to Luanda, Angola for which he was preparing a design proposal for a U.S. Consulate complex consisting of two separated residence and chancellery buildings. (Figure 1) In particular, Kahn recalled the "marked glare in the atmosphere," saying "Looking at a window was unbearable because of the glare. The dark walls framing the brilliant light outside made you very uncomfortable." [1] Glare, as Kahn knew, is not absolute brightness. It is the condition in which the eye tries but is unable to adjust itself to both bright light and darkness in the field of vision at the same time. This results in an inability to see clearly or comfortably. In Luanda, Kahn sought to develop an architectural response to this condition. He found his response, not surprisingly, in the everyday behavior of Luandans. Kahn said,

"I …noticed that when people worked in the sun—and many of them did—the native population…usually faced the wall and not the open country or the open street. Indoors, they would turn their chair toward the wall and do whatever they were doing by getting the light indirectly from the wall." [2]

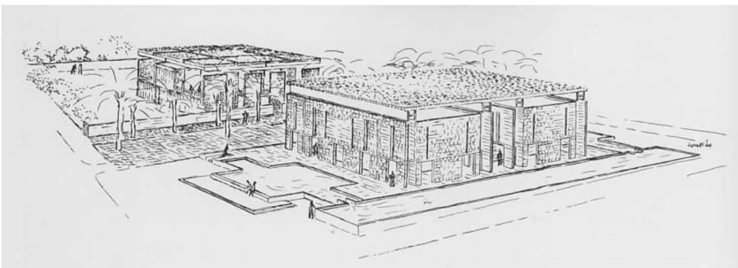


Figure 1. Sketch by Louis I. Kahn of his design for the United States Consulate Buildings in Luanda, Angola.

Kahn found himself doing the same thing as the Luandans, looking at daylight as it was captured on wall surfaces:

"I …noticed that buildings which were very close to windows--were very pleasant to look at from the windows…That gave me the thought of a wall a small distance in front of every window…One doesn't feel like having the view cut away, so I thought of placing openings in the wall." [3]

Kahn's simple observation led him to propose walls whose primary purpose, instead of supporting the roof or providing enclosure, would be to catch daylight. In practice, his proposal meant placing an additional layer of wall and space around a building to protect inhabitants from intense sunlight or bright sky. Because of the wall's essential independence from other tasks and the absence of framed glazing, Kahn referred to this strategy as "wrapping buildings with ruins."

"I thought of the beauty of ruins…the absence of [window] frames…of things which nothing lives behind…and so I thought of wrapping ruins around buildings; you might say encasing a building in a ruin so that you look through the wall which had its apertures by accident. But in this case, you'd want to formalize these openings, and I felt that this would be an answer to the glare problem." [4]

Kahn's wrapping wall was not simply a shading device. It was intended to catch daylight that would be seen on its surface and would then and diffuse the light inward. Kahn proposed concrete panels as a wrapping wall at Luanda, walls whose finely textured, light gray surfaces would have absorbed roughly half of the incoming light and reflected the remaining half toward the interior. [5] Inside, people would live and work in spaces illuminated in the resulting comfortable light. And even if inhabitants saw a slice of the bright sky or sun, the softly lighted adjacent wall surface would, by providing an intermediate level of reflected light, reduce the contrast in brightness and minimize glare.

For Louis Kahn, certainly from this point on, light had to strike walls. Kahn understood that we do not see light hovering in space. We occasionally see light as it emanates from a source, but more often we see it when it is reflected from a material or surface. For example, we see "skylight" as it is reflected by particles (material) in the earth's atmosphere—this reflective activity is what we call "the sky"—and more significantly for architecture, we see light reflected by walls, floors, and ceilings placed in the path of daylight. Kahn made architecture in order to see light, enabling his architecture to make its own light, fashioned from that provided by the sun and sky.

The space between the building and the wrapping wall became an inhabitable, daylighted zone, a place in which the diffused light could be reflected and seen. In this way, the nested composition logically evolved to emphasize the transition from outside and public space to inside and private space; it created a threshold. In Kahn's hands, the architecture became a source of light, in condition in which daylight and inhabitable space collaborated and became inseparable. The new layer of space, the zone in which light is mediated, provided the kind of spatial concentration that makes us feel suitably protected while simultaneously exposed, and enabling us to participate in the inside and outside world at the same time.

The question is, in his proposal for Luanda, Kahn's first effort at employing his wrapping strategy, how effective would it have been? In order for us to evaluate this, we need to understand glare and evaluate Kahn's daylighting strategy with reference to the sun conditions in Luanda.

Mitigating Glare in Equatorial Sun

One of the great propositions of early twentieth century architecture was that we could bring daylight into interiors by replacing load-bearing walls with columns and beams and by replacing exterior walls with envelopes of glass. This enabled interior space to be filled with daylight. The problem was that when sunlight penetrates unprotected glass, heat and glare are introduced in summer, and cold and glare are introduced in winter months. Kahn was aware of this problem and questioned the solution endorsed by his then better-known professional contemporaries in the 1960's, Edward Durrell Stone and Minoru Yamasaki. Kahn observed that

"Some of the buildings used piece work, grillwork…in front of windows…(the grillwork) was dark against the light; it gave you just a multiple pattern of glare…little pin points…of glare against the dark ribs of the grillwork. And that tended to be unsatisfactory. "[6]

Patterns of organized glare are acceptable in some situations, for example in the Mosque at Cordoba where daylight is incorporated into the intricate geometric patterns of wooden grillwork, partly for decorative reasons, and the grill is not prominent in our field of vision. But for general living and work conditions, glare is unacceptable. It causes the pupil in the eye to contract, admitting less light to protect the eye. The result of less light is less vision: glare is blinding. When this visual distress is added to warm air and the heat conducted by direct solar radiation, as in Luanda, the discomfort is multiplied.

Sun paths are significantly different from those conditions in the temperate latitudes. Over the course of a year, in Luanda and at other latitudes on or near the equator, the sun moves through *both* the northern and southern skies. The sun moves through the southern sky during December (summer) and through the northern sky after the March solstice until nearly the September solstice. These paths provide very high angle direct sun to both north and south elevations of a building. In the hours just after sunrise and before sunset, the angle of the sun above the horizon is low and directed onto the east and west elevations. Structures in these regions receive significant direct sunlight from all sides, and this calls for specific architectural responses.

The Consulate and the Residence

In fact, high sun, whether from south or north, is fairly easy to manage. In his design for the Consulate, Kahn proposed a parasol strategy, a "sun roof," as he called it, a trellis structure suspended above what he called the "rain roof," the roof structure and its weather resistant roofing material. The interception of direct sun by the sun roof and the air passing through the interstitial space would have helped the interior of the Consulate buildings avoid a substantial amount of direct solar radiation, heat and light. Kahn said,

I feel that in bringing the rain roof and the sun roof away from each other, I was telling the man on the street his way of life. I was explaining the atmospheric conditions of wind, the conditions of light, the conditions of sun and glare to him. If I use a device—a clever kind of device—it would only seem like a design to him—something pretty.

I didn't want anything pretty. I wanted to have a clear statement of a way of life [7]*…I thought wouldn't it be good if one could…find an architectural expression for the problems of glare without adding devices to a window…but rather by developing… [an] architecture…which somehow tells the story of the problems of glare.* [8]

The trellis would have been highly effective, but in other respects, Kahn's strategy remained underdeveloped. Typically, high angle sun is effectively shaded by roof overhangs, which are sometimes developed into porches or galleries. his strategy also permits low angle sun to enter and warm the building in cool seasons. However, Kahn does not use this approach at the north and south faces of the Consulate structures. Instead, he proposed nearly blank north and south elevations, with no fenestration and clipped his trellis, the sun roof, so that it ends in alignment with the exterior walls and cannot shade the north or south facades.

Kahn's wrapping walls create porches (at the ambassador's residence) and porch-like gaps (at the chancellery) and these spaces are protected overhead by his sun trellis, but only on the east and west elevations of the buildings. (Figure 2) They usually protect the inner building from high sun, but not generally from low angle sun at the beginning and the end of the day. Kahn's arched openings in the wrapping wall are large and so are the gaps between the wrapping wall and trellis. The interior rooms just inside the wrapping wall openings were to be substantially glazed. The arched openings do not align exactly with the inner glazed openings but are offset so that a good portion of the glazed window is overlapped by wall. So, at times the interior spaces would have been subject to intense solar radiation penetrating the openings and incident on the glass.

Figure 2. First floor plan of the chancellery with the north elevation at the top. (Drawing by Robert McCarter)

Not surprisingly, Kahn later reconsidered the size of the openings in the wrapping walls:

"I feel…that they're now a little too large, that they can be made smaller. It's only that I still haven't developed a kind of sense in lieu of experience to tell me whether they're large or small. I haven't developed this because they must be tried…I feel the openings should be smaller because you can…always have a side view. You can look out and see anything you want." [9]

Kahn's reconsideration is interesting. He seems to be saying that, at the chancellery, one might have stood on a west or east "porch" or in the gap between the building proper and the wrapper, and seen through smaller openings facing east or west. The alternate "side" views toward north and south into the intermediate or wrapped spaces--the two-story gaps--and toward high-altitude sun would have revealed skylight and limited sun to grazing the inner faces of the walls. Direct views out of the rooms would have been restricted but would still have been available from other rooms or from within the wrapped zone, where one might, "look out and see anything you want."

In fact, this strategy of openings to sky and light, but not directly exposed to the sun, is suggested by the rooms located on both floors at the middle of the west side of the chancellery. Note that glazed windows in these rooms face north and south into the protected gap between the inner and outer walls. Shaded by Kahn's trellis and stepped back from the perimeter of the building, those rooms would have received diffused skylight and sunlight reflected from building surfaces. Similarly, the deeply recessed, two-story entry areas centrally located on the north and south sides of the chancellery would have gathered skylight with sun filtered by the trellis before diffusing it toward limited and reasonably protected glazing. In general, this strategy of spaces with opaque wall surfaces facing the sun and with glazing limited to walls at right angles to the opaque surfaces would be an excellent approach to the problems of sun, glare, and heat in this climate.

But to take this one step further, this thinking suggests that the building would have been an even more effective diffuser of daylight if the plan were rotated 90 degrees from that which Kahn had planned. (Figure 3) As for his musings about smaller openings, there are other factors in the design of openings that are equal to or more important than size. The locations of openings relative to an interior room and its reflecting surfaces, the shapes of openings, and the orientation of openings toward sun and skylight are probably more significant. (Figure 4)

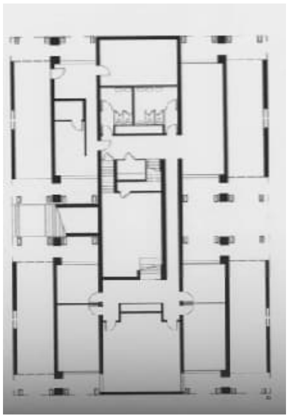


Figure 3. First floor plan of the chancellery with the plan rotated 90 degrees so that Kahn's intended north elevation is now oriented to the left and, by convention, facing west. (Drawing by Robert McCarter)

Figure 4. Model view of the Chancellery from southwest, as Kahn intended. Imagine the south (right side) elevation as if it were the west or east and the west (left side) elevation as if it faced north or south.

If the chancellery were rotated 90 degrees, the sizes of the openings would not matter much. In this hypothetical reorientation, this composition of porches or doubled exterior walls, and the trellis, would work well. The double-wall zones would filter high sun and receive diffused skylight from the north and south skies. The reoriented opaque east and west elevations, formerly vulnerable to low-angle sun, would occlude sun that cannot be blocked effectively by overhangs. The deep entry spaces, now facing east and west, would present opaque wall and floor surfaces to catch low angle sun and to diffuse the light into appropriately located glazing. These spaces would be shielded from high sun by the trellis overhead. Initial simulations indicate that with the alternate orientation, only the glazed rooms on the “new” north elevation would receive direct sun and then mostly at the rooms’ forward edges, and from sun sliding into the gaps between the outer wall and inner building—not usually through the arched openings. With the rotated orientation, Kahn’s bilaterally symmetrical plan would work quite well.

Having expressed a skepticism toward grille work and having considered, if in retrospect, smaller openings, it is interesting that Kahn later considered large, operable, wood shutters, at least at the Consulate Residence, which would have been located immediately north of the Chancellery. Previously unpublished drawings prepared in the Kahn office and dated February 1961, near the end of the project, show east and west elevations with shutters filling balcony openings, in partially open and closed positions. The office went so far as to show the shutters detailed in large-scale section drawings and referenced them in written outline specifications. [10] Undoubtedly, Kahn would also have considered the need for more privacy in the Residence, but clearly, late in the design process, the architect was still struggling with the problem of glare and thermal control strategies.

The Consulate design, as we know it, must be considered incomplete: Kahn lost the commission in August 1961. However, given the opportunity, it would be safe to speculate that he would have continued to refine the scheme as it came closer to construction, as was his habit. [11] Nor does this discussion take into account the progress he made in his comprehension of daylight and other design issues as he took up subsequent commissions for projects that permitted him to study daylight further. This was only Kahn’s initial look into this approach to daylight.

Community and Social Responsibility

Much of Louis Kahn’s reputation is based on his passion for and deft handling of daylight. But Kahn’s architecture about more. Kahn was deeply engaged with other architects and critics in the development of a modern version of architectural monumentality, the recognition of the significance of people, events, places, and contemporary public institutions through specific design strategies. Even more important, Kahn was committed to a firm social agenda and the establishment of community: the potential to represent the shared aspirations of common men and women through architecture and town planning.

Kahn understood the disadvantages of poverty, immigrant and outsider status, and membership in a persecuted ethnic and religious minority—he experienced all of this himself. Kahn sought to address these conditions through architecture. Sarah Williams Goldhagen has referred to this as Kahn's "long standing desire to create an architecture that would become a symbol of communal identity and encourage communal participation. [12] Eventually in Kahn's work, the streams of thought—the demands of daylighting, the interest in monumentality, and the significance of community—converged. Taken as a whole, these insights, manifested in Kahn's maturing architecture, reveal much about the man, as well.

Early in his career, Kahn applied himself to these circumstances through his work as a planner. He worked with the Philadelphia Planning Commission (1933-1935) and the remainder of that decade as an architectural consultant to the Commission and involved in neighborhood planning; he was convinced of the ideals of collectivism and social activism. He collaborated with his partner, Oscar Stonorov to publish pamphlets such as *Why City Planning* and *You and Your Neighborhood: A Primer for Neighborhood Planning;* and wrote letters to the editor of *Architectural Forum.* These writings encouraged local citizens to involve themselves in city planning processes by establishing neighborhood planning councils. Kahn gained recognition as a designer of public housing and an aspiring urban planner. [13] In his middle years, Kahn's design portfolio included commissions for buildings with social programs such as housing and community structures, and health facilities for two labor unions. During the mature period of his career in which he produced his most articulate work, his projects continued to address a range of cultural and educational missions. All of these programs explicitly recognized and celebrated the lives, aspirations, and cultural significance of common people. Goldhagen has written that

"Kahn fused his feelings about his own Jewishness with his response to contemporary trends in American religious culture to arrive at an explicitly non-transcendental religious ideal, which extended his conviction that each individual should participate in a community as a means to a richer, more responsive polis." [14]

Monumentality

Monumentality in architecture is an expression of some kind of greater significance, usually of a recognized political or social event. Kahn realized that it might be possible for a monumental architecture to represent the importance of the lives and aspirations of common people. Interestingly, Kahn's essay, "Monumentality," rarely uses the term. After four mentions on the first two of its ten pages, that word, or forms of it, appear but once in the middle and once right at the very end of the text. The article is really an inquiry into authenticity; it speaks of materials, how they perform, and how a particular material does its best work when employed appropriately. [15] Kahn wrote about how buildings might work rather than how they look. This attention to essential qualities and performance would later become the essential ingredient in Kahn's "monumentality" as his ideas were transformed into his great buildings. In the same way that he looked to his community of working people to inspire and inhabit his institutions, he looked to common materials, and how they work, to conceive his monumental spaces. He wrote:

"Neither the finest material nor the most advanced technology need enter a work of monumental character for the same reason that the finest ink was not required to draw up the Magna Carta." [16]

Kahn's discussion of materials includes, of course, steel, glass, concrete, and stone, but also notably, daylight. Daylight has long represented truth (light itself), enlightenment (understanding), and authenticity (undisputed honesty). Daylight is both that which is most common in our world and that which is transcendent. It is ever present, yet difficult to capture for any length of time, which ironically, lends it the characteristic of rarity. Light expresses both the everyday and the sublime, and both tendencies are present in Kahn's architecture. The weight of his architecture, as depicted in his hand drawings or as built, heightens the sense and presence--the monumentality--of weightless space and light. Kahn said that "the making of spaces is the making of light at the same time." [17] Space, too, can be understood as "monumental" when configured by Kahn and then seen in terms of its significance. The elements that constitute its configuration, including enclosure, proportions, the clarity and authenticity of the volume, serve to render space and its captured light and shadow as something of monumental significance; in Kahn's hands, space and light are ennobled.

In the 1950's," according to Goldhagen, Kahn sought to harness the authenticity of structure and fuse it with his ethical convictions. She writes that Kahn thought, "…architecture should perform the specific social role of symbolizing and reinforcing communal identity. He needed to move to an idiom that merged the authentic with the monumental and the symbolic." [18] Kahn's architecture eventually transformed the language of monumentality from one that had previously celebrated singular privilege into a vocabulary that operates in the service of real lives. The Consulate complex in Luanda, when it was designed, was perhaps Louis Kahn's most complete and coherent expression of these slowly converging interests.

About Face

The design of the United States Consulate in Luanda came to an unresolved end, it is fair to say, because it was never built; it was the end of construction that typically concluded Kahn's design process. It was not built for a number of reasons: the U.S. State Department's impatience with Kahn's lengthy design process; that agency's dissatisfaction with, and inability to understand, the design; [19] and perhaps the outbreak of the Angolan war for independence that began in 1961. [20] However, the project remains important for what it reveals about the architect and his work.

In the project for Luanda, practical concerns about daylight and glare led Louis Kahn to devise a daylighting strategy with implications well beyond those pragmatic concerns. Kahn's architecture was very much about daylight, but not about achieving specific recommended levels of illumination at some point in space. The work is about light as it conjures space, which eventually led to decisions about materials, building performance, circulation, structure, and to the resolution of Kahn's questions about meaning, monumentality, and the social significance of public institutions. It is this work with light that enabled him to uncover something important about the potential for meaning in modern architecture and to develop an ethical position relative to people and architecture. And, it is through this process that the architect also revealed himself and that we may realize a new understanding of the man.

All artists reveal something of themselves in their work. This is inescapable: we all reveal ourselves in what we do. Although these considerations are spoken of in an undertone in architecture, they are central to understanding work in the other arts and even in science. How could what we make or how we behave not be a reflection of who we are? As Stephen Greenblatt says of his scholarship on the work and life of William Shakespeare, "I believe that nothing comes of nothing, [21] even in Shakespeare. I wanted to know where he got the matter he was working with and what he did with that matter." An architect's work is a mirror of his or her character, powerful, non-verbal evidence of a life and beliefs. It may even be that the more articulate and insightful the architecture, the more revealing it is. So, as with makers of all manner of things, Kahn's buildings can be said to be reflection of their architect.

Kahn's elegant wrapping walls, revealed in daylight and shadow and exposed to the world, are highly abstracted and perfected expressions of sometimes tangled, but authentic, human activity. Like our faces, or masks, walls may be employed to create an impression; they even camouflage, but often end up doing the opposite: they reveal unseen truths. In the case of Louis Kahn, the interior workings of his architecture--even wrapped with highly refined geometries and the elegant use of materials, contain—doubly enveloped—the inevitable messiness of human work and habitation, the disorderliness and unpredictable patterns of human activity, now clothed impeccably. This can be seen clearly in Kahn's late buildings, in Ahmedabad, Dhaka, and La Jolla, where the works draw their second skins around themselves, becoming the "wrappers" referenced in the now axiomatic, "buildings wrapped in ruins." These works are the direct descendants of Kahn's Luandan strategy of intercepting sun with secondary wall surfaces, and the development of the architect's perfected expressions of the buildings' inner lives.

The façade is the most exposed and initially revealing part of a building and it is the same for a façade's creator. With this in mind, it is reasonable to ask, what did Kahn see, every day, when he saw his own face, and how did this reflect his outlook on the world? Kahn's early life was one of difficult circumstances. He was raised in poverty, an immigrant burdened with religious minority status. Even as a qualified professional he was an outsider, "a Jew working in a protestant gentlemen's profession." [22] Moreover, he was a physically unimposing man. As an adult, he stood about five foot seven inches tall, [23] with receding white hair and a scarred lower face, the outcome of a childhood accident in which he grabbed at the glowing coals in a fireplace. [24] The evidence of his complex and imperfect family relations is now well known and has been documented on film by his son. [25]

Figure 5: Louis I. Kahn, self-portraits

Clearly, the attraction Louis Kahn held for others and his influence over them was a demonstration of charisma, personal wisdom, his artistic and musical talents, and a kind of fineness that emerged from an inner, but beautiful, messiness. If only Kahn could have created a face for himself that fully expressed that inner beauty! He could not change his own face, but he did so for others in his architecture, providing for his buildings and the people who inhabit them a perfected version of themselves, and in a sense, of himself, for all to see. Who else but an individual with a less than perfect face, and with the finest, if conflicted, heart and mind, would have been open to understanding how inner beauty needed to be translated to the façade? Interestingly, the way he spoke in public about his work also seems to have been a redirection from reality, the daily disappointments and compromises of architectural practice. Kahn's talks concentrated on larger, nearly philosophical thoughts that veiled the everyday professional struggles. Kahn, renowned for speaking in great, glowing language about architecture, inspired many but confounded others, such as his partisan Vincent Scully, who referred to Kahn's rambling talks as "a smoke screen around his actual methods." [26] Kahn's building facades screen inner conflict, uncertainty, and daily chaos, as much as they reveal aspiration, contentedness, concord, and decency. Kahn alluded to this, citing Jorn Utzon's Sydney Opera House as an example, and rendering the relationship between its inner life and public persona in this way:

"It was approached…by a cascade of steps that gave you a sense of the ceremonial--seeing that which is not…formally real but internally real, as though the truth was being brought before you…" [27]

Louis Kahn's double life is well known; the story is told by his son on film with the empathetic participation of his sisters, each a child of a different mother. It might be more accurate to say that Kahn had multiple lives, counting not just his three families, but also his intense intellectual life, which formed the basis of his architecture, lectures, and writings; and his office life, which contained the facts of his transforming his intellectual life into built form. Kahn's insight was to make an architecture of several lives, with layered orders of space, so that each life might be given its own space and a sense of belonging: an acknowledgement that the competing elements of our lives might be recognized as deserving of a place in the world. Kahn's layered spaces, rigorously defined orders, proportioned rooms, and geometrically refined openings, organize our lives by giving each its place and lending us the impression, at least temporarily, that they all make sense.

Andre Malraux wrote: "Man is not what he thinks he is; he is what he hides." [28] Who but a man with visible facial imperfections, who struggled early and faced and mature life conflicts, but with a mind that generated beautiful ideas about how people could live together, would fully, if perhaps subconsciously, appreciate the value of presenting to the world a new, more perfect face for himself and for his buildings? Through their work, artists have the opportunity, to present to the world their best natures, perfected versions of their unfinished selves. Kahn's architecture presents us with an idealized, yet in some ways more complete, version of himself. He devised for his architecture, and through architecture for himself, new faces that revealed hidden truths, those of his and our unruly, but noble, inner lives. He achieved this through his understanding of daylight acquired through his work at Luanda. Kahn's architecture was illuminated by daylight from the outside so that it seemed to emanate from interior space. Kahn, too, shone most brightly from the inside and, judging from his architecture, he must have believed that others do, too.

Acknowledgement

The author wishes to acknowledge the research assistance of Ms. Julia Jovanovic.

References

[1] Latour, Alessandra, editor, *Louis I. Kahn Writings, Lectures, Interviews*, Rizzoli, New York 1991; p. 122

[2] Latour, p. 123

[3] Latour, p. 123

[4] Latour, p. 123

[5] “An as-struck smooth grey Portland cement surface may have a reflectance of 40%,” but with some care and the appropriate materials, such as white cement, reflectance may reach 70. The Concrete Society, http://www.concrete.org.uk/fingertips_nuggets.asp?cmd=display&id=916; retrieved January 3, 2014

[6] Latour, p. 122-123

[7] Latour, p. 126

[8] Latour, p. 122

[9] Latour, p. 125

[10] Louis I. Kahn Collection, Architectural Archives of the University of Pennsylvania; folder 555A, 030.I.C.555.001; pencil drawings on tracing paper

[11] Wiseman, Carter, *Louis I. Kahn: Beyond Time and Style*, W.W. Norton & Company, New York, USA, 2007, p. 114

[12] Goldhagen, Sarah Williams, *Louis Kahn’s Situated Modernism*, Yale University Press, New Haven, CT, USA, p. 122

[13] Goldhagen, pp. 18-24

[14] Goldhagen, p. 91

[15] Kahn, Louis I., “Monumentality,” in *Louis Kahn, Essential Texts*, (Robert C. Twombly, editor), W.W. Norton, New York, USA, 2003, page 24. Kahn wrote, “The I-beam is an

engineering accomplishment deriving its shape from an analysis of the stresses involved in its use.…under test it was found that even the fillets, an aid in the rolling process, helped convey the stresses from one section to another…"

[16] Kahn, "Monumentality," p. 22

[17] Kahn, Louis I., "Talk at the Conclusion of the Otterloo Congress," *Louis Kahn, Essential Texts*, (Robert C. Twombly, editor), W.W. Norton, New York, USA, 2003, p. 48

[18] Goldhagen, p. 63

[19] Hughes, William P., Letter from William P. Hughes, Director, Office of Foreign Buildings to Kahn dated Aug 26, 1960, Louis I. Kahn Collection, Architecture Archives, University of Pennsylvania, Box 34, Folder 28: "Before going further into the details of your work on this project, I deem it advisable to point out to you certain very serious functional problems that appear as a result of our review of these sketches. Our main objections are as follows…The proposed roof construction is considered expensive and unnecessarily experimental, if not bizarre.... Particularly we do not like our public buildings to be planned as windowless buildings nor do we like them to have a fortress quality."

[20] Henderson, Lawrence W., *Angola; Five Centuries of Conflict,* Cornell University Press, Ithaca, NY, USA, 1979, p. 199-201

[21] This position may be traced to Lucretius, who pointed out that "Nothing from nothing ever yet was born." Lucretius, *On the Nature of Things*, Book I, 50 BCE, (translated by William Ellery Leonard), http://classics.mit.edu/Carus/nature_things.mb.txt, retrieved August 11, 2021

[22] Kahn, Nathaniel, "My Architect Press Kit," http://www.myarchitectfilm.com/presskit/MyArchitectPressKit.pdf, retrieved June 14, 2012

[23] Louis I, Kahn's 1928 passport is accessible at http://www.upenn.edu/gazette/0107/feature1_2.html, retrieved October 18, 2013

[24] Wiseman, *Louis I. Kahn: Beyond Time and Style: a Life in Architecture*, W.W. Norton and Company, Inc., New York, USA, 2007, p. 14

[25] Nathaniel Kahn, director, *My Architect*, New Yorker Films, New York, USA 2003

[26] Brownlee, David B., and DeLong, David G., *Louis I. Kahn; In the Realm of Architecture*, Rizzoli International Publications, Inc., New York, USA, 1991, p. 127; citation of an interview with Louis Kahn in by Alessandra Latour, *Louis I. Kahn, L'uomo, il maestro*, Edizione Kappa, Rome, Italy, 1986, p. 149.

[27] Steeley, Melissa, and Whitaker, William, editors, "Conversation between Louis I. Kahn and Doris Fisher; A House within a House," *Architecture and Urbanism (a+u),* number 461, February 2009, p. 48. The article is a transcription of a conversation that took place at the Fisher House on March 8, 1970.

