RESPONSIVE CITIES

DESIGN WITH NATURE

SYMPOSIUM

BARCELONA

11.11 – 12.11

SYMPOSIUM

PROCEEDINGS

2021

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RESPONSIVE CITIES: DESIGN WITH NATURE
SYMPOSIUM PROCEEDINGS 2021

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RESPONSIVE CITIES DESIGN WITH NATURE

Responsive Cities is a bi-annual international symposium on the future of cities organized by the Advanced Architecture Group of IAAC. The 2021 edition focuses on "Design with Nature" and takes place within the framework of the Building Urban Intelligent Living Design Solutions (BUILDs) project, co-funded by the Erasmus+ Programme of the European Union and developed by the Institute for Advanced Architecture of Catalonia - IAAC- (Spain), Université de Lorraine -UL- (France), Vienna University of Economics and Business -WU- (Austria), Ersilia Foundation (Spain), ECONICK (France), Plant-e (Netherlands), City Facilitators -CF- (Denmark), and GreenTech Challenge -GTC- (Denmark).

The Responsive Cities Symposium: Design with Nature is organized around the following topics:

- **DESIGN & ADAPT**
  Keywords: bio-design | environmental feedback | collective intelligence | nature-based solutions | biotechnology | black ecologies

- **BUILD**
  Keywords: reintegrating nature | digital fabrication | new bio-inspired planning paradigms

- **SHARE & LEARN**
  Keywords: participatory design | novel virtual environments for co-design | symbiosis | new educational models | applied research | making

- **PERFORM**
  Keywords: living systems | increased liveability | ecosystem services

RESPONSIVE CITIES SYMPOSIUM
DESIGN WITH NATURE

FOREWORD

Despite cities having strengthened their economy, efficiency, and liveability over the last decades, they are still facing major issues such as contamination, rising inequities, and unemployment, among others. These already harmful conditions for the environment and society are furthermore aggravated by crisis events such as the current pandemic. New planning paradigms that recognize the importance of ecology to respond to these challenges are being developed, by integrating living systems in urban environments aimed at improving cities' socio-economic and environmental conditions.

Living systems integrated in cities are also known as Nature-Based Solutions (NBS), defined as "living solutions inspired by, continuously supported by, and using nature, which are designed to address various societal challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits'' (European Commission, 2015). NBS can help address several challenges through the provision of multiple ecosystem services such as life support (soil formation and oxygen production); procurement (production of food, drinking water, raw materials or fuel); regulation (climate control and tidal waves, water purification, pollination); and cultural values, including the aesthetic, educational, and recreational values. Intelligent design strategies can help reintegrate nature in cities by transforming urban spaces into liveable, productive, and biodiverse systems.

Advances in digital technologies open new opportunities to facilitate the integration of NBS in the urban environment and to increase the number and the quality of the ecosystem services provided. Digital technologies, for instance, such as simulation tools, open the possibility to test in a virtual environment how the system performs, while digital fabrication allows for the production of non-standardized elements (like green facades, floor tiles, public space furnitures, etc) for a tailored integration of nature in cities. The convergence among biology, ecological sciences and information technology applied to landscape and urban design can create powerful synergies to address the current socio-economic-environmental challenges.

Figure 1
Advanced Architecture Group, 2021
CO-mida Automated Green Wall at Connecthort

Within this context, the Responsive Cities: Design with Nature Symposium has the objective to investigate how innovative and advanced technologies in the field of design can help to enhance and strengthen the use of nature-based solutions in the urban environment.

- Can the use of technologies support NBS integration in cities with the final goal to enhance the provision of ecosystem services?
- How can we strengthen social relations through the implementation of innovative NBS?
- Will the technology-mediated implementation of NBS in cities lead to the development of innovative business models targeted at addressing current urban challenges?

With cities required to adapt to the impacts of climate change, many are turning to nature for inspiration and understanding on how to overcome these challenges. There is a lot to be learned from nature, or that can be extracted to develop sustainable solutions to be implemented in the city and provide multiple ecosystem services. Through the exploration of nature-based solutions at the educational level, it instills the knowledge in students to research and find tangible solutions with the possibility of implementation.

The main focus of the Symposium is placed on key concepts such as bio-design - how we can design with living systems and implement them in our cities to increase liveability. In addition, a focus will also be placed on how designing with nature can be implemented into the educational system to train the next generation of designers, urbanists and architects.


DESIGN WITH LIFE
RESPONSIVE
CITIES
DESIGN WITH NATURE


SYMPOSIUM
PROJECT
PARTNERS:

Epiclay Wall Tile

BUILDING URBAN INTELLIGENT LIVING DESIGN SOLUTIONS (BUILDs)

Advances in science and technology are creating new types of biological and living materials, processes and systems which are turning a growing number of buildings and other urban artefacts into metabolic, breathing organisms. These artefacts are not just efficient and 'do less harm', but are actually restorative and 'give back' to the environment. Resource-smart architecture can generate energy, clean water, digest waste and purify air. The convergence of biotechnology and information technology applied to landscape and urban design may create a number of social challenges and at the same time it is a promising future.

With that in mind, the critical question is, why are products based on intelligent living solutions not yet used to address both local and global challenges? A possible explanation is that there is a distinct skill and financing gap in the biotechnology sector applied to smart architecture and design. For the biotechnology sector to succeed in meeting the challenges facing cities across the world a combination of good education, good science and good business is necessary (Moses 2011). While we currently have great researchers in biotechnology, too often the commercialization and hence implementation of their discoveries stumble due to a lack of personal experience in entrepreneurship and cooperation with industry leaders (Fritsch 2010).

BUILD Solutions aim to offer an educational programme engaging students, teachers and researchers and providing them with the necessary entrepreneurial skills and connections to bring intelligent living solutions for cities to the market, investigating biological systems, creating prototypes based on information technology and digital manufacturing, business plans and working with accelerators. Solutions which in turn can help us overcome the challenges posed by rapid urbanisation.

DESIGN & ADAPT

Within the "Design" & “Adapt” Section a selection of research papers seek to answer to questions such as:

How can bio-design aid in dealing with urban challenges such as the current pandemic?

How can nature-based solutions play a role in dealing with issues related to climate change and environmental degradation?

How can biotechnology impact the way in which we perceive, analyse or experience space?

THALASSIC MASKS

“Up-sourcing” as a renewed socio-ecological narrative for oil infrastructure

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KEYWORDS

mask, prosthesis, body-enhancement, postnatural, pandemic

ABSTRACT

This paper illustrates the research of the authors aimed at re-thinking medical devices, shifting the focus from their functional-only role, often unavoidable manifestation of physical limitations, to design objects and fashion statements. In the context of the current pandemic, the attention of the authors has been naturally drawn to the urgent need for respiratory prostheses. Protective masks with microbial filters are increasingly becoming essential, a body integration required to engage with the urban environment and allow interpersonal interactions. It is foreseen that protective masks will be needed for longer than initially expected, exceeding their medical function and becoming an essential fashion product and, as such, in need of careful design. The authors have addressed this challenge by making use of the latest cutting-edge additive manufacturing, within the framework of Refream, part of the EU funded STARTS Programme. Through the implementation of Polyjet 3d printing on fabric, allowing functional and formal qualities to be controlled and tuned at a very fine scale, a series of prototypes of protective masks were manufactured and tested.

1. INTRODUCTION

The work Thalassic focused on radically re-thinking the relationship between technology, in the form of wearable objects, and the human body. The research aimed to further explore the integration between the functionality of medical devices and the design criteria usually associated with art and fashion.

In the context of the current pandemic, the attention of the authors has been naturally drawn to the urgent need for respiratory prostheses. Protective masks with microbial filters are increasingly becoming an essential device, a body integration required to engage with the urban environment and to allow interpersonal interactions. Currently, commercial protective masks are adaptations of devices which were not designed for the extensive use they undergo these days. All the existing products are usually capable of performing a series of functions (for example offering protection from pollution or diseases) but they are neither designed for an almost constant use nor they aspire to rethink human interaction with the external environment.

Beyond Covid-19, the authors foresee those further implications of the disruption of ecological environments and climate change, such as air pollution and transformations in the atmosphere, would see protective devices become an essential extension of the human body. The mask as prosthesis of the respiratory system, will be needed for longer than initially expected, not only as a medical device but also as a fashion product, manifestation of new pandemic and post-pandemic identities.

The proposal of the authors aimed at a radical shifting of the focus of medical devices from unavoidable manifestation of a physical limitation to a design statement and functional fashion accessory.

The work has been carried out within the framework of Refream, part of the EU funded STARTS Programme (Science + Technology + Arts), with a focus on the future of urban manufacturing of fashion by using additive manufacturing (3D printing), electronics and textile and eco-innovative finishing together with social and environmental values to create a new value chain for the fashion industry.

2. METHODOLOGY

2.1 INITIAL STEPS

During the first phase of the work, the concept of the "protective mask" has been explored, deconstructed, contaminated, and re-assembled, setting the ground for new ideas to emerge. The initial design process consisted in developing a database of mask typologies, design options in the form of 3D models and physical prototypes digitally manufactured. Through the support of several different partners in the 3D printing industry, such as Stratasys Ltd, and in material science laboratories, such as the laboratory for biomimetic membranes and textiles at Empa, it was possible to explore different technologies and their applications from design to production.

The outcome of the first phase was a catalogue of radical, speculative design concepts, in the form of images, animation and prototypes where the combination of the different processes and new production technologies were tested (Figure 1). The objective was to promote a significant innovation of how essential aids for the body are thought, designed, and worn by users. Rather than trying to reduce these devices to their minimal function, providing anonymous standardised designs, the research tended to expand their integration with the body, developing new ways to interact and live with them. The emphasis was placed on the user's experience, the individual requiring a specific device, and how the design could be adapted to favour a personalised augmentation of the body.

All the design processes from conception to production were thought to be developed as seamlessly as possible so that the resulting products could be customised and produced on a mass scale.

2.2 FURTHER INFLUENCES

Inspiration for the project was also drawn from looking at the marine forms and their natural strategies, thus the name "Thalassic".
The authors were particularly interested in sea organisms that are capable of filtrating the water to survive. Marine life forms, such as corals, jellyfish and sea anemones, act as biological filters, extracting oxygen and nutrients from the water. They do so thanks to their inner structure, and by doing so they actively modify the environment they live in (Figure 2). This integration between functional requirements and three-dimensional features has been one of the focus of the work.

In addition to this, aquatic organisms often rely on their deceptive appearances to hide, or pray, within the underwater environment they are immersed in. Appearances then become part of the survival strategy. Thus, another aspect of for the research has thus been the concept of camouflage and, in turn, identity.

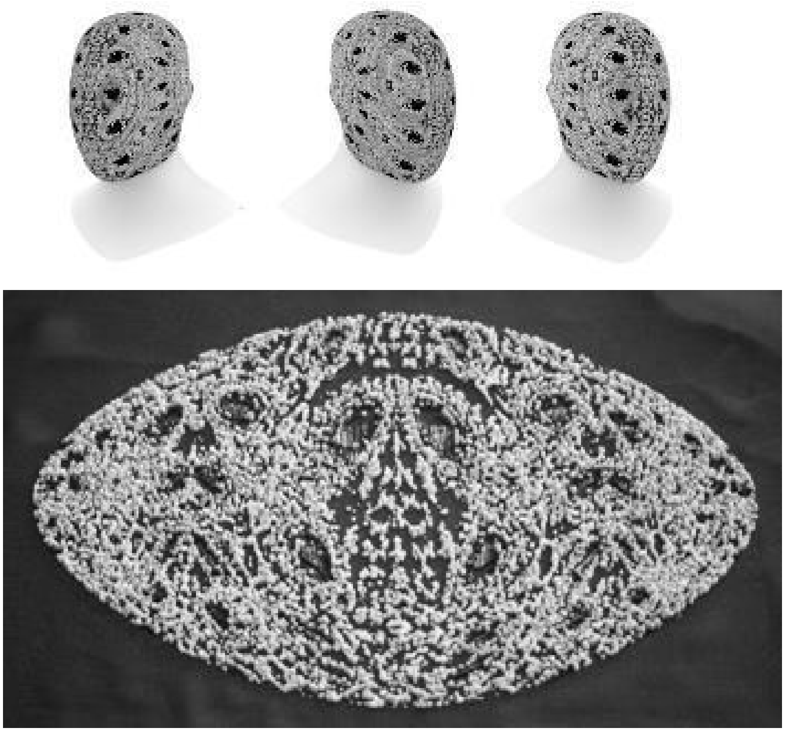

Figure 1:
Concept designs and initial Polyjet3d printing tests.

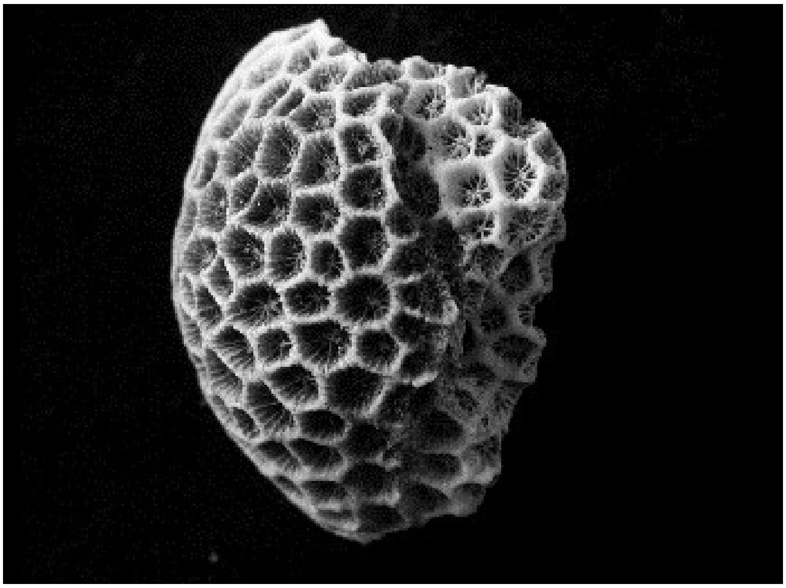

Figure 2:
Natural specimen, coral.

2.3 EXISTING METHODOLOGIES

The current respiratory prostheses rely mainly on the orientation of the fibres of the manufactured textiles to filter some of the particles from the environment. The way their performances and efficiencies are scored are based on international norms which prescribe specific standardised testing (e.g. DIN EN 14683). This results in products which, although potentially very effective, do not take into consideration customisation, comfort nor identity-related issues of the users.
Similarly, while digital fabrication techniques, such as additive manufacturing, have nowadays reached a high degree of complexity and versatility, these methods have not been extensively applied to the sectors of prostheses, especially when looking at the augmentation of fabric and garments. Thanks to their intrinsic characteristics, digital fabrication methods allow for the generation of intricate and customised structures, where added complexity does not necessarily mean an increase in price of the product. While many industries (from automotive to construction) have strived to make use of this potential, fashion and the textile industry appear to still be lagging behind.
The focus of this research was thus to try to combine the cutting edge potential of the digital fabrication, capable of naturally to embed biomimicry techniques thanks to the freedom in terms of complexity allowed with the goal of improving, specifically with regards to the topics of customisation, optimisation but also expression, protective garments.

3. PROCESS AND RESULTS

3.1 FABRICATION STRATEGIES

The research focussed on implementing different design strategies to articulate the surface of the mask by making use of Stratasys PolyJet 3d printing technology on fabric. Specifically the Stratasys J850TM 3DFashion TM was used. This technology allows to augment a textile by printing three-dimensional structures onto it, whose shape can be controlled through a digital 3d model, at the resolution of very fine particles.

The authors were intrigued by the ability of the technology to fabricate such complex formations, and the potential to control the material at a granular level to interweave functionality and aesthetics.

This technology allows, not only to augment a textile by printing three-dimensional structures, but also to customise and control their colour, transparency and flexibility.

Several tests were carried out by the authors to fine tune these techniques, informing the manufacturing process with digital, parametrically controlled, models (e.g. Figure 3)

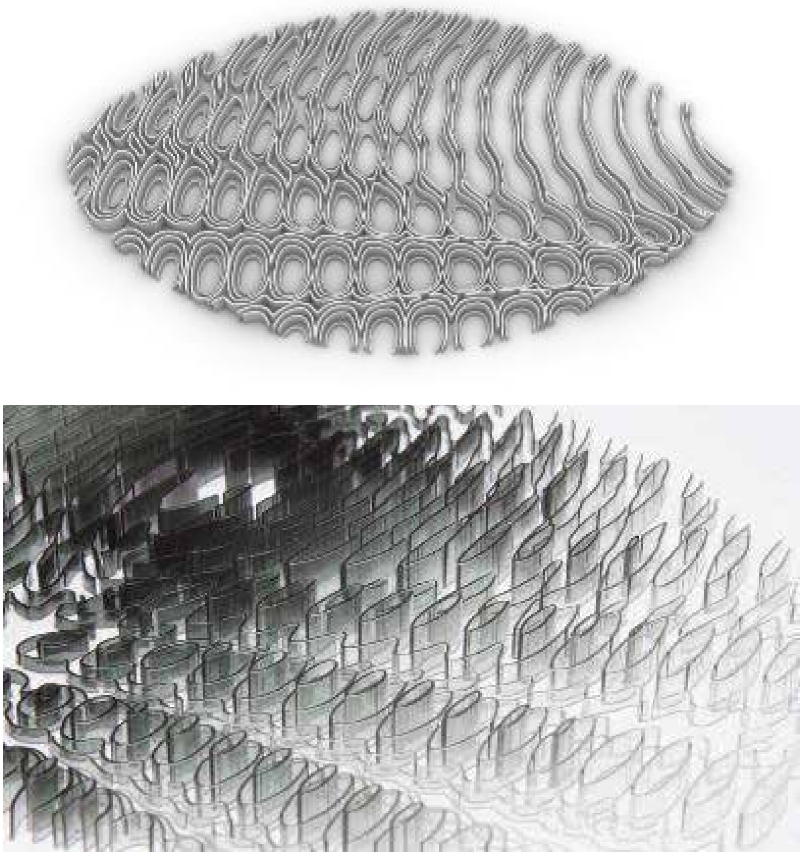

Figure 3:
Digital and physical prototype of the linear strategy developed. Note color and flexibility of the garment can be controlled and manipulated at a micro-scale.

4. FINDINGS / CONCLUSIONS

4.1 TECHNOLOGY OUTPUT

The ability of the technology to fabricate such complex formations, and the potential to control the material at a granular level to interweave functionality and aesthetics was explored through extensive testing.
Once the aesthetic and functional potential of the tools were investigated the focus of the research returned on the integration between the human body and the technology.
Together with aesthetic and functional requirements the design of the protective headpiece was augmented using studies of temperature maps provided by EMPA and of human head topology provided by UFG Linz (Figure 4). Temperature areas of the human head and sweat rates were based both on the existing academic body of research, for example the maps provided by Smith and Havenith (2011), and on the Empa own research and testing practice
Thus the production of different masks could be informed by these data, allowing for the optimisation of the material distribution and thermal performances. For example, the depth of the pattern and the amount of material deposited by the process would be reduced

in warmer areas of the head, allowing for the garment to be less obstructive to sweat and allowing for direct cooling.

Through the development of different toiles, a series of final working prototypes were then developed, allowing for the different features to be integrated in a full-scale wearable headpiece. (Figure 5, Figure 6, Figure 7). It was of the foremost importance in this part of the process to be able to combine both artisanal tailoring expertise with digital design and manufacturing know-how.

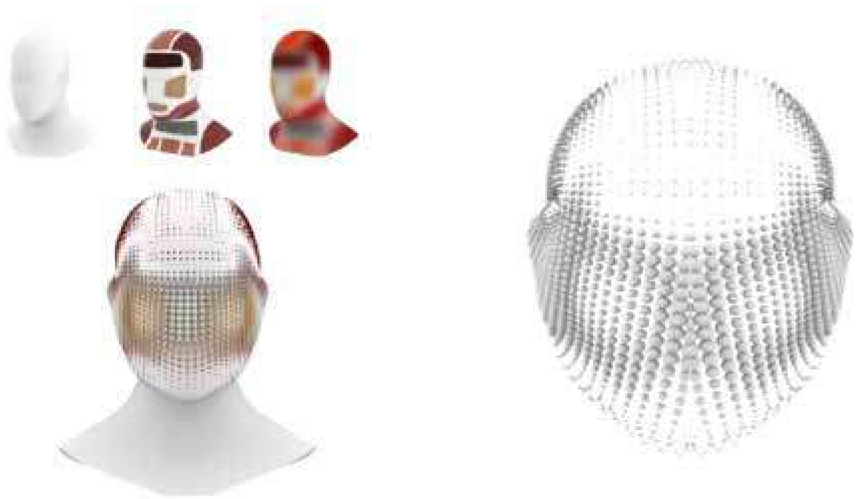

Figure 4:
Head heath mapping and conceptual studies of pattern application.

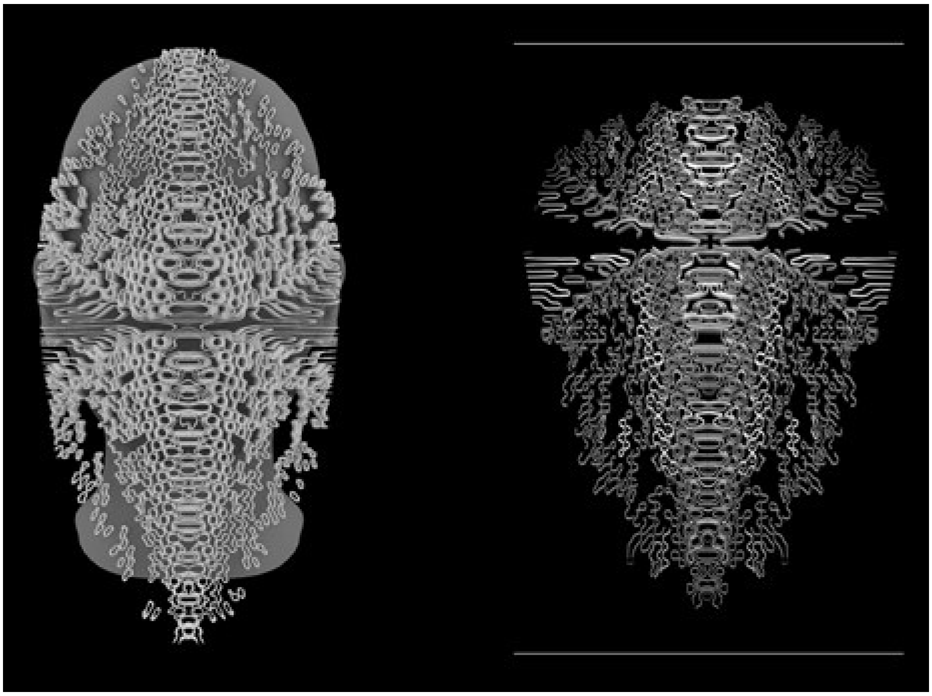

Figure 5:
Parametric toile development.

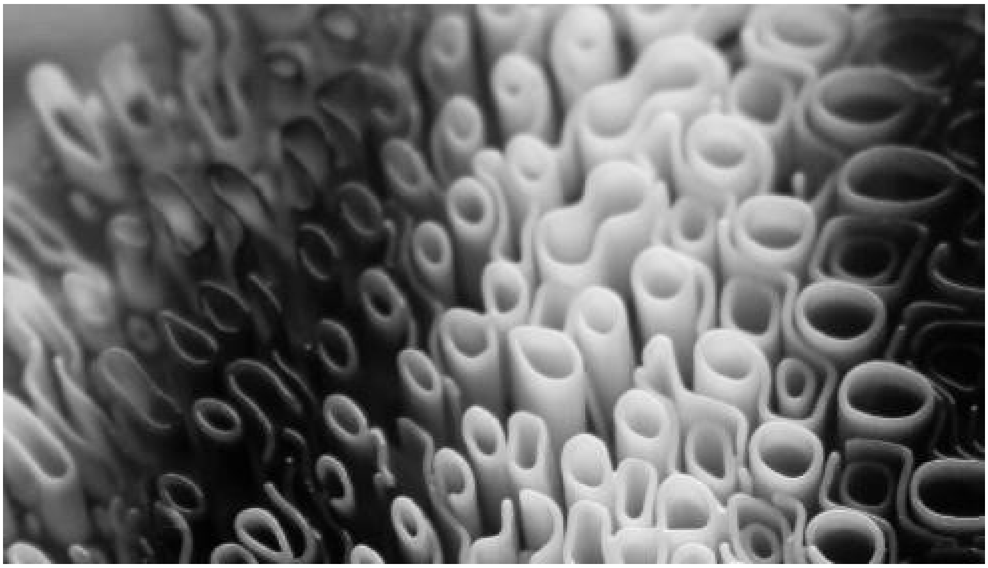

Figure 6:
3d printed pattern development.

Figure 7:
Headpiece sample.

4.2 FURTHER IMPLICATIONS

As the pandemic is changing the world, our identities, reflected in what we wear every day, are affected by that. In that sense, the scope of the masks developed goes beyond the objects themselves, but it is a reflection on how our lives are transformed by the dramatics and sudden global events of these years. As some specific elements were developed, eventually the thalassic masks may be just one step of a much wider ecosystem of products. The products realised represent thus a small subset of a potential wider exploration of the concepts of adaptation, identity, transformation highlighted during the research (figure 8 to 10).

Figure 8:
Thalassic Masks. Photo © Paul Farnham.

Figure 9:
Thalassic Masks. Photo ©
Paul Farnham.

Figure 10:
Thalassic Masks. Photo ©
Paul Farnham.

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GROWING LIVING BRIDGES IN MUMBAI

Migration of the concept of the living bridge from Meghalaya to Mumbai

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KEYWORDS
Living root bridges, Living Architecture, Nature-based Solutions, Sustainability, Ecosystem services

ABSTRACT
This research project is about the design and growth of a living bridge network made of Rubber trees that also functions as a communal laundry platform in the streets of Mumbai. The aim is to propose low-cost bridges that could increase local ecosystem services while adapting to the culture and environment of Mumbai. The design of these bridges has been adapted from the innovation of the Khasis people in Meghalaya. The final project comprises the living tree-bridge and the laundry platforms attached to the tree roots and increases the water supply from peoples' washing. Furthermore, a greywater filtration system is designed to filter the water before rinsing its root system. This revolutionary system can increase ecosystem services and community engagement. Finally, it is a sustainable model that could be used in other cities that lack infrastructure, accessibility, and public amenities, coupled with overcrowded living conditions amplified by pollution, flooding, and rising sea levels.

1. INTRODUCTION

This design research project focuses on the city of Mumbai and the lack of pedestrian footpaths and crossings on the streets to propose the design of low-cost pedestrian pathways. The goal is to create a second layer of infrastructure where living bridges made of rubber trees will grow into a floating footpath that will also increase the ecosystem services in the city. The ecosystem services created by this multidisciplinary proposal are numerous, such as reducing CO2 emissions, increasing biodiversity, and providing an elevated flood escape infrastructure on the streets of Mumbai (Fig. 1).

Living bridges already grow in Meghalaya, where Khasi people cultivate Rubber trees to create footpaths on top of fast-flowing streams. This research explores the feasibility of migrating this system from Meghalaya to Mumbai to create living bridges in the city that will self-grow and self-maintain by using limited funds, materials, and technological resources. Moreover, it incorporates community engagement as a fundamental element for the system's growth by integrating laundry platforms locals use for their everyday washing.

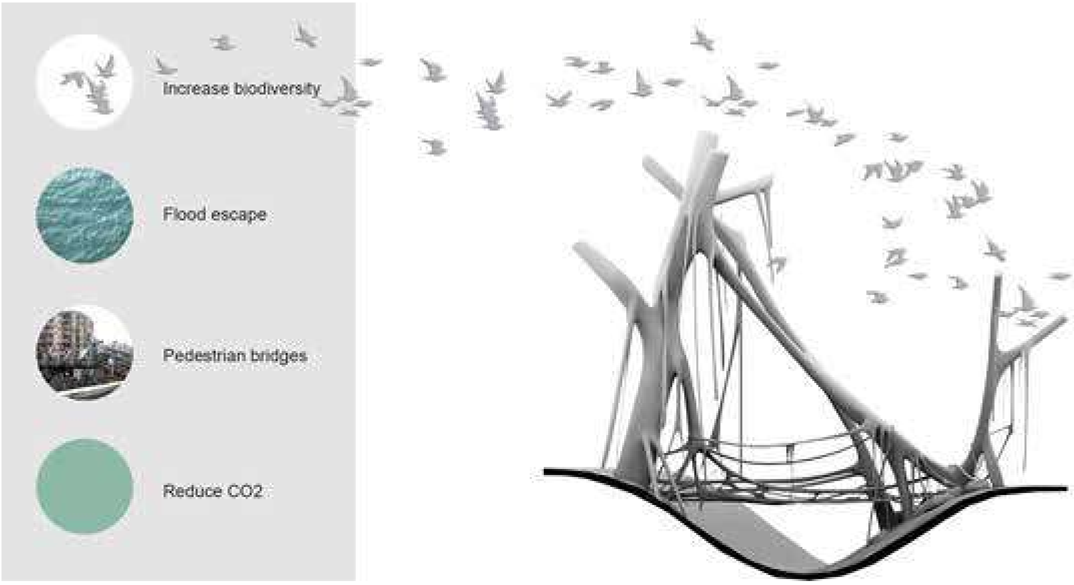


Figure 1:
Ecosystem services.

1.1. METHODOLOGY

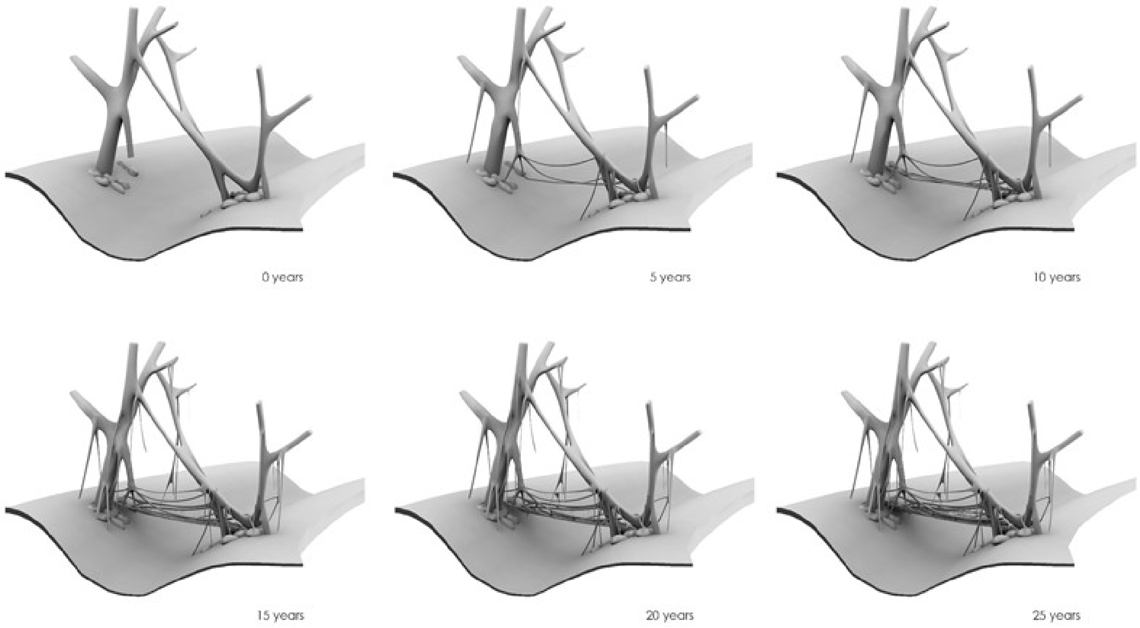
The feasibility study of this project was conducted by a multidisciplinary group of researchers and professionals. The first step was to analyze the bridges that are currently found on Meghalaya. The data was collected from literature review, satellite images and photographic analysis. The second step was to develop architectural design concepts for the migration of the system in the urban fabric of Mumbai. The third step was to test the feasibility of the concept by doing a civil and structural analysis.

2. RESEARCH BACKGROUND

The living root bridges of Meghalaya are found in northeastern India. They are known as "living" because they are made of the root system of the tree Ficus Elastica, a Rubber tree. Khasi people have been developing these bridges for hundreds of years to cross the streams of Cherrapunji (Ludwig et al., 2019). This region is the wettest place on Earth with annual precipitation levels of approximately 450 inches (2021, Hughes et al., 2019, Lodrick, 2020).

This humid environment favourites the rapid growth of Ficus Elastica. Khasis used the fast-growing roots of the tree to grow living bridges. These bridges take approximately 10 to 15 years to be fully functional (Material District, 2010a) (Fig. 2), with some to be hundreds of years old (Ludwig et al., 2019). The span of a living bridge ranges from 2 to 52.7 m in length, and most of them are less than 20m high (Ludwig et al., 2019) (Fig. 3 and 4). The shorter bridges are made of one tree, while the longest have two trees on each side of the stream. The maximum span from one tree is 30 m and two is 60m (Ludwig et al., 2019).

Figure 2:
Evolution diagram.



To construct the bridges, locals use the aerial and buttressing rubber tree's roots. The buttressing roots support the tree on the ground, while the aerial roots can be easily woven into strong latticework structures (Watson, 2019). The first step to form the bridge is to use betel nut trunks to create root-guidance systems to spread the roots of the bridge across the stream. When the roots reach the other side, they anchor in the soil of the opposite bank. A secondary root system is developed by knotting or twisting two or more aerial roots together (Ludwig et al., 2019). The roots merge and grow thicker at these connection points, creating a stronger structure (Fig 5). To cover the gaps in between the roots, they use flat stones. After years, the roots with the stones and the nut trucks merge into an integrated living structure. Their development never stops. The tree grows, and more roots are being developed.

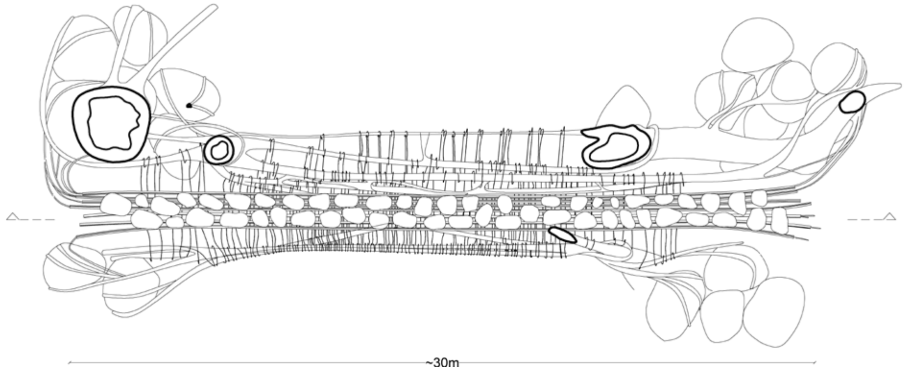


Figure 3:
Plan.

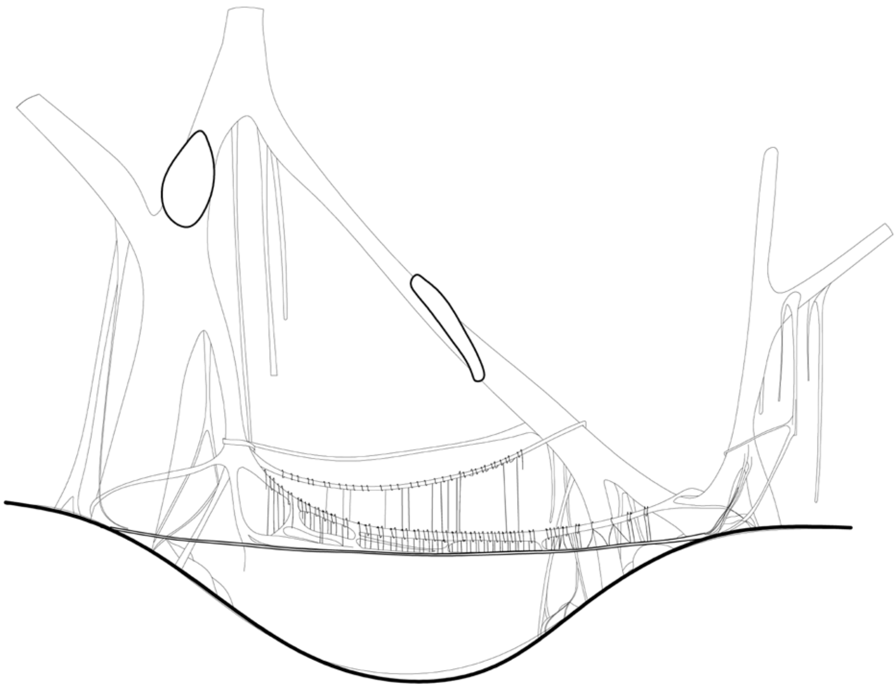


Figure 4:
Section.

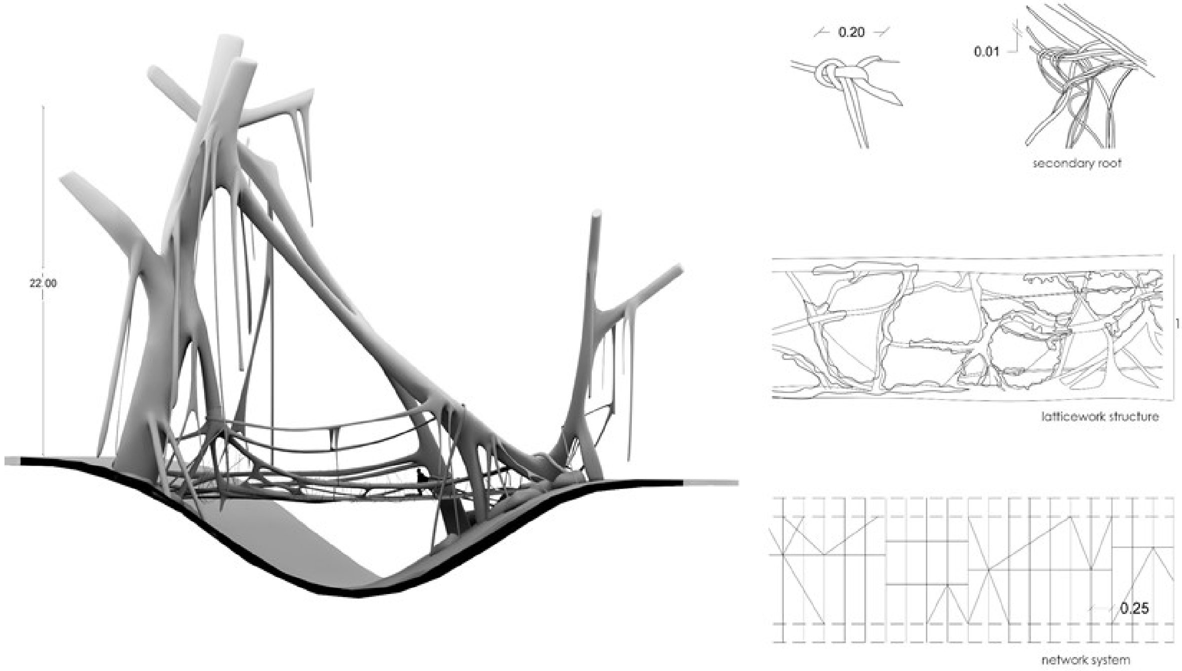


Figure 5:
Root system.

The living bridges are an impressive example of living architecture. First, they are built with no funds, materials, and technological resources. Moreover, they increase local biodiversity and reduce CO_2 emissions. However, they are vulnerable at their first stages of development, when the roots are fragile and require continuous maintenance. Also, they need a lot of water to grow, and they take time to be functional. Considering the above, this research explores how the system of the living bridges could migrate to the streets of Mumbai to develop a floating pedestrian path that could significantly increase the ecosystem services of the city.

3. CONCEPT DEVELOPMENT

Mumbai has numerous rubber trees on the street (Fig 6). The existing trees and new ones could be used to grow bridges in the densely developed urban fabric of Mumbai. As referred above, using one rubber tree creates a span of 30m max, while using two opposite trees could double the span up to 60m.

However, many things need to be considered. First, the bridge will take years to be fully functional. Consequently, a contemporary structure needs to be in place to hold and guide the roots during their growth. Second, Mumbai receives almost one-sixth of the annual precipitation level than Meghalaya. Therefore, the trees need to receive more water. To resolve that, this design combines the tree structure with communal laundry platforms, where people can wash

Figure 6:
Rubber trees of Mumbai.

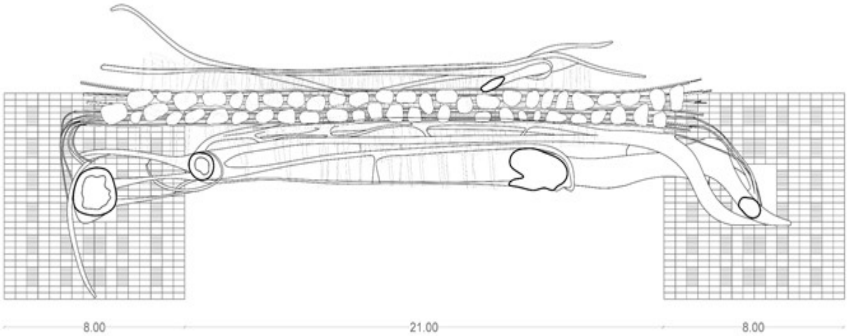


Figure 7:
Plan.

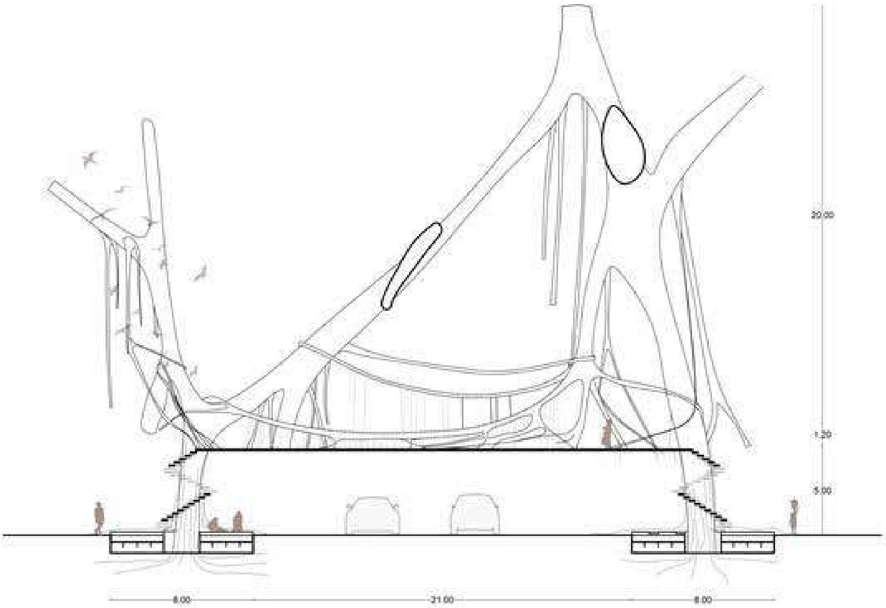


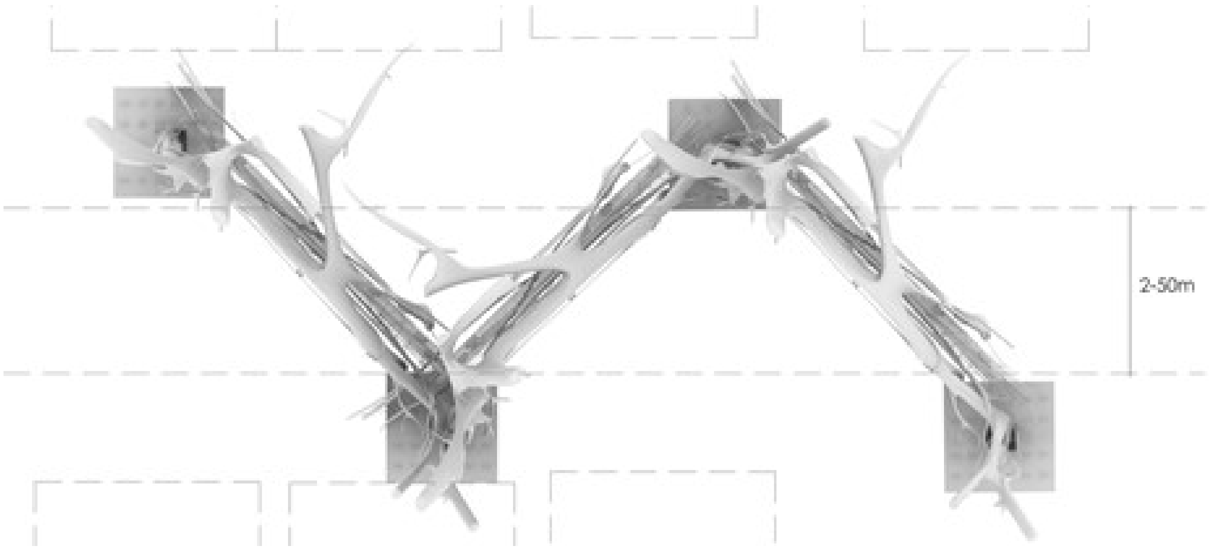
Figure 8:
Section.

their clothes and provide extra water to the trees. At the same time, it increases community engagement, proposing in this way a new public infrastructure.

Mumbai is the biggest open-air laundry globally, with 8,000 to 10,000 people washing their clothes on urban open-air laundries daily (The globe, 2010b). All this water could be filtered and used for the tree's growth by providing washing platforms. These platforms attach to the rubber tree roots, with an embedded filtration system for greywater treatment, which would provide two-fold benefits. First, it directs nutrient-rich water to the root system of rubber trees speeding up their growth. Secondly, the system provides an alternative to mitigate and control an environmental impact considering the local socio-cultural dimension, crucial for proper long-term system operation (Drechsel et al., 2015).

The communal laundry platform is designed to vary in size based on the urban footprint. The proposed one is 8m x 8m and consists of 24 clusters encompassing individual washing hubs with a vertical filtration followed by on-site disposal of the treated effluent (Fig 7,8, 9). The modular design adapts to the site and peoples need. Also, it allows for targeted maintenance and operation of problematic units that may need replacement.

Figure 9:
Rubber trees of Mumbai.



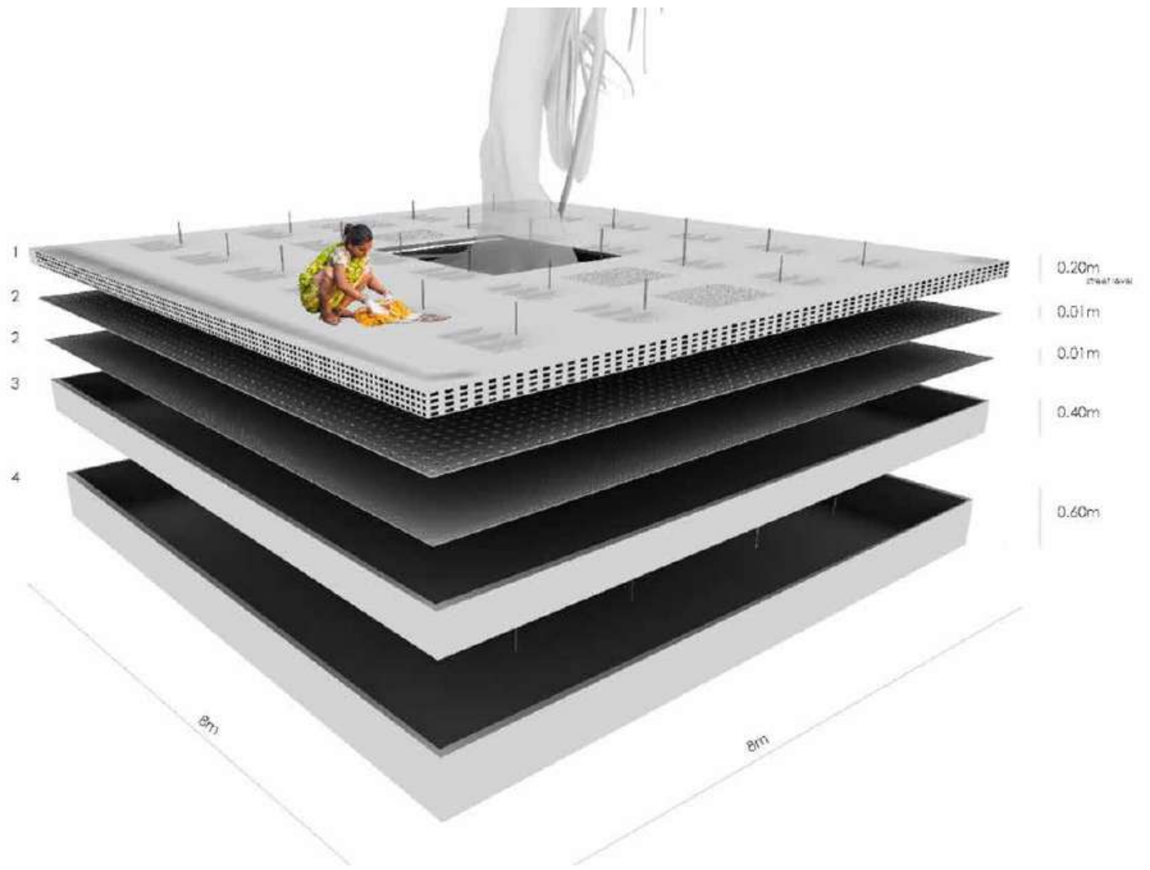
4. FEASIBILITY STUDY

4.1 GREYWATER FILTRATION SYSTEM

The open-air laundry can increase the eutrophication of natural water bodies since greywater from washing is often phosphorus-rich from soaps and detergents (Eriksson et al., 2002). This nutrient is usually the limiting nutrient for algal growth in natural environments (Conley et al., 2009). Therefore, its excess can result in harmful algal blooms, affecting public health and environmental balance (Rousso et al., 2020, Hamilton et al., 2014). For that reason, proper containment and treatment of the wastewater are installed on the platforms.

The user interface is an individual washing hub primarily designed to replicate cultural activities of open-air laundries and direct the greywater to the filtration system and disposal units. The filtration system has two layers that aim first to remove solids, organic matter, grease and nutrients from the wastewater, decrease clogging rate and increase the system's running time and operational longevity (Fig. 10). The first layer, also known as pre-treatment, consists of coarse gravel that aims to retain clothes fibres, grease, leaves and other large solids resulting in premature clogging of the system (Wang et al., 2021).

Figure 10:
Greywater filtration system: 1. washing surface, 2. grade 3. coarse gravel 4. slow sand filter.



The second layer is the slow sand filter, where most organic matter, nutrients and finer particles are removed from the wastewater through physical, chemical and biological pathways (Verma et al., 2017). On-site filtration systems are an effective treatment technology to reduce the environmental impact of greywater from locations where sanitation is not universal (Katukiza et al., 2014). Finer particles are physically retained in the media, while microorganisms oxidize organic matter and some nutrients. Other nutrients, such as phosphorus, are mainly removed through chemical adsorption in the media, becoming saturated after the long operation and requiring replacement or backwashing (Brix et al., 2001). This reinforces the benefit of having modular hubs that allow localized maintenance in premature clogged or saturated units.

After treatment, the treated greywater percolates into the soil. The rubber tree's root system consortium and soil microorganisms are further treated by the rubber tree's root system consortium (Vymazal, 2011). Besides favoring microbiologic activity (Pelissari et al., 2016) by introducing oxygen, the root system also reduces the pollution load by taking nutrients and water for plant growth (Brisson et al., 2006).

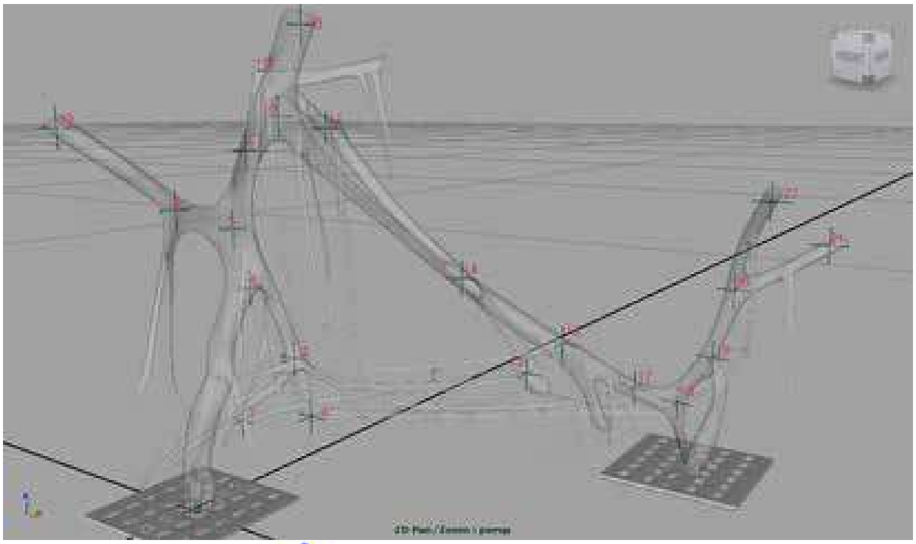


Figure 11:
Node location.

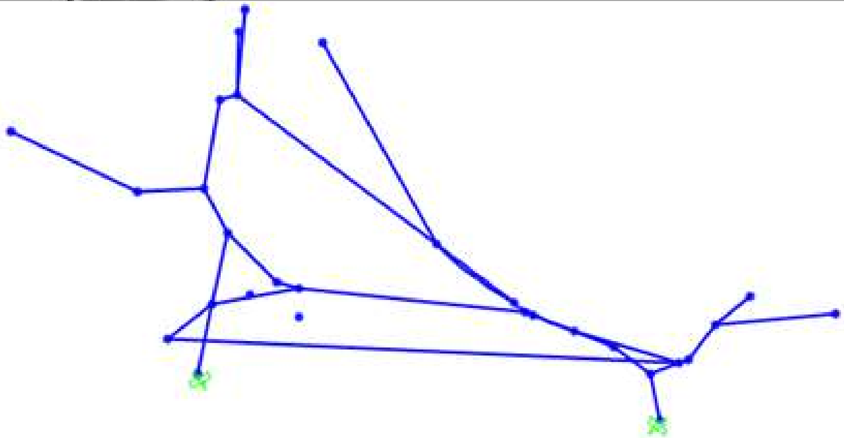


Figure 12:
Finite Element Model, Image Credit: E. Yaroni.

Thus, constructed wetlands are characterized as a robust, low-cost and simplified operationally on-site wastewater and stormwater treatment technology, favouring its implementation in developing or rural areas where operation and maintenance should be simplified (Lutterbeck et al., 2017).

Influent water for the communal laundry platform should be pathogen-free, so users are not at-risk during washing. Supply through the city water main is safer but represents poor potable water use for less restrictive washing. Rainwater can be an alternative but depends on the availability of collecting rooftops from surrounding buildings and the available area for a rainwater tank.

Table 1:
Structural properties.

Weight	944	Kg/m^3
Modulus of Elasticity	57,400	Kg/cm^2
Compressive Stress	144	Kg/cm^2
Tensile Stress	58.9	Kg/cm^2
Shear Stress	113.1	Kg/cm^2

4.2 STRUCTURAL ANALYSIS

As a next step, this research analyzed the structural stability of the proposed living bridges. Based on a sample 3D model of a typical bridge configuration, a centerline model was created using nodal coordinates of intersecting root members (Fig 11). All members were modelled as frame sections with circular cross-sections. Members have divided amongst three root sizes: primary trunks were 1m diameter, secondary roots 0.5m diameter, and tertiary roots 0.25m diameter. Nodes 1 and 2, located at the trunks' base, were modelled with fixed base conditions (Fig 12). This assumes that the in-ground root system can absorb any moments or overturn seen by the natural form of the living bridge.

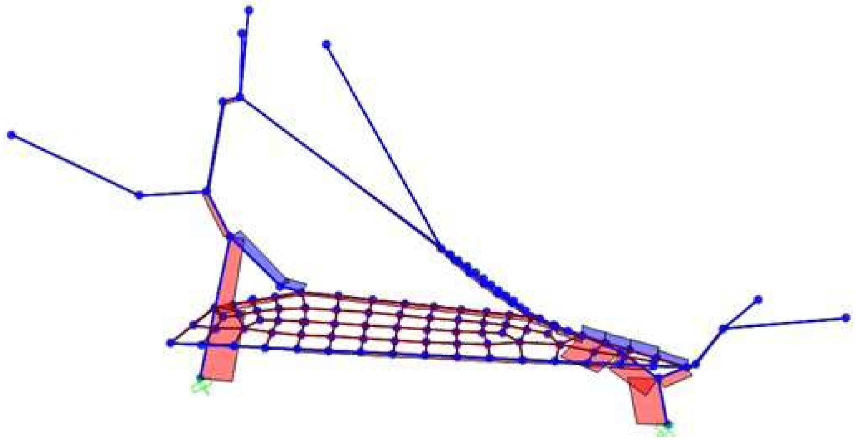


Figure 13:
Axial Load Diagram, Credit: E. Yaroni.

Using data from the Rubber Board, a statutory body constituted by the Government of India, material properties were applied to the structural components of the finite element model (Industry, 2014). All properties provided were based on dry rubberwood with 12% moisture content. In addition, a 30% reduction on all strength properties was applied to accurately study this model as a living bridge to capture a more realistic analysis of the living tree. This 30% reduction was based on research of other types of green vs dry wood properties. Table 1 summarizes the structural properties used:

Based on the research of existing living bridges in other regions of India, it is typical for around 50 people to stand on a bridge at any given time. Therefore, a conservative load of 100 kg/m2 was applied to the bridge walkway (Fig 13). The walkway itself was modelled as a 2m wide area surrounded by 0.25m roots. The walking path of the bridge is composed of a network of small tree roots that intertwine with additional planks of wood placed within to cover the gaps.

The image above shows the axial force diagram in the different tree members from this applied load. After analyzing the distribution of forces in the model, it became apparent that rubber tree bridges are extremely strong. These natural living bridges can withstand a tremendous amount of load. Based on a conservative 100 kg/m2 load, the worst-case root force was only 30% of its capacity. This finite element study shows that living bridges would withstand higher foot traffic, anticipated in Mumbai. It also shows that the rubber tree does not have to be fully matured enough to serve its purpose as a living bridge. Smaller root sizes can be enough to support the pedestrian traffic of the bridge.

5. CONCLUSION / FURTHER DISCUSSION

The proposed research project could provide many benefits in a densely urban environment. First, it is a low-cost system that self-grows and self-maintains with limited funds, materials and technological resources. Second, this system can scale up and replicate, covering a larger area in the urban fabric. Moreover, it utilizes the existing rubber trees and proposes to increase the number of trees in the city, which will provide an extra benefit by reducing CO_2 emissions, reducing pollution, and increasing biodiversity.

The project addresses pressing issues of overpopulation and the effects of climate change with a revolutionary approach that would define social interactions between humans and nature in a sustainable way. By incorporating an existing social activity, the project inherently strives to achieve greater welfare through community participation.

This research is an exemplary case for hybrid architectural and civil eco-technological design that solves social and environmental problems of fast-growing cities in the developing world. Last, it suggests that changing the way cities are designed using nature-based solutions could beneficially change people's lives.

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PREPARING PERIPHERY

Towards a Cultural Reparation Ecology in America's Empire

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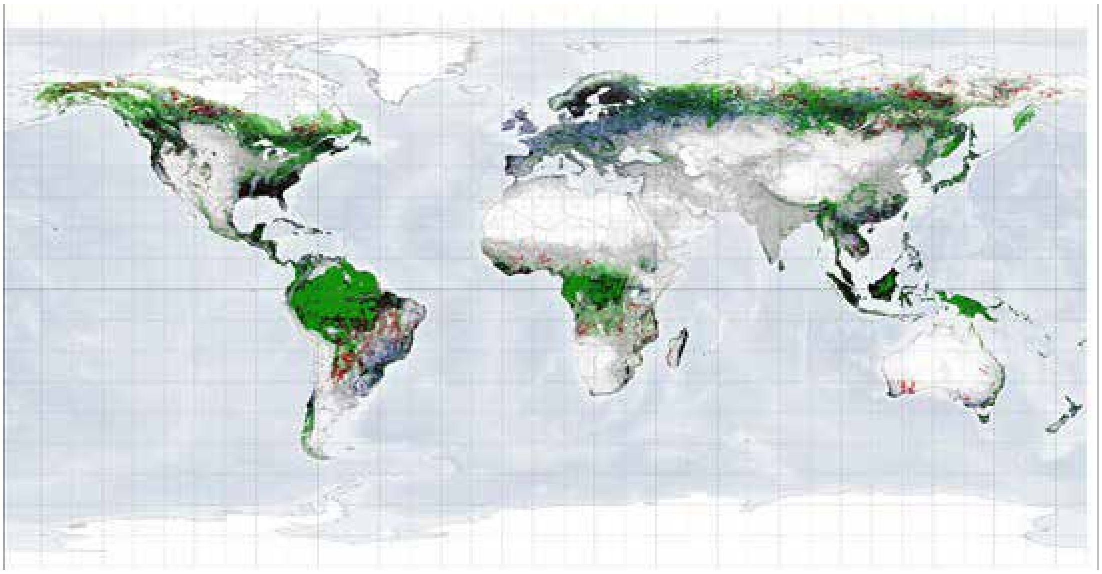
KEYWORDS
climate change, american history, postcolonialism, plantationocene, cultural ethnography

ABSTRACT
Climate change has been ubiquitously defined as a global issue and must be tackled as such. But how do these strategies land on the ground we know, in the cultures where we live? Antiquated definitions of conservation and ecology stand disconnected and rigid in the face of how climate mitigation can work to address centuries of systemic and widespread cultural issues. In other words, how can the work of climate adaptation help to fix the environmental and social violence and destruction that helped create it? By looking at the potential of a cultural reparation ecology, climate resilience and mitigation can be understood and communicated as a cross-disciplinary method towards simultaneously addressing issues of cultural, ecological, and social change. Here, Hawai'i and the US Virgin Islands, both American peripheral lands, offer examples of how ecological thinking and practice can further evolve and work towards climate mitigation. This work can not be done alone by landscape architects and frankly the design professions at large. This paper argues that a cultural reparation ecology necessitates an approach that pulls from multiple disciplines in order to successfully be integrated into how we work together to address the issues of the climate crisis.

1. INTRODUCTION

We are now witnessing the results of our collective destruction around the world. From centuries of colonialism and industrialization where forests were leveled (Figure 1), marshlands drained, rivers tamed, and oil burned, this global alteration is no longer hidden. Within this crisis, the design professions, namely landscape architects, are leveraging the general term of ecology to fight and combat climate change. Subdisciplines like restoration ecology (Jordan et. al, 1987), conservation ecology (Cox, 1963), and more can be seen in both academic works and on the master plans of restored shorelines or a new urban village. But these branches of ecology are predicated solely on the natural systems themselves, when they are working alongside human settlements and communities. As systems of colonialism, industrialization, and capitalism have decimated indigenous cultures and segregated our communities and cities, how can our natural environment work to repair the cultural violence that has been created and further exacerbated by the climate crisis? Governments at multiple levels are beginning to consider how to solve long-standing cultural and racial violence. How then can the environment play a role in this? Here, I argue the concept of cultural reparation ecology (CRE) can bridge the gap between environment, human community, and disciplinary separation to work towards a pluralistic approach to how the field and application of ecology can better represent, operate, and solve the myriad issues of climate change.

Figure 1: Comparing Human Settlement with Global Forests (Green), Deforestation (Red), and Reforestation (Blue) and areas of overlap (Black).



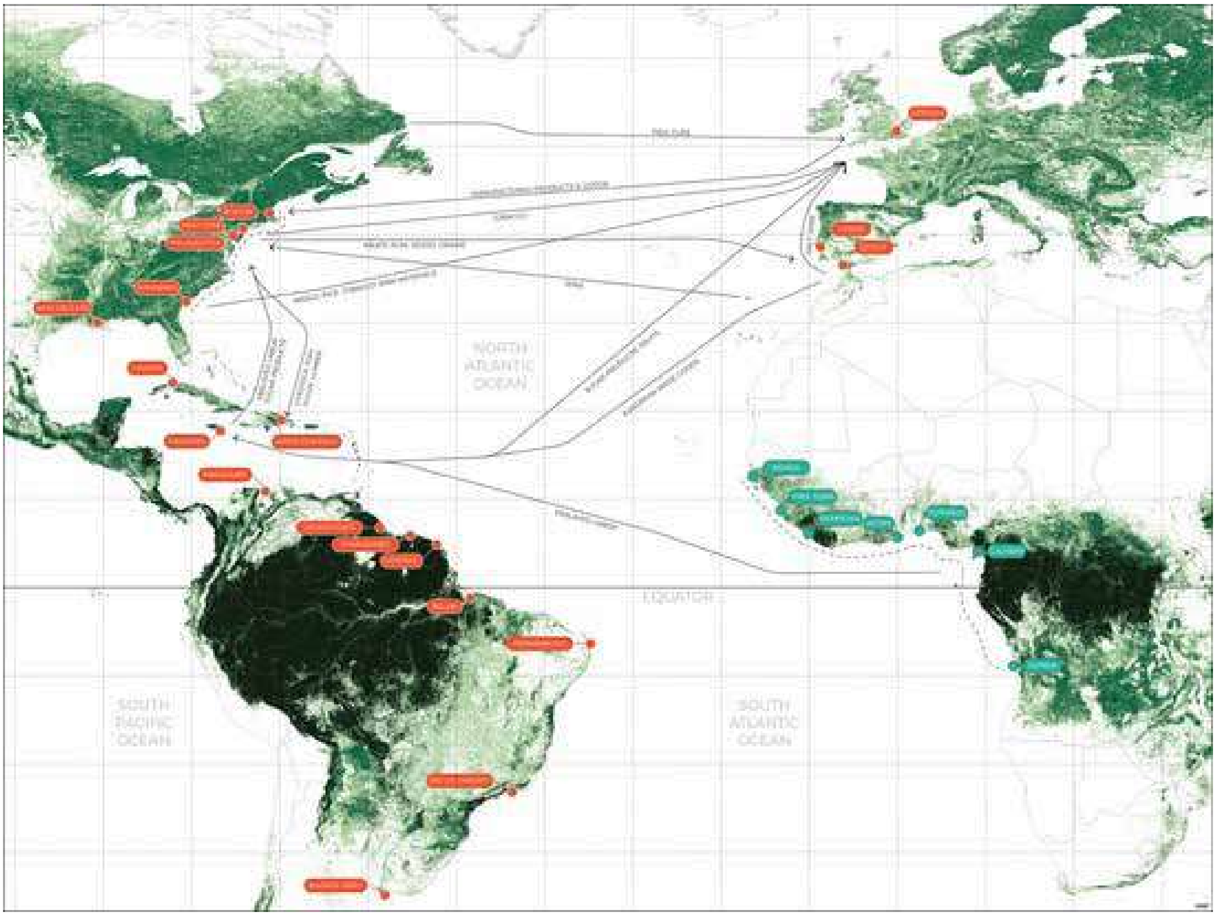


Figure 2:
Understanding the Transatlantic Slave Trade and Forest Resources.

As the United States maintains peripheral land holdings as both states and territories in the Caribbean and Pacific (Immerwahr, 2019), it is imperative to recognize their people are now facing the summation of centuries of plantation operations (Figure 2). Hurricanes, flooding, mudslides, drought, and biodiversity loss are deeply felt environmentally and culturally. Plantation systems have been a critical force in carbon accumulation from the 15th century to today (Tsing, 2005; Haraway, 2016). But the indigenous groups and forced labor on these lands have been the ones to bear the brunt of environmental and cultural violence and are now weathering the effects of greater climatic instability under the guise of American identity. Paradigmatic shifts in preparedness and response are needed to ensure these cultures and ecosystems can persist through this climate crisis. Moreso, how can the indigenous voice regain sovereignty over their land to ensure proper land stewardship and reparation?

Two examples of American peripheral lands can serve as case studies towards an understanding of cultural reparation ecology: Hawai'i and the US Virgin Islands. Both exemplify physical and metaphysical distance to the mainland US and currently experience heightened issues stemming from the climate crisis and centuries of systemic socio-political policies and violence. I further argue that the approach of CRE necessitates a call for multiple disciplines to bridge together disciplinary gaps in the academy and professionally and create new hybridized understandings towards the human and non-human benefits of nature-based solutions and adaptations.

2. AMERICA AND ITS PERIPHERAL LANDS

The United States maintains a calculated disguise to reduce its image of being an Empire. Looking at typical maps of the country, the contiguous 40 states are frequently the image understood by many, with the states of Alaska and Hawai'i being tucked away neatly in the corners, void of any context. What these maps refuse to show are the five main territories of the US (Puerto Rico, US Virgin Islands, Guam, the Northern Mariana Islands, and American Samoa). To draw this map is to draw an aggregate of land holdings across much of the globe, spanning both the northern and southern hemispheres.

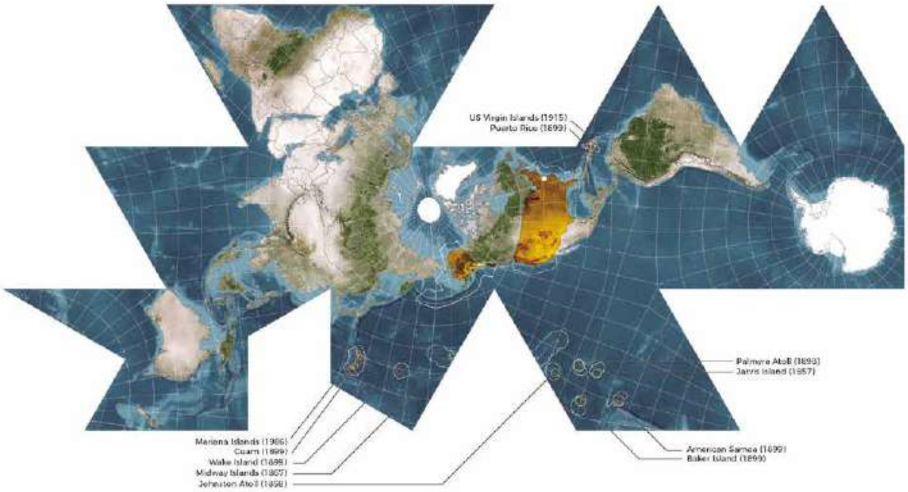


Figure 3:
The Greater American Empire with its Major Territories and Minor Lands.

But this notion of periphery is more than just geography, it is also a political and social construct. As James Baldwin argues, "it is true that the nature of society is to create, among its citizens, an illusion of safety; but it is also absolutely true that the safety is always necessarily an illusion." (Baldwin, 1961) Each territory retains minor representation in Congress, with each electing one non-voting member or a liaison to the House of Representatives. American Samoa is the only inhabited territory left to not be guaranteed birthright citizenship to its population, with American Samoans being labeled as US Nationals. This is the result of a purposeful "otherness" applied to US territories and peripheral lands. By keeping these lands and its people written and understood as distant and "othered" and moreso non-white, their identity in the greater American conscience has been constructed as something separate and lesser than. As David Immerwahr writes, "[a]t various times, the inhabitants of the U.S Empire have been shot, shelled, starved, interned, dispossessed, tortured, and experimented on. What they haven't been, by and large, is seen." (Immerwahr, 2019. p.19)

The climate crisis is now exposing these fragmented relationships in new ways. Federal funding and conversations around infrastructure improvements, clean air and water, and climate change frequently remain within the boundaries of the mainland. But as the climate crisis only intensifies, America must address the needs of its peripheral lands, its territories, and its peoples. These lands are situated in pathways of hurricanes and typhoons, rising sea levels, and tropical heat. Inaction will be a new line of American failure to protect its citizens and nationals and its Empire. Furthermore, it will underscore that national security and infrastructure is only an illusion.

3. ASSEMBLING A NEW ECOLOGY

Since Ecology's inception in 1866 with Ernst Haeckel, the field of study has evolved and expanded to include notions of cultural ecology, restoration ecology, conservation ecology, urban ecology, and more (Perlman, Milder, 2004). However, these often choose to neglect deep soco-political ties to ecology. With the continued rise of racial and social discord in the United States, how can ecology operate to include these issues? Scholars are moving towards this. Holly Jean Buck posits that, "Reparation ecology is a way to see both history and the future: 'redistributing care, land, and work to so that everyone has a chance to contribute to the improvement of their lives and to that of the ecology around them can undo the violence of abstraction that capitalism makes us perform every day," (Buck, 2019. p. 245) But with the rise of legislation like the Apology Resolution of 1993 to the people of Hawai'i during the Clinton Administration and even H.R 40 in 2021 that aims to explore reparation to Black Americans, it is critical to include how reparations to the natural environment and ecosystems can help solve these issues. As these are the communities that have been left out of critical decision making, disenfranchised, and now at the doorstep of climate destruction, climate adaptation must address their needs immediately.

Cultural reparation ecology seeks to synthesize these efforts and catalyze a new mode of operation. The term itself is four terms/ practices in one: ecology, cultural ecology, reparation ecology, and cultural reparation. Each lacks the capacity for a comprehensive approach, yet together have a latent potential to tackle the myriad issues at hand.

This approach to ecology also shifts its basis from a strict scientific framework to one that is more humanities-oriented. Pivoting the ecological foundation unlocks a new set of disciplines and knowledge to contribute towards the solutions ecology affords. Ecology can now accept strains of cultural ethnography and anthropology, racial justice and gender studies, religion and sociology. A multi-disciplinary approach, manifested as cultural reparation ecology, aims to understand and address the needs of environmental and cultural systems equitably through nature-based solutions to provide robust approaches to racial, social, and environmental justice and crises.

To begin to understand this new branch of ecology and its application towards the United States, I present two case studies to realize how CREis a stronger method to address the multiple issues present in the country's peripheral lands. First is examining the ongoing loss of 'Ohi'a Lehua (Metrosideros polymorpha) on the Hawaiian islands and the potential towards building a new form of cultural and environmental resilience in a peripheral state. Second, I explore the loss of red mangroves (Rhizophora mangle) in the US Virgin Islands and how methods of afforestation can aid in storm surge and biodiversity loss in an American territory. Together they provoke how typical methods of nature-based solutions can address larger political and socio-cultural issues for a more comprehensively resilient future.

4. MALAMA A'INA: CULTURAL RESILIENCE IN HAWAI'I

The Hawai'i understood by many Americans is one of imagination. A tropical paradise complete with cerulean waters, lush vegetation, pristine landscapes, and welcoming people. But this is just an imaginary. What is left out is the colonial system that exploited the Hawaiian islands and its people, removed its monarchy, and subvertently put it under American control as a territory in 1893 (Aikau et. al., 2019). The resulting plantation economy induced vast amounts of land clearing, forced labor, and cultural erasure (Takaki, 1983). David Swanson and the Pew Research Center estimate that precontact in 1778, the islands were home to over 700,000 people. But due to introduced disease, conflict, and exploitation, the population cratered to 24,000 by 1920. 2010's census however, offered a ray of light documenting that there were over 300,000 people identified as Native Hawaiian (Swanson, 2019).

What is critical to understand in these islands is that the period of time where Hawai'i annexed, deemed a territory, and became a state (1893-1959), the United States critically altered human and non-human systems. While the Native population is rebounding and has been recognized with federal legislation such as the Apology Resolution (Public Law 103-150), there is a critical gap in leveraging indigenous wisdom and practices to address crippled ecosystems. One step towards this is the practice of Malama A'ina or "protect the land".

Native Hawaiian culture approaches a total form of land stewardship where the human agents ensure a healthy reciprocal relationship with the land, doing their part to ensure it's health and longevity. This practice offers a potential space where CRE can work towards amplifying these indigenous practices and apply them towards a growing threat to a critical ecological and cultural tree, 'Ohi'a Lehua (Metrosideros polymorpha).

Figure 4:
"Waimanalo Sugar Company locomotive and train with Koolau mountains in background" ca. 1900, Hawaii State Archives Digital Collection.

The 'Ohi'a Lehua tree is deeply regarded in Hawaiian folklore where the Goddess Pele's jealousy for a lover ('Ohi'a) caused her to turn him into a tree. His lover, Lehua, appealed to the Gods offering for this to be undone, but a compromise was made and she became the flower for the tree, letting the two live together for eternity. Outside of folklore, the tree is a pioneer species, populating newly formed land in lava flows and building new ecosystems and future forests. Native forests across the islands range from 50-80% 'Ohi'a. It's flowers are also important sources of nectar for pollinators (Hodges, 1986). Today, these trees are at threat of Rapid 'Ohi'a Death (ROD), a fungal disease (Ceratocystis fimbriata) classified in 2010 (Schuler, 2016). The fungus quickly kills 20 - 25%of an area's 'Ohi'a and over 71,000 hectares of forest on the island of Hawai'i, and has been documented on Kaua'i, O’ahu, and Maui (Mertelmeyer et. al, 2019). The seeds of the trees, however, are resistant to the fungus. Action is being taken, with the state enacting new legislation and works towards protection of forests and quick removal of infected areas.

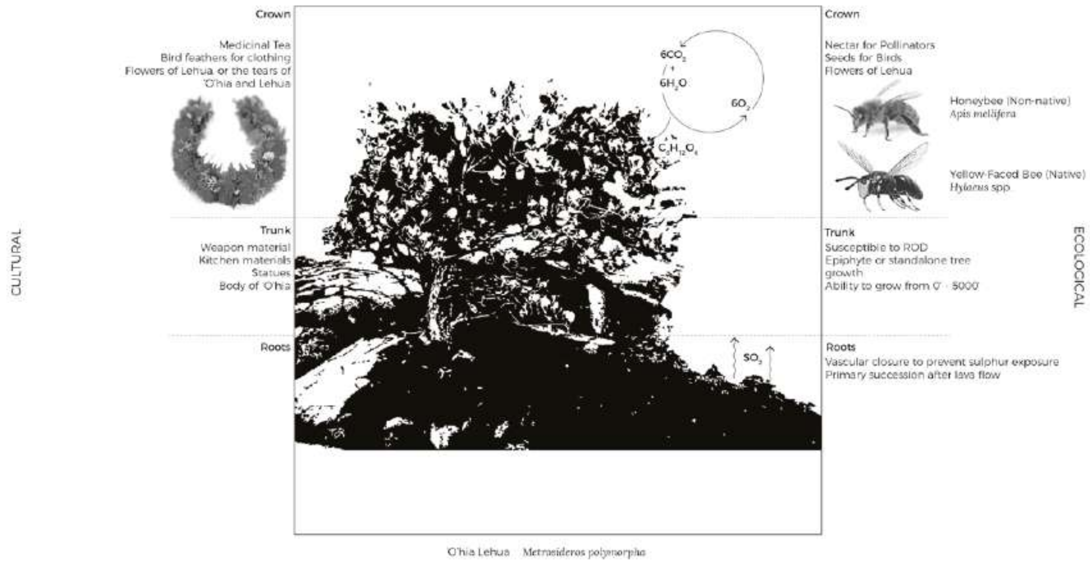


Figure 5:
The Cultural and Ecological Parallels of ‘O’hia Lehua.

But how can indigenous wisdom work towards combating this disease? I argue that Malama A’ina can work towards rebuilding these forests and larger landscapes. The wisdom and knowledge of Native Hawaiians can work in tandem with scientific knowledge, towards creating new systems and methods of forest regeneration, helping to not only heal the land, but work to rectify years of cultural exploitation (Figure 5). The islands have an opportunity to leverage the ‘O’hia Lehua tree as a point of cultural reparation ecology; a method that addresses emergent ecological devastation with longstanding socio-cultural violence to rebuild and generate a new and resilient Hawai’i.

5. BLUEGREEN BUFFERS: MANGROVE RESTORATION IN USVI

The US Virgin Islands have been a territory of the United States since their purchase from Denmark in 1915. In the years since, mainland America has crafted these three islands (St. Croix, St. John, St. Thomas) into spaces that meet specific needs: tourism, conservation, and industry. Today, these islands are at immediate threat of the climate crisis. From hurricanes, to hyper-salinity, and even to oceanic current disruption, the extractive and violent plantation system applied here, played a role in creating the crisis we have today. Historically, the islands were surrounded by dense and lush mangrove stands. These trees were not the main commodity of extraction during colonialism, but a physical wall preventing the efficiency of the process (Hall, 1992).

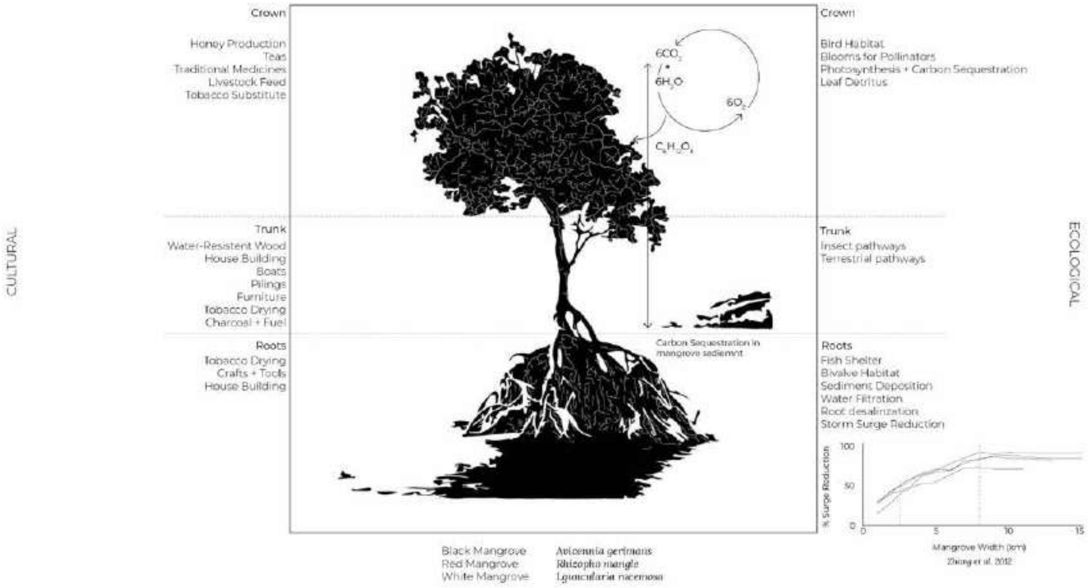
Figure 6:
Sussanaberg and Adrian Plantations on St. John, 1838. Credit: Royal Danish Library.

The ecological benefits of mangroves are many: aquatic roots for fish spawning and coral growth, rich leaf litter for seabed nutrients, wave attenuation, bird nesting sites, etc. But the indigenous cultures on the islands, primarily Taino, also used mangroves for tobacco drying, timber, honey cultivation, tools, and more. These trees and people proved to be a nuisance for colonial powers, looking to expedite extraction through the plantation mechanic. As Gomez-Barris writes, “since dense genetic plant life and natural resource regions often overlap with Indigneous territories, then we must work to analyze how Native peoples are both constructed by the state and corporate entities as obstructions to the expansion of extractive capitalism and literally block its reach.” (Gomez-Barris, 2017, p.xvii) The islands were then cleared of their many mangrove forests, among other terrestrial forests as well (Figure 6). But in the process, the islands lost their critical ecological services.

As the islands are at increased risk due to climate change, the restoration of mangrove forests is an incredible tool of blue-green infrastructure that can help provide critical protection against hurricanes and other threats (Rossi, 1990). What’s more is the ability to preserve and reinforce the embedded cultures and peoples on the islands (Soanes et. al., 2021) (Figure 7). By working to rebuild these red mangrove stands, the federal government has the opportunity to illustrate a climate adaptive future for its peripheral lands and their people. Investment and implementation have myriad benefits. But the most important is the purposeful inclusion of historically excluded people and land.

This form of CRE provides for a new approach to how the United States maintains its peripheral lands and territories. With histories that are plagued with exclusion, investment in blue-green infrastructure like mangroves allows for broad and deep forms of healing that can be felt and seen. Critical to its success though is the actual action the federal government must take to work against the climate crisis in such a high risk area. If the US continues to delay, the threats to people and their land only rise.

Figure 7:
The Cultural and Ecological Parallels of Red Mangroves.



A territory like the US Virgin Islands must no longer be seen and categorized as a mainlander's vacation destination or a federal government petrochemical powerhouse. These are islands that have fragile human and non-human resources and systems that are witnessing the combined effects of the plantation mechanic. By working towards a climate adaptive future for this territory, the US can begin to construct new methods of reparations and methods of inclusion that can define a new paradigm of territorial management.

6. BLUEGREEN BUFFERS: MANGROVE RESTORATION IN USVI

Ecological strategies and implementation will continue to solve the voids in anthropogenic environmental destruction, but they must also be understood in how they can address cultural destruction as well. As we witness more effects of climate change across the world and in our communities large and small, urban and rural, it is imperative to understand ecology as a practice of cultural resilience and reparation. Leveraging ecology solely as an environmental remedy is no longer enough. A larger and more radical comprehension of what ecology can mean is needed. Ecology can work towards challenging long-standing power structures and socio-cultural imbalances we see today. Through this radical rethinking of how ecology can disrupt destruction at many scales and systems, we need to move away from the thought of how this will bring the place, people, and landscape back to a certain point in time. We must now look to how ecology can radically move us forward and take us to a future imaginary and condition that is not disguised in the past, but breaks the constraints of colonialism, imperialism, capitalism, and into an unknown climate future. This work is not up to the design professions alone. This work towards a cultural reparation ecology necessitates agents from all disciplines.

By rethinking and synthesizing ecology as a form of cultural reparation, the design disciplines can lead a charge towards designing and implementing ecologically-based strategies that champion and amplify the cultures that were disenfranchised, broken, or even erased. Cultural reparation ecology can also work to bring in additional thinkers to achieve a broader and a deeper path forward as responsibility shifts. Landscape architects, architects, and planners can work alongside community leaders, economists, politicians, anthropologists, archaeologists, local business owners and more to disrupt the deeply embedded systems that were created through cultural destruction. This approach can challenge power structures and ensure that the legacies of destructive forces are held responsible for the future. Our combined work can not continue to just be added street trees or a restored marshland, but it must be a revivification of a way of life, a form of knowledge, that carries deep wisdom and the ability to amplify the voices of many outsiders and peripheral lands and work towards establishing a radical future of cultural sovereignty and climate action.

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THE ROLE OF NATURAL COMPLEXITY IN ADAPTIVE ARCHITECTURE

Eco-based design: Nature as pattern and architecture element

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Adaptive architecture, eco-based design, resilience, metereosensitive architecture, More-than-human design

ABSTRACT

In the broader context of an ongoing doctoral research, it is possible to consider adaptive architecture as a possible solution for designing resilience. Despite the large use of technology, it is possible in fact to recognise different design approaches that involve Nature in the whole process, form the initial conceptual phase toward the effective construction stage. Among these different ways, which underline a biomorphic common perspective, this paper would focus on two of them, underlying the role of nature in the design approach. The first is referred to the consideration of Nature as design material and is shown through the projects of the American architectural firm SCAPE, 'Living breakwaters' and 'Oystertecture'. The second approach instead will introduce the use of natural pattern as a way to conceive architecture through geometries, as shown in 'Hygroscope' and 'Pad Hygroskin', two projects conceived within the Institute for Computational Design, University of Stuttgart. The aim of the paper is to show different vision of the More-than-human approach in architecture, envisioning a more responsible way to think of the built environment through Nature to design resilience.

1. INTRODUCTION

Analogies and contradictions have characterised the dialogue between architecture and nature for centuries, in a continuous exchange of roles for a formal supremacy led by technical knowledge. From the constructions of the ancients (guided by a close relationship with the natural context), through the different concept of Nature of the Modern Movement (passing from functionalism to organicism) up to critical regionalism and the most recent approaches on digital design, nature has always played a crucial role in the process of understanding and intervening on the existing. This long and articulated path has also allowed the parallel development of numerous branches of technology, in order to support man's desire to understand, control and overcome the natural element. This desire to control technological data, however, has led recent literature to consider man's current ability to make as superior to his ability to predict the effects of his actions (Galimberti, 2011). The attitude of not being able to control technical and technological data requires to reflect on the way architecture should intervene today, progress on the one hand, by incorporating technological and on the other, by understanding the renewed needs of a complex environmental system. What is noticeable nowadays is a succession of environmental changes, which often generate unpredictable and uncontrolled natural disasters, with which contemporary architectural design is called upon to deal. Rethinking the way of conceiving design therefore also implies a review of the potential induced by architectural transformations, not only on the human or urban scale, but also on the macro environmental scale, constituting in itself a tool for understanding what exists. Designing for Nature and with the Nature, in such a complex context of inter-scalar relationships, constitutes a vast portion of the scaffolding of knowledge that enables the development of the theme of resilience. Resilience is therefore firstly a means of understanding what exists and then a tool for implementing processes of adaptation and transformation, in a dual and heterogeneous relationship between architectural design, technology and the environmental dynamics at different scales. Therefore, with the aim of understanding the importance of architectural design on the natural environment and the urban tissue, especially in the light of continuous environmental and climatic changes and their tragic consequences, it is important to question the way in which we make architecture, think about it and realise it.

In fact, it is believed that the aim of resilience can be achieved, in the architecture field, not only through new social policies and cutting-edge technological tools, but also through new design approaches that make transformation and interaction as formal features. In fact, with the advance of time and technologies, different design approaches have developed, based on the heterogeneous degrees of interaction with the outside world. The introduction, also in the architectural field, of new technologies has then allowed the design of architectures capable of changing partially or totally in their spatial layout, identifying different levels and types of adaptability, due to the involved components (Elmokadem et alii, 2016). In an additive sequence of complex systemic features, interactive architecture and responsive architecture give way to adaptive architecture, which incorporates the previous features and makes the temporal component its core element (Fig.1). The fact that a building or an urban project is able of modifying its constituent elements through a digital and technological mechanism makes possible to identify a parallelism with natural ecosystems, which are innately capable of reforming themselves and adapting to external adversities. Therefore, it is possible to recognise different types of adaptive design that consider the natural element in different phases of the creative process, from the initial conceptual phase to the actual construction phase.

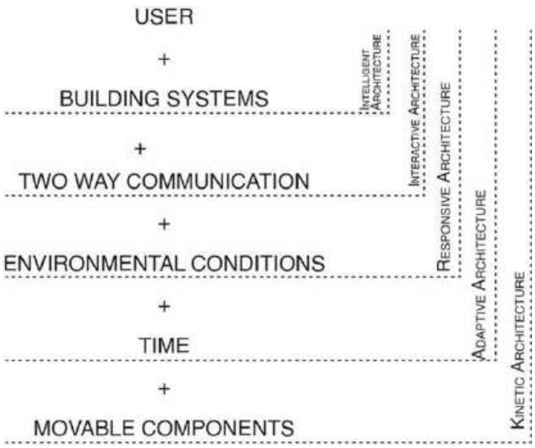


Figure 1:
Graphical visualization of the scheme proposed on Elmokadem, D.A., Ekram, D.M., Waseef, D.A. and Nashaat, B. (2018), "Kinetic Architecture: Concepts, History and Applications", in International Journal of Science and Research, Vol. 7, No. 4, pp. 750-75 (credit: Andaloro, 2021).

2. HOW TO DESIGN WITH NATURE

Within transformable architectures, be they responsive or adaptive, it is fundamental to consider the role of digital components, as new tool for the representation of transformative processes, as well as for understanding and interacting of architecture with the external environment. The importance of these elements (which appreared iwith the architectural tool for the first time with the experiments of the English architect Cedric Price on the Fun Palace or the Generator Project) is crucial for the understanding of the systemic feature of these creative processes. In fact, at the core of this process is future interaction that the project will be able to convey through its architectural materials. Interaction, which can be active (the two subjects interact bilaterally) or passive (one subject acts and the other perceives) guarantees, on the one hand the passage from 'data' to 'information', and on the other, the passage from physical to virtual. In this frame, the transition from data to information is crucial for the understanding of the Information Technology Revolution on society and on architectural design, i.e. the shift of design attention from the object to the subject (Saggio, 2010). Information technology introduced the concept of automation, or the possibility of automatically processing data, according to the rules and principles of computer science and transforming them into information. From this point of view, in 1989 Russel Ackoff defined data as a collection of symbols and signals (the signifier), that is, stimuli, which cannot be used unless they are discretized and made comprehensible through the establishment of a reading system of reference that is capable of attributing a specific meaning. This is where the difference between these two elements is revealed: data is identified as raw material, without explicit intentionality, while information is defined as knowledge that is the result of a description (Fig. 2). 'Data with a purpose' therefore, participate in the knowledge process by triggering reflections and design actions (Ackoff, 1989; Kitchin, 2014).

Figure 2:
Structure of human mind in the knowledge process. From: Ackoff, R. (1989), "From Data to Wisdom" in Journal of Applied Systems Analysis., vol. 16, pp. 3–9 (credit: Andaloro, 2021).

The conscious use of information for the comprehension of a design problem is a crucial point in the definition of adaptive architecture, which elaborates a spatial, temporal and scalar transformation in response to an external crisis within the architectural system. Through interaction between users, building and environment, many projects use the information related to a specific external condition (a risk, a crisis) in order to com-pose the architectural materials in a unique relationship that makes the adaptability of the building possible. This correlation then show the role and the impact of digital elements and technologies in the process: the building is conceived after a catastrophic event which, on the one hand, provides the necessary information to understand the ongoing current; on the other hand, it could be used to augment the built environment with an interactive learning process.

In this perspective, therefore, it is possible to identify different design approaches that relate the digital element (mainly identified in the capture of data from the external environment) to the natural system. The natural element (as well as data at the beginning of the digital revolution) can be considered as a real design material (capable, moreover, of autonomous and specific reactions and behaviours) or as a pattern of information, whether genetic, parametric or behavioural.

2.1 DESIGNING WITH NATURE: A MORE-THAN-HUMAN DESIGN

Considering Nature as a common design element means widening the horizon of the project's potential, introducing the features of multi-materiality, multi-scalarity and multi-temporality, all recognisable in adaptive architecture. After the ideas of the ecologist and philosopher Dave Adams in the early nineties, many design theories have been developed about the 'more-than-human' component on a par with the human one (Abrams, 1997). In parallel with the theories on the new Anthropocene, the design approach centred on the integration of the natural element (in the form of animals or plants) is quickly widespreading, especially in the fields of landscape design and biotechnology. In the architectural field, instead, as will be shown below, it is possible to design an integrated complex system where the natural element participates in the social process that the urban space puts into place.

2.2 DESIGNING WITH NATURE: A BIOMORPHIC DESIGN APPROACH

From the inclusion of Nature in architectural design derives the definition of different currents of thought, developed around the character that defines them. The three currents, which we can identify as ‘genetic’, ‘parametric’ or ‘behavioural’ are all related to a common factor, namely the biomorphic tendency of architecture. Designing in a biomorphic way therefore implies conceiving a project that semantically or conceptually simulates the different behaviours of living beings (animals or plants). This is made possible by the vast technological range of tools for analysing and implementing biomorphic mechanisms, as well as by nano-technologies and nano-materials, capable of reproducing the physical characteristics of other living organisms. Within the biomorphic macro-category we therefore find the 'genetic', 'parametric' and 'behavioural' approaches. The first current, of a 'genetic' kind, extracts the distinctive elements of individual species from the natural world in order to transfer their main characteristics to the component of the architectural project:

Figure 3:
François Roche: (top): Dustyrelief, Bangkok , 2002; (bottom left): (Un)Plug, Paris, 2001; (bottom right): Olzweg, Paris, 2006.

examples of this are some of the projects of the French architect and artist François Roche, who introduced an 'embodied' conception of the cognitive aspect (Di Raimo, 2014) (Fig. 3). Among others, Dustyrelief (designed for Bangkok in 2002), (Un)plug (designed for Paris in 2001) and Olzweg (designed for Paris in 2006). The ‘parametric’ current, refers to the connection of parameters from the natural systems to different (usually technological) components. This approach will be explored in more detail through the projects developed by the Institute for Computational Design of the University of Stuttgart. Finally, it is possible to emphasise ‘behavioural’ traits of animal species or other living beings that can be reproduced in the form-finding process, as in the research of the Greek architect Theodore Spyropoulos at the Architecture Association Design Research Lab (Spyropoulos at al, 2013).

3. AN OYSTER-PARK FOR THE SHORELINE OF NEW YORK

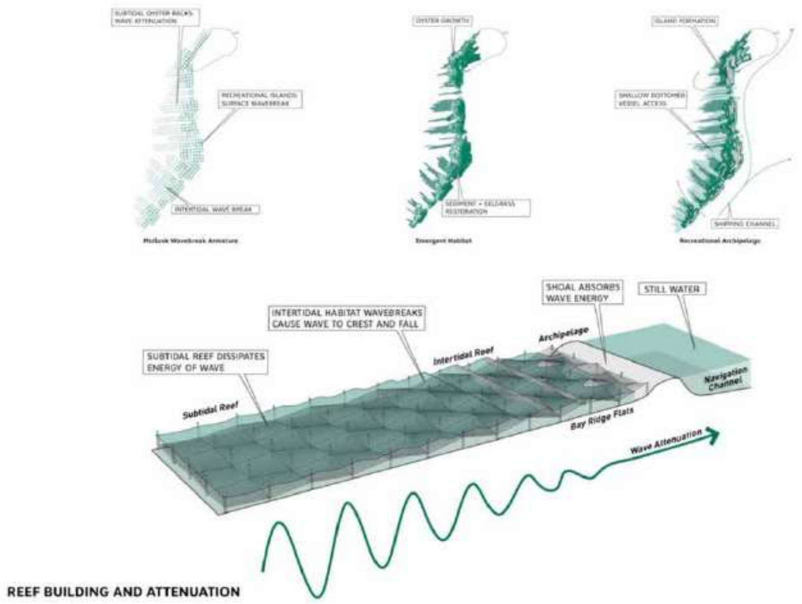
More-than-human' design plays an important role in the definition of projects that involve other living beings as effective constituent elements of the entire architectural or urban system. This is then a way of conceiving architecture in the whole respect of other species and in order to implement the sustainability and the resilience of different eco-systems (Orff, 2016). In order to achieve this purpose, a continuous adaptability of the system is guaranteed, thanks to the inter-scalarity of its components, which respond to a swarm paradigm (Oosterhuis, 2003), in a mutual dialogue between the parts and between the parts and the whole. Presented as a pilot project for the 'Rising Currents' exhibition (hosted at the Museum of Modern Art of New York in 2010), the Oyster-tecture project by the American studio SCAPE opens up an unusual and heterogeneous scenario to introduce, yet ten years ago, the theme of urban resilience through multi-disciplinarity. Far from being a way of recalling the idea of a New York of the past (in which the cultivation and sale of oysters was a key element of the city's economy and the entire ecosystem of the Bay) or even being understood as a different form of speculation (e-flux architecture, 2010), the Oyster-tecture project proposes to build an active oyster barrier, capable of reinvigorating the marine life and the playful potential of New York harbour and waterfront (99percentinvisible, 2017). The project, initially designed in 2010 and subsequently developed and presented at the Rebuild-by-Design competition in 2012 under the name of Living Breakwaters, proposes a solution based on a full and profound understanding of the biotope in which oysters live and which they help to modify. The installation of a sub-layer of rope on the seabed of the New York Bay is in fact functional to the implantation of new oysters, which otherwise could not survive the level of pollution of the current seabed (Fig. 4). Similarly, the oysters are instrumental in helping new species of fish to populate the marine environment and in purifying the water of the waterfront, thanks to the biotic filtration processes of the oysters themselves (Figg. 5,6). Furthermore, with their 3D texture, they are able to break large tsunami waves before they reach the shore, thus also slowing down sea currents and ensuring a climate-proof environment. Oyster-tecture first and Living Breakwaters later (Fig. 7) provide a model for eco-based adaptive design, which places all living beings at the centre of the project to modify the existing environment and once again demonstrates the great potential offered by the constant and continuous interaction between architecture, the external environment and its users.

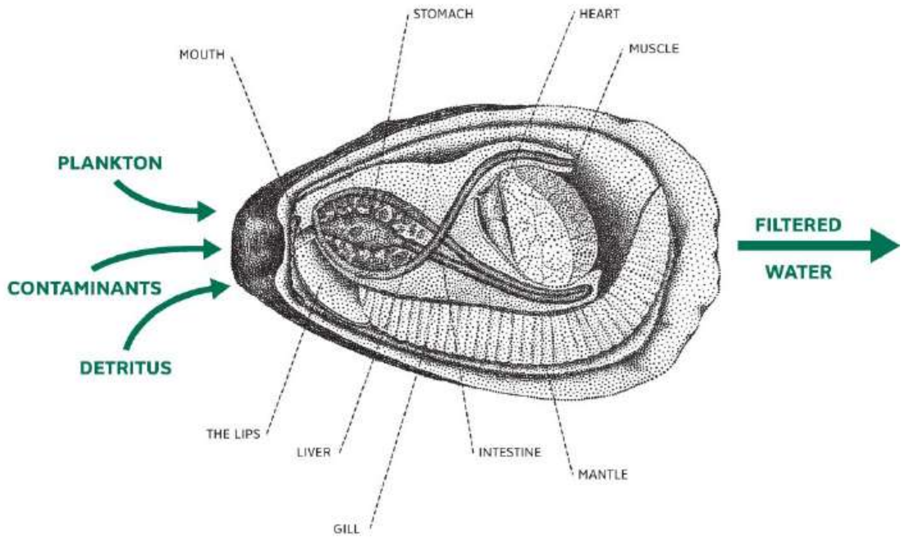
Figure 4:
Oyster-tecture, general overview of the project, as presented for the 'Rising Currents' exhibition in 2010 [Source: https://www.scapestudio.com/projects/oyster-tecture/].

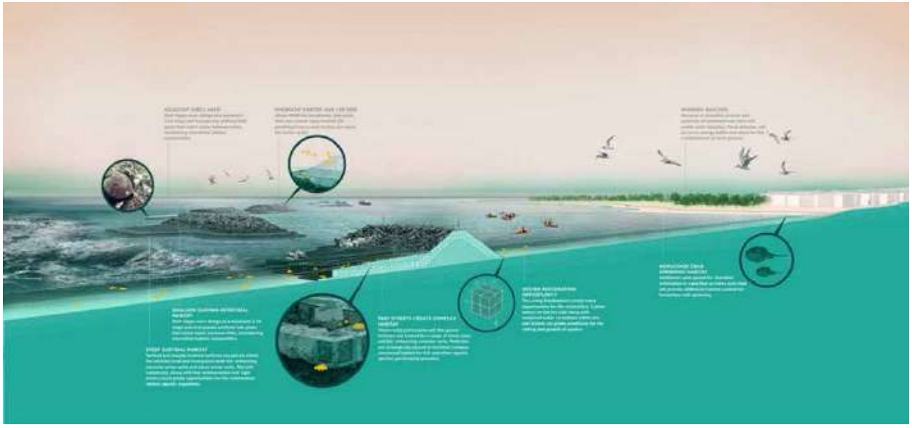
Figure 5:
(top)
Reef building and attenuation, Oyster-tecture, SCAPE, Exhibition project, 2010 [Source: https://www.scapestudio.com/projects/oyster-tecture/].

Figure 6:
(center)
The filtering system of the oysters shown between the submission documents of the project. This underlies the importance of 'More-than-human' components in the whole project. Oyster-tecture, SCAPE, Exhibition project, 2010 [Source: https://www.scapestudio.com/projects/oyster-tecture/].

Figure 7:
(bottom)
Living Breakwater, SCAPE, New York, 2012. General overview of the project [Source: https://www.scapestudio.com/projects/living-breakwaters-design-implementation/].







4. HYGROSCOPE AND HYGROSKIN: TWO WAYS OF DESIGNING WITH NATURE AND GEOMETRY

Another way of approaching adaptive design through the complexity of nature is through the discretization of the properties of natural elements into geometric compositions. The abstraction that derives from geometry allows to design from a rule by defining the relationships between different elements. In other words, natural elements with complex geometry provide the basis for parametric adaptive architectural design. Two projects developed between 2012 and 2013 by the Institute for Computational Design, University of Stuttgart) can demonstrate it: 'Hygroscope' (Menges Achim, Steffen Reichert, in collaboration with Transsolar Climate Engineering GmbH) and 'Hygroskin' (Menges Achim, Oliver David Krieg and Steffen Reichert). The first, 'Hygroscope', consists of a first attempt to create a metereosensitive architectural element on a medium scale, capable of changing (according to opening and closing mechanisms) based on external environmental variations in humidity (Fig. 8). The second, 'Hygroskin', is the realisation of a meteorosensitive pavilion that opens and closes autonomously in response to external meteorological changes (mainly related to the humidity level of the air) without any kind of mechanical intervention (Fig. 9).

Figure 8:
Hygroscope, ICD (Menges Achim, Steffen Reichert, with Transsolar Climate Engineering GmbH), Centre Pompidou, 2012 [Source: https://www.icd.uni-stuttgart.de/projects/hygroscope-meteorosensitive-morphology/].

Both promote a kind of 'metero-existential architecture', which is achieved through the use of design strategies that do not require mechanical or electronic controls to function (Menges et al., 2015). In particular, these two examples are sensitive to external climatic conditions and are able to change their characteristics (shape, position) to provide better comfort. Furthermore, they are realised as prototypes at different scales, through automated construction methods derived from computational design. In particular, the computational process integrates the ability of the material to physically calculate the shape in the elastic bending process, the structure of the resulting building components, the computational detailing of all joints and the generation of the machine code required for fabrication with a 7-axis industrial robot. Motion operation is fully automated and made possible by the same material that defines the structure of the architectural element, namely wood. Its ability to change its shape in relation to the perceived humidity rate has made it possible to predict, calculate, simulate and implement the spatial transformation of the shading elements, so that they can be opened and closed: in essence, the structure of the material itself is the machine.

Figure 9:
Hygroskin, ICD (Menges Achim, Oliver David Krieg e Steffen Reichert), FRAC Centre Orleans, 2013 [Source: https://www.icd.uni-stuttgart.de/projects/hygroskin-meteorosensitive-pavilion/].

5. CONCLUSIONS

In conclusion, it is believed that the examples shown and the approaches identified provide a broad overview of the way to conceive the relationship between natural elements and architecture, especially adaptive architecture. Indeed, this should be explored in its several facets, involving in different ways the digital component, as a means of interaction between architecture, its users and the external environment. Designing "with nature, for nature" is therefore possible, in an attempt to identify a possible resilient response to the needs of the ecosystem in which we live. Thus, even beyond the use of the most modern sensor technologies (which also constitute an important strand of adaptive and responsive architecture), it is possible to construct systems, buildings and architectural components capable of responding adaptively to external changes, exploiting the performative capacities of the natural elements themselves.

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ORDERS OF MAGNITUDE

Climate Change and Disequilibrium Design

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Climate change, Landscape, Hydrology, Climate Modeling, Acceleration

ABSTRACT
As climate change destabilizes the assumptions built into normative design thinking, there is an opportunity for designers to add climate-scale dynamics to our methods for engaging earth systems. Phenomena that once took millions of years are happening hundreds of thousands of times faster, and this great acceleration emanates its own time and space. This paper challenges the epistemological framing of climate adaptation and presents methods for tracing the magnitude of accelerated climate change, to more directly participate alongside monumental forces whose contours are only just beginning to be understood. Exploring a few energetic regimes (the planetary, the continental, and the regional) through geospatial mathematics gives shape to the strange realism involved in coming into contact with material and energetic variability of changing climate regimes.

1. INTRODUCTION

Our understanding of the climate crisis was borne of a tendency to count. Carbon concentrations, degrees gained, and irreplaceable losses of species: the sixth Great Extinction, ongoing. This process of cataloguing change, paired with the increasingly exact ways that we can measure it, has dilated time. More and more can fit into every second and every square meter, into dense cubes of information; but these archives have increasingly short shelf lives as the dynamic loops between these bits of information get tighter, hotter, and more unstable.

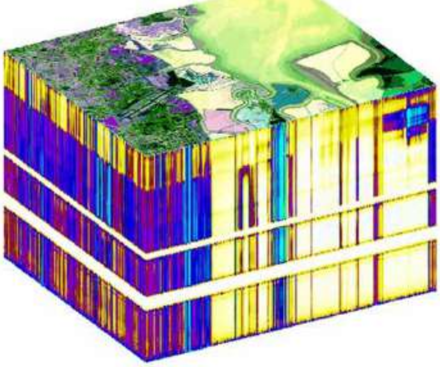


Figure 1:
A representation of a 'data cube;, a dense packet of information that archives landscape change over time (Heney 2020).

These loops move too fast for Baconian torture (Bacon, 1620) to extract timely, coherent intelligence. For example, it is only as of this year that it is possible to say that there is unequivocal evidence that human action has led to current rates of climate change (IPCC, 2021): we are left wondering about the value of statements that seem to come too late. The climate is a difficult thing to capture. But although the exact shape of climate futures remains elusive, we are with certainty at a point where oceans and ice are altered for timescales that range from centuries to millions of years (Masson-Delmotte et al., 2021). We have very few cognitive tools to think about these timescales and the wide range of uncertain futures we face.

In the face of all this uncertainty we are haunted by the specter of stability, but this project is doomed to violent failure (Nicholls et al., 2007; Wong et al., 2014). For all its dystopian grandeur, geoengineering can feel convincing (to some) because it represents a return to simpler mechanics, where actions and reactions are predictable and provable (Buck, 2020). The work presented here offers a counterpoint to the geoengineering approach by discussing a mode of climatic design that takes disequilibrium as a starting point. Rather than trying to slow change, this work is interested in harnessing its power – to ride landscape dynamics hurtling by. The work below starts to sketch rough outlines of the scales and materiality of atmospheric and hydrological energy to take a position about how we can design with climate.

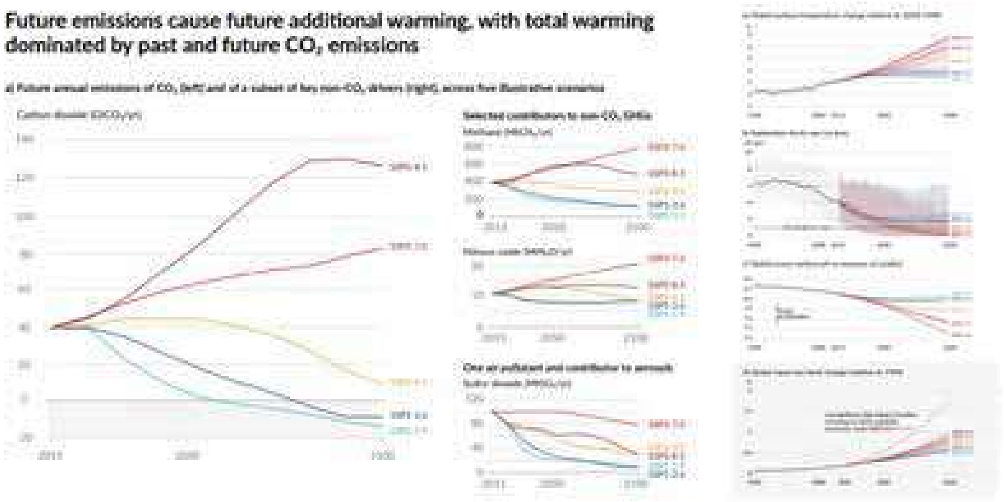


Figure 2:
(top)
Excerpt from IPCC 2021 comparing shared socio-economic pathways and their potential climate trajectories for a range of metrics.

Figure 3:
(bottom)
Von Humboldt's illustration of 'Botanical Geography' demonstrating the relationship between changes in climate and the living organisms a climate supports alongside a photo of geological strata (Colantonio 2009).

2. SPEED AND MODELS

Biomes are shifting poleward about six kilometers every decade (Staudinger 2012). This means forests are drifting across continents, vast swaths of land are getting less water while others are getting far more than they can handle, fish can no longer spawn where they used to, people can't live where they once did. Accounts of the links between lived landscape and climate are old and deep: from 200-year-old maps to million-year-old geologies (Figure 2), there has been a way to read change through layers of information accreted over time.

But intertwined phenomena that were once legible in these accounts and that once took millions of years, are happening hundreds and thousands of times faster now (Ceballos et al., 2020). The theoretical project of dismantling 'nature' as an artifact of human thinking is relatively straightforward in this light. The shape of how and what we know about earth systems are off by orders of magnitude – bucking the mechanical models that give designers and planners best management practices.

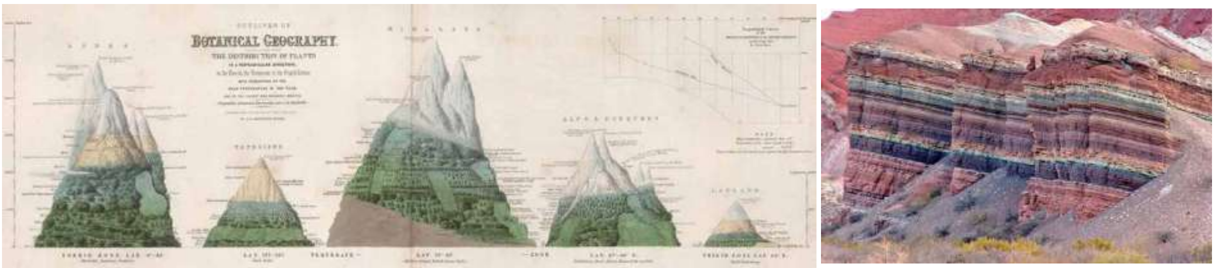
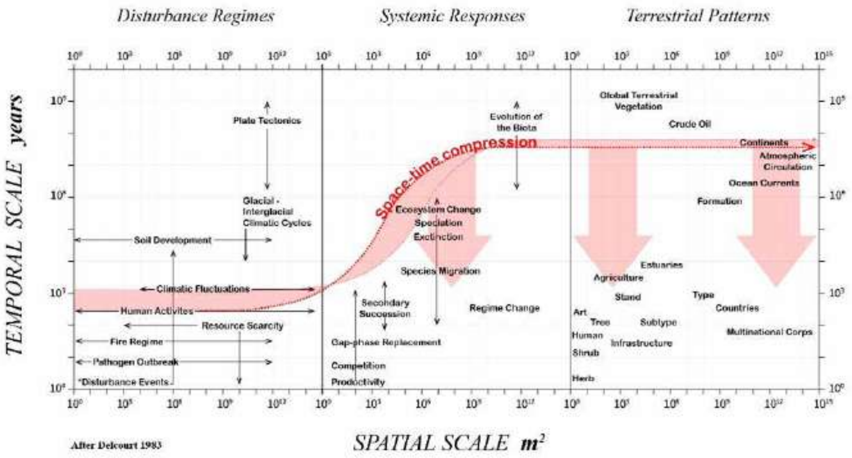


Figure 4:
Diagram of environmental disturbance, response, and terrestrial patterns that keys them to associated temporal and spatial scales. The red line indicates how climate change is significantly altering the rate and scale of these processes.



Models can help to make sense of new forms of environmental change by taking hypotheses and testing them against reality. But they are at once incredibly accurate and incredibly inaccurate. They are always approximations with their own, very particular, scales. Each model is simply one version of reality. Even the roughest, simplest one-dimensional energy balance equation reveals relatively accurate accounts of climate disequilibrium. Solar energy x (1 – Earth's albedo) x π (Earth's radius)2 should balance with outgoing energy, but after accounting for the beneficial greenhouse effect that allows water to take a liquid form, current temperature inputs reveal that about 1 watt per square meter is unaccounted for. At a global scale, this is accurate (IPCC 2021), and this kind of model is a powerful illustration of average global change, but of course this conclusion means very little to any landscape in particular.

Attempts to use our current climate models to predict more granular futures are still plagued by issues of resolution, boundary conditions, parameterization, the representation of physical processes, etc. (Srivastava et al. 2020). Seemingly little technical questions about how a model averages sea level, parameterizes cloud cover, or resolves topography can set off extreme changes in what the future of a city looks like. Below (Figure 5) is an illustration of Bangkok's flood risk before and after improvements to global elevation. A new global elevation dataset revealed that coastal elevations are significantly lower than previously understood across wide areas (Kulp & Strauss 2019). The differences here are extremely significant. In this case, DEM accuracy affects our understanding of millions of people's communities. When it comes to design decisions, margins of error are similarly tight. The devastation of Hurricane Katrina was the culmination of a lot of issues, but we can say that much of its destructive capacity was a matter of 60cm (Titus et al., 2009).

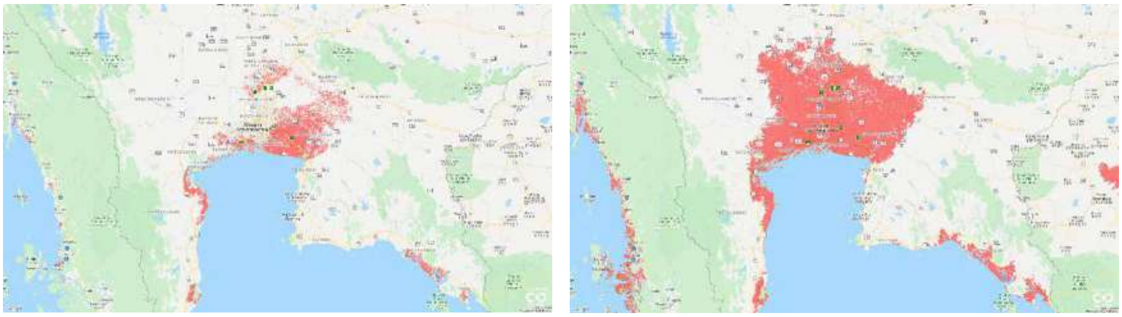


Figure 5:
Comparison of the Bangkok metro region flood risk highlighted in red before and after increased accuracy of coastal DEM (Kulp & Strauss 2019).

Design disciplines can play an important role by mediating these modeled versions of reality and challenging their conclusions; as well as resolving how these huge changes are lived on the ground, and in so doing creating new models for understanding change and contingency. But this requires far more than flat metaphors about collaboration, contingency, or flow. Earth system dynamics are spinning out. When engaging these hulking masses of material energy, specificity is critical. This kind of work needs to be explicit about scales of material and elemental change.

3 ENERGETIC DESIGN

Here we describe how a climatic imaginary can land in the world with some approximations of material reality. These are all extremely broadbrush explorations that push on some of the relationships that climate change is throwing into sharp relief. We are not offering any semblance of prescription. Instead, we are offering a new perspective. This is a first pass at low-hanging fruit: an approachable set of dynamics that explore how terraformation can unlock elemental interactions with climate. This paper walks through three different scales of understanding hydrological dynamics – from the planetary, to the continental, to the regional.

3.1 PLANETARY SCALE
Billions of Years

The sun's energy hits the earth, which rotates on a 23° axis every 24 hours and around the sun every 365 days (Figure 6). The regional differences in how incoming solar energy is distributed across the planet drives atmospheric and oceanic circulation: the tropics gain more energy than the poles, and the transport of heat and coolth across the globe is an attempt to rectify this imbalance. Ocean currents transport energy and precipitation – climate at a large scale, and weather at a smaller one – between the equator and the poles. Currents are created largely by surface winds, tidal action, temperature and salinity gradients, and Earth's rotation. They are interrupted by physical and atmospheric phenomena like banging into continental shelves, breaking on shorelines, etc. Changing currents changes the way heat is distributed. Without them, latitudinal regional differences would be much more extreme.

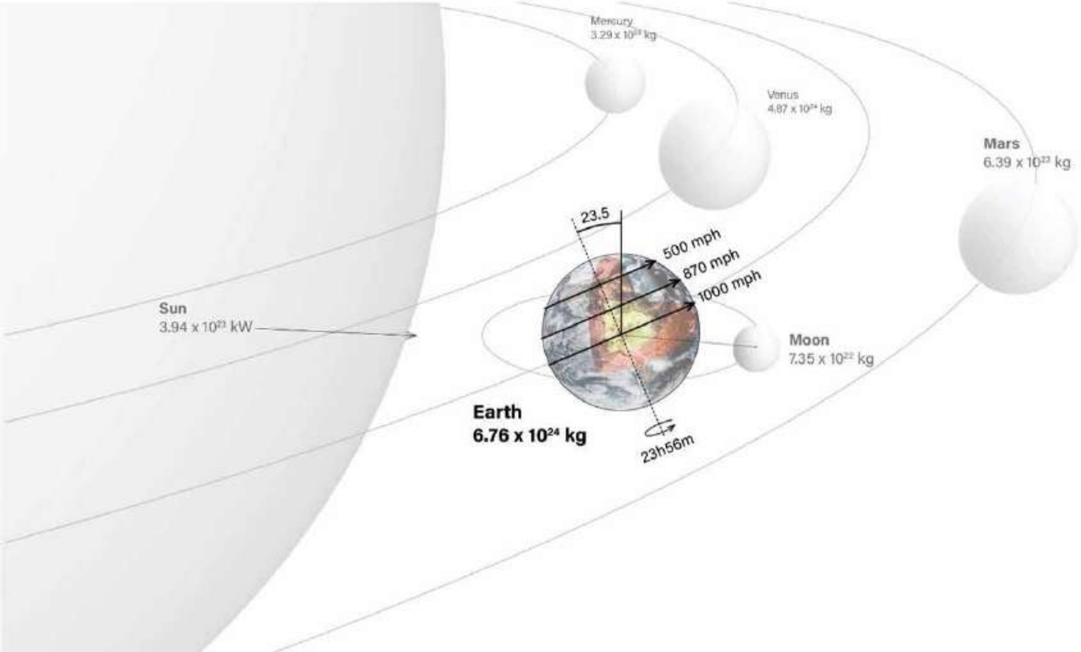


Figure 6:
Planetary angles, speeds, and masses for the first four planets circling the sun.

We enter this scale through a model for geostrophic current velocity, to engage ocean currents. The parameter of interest with relation to planetary change we explore how to change the Coriolis parameter using mass change. The issues of interest that emerge from this method are planetary heat transfer and sea ice protection: adding mass slows the geostrophic component of current velocity and slows heat transfer.

As described in the figures above and below (Figures 7, 8), it would take a little more than the mass of Mars to lengthen Earth's day by 4 hours, which would change ocean currents by 15%. This change would regulate midlatitude and pole climates, but equatorial regions would get much hotter and would very likely face even more extreme weather. The geopolitical implications of climatic design become apparent, regardless of the fact that distributing Mars' mass across Earth's crust would be nearly impossible, and that this type of work would change the world in ways that we don't have the tools to understand. Astronomical forces would be required.