[28] Siegel, Lee, "We Are What We Hide," *The New Yorker* online, http://www.newyorker.com/online/blogs/books/2013/11/we-are-what-we-hide.html?mbid=social_mobile_email; posted November 15, 2013

2D-3D DATA FOR MACHINE LEARNING - PROBLEMS AND METHODS

Sandra MANNINGER*, Matias DEL CAMPO

*School of Architecture & Design, New York Institute of Technology
1855 Broadway, New York, NY 10023, USA; smanning@nyit.edu
and
Taubman College of Architecture & Urban Planning, University of Michigan
2000 Bonisteel Blvd, Ann Arbor, Michigan 48109 USA; mdelc@umich.edu

Abstract

With the ubiquitous emergence of machine learning (ML) into daily life there is no question that these methods have entered the field of architectural conception, design, and production but it is still not certain how these techniques should be implemented. One particular problem within designing with artificial intelligence is the availability of data. Most ML experiments are conducted through 2D imagery, and the challenge is to translate this ML generated 2D imagery into 3D designs. This paper introduces ways to establish a 3D dataset for housing projects, its challenges and progress.

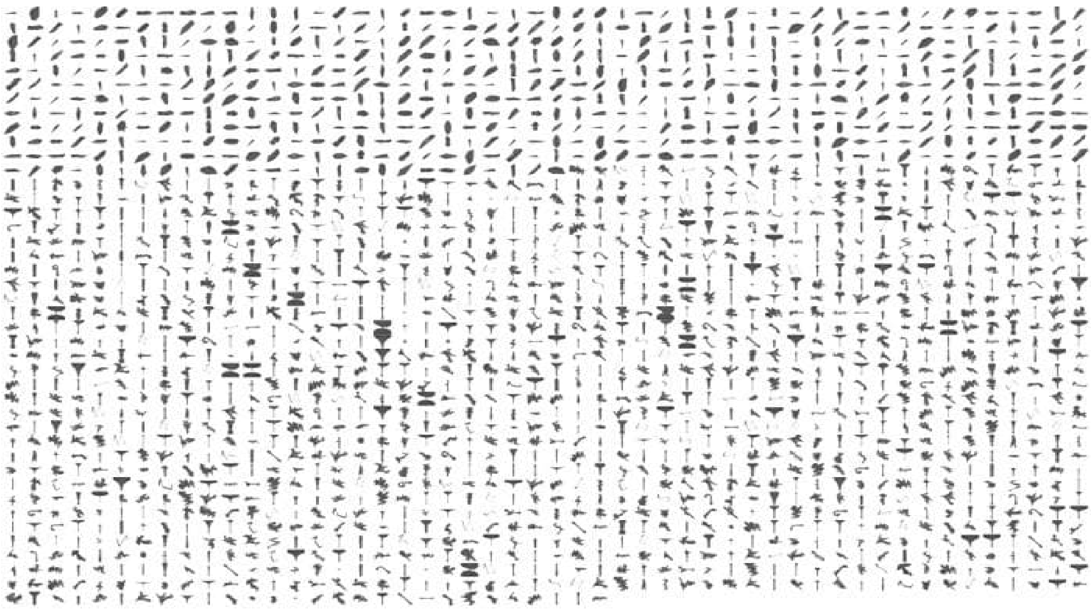


Figure 1. Small Dataset displaying models of columns and houses for a graph convolutional neural network (GCN).

Keywords: Architecture Design, Artificial Intelligence, Automation, Data, Machine Learning

1 Introduction

The recent rise of Machine Learning (ML) applications in architecture design has uncovered a specific flaw in the method: the lack of architecture-centric datasets. The architecture discipline counts among the oldest disciplines with a continuous history of production. In theory, architecture can look back to a plethora of examples, and possible data points, in its own 2000+ years of history. It seems obvious that because of this wealth of data, there must be an abundance of datasets that can be used as the point of origin for countless novel architecture designs. Paradoxically, this is not the case, as architecture, in contrast to other disciplines, can be considered data poor. Why? Because of the lack of qualitatively annotated data. There are indeed some examples out there of plan datasets, such as Cubi Casa and the Zillow database; however, the problem with those datasets is that they were not annotated by architects and thus lack the critical agencies to assess the architectural quality of the data. Datasets that are not, at least at the beginning, interrogated for the quality of the semantic information can not produce any qualitative results. The ancient computer science mantra “garbage in, garbage out” is true for the vast majority of architecture dataset building and subsequent applications in Machine Learning processes.

1.1.

This brings us to the problem of plan annotation. Why annotate at all? Could we not use an unsupervised method to achieve the same result? Well, yes, but with two huge caveats. For one, to achieve a result that is representative of the semantic information in the plan, i.e. what is a living room, what is a sleeping room, what is a kitchen, etc., the training set would have to be enormous. The more examples are provided, the more precise the unsupervised learning model can understand the various elements of a plan. Millions of examples would be a good starting point. Well - where to get so many plans? Scraping the internet does not produce that many plans - of the kind that are useful for this process. The authors of this paper have tried it to no avail. The second large obstacle in the creation of well-informed datasets for architecture is that it is necessary to create individual datasets for every single architectural program. One for housing, one for hospitals, one for schools, one for offices, etc. At least for now, we can not create a uniform ‘global’ architecture dataset. This brings us to the point of manual annotation. The authors used a combination of crowdsourcing and students who were compensated for their efforts in annotating plans; more about it in section 2.1 ‘crowdsourcing.’ In the following, the author would like to offer a closer look at the process used to create two particular datasets: the Common House and the Model Mine dataset.

2 Introduction of methods

The creation of datasets particularly designed for architectural applications can be traced back to Stanislas Chaillou’s thesis project at Harvard GSD in 2017. With this project Chaillou delivered a proof of concept project for the use of neural networks trained on architectural data. In his thesis, the annotation of the plans was manual labor - no unsupervised learning was applied. This is also visible in the raw, unprocessed results. The resolution was very low, and the results were hard to read. Interpretation was part of the process. Chaillou most certainly had to post-process the results to get readable plans. Since 2017, the process has made huge steps forward, not lastly by the work of the authors. The relentless testing and pushing of the resolution have improved the legibility of plans. The manual annotation is of crucial importance to maintain the architectural integrity of the results. In 2021, with the founding of the AR2IL laboratory, two particular projects became the main focus of the work in the lab: the Common House dataset and the Model Mine dataset. Whilst the first one addresses apartment plans, the latter consists of a dataset of 3D models of one-family housing units in the form of obj meshes.

2.1. Crowd Sourcing

Right at the beginning of launching the AR2IL 2021, we published a global call to collect annotated plans. The idea developed together with people from Michigan's Computer Science and Robotics department, basically suggested a communal effort to annotate as many plans as possible. This approach has a series of advantages. Apart from the chance to grow the dataset fairly quickly, the inclusion of people from all over the world to join the labeling effort can help curb the possibility of the creation of a dataset only appeasing a Western architecture audience. In other words, we tried to reduce the bias of the dataset towards Western architecture. A problem that every other attempt to create datasets for Architecture has experienced so far. To increase the diversity of the datasets, participants were also allowed to upload plans from their own cultural contexts. The idea of addressing the problem of cultural bias in AI datasets was inspired by Katherine Crawford's Atlas of AI' and the a study analyzing the COMPAS parole algorithm. It is not a trivial problem. Right now, at the beginning of the development of AI tools for architecture design, is the right time to address this problem. To the astonishment of the authors, the awareness of the crucial role of datasets within any form of AI application is, unfortunately, rather underdeveloped within the architecture discipline. We hope that with the work we are doing with the AR2IL lab and papers like the present one, we can increase the awareness of how important datasets are and how much of a role databias play in creating (again) disadvantages for minorities and underrepresented populations - not to speak of gender bias. That is why we aggressively pursue the inclusion of various cultures in our datasets. It is also possible to critically interrogate this approach. The reason why we are engaging in cultural diversity was answered in the lines above. The next question would be 'what is the goal? what is the result?' Following the logical string of 'ontology - epistemology', the question is entirely reasonable. Here is where things become a bit murky, as we are literally navigating uncharted territory, or staying within the terms of computer science, we are exploring the latent space of cultural production. The latent space denotes the area that neural networks are able to create between known data points, thus allowing humans the opportunity to discover unseen solutions. Regarding the question of cultural bias - would that mean that by mashing up different cultures, we are potentially creating a re-interpretation of the International Style? The authors would argue that no, that is not the case, as the goal of the International Style was to create a uniform architectural language for every point of the planet. The complete opposite is the case with results using global datasets.

2.2. 2D Plan Datasets

Circling back to the dataset collection techniques.

As mentioned before, we had a two-prong method of collecting data. Crowdsourcing and paid students. In both cases, the same interface was used. We used a labeler that is openly available on GitHub called the 'Django Labeler' developed by Brite Fury.The labeler is scripted in Python and was originally designed to allow for the creation of segmentation datasets. Segmentation datasets are a crucial tool when creating image segmentation data used, for instance, in automatically driving cars. They aid computational systems in recognizing the difference between, for example, the street, the next car, pedestrians, bikers, etc. Our team remodeled the labeler to comply with architectural needs i.e., putting together a long list of possible programmatic elements of apartments. See the full list in Figure 1:

● Balcony/Terrace/Loggia	● Dressing room
● Bath	● Elevator
● Bedroom	● fireplace.
● Dining	● French_Window
● Door(exterior)	● Garbage
● Door(interior)	● OpenToBelow
● Entrance	● Sauna
● Entry	● Stable
● Hallway/Corridor	● Stairs
● Kitchen	● Study/Home_Office/Office
● Living_Room/Den	● SwimmingPool
● opening	● User-Defined/Entertainment/Recreation_Room
● Shaft	● Vestibule/Draught_Lobby
● Storage/Pantry	● Walk-In Closet
● toilet	● basement
● Undefined	● DressingRoom
● Utility	● Hall
● Wall	● HotTub
● Wardrobe/Closet	● laundry
● window	● Lounge
● Carport/Garage	
●	

Conservatory/SunRoom/greenhouse/Winter_Garden ● TechnicalRoom	● Railing ● Ramp ● RetailSpace ● StairWell

2.3 3D Model Datasets

The lack of 3D datasets that are fir for use in Neyrla Network applications is clearly visible. Current explorations in this area, are conducted by architects, and primarily focus on two existing datasets. Meshnet and Modelnet. Both datasets only contain a neglectable number of building examples, thus making it very difficult to train any machine learning process able to produce robust results. The results tend to be overfitted, thus not being able to provide meaningful results. Thus the current examples we see in architecture research tend to be trained on chairs or airplanes, as those are present in high enough numbers in the datasets to produce viable results. With this in mind, the AR2IL laboratory took up the mantle to create a dataset of one-family housing projects as proof of concepts for 3D Neural Network applications in architecture design.

The approach is similar to the example above of the 2D dataset 'Common House'. A two-prong process involving volunteers for a crowdsourcing approach, and paid students creating models for the dataset. The ambition was (and still is) to create a dataset with more than 10.000 models. In a preliminary experiment, the authors created a smaller dataset of 1500 columns and houses, which were used to perform feature recognition and model creation using a Graph Convolutional Neural Network. The result of this project was 'House Alpha'. The main difference between the dataset 'Model Mine' and the dataset for the 'Alpha House' is the fact that the 'Alpha House' dataset was entirely modeled and labeled by one hand, thus presenting a very subjective method, vs. the 'Model Mine' which is an attempt to create an objective dataset that tries to avoid the biases of an individual designer.

Not every 3D model is fit for the dataset. We can not just scrape the internet to find a number of models from various 'free obj' sites, or just collect BIM models for the purpose of assembling a dataset. The reason for that is that the models have to comply with a series of premises to be fit for any use in NN applications. They have to be watertight, they are not allowed to exceed 10.000 faces, they all have to be of the same scale, and they have to be oriented correctly. In order to streamline the process, an online model checker, programmed in Python, was introduced, that allowed participants to check their models, before being admitted into the dataset. One of the disadvantages of the method, is that the models have to be hollow polygon shells, without the interior. This is, unfortunately, one of the main caveats of using NN's, they either can operate with the exterior, or the interior, but not with both at the same time. A concatenation of two processes might be the remedy in future research. After reaching 1500 hand-generated models, it was possible to introduce a series of synthetic dataset augmentation methods, derived from applications in Grasshopper. This allowed a fast growth of the dataset to almost 10.000 models.

There are other attempts of creating 3D model datasets, using, for example, 3D scanning, but they have the massive disadvantage of overly heavy model, with millions of CV points, thus rendering them too big for any meaningful machine learning application. In our case, the focus is on two particular machine learning processes using 3D models: 3DGraphCNN and TreeGAN.

The output of the process can be considered a first step into successful 3D GAN applications, based on native architecture 3D datasets. They are far frm perfect, but this is true for any novel approach in using machine learning in architecture design based on novel concepts. It can serve as a starting point for further interrogation. The aforementioned possibility to concatenate various processes to achieve robust results is certainly the next step to achieve results that are easier to implement in an architecture design pipeline.

2 Conclusion & Outlook

It is astonishing that architecture is a data-poor discipline despite the fact that it has in its possession several thousand years' worths of examples. What sounds like a contradiction seems clearer if observed through the lens of Machine Learning (ML). Applications that are based on Neural Networks (NN's) such as the entire family of Generative Adversarial Networks (GAN's). These algorithms are profoundly data hungry[3]. However, it can not be just any data if specific ML approaches are considered. In order to achieve robust, qualitative results, the data has to be prepared accordingly. The example presented in this article is the dataset “Common House”, that is currently under construction. The dataset is designed to provide the basis for a multitude of generative planning solutions in particular for housing projects. Why not use existing datasets? There are examples such as Cubicasa[4] and the Zillow indoor dataset[5] that provide thousands of annotated plans. The problem with these datasets is that they were created with minimal involvement of architects, and thus do not contain the inherent expertise to evaluate the plans through the lens of qualitative architecture. This means that for example a GAN trained on these datasets would inherit the flaws contained in the semantic information of the dataset. Thus potentially generating bad plans. The old axiom in computer science “Garbage in, Garbage Out” is still very much valid today. One of the major concerns in creating the dataset is the minimum size of the dataset necessary to avoid performance deterioration and model collapse. In the full article we would discuss the differences between supervised, unsupervised and reinforming learning, and the data necessary to achieve those. The discussion also contains a section on the advantages of data efficient algorithms as the base of further development. It seems unrealistic to achieve the scale of, for example, ImageNet, in regards of labeling in architecture. Especially if considering aspects of equality, ethics, diversity and inclusion in data harvesting.

We used the dataset, annotated by a group of students and performed initial analysis to use it as a dataset for floor plan graph generation. The hypothesis here is that we can treat a floor plan as a graph and use techniques from Graph Generation for the problem. The graph illustrated in figure 1 shows how we can transform a floor plan into a graph. We are currently working on this specific use case and experimenting with using Generative Adversarial Networks for the floor plan generation.

The Dataset will be publicly available, once the harvesting is far enough that the dataset can fulfill its role in plan generation. One of the major findings so far was the possibility to reverse the nature of annotated boxes describing spaces towards the use of graphs to describe space. This approach gives much larger freedom in the resulting design. Meaning that instead of learning that an apartment consists of a series of connected boxes, the NN learns that it is a graph of particular functions. Thus providing the user with the possibility to switch between open and closed plan generation. The approach of using a graph instead of boxes allows also to expand the idea into 3d, by providing a possibility to create a Raumplan.

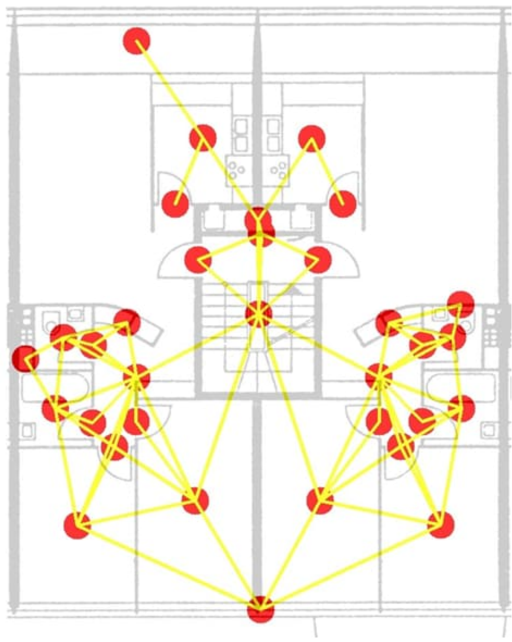


Figure 2 Typical floor plan from our dataset

The approach presented in this article is dependent on the participation of architects and architecture students worldwide. At the moment the mindset to understand the value of data for ML applications is not yet far developed in architecture, thus participation in the effort to create datasets particularly geared towards architecture design is underdeveloped. Circling back to the beginning of the paper, we would like to provide a simple example: Googling the term "Plan" returns more than 7.2000,000,000 (!) results. The CubaCasa dataset has about 5000 annotated plans, Common House has currently around 1300 annotated plans. The data is there, but the discipline has to put the work in mining its own history. Or as Pedro Domingos put it: *"If you want to be tomorrow's authority, ride the data, don't fight it."*

Acknowledgements

The authors would like to thank Taubman College of Architecture and Urban Planning, and NYIT for the generous support in conducting this research. The authors would like in particular to thank ArtsENGINE at the University of Michigan, UMOR-TCAUP RCI Award and the continuous support by Dean Jonathan Massey and Associate Dean of Research and Practice, Prof. Kathy Velikov. A special thank you to Prof. Justin Johnson (Computer Science Department of the University of Michigan) Prof. Jessy Grizzle (Michigan Robotics), Dr. Alexa Carlson (Ford), and the many volunteers worldwide and students of Taubman College helping to make this project a reality. Janpreet Sing for coding the online model checker

References

[1] Author(s)[1], Paper title, *Journal title*, *Volume number*, (Year), Issue, pp. xx-yy, DOI number[2]. (for Journals)

[2] Author(s)[1], *Book title*[3], Publisher, City, Country, Year (for Books)

[3] Author(s)[1], Chapter title, in *Book title*[3], (Editor(s) of the book)[4], Publisher, City, Country, Year, pp. xx-yy (for Chapters)

[4] Author(s)[1], Paper title, *Proceedings*, Proceedings information5, Conference, City, Country, Year, Volume[6], pp. xx-yy (for Proceedings, Transactions, Book of Abstracts)

[5] Author(s)[1], Thesis title, Thesis rank, University, City, Country, Year (for Thesis)

[6] Author(s)[1], Report title, Report number, Institution, City, Country, Year (for Reports)

[7] Author(s)[1,2], Title/Data/Institution, Link (for Literature or Data on web Sites and Documents without Authors)

[8] Owner(s)[1], Title of patent, Patent number, Year (for Patents)

---

[1] Last name, Initial (optional), First name

[2] If exist

[3] Title in original language or in transliteration, the English translation in parentheses with the indication of the original language

[4] Editor(s)[1] (in parentheses)

[5] (Name(s) of the editor(s), if exist, in parentheses), Title of the publication if it is not the same as the title of the meeting

[6] Only for Transactions

A MODERNIST CULTURAL HERITAGE CHALLENGE: JMM BUILDING IN RIO DE JANEIRO.

Andrea BORDE, Alexandre PESSOA

Federal University of Rio de Janeiro

Av. Pedro Calmon 550, Cidade Universitária, Rio de Janeiro, Brasil.
andrea@fau.ufrj.br
alexandrepessoa@fau.ufrj.br

Abstract

The Jorge Machado Moreira (JMM) Building is a remarkable edifice of the Federal University of Rio de Janeiro (UFRJ) in the insular University City. It has been the headquarters of the Faculty of Architecture and Urbanism since 1961. This masterpiece of the university's modern cultural heritage house, from the end of the 1960s, has two other academic units, the Central Administration and a Deanship. The sharing of spaces took place without considering the compatibility of uses and without prior planning. That was the scenario in 2016 when a fire and a flood swept through the main block. This paper seeks to unveil the factors contributing to these risks and the measures that can be adopted to reverse this situation. To this end, this research adopted a methodological approach oriented by the history of the building and its cultural significance.

Keywords

cultural modern heritage; university buildings; architectural conservation

1 Introduction

The Jorge Machado Moreira (JMM) Building is a remarkable university's modern cultural heritage that has been the headquarters of the Faculty of Architecture and Urbanism since 1961. This edifice, located in the University City of the Federal University of Rio de Janeiro (UFRJ), has undergone successive reorganizations of its internal spaces to accommodate the Central Administration, a Deanery and other academic units. A process that, if not wholly mischaracterizing it, has contributed to the risks and accidents that have hit since 2016. This building is the icon of the modern UFRJ.

The JMM Building constitutes a relevant case study regarding the challenges of conserving the modern university heritage. Furthermore, the sharing of actions and practices adopted in favour of its conservation can become a living laboratory of heritage education for the university staff (Students, professors, employees and all the public that enjoys the university facilities). The biggest challenges, in this sense, are the still incipient knowledge, for the demand, of the methods that can be adopted for the preservation of the buildings in glass and reinforced concrete of the modern heritage. The lack of means to enable projects to recover the physical integrity of modern structures and for their preventive maintenance not to mention the fortuitous — but not unpredictable — events that affect modern university facilities, such as those that have damaged the JMM Building since 2016.

In October 2016, a massive fire swept through the top floor of the taller block of the JMM Building and damaged almost all the floors below. In November 2016, a flood reached the first two floors. These events exposed the fragility of a building conceived for educational use that inappropriately received administrative facilities. Finally, in December 2016, the Municipality recognized the cultural significance of this modern university heritage site awarded in the 1950s. However, the recovery works did not start immediately, compounding the damages. In April 2021, a new fire swept the Library on the second floor. The building's infrastructure works gained new momentum after the pandemic years.

A new chapter in the history of the JMM Building is being written. The expectation is that the new social, political, and economic context started this year will make it possible to recover the current facilities, making them compatible with the new demands (educational, technical and sustainability).

This paper follows a timeline in its three sections organized according to the institutional and educational contexts of the JMM Building. The first one retraces synthetically the creation of the Fine Arts Academy (1816), the University of Rio de Janeiro (URJ) by decree in 1920, the incorporation of the Academy (1931) until the inauguration of the JMM Building (1961). The second section addresses the transformations of use and spatial rearrangements from 1961 to 2016/2021. The third section analyses the ongoing conservation measures to re-establish the physical integrity of this iconic building and the possibilities of its conservation according to the parameters of patrimonial sustainability. Finally, we pinpoint in the final considerations the cultural significance of the JMM Building arose from each historical moment.

Figure 1. JMM Building in 1961 Source: Arquivo Nacional, Correio da Manhã Founds

2 Creating an Academy and a University (1816-1961)

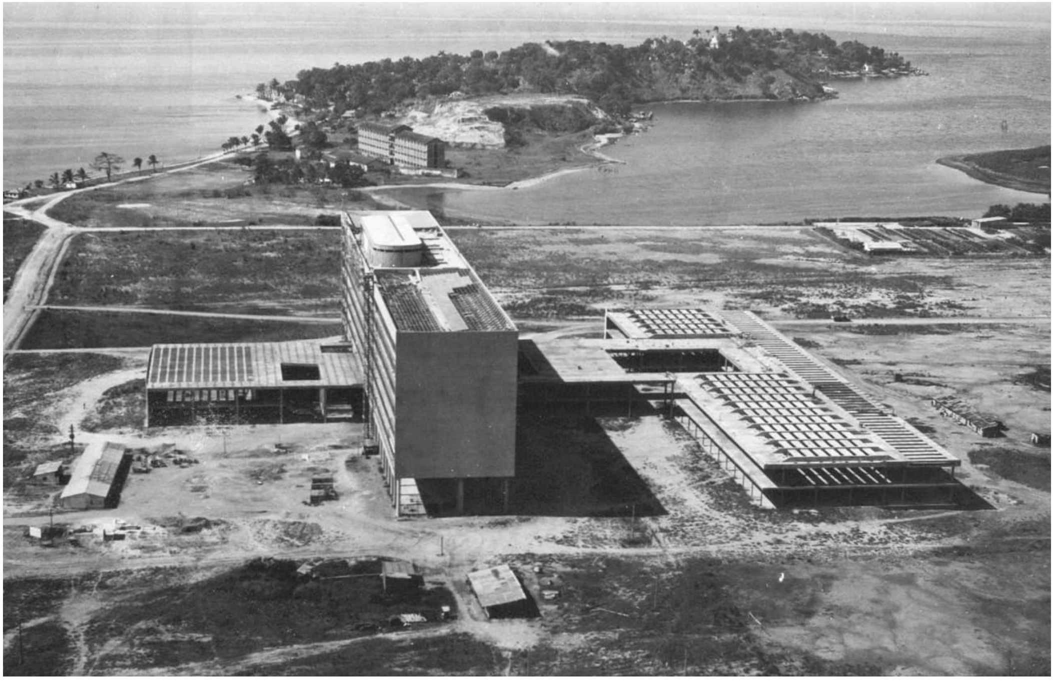


Figure 2. The JMM building, former headquarters of the FNA, under construction in 1959.
Source: NPD/ FAU

Unlike other American colonies, Brazil had to wait until 1920 to have its first University, the current Federal University of Rio de Janeiro[1]. Higher education dates to the end of the 18th century/beginning of the 19th century. Especially since the transfer of the Portuguese Crown to the colony in 1808. The history of architectural teaching was initiated a few years later, in 1816, boosted by the arrival of a French Artist Commission a year before.

In 1826, the neoclassical headquarters of the new Imperial Academy of Fine Arts, conceived by the architect Grandjean de Montigny, opened its doors. The teaching of fine arts, including architecture, followed the French tradition. The Academy remained in this building until 1906 when it moved to Central Avenue into a huge eclectic building conceived by the architect Adolfo Morales de Los Rios, a former student of Montigny. In 1920, the Rio de Janeiro University (URJ) was created by decree and, in 1931, incorporated the National Fine Arts School (ENBA). A few years later, in 1945, the teaching of architecture conquered its autonomy, demanding a new headquarters. Between 1947 and 1961, this Faculty stayed temporarily at Praia Vermelha Palace, a neoclassical facility conceived by former students of the Academy, who transferred to the University in 1944. Meanwhile, the Federal Government created the Brazil University Technical Office to plan the modern University City and its buildings. The objective was to transfer the university facilities, distributed throughout the city, to the new campus.

All three headquarters of the units dedicated to the Architecture teaching in this University related to the innovative architectural language of each time and became an architectural

[1] The Federal University of Rio de Janeiro has received three names since 1920. The current Faculty of Architecture and Urbanism also changed its name, beginning with the Fine Arts Royal Academy (1816). The identity of the teaching of Architecture and Urbanism as Faculty appeared when it became autonomous (1945). In all these three cases, we adopt the last denomination of each one: UFRJ, EBA and FAU.

classroom. It can be assumed as an exception that the mismatch observed between the modern language of the JMM Building and the conservative teaching in the 1960s. This situation differs from the connection between the modern building and innovative teaching in Brasilia then.

However, it is essential to point out that renowned architects became professors of this Faculty. Lucio Costa directed the school briefly in the early 1930s. However, architects of the most conservative wing soon replaced him. Even so, exponents of the modern and innovative wings had their place on the teaching staff, such as Ernani Vasconcellos, Augusto da Silva Telles, Flávio Marinho do Rêgo, Affonso Eduardo Reidy, Ulisses Burlamaqui and Luiz Paulo Conde.

3 The modern headquarters of the FAU/UFRJ - 1961/2016

The Occupation Plan for the University City and its buildings — including the new FAU headquarters — was the responsibility of the team leader by architect Jorge Machado Moreira at the University Technical Office (ETU) created for this purpose. Moreira's team of eighteen collaborators affiliated with the modern movement included names such as Aldary Toledo (buildings), Roberto Burle Marx (landscape design and murals) and Anísio Medeiros (murals). The new campus plan and the design of the two initial buildings awarded significant architectural prizes in the 1950s. The JMM building was the pearl of the site. The Faculty of Architecture students were longing to experience studying on the *brave new* campus. Fulfilling the students' demands, the inauguration of the building happened in 1961, even before its conclusion.