Geostrophic velocity	$u = \frac{gH_B}{fL}\left(1 - \frac{\rho_B}{\rho_A}\right)$
Coriolis parameter	$f = 2\Omega \sin \Phi$
Rotation rate	$\Omega = \frac{2\pi}{T}$
Spherical Moment of Inertia	$I = \frac{2}{5}MR^2$
Rotational Energy	$E_{rot} = \frac{1}{2}I\omega^2$
Earth relationships	$E_{rot} = \frac{1}{2}\left(\frac{2}{5}MR^2\right) \times \left(\frac{2\pi}{T}\right)^2$
Earth conditions	$E_{rot0} = 2.138 \times 10^{29}\,J$ $\Omega_0 = 7.29 \times 10^{-5}\,rad/sec$ $M_0 = 5.98 \times 10^{24}\,kg$ $R_0 = 6.38 \times 10^{6}\,m$ $T_0 = 23h56m4s$
New day length	$T \rightarrow 28h = 100{,}800s$

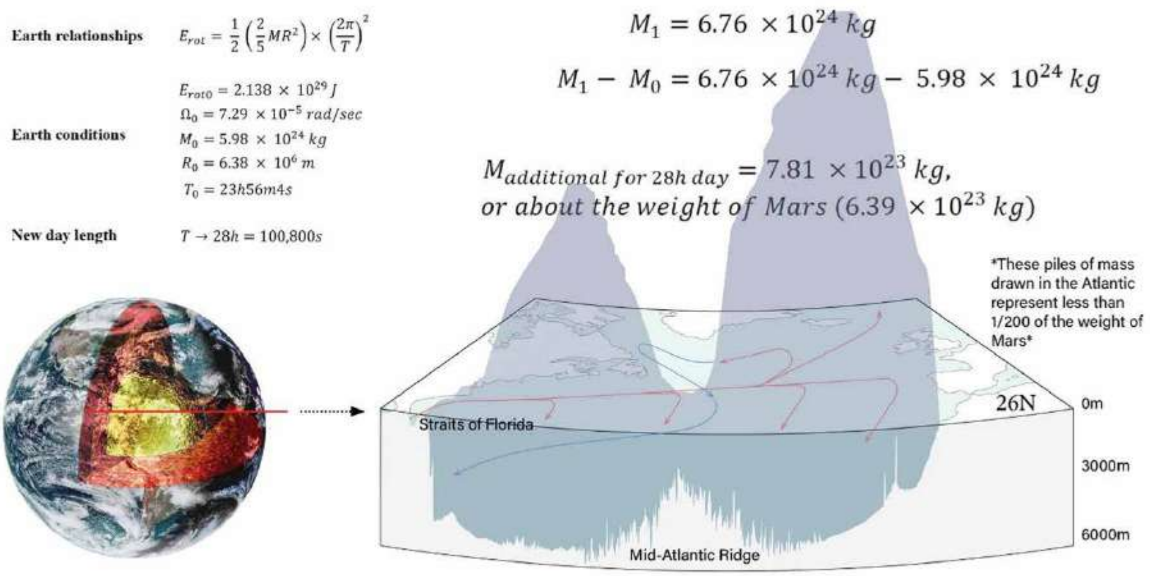
$$2.138 \times 10^{29}\,J = \frac{1}{2}\left(\frac{2}{5}M(6.138 \times 10^{6}\,m)^{2}\right) \times \left(\frac{2\pi}{100{,}800\,s}\right)^{2}$$

$$\frac{5\,(2.138 \times 10^{29}\,J)}{\left(\frac{2\pi}{100{,}800\,s}\right)^{2} \times (6.138 \times 10^{6}\,m)^{2}} = M_1$$

$$M_1 = 6.76 \times 10^{24}\,kg$$

$$M_1 - M_0 = 6.76 \times 10^{24}\,kg - 5.98 \times 10^{24}\,kg$$

$$M_{additional\ for\ 28h\ day} = 7.81 \times 10^{23}\,kg,$$
$$or\ about\ the\ weight\ of\ Mars\ (6.39 \times 10^{23}\,kg)$$



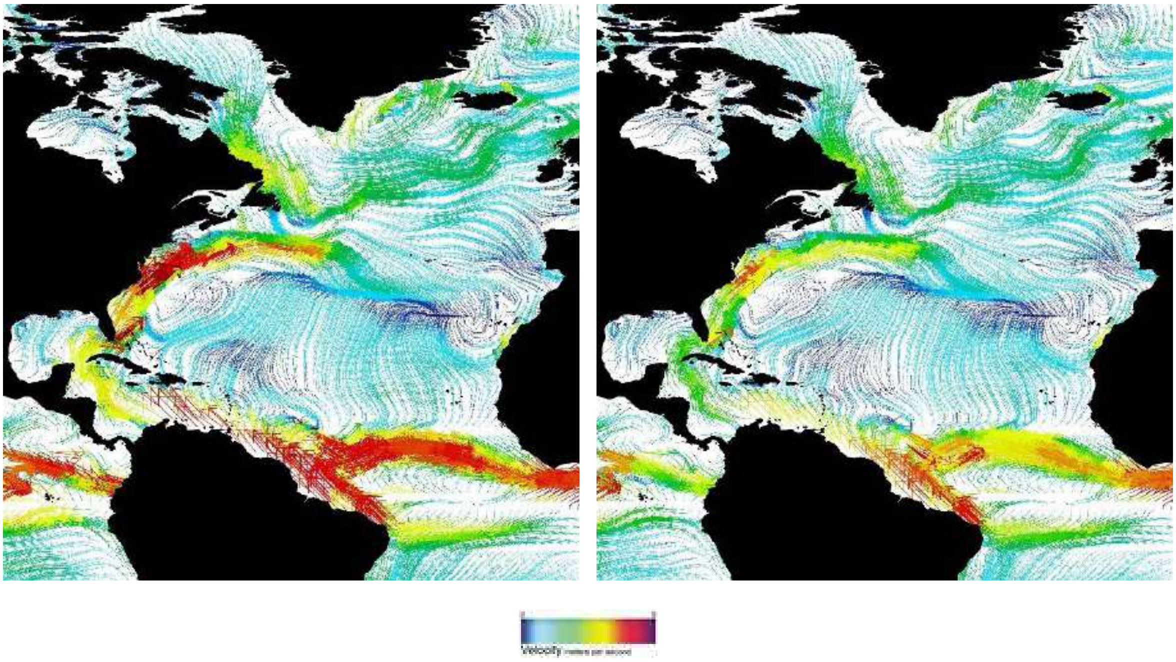


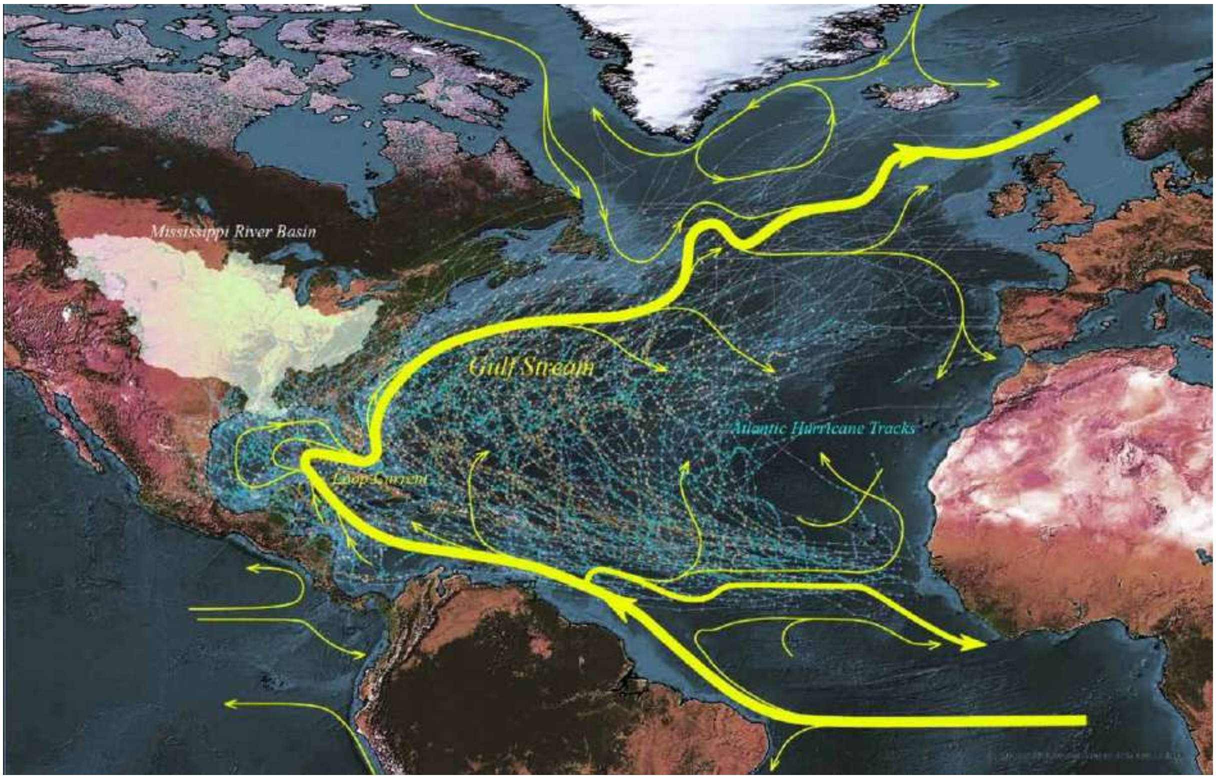
Figure 7:
(top of previous page)
Mathematical formula calculating the required mass to increase the earth's rotational period by 4 hours, and diagrams highlighting the relative scale of that mass to the earth's crust and ocean depth.

Figure 8:
(bottom of previous page)
Maps of Atlantic geostrophic velocity illustrating existing conditions (left) and the resulting reduction in velocity and reduction in oceanic westward intensification that would result from increasing the earth's rotational period (right).

3.2 CONTINENTAL SCALE
Thousands to Millions of Years

The Gulf Stream is a warm ocean current that travels up the east coast of the United States, carrying heat from around the Gulf of Mexico into the North Atlantic. It keeps British and Scandinavian weather mild and adds warmth to the eastern coast of the US. But under human-induced climate change (and given the hypothetical mass shifts explored above), the Gulf Stream is predicted to get weaker. This weakening would mean that less of the Gulf Stream would be able to travel northward toward Northwestern Europe and that more heat would remain in the tropical and subtropical regions of the world. This would be disastrous for billions of people in terms of temperature, sea level, ecology and resource availability, extreme weather. This scale of exploration specifically engages extreme weather, which is projected to increase with global warming with high confidence (IPCC 2021). The Loop Current in the Gulf of Mexico has a particularly strong effect on hurricanes. Deep warm water can create conditions of rapid intensification and can strengthen storm systems (e.g. Hurricanes Camille, Allen, Katrina, Rita).

Some of the ways design combats intense storms in the Loop Current region include changing roof pitch, adjusting building structure, and softening coastal edges. These are passive forms of coping with change. But we are interested in engaging these elements in an active way, and below we show how design techniques like levee breaching can reduce storm intensity. Here, a weather regime is not just as a thing that happens but a thing that can be designed, and that has been designed over centuries. Starting in the early 18th century, settlers built levees to control the Mississippi River; "entering into a complex geoclimatic relationship with over 41% of the United States" (Madrigal, 2011). This geoclimatic relationship can be reimagined to new ends. Below, we take on the question of undamming all the rivers in Mississippi River Basin, creating much larger flows of fresh and cold water and using continental scale water flows to (1) change the density gradient of the Gulf Stream and (2) alter the synoptic patterns of the oceanic region: resuscitating the river to shield this part of the hemisphere from the effects of climate change in the subtropics.



Geostrophic velocity	$u = \frac{gH_B}{fL}\left(1 - \frac{\rho_B}{\rho_A}\right)$
Current Mississippi Discharge Rate	$Q_0 = 16{,}791\frac{m^3}{s}$ or $5.29 \times 10^{11}\frac{m^3}{yr}$
Altered Mississippi Discharge Rate	$Q_h = 3{,}224{,}535\ km^2$ basin area $\times 1.65m$ rain annually $= 5.31 \times 10^{12}\frac{m^3}{yr}$
Atlantic Density	$Temp_{Atlantic} = 30.3°\ C$ $Salinity_{Atlantic} = 36\ ppt$ $\rho_{Atlantic} = 1022.38\ \frac{kg}{m^3}$
Current Gulf Density	$Temp_{Gulf0} = 29°\ C$ $Salinity_{Gulf0} = 35\ ppt$ $\rho_{Gulf0} = 1022.07\ \frac{kg}{m^3}$
Altered Gulf Density *Densities calculated using wkcgroup seawater density calculator	$Temp_{Gulf1} = 27°\ C$ $Salinity_{Gulf1} = 25\ ppt$ $\rho_{Gulf1} = 1015.21\ \frac{kg}{m^3}$

Geostrophic velocity in Current Gulf of Mexico

$$u_0 = \frac{9.81\frac{m}{s^2} \times 1524\ m}{(6.16 \times 10^{-5}\ s^{-1}) \times (3.5 \times 10^5\ m)} \times \left(1 - \frac{1022.07\ \frac{kg}{m^3}}{1022.38\ \frac{kg}{m^3}}\right)$$

$$u_0 = 0.21\frac{m}{s}$$

Geostrophic velocity in Altered Gulf of Mexico

$$u_1 = \frac{9.81\frac{m}{s^2} \times 1524\ m}{(6.16 \times 10^{-5}\ s^{-1}) \times (3.5 \times 10^5\ m)} \times \left(1 - \frac{1015.21\ \frac{kg}{m^3}}{1022.38\ \frac{kg}{m^3}}\right)$$

$$u_1 = 4.86\frac{m}{s}$$

$$\boxed{u_1 >> u_0}$$

Figure 9:
Illustration of the relationship between the Gulf Stream, the Mississippi River Basin, and historic Atlantic Hurricane courses.

Figure 10:
Calculating momentary geostrophic velocity within the Atlantic Ocean that would result from undiverting the entirety of the Mississippi River Basin and discharging it into the Gulf of Mexico.

Undamming the Mississippi River Basin would lead to less intense storms and dramatically faster currents at the instant of change, as shown above (these would dampen over time). Currents grow to an impossible 4.86 m/s in the Loop, with the direct effects on current dropping off around 2000 km. But this is another massive change, with aforementioned effects on local weather, as well as on continental-scale settlement, agriculture, and economy.

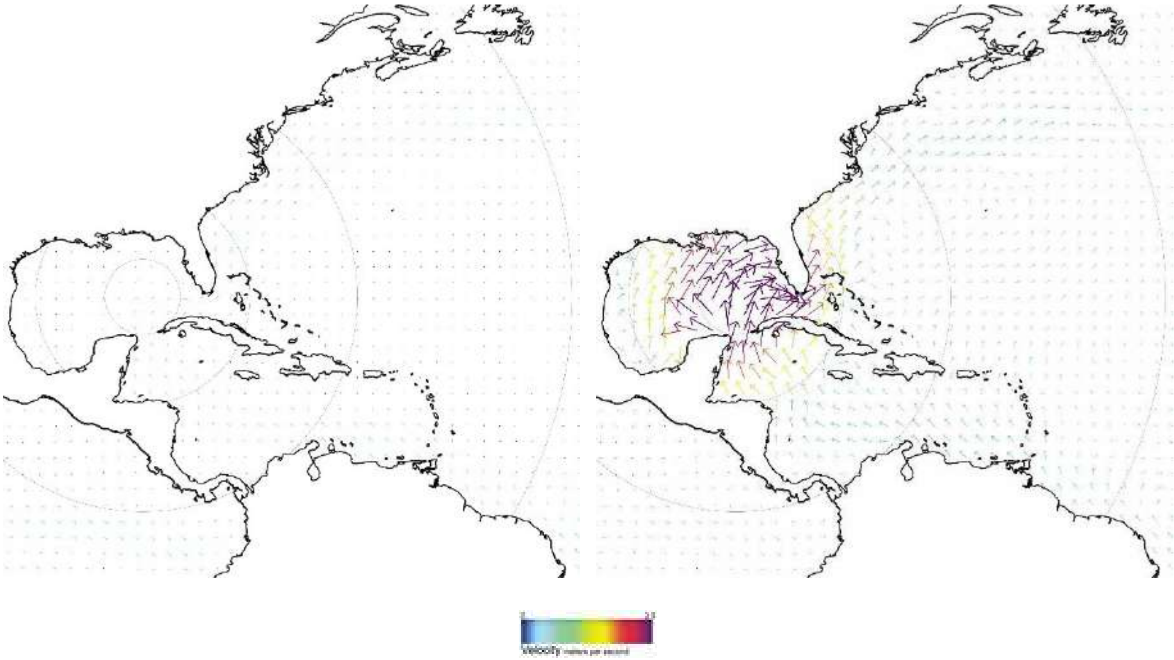


Figure11:
Map of geostrophic velocity in the Gulf of Mexico both existing (left) and at the moment of discharging the fresh waters of the Mississippi into the system (right).

3.2 CONTINENTAL SCALE
Thousands to Millions of Years

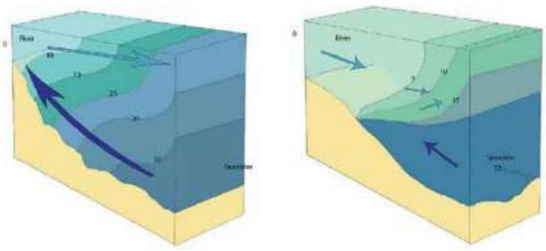
In geologic time, which is measured on scales of hundreds of thousands to millions of years, estuaries are fleeting features of the landscape. Most of them are less than 10,000 years old . Often the climate issues we face become too human too quickly; leading to small fixes like decreasing erosion on a small stretch of sensitive land. But it is possible to design in a way that engages climatic effects with these much wider frames of reference both geologically, and hydrologically: to design in a way that is more sensitive, more resonant, and much longer-term. This section takes on the Chesapeake Bay, which is a larger estuary on the east coast of the US. As a system open to both rivers and the ocean, salt and sediment travel in and out of it in flows governed by its contributing rivers and largely, tidal patterns (Figure 13).

The climate issues at hand at this scale are tidal amplification and salinization, which are exacerbated by sea level rise associated with climate change. These phenomena are exacerbated by irrigation, land use, and all these messy and unwieldy things that together control regional ecologies, exchanges, and energy. The pathway into these climate issues is the boundary between salt and freshwater (Figure 13), explored in two rivers: the James and the York (Figure 14). The design media are flow density and speed. Tstream scale requires more explicit tuning of material transfer rates, as seen below.

At the regional scale, it is possible to be much more specific – we see here two adjacent rivers that can be designed in completely different

Figure 12:
(top)
Map of the Chesapeake Bay region topobathy, with shipping routes and urban regions highlighted in red (Davis, Dawkins, and Putalik 2021).

Figure 13:
(bottom)
Diagrams illustrating fresh and seawater exchange in a slightly stratified estuary (left) and a salt wedge estuary (right). Exchange rates are governed by climatic forces and estuarine geometry. (Webb 2019).



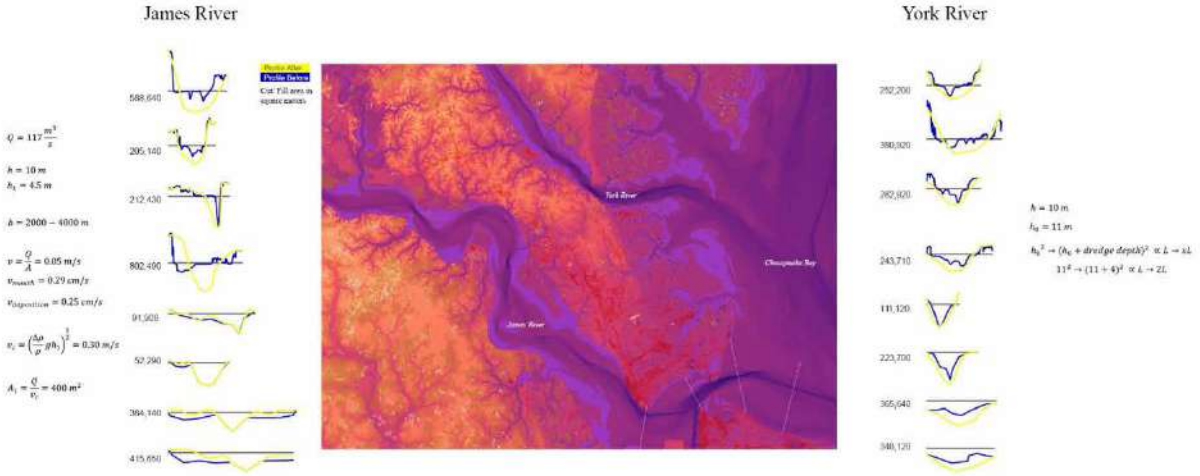


Figure 14:
Map of the James and York Rivers, accompanied by channel sections before and after manipulation, and mathematical descriptions of the effects these changes would have on hydrological dynamics.

ways, to different effect, in response to the exact same climatic forces. Channel manipulation induces freshwater acceleration in the James, which increases stratification and protects upland agriculture from salinization; and tidal flushing is increased in the James to align with emerging aquaculture industry. This kind of work has a precedent: several hundred million cubic meters of material is dredged from US ports, harbors, and waterways every year. The effects of the volumes explored here, ~10 billion cubic meters per river, do not have as many loose ends. Unlike the planetary or continental scales, regional climate design is within reach (fairly distant reach) of existing practices.

4 CONCLUSIONS

Terraformation is not new: anthropogenic spaces have overtaken the wilds of the Earth, and the forces of urbanization and capital have organized environmental time and matter in ways that will reverberate for millions of years. Here we explored terraformation as an intentional tool in service of climate adaptation, and as a provocation to harness climatic energy rather than control it.

From these thought experiments, we see the magnitude of climate change come to life in tangible, material, space and time. Climate dynamics become productive design media. The simple mathematical models we describe above act as translators for conversing with the elements, and in that communication exists the possibility of influencing how immense forces pattern the ground. This process demonstrates its limits and assumptions, as well as the uncertainty and impracticality involved in taking next steps. But despite these hurdles, there is great value in bringing design thinking into contact with the fuzzy scales of elemental power careening around the planet.

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ELECTRICAL ECOLOGIES

Architecting neural ecologies, from the cerebral to the planetary.

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KEYWORDS
Neurotechnology, Biocomputation, Ecology, Planetary-scale Computation, Artificiality

ABSTRACT
The current technosphere demands a shift in design theory comprehension and consequently action moving forward across the design discourse from the atom to the territory. More specifically, advancements in neurotechnology, planetary-scale sensing (Bo Wu et al 2019), big data, territorial surveillance, and artificial intelligence can be drivers to a new design discourse amidst ecological challenges currently at play.
This abstract introduces Electrical Ecologies as a method of both, comprehending ecosystems by ontologically flattening them to their "electrical layer", and operating at that layer due to its quantitative and workable nature. Given the planet's sensing and processing capabilities, Electrical Ecologies aims at conceptualizing a framework for closing the loop: sensing, processing, and automated action, at the scale of the planet, hence a planetary-scale nervous system.
As the research examines the topics mentioned above, it dwells on the IoN - Internet of Neurons- as the next step within the internet's milestones, allowing simultaneous bidirectional communication between brains and the web.
Seamless communication between both worlds, while reframing the natural and artificial lays the groundwork for a paradigm shift across design disciplines - spanning the spectrum from the abstract to the phenomenological. This abstract concludes by tackling the architectural and urban scale on both theoretical and prototyping levels.

1. THE PRESENT-FUTURE TECHNOSPHERE

From consumer-grade, EEG sensing -Electroencephalography - wearables to neural dust (Warneke, B et. al 2001), urban surveillance cameras to territorial remote sensing, the current status of technology with advancements in science within the fields mentioned, is fertile soil for exploring alternative methods to dealing with current pressing challenges from a design standpoint. Challenges at the scale of the planet require action at the same magnitude, and therefore, the research operates across scales, maintaining a planetary-scale overhead.

Optimally, this work aims at providing a model understanding of the context, through conceptualizing a planetary-scale nervous system through the device of Electrical Ecologies while investigating methods to designing these ecologies, at the electrical layer [neural ecologies]. The Electrical in this context is a manner of functionally and operationally flattening all electrical objects [from charged matter to human brains to megagrids] to define a new design agenda aligned with an understanding of intelligence as a neural effect of Spatio-temporal material assemblages. The terms Electrical Ecologies (Safieddine F. 2019) and Planetary-scale nervous system will be expanded on in the following parts.

2. ELECTRICAL ECOLOGIES

Electrical Ecologies is Black Ecologies comprehended as to where sub-ecologies fall on the charged-to-neural spectrum being functionally hackable through manipulating the electrical layer. It is a form of putting Black Ecologies into action.

Geology is a precondition for Biology, and in the primary linear model, when biology emerges, it creates technology whereafter the sequence becomes nonlinear, it consumes all the above generating new geologies, biologies, and intelligence simultaneously (Parker, E. et al, 2014). The electrical is conceived as an advanced state of the charged, and the neural as an advanced state of the electrical. Hence recognizing that all neural-ecologies are electrical ecologies, while not all electrical ecologies are neural ecologies, yet. (Malmivuo J & Plonsey R, 1995)

The decentralized and increasingly distributed state of intelligences and electrical ecologies across the planet has been crucial in giving the planet senses of relatively high resolution, networks of mobile matter, and a processing capacity necessary for conceiving both. As we achieve a rather complex state of sentient planetarity, that is the planet is equipped with a sensory layer at its scale. In other words, data-to-information transformation machines happen through manipulating the geological layer by all other actors, from biology, technology, and geology itself. And due to the potentiality the current landscape holds, the paper presents a framework for augmenting the sensing -and processing- layer with an automation layer, similarly at the scale of the planet, and therefore the argument for a planetary scale nervous system.

A system at that scale does not imply a center, but rather a coexistence of multiple centralities that co-occur and change constantly at all scales.

2.1 A PLANETARY-SCALE NERVOUS SYSTEM

A planetary-scale nervous system - or automation at the scale of the planet - is presented as a necessary perceptual set for moving forward with an ecologically operational model and as an emergent model of planetary-scale computation (Bratton B. 2021)

It is introduced as a framework of distributed networks, a hybrid amalgam of mineral and biological intelligence with processing capacity capable of responding to a perceived state of planetary condition.

For example, what if forests of the world had automated fire extinguishers that function to counter any fire without human intervention? given all the sensing capacities present, and the processing capacity.

As a foundation, the work looks at intelligence as an emergent phenomenon of particular spatial configurations of matter. While intelligence is at stake, the paper is interested in framing ecosystems - ecologies- within their relative position on the spectrum proposed, from charged matter to neural assemblages; where charged and neural bound the electrical spectrum.

In a word, automation at that scale is called in a two-fold manner, first, to test the validity and potentiality of such a framework given the technologies, geographies, and biopolitics currently at stake, and second, to construct a viable agenda for design across scales; redesigning from the human body to the geological territory.

2.2 THE INTERNET OF NEURONS AND A NEW DESIGN AGENDA

From Arpanet to the Internet of Things, accompanied by advancements in brain-computer interfaces, biocomputation, and artificial intelligence, the Internet of Neurons - IoN- (Sempreboni, D et al 2021) seems to be the next chapter on the internet timeline. Hence a seamless bidirectional communication between our brains and the internet opening a new era of interaction with the physical and digital worlds.

While the second Copernican turn has not sufficiently changed the design discourse yet, the proposal finds its raison d'être, a pressing need for a design agenda grounded in a projective entanglement with the present elephants-in-the-room[to be].

Specifically, bio-computation, artificial [designable] intelligence, data at scale, and the proposed IoN. With this at hand, we stand upon unprecedented access to designing the neural [both mineral and biological]. Complementary to the material component -and operating at the electrical layer- interactions with neural ecologies, or other sub-ecologies, are rather read-write mechanisms that allow not only data mining from electrically active neural environments but also writing back, by changing physical features such as the spatial layout, or wiring. Hence an approach that performs on the spatial distributions of material assembles to construct intelligence.

In parallel, the capacity to bidirectionally communicate between our brains and the web opens doors to a radical shift in design, at the core, moving from a discourse that serves the user, i.e. designing for the user, to a "designing the user" directly.

3. AT THE ARCHITECTURAL AND URBAN SCALE

Grounded in disciplinary questions, and the present-future technosphere, the research is interested in designing neural ecologies - mineral and biological, organic and non-organic assemblages [from silicon assemblages to organoids]. Accordingly, shifts in the material medium in architecture affect the discourse and thus the research explores micro ecologies of a near-future where brains become grounds for design, at the electrical layer specifically.

Along these lines, the manner the mentioned assets are recruited is pivotal to produce a viable framework towards developing urbanscapes, architecture, and environments that surpass the current format of at best, direct automation, to a more subtle and complex interaction scheme which requires a new kind of agency.

While architecture can be understood as a medium that affects, or is perceived as an experience and therefore changes the user, a shift towards directly manipulating brain circuitry to produce interiority as architecture is of interest here. Intelligent spatial behavior based on the unconscious is an example of how brain-computer interfaces can change how we design.

At the theoretical basis, we reutilize two terms that were coined in the second half of the last century tackling emerging subjects that are slightly modified in the context of Electrical Ecologies.

3. 1 NEURAL EXAPTATION

The concept put forward by paleontologists Elisabeth Vrba and Stephen Gould in 1982, "Exaptation" (Gould, S et al, 1982) is described by them as "a counterpart to the more familiar concept of adaptation." Within this paper's context, exaptation is understood as the process by which features acquire functions for which they were not originally adapted or selected.

A function that was not originally set implies an expected outcome of several functions that haven't been exactly met. Evolutionary systems acquire functionality at a later stage of development, the sequence is gene - structure-function, which implies that function is what the process concludes to. So what is really meant here is a shift in the function or trait during evolution within the two specified circumstances; the first is when things are co-opted for a new use after being evolved to a particular function [an adaptation] or the second case applies to characters whose evolutionary origin can not be specified and are thus co-opted for a new use.

Neural Exaptation within EE requires a reappropriation or overtaking of objects at any entry scale to arrive at a neural object. Neural exaptation is the neuroticization of electric objects. In this situation, Neural exaptation is the process in which the environment, as referred to in the affordance section, is enriched by increasing all system layers' capacity.

3.2 NEURAL AFFORDANCE

Coined by psychologist James J. Gibson, affordance in this context is "what the environment offers the individual". Being part of his 1966 book: The Senses Considered as Perceptual Systems, the term is resurrected in his 1979 book, The Ecological Approach to Visual Perception: "The verb to afford is found in the dictionary, the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment." (Gibson, 1979, p. 127)

Of interest to EE, two aspects of the term; the complementarity of animal and environment and by that forming a closed circle, and the second is the potentiality within any environment, as it is not merely what it gives, or offers, but all the other possibilities that could emerge at other instances. The likelihood of probable phenomena becomes a more decisive aspect, which would be suggestive but not definitive. The environment is not nature, the environment is everything else, i.e. the environment is relative to each thing, in such a way that every other thing becomes the environment. Environments offer stimuli that are selectively sucked in and processed to make sense of. Affordance is a flexible and dynamic term that so far seems necessary for our brains to form and function.

Neural or Electrical affordance then is what becomes the environment within the electrical layer. The more objects involved, the bigger the environment, as all which is not the object, become the environment to that object.

3.2.1 NEURAL INTERIORITY

Intelligences, as mentioned before is a plural term, that reflects the ontological variability of various forms of intelligence; biological and mineral. Transitioning from the larger scale to the scale of the urban or the architectural, the agency of mineral intelligence is expanding the discourse, and informing design questions is vital. While it is trivial to ask if AI algorithms can produce 3-dimensional objects, it is a more subtle question to pose, whether creative AI algorithms are capable of producing interiority; the condition created by enclosures, contrasted by the perception of the subject.

In an attempt to test that, spatial ecologies and spatial intelligence surfaces, as a possibility of creating spatial assemblages - using machine intelligence- that are capable of expressing a complexity of assemblage at the level of intelligence.

Spatial AI Ecologies is an attempt to create an ecology of ai-generated objects, such as the enclosure, the population, spatial sound, and digital material. These spatial ecologies are emergent of machine intelligence and thrive in the same environment.

Figure 0:
Spatial AI Ecologies - Still shot showing the ai generated form, digital material, mineral artifacts,avatars, and artificial flora.

4. BRAIN-SPACE

Understanding 'Ecology' as the product of a spatiotemporal distribution and interaction among actors within an ecosystem sets the bedrock for the discourse behind the ideas that will follow.

Rewriting a simplistic historical timeline of architecture based on the medium boils down to the progression from designing for bricks [physical building directly] to designing for paper, to designing for indexical systems (Scherr, R. 1991), and finally to screens and other visual interfaces. Next to this lineage, comes the challenge of designing for immediate biological interfaces such as neural implants. How does our cognitive and perceptual system, or neural implants as a new design medium affect the discourse?

Deploying read-write neurotechnology in the framework mentioned allows the built environment to ‘know who we are’. In other words, buildings will perceive and interact with us given access to our brain data, rather than sensing us as a mass. This is possible through physio-neural data pattern recognition while conceiving a new Internet of Things [IoT], the Internet of Neurons [IoN]. In a word, users still navigate spaces with a lack of bidirectional interaction; understanding the built environment as part of an ecology, as an element that can acquire intelligence - in that case, spatial intelligence- creates a new way of comprehending and interacting with the environments around us.

Figure 1:
(top of next page)
BrainSpace Interface visualization of data collection and visualization.

Figure 2:
(bottom of next page)
BrainSpace Apparatus Sensors .

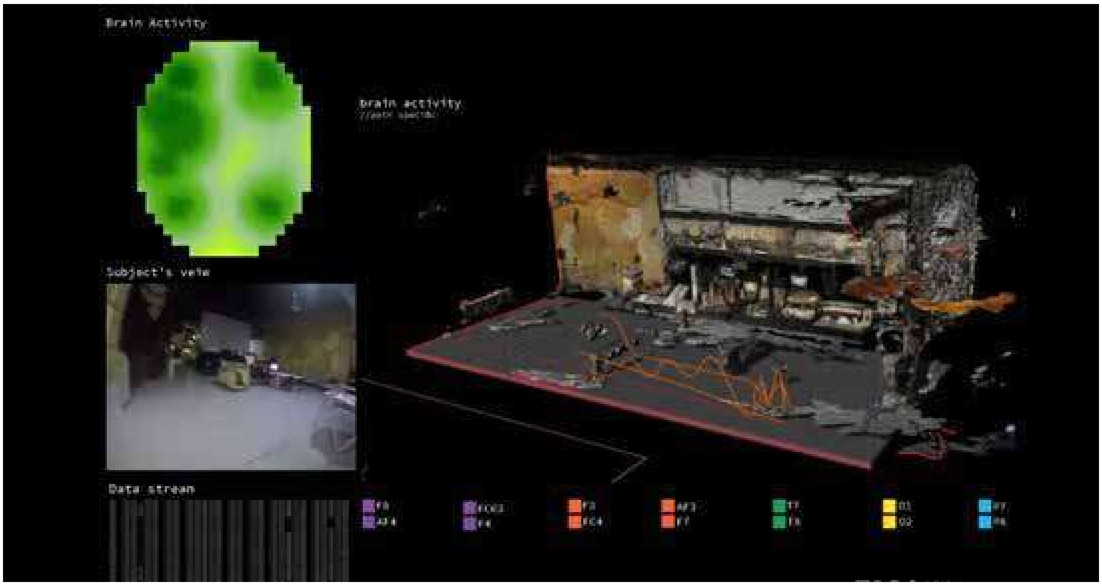
4.1 SPATIAL RESPONSIVE BEHAVIOR BASED UPON THE USERS’ UNCONSCIOUS

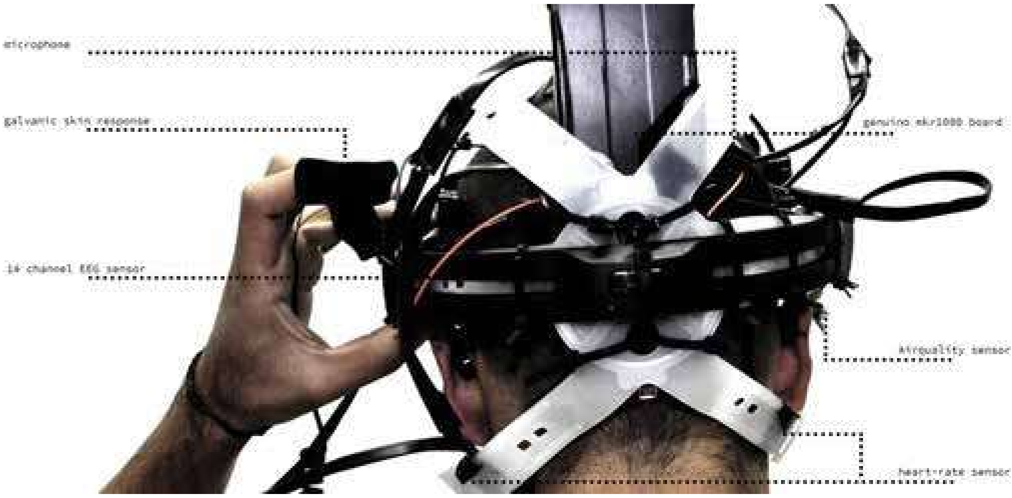
The intelligent responsive behavior of architectural spaces is its affordance to a user. That is achieved by equipping architectures with an extra layer of complexity at the electrical layer, producing neural ecologies. Human brains are introduced as a fundamental of these ecologies of the user, space, and context. The interaction is based on quantifying perception and finding key correlations and causations in relation to architectural features and our experience.

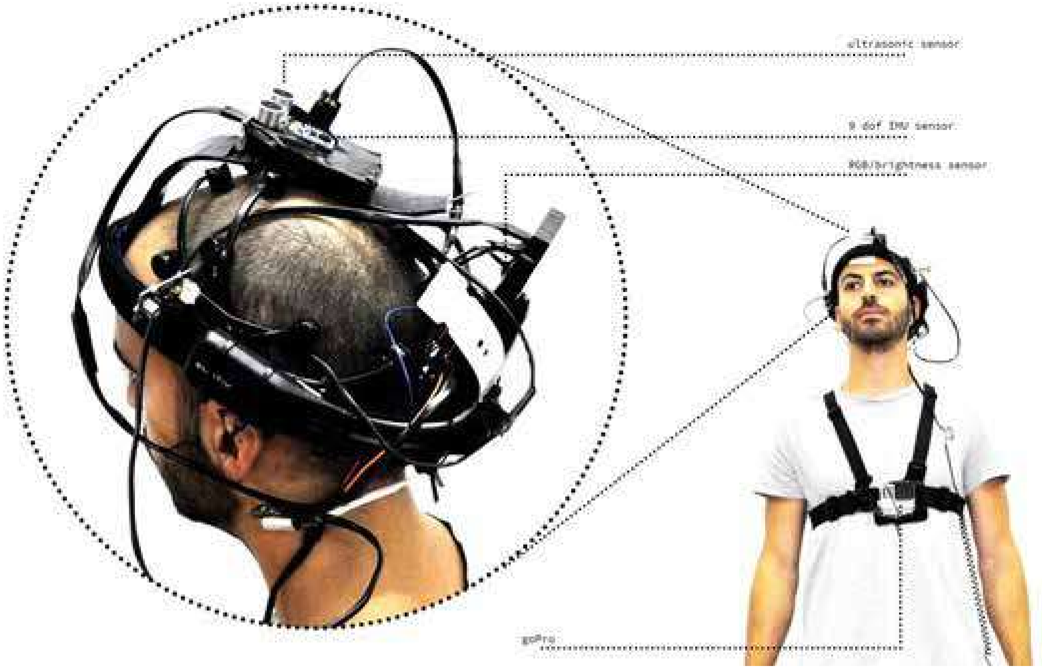
On the other hand, analyzing humans and spaces simultaneously is foundational to how we design and experience space. Therefore, a wearable prototype will be presented as a tool for achieving an ecologically viable model, where both spaces and brains operate at an equal footprint.

The prototype is the first step into simultaneously mapping, visualizing, and correlating spatial and biological quantified features, aimed at finding patterns that can drive responsiveness of the ecosystem. Operating at both ends, the space and the user, the apparatus collects data through sensors shown in Figure 1.

This research tool quantifies space, through measurable features such as the ceiling height, formal outlines, auditory noise, temperature, humidity, and dominant color. And in parallel, it mines data from the person such as head inclination, the electrical activity of the brain [EEG data], galvanic skin response, and heart rate. Figure 2


Brain Activity
brain activity
Subject's veiw
Data stream


microphone
galvanic skin response
genuino mkr1000 board
14 channel EEG sensor
Airquality sensor
heart-rate sensor

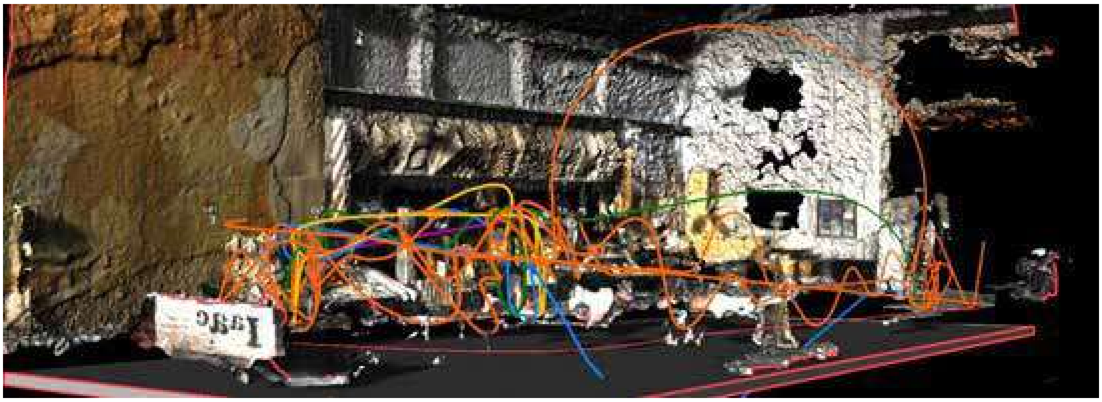

ultrasonic sensor
9 dof IMU sensor
RGB/brightness sensor
goPro

4.2 INTERNALIZING THE PROCESS

With this data at hand, the methodology proposes internalizing the process, thus 3d scanning the environment, and reconstructing a multi-dimensional visualization software capable of mapping the data collected at once.

As demonstrated in the images below, the interface displays a brain activity heatmap, a stream of the person's camera view, and a 3d color-coded mapping of the mental states along the person's trajectory in space. Figure 3

Figure 3:
Space and Brain activity depicted in an internalized digital interface.



5. FINDINGS AND CONCLUSIONS

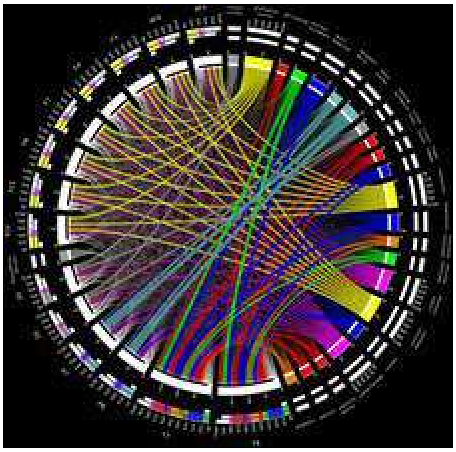
By simultaneously visualizing both quantified space and quantified user, the correlation map demonstrates a strong correspondence between metrics from both actors in the ecosystem. Figure 4. Consequently, correlations found are communicated back to the space, and therefore, a spatial responsive behavior is stimulated based on pattern recognition within biometric data measured from the user.

Electrical Ecologies is the lens and discourse through which a new trans-scalar, operational method of comprehension and action is realized. Through that, the research demonstrates the potential and the opportunity the current technosphere holds for a shift in the design discourse, in the shadow of advances in planetary-scale computation, neurotechnology, and synthetic intelligence.

The work presents a theoretical foundation for a new discourse through concepts necessary for navigating such a space. Moreover, the research proposes a framework for a viable planetary-scale nervous system, given the current sensing and processing capabilities the planet has. Therefore, aiming at transforming objects, users, and ecologies to neural ecologies, i.e. reconfiguring ecologies create intelligence.

At the architectural scale, a radical shift is demonstrated, through a first step prototype, that has its end game a transition away from anthropocentric architectural design to an ecological one. Breakthroughs such as the neural dust presented, make it possible to rethink the brain, as the new medium of design, where it becomes a hackable object, in a read-write communication system between the user-space-context ecology.

Figure 4:
Correlational mapping between spatial factors and EEG channels.



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BUILD

Within the "Build" Section a selection of research papers seek to answer to questions such as:

How can digital fabrication strategies and techniques be used to enhance the design process and final output?

How can nature be (re)integrated into the built environment?

How can new bio-inspired planning paradigms change the way in which we design?

DESIGN & BUILD

BUILD

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POSTERS

CFD DESIGN SOLUTION IN DRAINAGE OF YANGON, MYANMAR

Drainage Upgrade

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KEYWORDS
Computational Fluid Design, Yangon, Drainage, Obstacle

ABSTRACT
This research aims to explore the new methodologies and possibilities of designing with nature. It explores how to utilize computational fluid dynamics in urban redevelopment of infrastructure in Yangon, Myanmar. The projects mainly focus on the site-specificity, incremental upgrades, modularity and low cost, efficient design.
The following project based on the town redeveloping research by Japan International Cooperation Agency (JICA). The design process is adaptable, guided by real life experimentation, hyper-specific approach and the analysis of reappropriation by the people.

1. INTRODUCTION

Yangon is a city that is facing difficulties in urban infrastructure development in terms of water supply, sewerage, drainage, electricity and transportation systems. Under the "Project for the Strategic Urban Development Plan of the Greater Yangon (2013-Japan International Cooperation Agency (JICA) Urban Development Plan)", several planning solutions and urban updates have been researched and are currently being developed (JICA, 2017). Over 2300 tons of waste from 5 million people is disposed of in the drainage system of Yangon each day (Aung, 2018). Moreover, because of erosion during the rainy season and the lack of proper retaining walls along the drains, sediments deposit themselves at the bottom and clog the drain. This poses a great threat to the sanitation of the city, creates flooding, spreads mosquito-borne diseases, and more. The purpose of this research is to design an obstacle that could naturally concentrate the collection of the sediments and waste into specific target areas along the drainage to allow for cheaper and more effective maintenance by the city municipality. By studying the behavior of water when hitting obstacles, we can start to find patterns within the turbulence. Fluid dynamics becomes a tool for design to control the recirculation of water after hitting an obstacle to partially control the velocity of the fluid without affecting the whole. This effect locally reduces the speed of the particles that we are trying to capture and gravity plays its part. This proposal contains the possibility of to scale up the design to an urban level, it is a non-site-specific solution to a site-specific problem.

In Mandalay, during my visit to the drainage prefabrication factory (figure 1.1), I witnessed the construction of modular concrete elements that are being used all around the drainage system to reduce the sedimentation rate. On the other hand, sedimentation problems in Yangon have been resolved with a band-aid solution such as collecting waste along the entire length of the public infrastructure; this isn't sustainable in the future as it is very much labor-intensive.linn aung

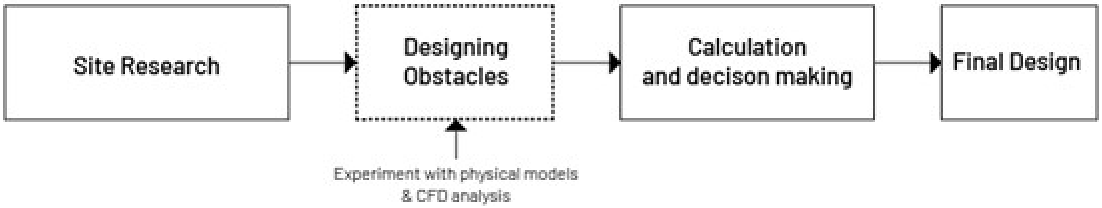
In recent years, there seems to be a more conventional and international definition to the word 'sustainability'. In South East Asia, it can be labelled as "Singaporization" amongst others. Like many other developing countries, Myanmar has been struggling to find its own interpretation. Along with the unique urban fabric and identities of Yangon, the solution to this sedimentation of drainage problems allows me to explore and experiment with designs in this research.

Figure 1.1:
(top)
Drainage Prefabrication Factory (Mandalay).

Figure 1.2:
(bottom)
Design Process.

1.2 OBJECTIVE

The following research project essentially focuses on the implementation of incremental upgrades in different locations of urban scenarios in Yangon. The design process is based on collecting intangible data, utilizing and adapting with the existing nature.
With the aid of computational tools, there are many possibilities of nature-based design solutions that can be explored along with the informalities, spontaneity, and unpredictability of Yangon.
The majority of the development projects in the city seem to avoid considering the inherent aspects of a busy city life-grand towers surrounded with well-manicured landscaping and wide-open concrete plaza.
From the specific site of the drainage, there needs to be a full understanding of how the sediment deposition occurs within the flow of the water. To prevent that, I aimed to build a system of obstacles that reduce the velocity of water flow and let the sediment be deposited in a specific area to collect. The design process is mainly based on the in-depth research, experiments and computational analysis.



2. SECTIONS, SUB-SECTIONS, CITATIONS, TABLES AND FIGURES

2.1 THE SITE

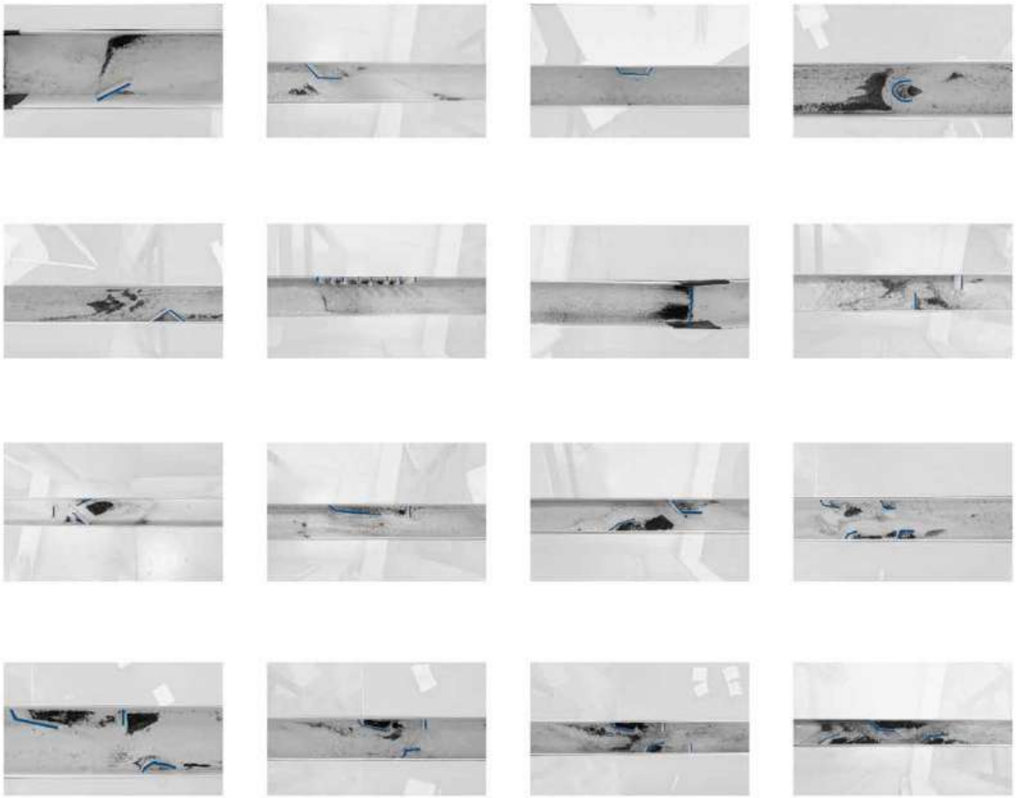
The pilot-project is located at the borderline between Alone Township and Kyi-Myin-Daing Township of Yangon. This piece of infrastructure was built in the colonial times in Myanmar, it acts as a line drawn to divide different parts of the city; this choice of limited designation emphasizes the importance that colonial construction can have in shaping the city. It shows the importance as an infrastructure of the city both physically and functionally. The major problem of the drainage system in Yangon is its maintenance. Sediments slowly accumulate and clog water flow. Consequently, due to the lack of proper design solutions and the rise of impervious interfaces due to rapid urbanization, the city has been facing stormwater management issues for years. The majority of the drainage seems to be built from the time of the British colony and since then, no other upgrades or redevelopment programs have been actively put into place. There has only been a temporary solution by repairing to keep its tattered mechanisms running according to the latest studies (Khant, 2017).

Figure 3.1:
1:10 Scale Model Experiment.

2.2 THE MODEL EXPERMENTATION AND FINDINGS

The experimentation phase of the research was conducted through an actual 1:10 scale miniature model, experimenting real-life the effects that obstacle and turbulence can have on sediment deposition. In this process, 16 different variations of obstacles were experimented with.

Then, allowing the water mixed with sediments flowing inside the model to see how water flow reacts to each obstacle design. The experiment resulted in different findings and results.



2.3 THE CFD WORKFLOW, FINDINGS AND VALIDATION

Using the 16 candidate obstacles from the above experimentation, I proceeded to the more theoretical part of the research by using CFD tools.

Figure 3.1:
(top)
Top View of Results from Experiment.

Figure 4.1:
(bottom)
CFD Simulation Workflow.

As you see in the diagram, this shows the entire work flow starting from the site modelling stage to the visualisation stage. The modeling process starts from the 16 selected designs and simple geometry of the site area. To produce the velocity data and the water flow direction, the procedure starts with the boundary conditions from the existing site. After setting up the detailed data for the boundary conditions, the steps continue with the process of simplifying the geometry and creating a closed solid to form a successful mesh.

The recipe, foam file for main simulation will be received by running the butterfly software, then run through the open-source software called Open FOAM to get the final solution. The final file onwards can be ready to be visualized and reviewed.

2.4 ANALYSING THE CFD DATA

For this stage, I used another open-source software, Para view, to extract the streamline geometry and data. The streamlines indicate how water flows in the drainage. These visuals also help to understand more about how fluid reacts when it meets the obstacles as in figure 4.1 and figure 4.2.

Figure 4.1:
Visualization of CFD data with Para view (1).

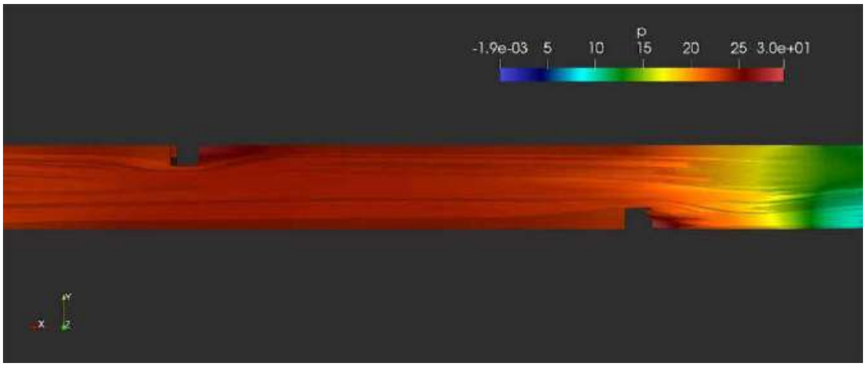


Figure 4.2:
Visualization of CFD data with Para view (2).

Furthermore, the colors can be visualized with the specific data with the gradients. Since I have already observed how water travels with the sediments. It is already clear to say that the sediment deposits in the area where it slows down from the observation of the model experiment. To be precise, I cross-referenced both of the collected data, from the physical and digital model, the color map from the photograph of experiments and the velocity graph from these simulations, to see if there were any discrepancies.

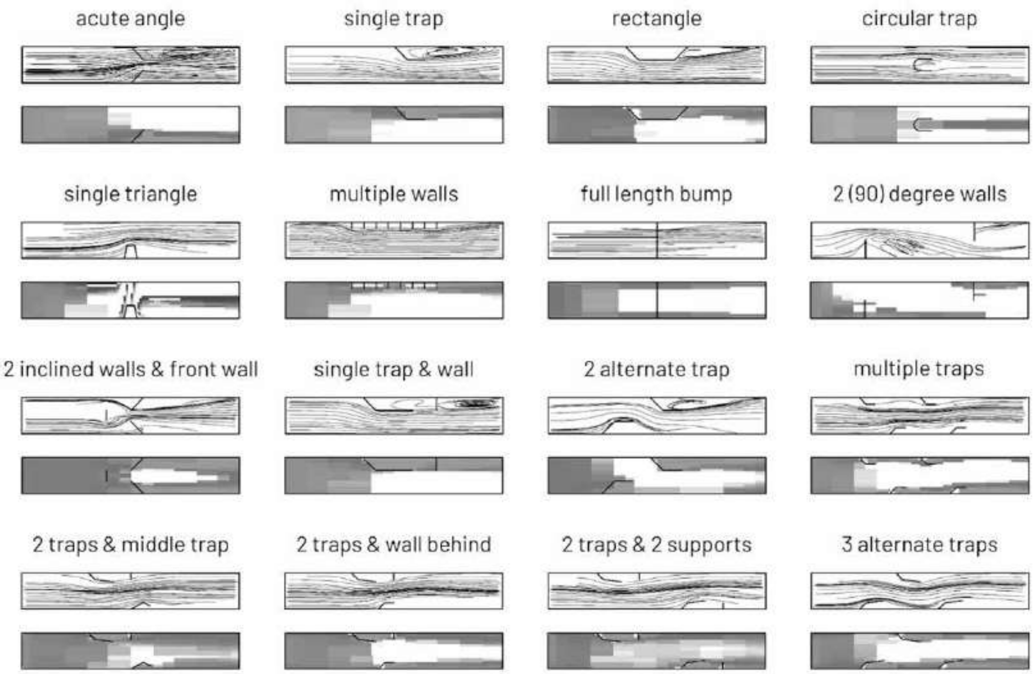
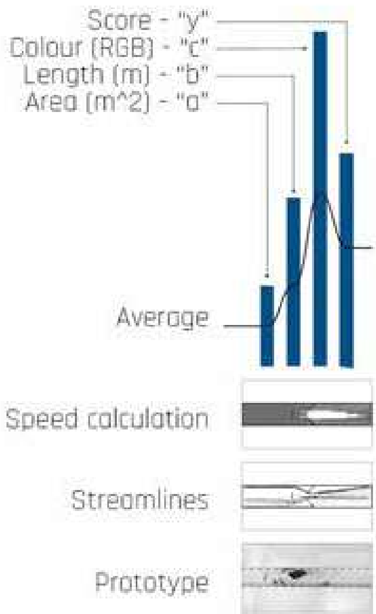


Figure 4.3:
(top)
Shading and Analysis process.

Figure 4.4:
(bottom)
CFD data, model experiment, and Score Result of 2 Inclined Walls and Front Wall.

2.5 THE SCORE CALCULATION

The final equation computes y, the score, which shows the efficiency level of each obstacle design. The elements in the equation are, a, the net area of the obstacle, b, the overall length of the obstacle and c, the color intensity (alpha value). The score is inversely proportional to the values of the variables of the equation. As the colours are shades of grey, the RGB values are the same. I considered all variables as important in the equation, thus all having a coefficient of '1'. he greater the value of the score, the more efficient the obstacle design is. The final design will be reviewed again and continued to proceed in the final design stage.

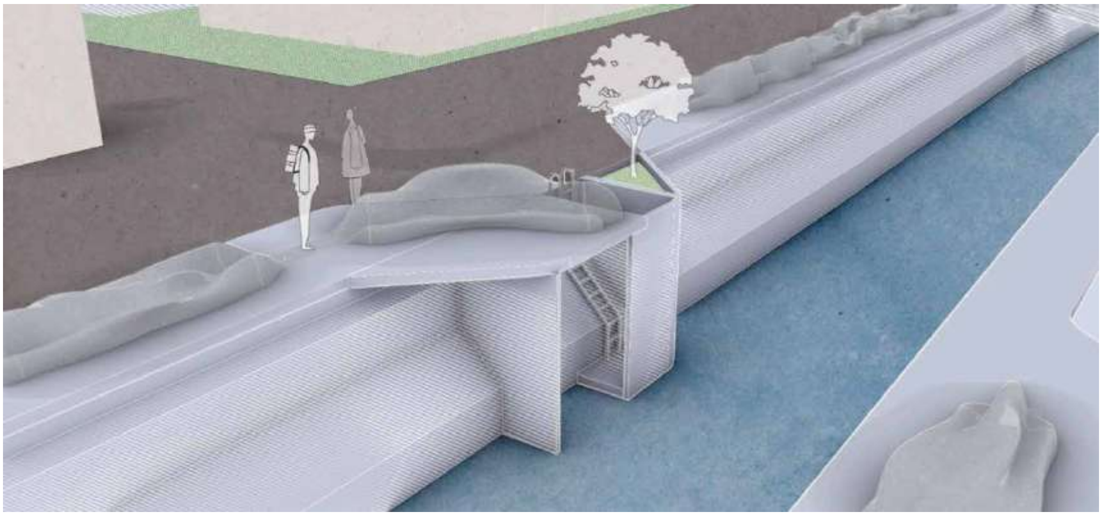


Score Calculation: y = (1/ (a+b+c))*100

Figure 4.5:
(top)
Final Obstacle Design with Benches.

2.6 FINAL OBSTACLE DESIGN

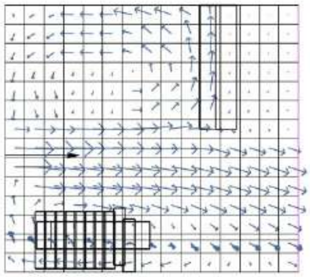
After calculating and examining all the 16 candidate obstacles, the trap and wall design is claimed to be the best option from all. For the positioning of the obstacle, the location needs to be convenient for the trucks to park and collect the sedimentation. Two of the same obstacle units are decided to be placed on each side of the drain; at the junction of drain and the streets. The obstacles are designed to collect the sediment in convenient ways for the laborers. However, on the top of the structure, it can still be usable for other functions. Therefore, two public recreational spaces and the plant box are added on top of the design due to the lack of public space nearby. As the extension of the project, the bench design on the sidewalk of the drain has additionally been designed on the other hand. The sidewalk as well as the bench continue to become connected and create more useful space not only for the sediment collecting process but also for the public.

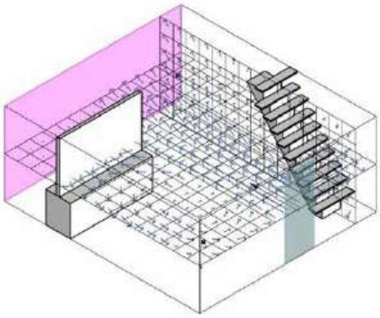


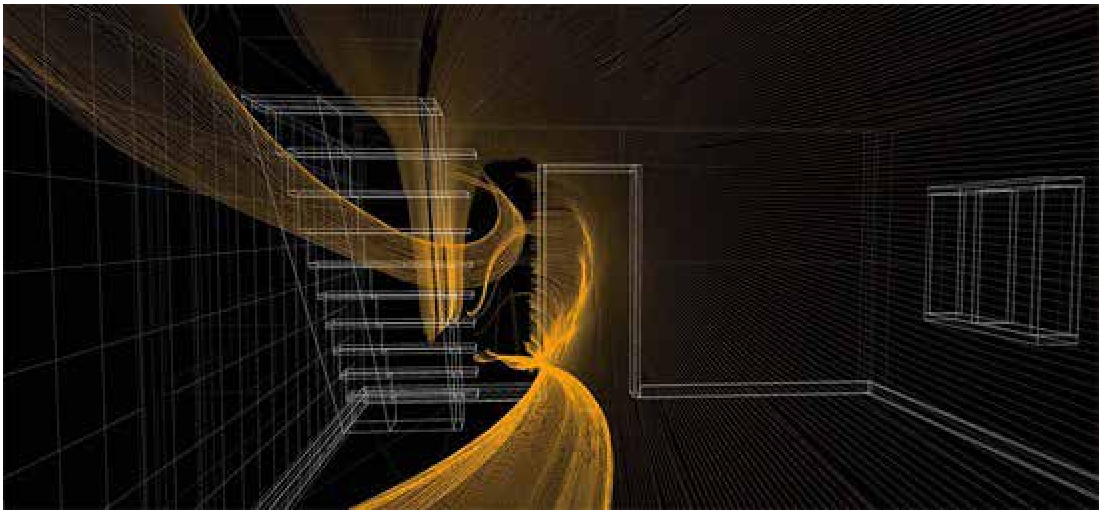
2.7 FINAL OBSTACLE DESIGN

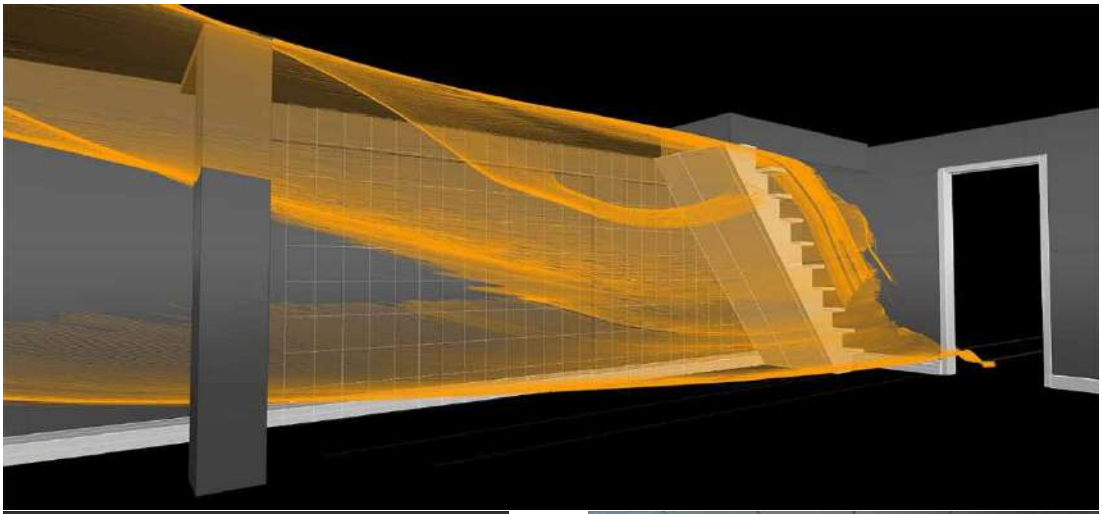
This project looks at the design by nature process on a new level of abstraction. The CFD software simulates the behavior of fluids. By designing this staircase according to a simulation of fluid dynamics, I am creating a simulation within a simulation. The goal is less about perfecting the aerodynamics of the staircase, but to create the illusion of aerodynamics of the staircase. CFD used for pure form-finding.

The first step starts with the simulation of indoor air flow that occurs in the room by using the Butterfly software again (figure 6.1). Afterward, the result foam file from the simulation is imported in the visual software for CFD called Para view. The vertical plane at the edge of the stair cuts the CFD foam and shows the fluid geometry form. The vectors of the ventilation are in turn extracted and imported into the modelling software. The streamlines from the fluid dynamics are over complicated to build in practicality. According to the curvature graph of the geometries and required dimension, the most suitable eight curves from the streamlines are chosen and repositioned with









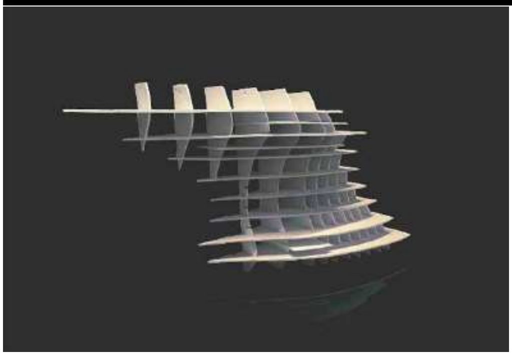


Figure 6.1:
(top of previous page)
Ventilation Analysis, Indoor Airflow, of the Office.

Figure 6.2:
(center of previous page)
Staircase Design.

Figure 6.3:
(bottom of previous page)
Miniature Model and Final Design after Installation.

the steps of the staircase. The final design will be in waffle structure by using those curves with the interlocking mechanism of vertical and horizontal sections. Later each member of the final design is nested into 8' x 4' rubber wood boards by using the algorithm of Open Nest software. The boards are sent to the local CNC machine factory for cutting. The final boards are easily assembled and installed on site as a final stage.

2.8 CONCLUSION AND FINDINGS

In a country like Myanmar where the future of architecture is moving backward, there is a vast variety of problems that need to be solved with risks. Urban upgrades have been a problem for long decades since the last colonization by the British back in 1947 after the country separated itself to be independent. People have very low standards and points of view on the word "research" in the urban architectural community. Contact to professional software was more than a luxury for us back until a decade ago. The lack of risk-takers and chasing a higher standard trapped potentials in a box of basic architectural tools such as AutoCAD,3D MAX, and Sketchup. In an area where urban upgrades have problems, this shows the lack of research studies. People relied on an Objective base instead of a Solution base process. For this project, professional researches of nature base solutions have been studied and examined together with real-life work experience. My interest in competition design and the will to promote this problem-solving equation allows me to explore and find out a new methodology for this project.

Computational design projects are very new to this country which can cause doubts especially in moments of great political and international trading system changes. But the natural resources provided in Myanmar are none like the rest of the world, where people search for specific data and look into it. It's a place with a world of undiscovered problems together with potential for new base solutions.

This is my second year of studies on CFD, one academic and one professional year, testing on open-source software instead of professional commercial software which I plan on using in the near future. This research might not be perfect like other researchers and professionals that have years of experience ahead of me, but I am willing and motivated to overtake them. Here is a question for you from the rest of the world. If a simple simulation like this project could fix the problem of the whole country, what do you think a more advanced computational tool with an experienced nature-based solution project could do?

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THE OTHER FOREST

A nature-based tool for ecological and social regeneration

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KEYWORDS
Afforestation, Communities, Biodiversity, Ecosystem services, Mitawaki

ABSTRACT
theOtherForest is an afforestation initiative by theOtherDada [tOD] that aims for ecological and social regeneration in cities. This initiative rewilds and restores ecosystems by growing forests using the Miyawaki technique in urban landfills of Lebanon and the region. theOtherForest empowers communities to reclaim public spaces and catalyze ecological and psychological healing. It also provides habitat for birds, beneficial insects and underground microorganisms in degraded areas. The planted forests connect across territorial borders, watersheds, and ecosystems, and are not defined by cultural and political boundaries. The community is at the heart of all public afforestation projects.

1. INTRODUCTION

theOtherForest is a nature-based tool for ecological and social regeneration in urban settings. This initiative includes 6 urban afforestation projects, planted over the past 3 years. The combined planted forests so far, form over 5,200 trees and shrubs from 26 different native species in 1260 square meters of land. Through utilizing the innovative Miyawaki Technique, the forests created are to be 100% more biodiverse, 30 times denser, growing 10 times faster as well as absorbing noise and air pollution 30 times more efficiently than conventional man-made forests.

The Miyawaki Technique of afforestation used is a unique methodology proven to work worldwide, irrespective of soil and climatic conditions, from tropical ecosystems to the most arid deserts. More than 3,000 forests have been successfully created worldwide using this methodology since the 1970s.

Moreover, theOtherForest contributes to improving urban liveability by fighting climate change, filtering air pollutants, cooling cities, protecting biodiversity, managing urban floods, restoring water cycles and improving physical and mental health. The Miyawaki forests are also maintenance free after 3 years of planting, rendering them more sustainable and efficient for future generations.

Figure 1:
Beirut River & Pilot project location.

2. BEIRUT'S RIVERLESS FOREST

Located in Lebanon, Beirut River extends 30 kilometers from its natural mountains through the city of Beirut and into the Mediterranean Sea.

The river provides us with ecosystem services such as: provisioning services: it used to provide freshwater for irrigation and potable water supply through the roman aqueducts and transport sediments, organisms and nutrients, regulating services: its hydrological cycle is influenced by 190 sources that are locates in the area of its watershed, supporting services: Beirut river valley is classified as A4iv category IBA (Important Bird Area) by birdlife international and Society for the Protection of Nature in Lebanon SPNL, and cultural services: it used to provide a natural space for recreation and cultural events for the communities such as for example, the renowned Armenian Water festival Vardavar.

Especially in the area water is the new oil. The world is at war over water. Goldman Sachs describes it as “the petroleum of the next century”. And the world Economic Forum in Davos Switzerland, ranked the water crisis as the Number 1 global threat.

The degradation of the Beirut River and connected infrastructure from natural to artificial, results in a negative impact on the surrounding communities and environments. Due to the illegal dumping of wastes (raw sewage, garbage, industrial waste, slaughterhouse waste, unloved pet) that all flow in the Mediterranean Sea, the loss of the ecosystem services and the high population density (further compound by the influx of 1.2 million Syrian refugees).

Beirut RiverLESS aims at bringing Beirut River back to life through a human centered perspective: environmentally by storm water and flow restoration, socially with community engagement and economically using collaborative partnerships. Using biomimicry at the systems level and developing the Beirut River Genius of Place, will bring back the ecosystem services to improve the resilience of the city and the living conditions of the communities nearby.

For instance, looking at storm water drainage as an example of a lost ecosystem service (due to the concrete walls built in 1968), the river has lost its ability to regulate floods. The first step is to understand how nature manages the flow and it’s by embodying resilience through variation, redundancy and decentralization. Then to intervene with blue–green streets, sponge parks, green roofs that work together to protect natural & man-made assets, maintain ecosystems & infrastructure and ensure public health services. The genius of place developed, was the champion organism platanus orientalis or plane tree which can intercept around 3000 gallons of rainfall annually by having a multi-layered architecture to its canopy. Its role is to delay rainwater runoff, reduce the volume of water reaching the ground and increase areas for potential evaporation.

Inspired by those ideas, on May 2019, theOtherDada planted the pilot project of theOtherForest, Beirut's RiverLESS Forest in Sin El Fil. It was allocated in a public plot next to the channelized and polluted Beirut River and was commissioned in collaboration with SUGi project as well as private donors. The preparation and implementation of this forest were successful due to coordination with the municipality, Miyawaki afforestation workshops with Afforestt and research of native species with botanists. The end result has been acting as a healing place for a lot of volunteers and locals who visit the forest on a weekly basis to engage in its conservation and maintenance.

Figure 2:
The Before and After of Beirut's RiverLESS Forest.

3. CEMETERY FOREST

During the same week, tOD planted a forest in a cemetery with the help of the community. It spans over 100 meters and acts as a natural screen between the cemetery and the urban context.

Beirut's environmental degradation has left communities detached from nature and surrounded by pollution.

Planting in communal spaces such as this cemetery is one aspect of tOD's work to provide an alternative approach to sustainability; through invoking new relationships between climate, landscape and inhabitants.

Figure 3:
The Power Plant Forest.

4. POWER PLANT FOREST

Lebanon suffers from the highest rate of premature deaths in the region due to extremely high levels of air pollution, according to a Greenpeace report 2020. The country's burning of Heavy Fuel Oil in power plants, unfiltered generators and endless traffic fumes contribute to record levels of nitrogen oxide particles in the air. Nitrogen oxide is a dangerous pollutant released when fuel is burned, and can cause respiratory problems and damage to lungs.

According to Greenpeace's air pollution report of 2018, Jounieh is the most polluted town in Lebanon and listed as the fifth-most-polluted region in the Arab world. The town's location beside the highway and the impact of the power plant have been factors in the city's poor environmental standing.

theOtherDada proceeded to plant the Power Plant Forest in the media strip of the Zouk Mosbeh highway nearing Lebanon's biggest power plant in November 2020. The forest occupies 180 sqm and is home to 720 native trees and shrubs. It not only has the power to reduce the region's air and noise pollution, but also to restore natural water systems and become a haven for migratory birds. Lebanon lies on the second-most-important flyway in the world for such birds, which are often at risk from hunting or logging. theOtherForest is therefore aiming to recreate a healthy forest ecosystem that hosts a multitude of species and contribute to a better urban environment.

4. CONCLUSION

While implementing the urban afforestation programs, tOD have documented the transformation of the planted lands from empty abandoned plots into educational and public spaces for workshops and natural discovery. This way, they can catalyse communities to take ownership of spaces they preside over by creating spaces that are meant to be shared.

These Miyawaki forests aim to recreate natural forest communities, composed of plants that have coexisted and interacted in a particular place for millennia.

Sophisticated technology wasn't needed for the making of the forests, but tOD is partnering up with institutions in the area to start using remote sensing for a faster and more advanced understanding of the soil (humidity, temperature…) that will improve the maintenance of the forests, and to introduce air pollution sensors to track the effective changes of the forest on the environement.

theOtherForest is one aspect of theOtherDada's work in climate action, architecture, and consultancy to provide an alternative approach to sustainability through invoking new relationships between climate, landscape, and inhabitants.

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INTEGRATED URBAN-WETLAND SYSTEMS

A system thinking conceptual planning and design method

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nature-integrated planning tool, ecosystem services, symbiotic urban wetlands, system thinking applications

ABSTRACT
The paper describes the methodology and design approach which form the basis for the development of an interactive conceptual planning and design tool prototype for nature-integrated urban-wetland developments.

By merging aspects of several theoretical frameworks (e.g. metabolism, biomimicry or permaculture) which define relationships between urban systems and ecosystems, a method for identifying, assessing and pairing potentially symbiotic ecosystem and urban functions was proposed.

This method was subsequently applied to develop a planning tool which provides a simple graphical interface that can aid stakeholders to manage complexity, understand interdependencies and assess design priorities and decisions in the early conceptual phases of a project. By use of a system thinking causal diagram, the interface connects social, ecological and urban interests with design parameters, providing a holistic understanding of the implications of design decisions such as use of wetlands for water treatment, energy and water efficiency. Furthermore, user defined scenarios can be assessed in terms of two main criteria: cost/benefit ratio and “fair share” ratio (ratio describing the equitability of resource allocation and provision of services between urban and ecosystem components).

1. INTRODUCTION

1.1 URBAN-WETLAND INTERACTIONS

In the context of current climatic changes, wetlands represent one of the many ecosystem types that are under threat due to the combined effects of the changing climate and expansion of urban areas. The Ramsar Convention on Wetlands reports a global decline of coastal wetland areas across all classes (Ramsar, 2018).

At the same time, as transitional ecosystems between land and water, these ecosystems are particularly important as they provide habitat and nutrients for a great variety of species.

As integrated urban landscapes, wetlands provide numerous vital ecosystem services such as wastewater treatment, coastal erosion protection or flood protection. However, the full range of services and potentials associated with urban wetlands is often underrepresented (McInnes,2013).

While, at a large (national/regional) scale, there is an intense focus on the conservation of existing wetlands, strategies which balance interests at the small scale of individual stakeholders are less developed. Albeit their numerous ecological functions, especially in sites located in proximity to existing urban centres, urban growth represents a tangible threat to the preservation of these endemic ecosystems and the associated ecosystem services they provide.
As cities expand, wetland areas outside of designated natural conservation zones are commonly reclaimed for urban development (Davidson,2014), to maximize short-term profits for landowners.

The research therefore focuses on small scale developments and the integration of symbiotic urban-wetland relationships that can be multiplied at city scale.

1.2 IMPLEMENTATION CHALLENGES

Both the urban and ecological systems can be described as complex systems based on non-linear causal relationships. To optimize and design sustainable urban-ecosystem relationships, stakeholders and planners/designers must be able to manage high degrees of complexity, consider interdependencies and implications at a systemic level and work within interdisciplinary teams.

In the context of small-scale development, which is primarily driven by homeowners or individual land developers and are intensely focused on immediate land values and profits, complex interdisciplinary systemic approaches often prove impractical. This issue may lead to the implementation of less sustainable strategies and through multiplication, to less sustainable future cities.

To address these challenges, the project aimed to synthesise current theoretical and practical design approaches in the form of an interactive planning tool which would enable small scale development stakeholders to manage complex interdependencies and assess cost/benefit ratios and urban-ecosystem equitability of design proposals at a systemic level.

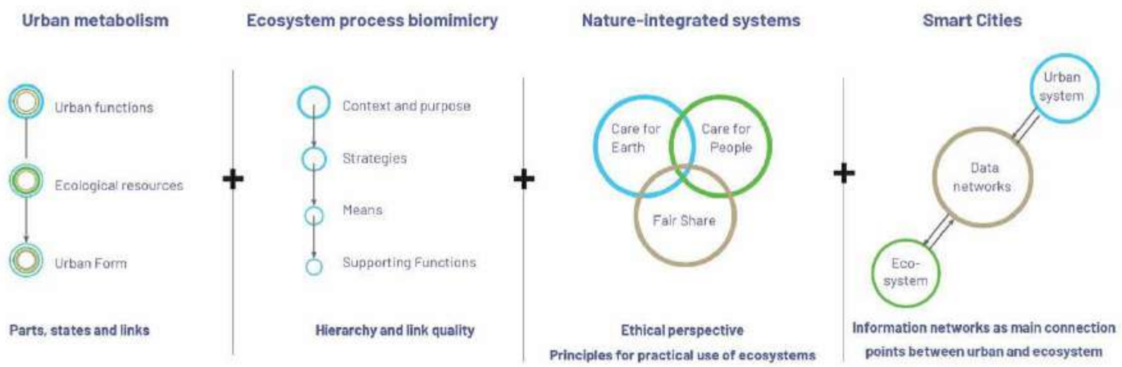
2. METHODOLOGY

2.1 THEORETICAL FRAMEWORK

Based on a qualitative literature review, several theoretical frameworks that aim to define symbiotic relationships and mimic natural behaviours to enhance the provision of ecosystem services were compared. Four main approaches (Figure 1) were selected with the aim of holistically portraying the state of the art in terms of sustainable urban-ecosystem relationships.

The main urban functions and flows were defined based on an urban Metabolist approach (Baumeister & Ottmann, 2015) with hierarchies defined based on the four tier ecosystem process biomimicry approach as proposed in Regenerative Urban Design and Ecosystem Biomimicry (Pedersen 2018). The ethical and practical application framework was defined through permaculture principles (Hemenway, 2015). Lastly, a connection to digital urban networks was established through the Internet of Nature smart city framework approach (Galle, 2019).

Figure 1:
Combined selected theoretical frameworks.



2.2 URBAN FUNCTIONS AND THEIR ECOLOGICAL COUNTERPARTS

Using a qualitative literature review process, focused on wetland functions, the above-mentioned Metabolist urban functions were compared with specific ecosystem functions. Based on the degree of similarity, each urban function was associated with an ecosystem function counterpart.

2.3 DESIGN ASESSMENT CRITERIA

Due to the variety of factors, units and subsystems needed to holistically describe a hybrid urban-wetland system, a unifying index or assessment criteria was sought. A review of various urban sustainability indicators (including SDG goals, liveability indexes, etc.) was conducted.

Considering the importance of economic impact for small scale development stakeholders as well as the cross-discipline applicability, cost/benefit ratios were chosen as one of two design assessment criteria.

The second criterium relates to the equitability of resource allocation and provision of services between urban and wetland systems. As most current sustainability indicators focus on specific aspects rather than a holistic appraisal, a new indicator, based on the selected permaculture ethical framework "fair share" principle was proposed. The indicator represents the sum of urban versus ecosystem percentage of contribution across the entire system, allowing for normalized inputs from the various subcomponents.

3. SYSTEM THINKING PLANNING TOOL

Based on the synthesized theoretical frameworks and identified urban-ecosystem counterpart functions, the framework principles were applied to generate an interactive graphical representation of the urban-wetland system.

3.1 DESIGN ASESSMENT CRITERIA

There are two main types of inputs that determine the outcomes and overall system performance and evaluation potential of the tool: base data and in-tool user defined options. The base data include environmental, site and performance parameters, allowing for a customizable range of in-tool options (e.g. defining range of building energy efficiency targets). The in-tool user options allow for testing of different design configurations, with each parameter within the base data range.

3.1.1 BASE DATA

Base data files are .csv file formats which can be adjusted by the user to reflect the parameters of a specific project. There are five main categories of base data used (Figure 2).

The climate and site data file includes monthly averaged values for a series of environmental parameters such as mean solar radiation, wind speeds, tide, and temperature ranges as well as basic site dimensions and relevant existing site areas (e.g. mangrove, salt marsh and nearshore coverage, tidal creek areas, elevated dryland areas). The current version of the tool includes data for an Australian coastal wetland case study site located in Gold Coast, Queensland.

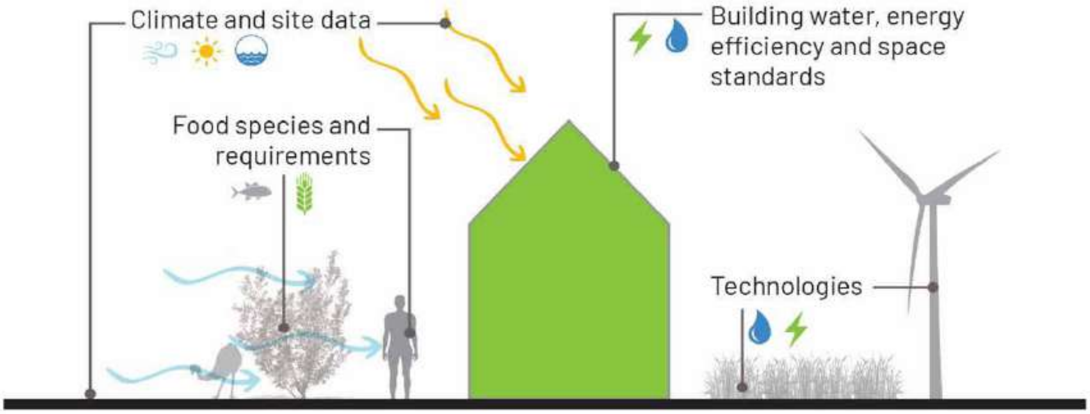


Figure 2:
Base data input types.

The food species and requirements files relate to potential on-site food production. The requirements file represents recommended daily intakes (KJ/person day-1) for each of the five food groups as defined by the Australian NHMRC Guidelines (NHMRC, 2013). Food species data incorporates species that could be cultured on site and contains the energy value (KJ/g) as well as yields (Kg/m2) for each crop.

The current version of the tool includes potential cultured species that can directly be grown in the salty environment of coastal wetlands. The main species types are halophytes, mangroves, oysters and fish suitable for silvofishery integrated-mangrove aquaculture techniques such as those practiced in the Philippines (Takashima 2000).

The building standard files incorporate specifications for average, good and best practice values relating to minimum standard space requirements, water and energy consumption.

Space standards provide minimum residential areas (m2/person), energy standards include standard energy consumption targets (kWh/m2) and water standards include data regarding specific flows and volumes for the main fittings and fixtures as well as water efficiency ratings for white goods.

The current version of the tool utilizes the UK AECB Water Standards (AECB,2009) for fittings, the Australian WELS standard for white goods, the Passive House Low Energy Building and Classic Standards (PHI, 2016) for energy efficiency while space requirements are calculated based on Australian averages (for low and medium compactness) and the UK Nationally described space standards (DCLG, 2015) for compact options.

Lastly, the technologies files include data regarding the performance and specification of various renewable energy products as well as on-site water treatment types (e.g. constructed wetlands, solar stills).

3.1.2 IN-TOOL USER DEFINED OPTIONS

BThe interface incorporates four main tabs, three design option tabs and a main tab which provides an overview of the interlinked functions. The three option tabs target spatial footprints of the built envelopes as well as the food, energy, water nexus and are based on the above base data input ranges.

The first options tab (Figure 3) relates to general consumption and production targets for food, water and energy and allows for comparison of the output and required areas for specific technologies.

In terms of food consumption, this tab provides only target on/off site food supply proportions for each food group with further detail being given in the other two option tabs.

The specific monthly water demand is calculated based on daily consumption rates for each standard (l/person day-1) and the input for number of people occupying the site. Additionally, daily consumption assumptions can be adjusted in the adjacent parameters tab.

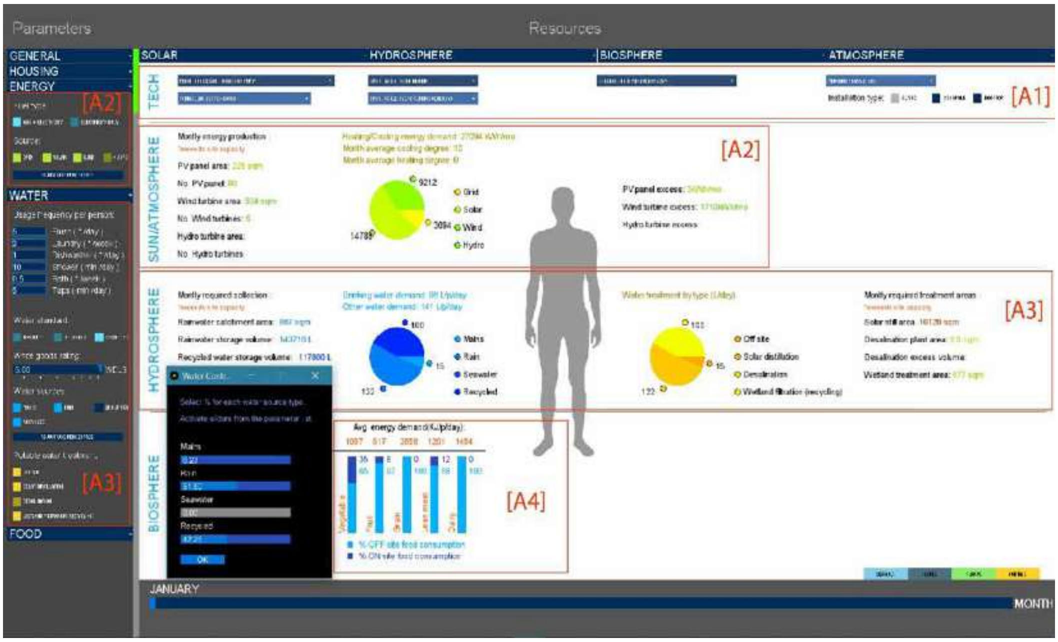


Figure 3:
Tool preview showing “People” options tab and food, water and energy options. [A1]-technology selection, [A2]-energy parameters, [A3]-Water parameters, [A4]-On-site food production targets.

Based on the technology/product selected, alternative on-site water supply sources as well as on-site water treatment can be optimized for output and site area occupied. Similarly, the monthly energy demand is determined based on the building standard selected (Figure 4) and renewable supply options can be explored through the selection of technologies.

While water and energy demands are frequently expressed as yearly values, monthly values may provide better insights into the performance of each technology in relation to environmental conditions and thus, potentially allow for more targeted decision-making.

It is interesting to note the difference in impact of technology performance on the footprint and characteristics of the existing site ecology. For example, a low-cost solar still water treatment system, is beneficial in terms of reducing off-site energy and water consumption but due to the low rates of water production, the footprint of the system may be very large and ultimately decreases the amount of ecosystem services that can be achieved via the existing wetland. On the other hand, a wetland water treatment plant with slightly larger water production rates, has a similar effect in terms of consumption reduction but adds to the biodiversity of the site and can, therefore, enhance the ecological performance of the site, albeit requiring a large land area.

In terms of the spatial design options and assumptions, based on the average floor area per person determined, the tool allows for three types of spatial distribution scenarios. The scenarios reflect different compactness, occupancy and ground footprints (Figure 4) having a marked impact on the footprint ratio between the urban and natural environment.

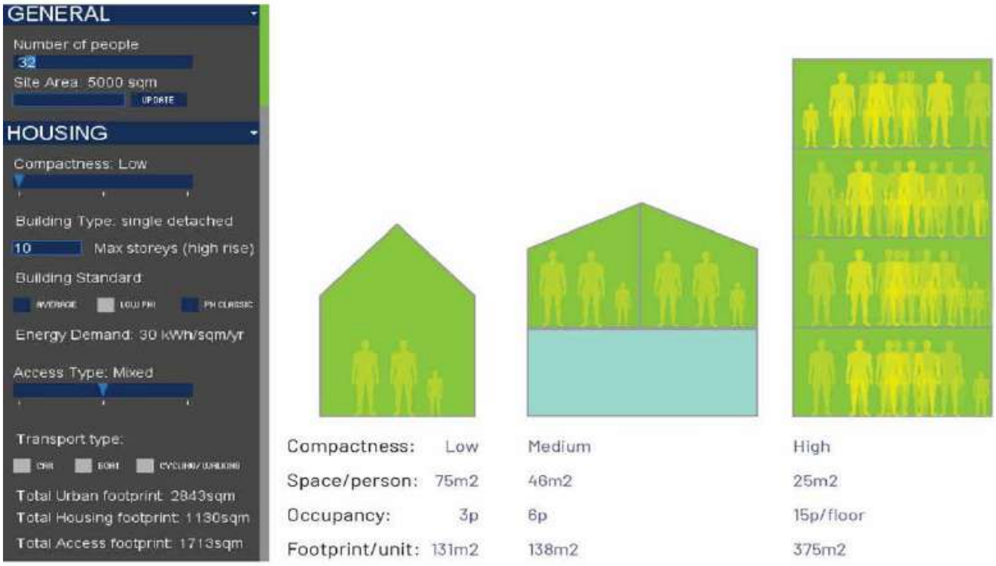


Figure 4:
Tool options (left) and assumptions (right) for estimating total urban footprint.

Maximising ecosystem services and implicitly the ecosystem footprint, implies minimizing the urban footprint. Depending on property market trends (especially in the case of Australia), high-rise development may not be a feasible development option. Based on the urban-ecosystem balances explored through the tool, alternative, integrated designs (such as stilt infrastructure) which allow for both urban and ecosystem growth may be proposed.

Finally, the second and third option tabs focus on food production and hybrid wetland culture areas. Cultured species can be selected from the context menu, with required crop areas to meet yearly energy requirements displayed (Figure 5). The current tool version distributes demand equally, among selected species in each food group, therefore, the specific caloric energy and yearly yield plays an important role in balancing cultured and natural areas. The included species were endemic species that can be grown without significant fertilizer addition and would contribute to enhancing ecosystem services.

The impact of species characteristics is exemplified in Figure 5, where, shrimp and mud crab cultures were selected to contribute to meeting 20% of the lean meat demand for 20 people occupying the site. Due to a relatively low caloric energy and very low yields for the silvofishery system, the areas that would be required are ten times the site capacity.

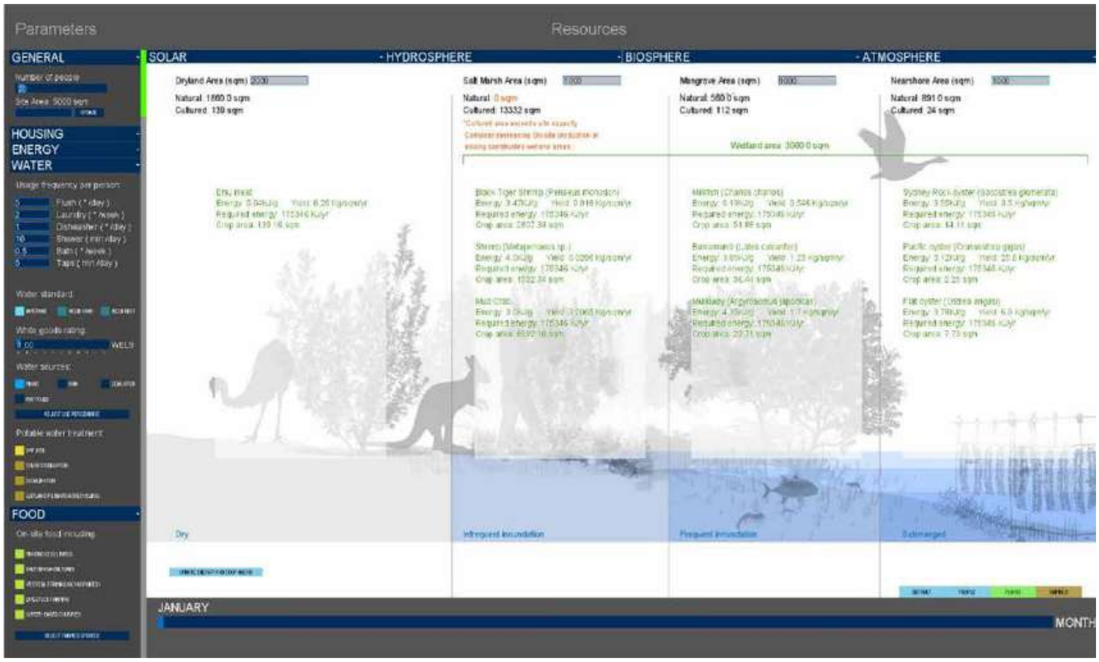


Figure 5:
Example scenario for cultured animal species showing high sensitivity to specific yields and caloric values.

Overall, in terms of the input options impacting the food, energy, water nexus, a balanced result can be achieved through considered selection of technologies, cultured species and target urban density levels.

3.2 OUTPUTS AND PRELIMINARY OBSERVATIONS

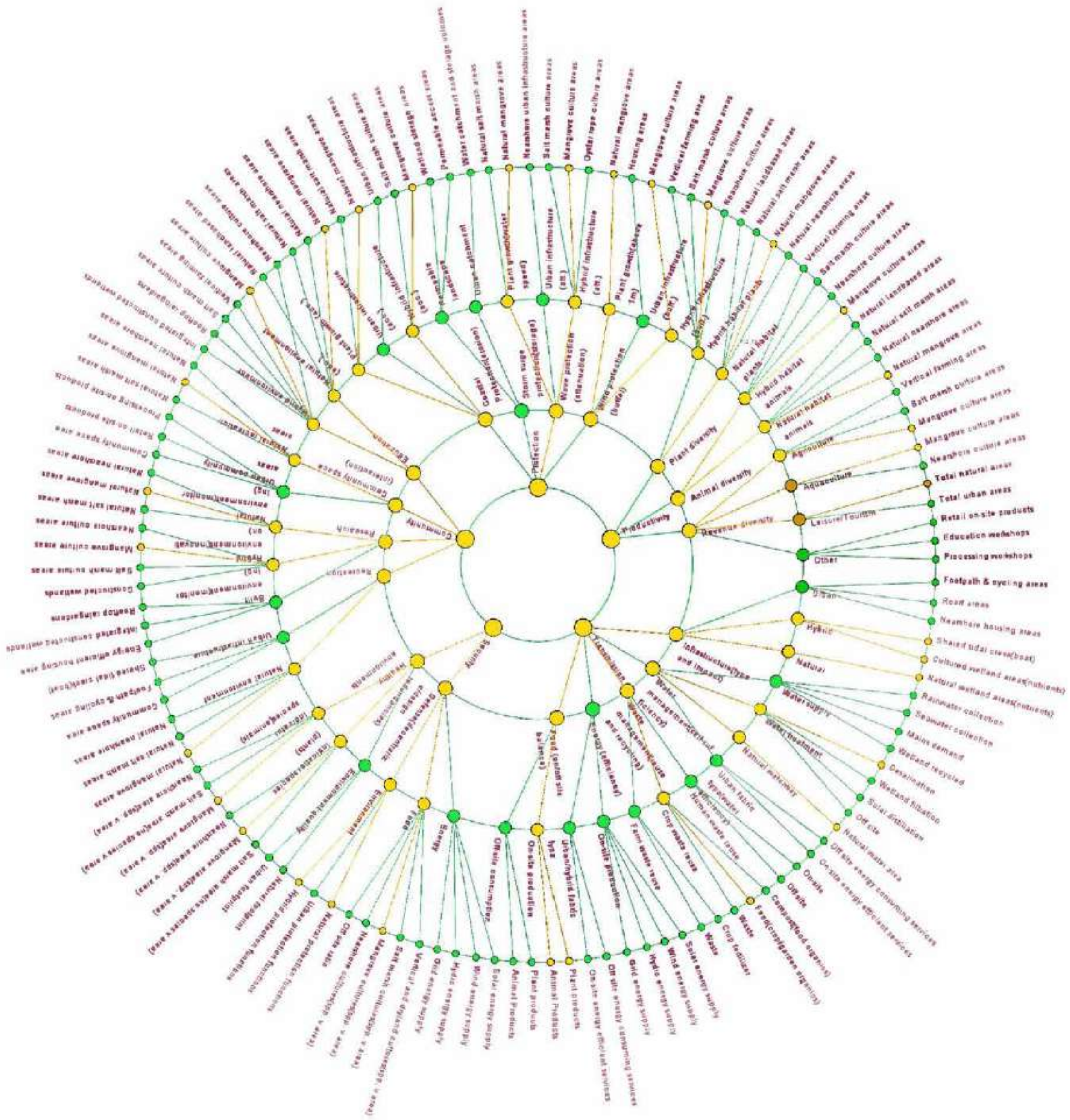
The combined effect of the food, water, energy and spatial options, at a systemic level, is assessed via two criteria: fair share percentage and cost/benefit ratio.

While basic calculations have been integrated, the tool is still in the proof of concept, early development phase and therefore has undergone limited testing. The following sections discuss some preliminary observations of the fair share and cost/benefit assessment criteria.

Of the urban and ecological functions identified through the literature review, 48% can be categorized as hybrid functions supported by both urban and ecological processes while only 27% and 25% were strictly supported by the natural ecosystem and urban system respectively. At the same time, a number of ecological functions such as nutrient delivery or water filtration rates can be directly related to the afferent ecosystem area. The ecosystem services that can be provided by on-site wetland systems, therefore, rely in part on either minimizing urban functions or on integrated design features that support ecosystem processes.

Figure 6 shows an extract of the main system diagram and highlights the functions affected by mangrove ecosystem components (natural and hybrid). The contributions range from social, educational to potential alternative revenue streams and alternative food sources, indicating that wetland areas could act as connectors and balancing components between urban and natural processes. Further testing is required to determine optimal urban-wetland ratios and the resulting overall fair share percentages.

Figure 6:
Tool interface system diagram showing connections for mangrove cultured and natural areas.



The diversity of functions performed by a single ecosystem component has an impact on the approach to cost/benefit calculation. Standard urban per m2 costing approach cannot be applied directly in this case as the cost/benefit would need to be broken down for each specific ecosystem function. Further development of the prototype will aim to assess the cost/benefit performance of the urban fabric and highlight benefits provided.

4. CONCLUSIONS

A specific design and assessment method was developed with the aim of developing a tool which aids to assess equitability, manage complexity and interdependencies in the case of integrated urban-wetland system designs for small scale developments.

The methodology provides a strategy to synthesize state of the art theoretical frameworks related to defining the urban-ecosystem relationship, at the same time identifying links between urban and wetland functions.

The tool described applies the theoretical synthesis in a quantitative system thinking model which allows the assessment of the interactions between design decisions in the early conceptual phases of a project. Although the tool is in a very early development stage, the initial modelling revealed that a high number of urban functions are or can be supported via the expansion of wetland areas. Additionally, a strong connection between decreased ecosystem services and low efficiency of on-site technologies was observed. In contrast, nature-based solutions such as constructed wetland water treatment plants still supported ecosystem functions albeit lower filtration rates and large footprints.

In terms of the urban footprint, low density development decreased the overall ecosystem potential. For the Australian property market trends, integrated solutions that support ecosystem processes may be a viable alternative to high rise/low footprint development.

Further testing and development are required to provide recommendations and conclusions in relation to the proposed assessment criteria. However, initial observations of the subsystem calculations and interactions, suggest a potentially viable model for early conceptual project phases.

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AMBER LAMINARIA

Additive Manufacturing of Seaweed as a Biocomposite Material

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KEYWORDS
Seaweed Biocomposite Material, Paste Extrusion Method, Water-based Robotic Fabrication, Circular Design, Material-informed Design

ABSTRACT
This research aims to develop and understand additive manufacturing of seaweed as a biocomposite material within the built environment. The research is motivated by current challenges such as carbon drawdown, the problem of material waste, and the need to create more sustainable manufacturing processes. Seaweed is an organic and underutilized resource that does not require land, fresh water or fertilizers to grow. Growing seaweed can reduce the effects of global warming as it sequesters large amounts of carbon dioxide and is harvested for a variety of uses including food, biofuel, fertilizer and bioplastic. The research focuses on the development of a water-based biocomposite material made from sodium alginate, a derivative of brown seaweed, combined with cellulose powder as biopolymers; vegetable glycerine as a plasticizer; and kelp powder as an additive. A set of methodical experiments were conducted and recorded, with the aim of creating a bioplastic material with adaptable properties stemming from its strength, translucency and flexibility. The material's shrinkage and viscosity steered the research towards an additive manufacturing process which allows for adaptation and scalability. By creating, designing and fabricating using renewable resources, one is able to create products that are carbon neutral and contribute to a natural resource cycle. Ultimately, the material can decay and return to the earth, for the purpose of remediating soils and replenishing growth.

1. INTRODUCTION

The global challenges we are facing due to climate change and the depletion of natural resources is forcing us to radically change the way we construct our built environment and to take a new critical stance in how we design and construct. The construction industry plays an important role in all industrial sectors, as it currently is responsible for a large share of resource consumption, energy use, carbon dioxide emissions and waste generation (Bekkering, Nan, and Schröder, 2021). This is having a catastrophic effect on our surrounding environment which can be seen within the ecosystems around us. With growing concerns about the effects of global warming on the environment, there needs to be a shift in the way we interact with our natural environment by integrating nature-based solutions into all sectors of our daily lives.

The research is framed within the same aspects as the Sustainable Development Goals (SDG) which are a collection of goals that are designed to achieve a better and more sustainable future for all. This research focuses on three interrelated goals of the SDGs, namely goal 12: to ensure sustainable consumption and production patterns; goal 13: to take urgent action to combat climate change and its impacts; and goal 14: to conserve and sustainably use the oceans, seas and marine resources. The challenge is to reduce non-renewable resource consumption by turning to renewable resources that alleviate the effects of climate change in their production instead of contributing to it. This research focuses on tackling these goals by looking to the ocean for alternative renewable resources from Blue Carbon strategies, such as kelp forests.

2. BLUE CARBON STRATEGIES

In response to growing concerns about climate change, considerable interest has been drawn to the possibility of increasing the rate of carbon sequestration through natural technologies within the ocean. The oceans itself accumulates carbon within coastal ecosystems, known as Blue Carbon. These ecosystems occur in shallow waters and account for 50% of long-term carbon sequestration, while only making up 2% of the ocean (IUCN, 2021). These include seagrass meadows, mangrove forests, salt marshes and kelp forests. They provide numerous other benefits including shoreline protection from storms, rising sea levels and erosion, regulation of coastal water quality, provision of habitat for marine life, as well as food security for many coastal communities (The Blue Carbon Initiative, 2021).

Kelp, the largest subgroup of seaweed which also includes the largest and fastest growing seaweeds, is placed in the Phaeophyta (brown) category. On average, giant kelp is able to grow at a rate of 28 cm, making it one of the fastest growing plants on the planet (NOAA, 2021). Kelp grow in dense groupings that form an ocean forest. These underwater forests do not overlap with other blue carbon coastal ecosystems, as they grow in more colder waters.

Compared to other Blue Carbon strategies, kelp forests pull more carbon dioxide from the ocean and atmosphere than seagrasses, mangroves and salt marshes combined, based on biomass (NOAA, 2021). Kelp is incredibly efficient at absorbing vast amounts of carbon dioxide, heavy metals and other pollutants from surrounding waters. This means that farming kelp could help combat impacts within local communities such as ocean acidification and marine habitat loss, and is becoming an increasingly competitive biomass production candidate for food, biofuel, fertilizers and bioplastics as it does not require land, fresh water or pesticides and fertilizers.

There are a number of organizations such as AtSeaNova and GreenWave that are developing systems that focus on regenerative seaweed farming. GreenWave has come up with a 3D vertical ocean farming system which consists of underwater vertical gardens that grow kelp and shellfish on suspended floating ropes (Figure 01). GreenWave's vision is to create clusters of kelp-and-shellfish farms which stack a number of enterprises on top of each other, creating high abundance in a small area, as the farms are typically 20 acres. The National Oceanic and Atmospheric Administration (NOAA) is investigating this industry’s benefits, as it is still in a developmental stage, which will lead to more efficient permitting and allow seaweed farming to expand while being economically and environmentally sustainable (NOAA, 2021).

Figure 1:
Regenerative Ocean Farming at GreenWave.

Instead of harvesting these marine plants for food like commercial farming, communities and other stakeholders could establish seaweed farms in polluted areas with the purpose of improving the health of the coastal ecosystems, and at the same time harvesting the kelp to use as a construction material, storing and preserving carbon within the built environment for as long as the building remains standing.

3. SEAWEED STATE OF THE ART

There are few architectural projects that incorporate seaweed as a construction material, however, eelgrass (a type of seagrass) has been established as a natural material on the Danish island of Læsø for roofing and wall insulation due to its large salt content which restricts mold and ultimately preserves the material for centuries. Seaweed displays material properties that can be highly functional. As well as being an exceptional insulating material (comparable to mineral wool), it is non-toxic, fire-resistant, has high acoustic absorbing qualities and has the ability to absorb and give off moisture (MaterialDistrict, 2016). Because of its high salt content, it is also mold resistant and does not decay easily. The combination of these efficient properties allows for this material to be extremely durable, giving it a long life-span.

The Modern Seaweed House, designed by Vandkunsten and Realdania Byg pays tribute to the island of Læsø and it's traditional method of using locally sourced eelgrass as a building material, demonstrating the combination of modern construction techniques and eelgrass as a sustainable, locally sourced material that has extremely low energy consumption. Similar works done by designers Kathryn Larsen and Tobias Gumstrup Lund Øhrstrøm also use eelgrass in new products. Tobias Gumstrup Lund Øhrstrøm has developed acoustic panels at Søuld, making use of the material's porous structure (Figure 02).

Figure 2:
The Modern Seaweed House by Vandkunsten and Realdania Byg (left) and Acoustic Panel by Søuld (right).

Another approach of using seaweed in design is by combining it with other materials. Danish designers, Jonas Edvard and Nikolaj Steenfatt have created a new material combining locally harvested fucus seaweed and recycled paper to create furniture pieces. The idea behind this bio-based material is that it can be broken down and reused or recycled as a natural fertilizer as seaweed contains large amounts of nitrogen, iodine, magnesium and calcium (Treggiden, 2015). There has been recent interest towards using seaweed as a base material in yarn for weaving rugs and as a dye for colouring textiles (Treggiden, 2015). With limited resources showcasing the use of seaweed in its raw form or an extraction of it, there is a pressing need to explore this renewable biomass. There has also been growing interest in using seaweed as a base material in bioplastics, as a way to fight both plastic waste and food waste. Sodium alginate, a derivative from brown seaweed, is a multifunctional material with the ability to homogenize with other materials and has previously been used as a biopolymer to create bioplastic materials.

The use of renewable bio-based materials for large-scale applications within the built environment is still not widely acknowledged or accepted despite an urgent need for alternatives to non-renewable materials as natural resources are depleting. This is in spite of the fact that recent studies have proven that organic materials display high mechanical properties (Mogas-Soldevila, Duro-Royo and Oxman, 2014). Organic compounds embody more efficient and adaptable properties compared to synthetic materials, and leave no environmental mark. Natural resources such as polymers and polysaccharides, which include chitosan, cellulose, pectin and alginate, are all found naturally in abundance compared to many man-made synthetic materials (Mogas-Soldevila, Duro-Royo and Oxman, 2014). These organic ingredients are renewable, available in abundance, bio-compatible and environmentally friendly.

4. SEAWEED MATERIAL RESEARCH

4.1 SEAWEED PROPERTIES AND CHARACTERISTICS

As a natural resource, seaweed is not only harmless to the environment but also rich in various nutrients that are beneficial to other organisms such as plants and animals. In addition to organic compounds such as proteins, amino acids, lipids, cellulose and vitamins, seaweed is rich in alginate and polysaccharides that are not present in terrestrial plants. This is one of the many reasons this versatile macroalgae is harvested and used in its raw or extracted form in a variety of products including food, biofuel, pharmaceuticals, cosmetics, bioplastics, fertilizers and livestock feed. The food industry exploits their gelling, water-retention, emulsifying and thickening properties, and cosmetic and pharmaceutical products incorporate forms of seaweed mainly because of its water retention properties (Martau, Mihai and Vodnar, 2019).

4.2 SEAWEED EXTRACTION: SODIUM ALGINATE

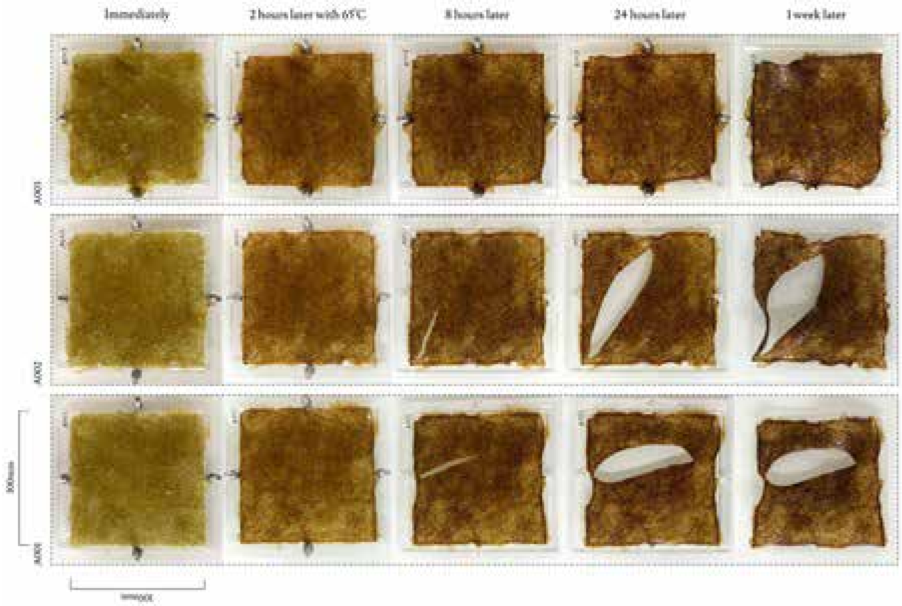
Sodium alginate is a naturally occurring biopolymer which has been extensively investigated and used for many biomedical applications such as tissue engineering and drug delivery, due to its biocompatibility, low-toxicity, relatively low cost and mild gelation by addition of divalent cations such as calcium. The use of alginates is based on two main properties. The first is their ability to thicken in the presence of water or increase the viscosity of aqueous solutions and the second is their ability to form gels due to cross-linking of ions in the presence of calcium (Lee and Mooney, 2012). Gels formed from alginates have the amazing ability to withstand heat and temperature of up to 150 degrees celsius without melting. Alginate bioplastics that are sprayed with calcium chloride, are water resistant with neutral or acidic solutions, and will dissolve within a few hours if submerged within an alkaline solution (Raspanti, 2020).

4.3 INITIAL BIOPLASTIC MATERIAL EXPERIMENTS

The first material experiments were designed to understand how to make a novel material using a combination of natural resources. Bioplastics consist of a biopolymer for strength, plasticizers for flexibility, a solvent such as water, and additives for additional properties such as texture, colour, strength, and durability. Bioplastic materials are usually cooked using a heat source to create a homogeneous solution that can be cast into a die and dried using a heat source (to speed up the curing time).

During this material study, multiple combinations were explored always with a constant base of water, glycerine and sodium alginate. Additional ingredients such as cornstarch, vinegar, sunflower oil, beeswax, kelp powder, chitosan and cellulose powder were tested in combination with this and analysed. Additional fibers were added for structural support. Once these initial tests were done, the novel material prototypes were evaluated and compared based on strength, translucency, flexibility, and appearance (Figure 03). Casting of bioplastics is a common way of exploring base properties of different ingredients and is largely done in bioplastic research, however it is limited in size and control of the material. The deposition of the material is not always equal and so an alternative fabrication method was considered. The viscosity of the wet material due to the natural thickening properties of sodium alginate is a suitable consistency to be robotically extruded. Because of this material quality, additive manufacturing strategies were explored to produce larger products with precision and control.

Figure 3:
Initial Kelp Bioplastic Casting Experiments.



5. SEAWEED BIOCOMPOSITE ADDITIVE MANUFACTURING

5.1 EXTRUSION PRINTING STRATEGIES AND PARAMETERS

The fabrication methodology chosen was to start on a small scale to determine the possibilities and limitations of the material and to then gradually progress to a larger scale. This extrusion printing method selected, ensured there was no possible material wastage during the additive manufacturing process. The first experiments looked at printing three-dimensionally. The alginate biocomposite paste was able to extrude and stick together horizontally and vertically, allowing for different opportunities to emerge, however the outcome of the material due to shrinkage, was not desirable. The printed prototypes shrunk by more than 50%, resulting in brittle elements (Figure 04). An alternative solution was to print two-dimensionally, in order to get more promising results. Flat sheet printing was explored, bringing resemblance to casting but instead of the material being deposited into a die, the material was deposited evenly without any scaffolding, giving adaptability to the printing process.

3D printing outcomes are affected by different parameters that can be controlled during the printing process. These parameters include: the extrusion height above the surface bed, the toolpath direction, the nozzle size and shape, and the flowrate of the material. After changing certain parameters, it was determined that this seaweed biocomposite material is strongly influenced by the directionality of the machine's toolpath.

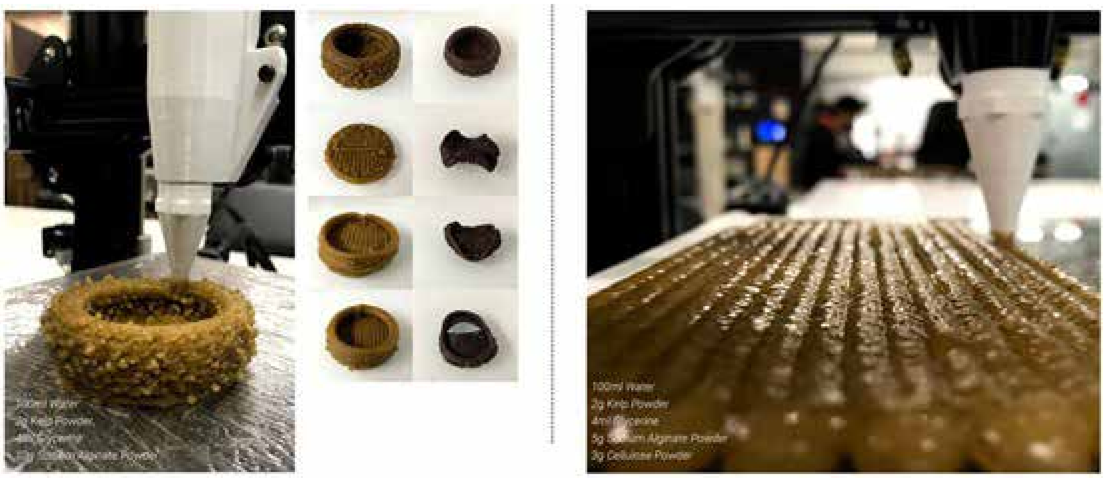


Figure 4:
(top)
Initial 3D Printing Extrusion Tests of Seaweed Biocomposite.

Figure 5:
(bottom)
Analysis of 2-Layer Extrusion Printing.

These tests were translated onto a bigger scale using the ABB140 robot where sheets of up to one meter in length could be printed. Flat, one layer sheets were successfully printed creating flexible membranes. It was observed that if a shape border is printed first and then filled in, the material is contained and pulled within this border. By combining a shape outline with a regular toolpath pattern, an evenly distributed sheet could be printed. During the drying process, the sheet shrinks in height and length through evaporation and curls upwards away from the surface.

This progressed to printing with multiple layers on top of each other. These multi-layered membranes give a certain composite 'laminate' finish, which shows the assembly of layers that are engineered to work together for a more structural element. This gives reference to the project's title as the sheets act as composite laminates of kelp (laminaria) pieces. The flat layers act as a membrane while the top ribs act as structural support. This gave way for interesting shrinkage patterns and deformations . Due to the placement of these ribs vertically and horizontally, an equal distribution of shrinkage occurred throughout the sheet (Figure 05). When the material is thicker in height, more deformations are imminent. An interesting outcome is the sine wave created on the edge of these sheets due to these ribs pulling away from the material, giving visual reference back to large kelp elements (Figure 06).

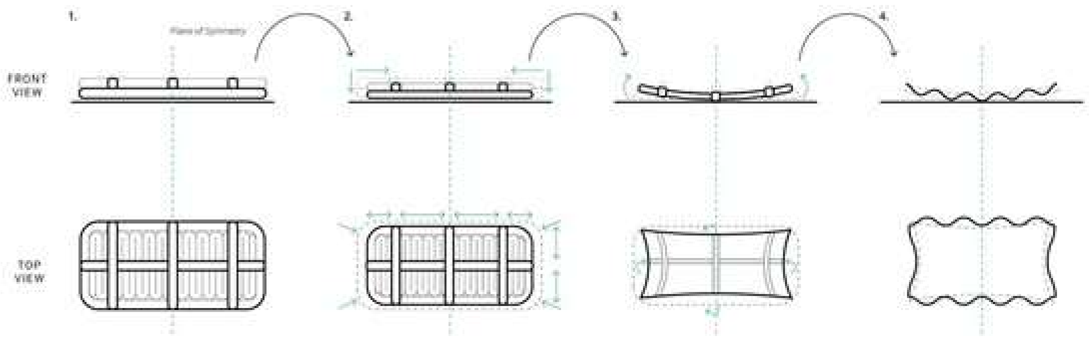


Figure 6:
(top)
Robotically Extruded Kelp Biocomposite Membrane (left) compared to Large Kelp (right).

Figure 7:
(bottom)
Distinct Physical Characteristics of Extrusion Prints.

A catalogue of one meter long sheets with shapes and strategies were tested all with two to four layers. All sheets were recorded and analyzed on their size, percentage of shrinkage, as well as effects of translucency, strength and flexibility. It is noted that on average that the sheets shrink 10 to 20 percent in length and 5 to 10 percent in width. From this catalogue of experiments certain material behaviors started to emerge, from which the designer can adapt to for a material driven design (Figure 07). Top layers, designed for structure, emerged on the underside of the sheets, giving a sense of multi materiality. Uniform sine waves appeared along the edges, due to shrinkage and pulling of material between the strategically placed ribs, giving a resemblance to its kelp material origin. Translucent patterns were seen with the presence of light, giving these flat sheets more dimensionality to them. Uniform gaps and openings started to emerge during the shrinking process where there was not enough overlapping material or weak points in the print. This shows that certain material behaviors remained the same between prototypes, where the material seemed to behave in the predicted manner.

6. RESULTS

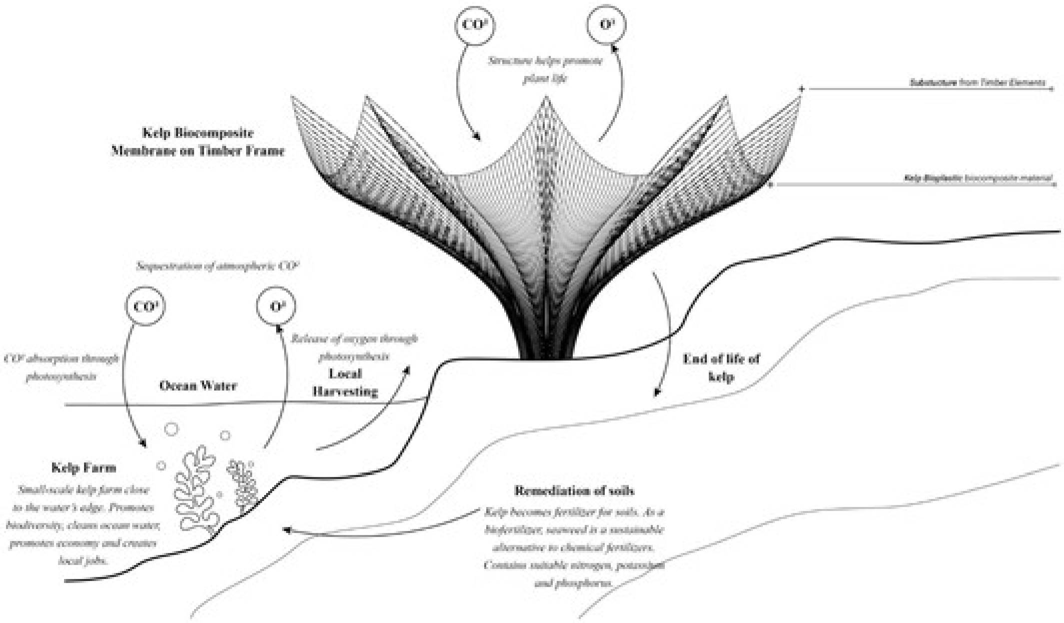
6.1 SCALABILITY OF THE MATERIAL

By combining the use of this adaptable material with additive manufacturing methods, the research opens up new possibilities for sustainable manufacturing to create large-scale biodegradable materials within the built environment. Initially it was imagined to create self-supporting membranes, that with time, because of the evaporation of water from the bioplastic, the pieces will transition from flexible elements to a rigid, more structural piece that will respond to the surrounding environment, especially heat, humidity and rain. Another approach could be to create a cladding system with this process.

6.2 MATERIAL INFORMED DESIGN & BIODEGRADABILITY

Generally, water-based bioplastics will shrink due to evaporation of water content as they cure. The loss of water causes the prototypes to shrink evenly towards the geometric centrepoint, causing spatial deformations. The inverse of shrinkage happens when you expose bioplastic to water. The presence of water or humidity can alter the overall shape of the element because of swelling due to sodium alginate related properties of water-retention. The fact that this research focuses on the recyclability of the elements, being able to dissolve within water is a key aspect that water-based materials have. By creating, fabricating and designing using renewable biomass resources, one is able to design an architectural strategy that would not contribute to carbon emissions but rather sequester them and have the ability to create a natural resource cycle. Therefore, the structure could decay and return to the earth, for the purpose of remediating soils and fueling new growth (Figure 08).

Figure 8:
Circular Resource Cycle of Seaweed Biocomposite Structure.



7. CONCLUSIONS

The research is motivated by current challenges such as carbon drawdown, material waste, as well as the need to create more sustainable manufacturing processes. The use of seaweed brings attention to underutilized resources that are found naturally in abundance and can be used and produced in a sustainable manner to create alternative renewable materials. Seaweed does not require land, fresh water or any additive fertilizers to grow naturally or farm, therefore, it does not compete with conventional agriculture practices for land space. As a natural polymer, sodium alginate is shown to have many environmental uses and benefits due to its high nutrient and salt content and remarkable mechanical and hydrophilic properties making it biocompatible and biodegradable. Due to its ability to thicken in the presence of water and form gels in the presence of calcium, it can easily be robotically extruded, dried and cured to create a water-resistant membrane which can biodegrade or be broken down and reprinted. By combining the use of this adaptable material with additive manufacturing methods, the research opens up new possibilities for sustainable additive manufacturing to create large-scale biodegradable materials within the built environment.

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HYBRID ENVIRONMENTS

A Timeline of Exploratory Nature Based Approaches in Spatial Practices

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KEYWORDS
Spatial Practices, Transdiciplinarity, Hybrid Environments, More-than-Human approaches, New Ecologies

ABSTRACT
The increasing complexity that we, as a species and civilization, are facing, ethically, socially and environmentally, require layered and complex solutions that are better achieved in and through transdisciplinary processes.

In this paper, we will showcase and analyse a timeline of spatial practices focused on transdisciplinary methodologies and biophilic design and research to expose how spatial practices research has been increasingly powered by the inspiration and potential of nature. This approach, combined with the potential of digital technologies and more-than-human thinking, is creating transdisciplinary research fields and hybrid outcomes that are acting as an important step for the ecological sustainability of spatial practices and urban systems.

The timeline unlocks a critical narrative about the importance of nature as inspiration and matter for spatial design and how technological development is merging spatial practices and natural sciences. This transdisciplinary collaboration is creating a meaningful and ontologically relevant impact towards healthier and sustainable spatial practices and built environments.

1. INTRODUCTION

The activation of transdisciplinarity in architecture is a mandatory step towards innovative spatial production and research, as well as upbringing new solutions and spatial typologies for urban contexts (Doucet & Janssens, 2011; Woiseth & Nilsson, 2011; Lawrence & Després, 2004). The set of relations architecture promoted with different knowledge fields has been changing throughout history accompanying different cultural backgrounds and its technological power, while providing solutions for the time's agency (Young, 2019; Gonçalves et al, 2018).

In this paper we will focus on new ecology urban planning, more-than-human thinking, and hybrid environments. This will be done by showcasing and analysing a timeline of spatial practices focused in transdisciplinary methodologies and biophilic design and research. This mapping exposes how the shift from mechanical to digital software enhanced research powered by the inspiration and potential of nature, creating transdisciplinary research fields, practices and hybrid environments

The timeline unlocks a critical narrative about the importance of nature as inspiration and matter for spatial design and how technological developments are merging spatial practices and natural sciences. This transdisciplinary collaboration is creating relevant impact towards healthier and sustainable spatial practices and built environments and exposes how spatial practices research has been increasingly powered by the inspiration and potential of nature.

2. METHODOLOGY

The paper will be divided in 3 parts: (1) literature review; (2) research method explanation and exposition; (3) findings and conclusions.

In the first part, we will present a literature review about the origin, definition and importance of transdisciplinarity and approach digital architecture as an inherently transdisciplinary practice.

We will show how new urban planning and spatial practices demands socially and environmentally engaged practices, presenting a literature review about more-than-human thinking (Jon, 2020; Maller, 2018; Latour, 1999), and its connection with hybrid spatial practices trough Biophilia, Biophilic Design (Chayaamor-Heil, Vitalis, 2020; Oxman, 2014; Menges, 2007; Kellert & Wilson, 1993). The literature review will show how transdisciplinary spatial practices are working with ontologically relevant questions of the practice and society, analysing its positive aspects to deal with complexity problems (Bernstein, 2015; Burry&Cutler, 2009; Young; 2019; Wilson, 1996).

In the second part, research, we will showcase a timeline of experimental spatial production and technological developments. The timeline maps the 1960-2020 period and is split in two main branches: (1) art and architecture production; (2) digital technology developments; and two secondary: transdisciplinary research centres; concepts and authors. This mapping exposes how digital technologies enhanced spatial practices and research powered by the inspiration and potential of nature, leading spatial practices towards transdisciplinary processes and hybrid outcomes.