It cannot be forgotten that Brazil was experiencing times of freedom after a decade of authoritarian government (1937 – 1945), a period where, among other facilities, the Ministry of Education and Public Health (MESP) in Rio de Janeiro was designed and built. Jorge Machado Moreira took part in its architectural team as well as Lucio Costa and Oscar Niemeyer, that conceived Brasília (1960), the new modern capital of the country. The Plan developed for University City is a kind of rehearsal for Brasília.

The rational architecture inspired by Le Corbusier was the jewel in the crown of the Urban Plan of the University City in Guanabara Bay. The construction of the insular campus started in 1948 with massive ground works to unite eight islets on an island of more than five million square meters. The precepts of functionalist urbanism organize educational, residential, and administrative functions in a territorially isolated area, removing them from the distractions of the traditional city. This Plan had awarded Gold Medal at the International Exhibition in Brussels in 1958, Brazil, presented freshness, technical and intellectual rigour to the post-war world and gave hope for a new type of western city.

Despite everything, the construction of the campus and its buildings developed slowly, mainly due to budgetary inconsistencies. At the same time, the federal government oversaw Brasilia and the new UFRJ campus. Between 1953 and 1966 came, only three original buildings were in use: Childcare Institute (IPPMG, 1953), Faculty of Architecture (1961) and Engineering School (1966).

The initial expectation turned into frustration soon for the university staff, as the campus was still under construction, and the transport and food options were precarious. The university facilities Downtown or South Zone offer entirely different conditions. Despite the initial setbacks, the University City and its infrastructures became consolidated. As other units moved to the new campus, increase the offer of transportation and restoration.

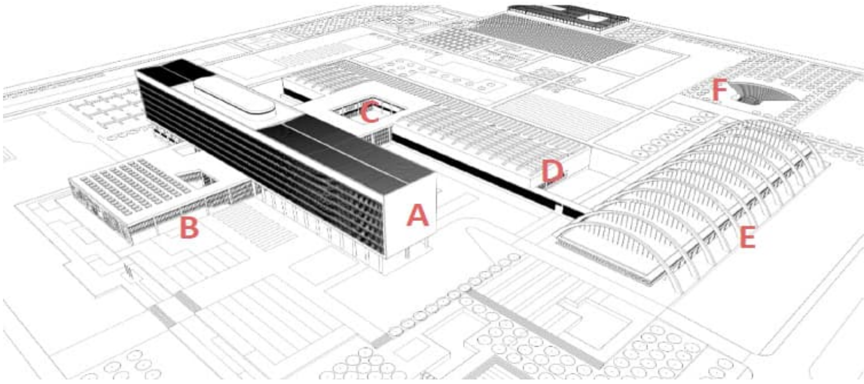


Figure 3. Original design by Jorge Machado Moreira presenting four built blocks (A, classrooms; B, Library; C , FAU Board of Directors; D, Laboratories) and two unbuilt blocks (E, Museum of Comparative Architecture and F, Acoustic Shell). Source: FAU/UFRJ

The original plan of the JMM Building comprehends five blocks of two floors and one highest with eight floors upon ten meters high colonnade. This volumetric arrangement is similar to the MESP building. In the lower blocks were allocated laboratories (photography, construction, modelling and material testing), library, the FAU board and a modern auditorium for around 250 people, with air conditioning and acoustic treatment, unusual at educational facilities then.

The highest block was dedicated entirely to theoretical classrooms, project ateliers and graduate studies in urbanism. The studio rooms, planned for eight students, with lockers, map libraries, and desks, are the highest quality facilities. The gardens, designed by Burle Marx, are exquisite and well maintained, serving as a resting space and with didactic aims.

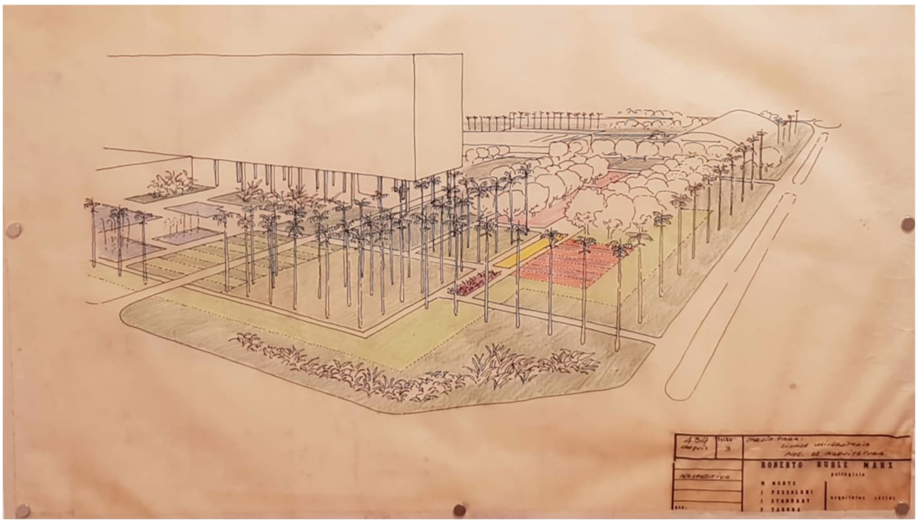


Figure 4: Block plan of the JMM Building (original project) with landscaping by Roberto Burle Marx, including an Educational Garden in the Block F area. Source: Burle Marx, 1961.

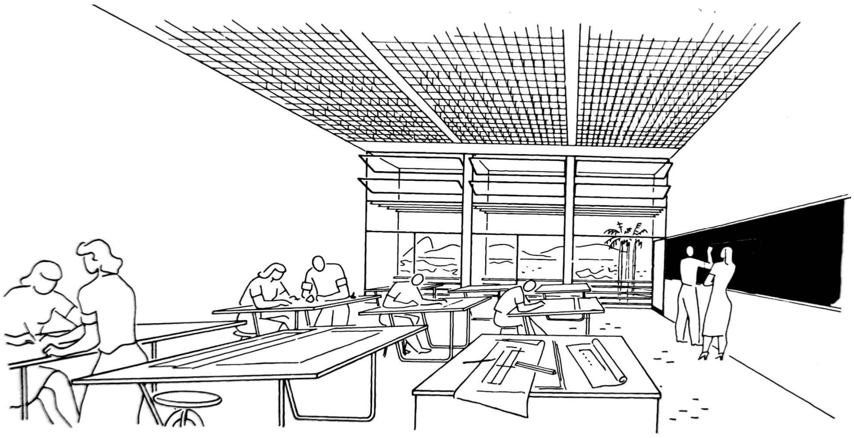


Figure 5. Perspective of the Project Ateliers. Source: NPD/FAU

However, the excellence of its traits, the original plan of the campus and the Architecture headquarters fall apart with the 1964 military coup. The civil-military dictatorship installed last twenty-one years ended the times of openness. The changes imposed a break in education investment, doubled the number of vacancies in federal universities, and reorganized the federal universities creating dean centres. Architecture belonged to the Arts and Letters Centre, which did not correspond to the vision of architecture as a technical discipline.

The changes made in those years give little attention to a campus filled with university staff. Symptomatically the territory of the University has been divided into lots and turned into a condominium. The University stop its development.

Since 1969 the Rectory, which never had a specific headquarter since 1920, occupied the spaces originally destined for de Architecture Board (Block C) and the entire eighth floor of Block A. In 1973 JMM building received new tenants: the Dean occupied areas of the ground floor originally destinated for collections and technical areas. The following year the School of Fine Arts' transferred their structure to the building, leaving the building on Avenida Central (now Rio Branco) intended only for the Museum of Fine Arts, with no connection to the University. This Scholl occupies the 6th and 7th floors, in addition to a good part of Block D. From 1979 onwards, the EBA installed the newly created D. João VI Museum, with a collection that dates to the 18th century, in Block B. Finally, in the 1980s the Institute of Urban and Regional Planning (IPPUR) moved to the JMM Building occupying the fifth floor partially. In 2014 they installed a few containers on the ground floor over Burle Marx gardens, expanding technical areas and classrooms.

All these tenants made conservation a big challenge. The collective management of condominium spaces was an abstraction until 2011, when, under the direction of Professor Denise Pinheiro Machado, a team proposed the first master plan for the building and the adoption of a new name for it, signalizing the value of the condominium dimension. The building rebaptized as Jorge Machado Moreira honoured the architect who left his mark on the University City and this building, ending the partial denominations (FAU Building, Rectory Building). However, condominium management started very slowly in the following years.

Figure 6. JMM Building façade with Burle Marx panel in 2015 Photo by Andréa Borde.

UFRJ should celebrate 2016 as the two hundred years of fine arts and architecture. Nevertheless, it did not happen as planned, as in October, the fire reached the top floor of the taller block of the JMM Building occupied by the UFRJ's Central Administration. Fortunately, it occurred at night when only the security staff were on the ground floor, and no one was hurt. The fire began, most likely due to an electric short circuit, and quickly spread all over the floors below, thanks to the inadequate accumulation of bureaucratic supplies, making it impossible to use this floor and the three floors below. In November, a new event damaged the building. An inadequate work on the Library's roof triggered a flood causing the loss of part of its collection. The building was unoccupied, and its structural recovery project began.

In December 2016, the Municipality recognized the cultural value of the building, establishing measures to recover and valorise the building. In 2020 the lowest floors began to be occupied in very fragile conditions when the covid pandemic spread worldwide.

The only way to continue the activities then was online. The following year the massive vaccination campaign allowed some activities and the development of the recovery project at some points. Then, in April, the inappropriate bureaucratic use caused a large-scale fire that reached the important document collection of the FAU's Nucleus of Research and Documentation (NPD) on the 2nd floor. It also happens by night when an Attorney's Office employee leaves the air conditioning on all night, overloading the still fragile electrical infrastructure of the building.

Against all odds, these severe events hit all the building and gave a new impulse to condominium management. Actions of this kind still need and should be better coordinated with the other tenants. Moreover, a Master Plan begins to be prepared for UFRJ in 2020, establishing guiding principles and priorities for action. This plan takes exceptional care of the UFRJ cultural heritage. It is about to be approved by the University Council this year.

Figure 7: October 2016, the fire hit the top floors. Photos by Andréa Borde, 2016

Figure 8: November 2016, the flood in the Library. Photos by the authors 2016

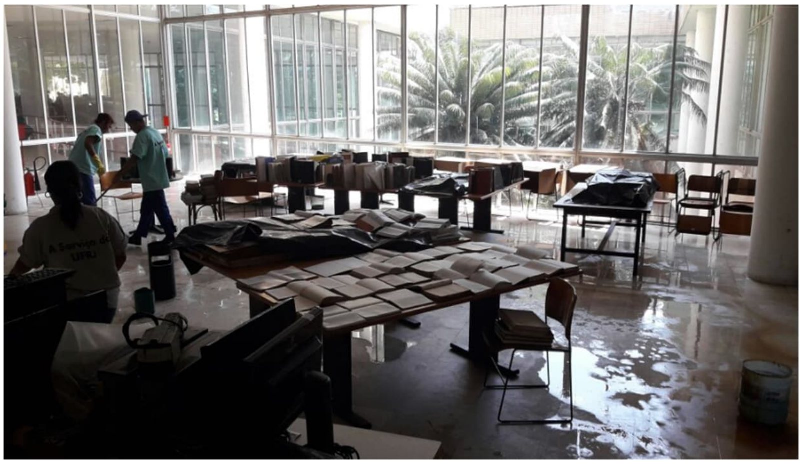


Figure 8: April 2021, the fire swept up the NPD. Photo by Andres Pássaro, 2021.

4 JMM Building after 2016/2021 events.

Only after the 2016/2021 events the management became aware of the necessity of maintenance and conservation measures to take care of the JMM. The initial investments focused on recovering the collapsed pillar, electrical and hydro-sanitary infrastructure from the eighth floor onwards, and the waterproofing of Block C. Another project, dear FAU, EBA and IPPUR Board, is recovering the library structure and proposing a new integrated program of the three units. The renovation of the classrooms must preserve its characteristics and follow more sustainable principles. This process should leave in the past the loss of identity and understanding of the cultural value that contributed to the generic and diffuse unplanned occupation of the JMM Building spaces.

In 2022 the Central Administration and the Attorney's Office left the building, allowing the three academic units to occupy the spaces more rationally. These two sectors did not directly benefit the JMM, neither maintenance nor hierarchy. The significant risks of these bureaucratic uses are the accumulation of flammable material and the functioning in later shifts in a building with precarious conditions of the electricity network and lacking investment in maintenance.

The occupants of the JMM Building and the public flock to it need a better knowledge of its cultural value. In this sense, cultural heritage education and Memory centres are foreseen in the new Master Plan and should emerge soon.

Despite losing its identity over the years and its precarious situation, the JMM building remains one of the best-finished examples of Brazilian rationalism. It is constantly associated as the icon of the UFRJ in all media portraying whether the UFRJ's abandonment or highlighting of the excellence of teaching. Architecture is one of the world's top five areas of UFRJ.

Figure 9. JMM Building exposes in the headlines of the medias. Source: CNN and UFRJ

The JMM Building has a remarkable cultural significance. It is the public face of UFRJ, the physical embodiment of the Faculty of Architecture and Urbanism, the symbol of its independence and the portrait of an era when Brazilian modernist architecture was a reference worldwide. This building references the new schools of architecture created in Brazil in the last decades, both in terms of curriculum and imagery. It is, therefore, the face of architecture education in the country.

The new measures should match preservation and innovation, moving towards a Sustainable Campus in which planned and culturally valued buildings emerge..

5 References

[1] BORDE, Andréa and BELLINHA, Paulo. Conservação e Restauro: Patrimônio Arquitetônico Universitário. Rio de Janeiro: Riobooks/FAPERJ, 2015.

[2] CZAJKOWSKI, J. *Jorge Machado Moreira*, Centro de Arquitetura e Urbanismo - CAU, Rio de Janeiro, Brasil, 1999.

[3] CORDEIRO, P. A cidade universitária da Universidade Federal do Rio de Janeiro: preservação da arquitetura moderna, USP, São Paulo, Brasil, 2015.

[4] COSTA, Lucia; PINHEIRO MACHADO, Denise B et allii. Roberto Burle Marx na quadra da FAU-UFRJ: possibilidades didáticas através da representação gráfica da arborização, *InfoDesign - Revista Brasileira De Design Da Informação,* v. 19, no. 2. (2022) DOI 10.51358

[5] JARDIM, Paulo. Por uma "nova arquitetura" no Brasil: Jorge Machado Moreira (1904-1992), PROARQ, UFRJ, Rio de Janeiro, Brasil, 2001.

[6] MAGALHÃES, M. Universidade e cidade: uma trajetória. PROURB, UFRJ, Rio de Janeiro, Brasil, 2005.

Acknowledgements

The authors gratefully acknowledge the UFRJ, CAPES, CNPq and FAPERJ for the financial support for this research. The organizer gratefully acknowledges the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2023 for efforts done for the success of this event.

PROCESS OF AN ARCHITECTURAL CONCEPT GENERATION: THE REVIVAL OF A HISTORICAL BUILDING: A CASE STUDY OF JIFNA CASTLE

*Marwa Al Shanti[1], Dr. Dalia Hafiz[2]

[1] Graduate Architect of Al Ghurair University, Dubai, UAE, m.s.alshanti286@gmail.com

[2] Assistant Professor of Al Ghurair University, Dubai, dr.dhafiz@gmail.com

Abstract

Concepts for an architectural design can be achieved by understanding the holistic nature of the project before adapting one main concept that will be the essence of the design. This paper presents an approach to develop a design concept by examining different influences that affect and could derive inspiration to develop and generate the architectural design concept, and how it can lead to the formation of the architectural design. The research methodology was based on a practical application to upcycle an ancient castle that dates back to the crusader era in Palestine, where several aspects were studied, e.g., historical, geographical, spiritual, and incidental aspects. In conclusion, the project application presents a process to generate and develop the design concept when approaching historical buildings to maintain and celebrate their values while accommodating the recent/existing needs.

Keywords

Concept Generation; Upcycling; Sustainable Historic Preservation; Village of Jifna; Contemporary reuse; Socio-Cultural significance

---

1. Introduction

The conceptual idea is the initial phase of the design process in which the design idea is externalized through abstract representations. In the conceptual design phase, sketches help students enter into formal and functional reasoning to visualize the spatial arrangements of shapes and provide alternatives for solving the design problem. It allows students to present ideas and potential solutions during the design process, together to record new ideas and evaluate design ideas. Also, it helps students transform their ideas and the meaning of verbal expressions and turn them into a graphical context that helps solve design problems. [1]

To develop a concept, there are different sources of inspiration that can be examined through the process that will help in making a unique and tie design that fits the building function and context and to tell a story through architecture. Through the case study, several aspects have been studied that influenced the decisions of creating the concept.

1.1. Approach to historical buildings upcycling

Historical buildings are vital as they symbolize and provide insight into similar past eras; Instead of destroying them, they must be preserved because they are evidence of the lifestyle and culture of the people who live in or around them. their location, size, and potential can help future generations understand where they are from.

If the useful life of the building stock retains its function, adaptive re-use with a new function is inevitable. The planned new use must be appropriate in terms of preserving the cultural significance of the historical structure. The functions, new uses, and interventions must preserve the originality and architectural character of the building so as not to give wrong or missing information to future generations.

1.1 CASE STUDY DESCRIPTION

The case study performed in this study is the author's thesis project which is a preservation and adaptive reuse project of an abandoned and underutilized ancient castle (El-Burj) located in the Palestinian village of Jifna.

Jifna shown in Figure 1 is a Palestinian village in the governorate of Ramallah located 8 km north of Ramallah and 23 km north of Jerusalem (650 meters above sea level). The village is one of the oldest villages in Palestine, with its history dating back to the bronze age, and it has got its importance during different eras. The castle belongs to the Crusaders and has historical importance, dating back to the different ages of the Crusaders, Mamluk, Ottoman, etc. It was preserved in 1999, however, the preservation process failed for several reasons.

This project aims to preserve (El-Burj) and reuse it, to employ it to serve the people of the village, and to develop tourism in the village. The proposed function is an exhibit that will protect the history of the building Respect its value of it and a hotel extension building as a tool to serve the main idea of celebrating the old history.

Figure 1: (Left) Jifna Village map (location and borders), (Right) Aerial view of Jifna [2]

2. INFLUENCES

2.1 Historical Influence

A project begins with understanding the story of the building through studying its history, context, culture, and neighbourhood, where it can be used in countless ways to create spaces that are meaningful reflections of their time and place, but free from the confines of a dictated historical style.

Jifna village was mentioned in the Old Testament of the Holy Bible as “Gophna” where it dates back to the time of the Arab Canaanites., but then the village was renamed as Jifna, which means “the vines in Arabic, because of the many vineyards in the territory of Jifna. Jifna had great importance in different eras, it was the county seat and administrative seat of the regions in the period of Herod as well as a military base. The Romans chose it to build castles, towers, and Khans for its location on the Roman road, which was built to facilitate the transportation of armies and the establishment of security.

Jifna was mentioned in the Byzantine mosaic map of Madaba and the importance of this period is shown by the remains and churches that are still present in the village; the church of the Latin sect on the northern side of the village, and the remains of the SS Giorg, a Byzantine church (Church of Al-Khader), On the southern, the remains of a mosaic tiled church and from the eastern side, it was found traces of a grape press for making wine. Other churches were built in the Ottoman era that still exist in the village, the Latin church on the northern side of the village, opposite the ruins of the old Byzantine church, and the Orthodox church in the southern region, outside the central old village. Jifna has been destroyed 7 times, and that was indicated through Jifna spring that was originally 3 steps up to the spring of water but now there are 27 steps down to reach it.

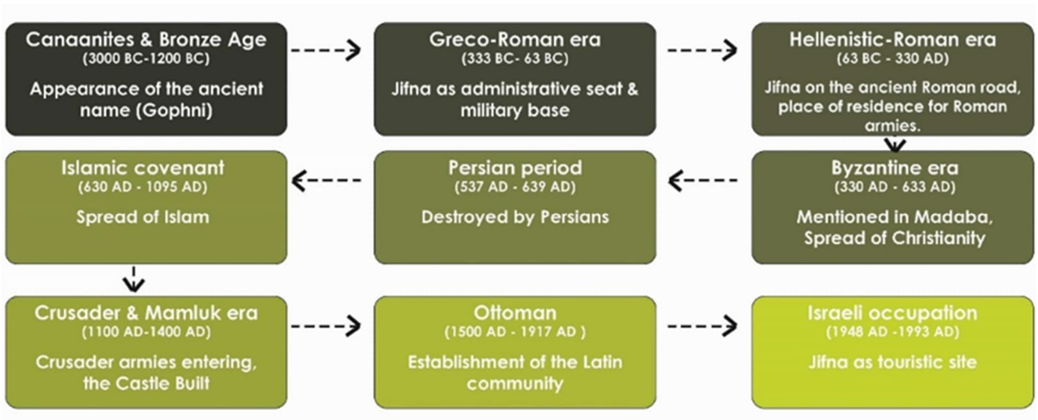


Figure 2 : Diagram summarize the history of Jifna (Author, 2022)

Figure 3: (Left to Right) The remaining of SS Giorg church, The remains of the first Byzantian Basilica, The Latin Church, Ein Jifna. [3]

El Burj castle shown in Figure 5 which is the selected building to be conserved that is located in the historic centre of Jifna. The historic centre is located on the northern side of Wadi Ashkol (vine valley) which divides Jifna into two parts. It includes almost all of the town's historic buildings, which form the historic traditional fabric of the town Al Burj Castle which dates back to the 5th century, Virgin Mary Spring, ancient Ahwash (old buildings) shown in Figure 4, and the old Byzantine Church. Also, there are remains of two ancient churches, tombs, and an ancient oil press. [4]

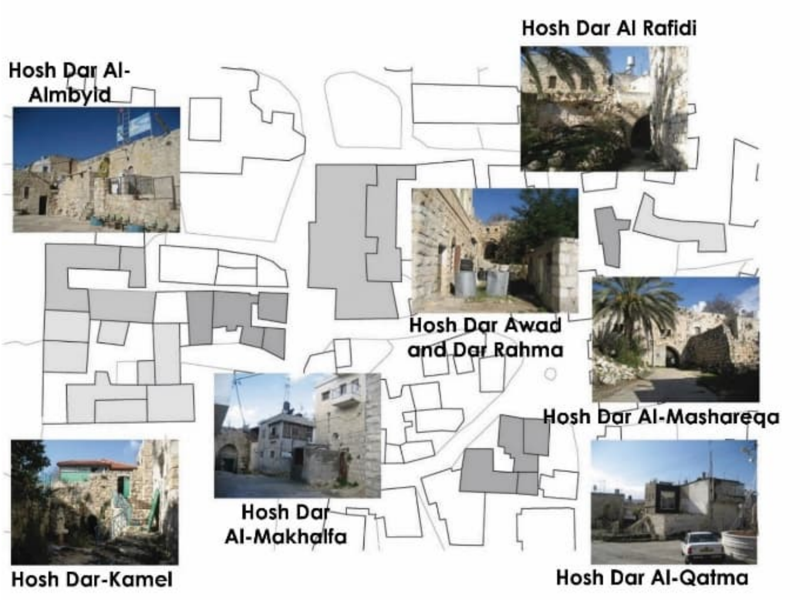


Figure 4: Hoshes of the old town (Author, 2022)

- The castle was chosen to be the location of the project for the following reasons:
- Its historical significance and age, which dates back to the succession of different eras on it shown in Figure 6, from the Crusader, Mamluk, and Ottoman periods.
- The nature of the spaces that make up this building, consists of two hoshes[1], which helped to merge them together and exploit them as a single building, consisting of three floors, which is thus different from the rest.
- It's a convenient location near the Al-Khdir Church and the Byzantine church, and the state of the surroundings, which allows horizontal expansion.

Historical and archaeological analyses carried out between 1970-1982 indicated that the castle served as a farm and as a hostel for pilgrims traveling along the road running from Acre to Jerusalem via Nablus. In the original site plan, the rooms of the building were constructed off the 2.05 m-thick exterior walls, creating a fortified structure that has a large internal

[1] The Hosh is a semi-public common space surrounded by a group of buildings. It is usually translated as "patio or courtyard" but these terms do not include the social value that Hosh implies. These semi-private areas are traditionally used as passages to private homes; in urban hosh, semi-private areas often disappear and the transition to private space is a door.

courtyard and an arcade in the east wing where the main entrance that was built in the crusader era is located [5].

It is inferred that the south wing, included a large hall used as a stable and pilgrims' dormitory, on the basis of a similar hall found in the north wing. The north wing contained a large hall, which served as a stable. During the clearing and restoration process, several channels for draining the stable were found. The structure was divided into two floors during the Mamluk pilasters. Stones, capitals, and columns from the old Byzantine church were used to modify the Crusader site for its new use during the Mamluk period. [6]

Figure 5: Views for the Castle [6]

At the beginning of the Ottoman period, the large hall was transformed. The second floor had collapsed and an olive oil press was installed on top of the debris. A second press was added later during the Ottoman period, during which the large hall in the south wing was also transformed into an installation for olive oil production. These olive presses indicate that the site was industrial in nature, serving not only the village of Jifna but also the entire territory [7]. The site continued in use, mostly for domestic purposes, until 50 years ago, when it was abandoned. The alterations made to transform the structure to serve domestic functions are still evident.

In April 1998 and until 2001, the castle restoration and preservation project were started to revive an important archaeological site in Palestinian history. The conservation work in the site concentrated on part of the Crusader manor, house complex, which included remains of previous Byzantine structures as well as of Mamluk and early and late Ottoman construction. Two olive oil presses were preserved and maintained within the restored buildings and the late ottoman tower to the left of the main entrance. [6]

Figure 6: Highlighting the different eras in the building (Author, 2022)

2.2 Geographical Influence

Some are inspired by the unique cultural heritage of the region to tell the story of a place through its built environment.

The village of Jifna is located on the slope of a hill that overlooks a green valley. It is situated to the west of the main road from Jerusalem to Nablus and Nazareth which was the ancient Roman Road and also the route of pilgrims during the time of the Crusaders from acre – Nazareth – Nablus – Jifna - Jerusalem. Jifna is a Palestinian village in the governorate of Ramallah located 8 km north of Ramallah and 23 km north of Jerusalem (650 meters above sea level).

Figure 7: (Left) Topography lines on the site plan, (Right) Site sections (Top) North South Section through the site, (Bottom) West East Section through the site. (Author, 2022)

The village is accessible by the main road which runs from the west of the village of Jifna and makes its way east to its border with Ein Senya. To reach the historic center of Jifna a roundabout must be accessed known as Abu Jassar roundabout where the castle (Al-Burj) is located.

As for the residents of Jifna village, to reach the tower, they pass one of the ways shown in Figure 8, according to the area of residence.

It should be noted here that the castle in the medium where it was found helped to distinguish it, due to the presence of a three-story tower, which is rarely seen in the old hoshes. The castle is located on the edge of the old town, which helps to create a strong visual connection with the building from the main road on the southern side due to the availability of open spaces on the west and south sides, while on the north and east sides it sticks with the old town hoshes.

Figure 8: Urban Studies. (Author, 2022)

2.3 Spiritual Influence

Art can be used to enhance the architectural concept to give it a spiritual aspect that will provide a deep meaning that would touch the human Soul.

For El-Burj reuse project, as the project is in Palestine and the site is near a settlement the theme of resistance were taken for the idea of protection and resisting. Some art pieces in Figure 9 that represent resistance were analyzed to adapt symbols or modes of resistance and understand how to present a story through art.

Figure 9: (Left) Temporary Escape, (Center) Olive Groves #1, and (Right) Rakan Artworks [8]

Table 1: Artwork Inspiration [8]

Artist	Painting title	Description	Adaptation
Sliman Mansour	Temporary Escape	This artwork expresses the predicament in the current Palestinian reality and the changes that permeate the nature of the Palestinian people by using the tension resulting from the prevailing rough mud cracks contrasting with the areas painted with acrylic on wood.	The use of local natural materials.
Nabil Anani	Olive Groves #1	This artwork expresses rooting in the ground despite adversity by capturing an empty semi-arid landscape, plants grow scarcely while olive trees spread out over the horizon.	Olive trees symbolize how to root in the land despite adversity.
Khaled Hourani	Rakan	This artwork focuses on the young generation who takes upon themselves the challenge of the occupation, as it shows a child jumping high in the air over the apartheid wall without giving it any importance.	Proving ownership of the building for the Palestinian people and preserving it for the future

2.4 Incidental Influence

Another painting under art of resistance that is a part of the permanent collection in Sharjah Art Museum is the Sabra and Shatila painting in Figure 10 by Palestinian Bashir Sinwar depicts the war in Lebanon in 1982 that killed thousands of Lebanese and Palestinian civilians and ended in the Sabra and Shatila massacre, in which Israel colluded in the killing of between 800 and 3000 civilians. [9]

Figure 10: Bashir Sinwar's Sabra & Shatila ,1984 [9]

Table 2: Sabra & Shatila painting analysis

Analysis	
Content:	The artwork is focused on a woman carrying her child in panic and bereavement, bodies of the martyrs are piled up after the massacre, and in the background, the place looks devastated.
Colours:	Black – White – Cool colors predominant (Blue – Green – Brown) – Warm colors (Red). Shade in the top – Tint in the bottom. The use of color in its different degrees
Function:	Expressing the Palestinian cause, specifically the killings that were carried out based on identity in Sabra & Shatila massacre
Feeling:	It left a tragic black memory, and a pain that the passing of days can't erase in the souls
Characteristics:	Huge mural \ Oil works \ Dramatic realism, expressing people's concerns and suffering \ The style and the drawing are realistic, with high quality and accuracy \Person and place are central axes in the work of art. \Its realism is lyrical and not photographic \ Experiences the personality or event to be highlighted, so it shows it inside and not only external form \Dramatic dimension with an emotional sense.
Meanings:	The steadfastness of the mother to preserve her son to complete what his ancestors did to resists. The use of the colors white, which indicates purity, and blue, which indicates hope. Overall express the hope for peace and a better environment for future generations.
Adaptation	The composition of the art work, and how to tell a story that will keep leave an impression on people. Adapting the Kufiya patterns.

3. CASE CONCEPT

The current status of the tower is similar to its pre-restoration status, as many of its sections are currently closed and its outer squares have become a dump, the only difference being the shape of the walls that have been restored and the part that is still in operation, the Palestinian village club, which occupies two rooms of the castle. The situation the village has reached may be due to a number of reasons, including the political situation and the deteriorating economic situation. Add to that there are some disagreements between the owners where each hosh is for an owner.

Figure 11: Creating a collage helps understanding the village ‘s cultural heritage through the built environment. (Author, 2022)

After all the examined aspects, the concept started to be generated. The idea is to develop a journey through spaces that create a narrative story from the history of Jifna and the castle the main aim of the project was to by recreating it with the same historical significance and to be an example of Palestine›s history and a symbol of resistance. The design creates different experiences through different spaces that will bring back the memory of how people lived through the years.

The proposed function for the building is an exhibition that will show the building’s history and focusing on the main valuable elements in the castle. In addition, to design an extension for a hotel to be as a tool to serve the main idea, as well as develop the economic situation of the village, and provide a place for tourists to stay in the village and explore all the historical landmarks.

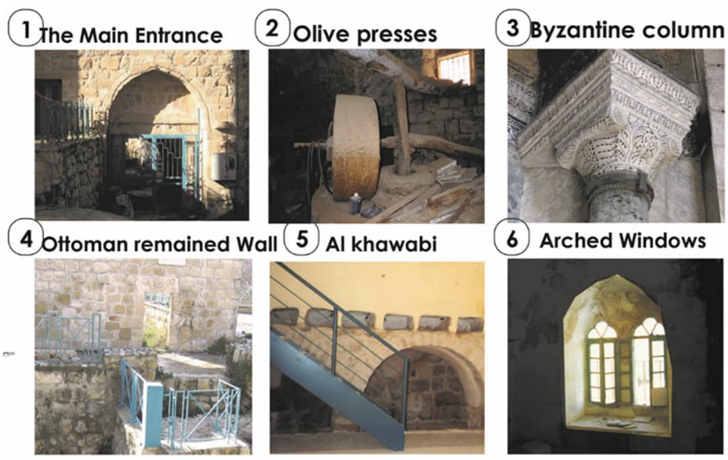


Figure 12 : Castle’s valuable elements (Author, 2022)

The following site plan in Figure 13 shows the conceptual design of the project where all the inspired ideas from the discussed aspects previously are shown and explained in detail.

Figure 13: Proposed Site (Author, 2022)

A. Memorial Path through the site to reach the castle

A path shown in Figure 14 that represents eras that Jifna went through using different types of arches were proposed to give the experience and celebrate Jifna's history while going to the castle which is an ancient monument in the historic center that is also shows different layers of history.

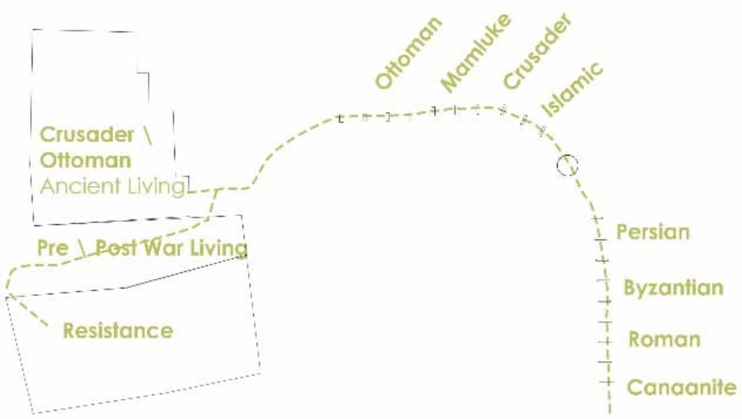


Figure 14: Journey through history using arches that represent each era. (Author, 2022)

B. Castle \ plaza \ Hotel extension journey

In the old local Palestinian architecture, the use of hoshe was always present. taking this characteristic to design the castle with the extension as a one building that are divided with a plaza that will serve as a hosh and the link of both of them. The castle represents ancient living, while the plaza will act as the living pre and post the occupation, and the hotel will be representation of the current status and the people resistance.

C. Hotel extension journey

The main idea is to connect visitors with all the landmarks that are in Jifna that represent different ancient eras shown in 15. For this reason, the building was designed as a journey on-ramps to allow viewing the landmarks from different levels because of the topography of the village, as well as using lines that are oriented to these landmarks to frame the views in each direction to a landmark. However, the main focus is to connect between the extension and the ancient building (Elburj), so from all levels and sides of the hotel, (Elburj) will be visible to visitors. Also, both buildings are connected through a bridge pass through the ottoman wall.

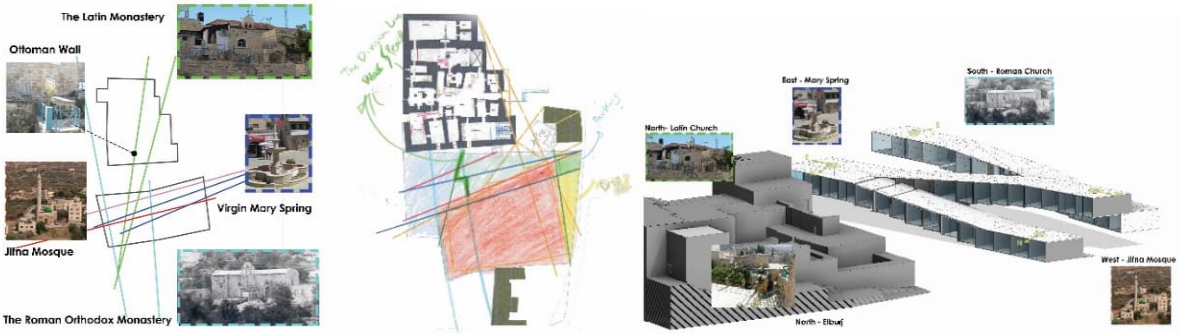


Figure 15: Design lines based on the landmarks. (Author, 2022)

D. Plaza

The plaza design shown in Figure 16 is proposed to use Kufiya pattern regularly for pre-war living zone and irregularly for the post war zone to show as space of resistance, and how the life can continue using rubble as a counter monument to design the landscape of the zone.

The plaza will be the central zone of the design that connects both the castle and the hotel, as well as the terraced garden on the west side of the castle, to be designed respecting the topography.

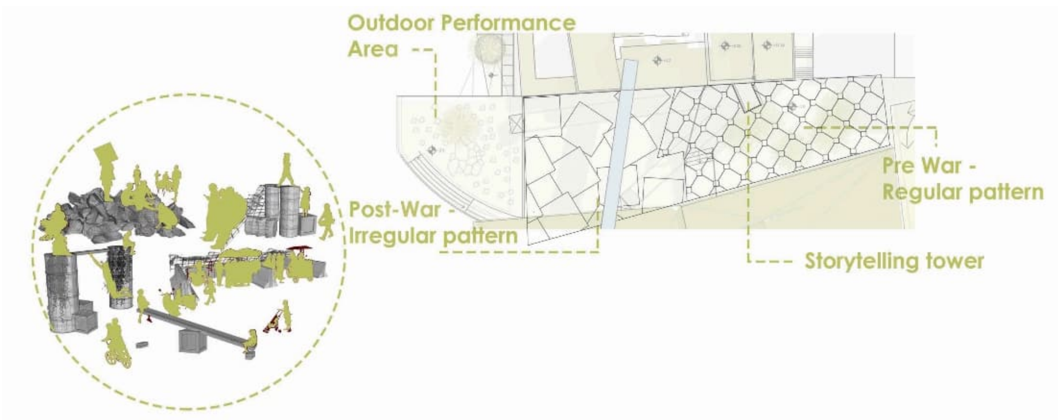


Figure 16: Proposed Plaza conceptual design (Author, 2022)

4. CONCLUSION

In conclusion, this paper offers an approach to upcycling an existing historical building through various sources of concept inspiration. The proposed process can be used as a framework to approach valuable buildings re-using, where the concept needs to be a combination of an interconnected ideas that can be generated from historically, geographically, spiritually, incidentally, etc. settings, as shown in Figure 17.

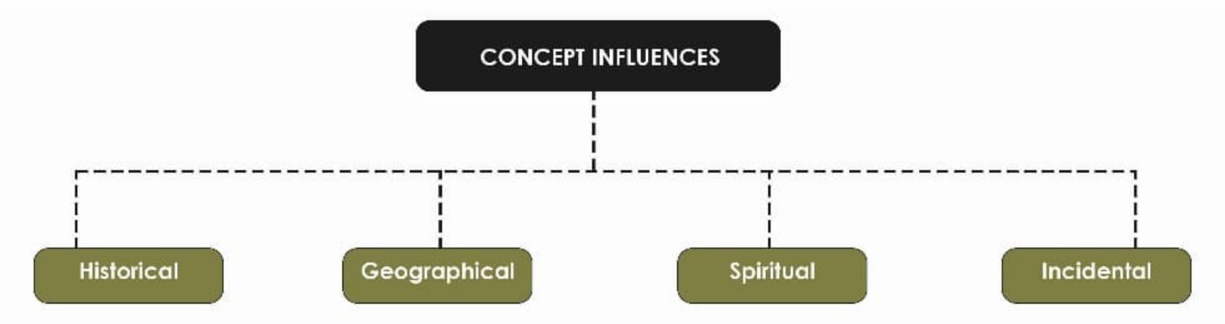


Figure 17: Concept generation framework (Author, 2022)

The proposed framework can guide architects, designers, urban planners and decision makers to redesign these buildings without deteriorating its historical and cultural values. The new approach can bring attention to the village, enhance its touristic value and its memory, and will activate its surrounding. Elburj castle gives Jifna its distinct character and at the same time provides a tangible connection to the past. It will show itself as a unique piece that will be given a second life to create a dynamic place and defines the character, spirit, and sense of belonging of a space.

ACKNOWLEDGEMENT

I would like to express my gratitude to Dr. Dalia Hafiz for providing guidance throughout this paper.

REFERENCES

[1] Z. O. Yalcin, “Intuition in the Design Studio: A Perspective on Student’s Creativity and Design Process,” *Design Studio,* vol. V.3, pp. pp 37-48, July 2021.

[2] The Applied Research Institute, “Jifna Village Profile,” 2012. [Online]. Available: http://vprofile.arij.org.

[3] Jifna, “Jifna,” 20 Dec 2021. [Online]. Available: https://www.jifna.org.

[4] Riwaq, Re-Walk Heritage: Ramallah Highlands Trail, Ramallah: Riwaq, 2012.

[5] O. F. Zahran, جفنا برج في التاريخ, Ramallah, 2004.

[6] O. Hamdan, Conservation of architectural heritage in Palestine – The Crusader manor house restoration and conservation project in Jifna and the establishment of the Museum of memory in Ein Sinia, vol. Volume 3, Hamburg: Gloss Verlage, 2000, pp. p, 214-225.

[7] I. Halayqa, "An Olive Press From Jifna," in *A Pioneer of Arabia*, vol. 10, Rome, La Sapienza, 2014, pp. 82-99.

[8] Z. Gallery, "Palestinian art : Resilience and inspiration," 2020. [Online]. Available: https://zawyeh.net/palestinian-art-resilience-and-inspiration/.

[9] B. Sinwar, Artist, *Sabra & Shatila.* [Art]. Sharjah Art Museum, 1984.

SUSTAINABLE DESIGN ACCELERATOR: ADVANCING ARCHITECTURE STUDENTS' KNOWLEDGE IN SUSTAINABILITY AND ENTREPRENEURSHIP

Omar Al-Hassawi*, David Drake
Carpenter Hall 118, Washington State University, Pullman, WA 99164, United States;
omar.al-hassawi@wsu.edu, mrdrake@wsu.edu

Abstract

This paper reports outcomes from the second year of the Sustainable Design Accelerator (SDA), a three-year externally funded project within our accredited Master of Architecture program. The SDA addresses three gaps in the curriculum. The first is the limited number of courses covering sustainable design issues and strategies with only one required introductory course offered at the sophomore-level. The second is the high interest in learning entrepreneurial mindset tools, and the third is the lack of opportunities for learning hands-on experimental evaluation methods necessary for the development of commercially viable solutions that mitigate the built environment's impact on climate change. The SDA fills these gaps by stacking two courses, a lab, and a studio, into a semester-long sequence.

The lab course challenges students to develop innovative and marketable building heating and cooling system prototypes. Students in the concurrent studio course are challenged to develop designs for a multi-family housing community that addresses broader sustainability issues while incorporating the systems developed in the lab course. Areas of knowledge covered in the SDA include whole system mapping, life cycle assessment, performance analysis software, entrepreneurial mindset and use of a Lean Canvas Model, and physical prototype construction and evaluation. A proprietary environmental test chamber is used to replicate climate conditions in hot regions and test cooling system prototypes.

Student responses to the exit survey indicated a significant improvement in their level of knowledge before and after the SDA in alignment with results from year one of the Accelerator. Modifications to version 3.0 being delivered this semester include having students in the lab course propose innovations to common enclosure systems and to integrate those systems in their studio design projects.

Keywords

Sustainability, Evidence Based Design, Building Performance Analysis, Business Model Canvas.

1 Introduction

With the rise in urbanization and the projected growth in global building stock square footage, especially in urban centres located in hot and warm climates, there is a need for innovative solutions in the design and construction of the built environment to minimize its impact on the natural environment [1]. Architecture schools in the U.S. are increasingly transitioning to carbon conscious curriculum [2]. The National Architecture Accreditation Board updated its accreditation requirements to emphasize the importance of curricula which incorporate tools and methods that enable future architects in mitigating the built environment's negative impacts [3]. The state of Washington where our program is located and where most of our graduates pursue their careers is known for its progressive climate initiatives [4]. These regional, national, and international purposes were the driving forces behind the modifications introduced to our curriculum to provide future graduates with the tools required in facing the challenges of the 21st century.

Our undergraduate and graduate curriculum have two points for introducing content focused on sustainability. The four-year undergraduate architecture program offers only one required course at the sophomore level that provides a broad introduction to the built environment's impact on the natural environment as well as sustainable design strategies that can help mitigate this impact.

No dedicated course on sustainability exists at the graduate level. Out of six studio offerings in the two-year path and four studio offerings in the one-year path, students can take one design studio section with emphasis on sustainability. The course is structured around the framework for design excellence outlined in the American Institute of Architects Committee on the Environment Top Ten Competition [5]. Students submit their work to this competition at the end of the semester and one student team led by one of the authors has been successful in receiving this award [6]. Since graduate studios are typically taught in two sections by different faculty members the introduction of this content fluctuates from year to year based on teaching assignments resulting in the potential that certain cohorts could not have the exposure to sustainability-oriented curriculum at the graduate level.

Developing an entrepreneurial mindset and learning hands-on experimental evaluation methods are critical tools in mitigating the climate crisis through validation of commercially viable design solutions. These skills are actively sought after by our students but only few opportunities are available to limited number of students through direct collaboration with the faculty members conducting research involving these skills. Additionally, curriculum opportunities are limited despite recent experience in this area by the authors [7, 8].

To have a presence of climate conscious design and construction curriculum in our graduate program, the authors proposed modifying two courses (a lab and a studio) to create a Sustainable Design Accelerator (SDA). The overarching goal of the Accelerator is maximizing students' skills in sustainability, hands-on research methods, and entrepreneurship. In the lab course, student teams design, prototype, and test innovations to common heating and cooling systems for carbon neutral/restorative architecture. Students in the concurrent studio course are asked to design a multi-family housing and integrate the systems developed in the lab course while focusing on broader environmental, social, and economic issues.

In preparation for the launch of the course sequence in January 2021, the authors sought internal and external funding opportunities and received two awards in summer of 2020.

External funding of $30,000 was awarded by the Lemelson Foundation through the VentureWell Faculty Grant and internal seed funding of $10,000 was awarded by Washington State University School of Design and Construction.

Funds were used to cover curriculum design, field trips, and student prototype construction in the lab course. Funds were also used for the design construction, calibration, and characterization of an environmental test chamber that can simulate hot climate conditions for testing innovative cooling systems. Figure 1 is an overall photo of the chamber from the northeast corner. Further details of the chamber have been presented and published by the authors in a conference proceeding [9].

Because of the COVID-19 global pandemic, our university moved to online-only education for the 2020-2021 academic year which coincided with the first year of delivering the SDA. This required significant modification to the accelerator, particularly for the hands-on experimental evaluation component as all instruction, including design critique and workshops, were delivered online synchronously via the Zoom platform, and available asynchronously through recording of the Zoom sessions. Iteration one of the SDA is reported in a conference proceeding by the authors [10] and year two reported in this paper builds on lessons learned from year one, and reflects the SDA design, delivery, and outcomes as it was originally intended.

Figure 1: Test chamber overall construction photo from the northeast corner of the site.

2 Sustainable Design Accelerator Skillsets

A total of five primary skillsets were introduced in the accelerator. *Environmental impact tools* were introduced in the lab and studio courses to help students understand the impacts associated with their design proposals. Specifically, the following were introduced:

- *Whole System Mapping (WSM)*. Architecture education typically focuses on understanding the impacts that the whole building has on its immediate context and limits the system boundaries to the building site. WSM is introduced in the lab course to expand the understanding of the buildings’ impact beyond its site and include the impact that the components arriving to the site have on the environment. WSM is a qualitative method, conceptualizing individual building products as part of a complex system of interactions and energy inputs incorporating resource extraction, manufacturing, interaction with other components, user behaviour, and end-of-life strategies, including disposal or reuse/recycling. Students learn the Faludi four-step methodology [11] and apply it to common building heating and cooling household items enabling them to propose sustainability solutions beyond the boundary of the building's site.

- *Life Cycle Assessment (LCA)* was introduced in both courses. In addition to qualitative WSM analysis, students are introduced to quantitative LCA cradle-to-grave analysis tools. This enables them to understand environmental impacts analysis of buildings at multiple scales. In the lab course, students are introduced to the Equalizer Eco Design database, coupled with a Microsoft Excel calculator [12] for evaluating lifetime environmental impacts of building product design alternatives. In the studio course, students are introduced to the Athena Impact Estimator calculator to understand environmental impacts over the lifetime of a whole-building, specifically the enclosure and structural systems [13].
- *Performance analysis software* were introduced in both courses. Students develop preliminary computer models and use performance analysis software to evaluate design performance. This helps students obtain quantitative data of performance parameters quickly and early in the design process for their design iterations when simulated under actual conditions. It enables students to compare several iterations and narrow them down to a single option prior to constructing physical prototypes. Autodesk CFD [14] is used for Computational Fluid Dynamics (CFD) analysis of heating and cooling systems developed in the lab course. This tool simulates air flow and distribution in and around the proposed system as well as temperature changes caused by the proposed heating and cooling mechanisms. Whole-building performance analysis of designs developed in the studio course was done using Solemma ClimateStudio which simulates daylight availability, energy consumption, and external surfaces incident solar radiation levels [15].

Entrepreneurial mindset tools are becoming increasingly important for designers moving into professional practice. To instil in students an entrepreneurial mindset, the Lean Canvas Model (LCM) is introduced in both courses so students can create business and marketing plans for their systems designs in the lab course and building designs in the studio course. This tool reinforced the need for commercially viable solutions to sustainability challenges in the built environment, and required students to clearly articulate value propositions, identify customers, strategic partners, and marketing strategies, while developing quantitative estimates of costs and revenue, as well as a path to profitability.

Hands-on experimental evaluation methods were introduced in the lab course and are necessary to understand system operational issues that would occur in real life and validate design simulation results. This is introduced to students in the lab course through physical prototype fabrication and validation of their heating and cooling systems. After narrowing down their design options to the preferred iteration, students build a scaled prototype in the school's fabrication labs. Fabrication methods and materials prioritized needs for testing and experimentation, and students learned rapid construction methods using readily available locally supplied materials. Depending on the system, physical testing of prototypes performance was conducted either outdoors or indoors using the environmental test chamber described above.

The lab course was delivered in 16 weeks and distributed into four modules whereas the studio course was delivered in 15 weeks and distributed into five modules. Figure 2 outlines the introduction of each skillset within each course and the build-up of student knowledge over the span of a semester.

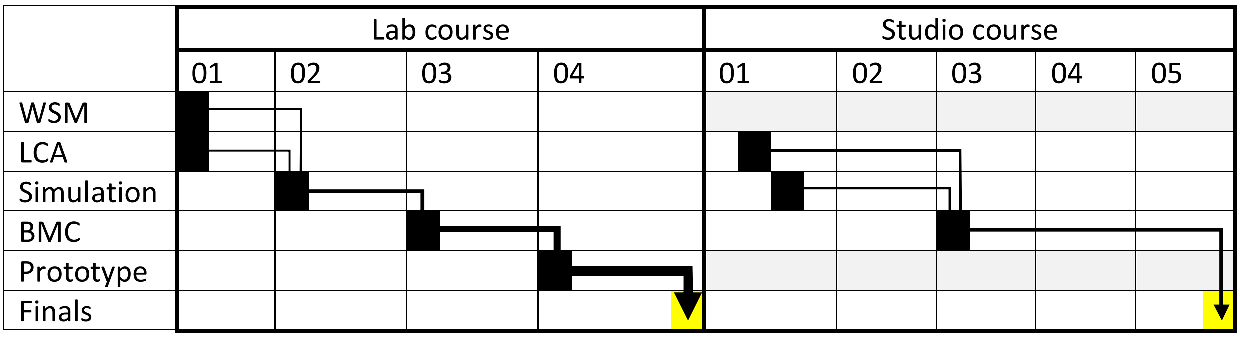


Figure 2: Progression of skillset introduction over the course of a semester in the SDA

3 Modifications to the SDA from Year One to Year Two

The authors cotaught both courses in the first year of the SDA to obtain a better understanding of opportunities and challenges in each course whereas each author delivered one course in second year while considering student feedback from responses to year one exit survey as well as the authors observations. The following adjustments were made to version 2.0:

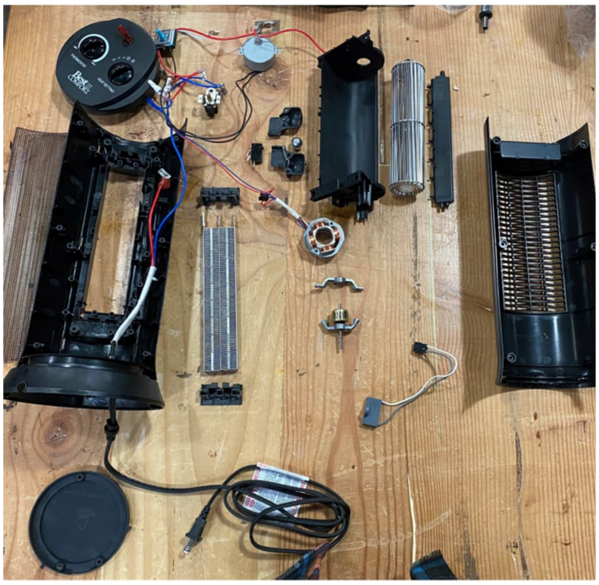
- *Create better integration between the lab course and the studio course:* In the first year of the SDA delivery, each course had a relatively large-scale project and each project was located on a different site with different climate conditions. The students in the studio had a site in Spokane, WA with predominantly cold climate conditions, whereas the students in the lab worked on a site in Tri-cities, WA with mixed climate conditions. To create a more meaningful overlap between the lab and the studio in the second year of the SDA, both courses were assigned smaller project and worked on the same site in Yakima, WA, which faces ongoing challenges with economic, environmental, and social justice. The range of climatic conditions, from hot summers to cold winters, allow for integration of passive heating and cooling design strategies.
- *Refine the delivery of entrepreneurship training*: In the first version of the accelerator, an entrepreneurial expert from the College of Engineering Entrepreneurship Institute was brought into the classroom once during the entire semester. To create a stronger continued impact in version 2.0, an expert from the University's Office of Commercialization was brought into the lab course multiple times. This included a lecture for students, as well as participation in student reviews to strengthen their proposals. Furthermore, students were encouraged to seek other entrepreneurial opportunities outside of the classroom, such as the NSF I-Corp Teams program.
- *Continue to make software training available asynchronously*: Students in version 1.0 appreciated having the software workshops recorded and available outside online

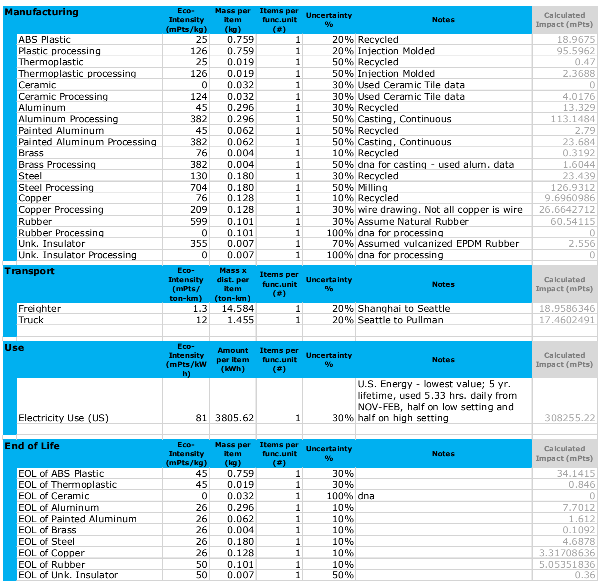
class meetings. Although version 2.0 was entirely in-person, delivery of software workshops continued to occur as synchronous online sessions, recorded, and made available for asynchronous review afterwards.

- *Create continuity between the learning modules in the lab course*: To better introduce the concept of WSM and LCA in the lab course, students analysed heating and cooling household items by breaking them down to individual components, itemizing and weighing the components, and conducting an LCA analysis based on their findings. This addressed feedback from version 1.0 of the SDC where students analysed generic household items not necessarily related to the semester's design challenge and relied on manufacturer's product specifications available online. Additionally, peer-to-peer mentors were introduced where students from version 1.0 helped students in version 2.0 with prototype testing and construction to allow for continuity of knowledge between the cohorts.