In the third part, we will share our final conclusions.

2.1 LITERATURE REVIEW

The activation of transdisciplinary architecture is a mandatory step towards innovative spatial production and research, as well as upbringing new solutions and spatial typologies for urban contexts (Doucet & Janssens, 2011; Woiseth & Nilsson, 2011; Lawrence & Després, 2004). The set of relations architecture promotes with different knowledge fields is changing throughout history accompanying different cultural backgrounds and its technological power, while providing solutions for the time's agency (Young, 2019; Gonçalves et al, 2018).

Applying More -than-Human and New Ecologies approaches by "recognising non-humans actors such as plants, animals and technologies" (Maller, 2018, p. 19), and questioning to which species we can be designing for, should be regarded not as a selfless gesture, but as a methodology to achieve ecologically sustainable urban systems and spatial practices.

Spatial practices are now, through exploratory research, asserting the human need to be in touch and in symbiotic relation with nature (Kellert & Wilson, 1993; Maller, Wilson & Townsend, 2009), discovering how to embed nature in the artificial environments we inhabit.

The mapping of Nature-Based Solutions and biotechnologies in spatial practices and the development of a correlation analyses between the practice, research and technological developments allows for a critical narrative about the increasing importance of embedding nature in the multiple scales of spatial practices, methodologies and our built environments.

2.2 RESEARCH: TIMELINE ANALYSIS

Climate change is demanding the adequacy urban territories to the current crisis and effects we are already feeling. Nature, “rather than being discounted as an inanimate background that merely hosts human affairs, is now considered an active agent that influences how we design and plan for a city” (Jon, 2020, p. 392).

This context is increasingly merging spatial production with natural sciences and potentiating digital technology application, expanding architecture’s field of action, with emergent hybrid practices based in transdisciplinary approaches (Vidler, 2004; Kak, 2007). Nature-based solutions and the inclusion of biotechnologies in spatial research, digital fabrication, materials and hybrid environments, that merge natural and artificial systems, can contribute to change contemporary spatial production and develop projects that are “acknowledging our material dependency on and interconnectedness with non-human critters” (Jon, 2020, p. 392).

The XIX century industrial shift can be used as an example of how spatial practices took advantage of the new available technologies: pre-fabrication and modularity were the basis of an exploratory approach to design and building that also relied on the new transport systems. The Expositions Universelles can be pinpointed as more exploratory research and application of the new technological possibilities provided by the industrial revolution. This exploratory phase can be traced as the basis of modernist movement, pre-fabrication and modularity, and the overall access to dwelling in urban territories. At the same time, authors, such as William Morris, and the eco-socialist movement were carefully analysing the impact of the new production system and economic growth, from a small, yet established, economy and social scale.

Nowadays, spatial practices are dealing with highly layered contexts, in which space cannot be detached from politics and economy, and also from the impact spatial production, and all the choices that are involved in its process, can have in our environment and nature.

The analysis starts with Buckminster Fuller’s proclamation of the World Science Decade, at the 7th International Symposium of Architecture, by the International Union of Architects, held in Mexico. The event was chosen as a starting point due to its inherent transdisciplinary nature, that challenged practitioners to overcome structurally compartmentalized thinking processes and engage in research that could change the relationship between world resources and human needs (Fuller & McHale, 1964).

In the macro urban scale, spatial practices should have in consideration the uniqueness of the specific environment of the interventions: the ecological systems, the flora and fauna, and its current state of health, local materials and resources.

In the micro project, scale, the potential of digital technology, and the increasing role of research in spatial design are changing the practice and the building industry towards transdisciplinarity and hybridity of building technologies, materials and environments. This paradigm was also favored by the shift from mechanical to digital technology, that had a profound impact in spatial practices

In the 2000-2020 period of analysis, scientific and artistic practices and research denote an overall tendency to inquire about our relationship with nature and its redefinition. Nature is being regarded as media.

These tracks and approaches are developing:

Building technologies, based in digital fabrication and robotic construction, vernacular structures and materials, exploring the potential of parametrization and digital fabrication;

Biobased and circular materials research;

new spatial conceptions and typologies developing new spatiality- promoting new possibilities of uses for public space and plural social interactions in urban spaces;

Adaptive and evolutionary structures and spaces, feedback and real time data processing to enable reactive solutions and informative devices.

These tendencies are responding to climate change and the necessity to create resilient practices and territories. Spatial practices, architecture, urban and product design must now, urgently, have in consideration a bigger scope of analyses regarding their environmental impact.

The analyses, or framework, should have in consideration micro and macro perspectives and regard local and global scale. This should be achieved from the point of view of spatial quality and social welfare (also from economical perspective - what kind of economy and politics is the space promoting and supporting), and the relation with local and external natural systems.

3. FINDINGS AND CONCLUSIONS

The conception and analysis of the timeline enables the development of a critical narrative about experimental architecture, urbanism, and the evolution of nature-based solutions in spatial practices. The intersection of art, science and technology (based in the analysis of natural structures, their performance, behavior and feedback), is becoming a fruitful research field for meaningful spatial research and production. Regarding nature as matter and inspiration is expanding architecture's field of action, possible contributions, and contributors.

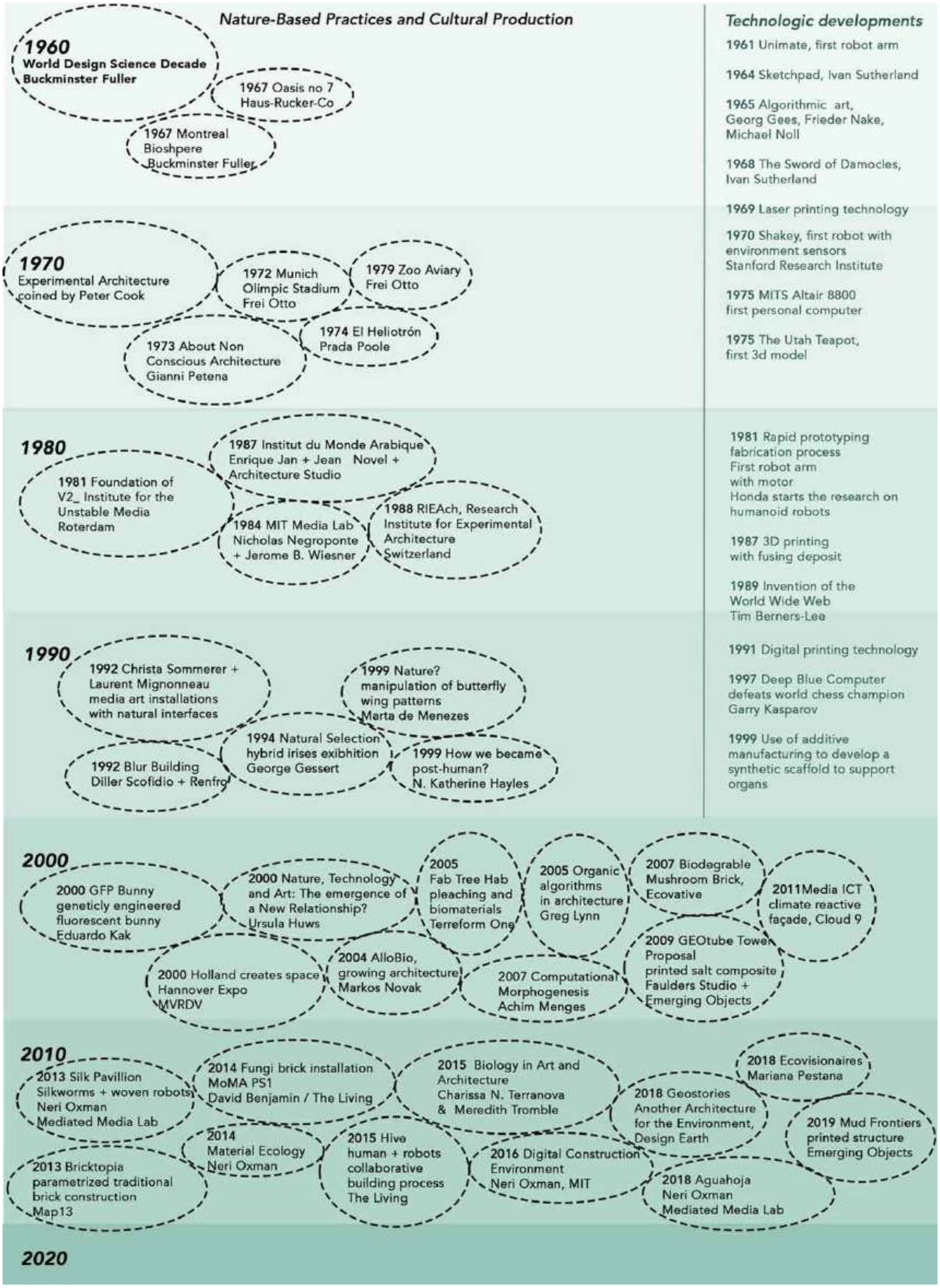

Figure 1:
NBS Cultural production in the 1960-2020 period.

The hybridization of spatial practices and built environments, with intertwined artificial and natural systems, can fulfil “the biophilia hypothesis (…) of a biologically based, inherent human need to affiliate with life and lifelike processes” (Wilson, 1984, p.1.) and the suggestion that human identity and personal fulfilment somehow depend on our relationship to nature (Kellert&Wilson, 1993). Instead of distancing society from its main provider -externalizing nature from our productive systems and cities (Latour, 1999), new urban design should and can allow humans to be placed in and depend on nature, in a direct and noticeable way.

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NOW AI

Data-driven web interface for Inclusive & Responsive Cities

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KEYWORDS
Urban Risk Management, NBS, K-means clustering, ArcGIS,RhinoCompute.

ABSTRACT
Nowadays, about 50% of the world's population lives in urban centres; this massive movement of people has developed a rapid urbanization process that falls into informal settlements increasing environmental and socio-economic risk. On the other hand, there has been a significant improvement in digital technologies applied to data analysis and design (Architectural and Urban Design). These new digital paradigms can help designers depict, analyze and utilize urban and environmental data in early design phases. This paper defines a new methodology using digital tools to interpret environmental and socio-economic data for Bogota – Colombia. Moreover, it suggests a new digital workflow that uses computational design techniques such as Machine Learning, Grasshopper, and Rhino Compute to identify vulnerable areas of the city.
The purpose is to demonstrate how a computational design workflow between ArcGIS and Grasshopper (Rhinoceros McNeel) improves the interpretation of urban data and helps identify communities exposed to emerging inequities and environmental conditions. As a result, this paper proposes manipulating GIS data into Grasshopper to introduce a new methodology that targets projects by implementing Nature Bases Solutions (NBS) to address environmental, cultural, and social values.

1. INTRODUCTION

The Urban Risk Assessment (URA) presents a flexible approach that city planners can use to identify feasible measures to assess a city's risk through three reinforcing pillars to understand urban risk: a hazard impact assessment, an institutional assessment, and a socio-economic assessment. (World Bank, 2021)

Risks can be described as an interaction between exposure to natural hazards, such as flooding, landslides, bushfires, and the vulnerability of societies. It is the function between the hazard (Probability of occurrence of potentially damaging events), the level of exposure of the societies (exposure receptors that may be affected), and the level of vulnerability. (Mc Gahey 2009)

In this sense, Nature-based solutions (NBS) appear as strategies and actions that help protect, restore and manage natural ecosystems and their services. (Oxford 2021). Therefore, by following NBS principal goals, it would be possible to enhance sustainable urbanization for economic growth, restore degraded ecosystems for resilient ecosystems, develop climate change adaptation and improve risk management (European Commission 2020). Implementing NBS on an urban planning scale could bring new sustainable processes and enhance the ecosystem services, such as water purification, soil erosion protection, floods damage control, and carbon sequestration. In addition, the NBS can protect against floods, runoff, and landslides through afforestation and reforestation. Likewise, urban parks, vegetation, and trees would effectively store CO2 and provide cooling and insulation to reduce the urban heat island effect. In addition, green roofs can decrease the need for heating and air conditioning.

Moreover, through watershed management and blue infrastructure, such as water covering surfaces, detention ponds, bioswales, It would be possible to reduce the risk of floods and droughts while improving water quality (Kabisch, N., Korn, H., Stadler, J., & Bonn, A. 2017).

There is a need to identify places where NBS should be located, identify local conditions, and identify the vulnerable population that could benefit. On the other hand, there is a need to propose integrating modelling techniques with collaborative processes. In this sense, risk maps are an essential tool to communicate hazards and associated risk levels. They are necessary for decision-making because they are visual tools that help determine the spatial distribution of vulnerable socio-economic and environmental conditions.

2. RESEARCH OBJECTIVES

The presented paper is placed in the computational design field applied to large-scale urban systems, focusing on socio-economic and environmental urban data in Bogotá, Colombia. This paper aims to implement a data-driven approach to urban policy decision-making by underpinning Bogota's environmental, cultural, and socio-economic values.

The result of this process is highlighted in a Risk Map that depicts the city's most vulnerable areas by incorporating multiple layers of information. Moreover, it explores a new workflow between ArcGIS, Grasshopper (Rhinoceros McNeel) & RhinoCompute (Rhinoceros McNeel), intending to manipulate and visualize the urban data to propose potentially locations to introduce Nature-Based Solutions (NBS).

3. METHODOLOGY

ArcGis was chosen as the primary tool to analyze the city of Bogotá to manipulate and develop an urban spatial analysis related to geographical information by using machine-learning classification methods (ArcGIS 2021). The methodology is proposed in three scales: metropolitan, urban district, and neighborhood-scale (Figure 1).

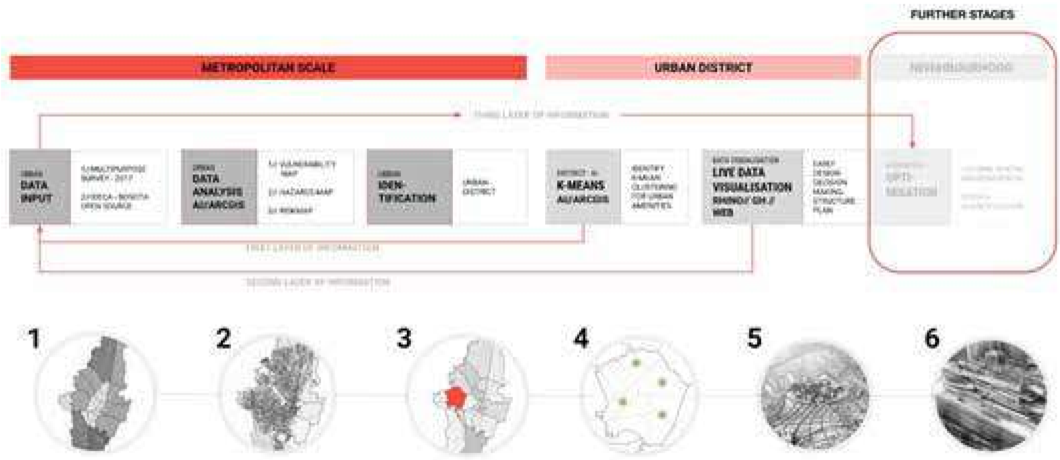


Figure 1:
Research Methodology Diagram.

A GIS-based spatial multi-criteria analysis was developed on the metropolitan scale to produce a Risk Index Map that combines environmental hazard data and existing vulnerability information (Figure 2) to identify the highest risk areas of the city. For this research, two data sources were selected: The Multipurpose Survey (2017) developed by the District Planning Secretary (SDP) and the open-source data collected from IDECA (Infrastructura de Datos Espaciales para el Distrito Capital) website.

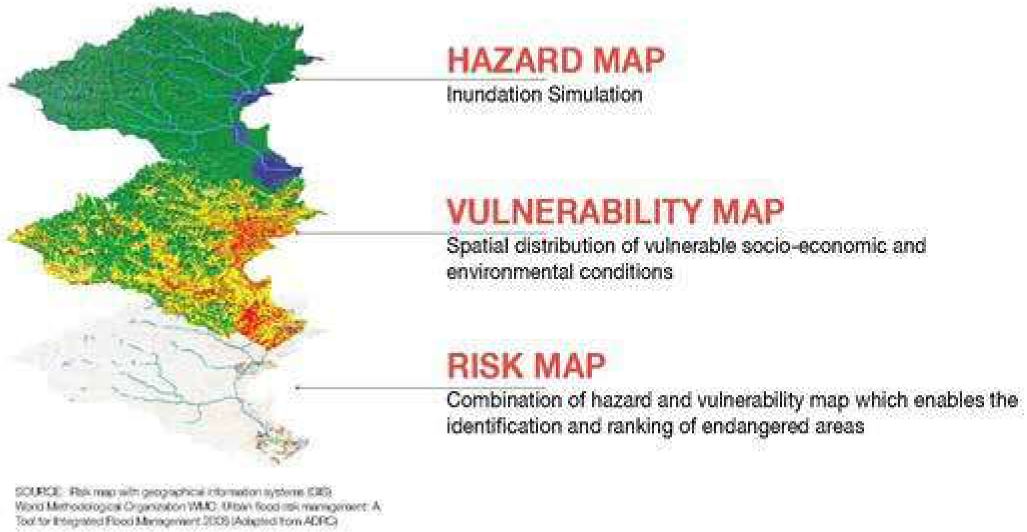


Figure 2:
Risk Map Layers.

In this way, a computational design strategy is proposed to identify places where Nature-Based Solutions could help risk mitigation and improve cultural, social, and educational values. The intention is to manipulate the result from ArcGIS into Grasshopper to visualize new urban data as a potential solution to the risk issue in the city. The final result is a user interface using RhinoCompute (Rhinoceros McNeel) that enables interaction and introduces new planning paradigms to visualize the impact & integration of NBS for early decision-making in real-time (Figure 03)

4. BOGOTA URBAN ANALYSIS

4.1 URBAN ANALYSIS METHODOLOGY

One of the most common methods to analyze, assess and evaluate the flood risk is the Multi-Criteria Decision Analysis (MCDA), which establishes preferences between options (choices) by referencing an explicit set of objectives. Typically, decision-makers use it, involving selecting tangible and intangible criteria with different units, scores, and weights (Mc Gahey 2009). MCDA provides a variety of techniques and procedures to structure decision problems, design, evaluate, and prioritize alternatives for decision-making. (Murayama 2011). In order to have equivalence and compatibility, a standardized process needs to be implemented to relate the information in an approximate equivalence. For example, map values are converted to a range between 0 and 1. The closer these numbers are to 1, the higher the probability or vulnerability is.

4.2 VULNERABILITY INDEX MAP DISTRIBUTION

The Vulnerability Index is a determinant in flood risk because it determines whether the population or assets are exposed to a hazard that can constitute a risk that may result in a disaster. For this research, the Vulnerability Index uses a group distribution that includes social and economic urban data; in addition, vulnerability considers concepts and the situation of a settlement in terms of its susceptibility, lack of coping capacities, and adaptability to adverse impacts of natural hazards (WorldRiskReport 2021).

4.3 POPULATION DISTRIBUTION & MULTIDIMENSIONAL POVERTY INDEX

The information about the population distribution was used to determine the densest area within the city. There is a significant concentration mainly in the periphery and a lower concentration in the city's centre due to economic activity (Figure 3). The Multidimensional poverty index is made up of five indicators: education, conditions of children, health, work, access to public services, and housing conditions. (Figure 4) The results reveal a concerning situation to the south of the city in Ciudad Bolivar and Usme, being Usme the district with the highest percentage (DANE 2017)

4.4 SECURITY PROBLEM & AVERAGE INCOME

The proportion of housing with security problems in Bogotá ranges from a minimum of 36.9 percent in Chapinero to a maximum of 86.8 percent in Los Mártires, a difference that can be explained by the presence of high-impact activities, particularly the red district in the city centre (Figure 5). In addition, the insecurity problems are related to the income level because the four districts with the highest security problems have the lowest levels of income to the south, which is the case of Usme, Ciudad Bolívar, Tunjuelito, and San Rafael. On the contrary, the highest income is located in the central and north areas of the city (Figure 6).

4.5 STRATIFICATION & HOUSING DEFICIT

Stratification is the classification of residential properties to receive public services (Figure 7). It was developed to charge each of the stratifications for the public services differently. In this way, those with more economic capacity pay more for the public services and contribute to the ones with the worst financial ability, and it is done based on the conditions of the building and the context (DANE 2021). The housing deficit determines the housing needs and conditions of households. Housing is a good that must supply a series of needs and consequently must have a series of characteristics that meet this. In Bogotá, the highest housing deficit is located to the south of the city, mainly in the districts of Tunjuelito, Rafael Uribe, San Cristobal, and Ciudad Bolivar and Usme (Figure 8)

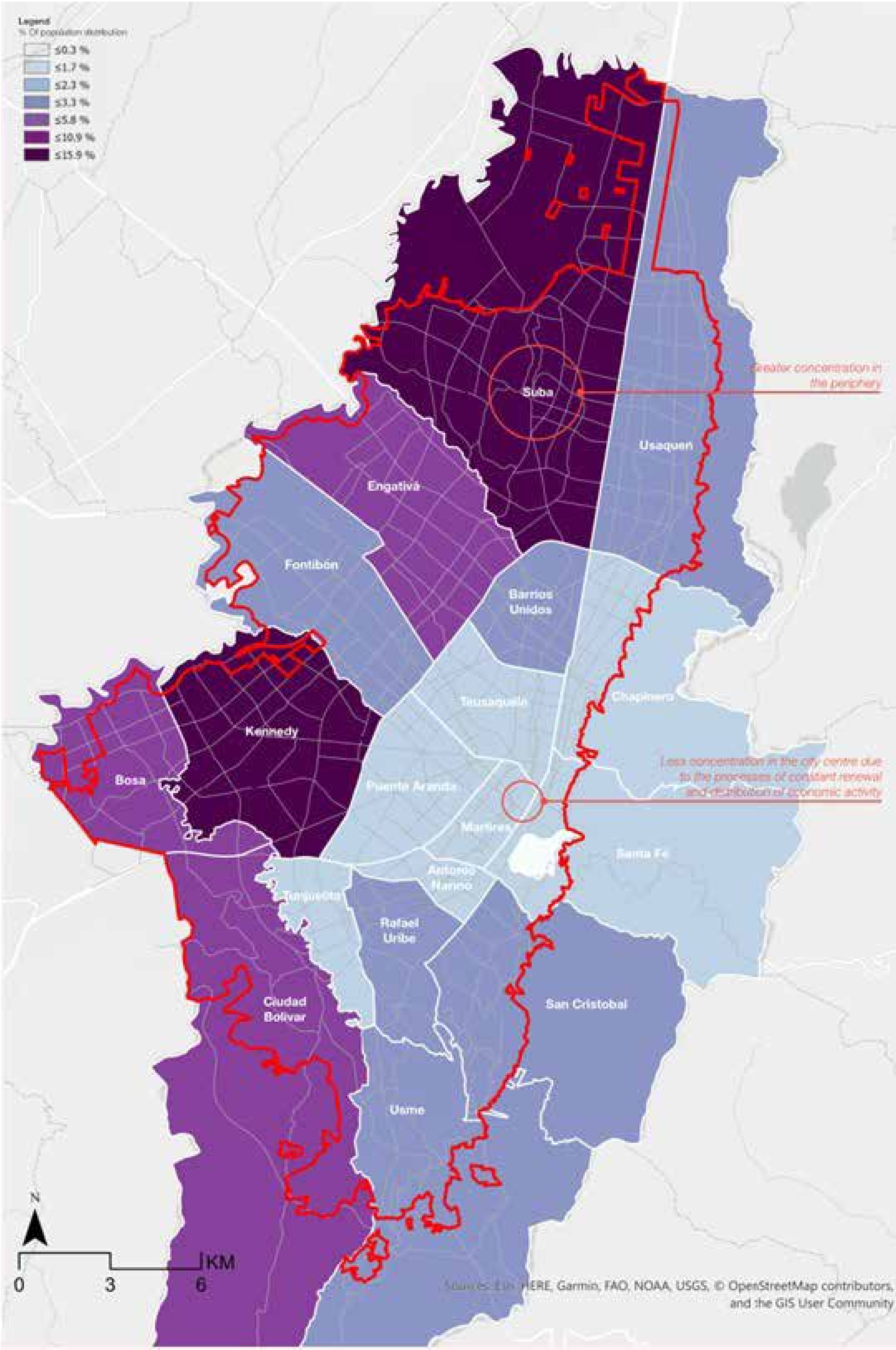


Figure 3:
Bogota Population distribution.

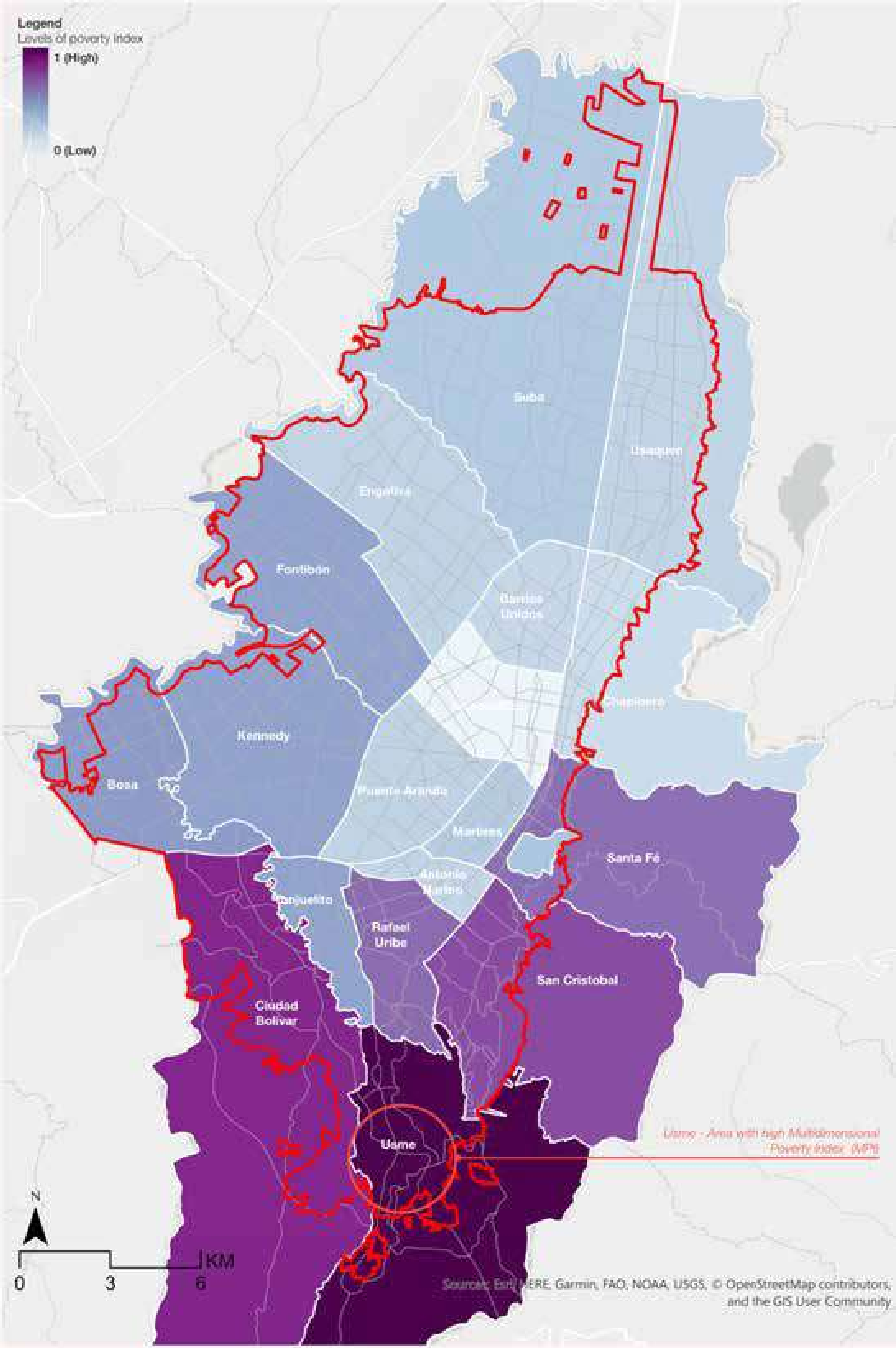


Figure 4:
Bogota Multidimensional poverty index.

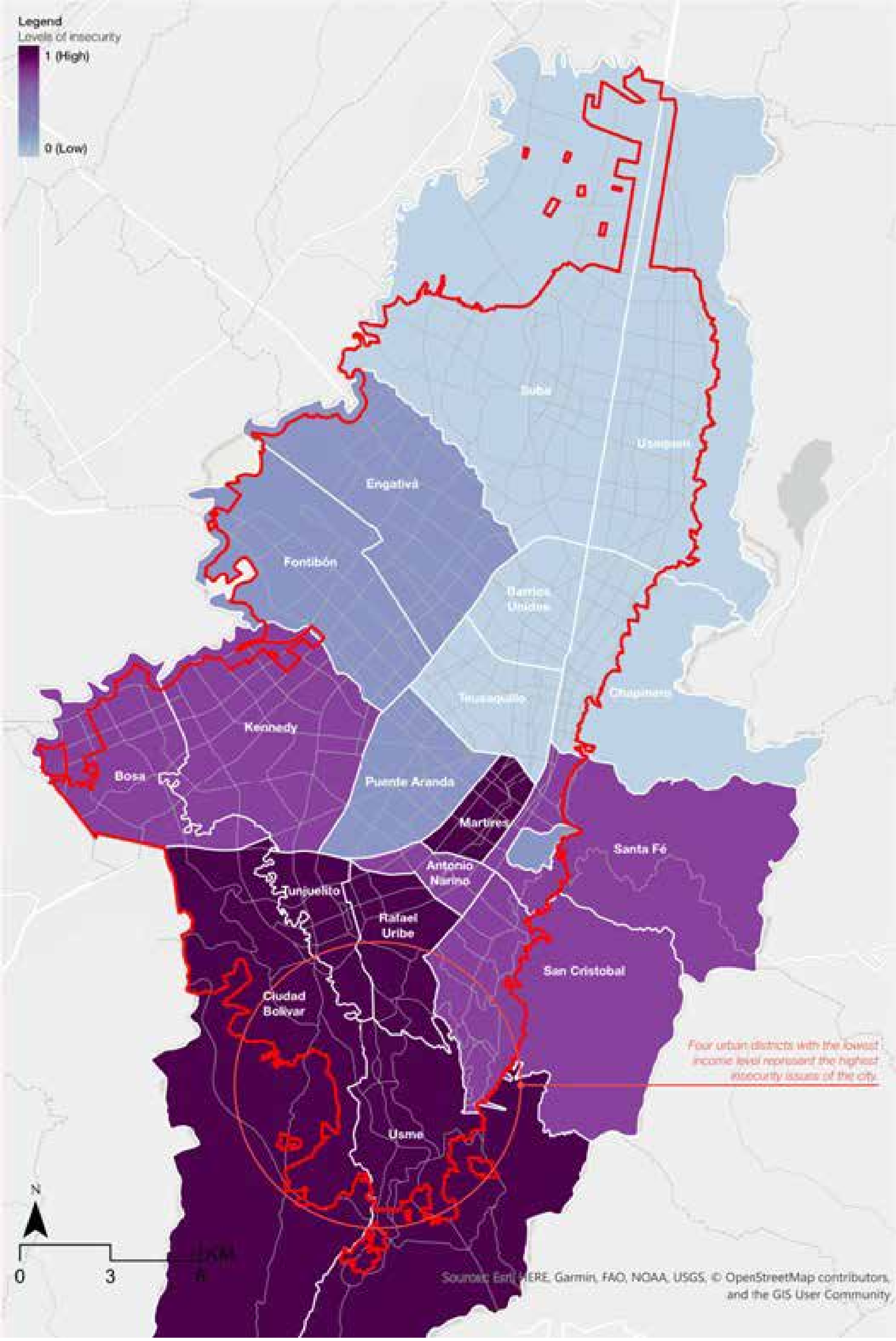


Figure 5:
Bogota Security problem.

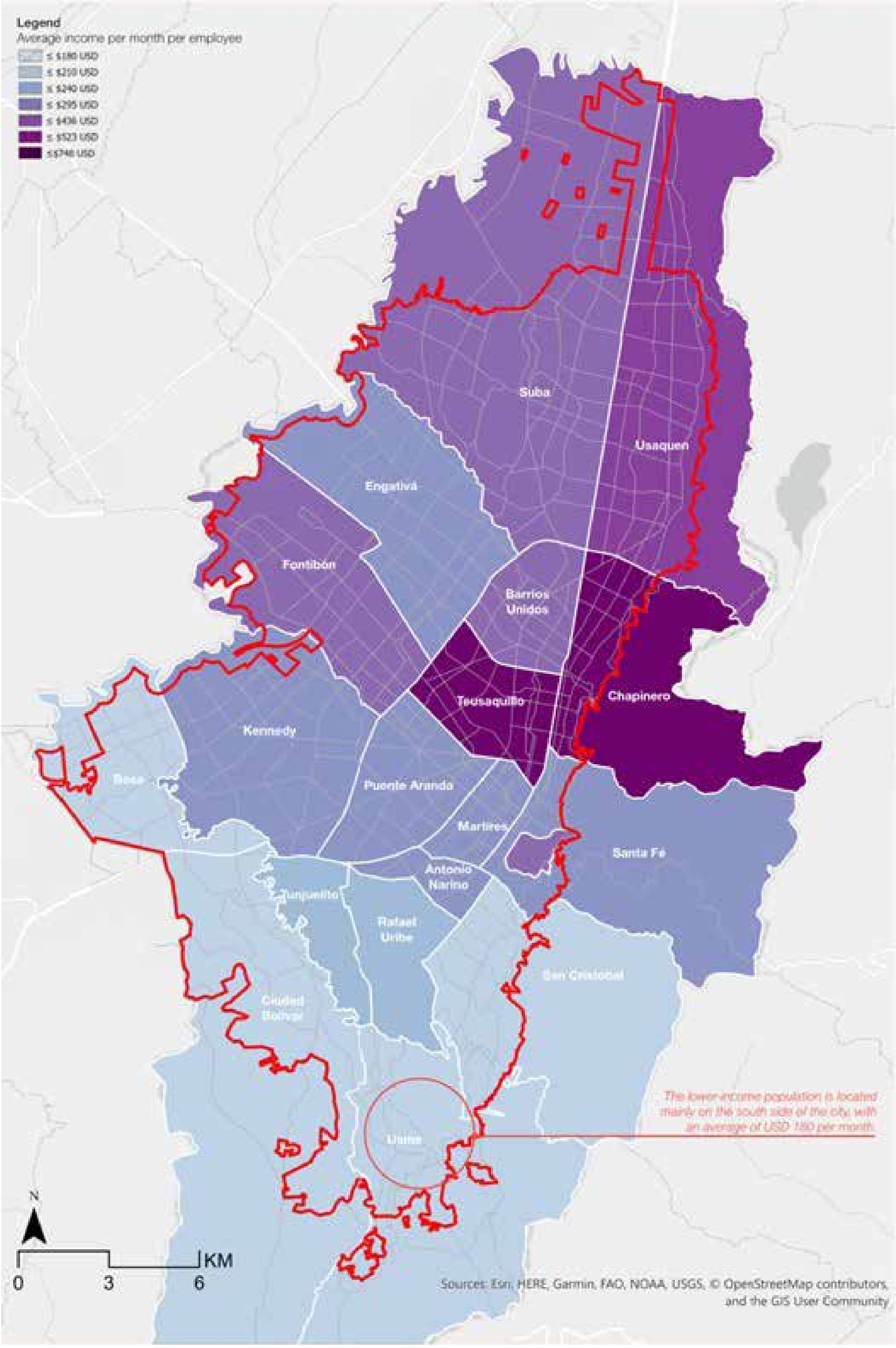


Figure 6:
Bogota Average income.

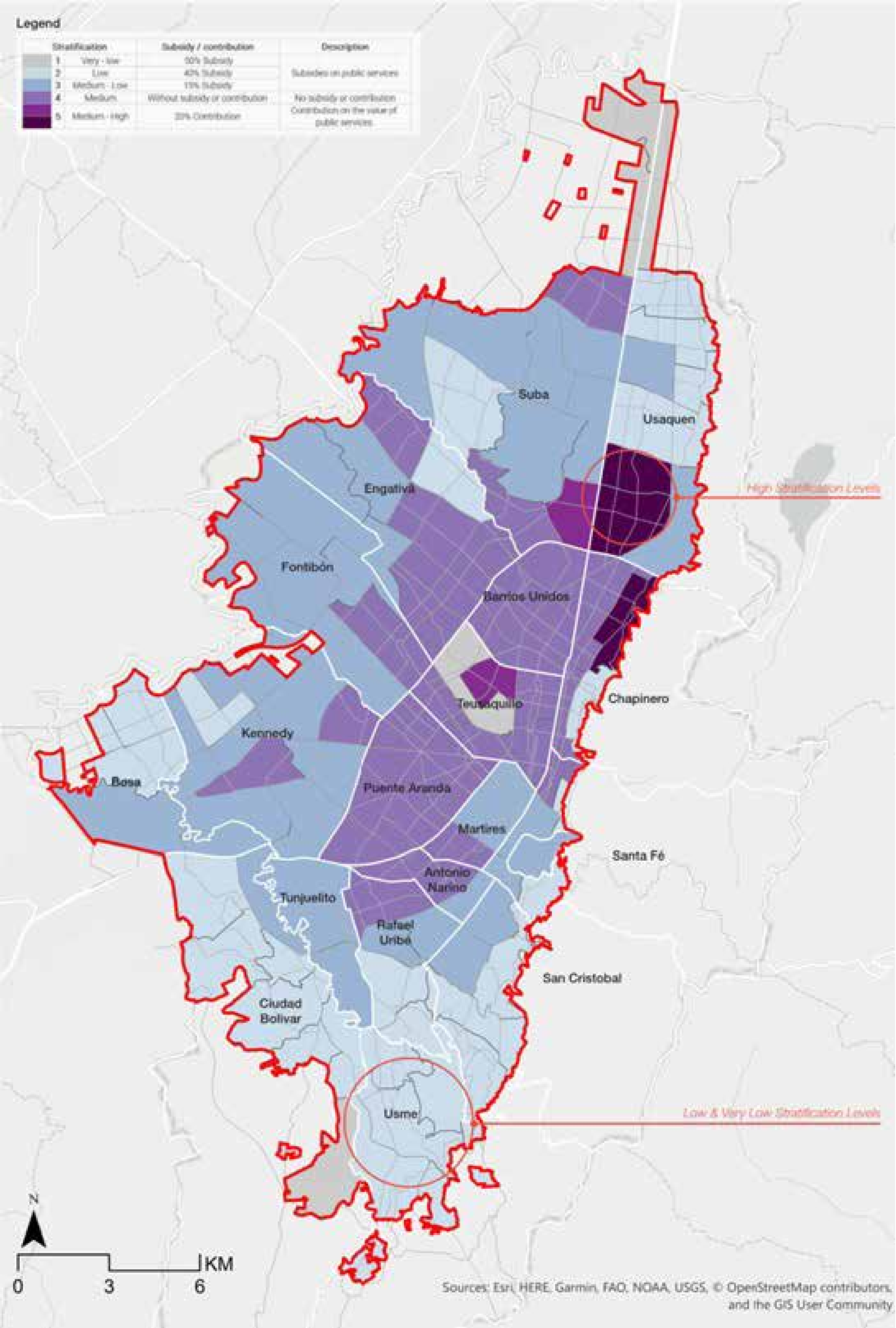


Figure 7:
Bogota Stratification.

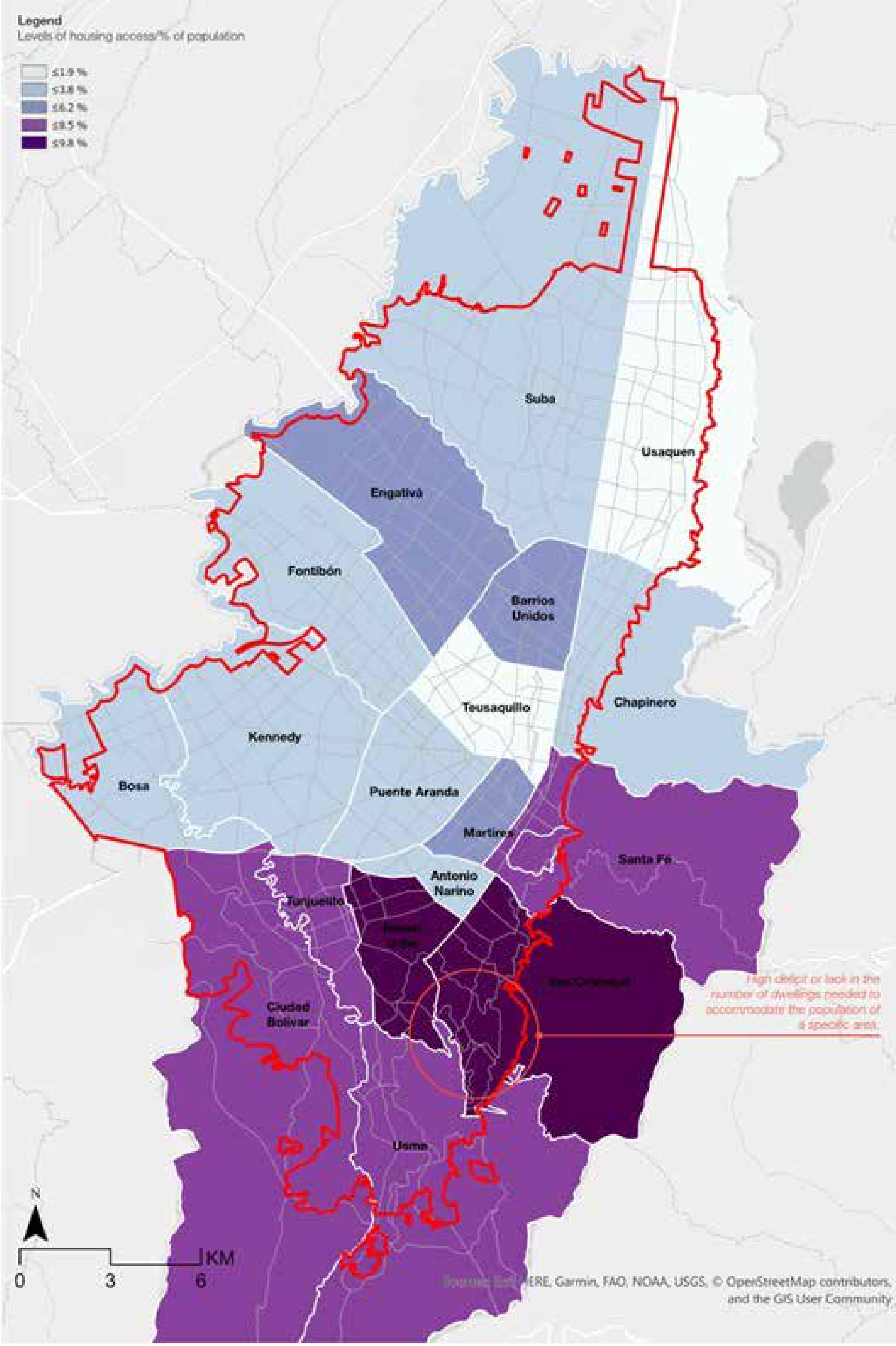
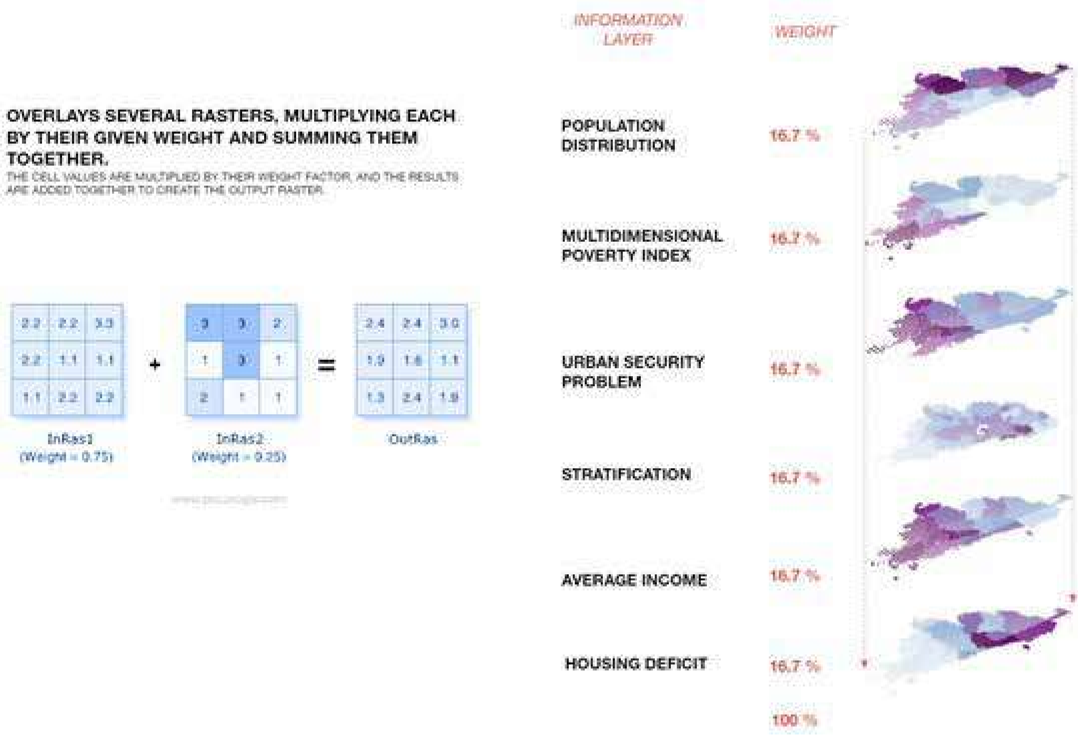


Figure 8:
Bogota Housing deficit.

Figure 9:
ArcGIS tool weighted sum.

4.6 GIS WEIGHTED SUM TOOL & VULNERABILITY MAP

In order to obtain the vulnerability index map and combine the selected criteria, the ArcGIS tool weighted sum was used, which can combine multiple inputs to create an integrated analysis (Figure 9). It multiples raster inputs, representing multiple factors, and can be easily combined incorporating weights, then it sums all input raster together to create an output raster. (ArcGIS 2021) In this sense, the six selected raster layers were overlaid, multiplied by their given weight (16.7%), and then summed up. As a result of the weighting and standardization, the final vulnerability index map is shown in Figure 10. The south part of the city shows to be the most critical location in the city.



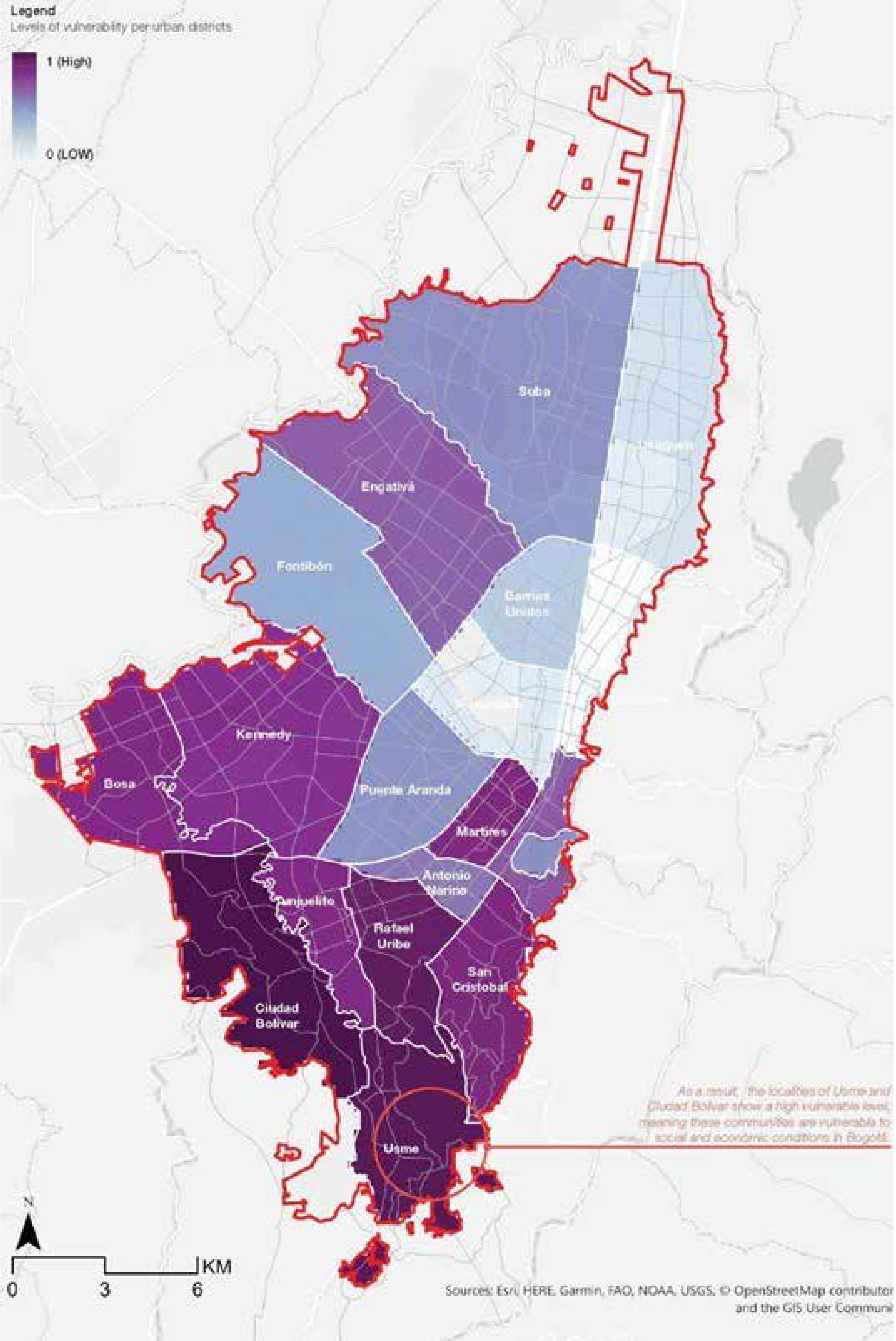


Figure 10:
Bogota Vulnerability Map.

4.7 THE HAZARD & WEIGHTED SUM MAP

The criteria selected for the Hazard map are landslides, bushfires, and floods. The origin of a hazard can be either a natural phenomenon or caused by human actions or activities. Hazards combine a complex mix of processes that involve environmental and human activities. Since it is understood as a phenomenon, its occurrence is hard to predict. One of the main reasons is the unplanned and fast-growing cities (Jha et al., 2012)

Due to the city's urban growth, a significant population is located on the eastern and southern slopes. Most of these sloped terrains are exposed to a high probability of a landslide hazard; Figure 11 shows the highest probability to the east and south of the city. Likewise, the flood hazard is the probability of occurrence of potentially damaging flood events. (Schanze et al. 2006). The flood caused in Bogotá happens due to natural influences (fluvial, pluvial, or groundwater causes) and can be human-induced, like the saturation of the combined sewage system by contamination (el Tiempo 2020) and the change of vegetation to impervious surfaces.

In Figure 13, is shown the highest levels of the river overflow probability located to the Bogotá River in the west; in the same regard, the bushfire event is related to the conditions of increase in temperature due to the incidence of the "El Niño" (Secretaría Distrital de Ambiente, 2020). In Bogotá, 42% of the territory is categorised as a high threat, characterised by high slopes and an abundance of vegetation, which, together with high temperatures, make fires easy to start (Figure 12).

The final Hazard map was created as well using the weighted sum. In this case, the three hazard-selected raster layers (Landslides, Flooding, and Bushfires) were overlaid, multiplied by their given weight (33.3%), and then summed up. The final result is shown in Figure 14. Areas with higher hazards remain in the periphery of the urban boundary. They have a direct relationship with the major river, Bogotá eastern hills, and the unplanned areas of the city.

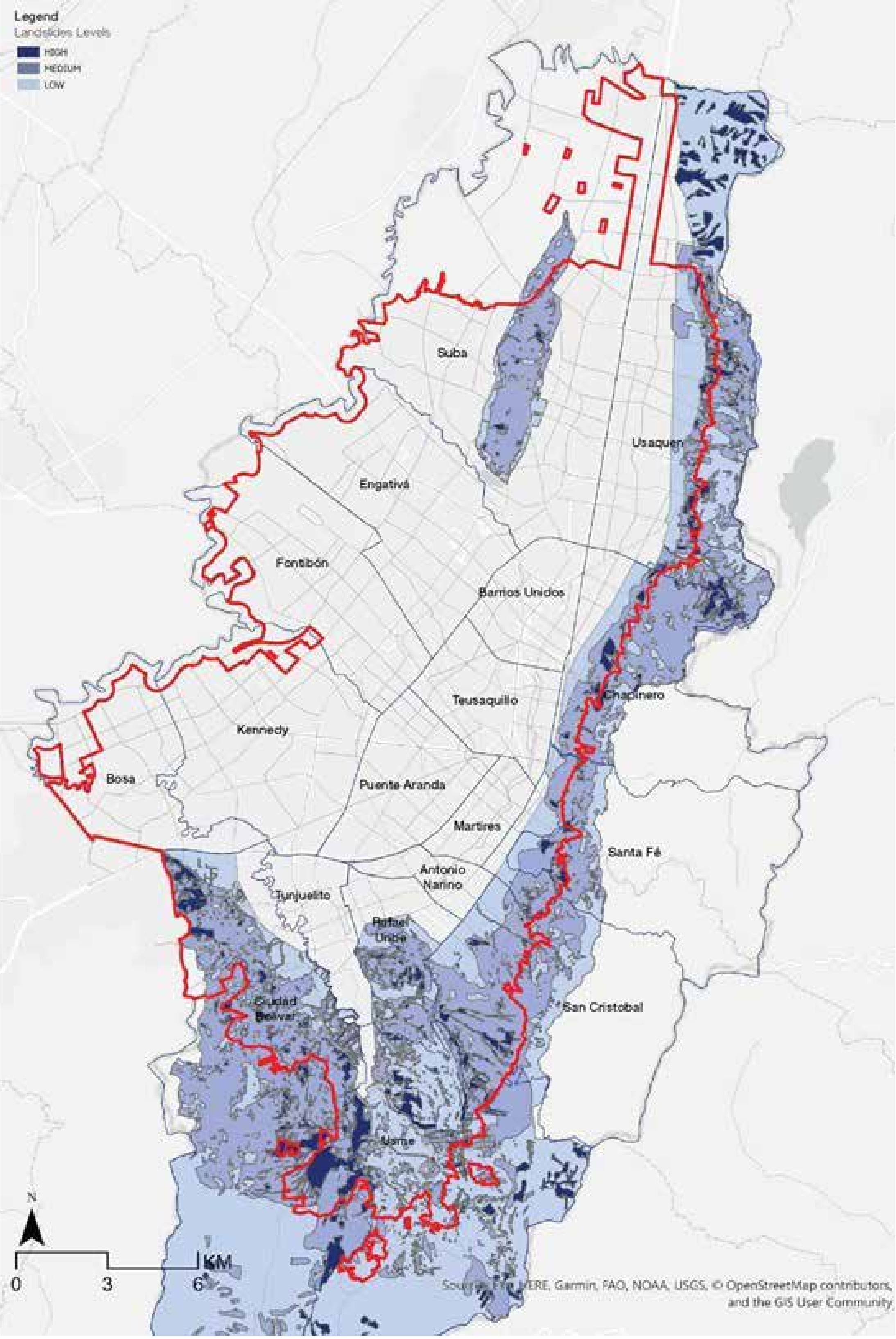


Figure 11:
Bogota Landslides Map.

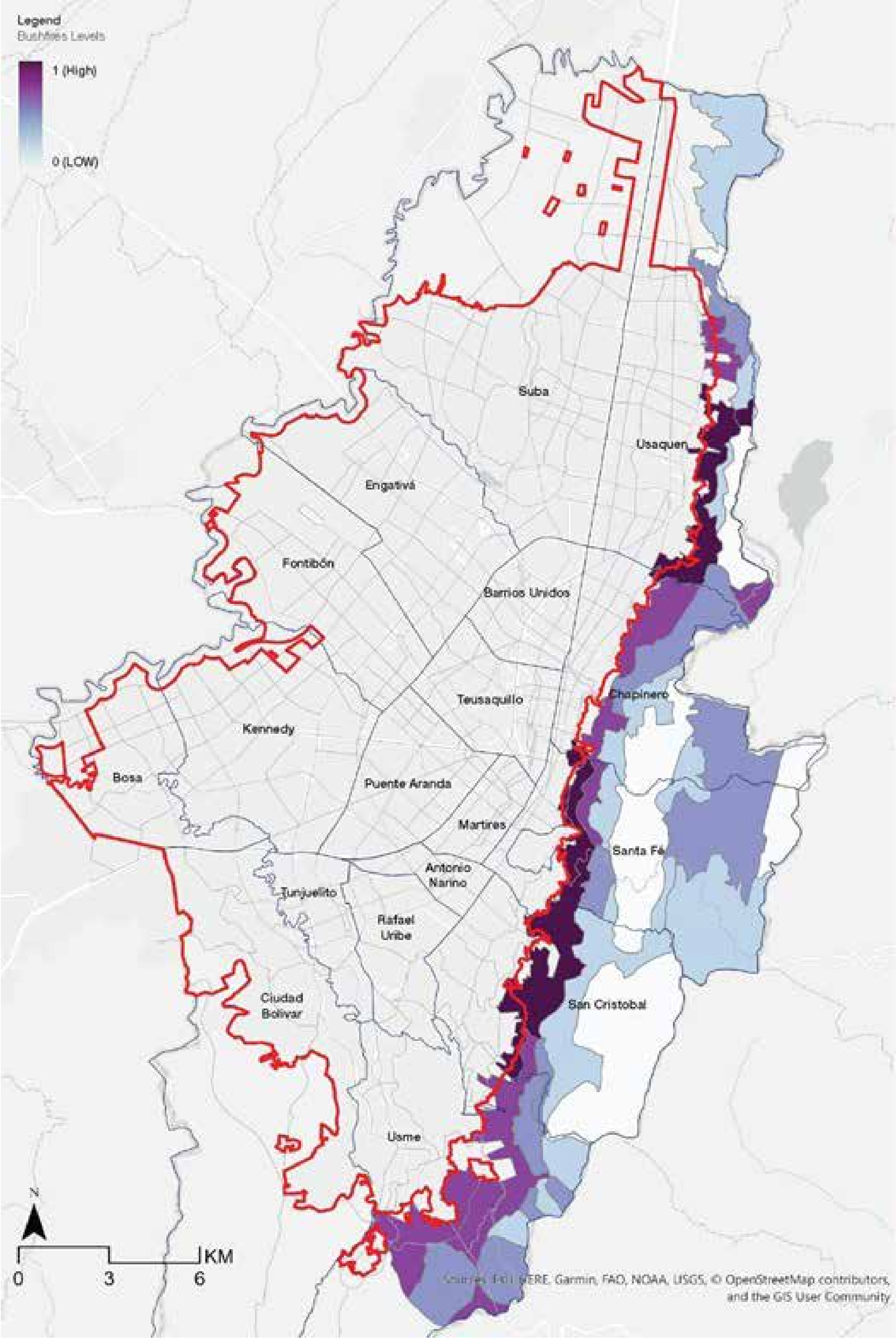


Figure 12:
Bogota Bushfires.

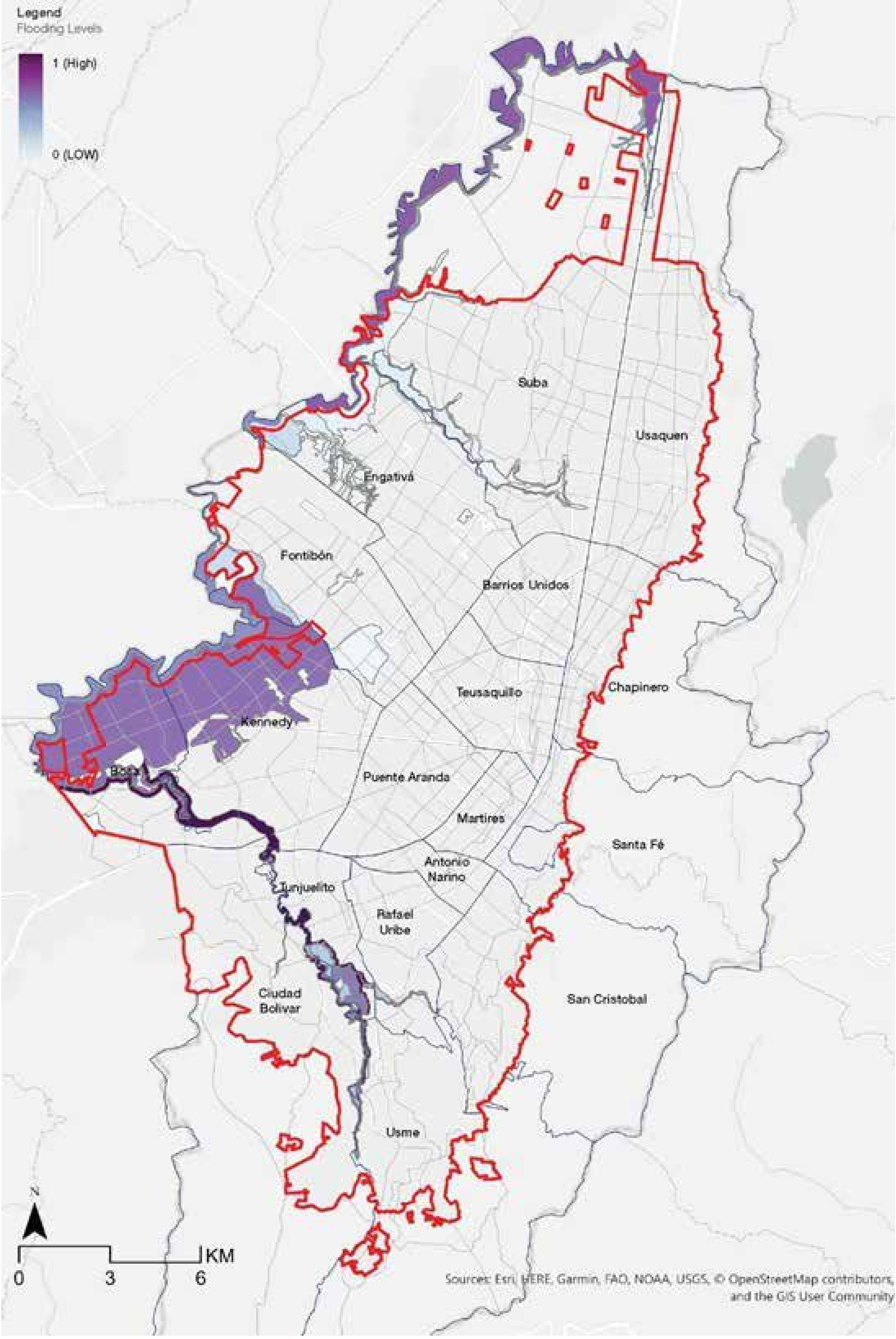


Figure 13:
Bogota Flood Map.