4 Example Outcomes from Students in the Lab Course

Each of the four learning modules of the lab course focused on one key skillset. Students worked in teams of three on average to propose innovations to common passive heating or cooling systems. Modules one and two introduced environmental impact tools. Module one lasted three weeks where students developed working knowledge in whole system mapping (WSM) and life cycle assessment (LCA). Environmental impacts of heating and cooling household devices (e.g. box fan, humidifier, heater, etc) were investigated through data collection in a hands-on exercise where students dismantled, inventoried, and weighed the actual components of their selected device (Figure 3). They then developed a WSM for their product and used the Ecolizer Eco Design Database to obtain the Eco-Intensity values of their product's manufacturing, transportation, use, and end of life stages. These values were then inserted into an LCA excel calculator to estimate the product's overall impacts.





Manufacturing	Eco-Intensity (mPts/kg)	Mass per item (kg)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact (mPts)
ABS Plastic	25	0.759	1	20%	Recycled	18.9675
Plastic processing	126	0.759	1	20%	Injection Molded	95.5962
Thermoplastic	25	0.019	1	50%	Recycled	0.47
Thermoplastic processing	126	0.019	1	50%	Injection Molded	2.3688
Ceramic	0	0.032	1	30%	Used Ceramic Tile data	0
Ceramic Processing	124	0.032	1	30%	Used Ceramic Tile data	4.0176
Aluminum	45	0.296	1	30%	Recycled	13.329
Aluminum Processing	382	0.296	1	50%	Casting, Continuous	113.1484
Painted Aluminum	45	0.062	1	50%	Recycled	2.79
Painted Aluminum Processing	382	0.062	1	50%	Casting, Continuous	23.684
Brass	76	0.004	1	10%	Recycled	0.3192
Brass Processing	382	0.004	1	50%	dna for casting - used alum. data	1.6044
Steel	130	0.180	1	30%	Recycled	23.439
Steel Processing	704	0.180	1	50%	Milling	126.9312
Copper	76	0.128	1	10%	Recycled	9.6960986
Copper Processing	209	0.128	1	30%	wire drawing. Not all copper is wire	26.6642712
Rubber	599	0.101	1	30%	Assume Natural Rubber	60.54115
Rubber Processing	0	0.101	1	100%	dna for processing	0
Unk. Insulator	355	0.007	1	70%	Assumed vulcanized EPDM Rubber	2.556
Unk. Insulator Processing	0	0.007	1	100%	dna for processing	0
Transport	**Eco-Intensity (mPts/ton-km)**	**Mass x dist. per item (ton-km)**	**Items per func.unit (#)**	**Uncertainty %**	**Notes**	**Calculated Impact (mPts)**
Freighter	1.3	14.584	1	20%	Shanghai to Seattle	18.9586346
Truck	12	1.455	1	20%	Seattle to Pullman	17.4602491
Use	**Eco-Intensity (mPts/kWh)**	**Amount per item (kWh)**	**Items per func.unit (#)**	**Uncertainty %**	**Notes**	**Calculated Impact (mPts)**
Electricity Use (US)	81	3805.62	1	30%	U.S. Energy - lowest value; 5 yr. lifetime, used 5.33 hrs. daily from NOV-FEB, half on low setting and half on high setting	308255.22
End of Life	**Eco-Intensity (mPts/kg)**	**Mass per item (kg)**	**Items per func.unit (#)**	**Uncertainty %**	**Notes**	**Calculated Impact (mPts)**
EOL of ABS Plastic	45	0.759	1	30%		34.1415
EOL of Thermoplastic	45	0.019	1	30%		0.846
EOL of Ceramic	0	0.032	1	100%	dna	0
EOL of Aluminum	26	0.296	1	10%		7.7012
EOL of Painted Aluminum	26	0.062	1	10%		1.612
EOL of Brass	26	0.004	1	10%		0.1092
EOL of Steel	26	0.180	1	10%		4.6878
EOL of Copper	26	0.128	1	10%		3.31708636
EOL of Rubber	50	0.101	1	10%		5.05351836
EOL of Unk. Insulator	50	0.007	1	50%		0.36

Figure 3: Example household heating device dismantled (left) and example LCA calculation with proposed modifications to the baseline (right). Image credit Ty Hash and Ryan Quinn.

Module two lasted four weeks where students developed working knowledge in system performance analysis using Computational Fluid Dynamics (CFD). Student teams aligned the system they innovated to the type of household item they analysed in module one. Their proposed innovation was designed to be connected to a 100 m^2 community space located on the site in Yakima, WA. Students first reviewed precedents to identify their baseline system and went on a field trip where they visited built projects that incorporate innovative systems. They then used CFD to simulate baseline performance and compare that to the performance of their preliminary design iterations. LCA comparisons between the baseline and the proposed design variations were also conducted. Figure 4 is an example of a team's baseline passive cooling system as well as two variations to the baseline (upper images from left to right) coupled with CFD temperature results through a cross section of their design.

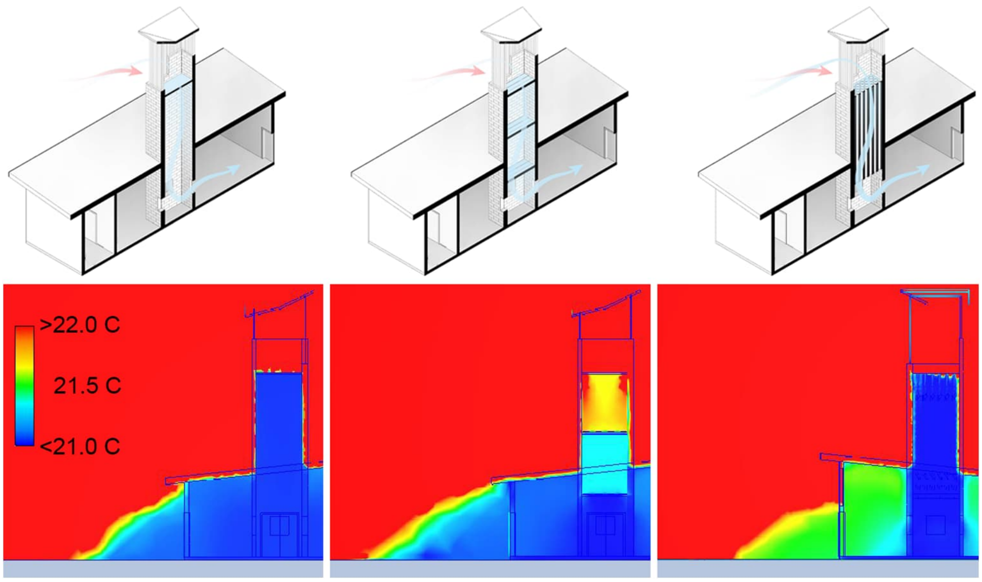


Figure 4: Example student outcomes from module two. Image credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook.

Module three introduced Entrepreneurial Mindset tools and lasted four weeks where students acquired working knowledge of business planning and developing a Business Model Canvas (BMC) to identify commercialization pathways for their proposed systems. In addition, students continued to refine their designs and narrow them down to one iteration informed by ongoing LCA calculations coupled with CFD simulations. As a transition into the final phase of the project, students created prototype fabrication plans, including detailed shop drawings; bill of materials (BOM); and a prototype construction budget.

Module four introduced hands-on experimental evaluation methods and lasted five weeks. Students refined their prototype designs and details, purchased construction materials, and building their prototypes. The last two weeks of the semester were dedicated to testing the and comparing experimental data to simulation results. Teams developed a final presentation covering outcomes from all modules and delivered it to external reviewers with expertise in product design and commercialization. Figure 6 is a series of construction photos from a passive cooling prototype tested in the chamber (left) and a passive heating prototype tested outdoors (right). Figure 7 represents a portion of the deliverables from the final presentation.

Figure 5: Example passive cooling prototype (left). Images credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook. Example passive heating prototype (right). Images credit Keaton Cox, Theo Clarke, and Jake McCornack

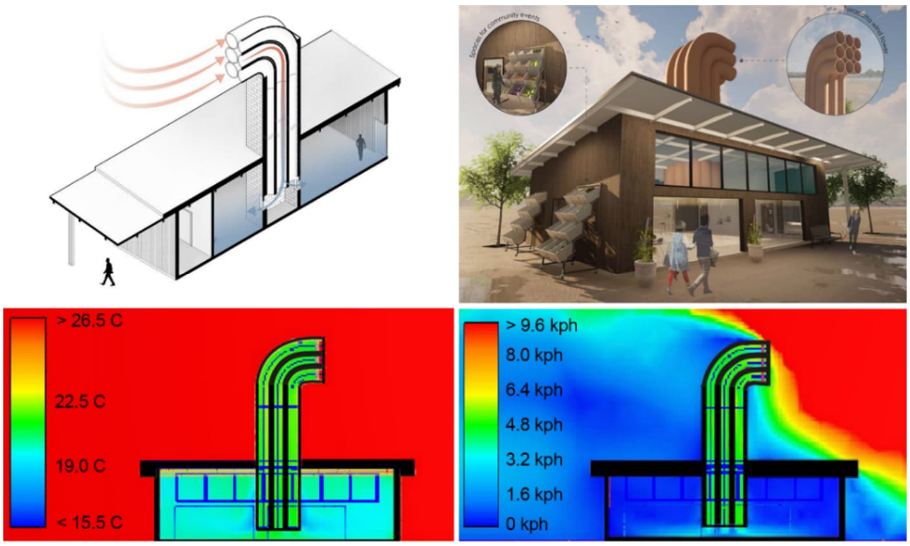


Figure 6: Example student outcomes from module four final presentation. Image credit Ruben Estrada, Ben Fleiss, Camree Kunze, and Naeem Shook.

5 Example Outcomes from Students in the Studio and Lab Courses

Students who were in both courses were in identical teams so they can incorporate their lab systems into their studio designs. The studio course was organized in a traditional format beginning with case study analysis which lasted four weeks followed by three weeks of site analysis and a field trip to the site. The remaining eight weeks were divided into three modules, each representing a primary stage in the design process from preliminary design to design development and final design. Students worked in teams of three or four to design a multi-family housing community in Yakima, WA, with a 2,000 m^2 built-up area.

Module one covered environmental impact tools at the whole building scale giving students the opportunity to practice applying these tools throughout the following modules of the semester. Solemma ClimateStudio was introduced during week two and the Athena Impact Estimator calculator was introduced during week three. Both tools were used as a feedback loop in the iterative design process to meet higher performance measures. Module three introduced students to entrepreneurial mindset tools with the focus in this course being on using the business model canvas for developing a business plan to promote their proposed community considering contextual and environmental factors.

The overlap between the two courses occurred with student teams integrated the system they are developing in the lab course into one or multiple programs in their studio project. Prototype construction reflected the spaces in the studio project to create more synergy and meaningful results from testing the prototype that can then be used to inform design decisions in the studio. Figure 8 is an example project where students proposed an innovation to the inlet of a passive downdraft cooling device and integrated that device into the residential occupancy program of their studio project. The upper images are outcomes from the studio course and the lower images are for the prototype testing of a reduced scale version of one residential unit.

Figure 7: Example studio course outcome (top) and concurrent lab course outcome (bottom). Images credit Trevor Zook, Mikke Wittenberg, Diego Quintana, Assani Kyanza.

6 Exit Survey Results

Analysis of result from version 1.0 exit survey informed modifying the survey questions for version 2.0. In the second iteration, four more questions which aim at collecting feedback on the connection between the lab and the studio courses were added, bringing the total to 14 questions. All 30 students in the accelerator responded to the exit survey. Seven were enrolled in both courses. The primary quantitative outcomes included the following:

- Level of awareness in all five skillsets increased. Results indicated significant improvement in students' awareness of the tools covered in the accelerator as illustrated in Figure 9. A five-point Likert scale was used to ask students about their level of awareness of the five skillsets before and after the SDA with one being the lowest or 'not at all', and five being the highest or 'extremely'. In all five skillsets, students' level of awareness drastically increased before and after the SDA. Scores of one and two were reported by 83 percent of the students before the accelerator (53 percent reported a score of one), whereas 85 percent reported a score of four and five after the accelerator (45 percent reported a score of five). Whole system mapping (WSM) was the most improved skillset where 73 percent were not at all aware of it before taking the lab course. 70 percent became extremely aware of it after completing the lab. Computational Fluid Dynamics (CFD) was the least improved skillset with 77 percent not at all aware of it before the lab course and only 13 percent extremely aware of it after completing the lab course.

- Level of understanding in all five skillsets increased. Using a five-point Likert scale, 80 percent reported a score of four and five. The same pattern noticed in the level of awareness with the individual skillsets existed here. WSM received the highest scores at 96 percent whereas CFD received the lowest at 50 percent.
- Ability to apply all five skillsets increased. Using a five-point Likert scale, 75 percent reported a score of four and five. Prototype construction received the highest score at 90 percent whereas CFD received the lowest at 43 percent aligning with the least improved skillset in the level of awareness category.
- Students preferred prototype construction and experimental evaluation over other activities. 57 percent indicated it as their favourite skillset and 67 percent preferred it over the field trips and the breakdown of the household heating and cooling items. Additionally, 67 percent are extremely likely to use this skillset in future coursework.
- Students in both courses indicated that more crossover is needed. Out of the seven students who were in the lab and the studio, 57 percent reported that the courses were moderately connected, and the remainder either perceived the courses very connected or not at all connected.

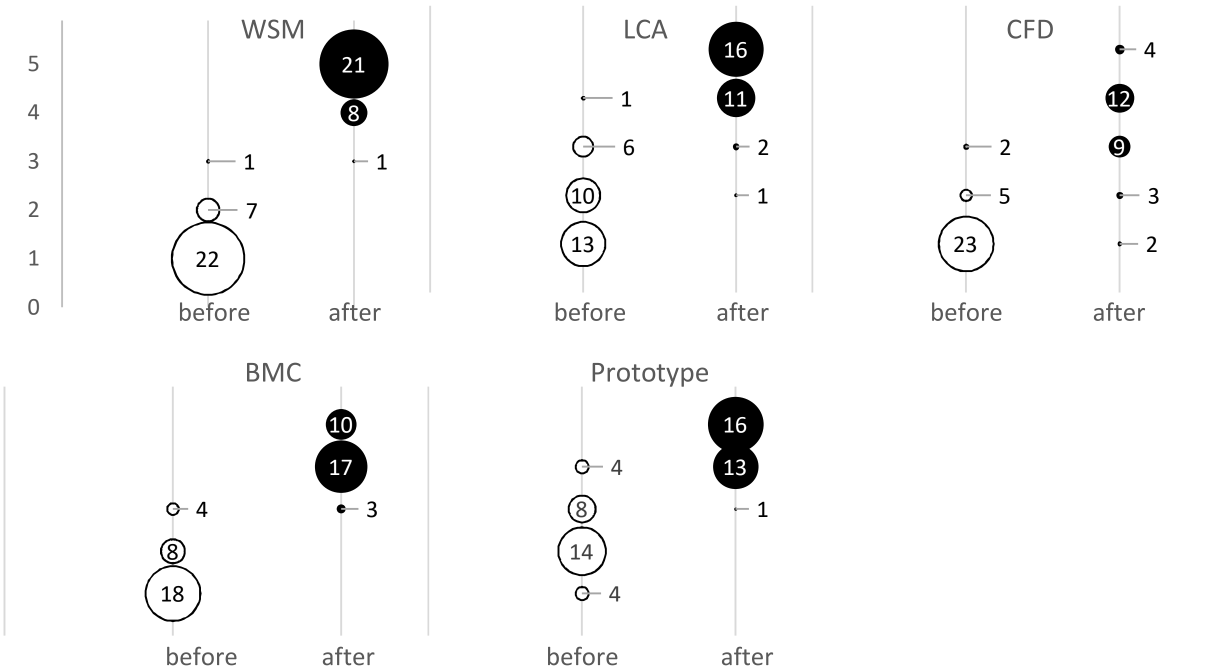


Figure 8: Results of students' level of awareness before and after completing the SDA.

Most of the qualitative feedback from the students oriented around course schedule, the continuity of the deliverables between the modules, more software workshops, and the integration between the two courses. Selected comments from the survey are as follows (lightly edited for clarity):

- "I think that getting into the phase of building and testing prototypes much earlier in the semester would have been beneficial and given us a chance to make design changes for the physical model."
- "More focus on developing a product from the start rather than starting out with taking household items apart."
- "More in-depth workshops on how to use some of the software tools and include examples for both heating and cooling rather than having a workshop focusing on cooling systems as the processes are different."
- "I wish the two courses were highly connected because it would have been better to learn how to fully integrate what we learn in Lab to Studio. However, it was a great course and I learned a lot from both tectonic and studio class. Most likely will use this information in the near future."

7 Discussion and Plans for Version 3.0

Survey outcomes demonstrated student satisfaction with the in-person delivery of the course. Moving forward, the following adjustments will be made to version 3.0 of the SDA:

- Continue to create stronger crossover between the two courses. Through student engagement in the whole-system mapping, the authors realized the need for students to have a firmer grasp of high-performing enclosure systems that will result in lower heating and cooling loads which will in turn enhance the efficiency of the space conditioning systems. Additionally, enclosure systems offer more crossover possibilities since enclosure detailing is typically a required element in studio courses. In year three of the SDA, students taking both courses will design a highly efficient enclosure system in the lab course and integrate that system into their studio projects.
- Expand the hands-on experimental evaluation component. Being the most preferred activity among students, year three of the SDA will include a wider variety of testing procedures to incorporate a calibrated hot box apparatus as specified in ASTM C1363. Students will use this to assess heat flow through 1m x 1m full scale mock ups of their high performing assemblies and compare that to a code minimum assembly.

Acknowledgements

The authors are grateful to the Lemelson Foundation who awarded them with the VentureWell Faculty Grant and the School of Design and Construction (SDC) who awarded them with the SDC Seed Grant. The researchers also wish to thank the SDC for donation of materials used in the construction of the environmental test chamber. Finally, we wish to acknowledge input and effort from Colter Nubson, Nathan Albrecht, Anguel Atanassov, Ryan Smith, Tom Jobson, David Thiessen, Miles Pepper, Rabindra Nanda, and Scott Hanson.

References

[1] Architecture 2030. 2022. “Why the Built Environment?” https://architecture2030.org/why-the-building-sector/.

[2] Bernstein, Fred. 2022. “Architecture Schools Begin to Put Embodied Carbon Front and Center.” Architectural Record. https://www.architecturalrecord.com/articles/15823-architecture-schools-begin-to-put-embodied-carbon-front-and-center.

[3] National Architectural Accrediting Board. “NAAB Conditions for Accreditation, 2020”

[4] WA Department of Ecology. “Climate Commitment Act (CCA).” https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act.

[5] Association of Collegiate Schools of Architecture. “2023 COTE Competition Program.” https://www.acsa-arch.org/competitions/2023-cote-competition/program/.

[6] Anderson, Sean, Tobias Jimenez, and Haley Ladenburg. “Wallingford W2E.” Architect Magazine. https://www.architectmagazine.com/project-gallery/wallingford-w2e_o.

[7] Al-Hassawi, Omar. “Design and Evaluation of Passive Downdraft Cooling Systems: Outcomes from Built Prototypes of Single Stage and Hybrid Downdraft Cooling Towers.” *Architectural Science Review 64 (1–2): 17–27*. 2020.

[8] Shaprio, Gideon. “Drywall Waste Block, a Green CMU.” Architect Magazine. https://www.architectmagazine.com/awards/r-d-awards/award-drywall-waste-block-a-green-cmu_o.

[9] Al-Hassawi, Omar, and David Drake. “Design + Construction of a Novel Environmental Test Chamber: A New Method for Evaluating Performance of Passive Downdraft Cooling.” In proceedings of the *36th International Conference on Passive and Low Energy Architecture: Will Cities Survive?* Santiago, Chile. 2022.

[10] Al-Hassawi, Omar, and David Drake. “Sustainable Design Accelerator: Infusing Entrepreneurship and Evidence-Based Design into Architecture Pedagogy.” In proceedings of the *110th Annual Meeting: EMPOWER*. Virtual. https://www.acsa-arch.org/conference/110th-annual-meeting/thursday-schedule/#toggle-id-44-closed.

[11] Faludi, Jeremy. “Whole System Mapping.” VentureWell Tools for Design and Sustainability. https://venturewell.org/tools_for_design/whole-systems-mapping/.

[12] Faludi, Jeremy. “Measuring Sustainability.” VentureWell Tools for Design and Sustainability. https://venturewell.org/tools_for_design/measuring-sustainability/.

[13] Athena Institute. “Overview | Impact Estimator for Buildings.” Athena Sustainable Materials Institute. https://calculatelca.com/software/impact-estimator/overview/.

[14] Autodesk. “Autodesk CFD.” https://www.autodesk.com/products/cfd/overview.

[15] Solemma. “Solemma Climate Studio.” https://www.solemma.com/climatestudio.

URBAN INFILL DEVELOPMENT POTENTIAL:

AN APPROACH TOWARDS FUTURE URBAN RECOVERY MODEL (THE CASE STUDY OF KURIL, DHAKA)

Sefat Sultana*, Anika Amzad Rachi

Faculty, Department of Architecture, Bangladesh University
Bangladesh University, 15/1, Iqbal Road, Mohammadpur, Dhaka 1207
City: Dhaka, Country: Bangladesh
E-mail address: sefat20006@bu.edu.bd *, rachi20072@bu.edu.bd

Abstract

Now a days cities are under continuous transformation due to urbanization which causes uncontrollable urban growth and deterioration of urban environment in socio economic, physical and cultural aspect. Infill development is being considered as the potential method of solving these issues. Being a developing metropolis, Dhaka is expanding too quickly due to unplanned development without taking preference of city dweller and viability into account. Kuril, a significant region within the city of Dhaka where numerous complex urban issues exist and certain areas are still underdeveloped and unutilized, leading to complicacy in socio economic and environmental standpoint. In this research, survey and site analysis are conducted using qualitative methods such as physical survey, image mapping, and literature review. The qualitative assessment and analysis of supporting literature are performed to make the write-up clear regarding the research objective. The goal of this study is to address the problems that we discovered in Kuril area while also establishing a healthy neighborhood that incorporates a variety of activities with the existing infrastructure and natural landscape. Through extensive review and site analysis seven major problems in Kuril area are identified and all these problems are presented in a qualitative study and image mapping. At the conclusion of the research work, several design solutions are proposed to address these seven issues. A number of architectural alternatives are discussed and evaluated including walkable network and accessibility, elevated walkway, spaces for commercial and public activity incorporated with natural open setting to enliven the neighborhood.

Keywords: Infill development, urban neighbourhood, accessibility and network, breathing space

1. INTRODUCTION

Increasing growth of population is leading to rapid urbanization in modern world. As a result, urban communities are extending. With the expansion of urban area, the environment is being affected in various aspects [1]. The rapid growth of urban areas has resulted in a variety of complicated issues, including unplanned land development, traffic congestion, pollution, the loss of open space, and the desolation of old urban centres [2][3].

The growth of urbanization is also prominent in Bangladesh. In 2022, The percentage of urbanization in Bangladesh is 39.7 %. Urban population of Bangladesh increased from 8.6 % in 1973 to 39.7 % in 2022 growing at an average annual rate of 3.21%. Dhaka being the capital city of Bangladesh, has seen astonishing growth and rapid development since 1971.Due to uncontrolled population expansion, urbanization and development in Dhaka city took place in a very unplanned manner and still this process is ongoing. Along with the uncontrolled development, some areas remain underdeveloped, vacant and less useful posing threat to the environment and neighbourhoods. Kuril is such an area in the Dhaka city where some areas are still under developed and unutilized which is causing numerous socio economic and environmental issues and also degrading the quality of adjacent neighbourhoods. Through site survey and study, it is found that there are several problems in that area which can be attributed to unplanned development and sprawl. Kuril Biswa Road is a heavy traffic and busy road. This is not just a transitional space within Dhaka city but also connected with inter district transit. Rail tract also divided the area and there is no safe rail crossing. There are not enough facilities for people to walk and cross the roads in that high speed of vehicles. Due to less human traffic and interaction, various anti-social activities and crime have been developed under the flyover, beside the running rail tract and in the surrounding empty spaces. As a result, some public spaces are worn out and the people of that area do not have much entertainment and open interactive space. Walkable network such as pedestrian walkways are not adequate there. Besides vendors create congestion on the pedestrian walkway as they do not have any organized space for them. Lack of recreational space, neglected existing water body and unutilized open spaces, underutilized spaces under the flyover are creating socio cultural issues as well as environmental problems which is degrading the quality of the neighbourhood and their lifestyle. But this area of Dhaka city is highly potential with natural setting such as open green space and water body. If these spaces can be revitalized with public amenities and activities this place will be livelier and more active which will reduce the probability of crime and anti-social activities. Also, the unused vacant land, spaces under the flyover can be utilized in many ways to revive the surrounding neighbourhood.

Infill development could be considered as the most basic intervention to address these issues in that area in order to meet the public demand and to achieve a higher quality of life. It is the enhancement of vacant, abandoned, neglected, or underutilized property in populated parts of established settlements with existing infrastructure. The infill development causes the existing gaps in the community to be filled, and this development plays a vital role in utilizing the existing potential of the city and protecting pristine land and preventing urban sprawl [4][5]. Effective infill construction fills gaps in the area while focusing on the existing community fabric. It is distinguished by a balanced mix of uses that support transit and a greater range of services and amenities that give life to the communities [6].

The purpose of this paper is to identify the problems in Kuril neighbourhood due to unplanned urban development and mismanagement of land usability, to identify the potential of that area and to explore the probable solutions in the form of infill development. The research method is a three-step process. At first Physical site survey is conducted to understand the existing situation and identify the issues. Then qualitative analysis is done on the survey data. Case study and literature review is done to understand the issues and their probable solutions. Finally, some design and planning initiatives are proposed to address these issues. From this research work it will also be evident that how infill development can enhance the neighbourhood as well as the environment and bring vibrance to the community life through the potential development of the concerned site.

2. Literature Review

Infill development and redevelopment can result in efficient utilization of land resources, Reinvestment in areas that are targeted for growth and have existing infrastructure, more efficient delivery of quality public services

There are various types of infill development. They are:

- Residential Development
- Small-Lot Development
- Mixed Use Development
- Transit-Oriented Development
- Brownfield Redevelopment
- Greenfield Redevelopment

Transit-oriented development (TOD) is a type of infill development design strategy that involves compact, mixed-use, pedestrian, and bike-friendly urban development which is closely linked to local transportation by adding workplaces, apartments, services, and facilities for public stops. It contains a high-quality, walkable pedestrian environment that integrates the street design. In this research, a mixed type of transit-oriented development strategy is implemented.

Somayeh Mohammadi-Hamidi et al [7] employed a mixed methodology to look into urban infill development policies as a potential means of preventing urban sprawl and safeguarding Ardabil, a peri-urban area in Northwestern Iran. They have used Landsat ETM+ and ArcGIS for mapping and finding out the potential of infill development.

Urban Landscape Analysis Tool and Landsat satellite data were utilized by Sharma and Joshi [8] to estimate Delhi's urban growth. In order to subjectively and statistically represent the patterns of urban expansion, the land cover maps that were created were compared. Three key types of developments made up new development areas: infill, extension, and leapfrog (development of land in a way that necessitates the extension of public infrastructure). Several studies have demonstrated that land-use change analysis, remote sensing, and GIS approaches do not appropriately handle infill development.

Mohammad Reza Pour Mohammadi et al [9] did a study which inherently categorized as an example of applied research, and based on the techniques employed, it is classified as a documental-analytic study that makes use of GIS technology (Model FUZZY-AHP) to prepare the final map and relevant layers and analyze data. According to research findings, Zanjan's urban regions have a great potential for infill development, and by pursuing these opportunities, the city's deteriorating texture may be effectively reduced.

Urban infill integrates walkable network which may consist of pedestrian walkway, side walk, elevated walkway etc. well-connected walkable network links the streets to low-impact sustainable transportation (walking, cycling, transits, and green vehicles), hence contributing to an environmentally friendly, affordable, fast, and convenient means of travel that benefit the environment, economy, society, and community health. The interdependence between walkability and city streetscapes promoted the experience of active physical activities, such as leisure, exercise, or recreation [10-16].

The developing concerns and issues with infill development were looked at in the report of H. K. Mado et al [17]. The advantages, variations, and effects of the infill development in Kaduna's Unguwar Rimi GRA are evaluated. Both an institutional survey and a field survey in the research region were used to collect data. In that they found out the impacts but the recommendations are not well defined.

Urban infill also provides breathing space for urban people. Parks and other urban green spaces are considered as the lungs of a city, providing places for residents to breathe and relax. Open green spaces, green parks, water body, landscape with natural features are some forms of breathing space. These spaces not only contribute in environmental development through reducing pollution but also render immense benefit to people’s health and mental wellbeing.

According to a study hypothesis developed by Aml T. Al Shamarti and Haitham A. H. Al Shammari [18], urban infill initiatives, including deletions and additions, can enhance the quality of life in these cities. They arrive at findings based on markers that may be used to stimulate the quality of life in traditional cities, which validated the research premise.

From all the studies and research mentioned above it is evident that urban infill is a great solution of urban growth and deterioration of urban environment.

3. Materials and Methodology

3.1 Study Area

Kuril is located between the Latitude 23.8211887 and Longitude 90.4195458 under the khilkhet thana of Dhaka city, which is the capital city of Bangladesh. The total population of this area is almost 130053 (according to the census of 2011). Kuril biswa road is a prominent transit point of Dhaka city. With numerous arterial, sub arterial street, collector street as well as flyover and express way it connects several areas of Dhaka city and works as a junction point. The surrounding neighbourhoods is divided by the running Rail tract. In one side there is Nikunja 1 residential area and, in another side, there is another neighbourhood named Kuratoli, Khilkhet. There runs Nikunja Lake alongside the road and also an open green space with natural water body in between the running roads. In terms of both population and size, Dhaka has experienced exceptional growth in recent years. Uncontrolled urban growth has resulted in unplanned development and sprawl. Kuril Biswa road area is also such an area where unplanned land use and lack of effective urban development is causing socio cultural deterioration to the neighbourhood. The next step is to analyse the existing situation of this area to understand the issues that are creating complexity in that region.

Figure 1: Study Site.

3.2.1 Methodology

In this work, qualitative analysis method is used to gain comprehensive insights about the site. The systematic literature review is done in the previous section of the paper which shows the scope and potential of infill development in the area with existing structure as well as vacant land. The site survey and findings, image mapping of the site area and the qualitative analysis are now presented in the next sections. Figure 2 presents the methodology in a flowchart.

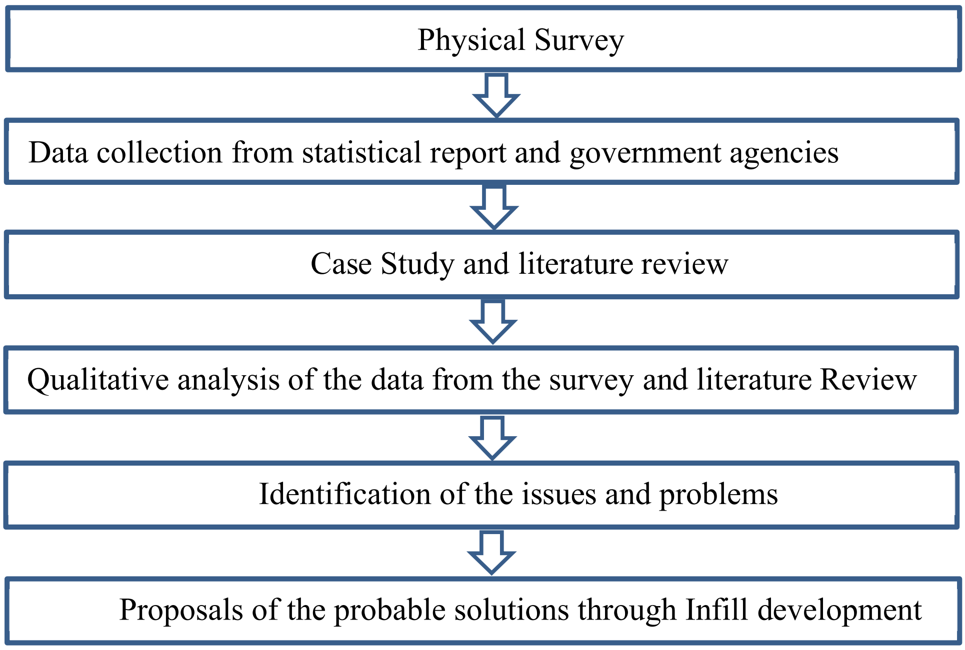
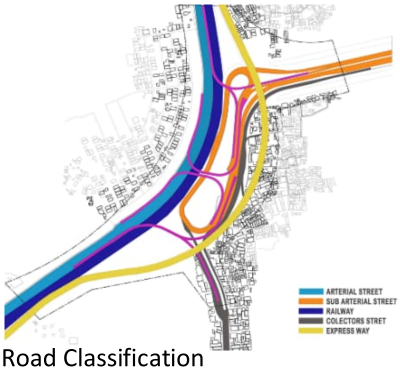


Figure 2: Flowchart of the methodology used in research

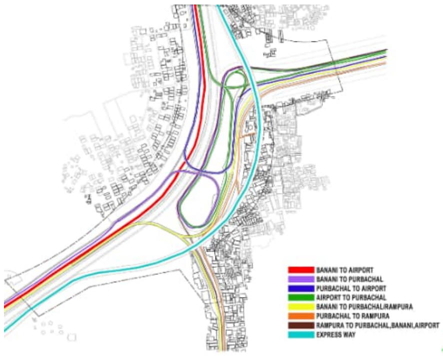
3.2.2 Image mapping

Map is used to analyse the existing situation of the site (Kuril Biswa Road). In this section, land use diversity, Road classification, Transportation network, traffic flow and pattern, open space, various commercial and trade activity, human activity and many other data are presented to understand the context and situation of the site. From this information qualitative assessment is done and problems are identified through systematic analysis.

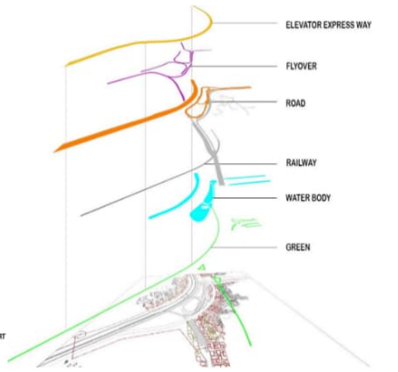
Road network



Road Classification

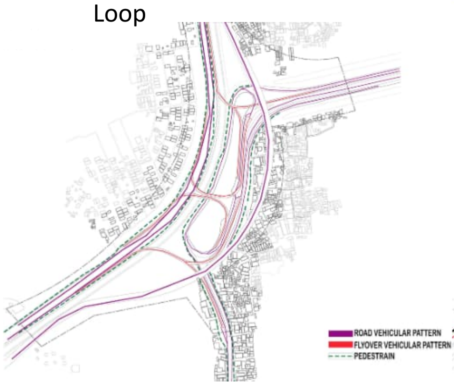


Loop

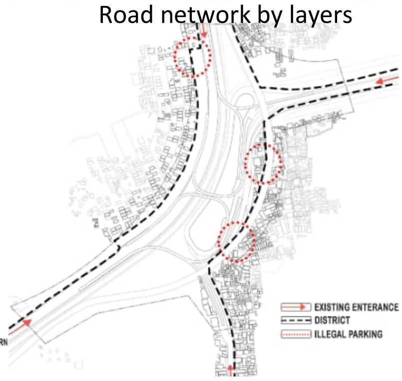


Road network by layers

Average Traffic flow



Traffic pattern

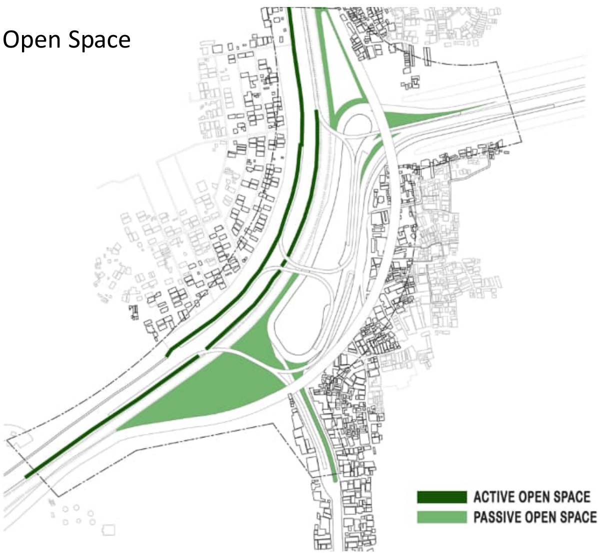


Permeability

Open Space and Security

There is active and passive open space in this site. Nikunja lake is running alongside the Nikunja 1 residential area. In the middle part of the site in between the roads and flyover there

Open Space

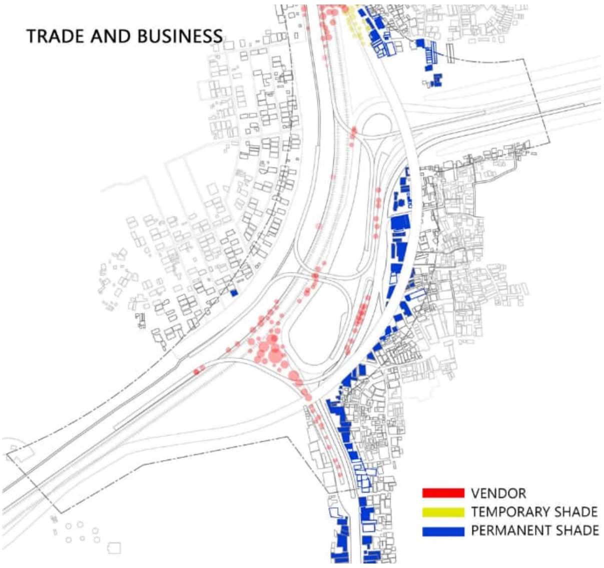


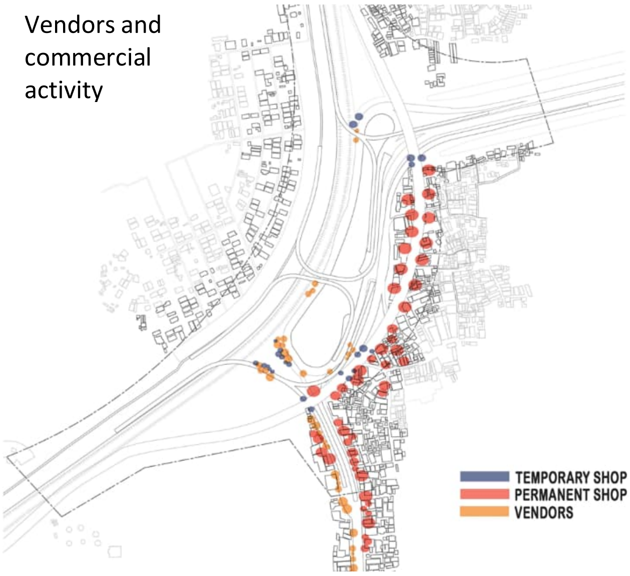
SECURITY

is open green space with natural water body. But these passive open spaces are lying vacant and is of no use for the lack of proper utilization. Moreover, these spaces are becoming dump yard and den for the unsocial activities.

Trade and Business Activity

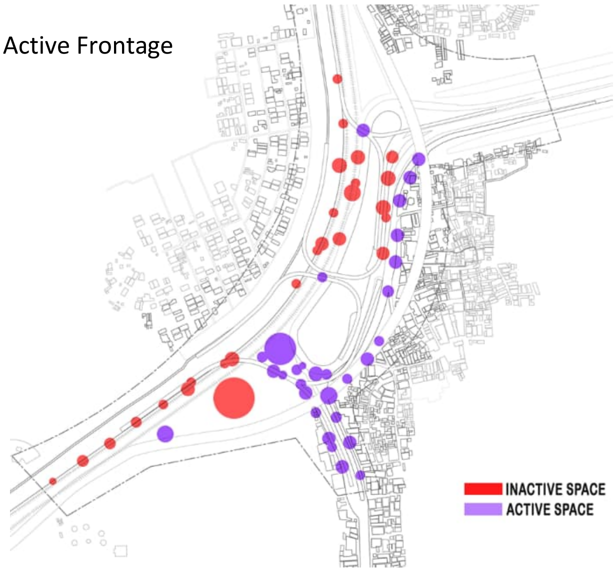
Some spaces are active with various trade and business activity. vendors occupy the pedestrian and active frontages and they don't have any specific space for trading.

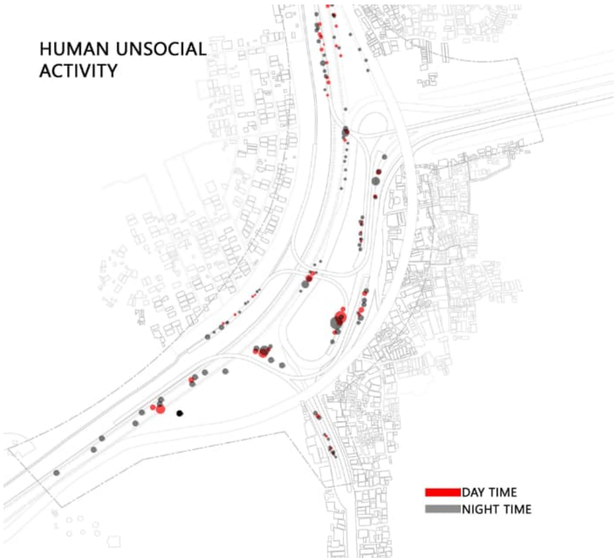




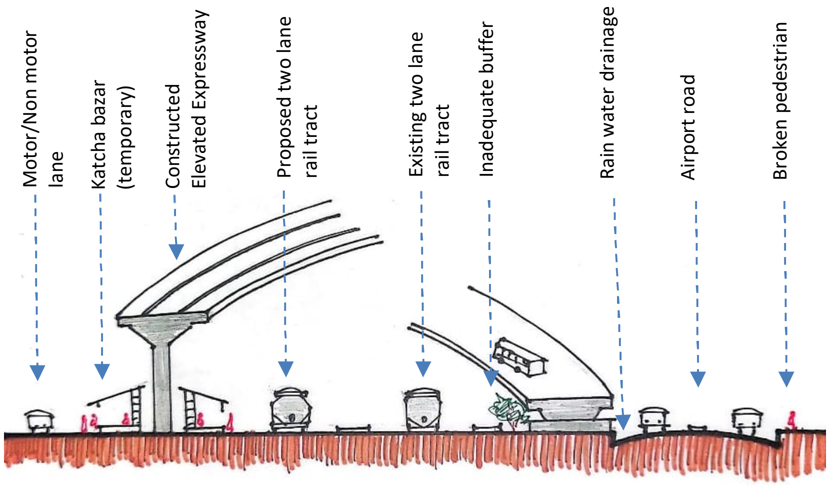
Active frontage and Human unsocial Activity mapping

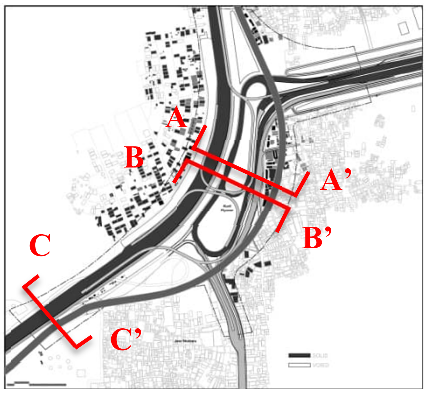
Road side and pedestrian facing spaces are active but some Spaces are inactive such as space



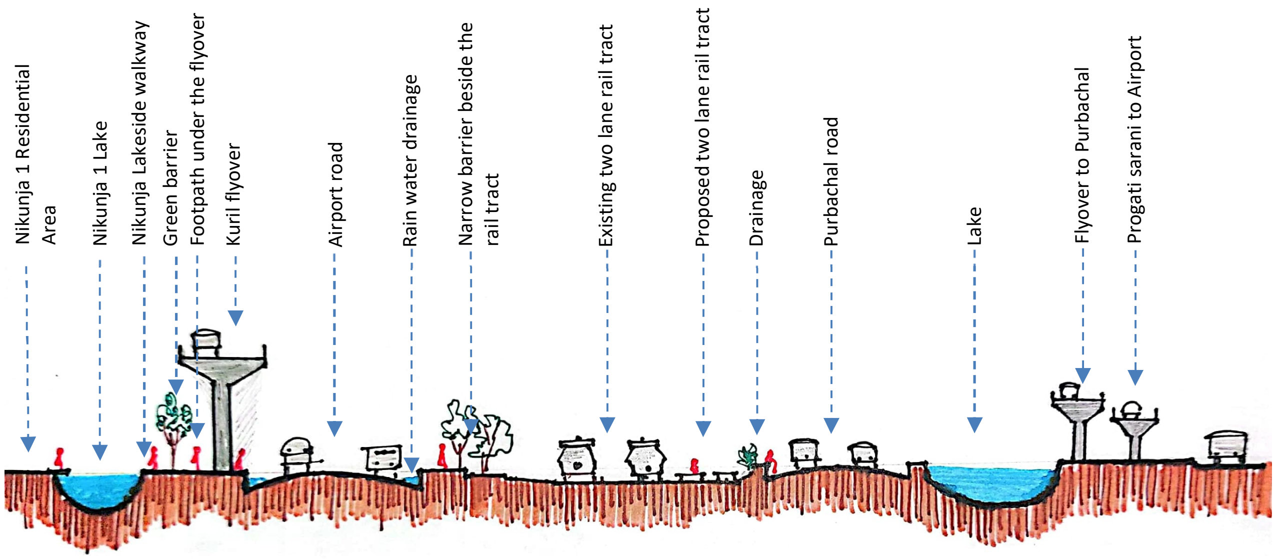


Some of the section views are now attached below-

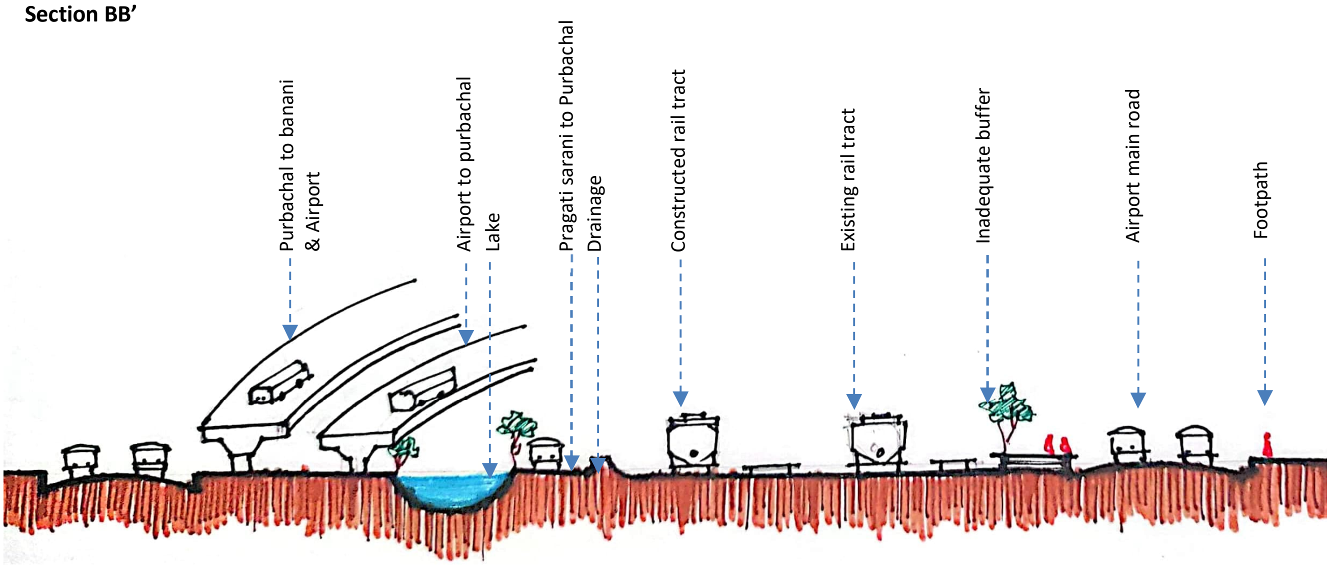




Section AA'



Section BB'



Section CC'

Figure 3: Sections of existing situations

3.2.3. Identification of problems and issues

From the above discussion seven major issues are identified in Kuril biswa road area of Dhaka city. These issues are as follows:

- No safe road crossing, unsafe rail crossing
- Low security condition
- Lack of recreational space
- Unsocial and illegal activities under the flyover
- Inactive open spaces
- Neglected and dirty water body
- Unorganized vendor occupying pedestrian and circulation space

3.2.4. Probable solutions in the form of infill Development

Vacant, abandoned or underutilized land within built-up areas of existing communities, where infrastructure is already in place can be regenerated or redeveloped through infill development.
There are some proposals for solving the issues that are found in the study site through survey and qualitative analysis:

- Developing the walkable network including Elevated walk way
- Creating Public activity space
- Creating Park and recreational spaces
- Elevated cafe and exhibition space under the flyover
- Incorporating the natural setting (open green space and water body) with landscape design for public gathering
- Riparian buffer, deck and walkway beside the water body

All the probable solutions are now presented below in the form of propose master plan in Figure 4.

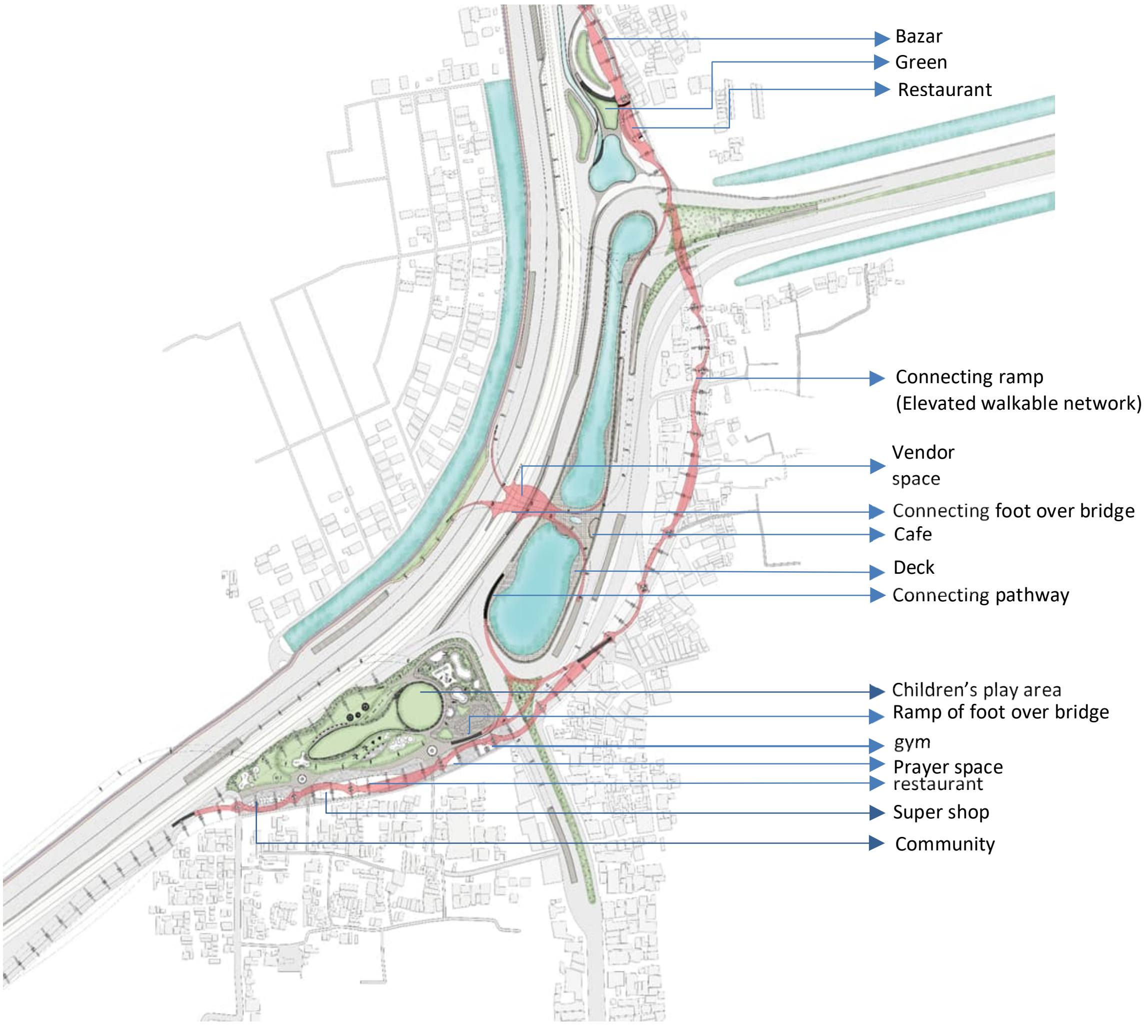


Figure 4: Proposed master plan with probable solutions

The results of the quantitative analysis and the expected outcome after infill development is presented at the later part of the research.

4. Result and Discussion

In this part of study impact of infill development and its potential is discussed. For rapid urbanization and unplanned development, natural open spaces are on the verge of extinction. But natural space is essential part for any urban area as these spaces act as buffer and reduce pollution. At the same time proper land use and management is essential to increase the usability of any vacant land or land with already existing structures which will enliven the community. Probable impacts of infill development in kuril biswa road area is discussed below in view of some aspects:

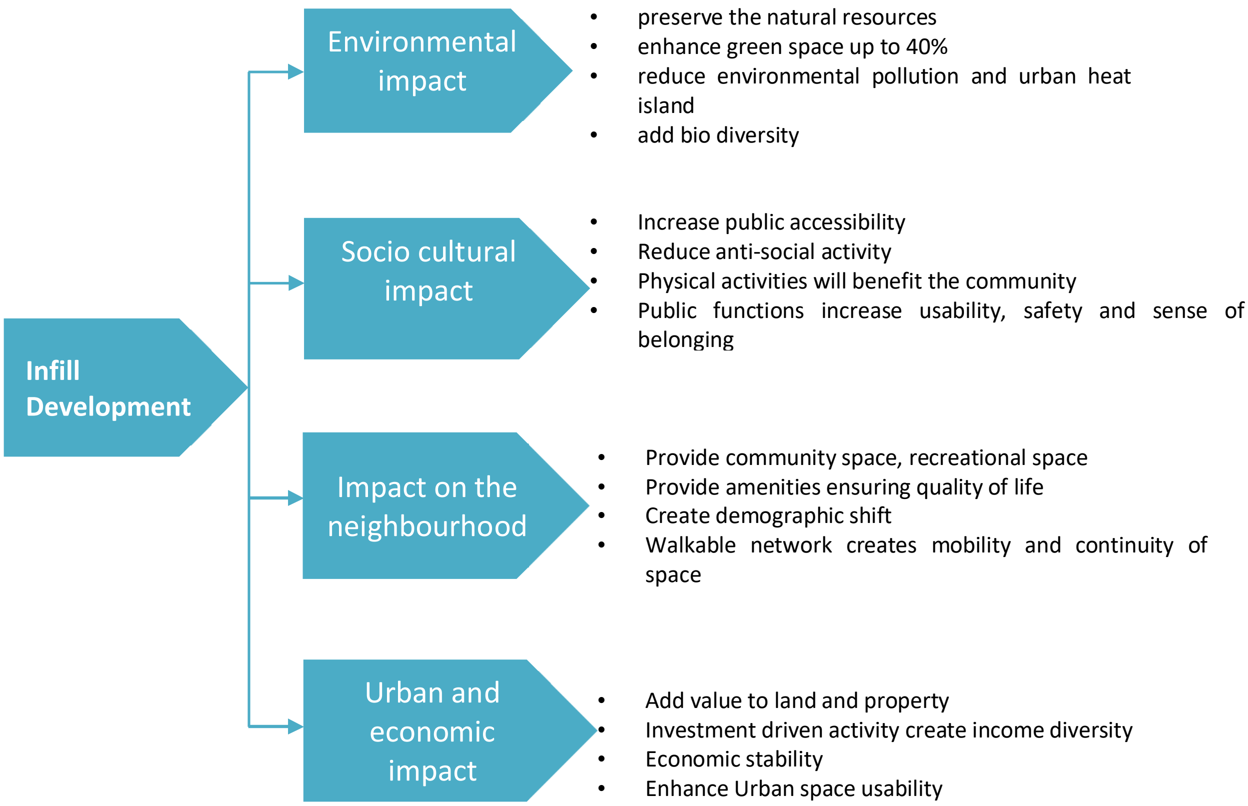


Figure 5: Probable impacts of infill development

The probable impacts of infill development is discussed above. The expected outcome after implementing the urban infill strategy is surely positive. Table 1 below illustrates the comparison of previous Situation of the site area and the Expected outcome after infill development.