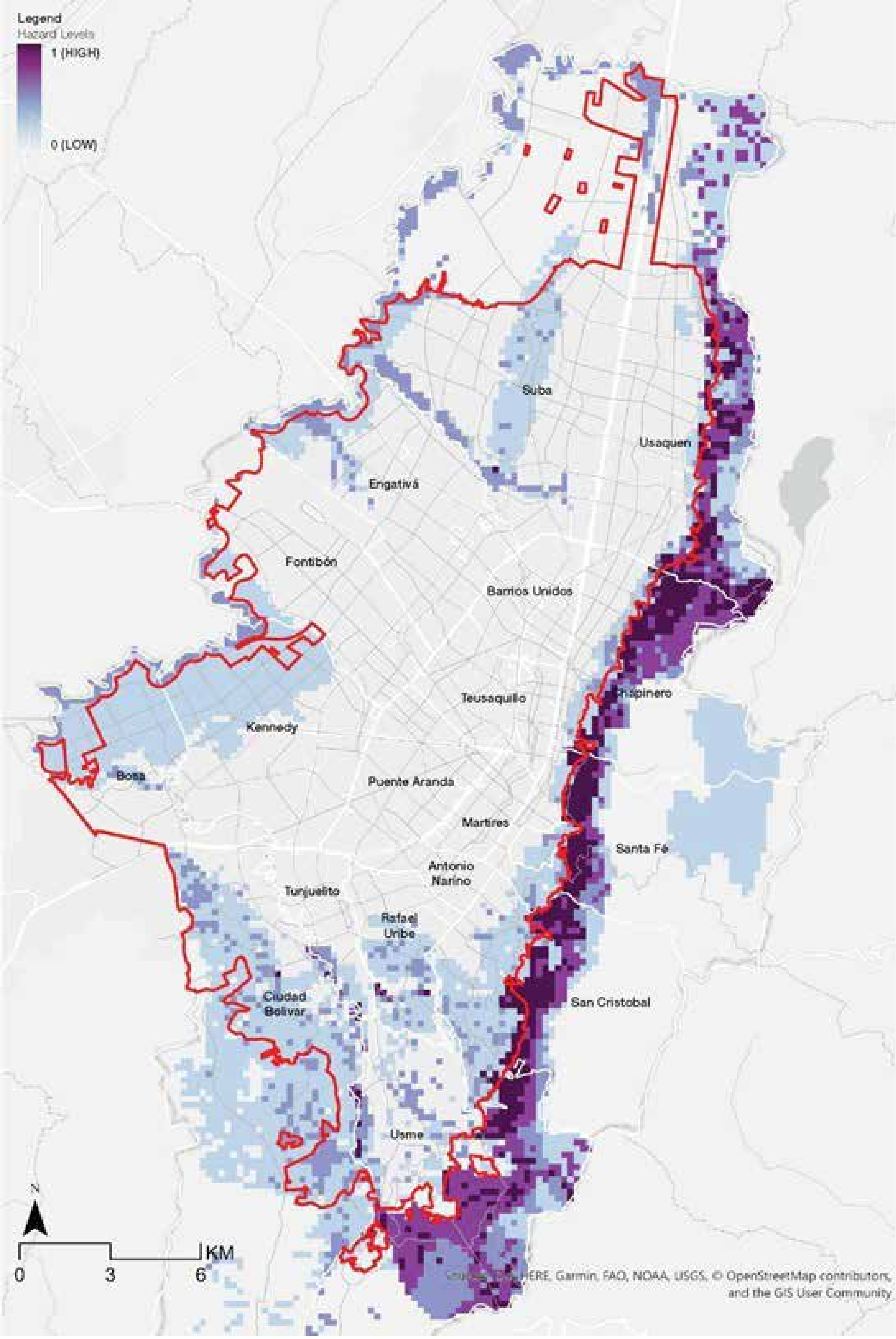


Figure 14:
Bogota Weighted Sum Hazard Map.

4.8 RISK INDEX MAP

The final step for the risk index map is the combination of the hazard and the vulnerability. In this regard, the raster calculator ArcGIS tool was used to execute a single-line algebraic expression using multiple tools and operators (Figure 15). For this case, the multiplication operation was used by multiplying the values of the two rasters on a cell-by-cell basis (ArcGIS 2021). Figure 16 shows the final risk index and clarifies the danger locations in the city. It was also re-classified in a range between 0 and 1, indicating that the darkest colour approaches one as the highest risk level and the lightest colour to 0, showing the lowest risk level. The map gives a general overview of the current situation and already locates the high-risk zones; in this case, USME was selected as the main area to be intervened.

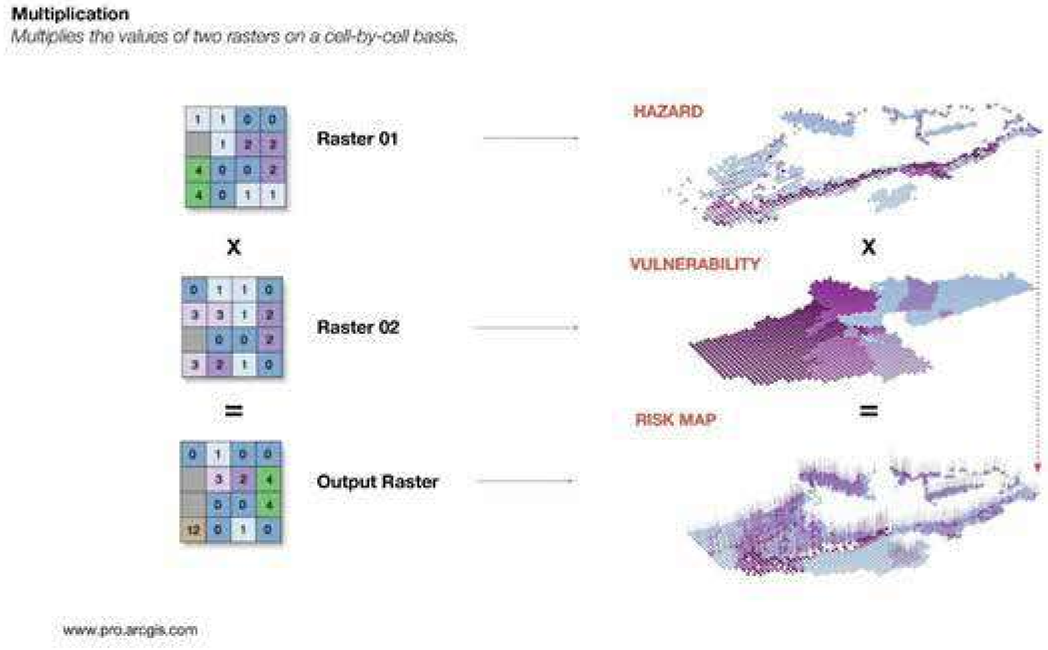


Figure 15:
ArcGIS raster calculator tool.

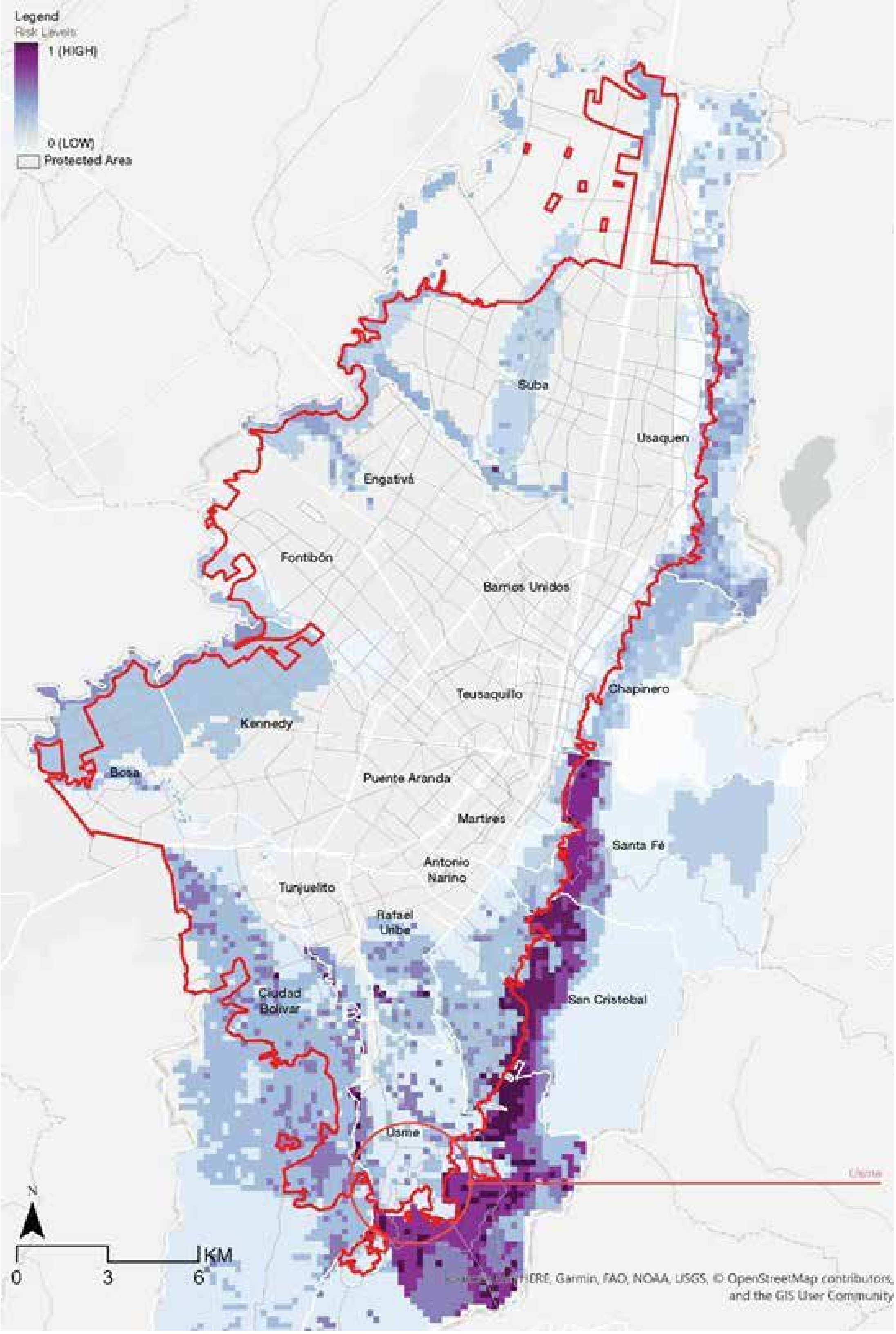


Figure 16:
Risk Index Map.

4.9 USME IDENTIFICATION PHASE

Figure 17 shows the results obtained in the Urban Risk map for the Usme district. The risk levels were re-classified in 5 levels, one the lowest and five the highest risk levels. This map helps to identify possible intervention zones implementing NBS where there is a critical situation. The first step was to identify the existing health, educational and cultural urban amenities within Usme; a 400 m (10 minutes walking distance) buffer was generated for each of the amenities to visualise the coverage area. Later on, using K-means clusters, it was possible to categorise the existing amenities, identify the relationship between the created clusters and their coverage, and identify which are located in protected and high-risk areas. (Figure 18)

4.10 URBAN DESIGN VISION

"The 'solution' in urban design is expressed as a product of urban design: a rule, plan, or pilot project that sparks and guides urban transformation. The process of designing the solution is done in constant collaboration with the community and under constant pressure from the forces of politics and finance. However, the scope is far narrower than designing the question" (Washburn,2013) In this sense; the urban design vision was developed under three different levels (Figure 19):

- Embrace (urban vision)

- Deep Design Thinking (urban principle)

- Implementing (urban policy)

In addition, this hierarchical categorisation aims to define a series of actions that take into account:

- Community: A vision to promote a participative, inclusive and diverse community; this vision can be implemented through open spaces, community rooms that would help to improve vulnerable areas.

- Environment: enhancing a reconnection with nature by introducing NBS like Green and open space infrastructure such as urban parks, community & rain gardens, afforestation, reforestation, green roofs, green walls, water covering surfaces, detention ponds, bioswales.

- Culture: creating new cultural spaces that share experiences, open new education networks, and promote performance and art events.

- Identity: adapting and improving the existing by introducing uniqueness and promoting a sense of belonging, social cohesion, and supporting local programs.

- Adaptable: introducing a modular system to future projects promotes vernacular principles, maximises affordability, and creates resilience.

- Integrative: promoting flexible urban amenities that share a vision to create social integration and regenerative processes. As highlighted in Figure 11, the urban design vision aims to tackle social inequality and mitigate risk by inserting NBS strategies for existing and future communities.

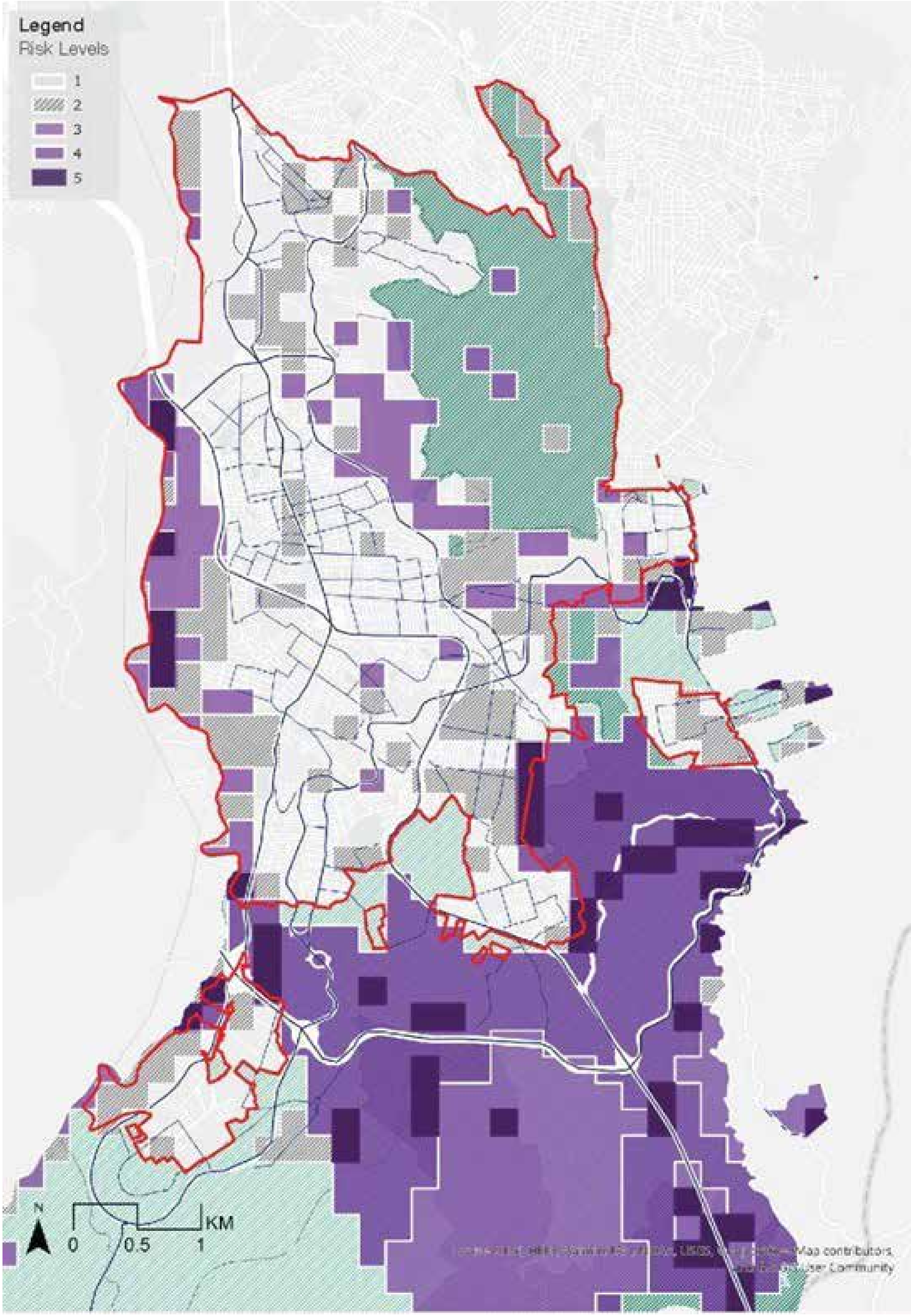


Figure 17:
Usme Risk Map.

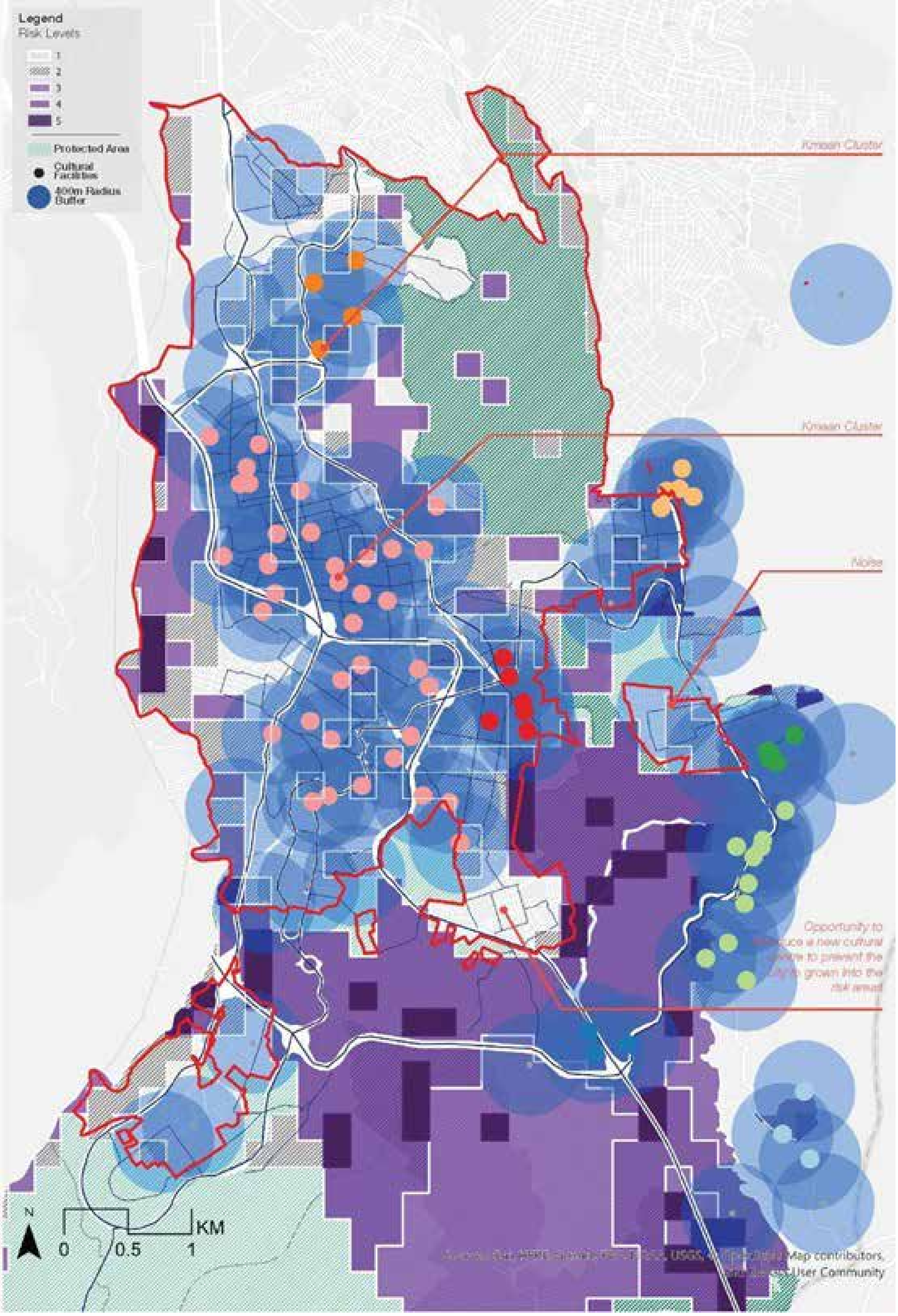


Figure 18:
UsmeRisk Map + K-means Clustering.

Figure 19:
Urban Design Principles & Targets.

5. NOW AI –COMPUTATIONAL DESIGN STRATEGY & WEB APP

5.1 BOGOTÁ & USME ARCGIS ONLINE PLATFORM

In order to make accessible all the studies created, the layers of information were uploaded to a website using ArcGIS Online. Figure 20 shows the interactive interface that can easily be manipulated to display urban data of Bogota & Usme. The tool provides an interface that enables multiple settings (base maps, measure distance & map location). Moreover, the user can manipulate all the layers of information to visualise different results and the Vulnerability, Hazard, and Risk Map. Furthermore, the existing cultural, health and educational facilities were combined with the K-means cluster tool to understand the existing urban amenities. The same tool was created for Usme as the site identified with the highest risk values; furthermore, the user can manipulate the urban district layers such as public transport, road hierarchy, and green network (Figure 21).

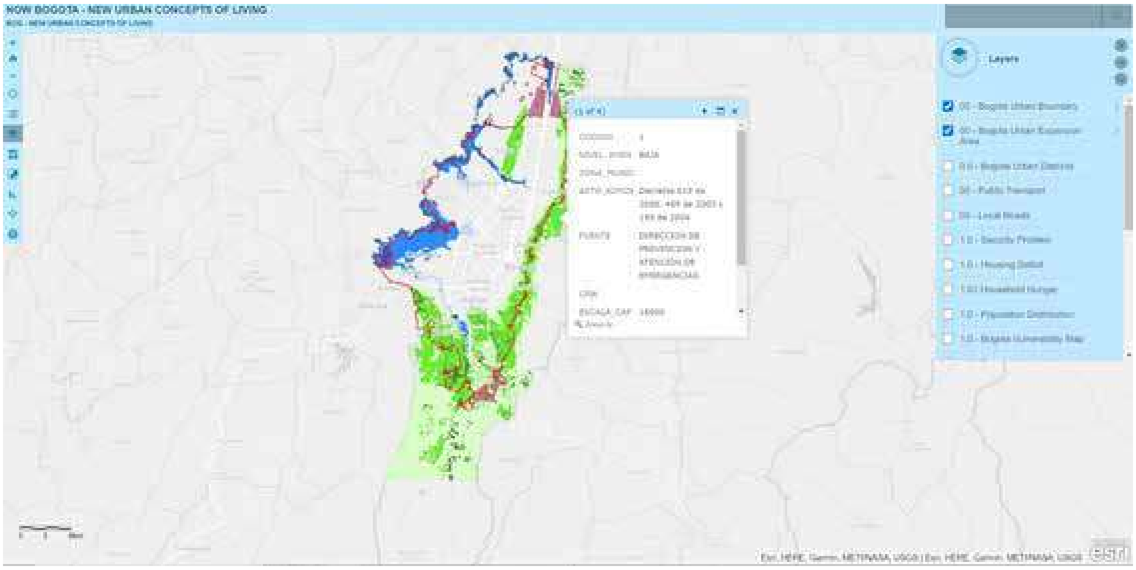


Figure 20:
Bogota - ArcGIS Online Platform - Cultural Facilities K-means Clustering.

LINK: https://www.arcgis.com/apps/View/index.html?appid=5a9dcc554fb7478cb35258b4eb5a2125

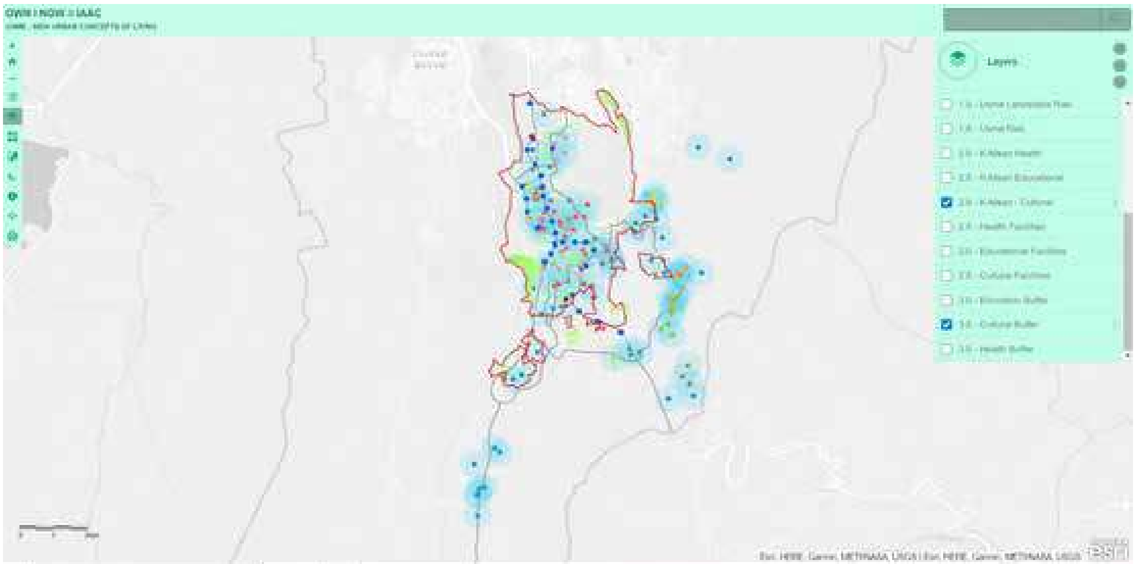


Figure 21:
Usme- ArcGIS Online Platform - Cultural Facilities K-means Clustering.

LINK: https://www.arcgis.com/apps/View/index.html?appid=11323e7a892a4a69b0a0368d31513c54

5.2 COMPUTATIONAL DESIGN STRATEGY

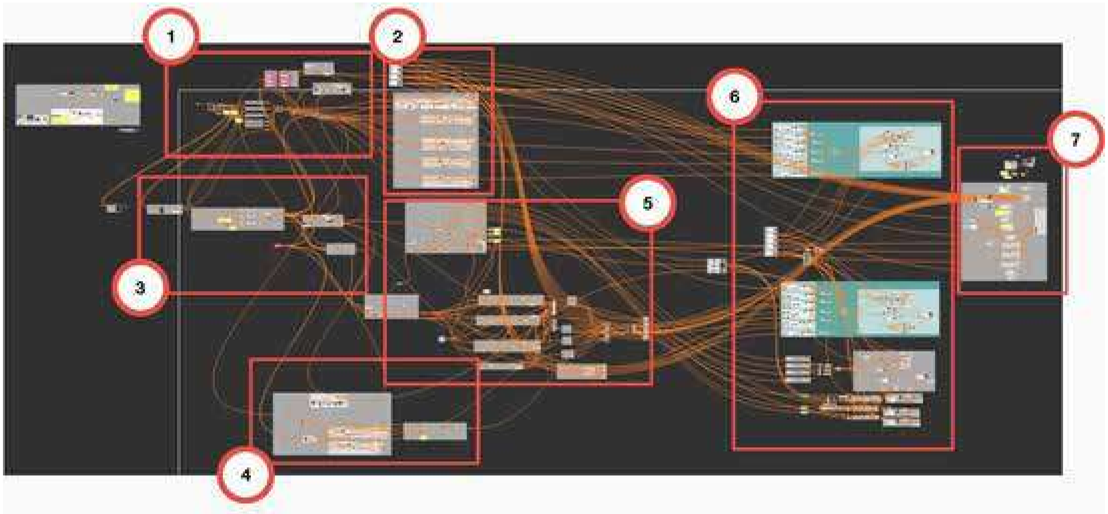
The computational design strategy of this project aims to encourage integration between urban design & planning with the architectural workflows. Therefore, it uses the power machine learning (ML) using K-means clustering in ArcGis with visual Scripting in Grasshopper. The integration between ArcGis and Rhino+Grasshopper was possible using the Plugin Urbano. This tool lets the user load urban data from OSM and manipulate meta-data from Shapefiles (SHP) into Rhino. (Urbano, 2019) Once the ArcGIS maps were brought into the Rhino interface, the following steps were to extract the meta-data part of the shapefile (for this case, the risk values). The meta-data was extracted to create a cloud of points where the different risk levels could be visualised with colours.

The purpose of bringing the maps into Grasshopper was to filter the information and select only the highest risk levels to intervene. Finally, some assumptions were developed within the interface to forecast the following:

- Percentage of the area dedicated to residential use.
- The average size of residential units
- Number of employments per future household
- Average of standard commercial unit (to forecast the demand of future jobs for future population)

The overall idea was to introduce new projects with these assumptions to visualise the future risk map; projects can target specific risks and introduce new mitigation strategies. The overall grasshopper script developed into seven main parts, starting from the extraction of the GIS file to the creation of a user interface (Figure 22).

Figure 22:
NOW - AI / Grasshopper Definition.



First Part: The first part uses Urbano to extract the fundamental values (meta-data) from the methodology developed in GIS. The overall idea was to generate a filter for the meta-curves with the different risk levels.

Second Part: The data tree was hierarchically organised by risk levels; this allows selecting the highest risk levels and visualising the areas to intervene.

Third Part: This step takes the highest levels and brings them as separate items to perform a mathematical operation that introduces new values based on multiple assumptions. (as mentioned before)

Fourth Part: Organise the data tree and the geometry for the lowest risk values, 1 to 2. Considering the lowest risk associated with these values, they were combined with the result of step 3.

Fifth Part: This step combines the geometry identified in GIS with the values resulting from the mathematical operation (step 3); the new values are embedded into the geometry using the Urbano plug-in. This step reduces the risk levels based on the user's definition of the assumptions (which for this research are focused on educational, residential, and cultural).

Sixth and Seventh Part: These two steps generate a spider diagram that changes based on the input values and creates a user interface using Human UI (plug-in for Grasshopper developed by nbbj). It can be argued that Grasshopper has the power to enhance architectural workflows rather than urban data; however, this research intends to give an idea of how a new workflow can be implemented between these two platforms.

5.3 GRASSHOPPER USER INTERFACE & RHINO COMPUTE

For this research, two interfaces were developed; one runs locally using Urbano (Grasshopper Plugin), and another runs on a cloud using Rhino Compute (McNeel). Human UI is an open-source project developed at NBBJ by the Design Computation Leadership Team (2016). This tool enables the opportunity to generate a user-friendly interface without needing to write any code. The user interface was developed to control the inputs for the urban design assumptions to visualise a proposed risk map.

The overall idea seeks to enable three different live maps that enable a comparative process as follow:

1. The app shows the map resulting from ArcGIS in Rhino.

2. The app shows an intervention map displaying different land uses (commercial, residential, and NBS public space).

3. A new risk map appears as a result of the input values by the user; some of the input values that adjust the proposed mitigation map includes:

a) Percentage of residential use

b) The Average unit size (sq.m) for residential uses Number of employments per household (unit)

c) The average size of retail/commercial space (sq.m) - this value provides a ratio to commercial/retail jobs

d) Area of desired public space introducing NBS for the future population (per inhabitant)

Finally, at the bottom of the interface, the user can visualise the percentages calculated based on different inputs and open the ArcGIS Online website (within Rhino) for Bogotá and Usme to validate data (Figure 23).

On the other hand, Rhino Compute is a cloud-based application developed by McNeel that opens the opportunity to (McNeel , 2021):

a) Operate Grasshopper definitions online in a serial or parallel solution.

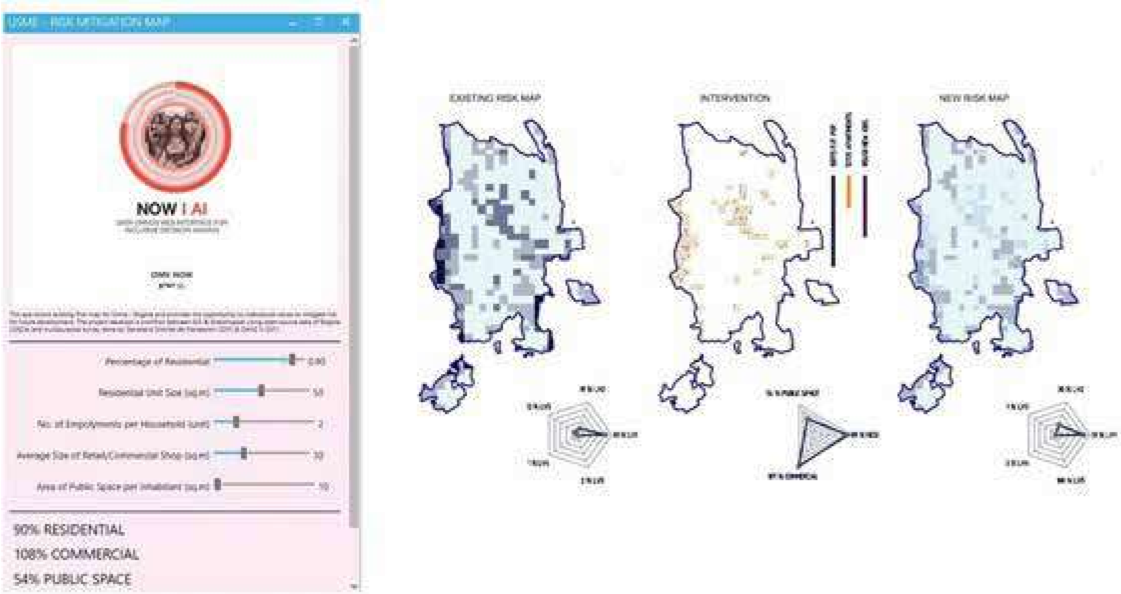
b) Manipulate Rhino (3DM) and other file types on the net.

c) Visualise geometric operations on custom objects, including points, curves, surfaces, meshes and solids.

The initial Grasshopper script was adjusted for this research to minimise the computation time and improve online performance. The overall goal using Rhino Compute was to develop an online interface that improves user's accessibility & manipulation. The interface uses the same logic to display the GIS & Grasshopper analysis, perform an online operation when changing the input values (sliders with the different assumptions) and provide a proposed risk map (Figure 24). Finally, the user can directly download the source code or also can consult the online Github repository.

5.4 URBAN DESIGN INTERVENTIONS USING NBS

The simplest example is the development of new public spaces and the improvement of the existing ones, and providing recreational areas transforms and benefits the construction of communities. From the environmental point of view, developing and adapting the public and flood spaces reduces impacts and increases the quality of conditions for bio-types and ecosystems. The economic aspect is reflected in reducing economic losses generated with flood impacts



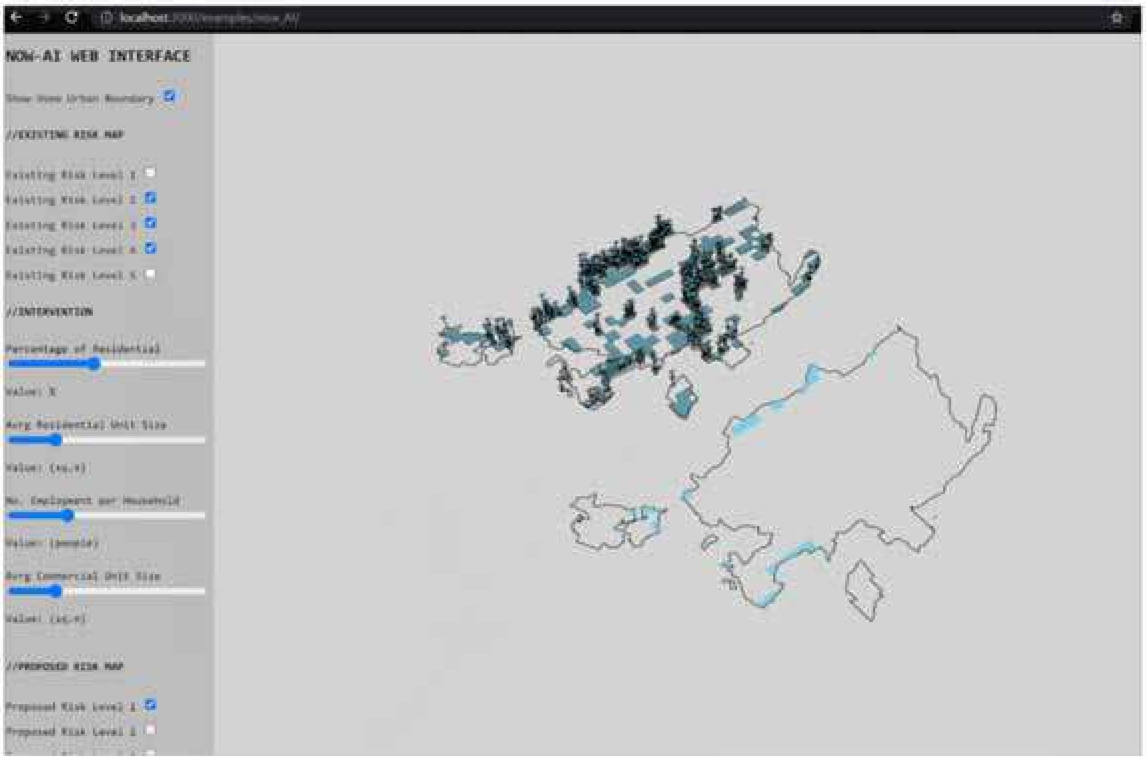


Figure 23:
(top)
NOW AI - Human UI Interface.

Figure 24:
(bottom)
NOW AI - Rhino Compute.

LINK Rhino Compute: https://nowaiserver.herokuapp.com/examples/
LINK GITHUB: https://github.com/Fromero8706/NOW_AI_compute.appserver

and the benefits to actors involved. This strategy is combined with the territorial planning instruments of the city and the risk management instruments as the main aim of the integrated risk management for the city (Figure 15 to 17).

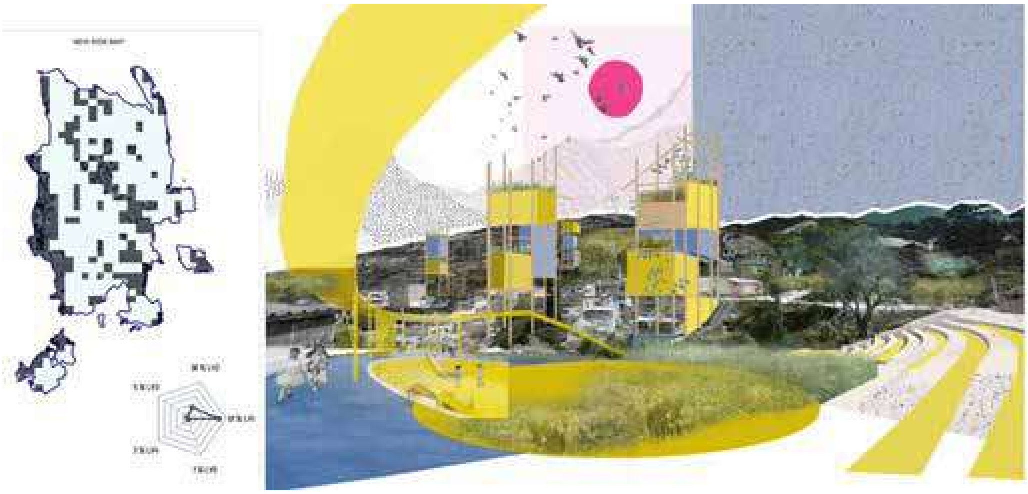


Figure 25:
(top of previous page)
NOW AI / Local green park, community & rain gardens, detention ponds, bios wales.

Figure 26:
(center of previous page)
NOW AI / Community gardens, green roofs, green walls.

Figure 27:
(bottom of previous page)
NOW AI / Green and open space infrastructure.

CONCLUSION

This research has demonstrated an opportunity to introduce a new workflow between GIS platforms and Grasshopper, introducing architectural workflows into urban data analysis. The project also shows a method to combine different types of information sources which opens the possibility of feeding the research with other sources. By integrating new Artificial intelligence methods and combining different information sources, it would be possible to develop a loop (Real-time workflow) to visualise results and dynamic urban predictions. This workflow could be potentially combined with optimisation processes, for mitigation of specific risks and resources management improvement.

The Risk map demonstrates how important it is, on the one hand, to communicate the existing physical and socio-economic conditions of a territory easily. On the other hand, it is crucial for decision-making where there is a need for mitigation plans and policy development. Artificial intelligence, in this case, using the K-means algorithm, opens the opportunity to identify groups that are not labelled as part of the initial dataset. Moreover, adding buffers shows a better understanding of the coverage and distances between different features, which are relevant to understanding the deficit, proximity, coverage of urban facilities such as health, cultural and educational. There is also an opportunity to introduce an optimisation process within the Grasshopper to target specific environmental issues and improve performance at a neighborhood scale.

It was more accurate to identify NBS intervention areas on the district scale by combining the risk maps and the K-means cluster methods. Likewise, the project allows the users to manipulate and decide what strategy to implement by observing the deficit values of an area and aiming to bring benefits related to the social, environmental, and economic aspects. In this regard, a participatory approach that allows users to visualize and make decisions can be beneficial for policy formulation and implementation of nature-based solutions.

The limitations in this project are related to the manipulation of online information. In this case Rhino-compute still has a limited capacity to manage large amounts of information. Therefore, the online version of the project should be as simple as possible, using a more simplified version of the script with less information, in order to run it successfully.

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BEYOND BIOMIMICRY

Creating a balance between humans, computers and the natural world through wearable interfaces designed by nature

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KEYWORDS
Wearable Technology, Digital Fabrication, Biodesign, Computational Design, Interspecies

ABSTRACT
As humans continue to augment their experience with technology, it becomes difficult to separate the influence of one from another. Nature is often not considered in the conversation between human and machine.

The Beyond Biomimicry collection attempts to make the next generation of machines by utilizing interspecies collaboration in the design process—both computationally and physically. This collection is a deep dive into understanding the natural growth process and structures of living organisms, simulating those structures in computational space to give humans, machines, and nature an equal voice and stake in the design process.

1. INTRODUCTION

Humans are merging with digital intelligence through wearable computers. But today's wearables are inspired by science fiction (Emerging Technology from the arXiv, 2018), which at its core is rooted in the ideal of leaving this planet, and its ecology, behind. As humans continue to augment their experience with technology, they move closer to becoming more computer than human. This development has shifted the evolutionary priorities from survival of the fittest to survival of the most augmented. Which is harming our planet with the excessive amount of waste produced as humans are constantly upgrading their technology.

Many philosophers, artists and futurists have attempted to create wearable technology that puts the wearer first. They often forget the context of the environment in which humans and machines developed.

The Beyond Biomimicry collection is an attempt to create balance between humans, computers and our natural world through wearable interfaces that are designed by nature, delicately adorning the human body to create symbiotic habitats between our technology and our ecology. Each piece in this collection is grown in computational space, 3D printed, and then when appropriate, adorned with living collaborators. The result is ecologically empowered, unique wearable objects that evolve our thinking for the future of wearable technology. The collection is different each day and plays off of our innate relationship with the natural world.

2. BACKGROUND

We separate human from non-human and non-human from machine. Yet at the same time, human's relationship with machines has become so intimately connected that it is nearly impossible to identify what is purely human and what is purely machine. (Haraway, 1991/2015).

As humans today, we lust for nature while we are trapped behind digital screens. We will not abandon the screens, or their descendants, as it would impede human economic, scientific, and technological growth potential. So we must find a way to merge human and technology with the insights gleaned from the evolutionary wisdom and marvel of nature. Beyond Biomimicry gives other species a voice and agency in the design process. It allows one to generate new forms and create new interfaces that merge nature and technology, calling attention to the importance of nature in the act of production. We are facing a pivotal time in our planet's history where we must collectively choose to bring nature with us, coinciding in harmony, or risk the consequences of ignoring what nature teaches in our quest toward further technological conquests.

How do we reestablish our relationship with machines to make their interfaces from nature?

The nature-technology conflict has been a theme in literature, philosophy, politics, film, and science for decades. I have approached this paradox through the development of Biomimetic Wearable Computers that merge man and machine via the imitation of nature in form and function. These wearable computers attempt to explore a technology that feels natural and comfortable to our bodies - but this is not enough.

The Beyond Biomimicry collection attempts to make our interfaces with machines truly an extension of our bodies.

3. METHODS

Integrating biology into design is not just about growing things in molds to make products for humans. It is about understanding the logic behind the growth so that we can co-design within the same medium to create true interspecies collaborations.

3.1 COMPUTATIONAL INTERSPECIES COLLABORATION

This collection began with computational interspecies collaborations, where authentic natural growth algorithms were created and simulated in virtual space. Five natural growth algorithms were explored through this collection: barnacle growth, meandering coral growth, slime mold growth, crystal aggregated structure growth, and mushroom growth. Translating analysis of the initial growth structures, the growth structure parameters and processes were documented and defined in various growth analysis coming from the field of biology.

In these virtual spaces, the parameters were simulated to create structures grown using the same logic as the initial physical growth analysis. The growth algorithm parameters were then fine-tuned to understand what outputs lie within parameters found in the natural world, and what outputs could be exaggerated through computational simulation. Ultimately, these algorithms are authentic simulations of the initial natural growth structures studied.

Within each growth process, organic structures formed from basic rudimentary parameters through looping algorithms. The ability to create and simulate natural growth patterns in a computational space allowed these growth structures to grow in circumstances they could never grow in real life, such as coral growing upon a face, or crystals forming around a human neck. These growth algorithms were constantly evolving in virtual space, only frozen in time by 3D printing pieces which creates fossils for the future.

3.2 SELECTED ALGORITHMS

Differential growth is a phenomenon found in plants where parts of the plant grow at different rates causing the plant to naturally curl in on itself (Barlow, 1989). The Beyond Biomimicry collection showcases differential growth in many instances.

An analysis of meandering coral shows that it employs a two-dimensional curve differential growth logic to develop and grow. I was able to simulate curve differential growth using Rhino and Grasshopper with the help of components from Kangaroo. By understanding the logic behind the growth algorithm, I was able to computationally collaborate with the growth, and design and extrapolate for de novo coral growth beyond its customary environment, and apply it to the human face.

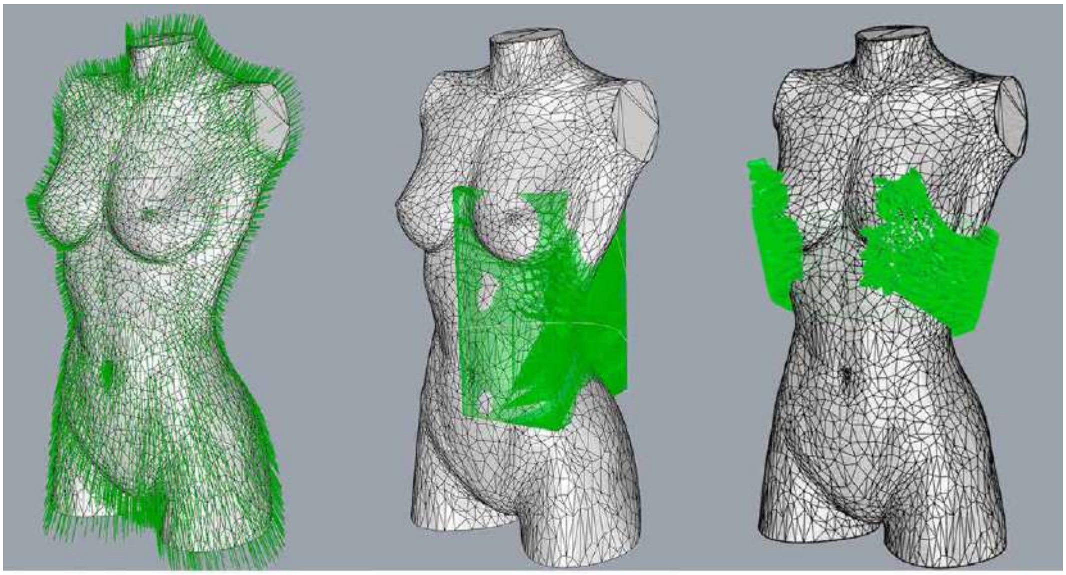
Figure 1:
The evolution of a shoe, designed with mushroom differential growth logic over a set number of loops.

This same differential growth logic is applied to a three-dimensional form in the case of the mushroom. The outer surface of the mushroom grows faster than the inside of the mushroom. This is simulated in Grasshopper by having surfaces that subdivide at different rates. The result is a compelling bubbly surface. (Figure 1.)

This same three dimensional differential growth concept is applied to the growing of an acorn barnacle shell. In nature, the barnacles grow by adding new materials to their heavily calcified plates. Because they are constantly adding new material, this process can be simulated as a differential growth, where part of the barnacle is not growing and the other part is growing quickly as the new material is added. (Figure 2)

In nature, slime mold oscillates between acting as a series of single-celled organisms and a swarm. By understanding the rudimentary rules of individuals exhibiting swarm behavior, for example moving in the same direction as one's neighbor and staying close to the neighbors without colliding, slime mold was able to be grown computationally using the Nuclei plugin for Rhino. This began to form an organized and predictable structure based on food source placements. (Figure 3.)

The last growth algorithm explored in the collection is the aggregated structure of a salt crystal. The aggregated structure refers to a mass composed of separate small crystals. In this instance, the form found is a representation of what the crystal looks like under a microscope.



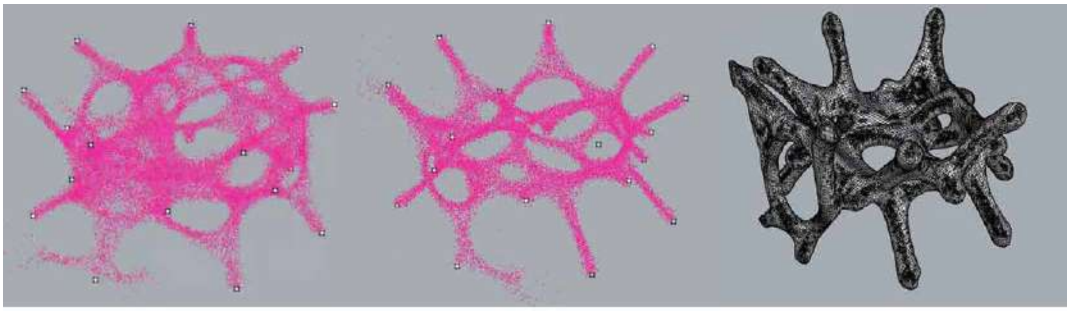


Figure 2:
(top)
Barnacle growth algorithm intersecting with the human body to create a bodice.

Figure 3:
(bottom)
Slime mold simulation using shortest path logic for form finding via the Nuclei Plugin for Rhino.

3.3 BIOLOGY RECLAIMING THE 3D PRINTED FOSSILS THROUGH A PHYSICAL INTERSPECIES COLLABORATION

By understanding the same logic used to computationally model the organisms, environments were set up to allow for the organisms to grow out of the 3D printed fossils themselves.

Not all pieces in the collection reached this stage of merging the physical and computational interspecies collaboration. The process is not just about filling vessels with living organisms, but rather about understanding the logic behind how the physical organisms work to make a well-informed decision to create a synthetic symbiotic relationship between the digital, physical and the natural. I define a collaboration as understanding the logic behind the growth of organisms so you can begin to grow with that organism.

Figure 4:
(top)
Sea Sprouts designed with barnacle growth algorithm paired with living mushrooms.

Figure 5:
(bottom)
Crystal aggregated structure paired with conductive crystal to create an interface that glows.

Sea Sprouts (Figure 4.), which were designed using the acorn barnacle analysis, were paired with physical mushroom growth. By applying the behavioral growth of mushrooms I was able to predict and create an environment where the mushrooms spored to fill in the gaps of the 3D printed bodice to create clothing. This piece then adorned the human body to create a living habitat. The mushrooms have high levels of kohl acid which create even skin tones soothing the skin of the wearer.

A form found using the crystal aggregated structure computation was then paired with epsom salt to grow crystals upon the form. Crystals were formed from a solution of epsom salt and conductive paint to create an interface connecting nature to the digital world.

4. RESULTS

Treating nature as a formulation and contributor to the design and manufacturing process is what separates this collection from others. Beyond Biomimicry creates a natural intervention for wearable devices at each step in the design and manufacturing process to allow design systems to be driven by and then inhabited by nature.

This project attempts to create intentional symbiotic habitats between human and machine by valuing natural organisms as stakeholders in the design process.

These natural growth algorithms lend themselves to digital manufacturing. The mushroom differential growth logic creates intricate three-dimensional models that can be printed with little to no support because the structure itself is naturally supportive just as mushrooms don't need support to grow in real life. This same mushroom differential growth logic can create structures that are extremely strong and tensile—the mushroom shoes can hold over 150 pounds even though they are 3D printed with only 15% infill (Figure 6). The meandering coral differential growth pattern when applied to the face creates a natural camouflage to computer surveillance (Figure 7.). The aggregated structure growth algorithm paired with the grown conductive crystals creates an interface designed by nature that can transmit data directly to our traditional machines (Figure 5.).

The Beyond Biomimicry collection is designed in conjunction with nature, which makes the wearer feel closer to nature — this creates a wearable biophilia effect, which is the human innate tendency to seek connections with nature (Wilson,1984). We resonate with the natural angles and curves in these pieces as they interplay with light, as if we are one, because these forms are more ancient than humans, harkening back to the very creation of our species.

Figure 6: (left)
Root shoe designed with mushroom differential growth algorithm.

Figure 7: (right)
Face mask designed with meandering coral algorithm.

5. DISCUSSION

Why is this beyond biomimicry and not just biomimicry?

This collection is designed by authentic, natural growth algorithms which allow nature to be simulated and computationally grown. The authenticity of the natural growth algorithms makes this collection something more than biomimicry. This collection is an attempt to study the parameters involved to create true interspecies collaboration by allowing for nature, humans and machines to communicate with the same medium of parametric design tools.

The transition between computational interspecies collaboration and physical collaboration is not perfect. This collection exists in the space between an interspecies collaboration and biomimicry. This collection represents something more intimate than biomimicry, which is why I call it Beyond Biomimicry. Each piece explores a different balance of designers between humans, computers and the natural world. Creating with living systems takes careful analysis and time.

This collection also entertains the nature vs nurture debate for how forms come to be. By simulating these natural growth algorithms in computational space it leaves no room for natural variance, or selection, two qualities that are crucial to the ideal of evolution stated in Darwins Origin of Species (Darwin, 1859). The natural growth algorithms simulate how these natural forms would grow in a lab setting which ironically is a place these organisms could never grow on their own. This collection therefore is dependent on humans to create the context and environment for which the organisms grow.

The goal of this collection is to bring the forms and elements of nature back into the machine to create machines that are truly an extension of our bodies and our biology.

6. CONCLUSION

Beyond Biomimicry is a humble attempt to merge humans, computers and the natural world in a symbiotic way. This five-part collection showcases five natural growth algorithms acting as the designers in an attempt to give equal agency to humans, computers and the natural world in the design process. Each piece in the collection explores different balances between humans, computers and the natural world, while not perfecting the symbiosis between the three stakeholders within any single piece.

This collection allows humans, computers and the natural world to communicate within the same medium and begin to influence one another. Beyond Biomimicry brings humans, computers, and the natural world together as equal stake holders in the design and manufacturing process, to try to make the merger between human and machine more equitable, ecological and sustainable to all parties involved.

7. ACKNOWLEDGEMENTS

Beyond Biomimicry could not have been made without Rhino and the open-source community, specifically the Nuclei Plugin by Madalin Gheorge, the Wasp plugin by Andrea Rossi, and the Anemone Plugin by Mateusz Zwierzycki.

I would like my natural collaborators, Slime Mold, Salt Crystals, Barnacles, Meandering Coral, Mushrooms, to also be named as they are equal contributors of this collection.

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NATURE-BASED RETROFITTING SOLUTIONS TO PROVIDE ECOSYSTEM SERVICES

A Case Study of Plant Your Future

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Retrofitting Solution, Ecosystem Services, Food Production, Urban Biodiversity, Metabolic Strategy

ABSTRACT

Increasingly people are becoming more and more aware of the impact we are having on this planet and the consequent challenges we are facing. In parallel population growth is unprecedented and more people are moving from rural areas to the city, putting greater pressure on our urban centres for the provision of accessible food sources. Cities, when combined with nature-based solutions, can provide many opportunities to tackle these issues, to name but a few, food, energy consumption and loss of habitat.

This paper presents the results of a thesis, Plant Your Future, developed to rethink existing buildings as living systems, each playing a part in contributing to and providing ecosystem services. Plant Your Future explores the possibility of re-greening existing buildings by retrofitting them for food production, pollination and urban biodiversity, and by designing a circular economy strategy focusing on nature-based solutions, more specifically plants. By breaking the current linear and global food production model and bringing food production back to peoples' doorsteps, multiple benefits can be achieved empowering a positive environmental, social and economic impact. Retrofitting existing buildings in our cities can redefine the urban tissue, while adding value and new opportunities.

1. INTRODUCTION

Human settlements and agriculture have always had a very close and interconnected relationship, which still exists today. However, over time, the relationship between the two has evolved. Historically, humans were hunters and gathers following the food supply and thus, food dictated where we lived. It was the Agricultural Revolution that was the catalyst for settlements emerging and the birth of the city (Harari, Purcell and Haim Watzman, 2018). From following the source, humans began dictating where and how the food was to be grown. Today, the global market sees food travel across the world creating a fragmented foodscape, where architecture is used to grow food, often disconnected from where the architecture that houses the food is then sold. This evolution between food and architecture has also greatly impacted our relationship with nature, many not even knowing where their food is coming from or how it is grown.

It is predicted that by 2050, 68% of the world's population will be living in towns and cities, meaning the demand for food in cities will continue to increase (United Nations, 2018). As cities continue to grow, so will the demand for housing, resulting in peri-urban areas densifying, reducing their potential for food production. To sustain the population, it is predicted that we will require an increase of food by 70%, a paradoxical fact considering that every year we are throwing away 1/3 of food produced for human consumption (FAO, 2011). This clearly demonstrates that there is a huge problem with the current food industry and supply chain. This being said, cities hold opportunities to rethink the current system and once again live amongst nature, and our food, through distributed and multiscalar urban agriculture techniques. The infrastructure and vast amounts of surface area in cities, provide multiple opportunities to bring nature into the city and provide ecosystem services for humans, buildings, and the urban environment, in particular biodiversity.

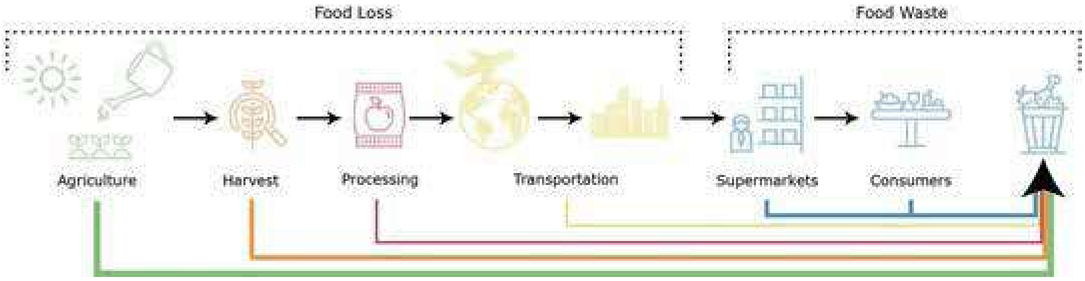
Plant Your Future provides a retrofitting and greening solution for existing buildings through the integration of plants within the built fabric. As a result, the plants provide food, they create habitats for urban biodiversity and turn a static building into a living system. A circular food-based economy is achieved, providing multiple ecosystem services through the use of existing products and strategies, that can in turn create a larger metabolic strategy implementable today.

2. A LINEAR FOOD PRODUCTION SYSTEM AND THE CURRENT ARCHITECTURAL SOLUTIONS

Food is a fundamental necessity, required to sustain human life, yet the impact of food on our planet, in particular its production and waste, often goes unnoticed. The United Nations Food and Agriculture Organisation with their report Global Food Losses and Food Waste, highlighted the significant amount of food thrown away, as well as its impact on the biodegradation of different food groups. In the Transforming Our World: The 2030 Agenda for Sustainable Development of the United Nations one can identify the goals of "Zero Hunger" and "Responsible Consumption and Production", as key to tackling the issues surrounding food and its production.

Contemporary living is often detached from the natural resources we consume, so much so that many do not even know where their food comes from. The linear journey food takes consists of five main stages (Figure 1), each contributing to the risk of food loss or waste. Food loss refers to food being discarded during the initial stages of the supply chain, i.e. agriculture production, post-harvest and storage, and processing. Food waste refers to food discarded during the distribution and consumption phases. Rethinking the food supply chain therefore presents itself as an opportunity to mitigate these risks.

Figure 1:
Linear Food Production Model.



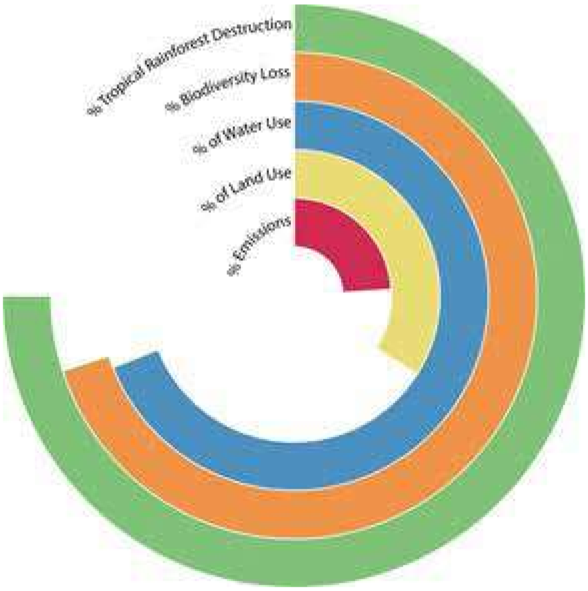
2.1 THE IMPACT OF GLOBAL FOOD PRODUCTION AND AGRICULTURE

Historically, human diets were heavily influenced by locally grown produce and food storage strategies. A study analysing diets over the last 50 years in 152 countries demonstrated that diets were individually identified as more diverse; however they were comparatively more similar (Kammlade et al., 2017). This is a result of the global food production system, enabled by inventions like refrigerators and steamboats, allowing goods to be transported long distances and preserved over longer periods of time (Lobb, 2013). Food transportation greatly adds to the carbon footprint of food, as does the biodegradation of food in landfills. According to an IPCC Report, 8-10% of greenhouse gases are produced from food, either lost or wasted (Agudo and Delle Femmine, 2019).

For agriculture to thrive, it relies on flourishing ecosystems, yet we are destroying land and ecosystems to produce food by means of agriculture. In particular, agriculture impacts land use, water consumption, biodiversity loss, rainforest destruction and produces emissions (Figure 2). Humans are consuming resources at an alarming rate, not giving nature a chance to recover or restore itself. Specifically, food production accounts for 26% of the world's ecological footprint (Laetitia Mailhes, 2018). There is a clear need to rethink our relationship with food, from where and how it is produced, to the reduction of risks related to loss, waste and the impacts of food production. Furthermore, there is a clear necessity to educate people about the importance of nature and biodiversity, the role they play in sustaining life, as well as their relationship to the food system.

Bringing food production back into our day to day lives, in particular in cities, and embedding it into the architecture we inhabit, as a performance, as a means to deal with the above mentioned challenges, is the approach adopted by Plant Your Future.

Figure 2:
Impact of Agriculture.