SL. No	Previous Situation of the site area	Expected outcome after infill development
1.	Unsafe rail and road crossing is interrupting public accessibility	Safe crossing and Elevated walkway can enhance public accessibility
2.	Inadequate pedestrian walkway and lack of walkable network create interruption in accessibility hence usability of land is also reduced.	Well-planned walkable network may connect the spaces and enhance the land use pattern through incorporating various public functions. People will be encouraged towards environment friendly transit (side walk, pedestrian, cycling etc) which will reduce pollution and energy consumption.
3.	No security and sense of belonging for the lack of public gathering and interaction.	Spaces, public functions, open breathing spaces can make the space lively, discourage crime hence it will enhance security.
4.	Space under the flyover lying unused and illegal works is taking place	Exhibition space, small shops, kitchen markets can be located under the flyover which will encourage public gathering reducing illegal works.
5.	Inactive open space, lack of recreational space	Existing open green space can be public park, urban breathing space.
6.	Neglected and dirty water body	Regeneration of urban water body, Riparian buffer, deck and walkway beside the waterbody make the neighbourhood lively and reduce pollution.
7.	Unorganised vendor create congestion on circulation space	Vendors and temporary shops can be relocated beside the pedestrian walkway or under the flyover or nearby public open spaces which will promote economic growth and also will not create chaos.
8.	Unused vacant land	Vacant land with natural features can be turned into breathing space with public amenities like restaurant, gym, exercise area, children’s play area etc.

Table 1: Comparison of present situation and expected outcome

So, from the above comparison, it is very much clear and evident that, infill development is the ultimate solution of urban growth and deterioration of urban environment in socio economic, physical and cultural aspect.

5. Conclusion

The above study indicates that urban Infill development has potential benefit in the kuril biswa road area of Dhaka city in the aspects of environmental, socio economic, urban and community wellbeing. The key finding of the study is the existing situation of the site area which is affected with so many socio economic and environmental issues. The result shows that infill development specially transit oriented development can be a potential solution to solve the issues of the kuril neighbourhood. It can change the land use pattern and add value to the land and existing structure as well as natural setting resulting in diverse community activity which can benefit the neighbourhood by improving the quality of life. Recreational facility, open breathing spaces beside the existing waterbody, easy access to the contemporary life requirements, enhancing the usability of vacant and unused spaces under the flyover, adequate and well-designed walkable network, improvised socio cultural, economic as well as public activities can bring a positive impact to that urban area. The neighbourhood of that area can be revitalized socially, economically, culturally, urbanely, environmentally leading towards a sustainable, active and healthy society characterized by mixed use development, variety of events and public activities in the form of infill development.

References

1) Schiller, G.; Blum, A.; Hecht, R.; Oertel, H.; Ferber, U.; Meinel, G. Urban infill development potential in Germany: Comparingsurvey and GIS data. Build. Cities, Vol. 2, Pages-36–54, 2021.

2) Lee, H. An analysis on development capacity of an urbanized area for urban growth management. J. Korean Urban Geogr. Soc.,Vol.11, Pages-1–18, 2008.

3) Rahimi, A. A methodological approach to urban land-use change modeling using infill development pattern—A case study in Tabriz, Iran. Ecol. Process.,Vol.5, Page-1–15, 2016.

4) Abbaszadeh, G. Pathology of mass housing projects in Iran (Mehr housing plan). *Journal of Fundamental and Applied Sciences, 8*(3), 885-915, 2016.

5) Aliakbari, E., & Akbari, M. ZONNING THE INFILL DEVELOPMENT, AN EFFORT ON PHYSICAL DEVELOPMENT SCENARIO OF TEHRAN, 2018.

6) Aly, S. S., & Attwa, Y. A. Infill development as an approach for promoting compactness of urban form. *Sustainable Development and Planning VI*, *173*, 455, 2013.

7) Mohammadi-Hamidi, S.; Beygi Heidarlou, H.; Fürst, C.; Nazmfar, H. Urban Infill Development: A Strategy for Saving Peri-Urban Areas in Developing Countries (the Case Study of Ardabil, Iran). *Land* **2022**, *11*, 454. https://doi.org/10.3390/land11040454

8) Sharma, R.; Joshi, P.K. Monitoring Urban Landscape Dynamics over Delhi (India) Using Remote Sensing (1998–2011) Inputs. J.Indian Soc. Remote Sens. 41, 641–650, 2013.

9) Mohammadi, Mohammad Reza Pour, Shahrivar Roostaei, and Ahmad Asadi. "Research Paper Infill Development Potential for Urban Deteriorated Areas (Case Study: Zanjan City)." International Journal of Scientific Management and Development, Vol.3 (2), 678-678 February 2015.

10) Zhoua H et al,Social inequalities in neighborhood visual walkability: Using street view imagery and deep learning technologies to facilitate healthy city planning Sustainable cities and society 50 101605, 2019.

11) Rafiemanzelat R et al City sustainability: the influence of walkability on built environments Transportation Research Procedia Vol.24, Pages-97-104, 2017

12) Wang H and Yang Y,Neighbourhood walkability: A review and bibliometric analysis Cities Vol.93, Pages 43-61, 2019.

13)Osama A and Sayed T,Evaluating the impact of connectivity, continuity, and topography of sidewalk network on pedestrian safety Accident Analysis and Prevention Vol.107 Pages.117-25, 2019.

14) Bhattacharyya D B and Mitra S , Making Siliguri a walkable city Procedia - Social and Behavioral Sciences Vol.96, Pages. 2737-44, 2013.

15) Nakamura K, The spatial relationship between pedestrian flows and street characteristics around multiple destinations IATSS Research Vol.39, Pages. 156-63, 2015

16) Said I and Wan Mohamad W S N, Differences of sreet connectivity between old and new Zone in Malaysian small town International Journal on Advanced Science, Engineering and Information Technology, 2017.

17) H. K. Mado, GarbaT., M. I. Ahmed, I. H. Gitaland, A. Belel, Impact of Infill Approach to Sustainable Urban Environment the Development, American Journal of Engineering Research (AJER), Volume-10, Issue-6, pp-01-10, 2021.

18) Al Shamarti, Ami T., and Haitham AH Al Shammari. "Urban Infill as a Tool to Activate the Quality of Life in Traditional Cities." *IOP Conference Series: Materials Science and Engineering*. Vol. 870. No. 1. IOP Publishing, 2020.

WINDOWS EMPLOYING VACUUM GLASS: ENQUIRIES INTO POTENTIALS AND CONSTRUCTION PRINCIPLES

Ulrich PONT*[,1], Peter SCHOBER[2], Magdalena WÖLZL[1], Matthias SCHUSS[1], Karin HAUER[2]

Research Unit Building Physics and Building Ecology, TU Wien, Karlsplatz 13, 1040 Vienna, Austria, ulrich.pont@tuwien.ac.at

Austrian Forest Products Research Society (Holzforschung Austria), Franz-Grill-Straße 7, 1030 Vienna, Austria, p.schober@holzforschung.at

Abstract

After more than a century of research and development (R&D), durable and affordable Vacuum glass products have emerged on the international glass market in the past 15 years. While these products have been integrated in fixed façade construction in South-East-Asia for some time by now, little R&D work has been invested into the development of new (operable) window constructions employing vacuum glass. Likewise, little effort has been spent into the employment of such products for window construction retrofit of architectonically sensitive constructions such as the famous casement windows, which can be found in many buildings of European City centres. To close this gap, the authors did conduct four research projects pertaining to window retrofit with vacuum glass products and design and construction of new window constructions in the past years. After extensively testing the properties and durability of different vacuum glass products in view of durability, thermal performance and acoustical performance, R&D approaches toward window constructions that employ vacuum glass have been started. Thereby, a multi-fold approach has been conducted: The methods we deployed, amongst others, included (i) extensive lab-testing of vacuum glass products, early window prototypes, mock-ups, and test specimen. (ii) Utilization of state-of-the-art numeric thermal bridge simulation for fast design alternative evaluation. (iii) Envisioning new ideas for windows via the creativity of architecture and building science graduate students in academic efforts toward designing windows of the future. (iv) Iterative dialogue with stakeholders and integration of the in-depth knowledge of window construction experts both from large scale industries and supplementary goods providers, as well as from small scale window-carpentry companies. Moreover, functional prototypes of new windows were constructed, equipped with state-of-the-art fittings and sealing technology (i.e. window motorization and automation) have been constructed and exhibited in a fair. Thereby these prototypes were subjected to the critical views and opinions of stakeholders from the window building industry. Furthermore, existing casement windows have been retrofitted with vacuum glazing products and have been subjected to extensive monitoring of their energy and hygrothermal performance to deliver a proof about their potential. These efforts can be said to have promoted the potential of vacuum glass for window constructions amongst many stakeholders. The present paper delivers a review of the conducted efforts, summarizes the

gained insights and results, and tries to envision the future for vacuum-glass equipped windows.

Keywords

Vacuum glass products, window constructions, numeric thermal bridge simulation, environmental monitoring, functional prototypes, window retrofit.

1 Introduction

According to the International Energy Agency (IEA), the operation of buildings accounted for about 30% of the global final energy consumption as well as for 27% of total energy sector emissions (8% direct emissions in buildings, 19% due to generation of electricity and heat used in buildings) in the year 2021 [1]. The IEA also states that the next decade is considered crucial to implement energy saving measures, in particular for all new buildings and 20% of the existing building stock to be zero-carbon-ready as soon as 2030. The European Commission states that buildings in the EU are responsible for 40% of the energy consumption and 36 % of greenhouse gas emissions (stemming from construction, usage, renovation and demolition) [2]. Moreover, the European Commission emphasizes the role that buildings play in the ambitious goals of carbon-neutrality by 2050, as stated in the European Green Deal. Windows herein play a crucial role, as different sources identify windows to be responsible for a major share of heat loss (and thus for Greenhouse Gas emissions): The US department of Energy amounts this percentage 25-30 % [3]. As such, technologies that allow for the reduction of heat loss in new windows as well as of existing windows can be considered beneficial. Innovative, highly-insulating glass products are amongst such technologies. While triple-glazing, foils that affect the radiative behaviour of the glass panes, specific fill gas combinations, as well as optimized seals and frame geometries have become industry standards and are commonly used, this cannot be said to be true for vacuum glazing products by now. The authors of this contribution did conduct four research and development projects that focussed on the utilization of vacuum glazing products for new windows and existing window improvement. In the following subsections, the vacuum glazing technology will be briefly introduced, observations and prerequisites for development of vacuum-glazing equipped windows will be discussed, and a short overview about the different projects will be provided.

1.1 Vacuum glazing products: Technology, advantages and disadvantages.

Vacuum glazing products regularly consist of two (mostly float) glass panes (typically of rectangular shape, and each between 3 and 6 mm thick) in a parallel/offset position to each other. The glass panes are separated by a small interstitial space with a thickness of regularly less than 1.5 mm. The two glass panes are connected with each other via a gas/vacuum tight edge seal around the brinks of the glass panes, usually made from glass or metal. In the interstitial space, a grid of distance pillars is positioned that maintains the position of the glass panes to each other. This grid is necessary to avoid a sag of the glass panes after evacuation of the interstitial space. The evacuation happens either via a specific opening in one of the panes that later is sealed, or via a gap in the glass edge seal which is sealed afterwards. Most vacuum glazing products possess a region named “getter”, in which remaining gas particles of the interstitial space later should be chemically bound. The degree of vacuum in the interstitial space is a so-called high vacuum. Thereby the very low pressure values (10_{-7} mbar) in the interstitial space increase the average path length a particle can travel without colliding with other particles from Nanometre range (under normal air pressure conditions) to Decimetre, Meter or even Kilometre ranges (in the high vacuum). Figure 1 illustrates the major constituents and terminology of typical vacuum glazing products and their surroundings as well as shows a typical vacuum glass product.

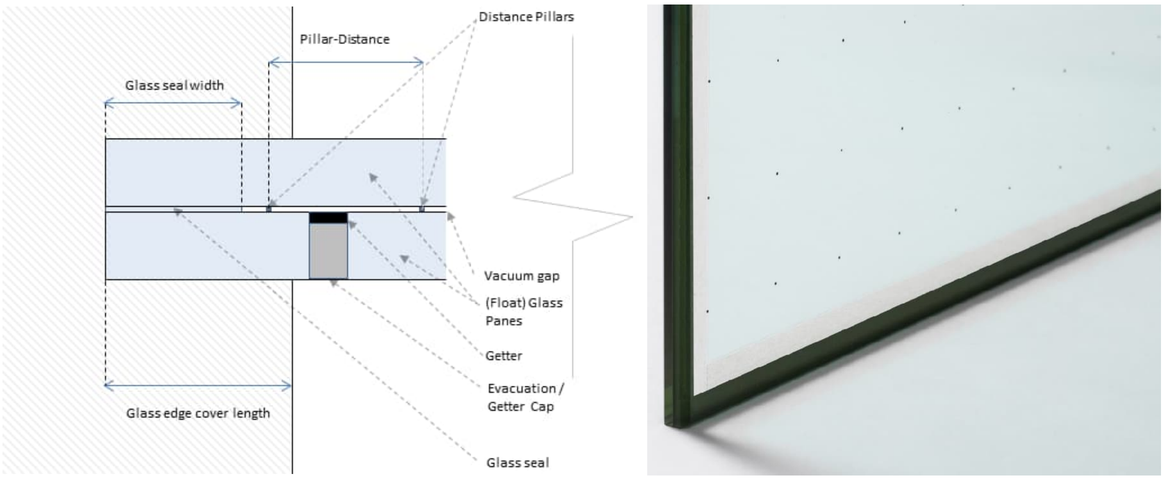


Figure 1. Left: Schematics of a Vacuum glazing product: Constituents and Terminology (Image Source: Authors of this contribution), Right: A typical vacuum glass product showing the grid of distance pillars (Image Source: AGC / Interpane, Product FINEO, available via https://www.baulinks.de/webplugin/2018/i/scaled/1144_x_1757-agc1.jpg, last call: March 2023)

Vacuum glazing products minimize heat transfer per conduction and convection by the vacuum gap (Conduction and Convection require a transfer media, which in the vacuum gap is widely eliminated) in the area of the undistorted glass-vacuum-glass areas of the glazing product. Thus, such glazing products reach amazingly low U_g-values (0.4 – 0.9 $W.m^{-2}.K^{-1}$) at a comparable small system thickness (mostly less than a centimetre).However, radiative heat transfer is widely unaffected by the vacuum gap. Moreover, technically speaking, the undistorted vacuum barrier is interrupted by linear (perimeter/glass edge seal) and point (pillars) thermal bridges. In previous studies, the impact of these thermal bridges was addressed: It was shown that the impact of the pillars is visible (e.g. in thermography photographs or false colour simulation result visualizations), but the pillar grid – due to the small size of the individual pillars – does not significantly increase the heat transfer and surface temperature characteristics [4]. In contrast, the glass edge seal might be problematic in view of hygrothermal effects and should be covered by a sufficiently dimensioned glass edge cover length [5][6]. We will not discuss the development history of Vacuum Glazing Products or the properties of individual vacuum glass products, however interested readers can find corresponding information in previous publications about our projects [7][8].

1.2 Observations and Prerequisites for the development of Vacuum-glazing equipped windows.

To successfully conduct R&D work in the domain of vacuum-glass equipped windows, clear targets, knowledge of the state of the art and the opinion and approach of different stakeholders is immanent. The following Table 1 narrates the observations and prerequisites that were necessary to end up with meaningful results. It shall be noted that these listing was put together from an ex-post perspective and is an elaborated version of a previously published list [9].

Table 1: List of Prerequisites and Observations connected to R&D work in the field of vacuum-glazed windows.

Observations	Prerequisites
(i) Despite a long track record on R&D on the generation of the product vacuum glazing, little to no research about vacuum-glass equipped windows. **(ii)** Relevant stakeholders (e.g. window producing companies) agree on the high-potential of vacuum glazing products, but are reluctant in being sole front-runners in development of vacuum glass windows.As such little knowledge about the specific requirements of Vacuum glass integration was there in the very beginning amongst industry stakeholders. Moreover, resentments about durability and availability of vacuum glass products could be observed. **(iii)** Stakeholders of the glass industry, specifically those of triple glazing products have/had resentements against the vacuum glass products, due to the “loss” of one glass pane in production /profits and issues with proprietary patents of few companies on vacuum glass products and production techniques. **(iv)** As stated in the introduction: Windows are widely perceived as weak spots of the thermal envelope of buildings by many stakeholders. As such, vacuum glass has some disruptive potential to change this view.	**(i)** Despite the tests of producers of vacuum glass products, it seemed wise to start with mechanical and thermal tests of their products in the first steps of R&D on vacuum-glazing equipped windows. Not only could independent lab tests satisfy the need for clear, non-lobby-istic information, but also the results are a *conditio sine qua non* for upcoming R&D stepts. **(ii)** Clear objectives are required in the R&D processes. For instance, there is an important difference between development of new windows with vacuum glazing and the improvement of existing windows. While the former can be engineered from scratch optimized for the necessities and specifics of vacuum glazing in view of an optimized performance, the latter regularly address a performance improvement under upkeep of the architectonical appearance of the windows, sometimes even stipulated by law or guidelines, e.g. from monuments offices. **(iii)** The R&D process is characterized by both a step-by-step approach and iterative optimization. For instance, for the new window development, the first approaches were made in an exploratory project that just encompassed scientific partners. Based on the findings of this project, design possibilities could be narrowed down to feasible approaches and the window-constructing industries were contacted and invited to join the efforts, which than lead to a cooperative experimental development projects encompassing a large number of partners. **(iv)** After preliminary design phases it is important to integrate the competences of different partners and approaches. As such, for new windows, large companies of the window-construction industry, as well as companies focussing on development of seals, fittings, and vacuum glass products joined the team. For the existing windows, the consortium relied strongly on the knowledge and craftsmenship of small scale carpentry companies that have window retrofit as their every-day-business. **(v)** Even if the vacuum glazing equipped windows bear a large potential on the market, it is important to ensure an open and innovation-driven atmosphere in such projects. Stakeholders interested in just consuming the knowledge of others instead of bringing in their knowledge and participating in the R&D processes need to be avoided in such projects.

1.3 Research projects pertaining to the development of vacuum-glazing equipped windows.

As already mentioned, the authors – together with a set of companies and stakeholders – conducted four projects that all addressed vacuum-glass-equipped windows. However, the thematic scope of each of the projects was different. Figure 2 provides an overview about the different projects. The projects VIG-SYS-RENO and MOTIVE were exploratory projects that discovered the potential of vacuum glazing products for retrofit of existing (casement) windows and the utopian generation of new windows. These projects were conducted by scientific partners only. In contrast, FIVA and VAMOS, both cooperative R&D project, included prominent partners from industry and craftsmanship, but focussed on realization (new windows) and performance monitoring of casement windows retrofitted with vacuum glazing products.

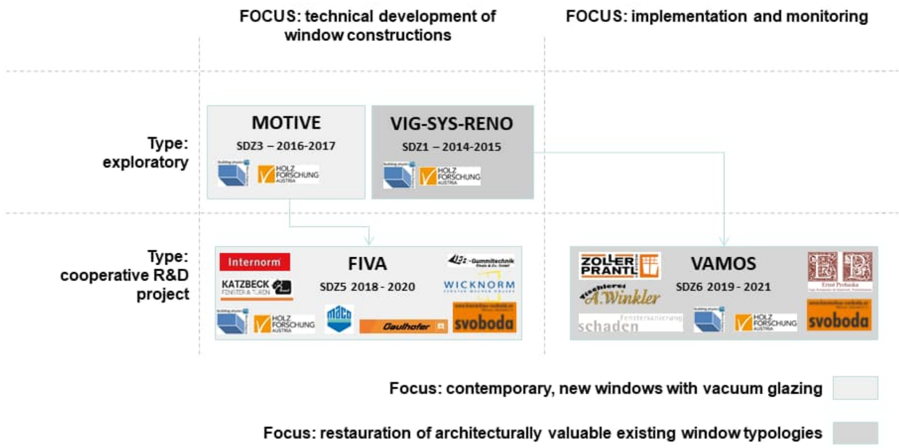


Figure 2. Landscape of R&D projects conducted by the authors (Image source: authors)

2 Applied Methods

To develop windows that employ vacuum glazing products requires – to be successful – a set of methods. Such windows – independent if we address new or existing windows – need to deliver an excellent hygro-thermal and acoustical performance and fulfil requirements such as air tightness, tightness against wind-driven rain. Moreover, aspects of window production and mounting / integration into the building envelope need to be considered as well as aspects of usability and user acceptance. Thus, a wide range of methods were in part applied iteratively to optimize the window designs and the window performances. To provide an example: Numeric thermal simulation was deployed by the building physics experts to identify potential issues with surface condensation in the basic conception of construction joints delivered by window engineers, and the simulations' results influenced the construction design. After optimization and redesign of potential problematic parts, simulation was applied again to proof that the optimization showed the desired effect. This iterative and trans-domain approach was conducted through all phases of all described projects. In the following sections, the applied methods are shortly described:

(i) Setting general goals and early stage construction design drafting and evaluation.

Both for the case of existing windows of architectural meaningfulness and for the case of the new windows specific objectives were set in early stages of the projects:

- For existing windows, the goal was to severely improve the performance (in view of both thermal comfort and energy consumption) of traditional windows constructions by utilization of vacuum glazing products without changing the appearance of the windows. We thereby focussed on casement windows (also known as box-type windows). Specific challenges hereby encompass the very small glass edge seal cover due to the slender wooden frame constructions and the condensation risk along the glass edge seal. Moreover, the required craftsmanship to change glass products in existing window constructions shall be as well named as challenge connected with this objective.

- For new windows, the major objective was a highly insulating thermal/energy performance. Moreover, the concept of different window opening and operation was a major aspect in the projects. As such, integration in building automation via motorizing the fittings, and non-of-the-shelf window designs that specifically considered the specifications of vacuum glazing products were topics in the projects MOTIVE and FIVA.

Figure 3 illustrates the genesis from early drafts to window Mock-Ups within the project MOTIVE (addressing new windows). Please note that during critical evaluation of these design drafts, those with high potential were kept, while utopian or problematic designs were discarded in a narrowing-down process. The project meetings with all involved stakeholders were conducted in pre-COVID19 times physically at the facilities of the scientific partners or in the production facilities of the involved companies. During COVID19 times, online meetings were deployed. However, especially in brainstorming, construction evaluation, conceptual sketching and discussion, real-world meeting proofed to be the more productive alternative.

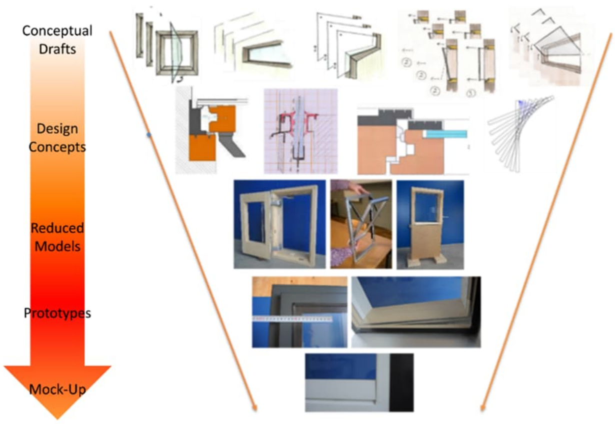


Figure 3. Narrowing down different designs to the most feasible ones in the project MOTIVE (Image source: authors)

(ii) Performance assessment via simulation and normative calculation.

Numeric thermal bridge simulation with a state of the art software tool [10] was deployed to assess the performance of different design variants and material combinations. Different previous publications highlight in detail the deployment of these methods and the connected results [4][5][6][11][12]. In short, the major challenge for any glass pane / window sash / window frame / wall connection detailing was to keep the indoor surface temperatures as well as the temperature in air caverns of fittings and moving parts as high as possible to avoid condensation. Threshold values from domain-relevant standards were thereby set as benchmark [13][14]. In a parallel effort, the U_{Win}-values of the window designs were determined [11][12]. Figure 4 shows numeric thermal simulation models and results (surface temperature along the perimeter) of a non-improved casement window, which acted as base case model for the efforts of the VAMOS project.

(iii) Laboratory testing

Laboratory testing included mechanical tests (structural stability of the glazing products and window prototypes), acoustical testing (noise reduction levels), hygro-thermal tests in the climate chamber, as well as tests pertaining to the tightness performance (air tightness, wind-driven rain, etc.). These tests were all conducted based on the current Austrian standards, and in part used to validate / contrast the findings of the numeric thermal bridge simulation described above.

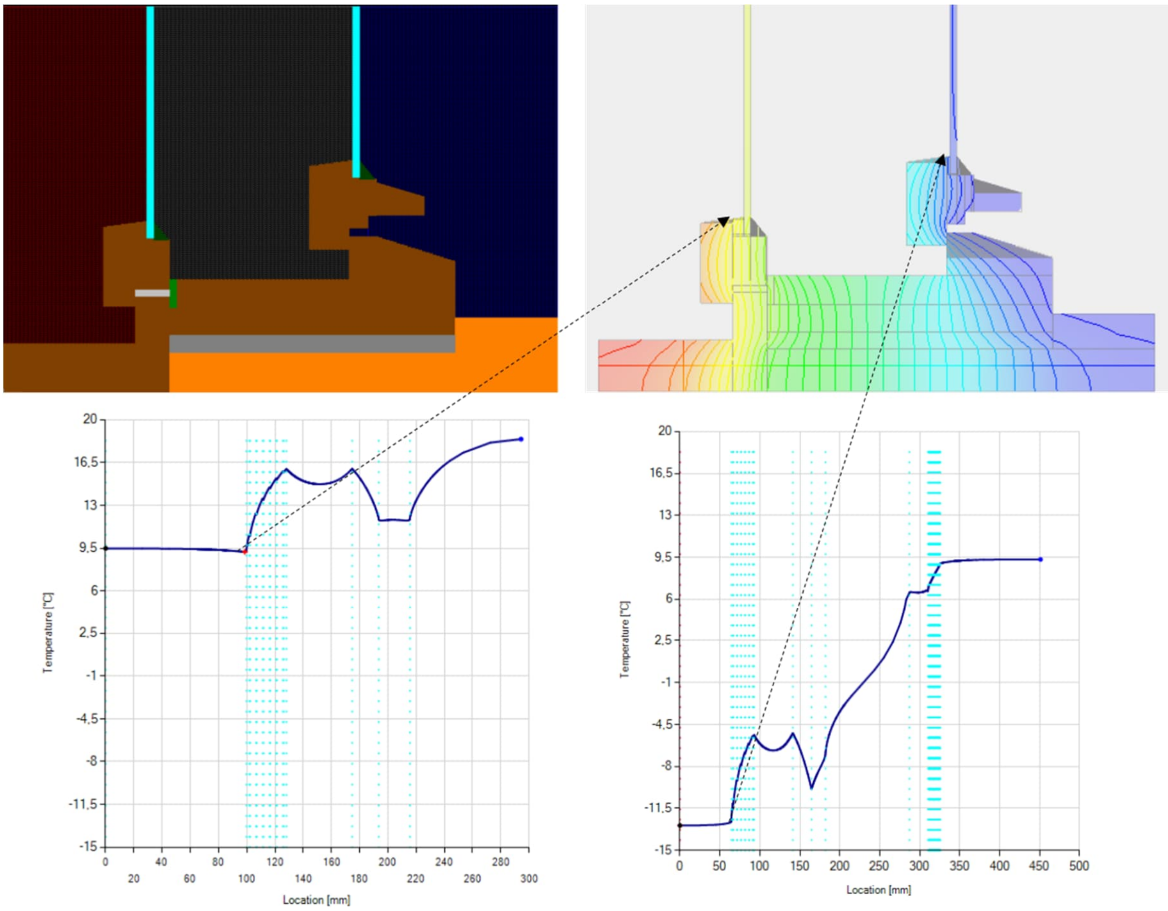


Figure 4. Numeric thermal bridge simulation of a casement window: upper left: Modell in the software Antherm, upper right: False colour result of the casement windo, lower left and right: Surface temperature course along the inner (left) and outer (right) sash indoor surfaces. (Image source: Authors)

(iv) Performance Monitoring of real case study buildings.