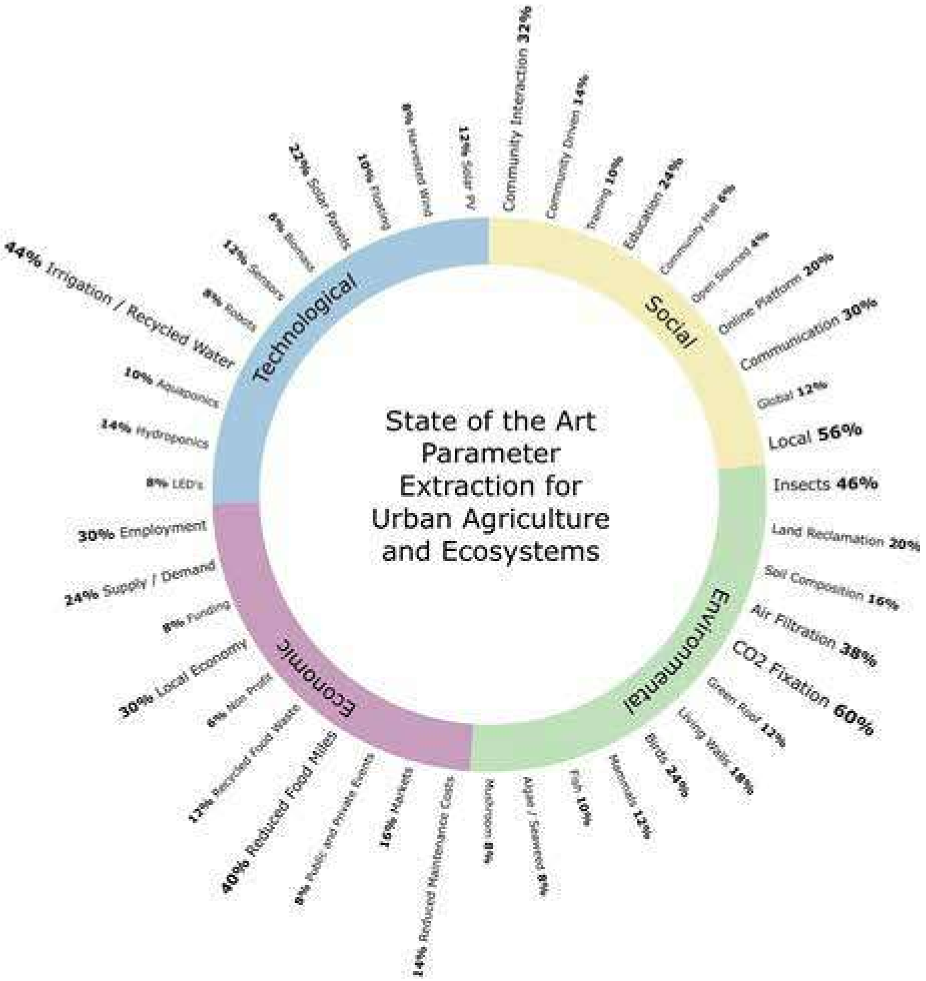
2.2 CURRENT ARCHITECTURAL SOLUTIONS FOR FOOD PRODUCTION

To clearly understand the current architectural solutions for food production and ecosystem services, 50 state of the art case studies from around the world were researched and analysed. They were quantified according to scale, accessibility, location, structure type and economic factors (Figure 3), and KPIs were extracted, (Figure 4) to understand the trends and success rate of these in terms of technological, social, economic and environmental factors. These state of the art cases included projects that reuse existing infrastructure, like Incredible Edible and the Brooklyn Grange; buildings integrating food production, such as Farming Kindergarten by Vo Trong Nghia Architects and Tainan Xinhua Fruit and Vegetable Market by MVRDV; hypothetical buildings, like The Farmhouse by Precht Studio and Urban Agriculture by Ilimelgo; and finally, edifices focusing on ecosystem services, such as Bosco Verticale by Boeri Studio and ParkRoyal on Pickering by WOHA.

Figure 3:
Quantifying the State of the Art Research.

From the research conducted, there was a clear trend where many buildings designed to be agricultural hosts were new structures, consequently consuming more land and resources. The most successful projects were those where community initiation and participation played a key role in their development and management. Finally, in many cases, the opportunity of providing multiple ecosystem benefits through plants and urban biodiversity were clearly missed, or not realised to their full potential. This poses the question: can we answer the challenges of food scarcity and waste through the integration of ecosystems into architecture towards a performative built environment?

Figure 4:
Parameter Extraction of State of the Art Research.



3. CASE STUDY: BARCELONA, SPAIN

3.1 FOOD AND SPAIN

Spain has a rich food culture and the Mediterranean weather provides the perfect environment to grow crops. While Spain has promised to reduce food loss and waste, 2019 saw an 8.9% increase on 2018. Studies show that 84% of the food being discarded had not even been cooked yet (Agudo and Delle Femmine, 2019). In Catalonia alone, the food wasted by consumers and supermarkets could feed half a million people (Coral·lí Pagès, 2010).

Research was carried out to understand what portion of food was being produced in Spain and more specifically Catalonia - for both human and animal consumption -, as well as understanding the amount of surface area required by this production (Figure 5). This last point quickly highlighted which crops would be most suitable to grow in a compact city, like the case of Barcelona. For example, cereals require a large surface area to grow, whereas fruit and vegetables in comparison, need less surface area. It is important to understand nature's requirements in order to find the best possible way to grow the crop.

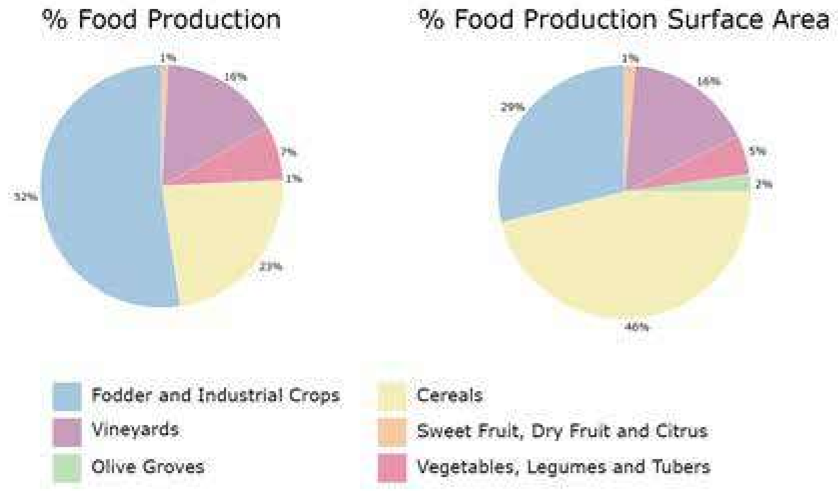


Figure 5:
Food Produced vs Surface Area Required.

3.2 A BASE FOR A REPLICABLE STRATEGY

The goal of the research was to design a strategy that could be applied to different types and scales of buildings, and potentially in different cities. Therefore, a generic building form was chosen in Barcelona's first Superblock, to test and design the strategy. The location of the Superblock was also key, as the goals of the Superblock are very much in line with those of this project.

The metabolic analysis consisted in 5 steps:

1. Research local crops, their growth calendar, and create a companion planting chart;

2. Research and understand the needs of local fauna and flora species;

3. Map the local climate throughout the year;

4. Conduct radiation analysis with Ladybug for Grasshopper on the existing building;

5. Understand the consumption levels of fruit and vegetables for the building according to its population.

From the research and analysis conducted, a clear approach to the design strategy could be made.

4. THE PLANT YOUR FUTURE STRATEGY

4.1 METABOLIC SYSTEM DESIGN

The main goal of Plant Your Future is to achieve a metabolic strategy to be implemented on existing structures – a retrofit solution. It is furthermore a solution that is based on existing technology, and consequently could be implemented today. The radiation analysis of the building is used as a starting point to define the key design strategies for the building, dividing the facades into food production (southern facades) and services (northern facades). Three key strategies helped to define the overall metabolic strategy:

1. Creating a Second Skin: the second skin provides access to the plants, allowing them to be maintained and harvested. In addition, this “skin” contributes to regulating the building's environmental performance, potentially reducing its reliance on other systems.

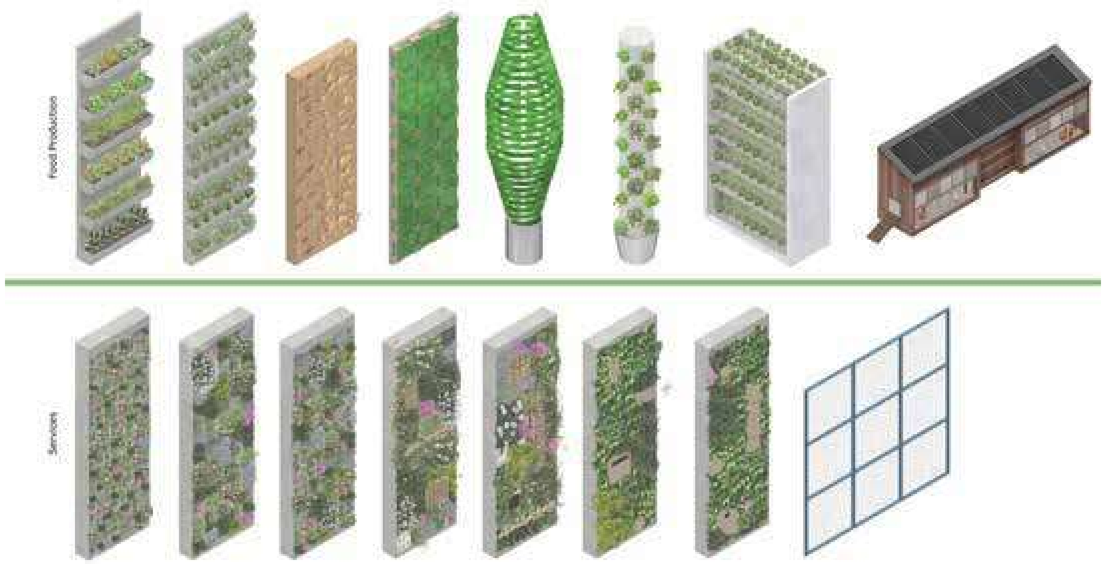
2. Division of Facades: as the radiation levels vary across the southern facades, they were divided in two. At the higher levels, hydroponic solutions are used to avoid the evaporation of water and to minimise weight. The lower levels focus on soil based planting.

3. Water Circulation: keeping the water circulating externally avoids major renovation works.

4.2 A CATALOGUE OF PARTS

The overall implementation of the strategy relies on a catalogue of parts. This catalogue uses and is inspired by existing designs and products on the market, each playing a crucial role in the overall metabolic strategy. The catalogue is divided to identify two types of components: those for food production and those for services (Figure 6).

Figure 6:
Component Catalogue.



Food production components include soil based planters, hydroponic and aeroponic solutions, mycelium panels, algae farming and a chicken coop for the rooftop. The service components focus on harvesting water, providing habitats for insects and birds, as well as plants to encourage pollination. Water is a fundamental part of the strategy, as most components rely on it. In cities such as Barcelona, where it does not rain many days of the year, other strategies can also be considered such as harvesting water from the air. Each component has a relationship with the other components in the larger strategy. When the components work together harmoniously, the ecosystem thrives.

5. A LIVING SYSTEM

5.1 A CHANGING LANDSCAPE

The components turn the static building into a living system – a strong self-sustaining ecosystem. Similar to that of a living organism, the building adapts with the seasons thanks to the plants on the façade and roofs, regulating the building's environment (Figure 7). In spring, the seeds will be sown and start to sprout, and fauna will begin to pollinate and nest. The sun is able to reach the building providing light and warmth for its inhabitants. In the summer, the plants will have taken over the facades protecting the inhabitants from the hot summer sun. The plants help to keep the building cool while starting to provide food. Autumn signifies the main harvest. Most fruits and vegetables will be ready to harvest and the plants will be cut back from the structure. In winter, to maximise sunlight hitting the building and heat penetrating the walls, the plants will be cleared ready for the new growing season.

In addition, each component has a unique calendar to consider (Figure 8). For example, during the winter months fewer crops grow, resulting in less food. Also, naturally chickens can only produce eggs for 250 days of the year, meaning that at times there may be less or no eggs at all. On the other hand, the homes for biodiversity can be used all year round by different species, and the greenhouses remain efficient during the winter months. In order to ensure a system that thrives, it is key to design with nature's needs and behaviours in mind rather than to exploit resources or animals to produce beyond their natural capabilities.

Figure 7:
Building Taxonomy.

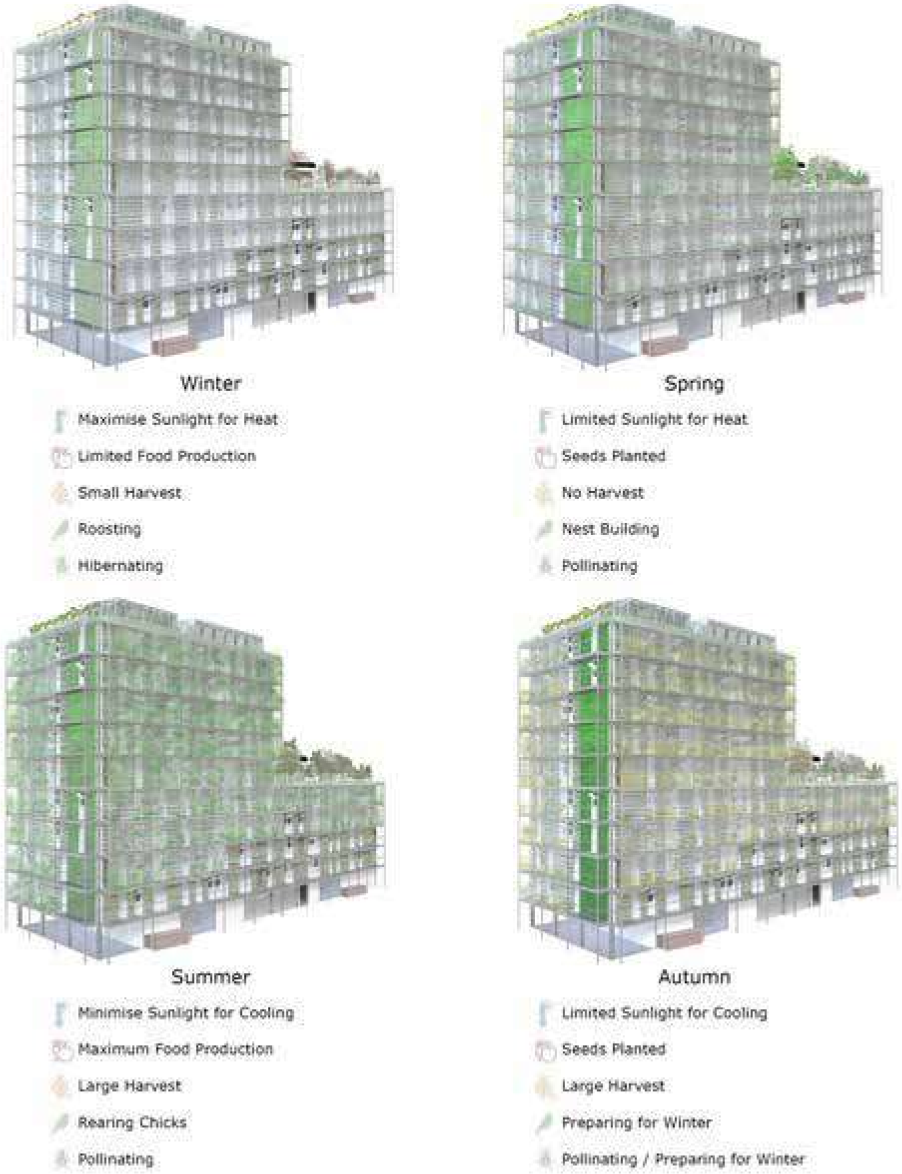
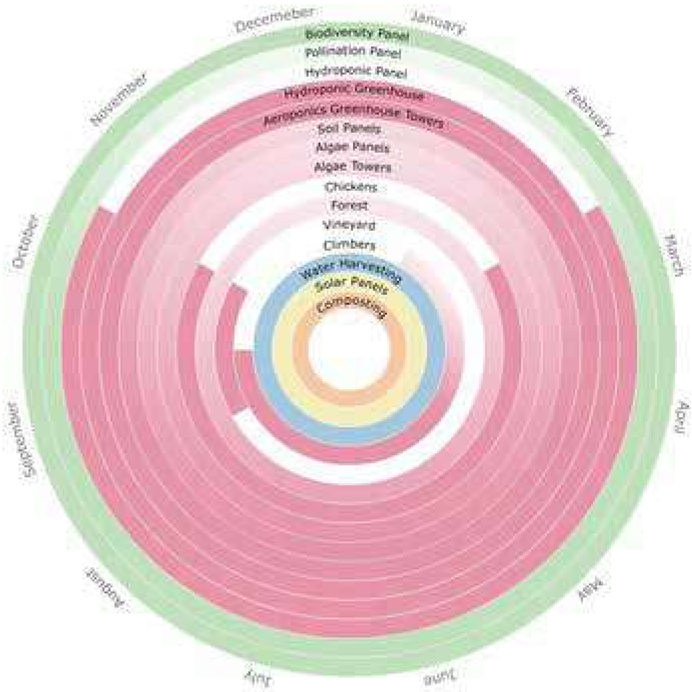


Figure 8:
Component Calendar.



6. RESULTS

6.1 TOWARDS A CIRCULAR ECONOMY

The circular economy has been at the centre of many discussions over the last years. The report Cities and Circular Economy for Food (2019) by the Ellen MacArthur Foundation highlights the key issues currently within the food system and promotes regenerative farming as a potential response. This is defined by "encompassing any production techniques that improve the overall health of the local ecosystem" (Ellen MacArthur Foundation and World Economic Forum, 2019). This was an important consideration when designing the overall metabolic strategy (Figure 9) in Plant Your Future. It demonstrates the relationship between different elements categorised by social, environmental, economic and technological flows. This helps to better understand how each component contributes to the larger ecosystem.

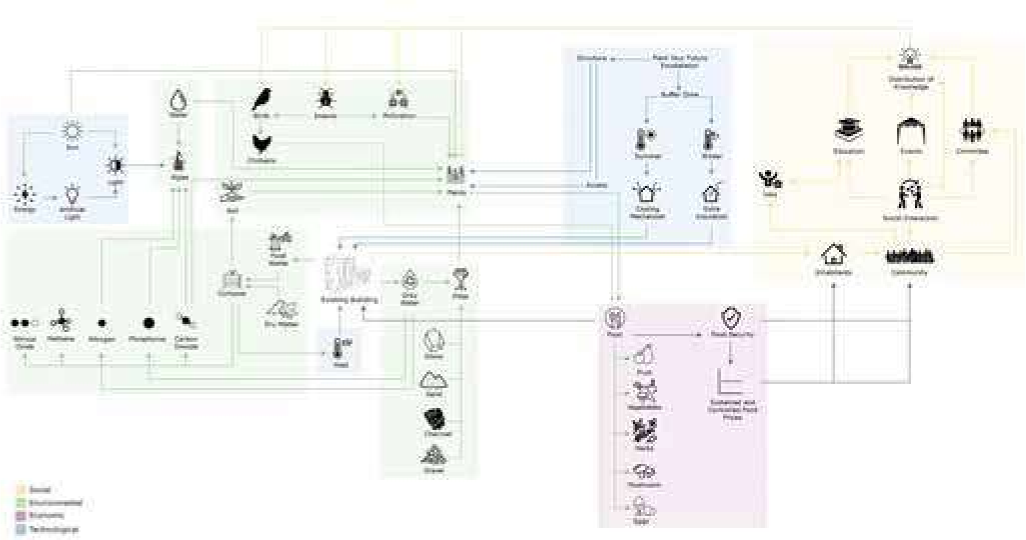
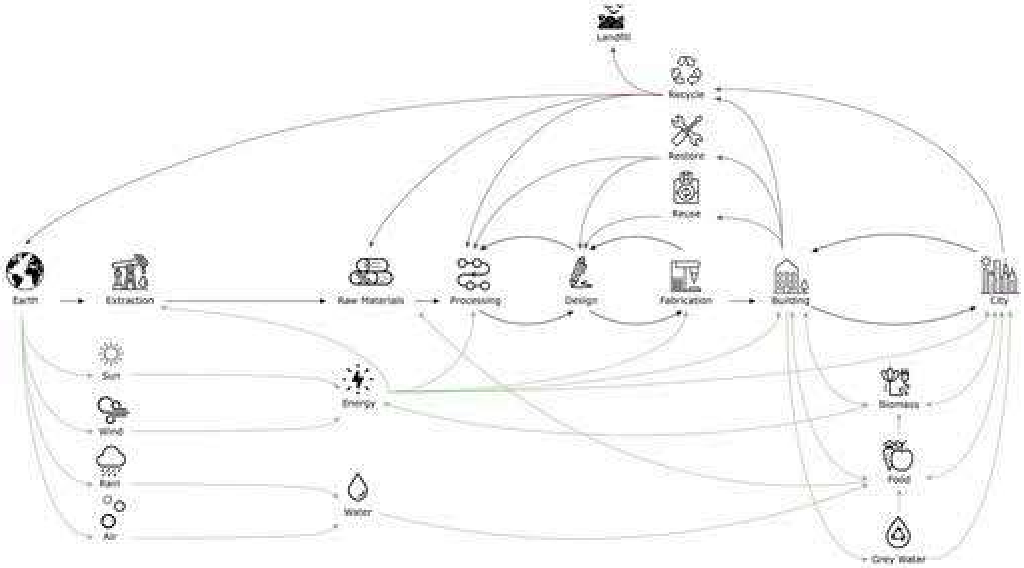


Figure 9:
(top)
Metabolic Strategy.

Figure 10:
(bottom)
Circular Economy Strategy.

When gaining a holistic perspective, one can envision the overall circular economy strategy applied to the design of the metabolic system. Circular economy is very complex and therefore, in this case, was broken down into natural elements and anthropogenic elements related to the built environment (Figure 10). The diagram helps to understand the material flows between the natural and built environment. Through retrofitting, emphasis can be placed on the reuse or restoring of buildings, avoiding the last resort of demolition and landfills.



6.2 REPLICABILITY & SCALABILITY

The main goal was to design a strategy that could be implemented at diverse scales and potentially on any building and therefore this approach focused on the building's envelope. It was however also noted that this strategy could potentially be amplified to include more extensive interventions in order to integrate grey water recycling within the proximity of the envelope. The two retrofitting strategies were consequently developed, featuring a "softer" intervention remaining within the envelope as a field of operation, and a more "invasive" intervention including the refurbishment of the building's water system in order to capture and harness the use of grey water resources (Figure 11).

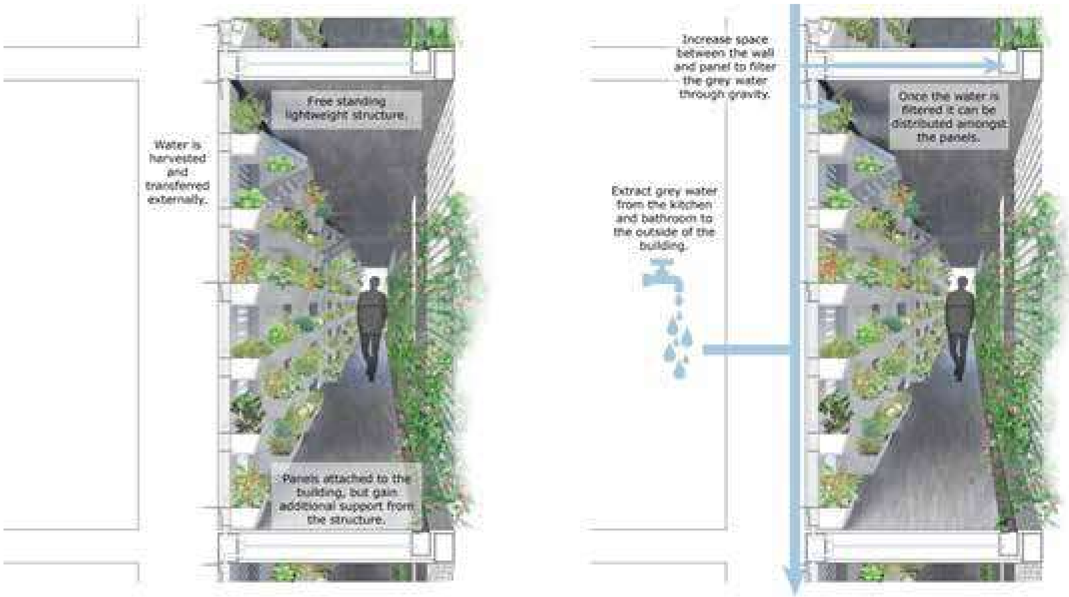


Figure 11:
Phases of Retrofitting.

There are many benefits to retrofitting existing buildings including extending the life of an existing structure and minimising the need for additional resources. However, there are also limitations; one major limitation being structural load related restrictions. In addition, many cities are built with pitched roofs, which currently limits the possibility for the rooftop to be considered as an active component, as in the case study developed.

The main argument against retrofitting would be that if one designs a new build, all the components can be integrated from the start of life of the building. This resolves any potential load bearing issues, and allows to integrate grey water recycling from the offset. While this strategy is aimed at retrofitting buildings, it shows potential to be easily applied to new builds as well.

6.3 IMPACT ANALYSIS & VISION

As previously mentioned, designing with plants can provide many ecosystem services. The Plant Your Future strategy was analysed at the building scale, the city scale and the food system scale from a social, economic, environmental and technological perspective to begin to understand and quantify the impact of the strategy.

At the building scale and from a social perspective, the strategy encourages the community to work together to produce food and maintain the plants. This allows for interaction with the ecosystem and food production, providing new skills and knowledge. Excess food can be shared or sold. On the environmental side, the building can house over 40000 plants producing food, and providing habitats for urban biodiversity, encouraging humans and animals to coexist in symbiosis. Furthermore, the plants help to regulate the building's thermal performance throughout the year, as well as absorbing particles and sequestering Carbon Dioxide. From the economic perspective, the building's lifespan is prolonged as it is protected from the elements and provides food security. If the food is sold, prices can be kept affordable and the maintenance is carried out by the community. With 24 free range chickens, 6000 eggs could be produced each year. Through the use of technology, algae can be grown all year round for 109 people, providing an excellent source of protein and biomass; solar energy is harvested to power lights and pumps required, and 572 litres of water can be harvested from the atmosphere to sustain the plants.

From a city's perspective, the impact is multiplied. There are many positive social implications, such as the transfer of knowledge and skills, community integration and a healthier society. It promotes environmental regeneration bringing nature into the city and encouraging urban biodiversity. Moreover, plants play a key role in reducing the urban heat island effect by reducing the absorption of heat, creating a healthier and cooler environment. It could provide an economic boost, adding value to the buildings, providing food security and creating jobs and local economies. This strategy also promotes the responsible use of water through water harvesting, filtering grey water and helping to reduce stormwater runoff and flooding. Once again we begin to live amongst nature and our food.

Trying to impact the global food system is much more complex, and trade-offs would have to be made. This being said, this strategy allows to rethink what is grown where and reduce the possibility for food to be lost or wasted. Essentially, this strategy eliminates the exclusive reliance on the current linear food system, in particular the processing, transportation and supermarkets. This leads to reduced food miles and a reduced carbon footprint, as the food goes straight from farm to fork. Waste is therefore being reduced and the need for processing and packaging materials are basically eliminated. Furthermore, adults and children will be engaged in the food production process from start to finish, providing opportunities for education, and most importantly eating healthily and locally.

7. CONCLUSION

The food system, as discussed in this paper, is very complex with many factors influencing the way in which it works. Changing the global food system would have major impacts on producers, especially in low income countries, this being said, where and how we produce food should nonetheless be rethought. The growing population will continue to increase demand and we cannot continue to deplete land and rainforests for food production, especially while we continue to increase surface area within our cities. A key aspect in changing our relationship with food, will be changing people's behaviours and teaching people how food is produced. One of the best ways to achieve this is to give communities the opportunity to grow their own food and take care of plants from seed to fruit.

Plant Your Future provides a larger metabolic strategy to simultaneously grow food, encourage pollination and create homes for biodiversity, all in symbiosis with humans and the built environment. The goal was to design a strategy that could be implemented today, with existing technology, and be replicated and scaled accordingly. Applying the strategy to just one building already has a significant impact, turning a static structure into a living system. If the strategy is applied at the city scale, the impact will be multiplied and cities would benefit from all the ecosystem services, as well as the potential to provide a long term plan for food security.

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SHARE & LEARN

Within the "Share" & “Learn” Section a selection of research papers seek to answer to questions such as:

How can Design with Nature be incorporated into educational models through computational strategies?

How can we Design with Nature for future scenarios and resilience?

How can educational tools such as frameworks promote critical voices in design?

TEACHING COMPUTATIONAL APPROACHES IN BAUBOTANIK

Developing a design-and-build workflow for a living architecture pavilion

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KEYWORDS
Baubotanik, Living Architecture, Research by Design, Parametric Design, Tree Engineering

ABSTRACT
Living architecture is characterized by dynamic and complex processes, thus requiring a non-static design approach with precise measurement and representation. The next generation of designers are data native and today's circumstances, such as international collaboration and pandemic restrictions, necessitate greater exploration of computational tools. This provides a good opportunity to teach landscape- and architecture students computational tools for living architecture design. This study establishes, through a taught studio, a workflow for designing and constructing with living trees. It involves photogrammetric surveying, tree representation, parametric design, prefabrication, final installation, and concepts for future growth management. A Baubotanik pavilion, around 12m by 4m, is designed and built. Its roof is supported by 32 London Plane trees around 3m above ground. In following decades, the trees are expected to grow into and through the structure as well as above the pavilion roof. The installed pavilion is scanned for deviation assessment.
The workflow proves the feasibility of design and build of complex geometry that fits existing trees. In this process, students are equipped with the iterative design thinking to work with trees in complex architectural settings, integrating dynamic plant growth into future city planning.

1. INTRODUCTION

In comparison to industrialized building materials, living tree structures are dynamic and heterogeneous. They have complex and diverse topologies and functions, and for this reason, can provide benefits throughout growth, human use, and decay. When these characteristics of living architecture are considered (Baubotanik, see Ludwig, 2016), they contradict the contemporary static design process, where complexity in design and construction is minimized. To address this, a feedback-loop strategy for living architecture is applied to Baubotanik projects using a research-by-design approach (Zimmerman, 2007): design decisions are not made once, but multiple times through the life cycle of the tree structure according to its actual growth; in the meantime, knowledge for manipulating trees is acquired during the repeated process of observation, decision-making and maintenance. This dynamic design process focuses on uncertainty (Cf. Ludwig, 2021), for which digital methods (such as capturing tree status and simulating growth) can be useful.

In this context, the integration of digital tools in a dynamic design workflow and the reactions of humans (both designer and user) and trees to that workflow must be explored. The next generation of landscape- and architecture designers are data natives. The role of computational thinking in science, technology, engineering, and mathematics education was widely discussed in recent years (Li, 2020). An education model specifically for living architecture design is therefore in urgent demand, where the future-oriented design approach with multiple dynamic uncertainties is taught. All in all, this study is motivated by two interconnected aims: to explore the workflow of computational living architecture design; and to teach Master students design with trees in a dynamic process. (see Figure 1)

The subject of the course described here is a Baubotanik pavilion located at Neue Kunst am Ried (Baden-Württemberg, Germany), a space for artists to exhibit work that engages with nature. At the site, a grove of 32 London Plane (Platanus hispanica) trees was planted in 2012. The trees surround stone tables and an oven for visitors to gather, eat, cook, and discuss. In Baubotanik projects, the feedback-loop strategy for designing living architecture is a ping-pong game between designers and trees. In previous Baubotanik projects, designers have always served the first shot – the initial settings are usually completely planned by humans. In the project presented here, the trees serve the ball. A team of 11 students, 3 instructors and 6 prefabricating helpers from diverse disciplines returns the ball by designing and building a roof structure (12m by 4m) supported by the trees. In coming years, these trees are expected to return the ball again by growing onto and through the technical structure. The ping-pong game will continue in this way until the end of trees' life cycle.

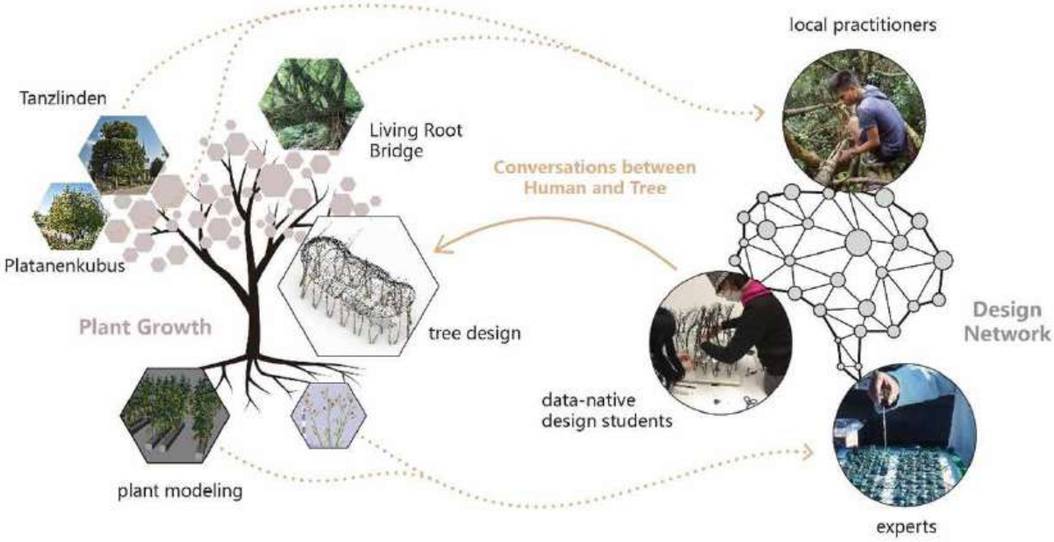

Figure 1: (top)
Teaching concept of the feedback-loop strategy for design of living architecture: on the left, knowledge derived from living architecture traditions and plant modeling in botany; on the right, the design network consisting of local practitioners, researchers and designers who learn from plant growth to design living architecture, which allows further understanding of plant growth.

2. METHODOLOGY

2.1 COMPUTATIONAL DESIGN

The computational design approach begins with a data workflow, including data acquisition, interpretation, and geometric design. To acquire the initial data, the trees were surveyed using photogrammetry (Middleton, 2019). About 1500 photos were taken at various positions and angles to generate 3D point cloud models of the site. Especially during the covid-19 lockdown in Germany, the point cloud replaced on-site excursions. The model consists of 70 million discrete points. To interpret the data, woody trunks and branches of the relevant trees are manually extracted from the scene. Wu B. (2020) provides an automated alternative. Then, a skeleton (Huang, 2013) is extracted for each tree. The average distance between surface points and the nearest trunk point is calculated as the radius of the trunk at various points along its length and cylinders fit accordingly to represent trunk and branches. The geometric design of the technical roof structure is generated in Rhinoceros and Grasshopper (McNeel, 2021). Inspired by Wang's (2002) study, a truss structure can follow complex Bezier surfaces, meeting both the geometric form and mechanical requirements. Moreover, a truss allows for thin rebar elements, which tree branches can easily overgrow and encase. For the Baubotanik pavilion, six pairs of approximately coplanar branches are selected. On each of the 6 planes, a curved truss is drawn to fit closely the shape formed by the branches. These 6 trusses provide the basic roof form. At regular intervals along the length of each truss, perpendicular trusses are added to connect the 6 original ones, forming a space frame (see Figure 2 upper left). In this way, the geometry of the roof is formed close to the natural shapes and positions of selected branches.

2.2 FABRICATION

The roof's fabrication relied on a combination of handwork experience and building tests using different materials. It was proved through 1 to 1 testing that pre-bent rebar (mostly in 8mm diameter) in slight tension would not deform significantly after additive welding into trusses. The 6 plane trusses were firstly fabricated on mounting plates that configured with digital drawings. Afterwards, the space frames were directly bent and welded on the plane trusses that positioned tightly on tailor-made wooden scaffolding. Then, the whole roof structure was divided into 14 pieces for lacquering and transporting. Finally, the 14 pieces were assembled into 3 larger components on the ground next to the site and lifted to the treetops (see Figure 2 right). At appropriate points of contact, the space frame was fixed to the trees with screws (see Figure 3). Every step in the fabrication apart from lacquering refers directly to the digital model.

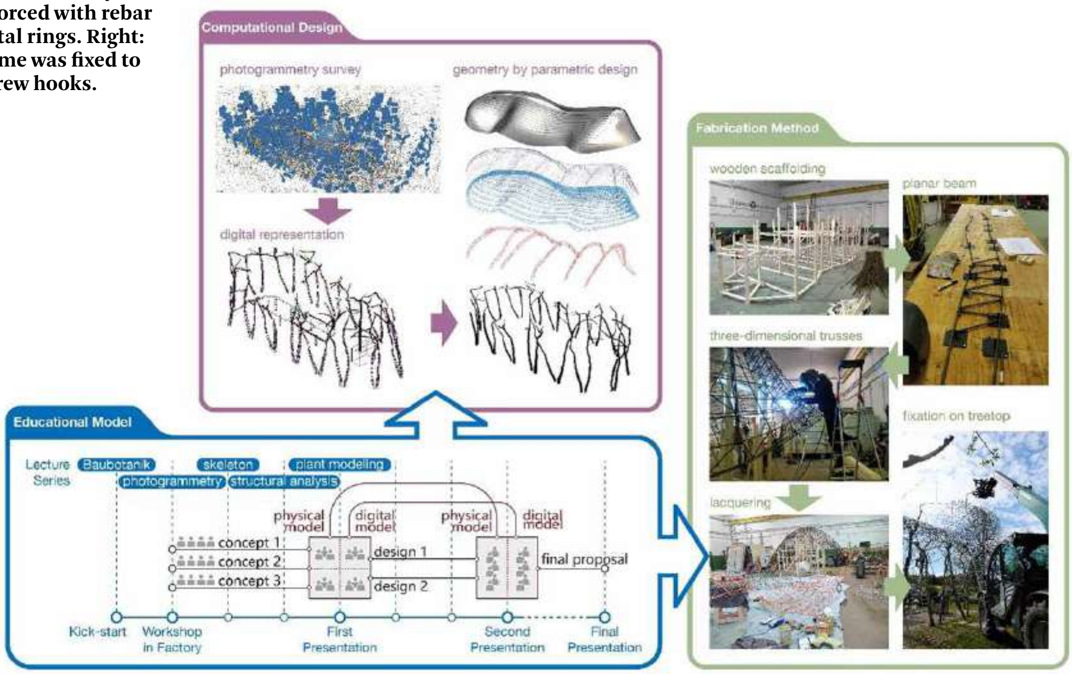

Figure 2: (top)
Overview of the teaching, design, and fabrication workflow. Bottom left: concepts and general application of digital methods were taught to students prior to design; three design groups competed to develop concepts, narrowing down to 2 groups at the design and modeling phase, converging on one proposal for fabrication. Top: digital methods learning was applied to develop the computational workflow including data acquisition, interpretation, and geometric design. Right: the group's diverse skills are needed to continuously refer the fabrication to the digital model.

Figure 3: (bottom)
Detailed connection techniques. Left: truss pieces were connected by M8 screws, reinforced with rebar stick and metal rings. Right: the space frame was fixed to trees with screw hooks.

2.3 EDUCATIONAL MODEL

In terms of the educational model, students began with a lecture series on computational tools and progressively explored deeper into their application in living architecture. The 11 students are skilled in (landscape) architecture design. Two have worked in the field of carpentry; Three have experiences with parametric design in Rhino and Grasshopper; but all are new to living architecture design and digital representations of trees (Godin, 2000). Through the lecture series, they learnt about spatial data, skeletonization, tree mechanics, and growth modelling. To explore the diverse applications for dynamic growth design, students worked in three groups, developing three concepts, which narrowed down to two for deeper analysis. These condensed into one design and the team members specialized on individual tasks for translating the digital model to a buildable structure (see Figure 2 bottom left). Merging the groups pushed communications and exchanges among students, forming an atmosphere of one team. This teamwork also motivated student to learn the novel methods despite difficulties in the process. At the end of the studio, an anonymous survey is sent to individual students. They are asked for feedback on the teaching method and their learning outcomes.

3. RESULTS

3.1 BUILT PAVILION

This study results in a reliable workflow to teach, design, and build living architecture on existing tree structures. Unlike building a structure on a solid foundation, young trees are not fully stabilized for structural load. The Platanus trees on site have diameters at breast height (DBH) ranging from 0.05m to 0.1m – one person can push and pull the tree to make the top of the trunk (at ca. 3m above ground) move up to 0.2m. So, the challenge lies also in dealing with the inconsistent deformation of the trees under the load. Considering this, the truss structure enables a tolerance for inaccuracies because the trunk can be fixed at multiple points to the space frame. Flexibility in spatial positioning is part of the proposed solution. Therefore, precise measuring equipment (i.e., total station) is not necessary during the prefabrication and installation on site. Instead, plumb lines are used to give a visual coordinate reference in space. By overlaying the LiDAR scan of the pavilion with the original digital plan (see Figure 4), the deviation is assessed precisely. In general, the geometry, position, and rotation of the pavilion in the digital plan match well with the reality on site. Most of the space frame does not deviate more than 0.2m, commonly around 0.1m. These deviations are likely caused by unstandardized handwork in bending the rebar and inexact estimation of trunk deflection under loading. The largest deviation is 0.4m. It occurs when one plane truss is incorrectly positioned 10.9 degrees higher on the wooden scaffolding than in the digital plan. This deviation did not affect the match of the overall fit of the truss to the trees. So, this workflow results in building structures with good

Figure 4:
Overlay of the computational model and the accomplished pavilion: trees in the digital model are drawn with white pipelines; designed truss system is represented with slim colored tubes; actual positions of trees and the structure after implementation are presented by the point cloud.

tolerance to fit existing living trees. Besides the trunk, branches at the higher end of the trees have been intentionally pressed down by the truss structure from their original positions to fit the roof geometry. They will begin growth to carry the load. All these adaptions are documented by the point cloud models scanned before and after the implementation (figure 4).

One feature of Baubotanik projects is the ongoing growth of trees. In the summer of 2021, all the 32 London Plane trees grew prosperously (see Figure 5 right). Screw hooks through the centre of each tree trunk to connect the trees with the steel structure did not affect the vitality of the trees recognizably (compare Ludwig, 2012 a and b). A truss structure without closed roofing allows adequate sunlight to reach the leaves. As the branches grow, they are pruned and manipulated to grow through the truss. Hook-and-loop fasteners are used to pull soft branches closer to the truss elements so that they encase the roof at many points with their girth growth. In this way, the structure grows stronger. In the next step, shingles will be progressively added to the roof as these connections strengthen, eventually covering the whole area, apart from a reserved hole at the top through which the branches can continue to grow (see Figure 6). As it is a ping-pong-like iterative design process (described in section 1), this scenario should not be a “final result”. Due to competition for space and light (Boeck, 2014) some mortality among these trees is expected. Such variables are factored into future design stages.

Figure 5:
(top)
Photos of Baubotanik Pavilion. Left: the situation immediately after the installation in April 2021. Right: 3 months after the installation, new leaves grow out. The project has a dynamic appearance through seasons with different shades, light and color.

Figure 6:
(bottom)
Scenarios for Baubotanik Pavilion: The branches grow under the roof and provide stronger support; shingles will be added.

3.2 TEACHING EVALUATION

The education model allows students to explore the broad horizons of a digital-first workflow, including dynamic growth prediction, precise tree mechanics, and environmental modelling. Nevertheless, they do not lose sight of the transition to a built structure, as the digital model runs continuously in parallel with the fabrication. From the 11 sent questionnaires, we received 6 feedbacks. 33.3% of the students "fully agreed" and 66.7% "agreed" that the teaching contents were well coordinated; 83.3% of the students fully agreed that the course structure motivate them to learn the contents better. 66.7% of the students found the difficulty level fit their ability while 33.3% said the course was a bit difficult. Half of students "fully agreed", and the other half "agreed" that they can transfer key skills from this design studio to elsewhere. The perspective this engenders in students is applicable in future urban design, in which precise data feeds complex dynamic models for living architecture design.

4. CONCLUSION AND VISION

This study aims at two questions: how to integrate computational approaches in a workflow of living architecture design; how to teach data-native student both new design methods with digital tools and dynamic design thinking for developing living architecture. To address these two questions, a Master-level studio was organized to design and build a Baubotanik pavilion. The design phase explored a computational workflow including photogrammetry survey, abstracting tree representation, and producing parametric geometry. The fabrication phase relied on the digital model from the design phase for tailor-making the complex truss system. The built pavilion was installed on the trunks of 32 London Plane trees on site. The deviation analysis using LiDAR scanning data proves the feasibility in this novel design workflow; the teaching evaluation from students proves the effect in the explored educational model.

This study extends the current scope of Baubotanik by achieving a design-and-build structure fitting existing trees. It is like returning the ping-pong ball served by the trees. However, it remains to be answered how to continue this game with an affordable solution to constantly make design decisions and perform periodic maintenance accordingly (i.e., pruning and bending). This involves deeper research in simulating tree's reaction to manipulations, setting goal parameters and a decision-making mechanism (Shu, 2021). Precise documentation is essential to the next phases of building, beginning with the design and construction of the roof shingles. Iterative LiDAR surveys will capture the density, extent and direction of new branch growth, and the degree of overgrowth of the truss – these conditions will inform the material, size, and attachment method of the shingles. The ping-pong between tree and human is multifaceted. Diverse environmental features such as light and air flow can be designed using the whole range of tools at the architect's disposal. Only then, Baubotanik, in other words living architecture design, can eventually become a common game played between humans and trees around the world.

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2050 SCENARIOS FOR CITIES

Perspectives and proposals of university architecture students in southern Brazil

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KEYWORDS
future scenarios, cities, architecture education program, sustainable development, learning process

ABSTRACT

The purpose of this work is to present the academic results developed in the Architecture and Urbanism course of the University of Passo Fundo, located in southern Brazil. The project aims to establish reflective thinking about how our actions in different sectors will produce scenarios for the coming decades and their impacts on climate change. The focus is on solutions for buildings, cities, and infrastructure, engaging public and private stakeholders, the university, and academia in making solutions through research and extension, on issues of housing, energy, water, food, mobility, and sustainability quality of life and social equity. The article presents the academic process of knowledge construction generated by the discussions and development of scenarios for the year 2050 and proposals for alternatives to such future scenarios, whether utopian or dystopian, but based on current reality and its scientific projections.

1. INTRODUCTION

According to the Intergovernmental Panel on Climate Change - IPCC, in the coming decades global warming will be exceeded by 1.5 °C, accentuating extreme climate events, requiring actions still in this decade to significantly reduce and avoid the consolidation of an even more catastrophic scenario (IPCC, 2021; WRI Brasil, 2021). The urban population is expected to grow 2.5 billion by 2050, and the difficulty in accessing basic services in urban areas can reduce the economic productivity of populations (WRI BRASIL, 2016). In Brazil, the estimate is of over 29 million inhabitants by 2050 and 90% will be urban population (ROSSI, 2021). Even with the drop in the global poverty rate, there is an increase of poor population in urban areas, with 70% of emerging cities population in Latin America, Africa, and Asia lacking access to housing, water, energy, and transport at reliable levels (The City Fix Brazil, 2016).

Therefore, actions that will impact the built environment in the long term need to be implemented now to meet the growing demands in urban centers and establish resilient human habitats. Any region on the planet will be affected by climate change, with increases in fires, droughts, floods, among other events, which impact infrastructures such as energy and transport, causing economic and human costs that will cost more than the actions that can be taken now (WRI Brasil, 2021). The infrastructure itself already presents several challenges for its maintenance or expansion, and climate change can seriously affect these issues.

For example, the energy sector can be affected due to climatic variables. Hydroelectric plants and other sources that use water in their processes can be affected due to changes in temperature, precipitation, irradiation (Soulaun and Cerda, 2020). In the US, weather events were responsible for 78% of supply interruptions from 1992 to 2010, in addition to reducing the infrastructure life cycle (Fant et al., 2020).

World electricity consumption grew by 0.7% in 2019, below the average of 3% between 2000 and 2018 (Enerdata, 2020). In Brazil, energy consumption grew by 1.3%, with demand expansion in the residential sector by 3.5%, and commercial by 4.5% (EPE, 2021). In contrast, electricity generation grew only 1% in 2019, even with a 24% increase in photovoltaic solar energy (Enerdata, 2020). In Brazil, there was a growth of 2.3% by wind and photovoltaic sources growth, added to hydroelectric generation, with 83% of the matrix composed of renewable energies (EPE, 2021).

Other sectors, such as sanitation, already present worrying scenarios even before climate changes. Actually, 2 billion people live under water stress (UN, 2018) and 82% of urban population and 51% of rural population have access to sanitation systems. Worldwide, 1 billion people don't have access to a toilet, and between 2000 and 2015 the proportion of the world population that has at least one basic sanitation service increased from 59% to only 68% (Trata Brasil, 2021a).

In Brazil, 83.7% of the population has access to treated water, with 35 million inhabitants still are without access. About 2% of Brazilians do not have access to toilets and only 41.5% of municipalities have a sanitation plan, regulated or not. Across the country, only 21 municipalities treat more than 80% of waste water, while 49.1% of the population has access to this service (Trata Brasil, 2021b). Insecurity about the resilience of basic infrastructures like energy supply or sanitation in face of climatic events will cause damage to the economy and society, also compromising the conditions for responding in extreme situations.

In addition to these challenges, part of the effects of climate change will reach the point of not being reversed, and aggravated as emissions increase. Redefining the means of consumption and production and how we use the soil is necessary to establish the level of zero emissions, considering that the natural environment will still take time to reestablish itself after the definitive emissions reduction (WRI Brasil, 2021). Topics such as the growth of cities, access and management of water, energy, food production, mobility, waste collection, and waste recycling have a significant impact on the future of cities and planet until 2050.

Actions taken already or not implemented now will impact life quality, social equity, and the natural environment, inserted in a context of accentuation of climate change. Therefore, it is necessary to build solutions in different fields, as well to introduce these questions to society in general. In the academic environment, the insertion of these themes and the urgency to search for alternatives that lead to resilience and impacts mitigation can contribute to the training professionals who provide answers and actions to climate change.

Based on the analysis, diagnosis and the construction of scenarios for 2050 (ARUP, 2019; IPCC, 2021), the methodological proposal of the discipline of the Architecture and Urbanism Course of the University of Passo Fundo (UPF) - Brazil, with an open learning character, aims to bring contemporary themes that allow the development of critical thinking about this contemporaneity. Mainly, the objective is to contribute to the discussion of individual responsibilities and as a professional facing the future, based on these scenarios elaborated by the students themselves and their proposals for alternatives. This theme connects to the scope of the international project "Transforming Universities for a Changing

Climate (Climate-U, 2020) and the Green Office UPF – Academic Center for Sustainability. This article presents the results of this construction of critical and active learning by academics.

2. METHODOLOGY

During the elective discipline of Special Topics in Architecture and Urbanism in the semesters 2020/2, 2021/1, and 2021/2 (under development) with a total of 77 students, themes related to climate change and concepts are inserted within the Black/Dark Ecologies, a concept developed by Timothy Morton (2007; 2015) for the construction and projections of possible scenarios for 2050. These concepts are connected with technologies within an integrated environmental sustainability approach (Gausa, Markopoulou and Vivaldi, 2019) and introduce experimental instruments for creative innovation inspired by nature (Brajovic, 2016).

The concept of Black Ecology or Dark Ecology developed by Morton (2007), refers to a new interest to explore a new nature, not only related to architectural space, but in a whole environmental framework beyond the generalized vision of ecology (Gausa, Markopoulou and Vivaldi, 2019). In this sense, Architecture and Urbanism is closely related to the areas of Design, Technology and Biology. The pedagogical premise considers what Guallart (2019, pp. 28) puts forward on multi-scalar education, centered on the human being and their abilities to interact with their immediate surroundings, intending to include the local production of resources (food, energy, and consumer goods) and the ability to interact globally and share knowledge through information networks. In this way, the proposals also addressed topics such as Net zero energy buildings, basic sanitation, urban segregation, and social housing, by a Problem Based Learning (PBL) approach.

Through propositional exercises, the students were encouraged to imagine possible scenarios for the year 2050, in different contexts of utopias, dystopias and retropias (Berardi, 2019), outlining the consequences of living conditions from the incisive adoption of sustainable practices or by maintaining current consumption and pollution patterns, referring to Rogers and Gumuchdjian (2015) and other authors.

At first, students develop a reflection on the perspectives of the evolution of anthropic actions in the natural environment, understood here as the built environment and the natural environment in its most direct meaning. As a training basis, scenarios for 2050 (ARUP, 2019) and reports on climate change (IPCC, 2021; WRI Brasil, 2021) are used, but another element of research is the students' free search for everyday references, from everyday life that presents a set of information about the contemporary condition of cities, covering this research with a dynamic and open character.

The works of the students, organized in groups, bring a variety of analyzes and prognoses, referring the use of conventional or advanced technologies in a speculative design of the future and as a tool to reflect on what steps design should take today.

3. RESULTS

As a result, it was intended to instigate critical thinking and induce the process of reflection on how current patterns of consumption, transportation, housing, and work will be in 2050, in view of the demands of climate change, productive capacity, and life quality. The Figure 1 show some of those student's perception about "the dream", the utopic scenery against the "nightmare", the dystopic future for 2050.

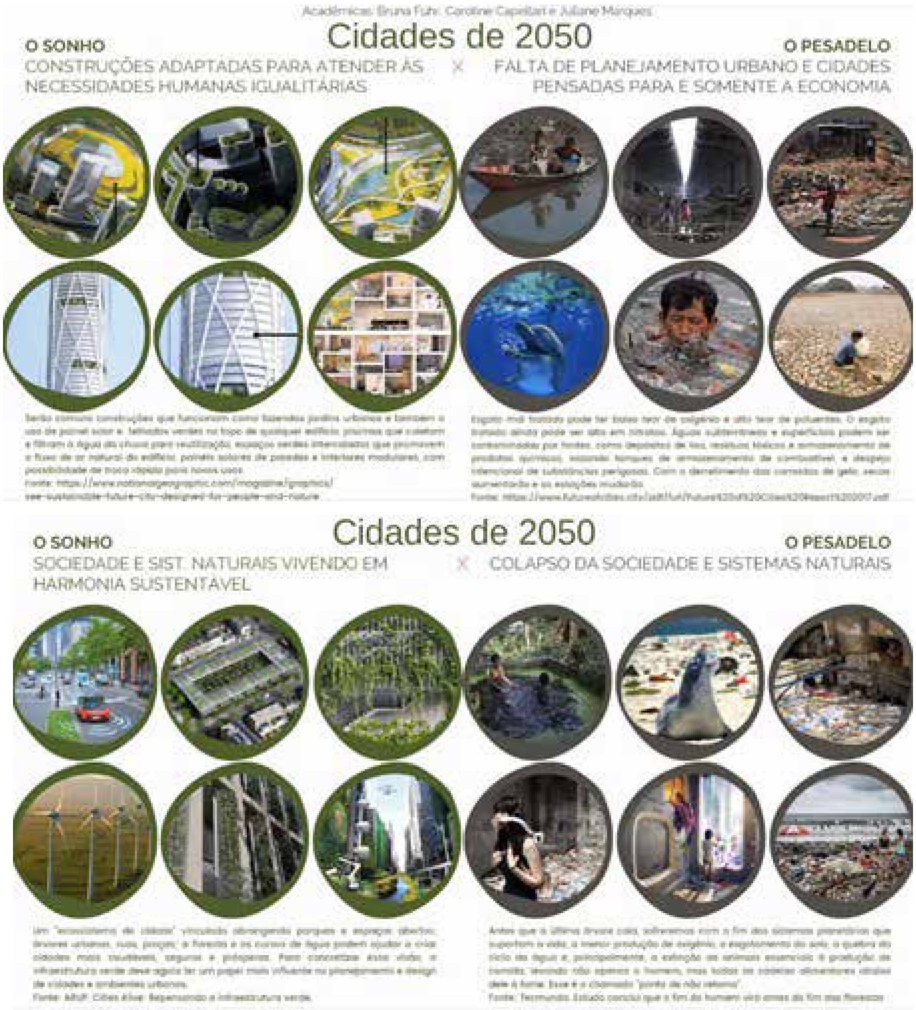


Figure 1:
Cities of 2050: the dream versus the nightmare. Source: Fuhr, Capellari and Marques, 2021.

Figure 2:
Cities of 2050: 2030 to 2050 dystopia. Source: Trilha and Teixeira, 2021a.

Other students reflected scenarios from a dystopian perspective, with natural resources collapsing according to a timeline for 2030, 2040, and 2050. Renewable energy sources will be unfeasible due to climate change and the densification of urban areas, which leads to use of nuclear energy sources, the scenario is shown in figure 2:

After making the scenarios, students were challenged to propose solutions for cities and buildings in response to the proposed situations and challenges imposed by climate change. Figure 3 describes the perception of the effects of the COVID-19 pandemic with a reflection in ways of housing with an urban exodus (Trilha, Teixeira and Frandoloso, 2021b), in search of life quality in rural areas, connected by communication infrastructure, mobility tools and other facilities allowed by technological development, also including proposals to local food production. In Figure 4, the approach is broader, bringing the urban theme with the discussion of smart streets, mobility and urban gardens for food production.

Biodiversity was the approach observed by the Arthropoda project group presented in Figure 5, considering endangered bees, and making a connection between climate change and the currently agriculture procedures adopted in Brazil, as well as indicating a change in these practices to ensure a broader and more integrated ecosystem for the future, including the design proposal for an artificial hive. The idea that generates concern about bees stems from the identification

Figure 3:
(top)
Urban exodus: rural housing in the future. Source: Trilha,Teixeira and Frandoloso, 2021b.

Figure 4:
(bottom)
Smart Streets: A Blueprint for the Future. Source: Schuster and Rigo, 2021.

that massive changes in climate dynamics lead to the issue of the division between human actions and the environment and that species diversity also considers the other 99% of planet's species, as presented by Terreform One for butterflies with the Monarch Sanctuary (Joachin and Aiolova, 2019).

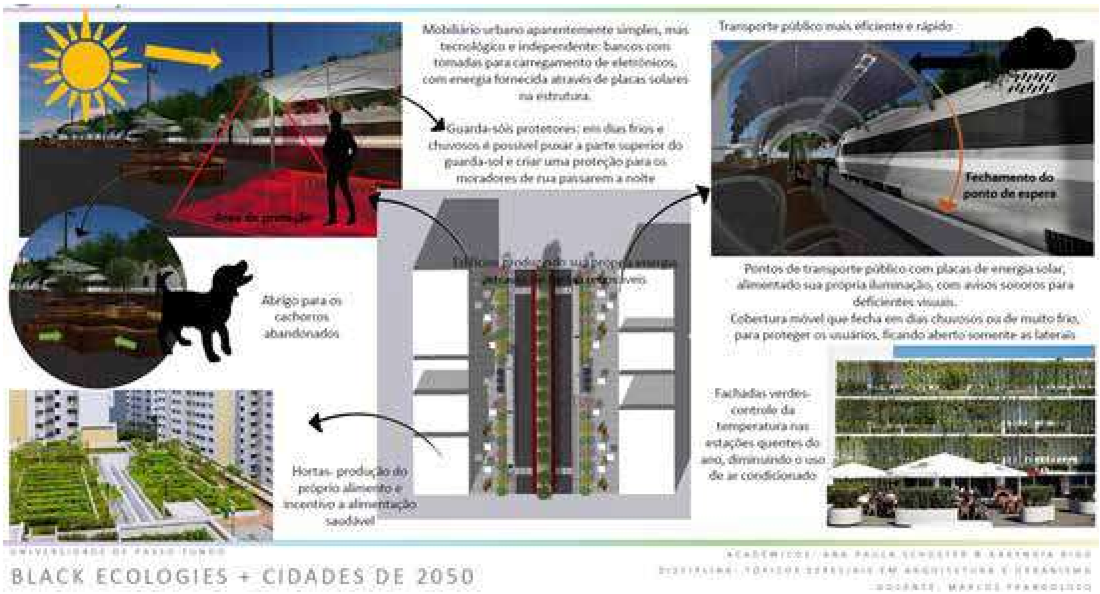


Figure 5:
Arthropoda project. Source: De Marco, Silveira and Del Ré, 2020.

Figure 6:
Moth-er Earth. Source: Gampert, Winkelmann and Meska, 2020.