In the VAMOS project, one important aspect was the performance analysis of the improved (vacuum-glazing equipped) casement windows in real buildings. Thereby, we monitored windows in six different locations in Austria. At each of these sites, a regular (non-improved) casement window was subjected to monitoring, as well as two windows that had been improved with vacuum glazing either on the inner sash or on the outer sash. Long-term monitored performance aspects included temperature and relative humidity at selected positions in the buildings, on the window sashes and interstitial spaces, as well as on the exterior. The observation periods included roughly one year, so that performance data in Winter and Summer season could be collected. In a previous study [13], we presented details about the deployed monitoring and measurement approaches and results.

(v) Peer review by relevant stakeholders

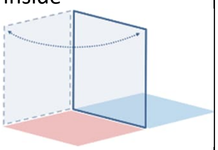
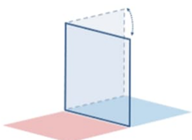
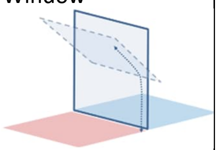
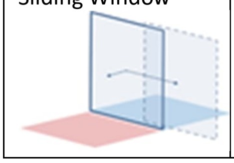
Due to constant opinion lead and presentation of methods and results, as well as exhibition of built prototypes, we were able to collect evaluation reviews by peers of the window-constructing domain.

3 Results

3.1 Results of "new" vacuum-glazed windows

All together, the FIVA project resulted in four highly-insulating window prototypes. Table 2 illustrates these window prototypes. Note that the minimum indoor surface temperature as well as the f_{Rsi}-values have been derived on the assumption of constant temperatures (Θ_i =20 °C, Θ_e=20 °C).

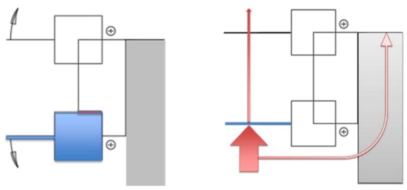
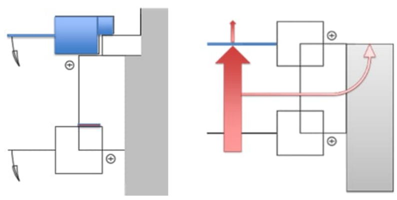
Table 2: Vacuum-glazed window prototypes developed in the FIVA project (Image sources: authors)

Prototype	Description	Key Performance Indicators	Image
A - Turn window opening to the inside 	This traditional concept is widely used in Europe, but window A renders an update to this traditional window typology. While using state of the art fitting technology, the window provides a glass-inline-with-outer-perimeter optics and offers common operation schemes to users.	f_{Rsi} 0.74 [-] | $\Theta_{min,i}$ 12.23 °C | U_{win} 0.78 W.m^{-2}.K^{-1}	
B – Turn window opening to outside 	While not common in Central Europe anymore, Scandinavian countries have a tradition of turn windows that open to the outside. The principles of such windows had been translated to state of the art fitting technologies, so that the window allows automation while mimicries rather reduced aesthetics by clear edges and one size opening in wall.	f_{Rsi} 0.77 [-] | $\Theta_{min,i}$ 13.05 °C | U_{win} 0.72 W.m^{-2}.K^{-1}	
C – Swing Window 	Inspired by classical garage doors, this window provides very space-efficient opening operation (opened window sash is stored above the occupants' heads close to the ceiling. Moreover, the window can be engineered to allow for flexible opening degrees and requires only a minimum of moveable parts.	f_{Rsi} 0.75 [-] | $\Theta_{min,i}$ 12.55 °C | U_{win} 0.68 W.m^{-2}.K^{-1}	
D –Offset and Sliding Window 	Window allowing an offset movement to the outside of about 10 cm ("ventilation position"). From the ventilation position, the window can be slid to the side on from outside invisible telescope rails.	f_{Rsi} 0.76 [-] | $\Theta_{min,i}$ 12.07 °C | U_{win} 0.64 W.m^{-2}.K^{-1}	

3.2 Results of "retrofitted" casement windows.

In contrast to the new windows that regularly have one glass sash pane, traditional casement windows come with two sashes, an inner and an outer wing. The interstitial space, regularly between 10 and 35 cm, as well as the air tightness of both sashes strongly influences the thermal performance of the window. Pertaining to the retrofit with vacuum glazing products, one has to ask the question, if the vacuum glazing product rather should be integrated in the outer sash or the inner sash. There are pros and cons of both application concepts: The application on the inner sash is in line with the concept of having the most diffusion-resistant layers of constructions on the warmer side of the construction, assuming that the vacuum glazing is air/diffusion tight (as well as the inner sash is tight from its seals). In contrary, an application on the outer sash would follow the rule to bring the layer of largest temperature drops to the far outside of construction, comparable to insulation layers of opaque constructions. These to concepts do contradict to each other, given that the vacuum-glazing equipped sash is both diffusion tight and presumably the layer of largest temperature drop in the overall layer-by-layer window construction. As such, no explicit recommendation can be made, without considering the details of specific windows. At none of the six demo sites issues with condensation could be monitored, if the window constructions were well constructed and seals where correctly mounted (in one case this was the cause for issues, after fixing that, there was no condensation at all to be monitored). Measurements suggested a significant reduction of heat transfer through the windows. Measured U_{Win}-values of the variant with the vacuum layer on the inner sash showed lower values, however, constructions with the vacuum glass layer in the outer sash provided higher interstitial space temperatures, thus generally a warmer construction. Based on this, one could conclude that the implementation on the inner wing might be better in view of energy savings, and the implementation in the outer sash might be risk-minimizing regarding condensation. Visualisations of the detailed monitoring situations can be found in [8] and [13]. Table 3 illustrates an easy-to-understand guideline for the implementation of vacuum glazing in casement windows.

Table 3: Schematics of heat transfer in casement windows with vacuum glazing in the inner or outer sash (Images: Authors)

Vacuum glass on the inside (inside sash)	**Vacuum glass on the outside (outside sash)**
 Casement windows opening in part to the outside or with highly conductive casement/box: Implementation should happen on the inside.	 Casement windows opening to the inside: Implementation is possible in outer and in inner sash.

Please note that the implementation of vacuum glazing in casement windows in any case requires careful consideration of the specific ancillary conditions (radiator positions relative to the window, general condition of the windows, quality and condition of seals, water vapour production in the rooms, orientation of windows, and airflow characteristics in vicinity of the window).

4 Conclusions

The present contribution displayed the performance impact that vacuum glazing products can have onto new and existing windows. In the case of new windows, it is important to state that windows should be engineered under consideration of the specifications of the vacuum glazing. Additionally, automation via motorized fittings and state-of-the-art seal technologies could lead to highly insulating, thin, and aesthetically pleasing windows. In the case of existing windows, a careful planning of retrofit measures utilizing vacuum glazing products allows to bring casement windows to a by-far-better insulation performance by only minimal-invasive retrofit measures. In [14] the comprehensive final R&D reports of all projects can be found.

Acknowledgements

This contribution contains presentations of approaches, methods and results of four R&D project that have been generously funded by the Austrian Research Promotion Agency FFG (VIG-SYS-RENO, 2014-2015, Proj.-Nr.: 845225|MOTIVE, 2016-2017, Proj.-Nr.: 854690|FIVA, 2018-2020, Proj.-Nr.: 867352|VAMOS, 2019-2021, Proj.-Nr. 878272). Beside the authors' affiliations, the following companies were involved in the projects: AGC Interpane, Dr. Hohenstein Consulting, Gaulhofer, Katzbeck, IeB Eisele, Internorm, MaCo, Prohaska, Schaden, Svoboda, Wicknorm, Winkler, and Zoller-Prantl.

References

[1] International Energy Agency (iea)(ed.), Buildings Sectorial overview, tracking report – September 2022, available via https://iea.org/reports/buildings (last access: March 2023).

[2] European Commission (ed.), In focus: Energy efficiency in buildings, February 2020 available via: https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en (last access: March 2023).

[3] US Department of Energy (ed.) Update or Replace Windows, 2023, available via https://www.energy.gov/energysaver/update-or-replace-windows#:~:text=Heat%20gain%20and%20heat%20loss,heating%20and%20cooling%20energy%20use. (last access: March 2023).

[4] U. Pont, A. Mahdavi, A comparison of the performance of two- and three-dimensional thermal bridge assessment for typical construction joints; in: "Building Simulation Applications Proceedings", M Baratieri, V. Corrado, A. Gasparella, F. Patuzzi (ed.); bu.press (publisher of the Free University of Bozen-Bolzano), 3. (2017), ISSN: 2531-6702; Paper ID 75, 8 pages.

[5] M. Wölzl, U. Pont, P. Schober, A. Mahdavi. Simulation-based performance comparison of Facade Constructions: Vacuum glazing versus common insulation glass; Talk: EnviBUILD2019 - Buildings and Environment International Conference, Bratislava, Slovakia; 2019-11-07; in: "Book of Abstracts of the 14th enviBUILD 2019", J. Hraska, P. Hanuliak et al. (ed.); Spektrum:STU, (2019), ISBN: 978-80-227-4959-6

[6] U. Pont, M. Wölzl, P. Schober, S.N. Khosravi, M. Schuss, A. Mahdavi. Recent progress in the development of windowswith vacuum glass, Talk: Digital Proceedings CESBP2019 - Matec Web of Conferences 282, 02020, Prag, Tschechische Republik; 2019-09-02 - 2019-09-05; in: "Digital Proceedings CESBP2019", R. Cerny (ed.); Matec Web of Conferences, 282 (2019), Paper ID 2020, 8 pages.

[7] U. Pont, E. Heiduk, P. Schober, H. Romirer, F. Dolezal, O. Proskurnina, M. Schuss, C. Sustr, H. Hohenstein, A. Mahdavi, Sondierung des Einsatzes von neuem, innovativem High-Performance-Wärmeschutz-Vakuum(Isolier)glas (VG), für hocheffiziente Fenstersysteme speziell für die Bestandssanierung Schriftenreihe 33/2018, BMVIT (ed.), 2018, available via: https://nachhaltigwirtschaften.at/resources/sdz_pdf/berichte/schriftenreihe-2018-33-vigsysreno.pdf (last access: March 2023)

[8] U. Pont, M. Wölzl, M. Schuß, P. Schober, K. Hauer, Kastenfenstersanierung mit innovativen Glasprodukten. In Weniger. Aber mehr daraus machen! - Less. But let's make more out of it! - Tagungsband 2023 - BauZ! Wiener Kongress für zukünftsfähiges Bauen / Vienna Congress on Sustainable Building (pp. 42–50). IBO-Verlag., 2023. Available via: https://www.ibo.at/fileadmin/ibo/wissensverbreitung/BauZ_/BauZ_tagungsband_2023_inhalt.pdf (last access: March 2023)

[9] U. Pont, K.P. Schober, M. Wölzl, M.W. Schuß, J. Haberl,. A Review on the FIVA-Project: Simulation-Assisted Development of Highly-Insulating Vacuum Glass Windows. In G. Pernigotto, F. Patuzzi, A. Prada, V. Corrado, & A. Gasparella (Eds.), Building Simulation Applications BSA 2022. 5th IBPSA Italy Conference, Bozen-Bolzano, 29th June - 1st July 2022. Konferenzbeiträge/Atti/Proceedings (pp. 69–76). bu, press - Bozen-Bolzano University Press, 2023. https://doi.org/10.34726/3864

[10] Software AnTherm. Available via www.antherm.eu [last access: March 2023).

[11] M. Wölzl, U. Pont, A. Mahdavi, P. Schober, Configuration Optimization of Building Details via Parametric Numeric Simulation: A Case Study of Windows with Vacuum Glass; Talk: SIMAUD2020, TU Wien, Wien, Österreich (COVID19-bedingt: Webconference); 2020-05-25 - 2020-05-26; in: "2020 Proceedings of the Symposium on Simulation for Architecture and Urban Design", A. Chronis, G. Wurzer, W Lorenz, C.M. Herr, U. Pont, D. Cupkova, G. Wainer (ed.); SIMAUD / The Society for Modeling and Simulation International, (2020), ISBN: 978-1565553712; Paper ID 281-287, 7 pages.

[12] M. Wölzl, Fensterkonstruktionen mit Vakuumglas: Simulationsbasierte Weiterentwicklung von innovativen Fensterkonstruktionen;Supervisor: U. Pont, A. Mahdavi; Institut für Architekturwissenschaften, Abteilung Bauphysik und Bauökologie, 2019; final examination: 2019-10-23.

[13] M. Schuss, U. Pont, M. Wölzl, P. Schober, A. Mahdavi, In-situ performance evaluation of historic box-type windows with vacuum glazing; Journal of Physics: Conference Series, 2069 (2021), 012128.

[14] OEGUT (ed.): Website www.nachhaltigwirtschaften.at (Portal to the final reports of all shown projects), 2023 (last access March 2023).

THE ECOLOGICAL TREND OF ARCHITECTURE

TAKE THE PRITZKER PRIZE WINNERS OF THE 21ST CENTURY AS EXAMPLES

Yidan LIU*
Department of Architecture and Urban Study, Politecnico di Milano
& School of Architecture, Tianjin University
20162, Milan, Italy; yidan.liu@polimi.it

Abstract

The stage of human civilization has shifted from industrial civilization to ecological civilization as science and technology progressed and the era developed. Architecture, like people, nature, and society, is moving toward an ecosystem. The Pritzker Prize is the highest internationally recognized architectural award, and it leads the aesthetic development trend. Since the dawn of ecological civilization, the Pritzker Prize has followed suit and advocated for more ecological architecture. Based on a large number of data points, this paper selects the Pritzker Prize winners of the twenty-first century and their architecture as research objects utilizing comparative and interdisciplinary analysis methods. This thesis summarizes the ecological influence on the development of architecture and the future development trend of ecology based on nature, materials, structures, construction technology, and other aspects. The goal is to integrate the key components of architectural design research with the overall development trend. Simultaneously, it can improve the sense of time in architectural design research and add to its charm.

Keywords

Ecology, the Pritzker Prize, development trend

1 Introduction

From the beginning to the present, humans have progressed through three stages of civilization. Agriculture is the first civilization. The function of buildings has been upgraded from a single shelter to one that can meet the basic needs of people's daily lives as labor tools have progressed and a gap between the rich and the poor has gradually emerged. Humans entered the period of industrialized society after 10,000 years of development with the British Industrial Revolution starting in the 18th century. Architecture is still a form of human shelter. However, with the enrichment of human recreational activities, commercial buildings began to develop, transport architectural rudiments occurred in the context of public transit innovation, and educational architecture is slowly developing as a result of gradual changes in educational styles. Industrial civilization lasted 300 years. During this period, the construction industry expanded rapidly, building types were created, and architectural shapes were initiated. Humans entered the post-industrial era when the construction industry's development was essentially stable. The explosion of network and electronic information technology has enabled people to truly see the world without stepping outside their homes, and information building has started. Today's society is moving ahead toward ecological civilization. The construction industry follows the times, responds to the general trend of human development, and begins to develop environmentally friendly dwellings.

Through their Hyatt Foundation, the Pritzker family established the Pritzker Prize in 1979, and each year one or more living architects who have made outstanding contributions in this field are chosen. The award is the highest honor in architecture and is also known as the "Nobel Prize of Architecture." Architects' research has shifted to regional and ecological characteristics since entering ecological civilization, and their works focus more on architecture itself, the mode of coexistence between architecture and nature, building materials and structures, and building techniques. Since its establishment, a total of 50 architects have been awarded this honor in 44 years.

They are the architectural top performers. The new ideas and methods they want to express in their work lead to architectural development in various directions. Their contributions guarantee that architectural development keeps pace with the times. Analyzing their design work highlights that their design concepts are malleable. Their methods become more mature and unique with the accumulation and precipitation of time. Despite the fact that their design styles and types differ, they have all had an impact on the growth of architecture. For architectural students, they serve as role models and weather vanes. When the winners of the 21st Century Pritzker Architecture Prize are summarized and analyzed, it is discovered that they are also following in the footsteps of ecological civilization, and the ecological trend of architecture is becoming more and more obvious.

2 Ecological Pattern of Architecture and Nature

The rapid development of the economy has accelerated the development of construction, and the efficient builder has flooded the city with an increasing number of ruthless reinforced concrete buildings. While architects pursue architectural height and technological innovation blindly, they are also able to notice that such a development trend will only provide short-term benefits rather than long-term solutions. Architects are members of society as well, and their sense of social responsibility keeps driving them to seek the origins of architectural design, abandon the pursuit of individual interests, and discover the value of architecture itself. The relationship between architecture and the surroundings is an important part of architectural design, seeing as architecture is an important part of society. As Ji Cheng mentioned in Yuanye, in order to create something, you must first establish a foundation, and then set it in between, and measure its breadth and width. It is clear that our forefathers understood the significance of architecture in relation to the environment. As architects' practice develops, they accept that, under the influence of environmental protection and eco-friendly concepts, the ecological change of architectural design is gradually becoming apparent, and the ingenious combination of architecture and the environment is also in line with it.

The popularity of each trend is the result of a long period of accumulation and precipitation rather than a sudden outbreak. This is also valid for ecological design in architecture. Glenn

Murcutt, an Australian architect, built Marika Alderton House in Yirrkala in 1991 (Figure 1). This design was the symbol of Murcutt's design practice for many years. Its owners are indigenous people who did not prefer traditional houses. They used to settle in a circular, elongated space covered in tree bark. Due to the limitations of sunlight, insects, and tidewater, Marcourt borrowed this form in the design, and the shape was slightly changed from the original foundation so that the house could enjoy the surrounding scenery like an open tree canopy. This work demonstrates Markut's architectural literacy as an ecologist, as well as the early stages of ecological architectural design prior to the twenty-first century. Marcourt won the Pritzker Architecture Prize in 2002 for his ecological and natural buildings. His most well-known works include the Magney House in New Hawaii (Fig. 2, 1988–1994) and the Done House in New South Wales (Fig. 3, 1988–1991).

Figure 1. Marika-Alderton House

Figure 2. Magney House

Figure 3. Done House

After 30 years of long-term collaboration, RCR Architects, the 2017 Pritzker Prize winner, has developed a philosophy with the environment as the first element. The jury said, "All their works have a strong sense of place and are powerfully connected to the surrounding landscape...... The siting of buildings, the choice of materials, and the geometries used are always intended to highlight the natural conditions and pull them into the building." This thought was reflected in the Tossols Basil Athletics Track's early design (Fig. 4).

Figure 4. Tossols Basil Athletics Track

In the early days of the studio, they designed a suburban natural park in 1990. They combine sports facilities and natural parks, challenging the original definition of stadiums. The old version of the organic park has been mostly preserved, and the space is defined by a metal mesh. Athletes can compete in their natural environment, which helps them relax. Some athletes believe it is not professional enough, but the citizens love it. Furthermore, the penetration of indoor and outdoor spaces, as well as the ambiguous relationship between architecture and the environment, are reflected in their design works: La Lira theatre public domain, Crematorium of Hofheide, and Les Cols Pavilions (Fig. 5-7).

Figure 5. La Lira theatre public domain

Figure 6. Crematorium of Hofheide


Figure 7. Les Cols Pavilions

Among the Pritzker Prize winners, Jorn Utzon's built Can Lis near Portopetro on the Spanish island of Majorca (1973), Kazuyo Sejima's Okurayama Apartments in Yokohama, Japan (2000), and Peter Zumthor's the Therme Vals (1994–1996) all highlighted the ambiguous relationship between architecture and nature, reflecting the architect's pursuit of ecological design.

3 Ecological Embodiment of Materials and Structures

The expression of architectural ecology has gradually evolved from a different mode of coexistence between architecture and nature to a diversified evolution, which has begun to be reflected in different aspects of materials, structures, and interior design with the gradual deepening of biotic fashion. Shigeru Ban has a unique material insight and design style, and he has been constantly creating through experiments with the goal of constructing ecological buildings with non-traditional materials. Kobe, Japan, was devastated by a major earthquake in 1995, leaving the city in ruins. Shigeru Ban won the trust of the priests by building historical residences for residents out of paper tubes. He used paper to rebuild the city's churches and provide people with more psychological comfort. The Takatori Catholic Church (Fig. 8) took five weeks to rebuild. The "temporary" church was supposed to be used for three years, but due to the strong feelings people had for it, it was eventually used for ten years. This paper church is still standing in Taiwan, Chian. Shigeru Ban donated it after the earthquake in Taiwan. He wishes to comfort more people.

Shigeru Ban not only constructs sustainable structures by improving materials, but he also proposes that changes in materials will result in structural reforms, which is inextricably linked to his findings on lightweight building structures. Another Pritzker Winner architect to mention is Frei Otto, who is unceasingly looking for ways to cover space with the least amount of material and energy and has performed thorough studies on the subject of lightweight building structures. The Hannover Expo Japan Pavilion (Fig. 9) was designed by these two architects in collaboration in 2000, and it is a concentrated expression of their design concept. The entire structure is made of recycled paper tubes and cardboard, the roof is a light paper surface, and the space is made up of intersecting paper tubes as a unit. Steel arches are erected on the space grid structure to increase its stability, and paper clips are laid on the outermost layer. Furthermore, New Zealand's Christchurch Cardboard Cathedral (2013), Paper Emergency Shelter for Hait (2010), Paper Loghouse in India (2001), and others all use recycled paper materials and lightweight structures. This also demonstrates that the trend of ecologicalization is being accepted and used by an increasing number of architects.

When it comes to the use of recycled materials, one thinks of Wang Shu, the first Chinese architect to win the Pritzker Prize in 2012. Wang Shu began designing the Ningbo Museum in 2003 (Fig. 10), and it took six years to complete. The museum's facade is made of old Ningbo bricks and tiles interspersed with each other. These old bricks and tiles were salvaged from various demolition sites. Roof tiles, roof ridge bricks, keel bricks, and so on have all been baptized by time, and the total number exceeds 7 million. They are piled up in an orderly fashion, which not only forms the exterior walls of buildings with the vicissitudes of life but also realizes waste material recycling. Wang Shu used the same technique in his projects such as the Ningbo Tengtou Pavilion for the Shanghai World Expo (2010) and the Central Academy of Fine Arts Xiangshan Campus in Hangzhou (2004–2007) to express his interest in traditional Chinese culture and modern ecological architecture.

Eduardo Souto de Moura created the Santa Maria do Bouro Convent in Braga, Paulo Mendes da Rocha optimized the Mario Masetti House in 1995, and Richard Rogers designed the Bordeaux Law Courts from 1992 to 1998, all of which express their understanding of architectural ecology by combining the reuse of traditional materials or the regeneration of waste materials.

Figure 8. Takatori Catholic Church

Figure 9. Hanover expo Japan pavilion

Figure 10. Ningbo Museum

4 Ecological Application of Technology

The arched structure gave birth to the Pantheon's sacred poetry; cast iron technology went into labor for the Crystal Palace's lightness and agility; and the glass curtain wall gave birth to the Seagram Building's exquisiteness. Every improvement in architectural technology advances the process of architectural history, and every significant change in architectural creation introduces new conceptual technology requirements. Currently, economic and environmental technology are at the forefront of architectural design and are rapidly evolving.

Jean Nouvel, the 2008 Pritzker Prize winner, is a designer who focuses on the use of architectural techniques. He took into account the influence of light, shadow, and time on the building when designing the Institute du Monde Arabe on the banks of the Seine (Fig. 11), and he added ecological technology to extend the building from three-dimensional to four-dimensional space. The two most important elements in Arabic architecture are light and geometry. The photosensitive components of the glass curtain wall on the south façade are supported by stainless steel lattice frames. It regulates the lighting and temperature in the building. Light enters the interior via the photosensitive components' carvings, casting geometric shadows on the ground that change over time. Jean Nouvel fully integrates traditional Arabic symbols and ecological technology, giving the simple, modern ecological building a traditional charm.

Figure 11. Institute du Monde Arabe

Like the Institute du Monde Arabe, Richard Rogers designed the Bordeaux Law Court (Fig. 12), which is fully integrated with the local context but employs different ecological techniques. Rogers uses the wind to bring the coolness of the pool water into the building, which is located directly in front of the building's entrance. Each court is also considered a separate space. The room is lit by natural light from the roof, and there are ventilation holes at the bottom. There is more thermal airflow in the upper part of the independent space under natural light illumination, which naturally generates Rogers skillfully combines these two ecological technologies with local culture, and their adoption demonstrates Rogers' emphasis on nature. Among the Pritzker Prize-winning architects, Peter Zumthor's project the Therme Vals (1994–1996) and the Burgo Office Building by Eduardo Souto de Moura use ecological technologies to reduce building energy consumption. Although there are relatively few applications, the development of ecological technology has become more and more mature, and more ecological technologies will be applied in more buildings in the future. air flow and forms vertical ventilation.

Figure 12. Bordeaux Law Court

5 Conclusion

This article begins by examining the architects who have received the Pritzker Prize in the twenty-first century and their works. It also discusses the future prospect of architectural ecology from three perspectives: the ecological pattern of architecture and nature; the ecological embodiment of materials and structures; and the ecological application of technology. Although some of these architects' works were not completed in the twenty-first century, their influence can be seen as a source of the evolution of ecological design trends. In today's world, architecture must not only meet the three principles of "applicability, economy, and beauty," but also keep up with the times, which is why the Pritzker Prize is awarded to different architects at different times. The ecological trend of this paper is summed up in the pursuit of the Pritzker Prize, and it is hoped that it will serve as a reference for architectural design research.

References

[1] Peltason, Ruth, and Grace Ong-Yan, eds. *Architect: The pritzker prize laureates in their own words.* Hachette UK, 2017.

[2] KALAYCI, Pınar DİNÇ, and Alia RAHMOUN. "Meaning Inquiry for 21st Century Architecture through the Pritzker Prize Laureates." *Online Journal of Art and Design* 7.3 (2019).

[3] Choi, Suhl Ah. "A Study on Pritzker Architecture Prize and Urban Society." *Journal of the Architectural Institute of Korea Planning & Design* 35.3 (2019): 21-30.

[4] Moffatt, Laura. "Laura Moffatt reports on Pritzker Prize winner Peter Zumthor, the Kolumba Art Museum and Gerhard Richter's window in Cologne Cathedral." *Art and Christianity* 58 (2009): 8-10.

[5] Adriaenssens, Sigrid, et al., eds. *Shell structures for architecture: form finding and optimization*. Routledge, 2014.