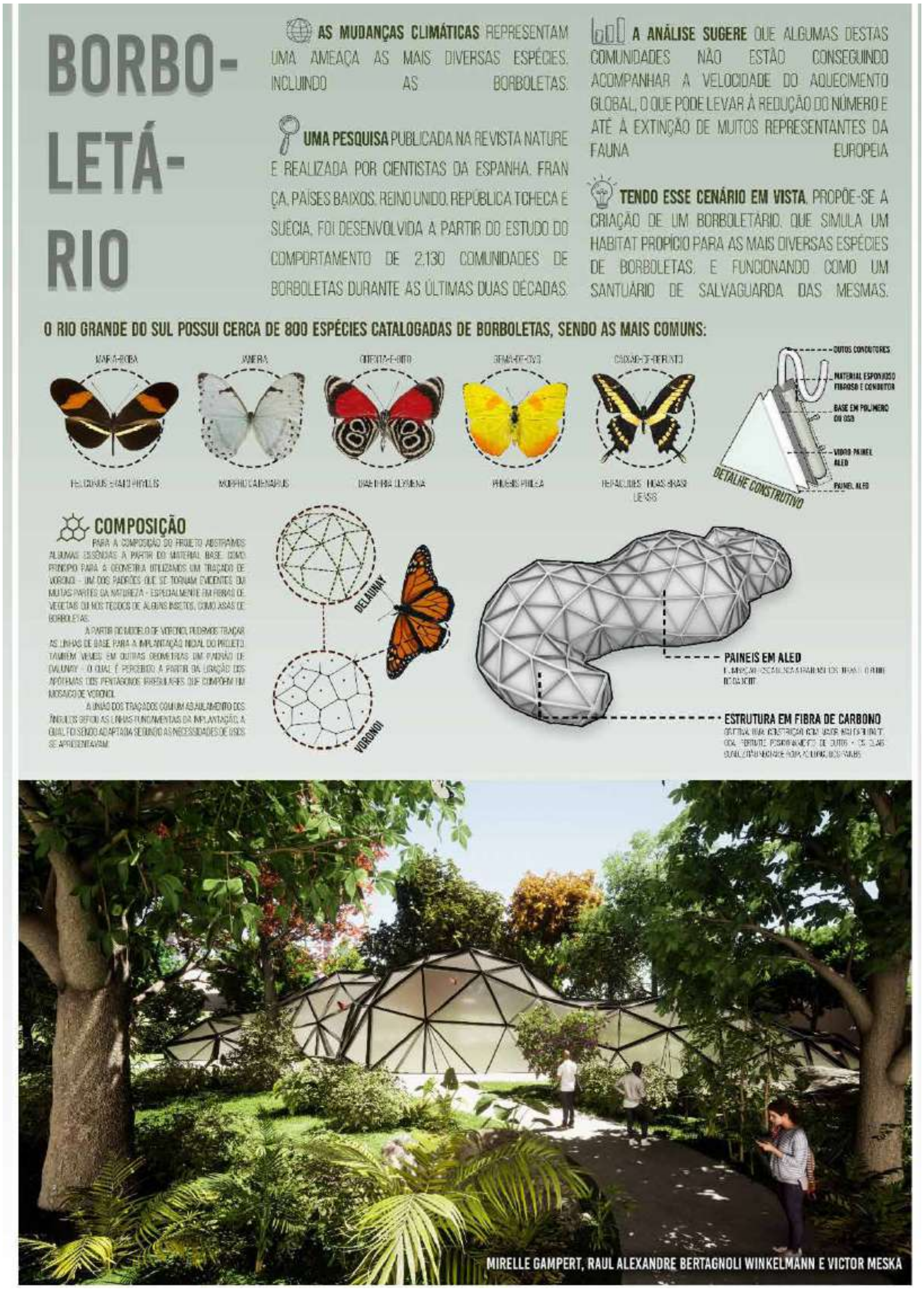
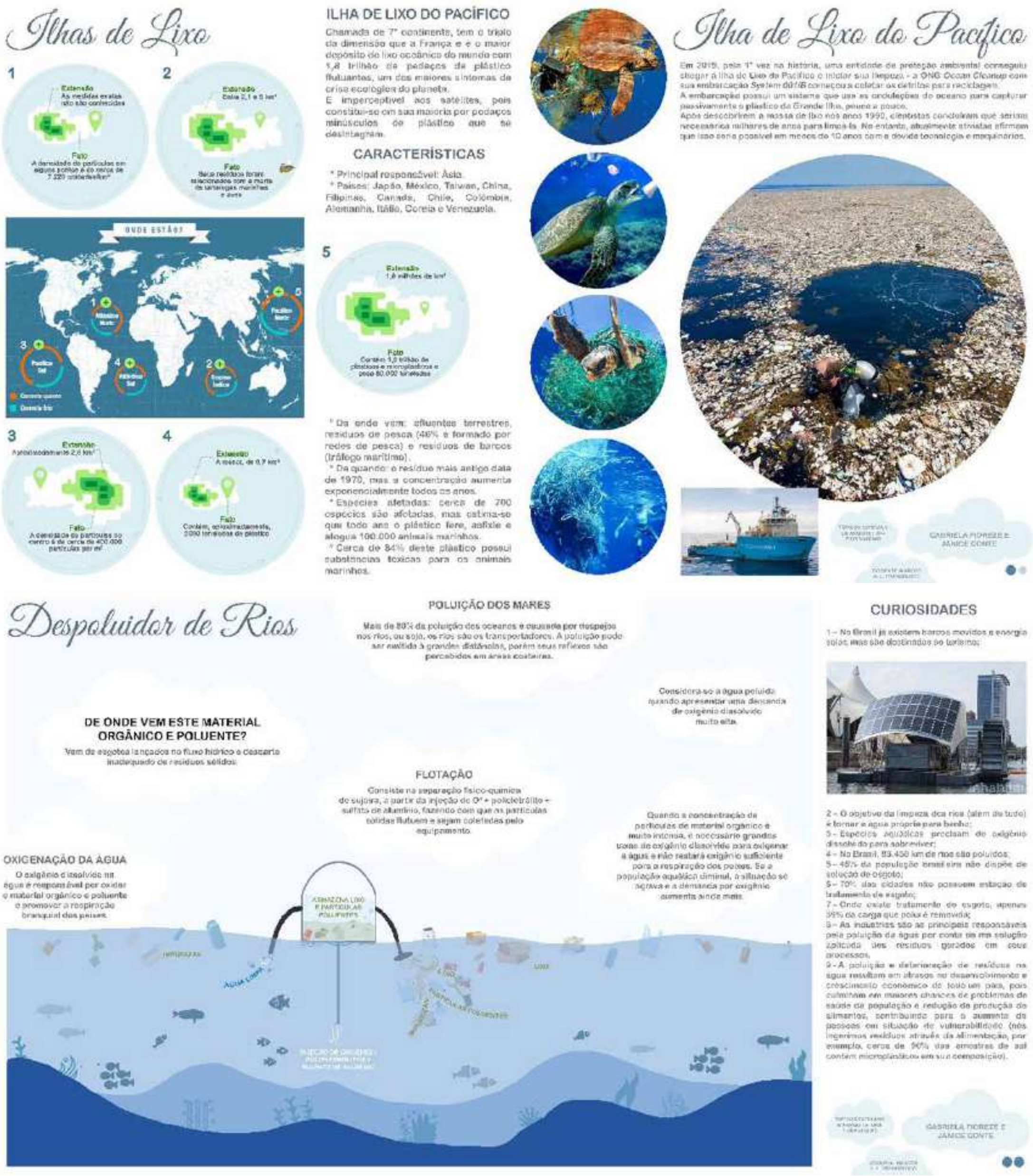


Figure 7:
The garbage islands and the river de-polluters. Source: Fioreze and Conte, 2021.

Figure 6 also follows the biodiversity approach connected to the concepts of Black Ecologies, locating a shelter to butterflies and moths with a regional habitat at an urban parks design based on regenerative landscaping approaches. The design process adopted several tools for modelling and rendering, like Rhinoceros Grashopper, Lunchbox, Twinmotion and Autodesk Revit.

The proposal in Figure 7 faces the plastic waste released into the natural environment, identified as the islands of garbage located in the Pacific Ocean. As a solution, the students developed research to seek alternatives for depolluting rivers and seas through physical-chemical separation of waste and devices for collecting the floating waste.



Considering that the discipline is elective, as the characterization of students from different academic levels, from intermediate levels to graduates, this knowledge has a transversal curricular action. The academic work resulting from the discipline will be organized and compiled with an e-book to be published in 2022. The e-book will have financial support from the Green Office Academic Sustainability Center (UPF, 2021) in partnership with the International Project Transforming Universities for a Changing Climate (Climate-U, 2020). The objective is to promote projects that aim to develop research, teaching, or extension actions in Climate Change and sustainability.

4. CONCLUSION

By the methodological approach used in the discipline, the course aims to instigate critical thinking and induce the process of reflection on how current consumption, transport, housing, and work patterns will be in 2050, given the demands of climate change, of productive capacity, of the quality of life, as a result of the discipline and the activities developed.

The proposals illustrate responses to situations that are already occurring and tend to become more accentuated by climate change. Data from ongoing research highlights the urgency in making solutions in actions against climate change and to present ways for new technologies to develop. The students' proposals bring themes discussed (global problems) to the local reality, where answers and solutions (local) can be used for global demands, by academics, students, public authorities, and the private sector.

Publishing the student's proposals through the e-book will broaden the discussion on how we can establish resilient buildings, infrastructures and cities in face of climate changes. Furthermore, approaches like this are considered proactive, as responses are projected before the extreme events occur.

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A HOLISTIC TRANSDISCIPLINARY ECOFEMINIST FRAMEWORK:

Advancing urban South Africa towards more just and sustainable green developments.

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KEYWORDS

Eco(logical)Feminism, Analytical Framework, Green Urban Spaces, Sustainable Just Developments

ABSTRACT

This paper proposes a holistic transdisciplinary ecofeminist framework which aims to advance South African urban spaces, through Eco(logical)Feminist ethics, towards more just and sustainable green developments. The proposed framework is an extension for existing ecofeminist models. Aiding them in dissecting, anatomising, and unravelling of complex power dynamics of oppressive conceptual frameworks within urban South African ecologies. Hence, this educational tool hopes to advance critical thinking in 'designing with nature' processes within Global South/ South African urban contexts.

1. INTRODUCTION

There is a demand for the reconceptualising of sustainable urban developments in response to today's local and global (glocal) just ecological challenges. Specifically, when it regards the developing/designing of just green Global South (GS) cities. Nevertheless, most urban spaces in the Global North (GN) over the past centuries have reinforced their economical, habitable, and efficiency qualities (Iaac, 2021). We cannot deny that scholars, designers, architects, and urbanists perhaps came this far by following a common agenda (Newalkar and Wheeler, 2017). Such as the 1987 'Our Common Future' or 'Brundtland' Report (Brundtland et al., 1987; Newalkar and Wheeler, 2017). The turbulent 'Paris Agreement', and the 'Transforming our world: the 2030 Agenda for Sustainable Development' (United Nations, et, al. 2015, 2019,). Moreover, the upcoming United Nations' (UN) COP26 shall undoubtedly guide the design profession' (conscious or unconsciously) towards new global goalposts i.e., a common agenda (United Nations, 2021 B). Foundational to the accepted common agenda is that they are based on the UN' 17 Sustainable Development Goals (SDGs) (United Nations, et, al. 2021 A; Struckmann, 2018). The SDGs were originally shaped along the imperfect sustainability pillars of 'social, environmental, economic' values (Basiago, 1998; Purvis, et, al., 2019). The later 2030 Agenda extending these pillars into a more inclusive framework of the five sustainability P's: 'People, Planet, Prosperity, Peace, and Partnership' (United Nations et. al. 2019, 2015). Albeit in general terms the SDGs and their foundational values have served the GN tremendously in advancing their sustainably agenda(s) and the 'greenification' of their cities (Hammer, 2011; Brilhante and Klaas, 2018; United Nations, et, al., 2021 C).

2. PROBLEMATISATION

However, many scholars argue that the SDGs and their consequential agendas are partially problematic (Kotzé, 2018; Sultana, 2018; Thakhathi;2019; Ndlovu-Gatsheni, 2014; Newalkar and Wheeler, 2017). As they mainly serve GN worldviews, notions, and values which perpetuate and sustain asymmetrical power relations between the GN and the GS (Ndlovu-Gatsheni, 2014). Northern agendas and their sustainable green development solutions do not always benefit the GS or their cities. Neither does the South have the same resources at their disposal to develop or maintain these GN initiatives. GN agendas do not always resonate with the GS values or contexts. For instance, the Paris Agreement set an acceptable global temperature increase at 'well below' °C2 pre-industrial levels (IPCC, 2021). However, the GS specifically sub-Sahara Africa cannot cope with more than °C1 increase (Shepard, 2019). E.g., consequently, droughts in combination with inefficient water management causes urban water crisis (Urbanet, 2020). SA' Cape Town even had to set a 'day 0' for when water resources would run out (City of Cape Town, 2020). Hence, "—the global acceptance of sustainable development goals has not necessarily ensured a good social and environmental well-being in cities." (Newalkar and Wheeler, 2017, p. 2). Moreover, many deep ecologists, feminists, environmentalists, architects, and urbanists have argued that there is an ethical deafness in the development and planning of green GS/SA cities (Newalkar and Wheeler, 2017; Struckmann, 2018). This as many green GN 'initiatives (as bright and well-intended as they are), often do not consider that one doesn't design from a relatively equal plateau in SA/GS cityscapes. Hence, SA cities suffer from spatial inequalities, due to colonialism, apartheid' urban-planning, and post-colonial spatial perpetuations (Harrisburg, 2020; Lemon, 2021; Smith, 2003). Additionally, due to these segregated urbanities black and poverty-stricken urban areas seldom benefit of sustainable green developments, resulting into a 'green apartheid' (venter, et al. 2020; Harrisburg, 2020). Moreover, there are many more complexities such as lack and inequality of infrastructure, lack of housing, economic inequality, unfair resource distribution, discrimination, gender-based-violence and other oppressive systems (Turok, 2011; Schensul and heller, 2011; Lemon, 2021; Smith, 2003; Struckmann, 2018).

3. CONCEPTUAL FRAMEWORK

Ergo, this paper argues that urban complexities and the concurrent power dynamics should be considered and analysed within the design processes of just sustainable green urban developments within SA. Hence, there is a need to recognize that SA urban issues, need SA urban solutions, which sensitivity and judiciously juxtaposition sustainable 'Global' and 'Local' agendas and their underlying values.

Now as many scholars, designers, architects, urban planners, deep ecologist, and (afro-)feminist have argued before me; Eco(logical) Feminism is a sensitive and appropriate theoretical terrain for promoting just green incremental change.

Ecofeminism is a deep ecology affiliated accumulation of ecological protection and feminist movements (Warren, 1990, 1993; Ling, 2014). Which has as "—position that there are important connections—Historical, experiential, symbolic, theoretical— between the domination of women and the domination of nature—" (Warren, 1990, p. 282). Moreover, the emotional, experiential, and empathetic comprehension of a shared oppression and domination is one of the main reasons these movements fused (Warren, 1990, 1997; Egri, 1997). This comes as no surprise as "Ecofeminism makes a central place for values of care, love, friendship, trust and appropriate reciprocity–values that presuppose that our relationships to other are central to our understanding of who we are" (Warren, 1990, p.291). Hence, ecofeminism is an inclusionary movement which promotes environmental ethics which overbridge gender, race, and class structures (kirk, 1997; ling, 2014; Warren, 1990, 1993, 1997, 2014). Another significant note is that "Ecofeminism refocuses environmental ethics on what nature might mean, morally speaking, for humans, and on how the relational attitudes of humans to others—humans as well as non-humans—sculpt both what it is to be human and the nature and ground of human responsibilities to the non-human environment." (Warren, 1990, p.293). Although, early environmental-feminist philosophy mainly focussed on ethical perspectives regarding interconnections between women, nonhumans and nature as stated above (Adams 1990, 1995; Warren 1990, 2014). Contemporary ecofeminism has organically grown into an umbrella term, encapsulating "—variety of different, sometimes incompatible, philosophical perspectives on interconnections among women of diverse races/ethnicities, socioeconomic statuses, and geographic locations, on the one hand, and nonhuman animals and nature, on the other." (Warren, 2014, p 1).

The ecofeminism umbrella enabled us to transgress many contemporary existential and spatial temporal urban fabric concerns at once. Ergo, no wonder there is no lack of literature on this topic (Crabtree 2006, 2010; Fakier and Cock, 2018; Triguero-Mas, 2021; van Schalkwyk, 2014; Gardener, 1999; Bayas Fernández and Bregolat i Campos, 2021). However, only a limited number of scholars/designers have developed ecofeminist models/frameworks, which are centred around ecofeminist values such as 'relationships of care, love, friendship, and trust between humans, non-humans and environments' (Warren, 1990). That guide designers towards the development of just green urban space 'for a fairer and more equal world' (Beavis, 1997; Chircop, 2008, 2011; Findahl, 2014; Newalkar and Wheeler, 2017; Barcelona.cat, 2021). Moreover, most frameworks lack critical contextual lenses when it regards the complexities of GS/SA urban ecologies. Entailing, they do not question or consider power relationships and positionalities within urban ecologies.

3. HOLISTIC TRANSDISCIPLINARY CRITICAL FRAMEWORK

Therefor this paper does not aim to replace existing ecofeminist frameworks. It rather proposes to address the identified knowledge gap through a holistic framework. Which functions as contribution (a sort of plug-in extension) to existing ecofeminism frameworks. Intending to provide creators of urban GS/SA with critical analytical lenses suitable to develop more genuine, appropriate, sustainable green places.

Ergo, the framework is centred around investigating urban relationships bound to oppressive and dominant structures. One must comprehend, that these structures are erected upon some basic beliefs, values, and assumption (Warren, 1990). Moreover, they are conceptual frameworks "—which shape and reflect how one views oneself and one's world. It is a socially constructed lens through which we perceive ourselves an others" (Warren, 1990, p. 283). For example, sustainable GN agendas are formed based on GN values. Which try to shape societies and cities to their basic sets of attitudes and beliefs. However, when these attitudes and beliefs become an oppressive conceptual framework towards the GS due to perpetuated global power imbalances, it becomes problematic (Martins, 2020; Warren, 1990). Now, there is no simple approach or solution to addressing these oppressive conceptual frameworks as every context is unique. However, at the hand of Warren' 'The power and the promise of ecological feminism' writing on oppressive conceptual frameworks (1990). This paper can provide is a holistic transdisciplinary framework consisting out of three critical ecofeminist lenses. From which green world creators can critically analyse and engage with GS/SA urban ecologies.

The first lens, (i) 'Value-hierarchical thinking' is based on 'up-down' thinking. Entailing, giving higher value to socially constructed things of higher status (warren, 1990). The second lens (ii) 'Value dualisms' perpetuates conceptual dichotomies. Implicating valuing reason, mind, culture, and male over emotion, body, nature, and woman (plumwood 1991; warren, 1990). These two lenses especially become problematic when part of an oppressive framework, justified by lens (iii) the 'Logic of domination' (warren, 1990). Entailing the 'logic argumentation' of justifying subordination (warren ,1990, 1997). To clarify warren wrote, "An oppressive conceptual framework—explains, justifies, and maintain relationships of domination and subordination." (Warren, 1990, p. 283)

Hence, Up-Down thinking (i) cannot place historical dichotomies (ii) on an equal plateau. Moreover, western ontologically narrow scientific-thinking and existing global power structures perpetuate and justify this subordinative plateau (iii). When applying the analytical lenses on GS/SA green urban developments. It becomes apparent that current oppressive conceptual frameworks, perpetuate historical concepts of 'civilization and urbanisation' by GN standards of 'forward thinking and innovation'. Which are based on promoting ideological capitalistic ideals of 'modernisation, industrialisation and rationalisation' (Cocks,et al 2020). Ergo, the same thinking which promoted "—ideologies and economies of domination, exploitation and colonialism." (Gaard, 2015, p.20). Thus, arguably the dominant GN worldview of what is valued higher for green urban development is a legitimizing of post-colonialism i.e. justifying subornation (Cocks, et al, 2020).

Ergo, it is a must to question value-hierarchical thinking when designing/developing urban GS/SA. Furthermore, comprehending the dichotomies between GN urban green developments and designing with nature, versus, the GS vernacular/indigenous building knowledges and other ways of being and living with nature. Hence, it is of great importance that other worldviews are considered in the analysing and designing urban ecologies. Because "General conversations on the sustainability of urban—spaces have predominantly used urban policies, planning theories and architectural engineering approaches to privilege quantitative aspects like morphology and energy, over qualitative aspects like experience, well-being, and equity; thus, giving greater value to the former.' (Newalkar and wheeler, 2017, p. 1). E.g., SA cities are experienced differently by woman, indigenous people, people of colour, and lgbtqia+ communities then by (white) men, whom mostly is develop these urban spaces (Beavis, 1997).

Commencing on worldviews, many indigenous communities have known for centuries that the world's wellbeing at large is intrinsically intertwined with theirs/ours. However, the western enlightenment movement has separated nature and humans and their combined well-being (boosting the exploitation of nature) (beavis, 1997; (warren ,1990, 1997). Therefor the framework must not only question worldviews but also the nature-culture dichotomy. Aiming to move towards more just inclusive ecologies for a greater wellbeing (cocks, et al, 2020). Moreover, an urban ecology which does not oppress nature, constitutes that within the complex rhizome of urban dynamics and ecofeminist ethics one must strive towards synergistic relationships with nature (Green, 2013; Warren, 1990). Further it is about judging if nature is put (through design) in an ethical condition and a non-exploitative just position within the urban ecology.

Nevertheless, there are many more predicaments and questions which can be addressed. However, it is up to the framework user' discretion and ability to analyse and uncover oppressive frameworks in GS/SA context. Moreover, frameworks are guides towards certain pathways and not step by step guides for designing. By this means, the holistic transdisciplinary ecofeminist framework intends to advance designers' critical thinking.

4. CONCLUSION

In summary the holistic transdisciplinary ecofeminist framework functions as contribution/extension onto existing ecofeminist models. Additionally, the framework is an educational guide which aids academics, architects, urbanist, and designers alike in dissecting, anatomising, and unravel complex oppressive power structures through ecofeminist ethics. Specifically, within the context of designing with nature in GS/SA urban ecologies. This analytical process manifests through a threefold of critical ecofeminist lenses. When applied thoroughly and sensitively, it could not only enhance critical thinking. But also, a more ecological just and pluralistic way of designing with nature, on road of promoting just green sustainable developments in Global South and South African cities (Cocks, et al, 2020; Escobar, 2018; Green, 2012, 2013).

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REWILDING LUXEMBOURG

Collaboration between humans and beavers to fight wetland fragmentation in Luxembourg

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Strategy Planning, Rewilding, Symbiosis, Ecosystem Management, Citizen Science

ABSTRACT

Rewilding is a habitat conservation strategy that increasingly draws the attention of the public as it offers a strategic restoration of natural ecosystems. Existing rewilding practices are often established upon binary views on ecosystems, such as illustrating ecosystems as “services” to human “beneficiaries" (Deary & Warren, 2019). In this paper, a methodology is established which challenges these binary views by inviting several species to co-manage the implementation of the strategy. Trial fields, used as the tool to actuate the approach, are divided into “core areas”, where the autonomy of autochthonous species is respected, and “buffer areas”, where humans cohabit in partnership with other species.

The methodology exploits several computational tools in order to achieve a data-driven design approach. Furthermore, a multiscale approach is adopted to identify key corridors for wildlife through the use of the linkage tool Circuitscape, while flooding simulations

and mobility patterns are analyzed as key elements for the selection and validation of the design. This methodology has been developed and tested in the case study of Luxembourg, providing a fertile ground for discussion in consideration of its high level of landscape fragmentation.

1.1 INTRODUCTION

Habitat fragmentation is a growing problem in Europe, with ecosystems degrading in both quality and diversity, on a large scale (Fischer et al. 2018). The size of the habitat required for restoration has posed great difficulties in the application of conventional intensive habitat restoration methods (Perino, 2019). Therefore, "rewilding"- a self-regulating habitat conservation strategy - has grown to become, over the past few decades, a popular approach worldwide. Within this context, humans are considered as co-managers and co-inhabitants in their environment along with other species, with the potential to play a fundamental role in sharing the responsibility of rehabilitation within the process of restoration and defragmentation.

Despite its popularity, rewilding is often questioned in both ecological and socio-economic terms. From the ecological perspective, uncertainty lies towards successful habitat restoration, for example, case studies from Bravo et al. (2016) indicate that the reintroduction of species could lead to unexpected ecological consequences that could potentially generate further fragmentation within the ecosystem. With regards to the socio-economic terms, on one side, local institutions are reluctant to support rewilding programs since the management of their sites often fails to address the human-wildlife conflict.

Current rewilding practices involve an often binary view between "human" and "wild" (Deary & Warren, 2019). To this end, the Scottish Beaver Trial case shows an exception to this conflict, with human land owners being able to observe beaver behaviors within the trial and reserving rights to set boundaries, if properties are negatively affected (Prior & Ward, 2018), placing humans as integrated actors within the rewilding process, as well as co-managers of this transition. The wider social impact is yet to be validated within this case, however it is clear that the process of Rewilding is not just a transition of a site, but of the society in itself. It is therefore apparent that the durability of these approaches can benefit greatly by empowering the community to play a key role within their implementation, as well as contributing to this same process by co-managing their uncertainty.

1.2 FRAMEWORK

This article aims to challenge the binary view within existing rewilding practices. A replicable methodology is developed for rewilding related planning practices, leading to heal and restore natural ecosystems, driven by community engagement, citizen science and co-management, towards the coexistence and symbiosis of all living systems, rather than reinforcing polarization of different species.

Luxembourg has been selected as a case study to test this methodology. The landscape of Luxembourg is one of the most fragmented in the European Union. Among its vulnerable habitats, wetland habitats have experienced the most significant consequences (MDDI 2010). The ongoing urban sprawl in Luxembourg poses a critical condition where both demand of human infrastructure and requirement for ecological - wetland - restoration emerge, making the country a valuable case to investigate.

To address Luxembourg's wetland fragmentation, an integrated framework of planning processes and co-management strategies is proposed. The core stakeholders are designed to take both human and other species into consideration. A keystone analysis of local species that can improve habitat biodiversity are selected - cross-species collaborators -, in relation to the ecosystemic values of the territory. With regards to the key human stakeholders within the process, children are integrated as main-drivers to catalyse the implementation and co-management, between humans and other species, on the common land - human counterpart of the cross-species collaborators.

1.3 METHODOLOGY

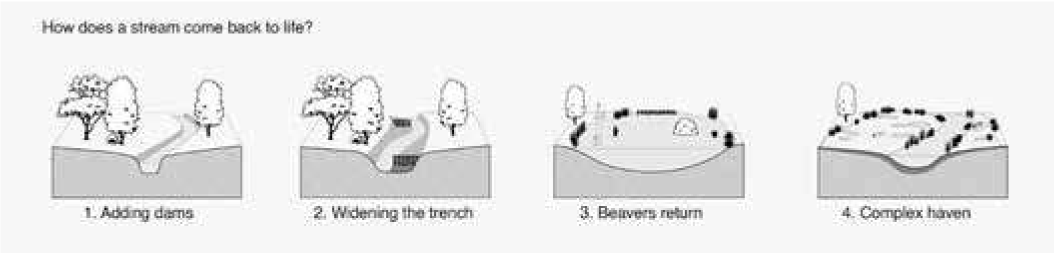
For the case study of Luxembourg, the first cross-species collaborator is the Eurasian beaver (Castor fiber), an ecosystem engineer. Besides humans, beavers are one of the few species that can generate significant landscape changes (Perino et al. 2019) and restore wetland ecosystems by means of their dam building behavior, which also attracts diverse species to settle and restore a more stable trophic chain (Gaywood et al. 2017). The survey of existing beaver occurrences is considered alongside landscape connectivity simulations, in order to identify the most favorable locations for beavers to thrive and succeed in the ecological restoration process. This is achieved through the implementation of GIS analysis and the landscape connectivity tool, Circuitscape.

In order to attract beavers from their existing settlements towards the newly integrated wetlands and further proliferate their reintroduction to the ecosystem, the use of Beaver Dam Analogues (Macfarlane et al. 2015) is proposed. A Beaver-Dam Analogue (BDA) is a technique based on structures, made by humans, and designed to mimic the form and function of a natural beaver dam. BDAs can increase the probability of successful beaver translocation by creating immediate deep-water habitat reducing the risk of predation. (Shahverdian et al, 2019)

Children of school age are identified as the driving human cross-species collaborators. According to Ardoin, Bowers and Gaillard (2020), environmental education for children could effectively encourage positive perception and actions towards habitat restoration among wider stakeholders. Their role is therefore key in empowering a behavioral change of the wider society.

Children play the important role of citizen scientists to stimulate bottom-up awareness by monitoring the whole process of rewilding (Hecker, 2018). Their role is to collect location based data - both qualitative and quantitative - throughout the process of implementation, allowing to measure the effectiveness of the process in itself, as well as being the basis for further development. Other actors, such as educational institutions, teachers and professionals, are also fundamental in ensuring the continuity of this same approach, as well as fostering societal change, through their behavioral change in an early stage of their life, becoming advocates for a holistic approach to life-centered living systems.

Figure 1:
Beaver Dam Analog technique.



1.3.1 THE DATASETS

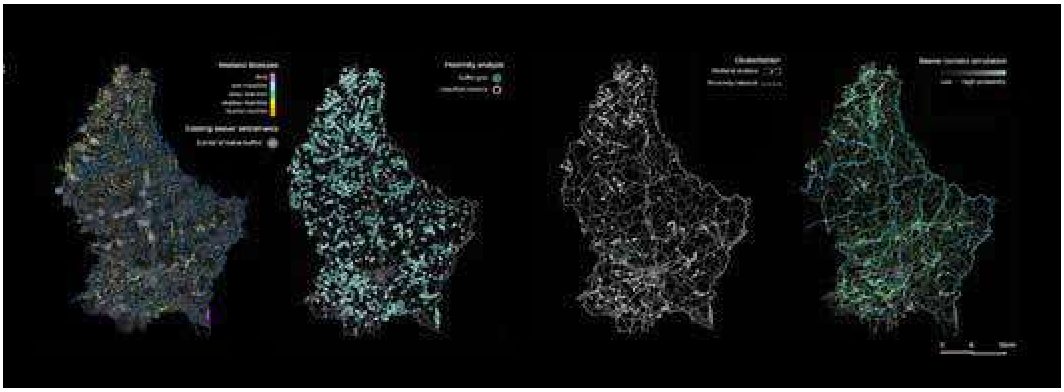
The methodology presented addresses two different scales: regional and local. Among the great quantity of data available, several open datasets from multiple sources have been selected and rendered interoperable (Table 1). Datasets collected do not respect temporal homogeneity; however, it is possible to assume that they could be compatible for the purpose of this work.

Dataset	Year	Source
Effective Mesh Density (seff)	2016	EEA Geospatial Data Catalogue
Corine Land Cover	2018	EEA Geospatial Data Catalogue - Copernicus Service
Luxembourg Habitat Range	2020	EEA Geospatial Data Catalogue - Natura 2000
Luxembourg Wetland biotopes	2018	Administration de la nature et des forêts Luxembourg
Luxembourg landuse	2018	Luxembourg Open Data Platform
Luxembourg water surface	2016	Luxembourg Open Data Platform
Luxembourg DTM 5m	2017	Luxembourg Open Data Platform
Luxembourg hourly rainfall mm	2020	World Bank Climate Knowledge Portal
Luxembourg facilities	2021	OSM Geofabrik - Luxembourg
Road Network	2021	OSM Geofabrik - Luxembourg

Table 1:
Dataset selected for both Regional and Local scale

1.3.2 REGIONAL ANALYSIS

The primary analysis is carried out on a territorial scale, with the intention of identifying the locations with most potential to develop a rewilding project in connection with the nearby communities. Firstly, every wetland biotope in Luxembourg is classified by typology, and clustered based on a proximity analysis that also allows to take into account Fragmentation Geometry (FG), roads and built-up areas - which break structural connection. Once the main wetland clusters along the territory are identified, a connectivity analysis is run between them (Figure 2), using Circuitscape. The use of this tool requires the identification of focal points to be connected and a custom-weighted conductance raster, in order to extract the main ecological flows and possible resistances. In this particular case, the main wetland cluster centroids are set as the focal points, while the conductance map is created through the reclassification of the Luxembourg Corine Land Cover raster according to the most favorable patches for beavers, and other wetland species. Running the analysis with the aforementioned inputs, results in the main wetland-wildlife corridors of the Luxembourg territory, which are cross-referenced with the stakeholders to be involved in the process. Given that for the implementation of the proposal, the work of children and their schools is crucial, the second step is to locate and filter, through a distance matrix, all primary and secondary educational institutions that are close to the wetland clusters and corridors extracted in the previous step. The output is a list of potential sites to develop the proposal, from which the city of Bertrange, next to the central wetland wildlife corridor, has been identified as a testing ground within the context of this research, (Figure 3).



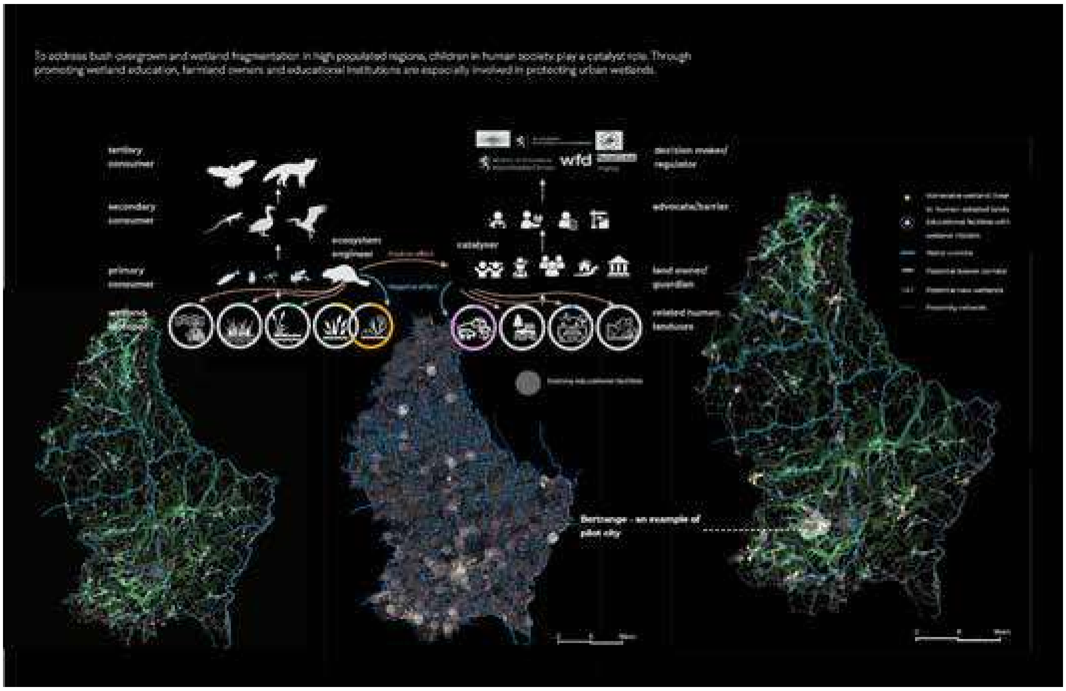


Figure 2:
(top)
Regional wetland connectivity analysis.

Figure 3:
(bottom)
Stakeholder mapping to determine pilot sites.

1.3.3 LOCAL SIMULATION

In order to determine the specific rewilding intervention spots, both educational facilities and wetland biotopes have been located, and are further studied to understand what kind of spatial interactions may occur between the two in this particular context (Figure 4). Moreover, other potential stakeholders who will come into direct contact with the spaces identified, including land owners and natural protection experts, are also integrated in the base map for the simulations (Figure 4). As a provision for avoiding severe conflict as well as increasing the citizen's awareness of the project, trial fields have been strategically located at the periphery of the urban centre along the main waterway, River Petrusse.

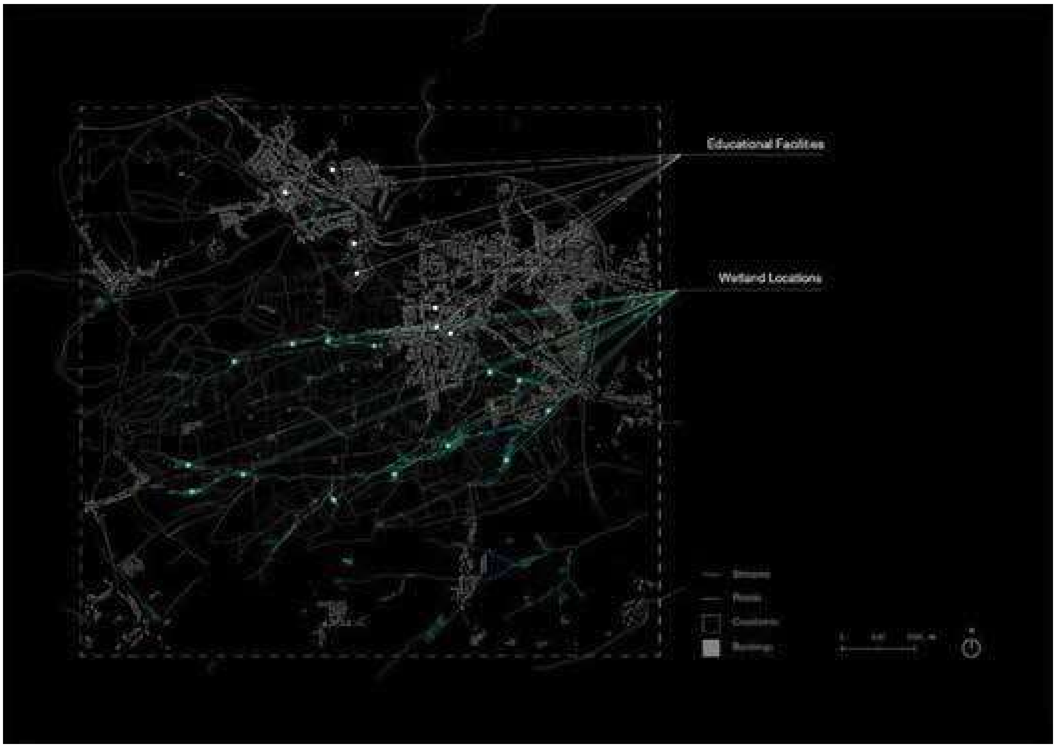
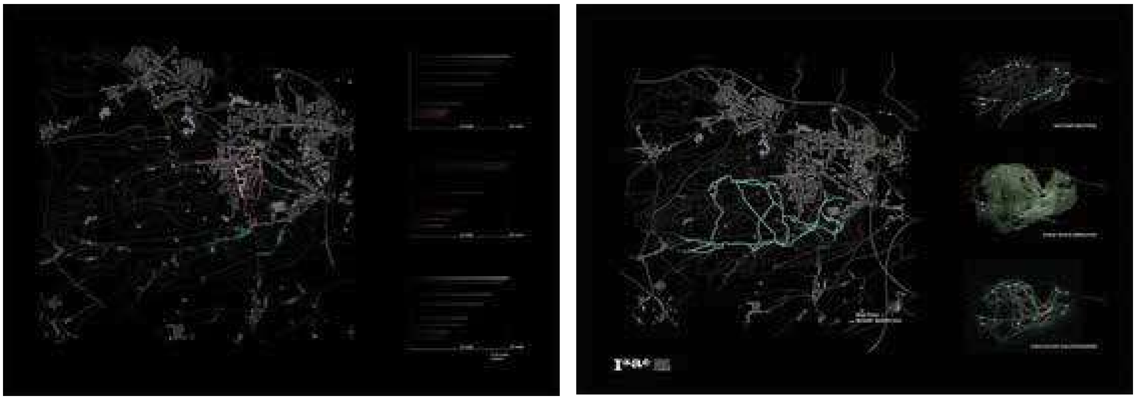


Figure 4:
(top)
Identifying Wetland Locations and Educational Facilities in Bertrange Area.

Figure 5:
(bottom)
Simulation of local beaver and human passages.

Within the same context, further geospatial analysis is conducted to locate rewilding intervention spots. These locations arose at the intersection points of human and animal paths connecting the existing wetlands on site. To obtain the most favourable beaver corridors, Circuitscape is used once again, with wetland biotopes as the focal points and the land use layer for the area, previously custom-weighted and rasterized in a similar manner as the territorial scale analysis. On top of this analysis, a network of the most desirable connections for the beavers is extracted - by skeletonization - and cross-read with its human counterpart. This is identified in the shortest pedestrian pathways from the local schools to the wetlands under analysis. For this goal, OpenStreetMap road infrastructure, consequently filtered on pedestrian-accessible paths, is used in conjunction with the shortest walk algorithm in Grasshopper 3D (Figure 5).



From a practical perspective, the intervention site is divided into core and buffer areas. The core areas are those designed for the introduction of beavers. These will be initially implemented by humans to then be maintained solely by the beavers. The buffer areas will be fully managed by the local community and children. For the identification of areas core to the restoration process and in proximity to the River Petrusse, a previously developed flood simulation of the river, using Caesar lisflood, is taken into consideration (Figure 6). The simulation runs on top of a Digital Terrain Model (DTM) and exploits historical rainfall data to forecast areas with higher flood risk. Once these areas are identified as potential core areas, where the Beaver Dam Analog technique can be applied, a second flood simulation is run to validate the effect of such an intervention. This is obtained by the digital modification of the terrain in order to incorporate the designed artificial dams.

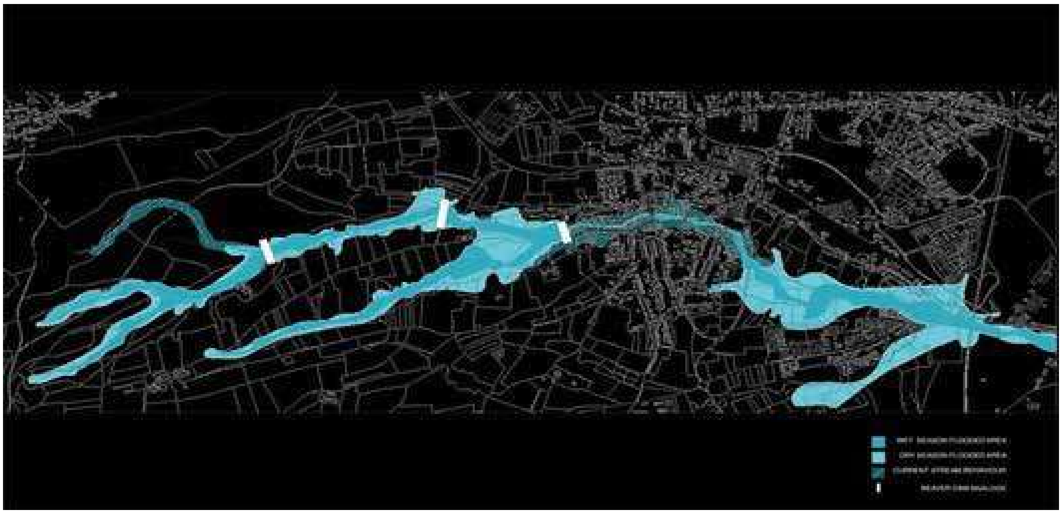
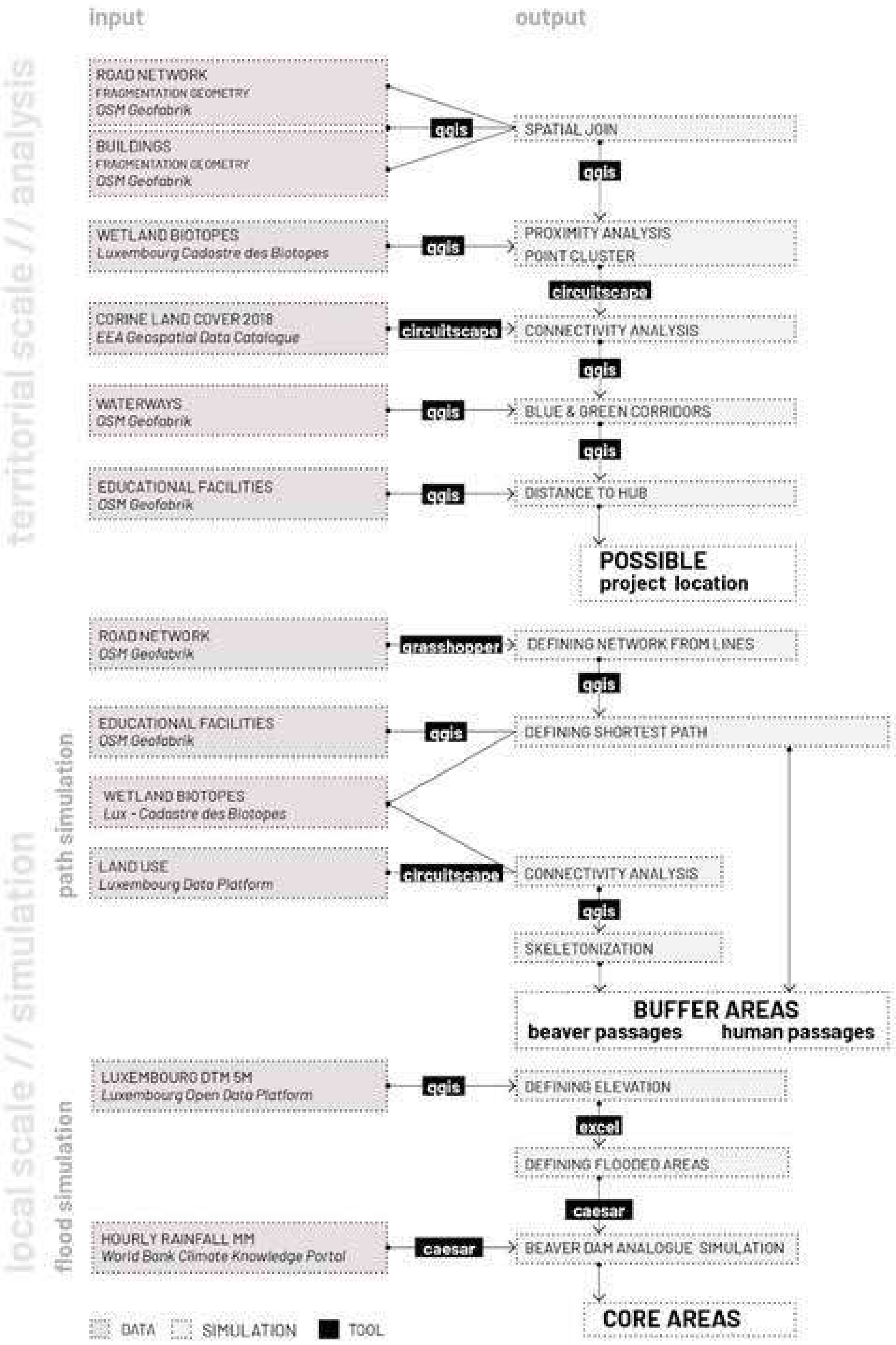


Figure 6:
Flood simulation with the construction of Beaver Dam Analogues.

1.3.4 DATA PROCESSING WORKFLOW

To replicate this approach, and select possible locations for further rewilding micro-interventions on a regional scale, and consequently define the proposal on a smaller scale, by Buffer and Core Areas, a sequence of data selection and processing can be applied (Figure 7).



input
output
territorial scale // analysis
ROAD NETWORK
FRAGMENTATION GEOMETRY
OSM Geofabrik
BUILDINGS
FRAGMENTATION GEOMETRY
OSM Geofabrik
qgis
SPATIAL JOIN
qgis
WETLAND BIOTOPES
Luxembourg Cadastre des Biotopes
qgis
PROXIMITY ANALYSIS
POINT CLUSTER
circuitscape
CORINE LAND COVER 2018
EEA Geospatial Data Catalogue
circuitscape
CONNECTIVITY ANALYSIS
qgis
WATERWAYS
OSM Geofabrik
qgis
BLUE & GREEN CORRIDORS
qgis
EDUCATIONAL FACILITIES
OSM Geofabrik
qgis
DISTANCE TO HUB
POSSIBLE
project location
local scale // simulation
path simulation
ROAD NETWORK
OSM Geofabrik
grasshopper
DEFINING NETWORK FROM LINES
qgis
EDUCATIONAL FACILITIES
OSM Geofabrik
qgis
DEFINING SHORTEST PATH
WETLAND BIOTOPES
Lux - Cadastre des Biotopes
LAND USE
Luxembourg Data Platform
circuitscape
CONNECTIVITY ANALYSIS
qgis
SKELETONIZATION
BUFFER AREAS
beaver passages
human passages
flood simulation
LUXEMBOURG DTM 5M
Luxembourg Open Data Platform
qgis
DEFINING ELEVATION
excel
DEFINING FLOODED AREAS
caesar
HOURLY RAINFALL MM
World Bank Climate Knowledge Portal
caesar
BEAVER DAM ANALOGUE SIMULATION
CORE AREAS
DATA
SIMULATION
TOOL

Figure 7:
(previous page)
Territorial Analysis & local simulations workflow diagram.

1.4 CASE STUDY RESULTS & DISCUSSION

Both simulations give an overall distribution of the Core and Buffer zones. Within these areas, a diversity of interventions can be applied, presented in the form of a catalogue of human interventions, each defined according to their specific location, main stakeholder and phase of development of the proposal (Figure 8). Core restoration zones are initially prepared by humans using tree protection techniques and planting new vegetation, in addition to the Beaver Dam Analog installation. Buffer zones are actively implemented by land owners in collaboration with school children, by means of guerrilla gardening, maintenance of wildlife corridors and road crossing tunnels, or the creation of pocket wetlands in the seasonal flood risk areas.

Along with these interventions, children are invited to observe and monitor the process as young citizen scientists. The development of a mobile application gives the children a platform where they can record and track their active role in the preservation of the area (Figure 9). Through a playful approach, children's engagement is ensured, while also learning how other species react to the interventions, and understanding how the ecosystems evolve through time.

Figure 8:
(map)
Map of possible interventions.

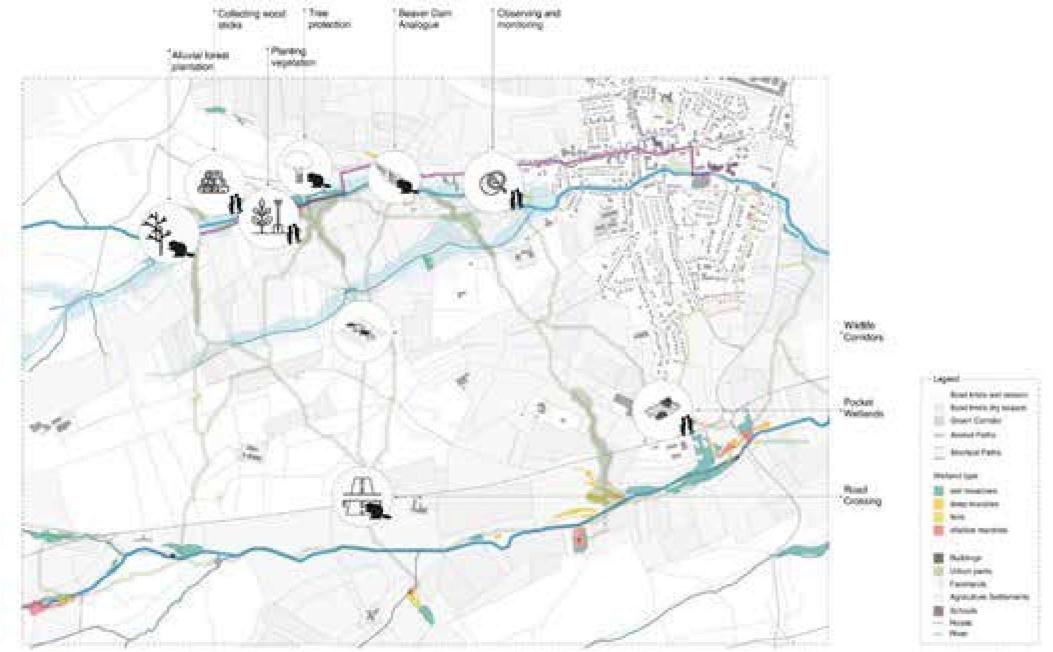
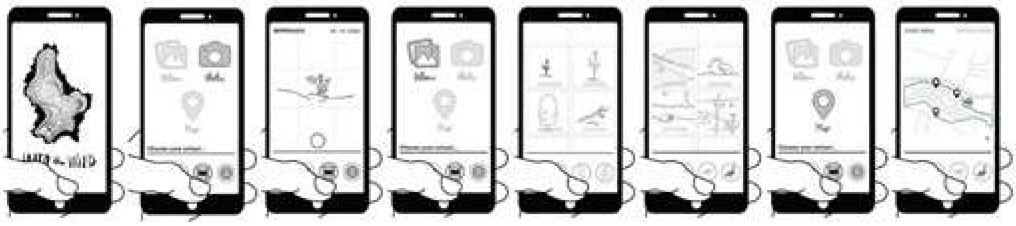


Figure 9:
(bottom)
App demonstration.



1.5 CONCLUSION

While Rewilding approaches have been criticized due to their great level of uncertainty with respect to the impacts they may bring, the simulation of behavioral aspects of different agents involved in the process, can provide more specific and consequently effective insights when planning. This data-driven approach allows us to make decisions based on information specific to the context, and lays the ground to promote policy changes customized to the environment, social and economic frameworks of these territories. Additionally, micro-scale interventions in the field, make it more accessible from an economical and administrative perspective, while working in a connected network to heal the once fragmented territory, leading towards a more integrated, connected and thriving ecosystem.

This methodology challenges the binary views on ecosystems, offering an integrated, distributed and data-driven approach to Rewilding fragmented landscapes on a territorial scale. The implementation allows for the cross-species collaborators - beavers - to thrive autonomously in the core areas, whilst the buffer areas thrive thanks to humans fostering an approach of symbiosis with other species. This enhances the activation of a behavioural change in society, moving towards a multi-species approach to living systems, from the involvement of children in the monitoring and preservation of these areas, to giving tools to the new generations to learn how to efficiently co-exist between species and ecosystems.

The vision promoted by this work guides the reflection on stakeholders and active participants in the implementation of territorial strategies not being limited to the anthropogenic realm. Through the case study of the wetlands system in the area of Bertrange, the paper envisions how beavers (Figure 10) can actively be engaged in changing the landscape of human society, while not being isolated in reserves. Through the adaptive intervention and monitoring on behalf of citizens, in this case children, and local communities, a more tolerant and non-binary co-inhabitation can thrive, resulting in our human society also being “rewilded”.

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Figure 10:
A Rewilded Vision.

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EXPERIMENTAL PARTICIPATORY DESIGN

Towards the idea of nature-based urban environements

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KEYWORDS
Urban environment, participatory design, nature, city.

ABSTRACT

Given the increase of inhabitants in urban settlements caused by the consolidation of globalized models of progress, cities -which in the case of Spain host more than 75% of the population- must ensure better places for citizens. To be aligned with the objective number eleven of the SDG 2030 (Agenda for Sustainable Development Goals): Make cities and human settlements inclusive, safe, resilient, and sustainable, the paper presents some innovative solutions for accessible public space, showing products and architectural projects that fully comply with variables of sustainable success, such as cities conceptually bio healthy, economically affordable, energy self-sufficient, technologically active, environmentally inclusive (without a trace), constructively standardized (lightweight, resistant structure), functionally reversible (detachable), dimensionally compatible, typologically original and recyclable. All these ideas are considered as design-optimized strategies that help reintegrate nature in cities transforming urban spaces into liveable, productive, and biodiverse systems. In this sense, looking for restoring the ecological balance of the city, new modes of collaborative design based on nature that result in more environmentally sustainable projects are essential. The paper will show how nature-based solutions (NBS) can inspire, drive, and enhance innovation and entrepreneurship to face the socio-environmental challenges of our cities.

1. INTRODUCTION

Nowadays, the design of cities limits the amount of ecosystem services they provide. The construction of buildings and streets removes vegetation and soil and replaces it with impermeable surfaces. This change in land use reduces water infiltration into the soil and increases runoff. It also reduces the evapotranspiration and therefore, climate comfort in the city is reduced. The lack of vegetation and soil limits the availability of habitats for urban biodiversity. Urban environments are hostile to most species and can host alien and invasive species more easily, displacing local biodiversity. This loss of biodiversity brings direct problems on human health. Besides, human beings are the dominant species in the city and that leaves us more exposed to pandemic and diseases. On the other hand, the urbanization process is compounded by the impacts generated by the city's own operation. Road traffic, as well as heating and cooling systems are the main sources of pollutant emissions in the city. Air quality is infinitely worse in cities that are being transformed into sinks of resources and sources of waste. That turns cities in one of the main drivers of climate change.

Regarding urban mobility, in recent decades, as a result of the absolute primacy of the private vehicle over other means of transport, and the continuous urban expansion that increasingly moves residential areas away from work and leisure centers, there has been an increase of the noise pollution, diseases derived from the concentration of pollutants in the air, traffic congestion, stress and energy waste, not to mention the difficulties of movement suffered by people with reduced mobility, functional diversity or pedestrians in general. It seems clear that the forms of mobility in the city must change, so that the right to mobility is guaranteed for all people. Thus, design should incorporate sustainability criteria to achieve a balance between mobility and accessibility needs, that allows citizens to enjoy the city with safe trips that save time and energy, favouring the protection of the environment and social cohesion. A transition towards a more sustainable urban mobility model should be promoted.

2. OBJECTIVES

To restore the ecological balance of the city and move towards a more sustainable urban mobility model, it is possible to promote new modes of collaborative design based on nature that result in more environmentally sustainable projects. Nature-based solutions (NBS) can inspire, drive, and enhance innovation and entrepreneurship to face the socio-environmental challenges of our cities. Nature-based solutions make use of both the complex characteristics and processes of nature, as well as its capacity to store carbon and regulate the flow of water, to face current challenges in relation to the risk of natural disasters, climate change and the improvement of human well-being, from social inclusion and ecological harmony.

To explore solutions and proposals, a series of projects developed during a collaborative design workshop are shown in this paper. The aim is to promote innovation in the urban and architectural environment through individual and group outreach techniques that enhance the flow of ideas. During the workshop, it was proposed to carry out projects with a technological background that would provide a value proposition for society based on nature.

In general terms, it is considered essential in the urban environment to expand green areas and spaces in cities, such as corridors, green roofs and walls, islands of vegetation and community gardens, but the urban elements that we currently have in our cities must also be improved by bringing them closer to the principles of NBS. The workshop intended to use an NBS approach where actions addressed social challenges in an effective and adaptive way and that last over time, improving the quality of life of citizens and their health. In this task, citizen participation was essential through co-design actions. Thus, during the workshop, collaborative work with people with special needs, was developed to design a more sustainable and accessible public spaces.

The aim was to devise solutions, actions, products, and architectural inventions aimed at promoting equal opportunities within the framework of inclusive city planning, which comprehensively comply with notions linked to environmental sustainability, with an open life cycle, functionally reversible and removable, self-sufficient from an energy point of view, economically accessible, standardizable from a constructive point of view and conceptually bio healthy.

3. METHODOLOGIES

The use of a Design Thinking approach allowed us to implement a creative design process to generate ideas, promoting co-creation with the end user of the project and introducing a series of guidelines. First of all, the use of empathy to understand the needs of the users to whom the project is directed; secondly, the promotion of teamwork to develop inspiring ideas, using materials that promote graphic or visual communication and that allow, in addition, to relate concepts and prioritize actions. And finally, the creation of physical and virtual prototypes using the technologies of the digital fabrication laboratory based at the Institute of Technology, Fab Lab Madrid CEU, that help us to fabricate scaled version of the prototypes for validation, by learning from the reactions of the users. All this was carried out through activities that allowed a certain playful spirit in the workshop to encourage imagination and creativity among students and participants.

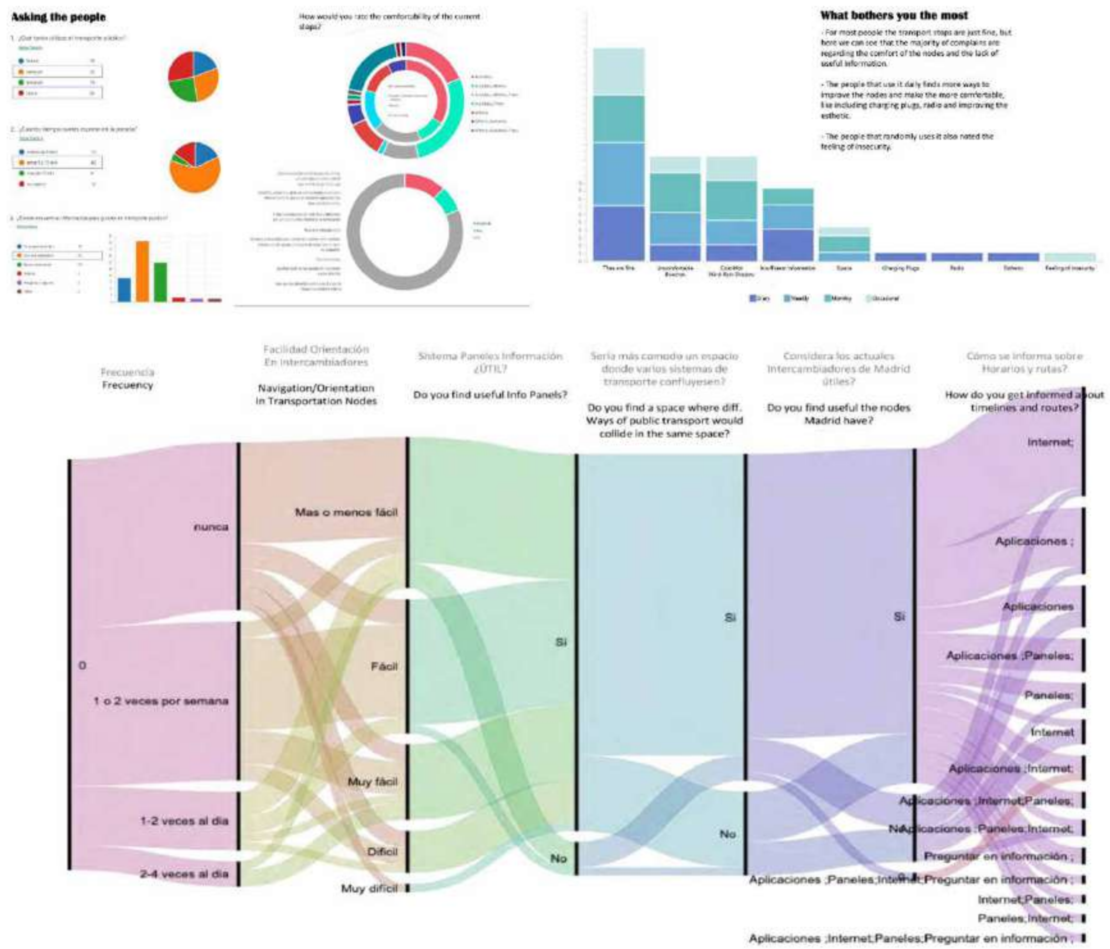
Participatory design was essential. The initial studies based on questionnaires, empathy maps, brainstorming diagrams and data visualizations made using open data from the Community of Madrid City Hall were carried out involving citizens, including those most disadvantaged, such as the elderly or people with functional diversity. Co design with end users allowed students to explore the interaction of different types of users with urban facilities, to find out new ways of offering information, adding comfortable and accessible urban furniture for all citizens, or using communication elements easily readable for people with some type of visual or hearing disability.

Nature-based solutions approaches were applied on the design, that also tried to support ecosystems, helping to give a solution to one of the great challenges nowadays: the climate change. The proposals stand out for their innovative ideas, their suitability for the user profile, their quality in terms of design, but also for their environmental sustainability. Some proposals opt for simple and inclusive designs so that residents of the neighbourhoods collaborate in the assembly, adapting the services to their specific needs. Others were designed as interactive spaces, allowing users to modify the urban elements according to their needs. In all cases, modular assembly systems have been chosen, with easily recyclable and reusable elements to adapt them to different needs depending on the time of year or user demand. But above all, the proposals sought to incorporate natural elements into urban services using, among other things, natural materials and vegetation, permeable pavements, and green urban furniture.

Figure 1:
Data visualizations made with end-user's survey data.

4. FINDINGS

As the proposals were designed in collaboration with people with special needs, more considerations were included during the design process. For example, apart from the multiple architectural barriers (obstacles on the sidewalks, lack of ramps for users with wheelchairs, discontinuities in the pavement, insufficient information for people with special abilities) that have been pointed out by the end users in public spaces, they revealed other factors considered a challenge for all citizens to move freely in the urban surrounding. Among them, the most prominent was the feeling of insecurity caused by the lack of accessible information for all those people who have visual or hearing disability, which prevents them from enjoying urban services with autonomy. Other challenges detected were, for example, the lack of comfortable of urban services, the emissions they produce, the lack of green urban spaces that provide more welcoming places to enjoy in the city, lack of comfort, a demand for better relations between different modes of transport, alternatives for entertainment for users while they wait the public transport, a dependence on the internet or apps to get transport information and finally, the need to make urban furniture and infrastructures more sustainable, integrated with the natural environment and accessible to all citizens.



The need to design safe itineraries, eliminate architectural barriers, use rough pavements to establish guided tours for visually impaired and use lighter and more sustainable means of transport, facilitate the autonomous mobility of people during daily journeys. Besides, the proposals studied new ways of offering a more sustainable urban mobility based on the design of transport nodes that facilitate the connection between public transport stops (metro and bus) and light means of transport (bicycles and scooters). The aim was to promote the use of non-polluting alternative transport that would complete the routes to be taken by citizens during their daily activities, discouraging car use and creating green areas in the city, linked to these nodes to re-naturalize the urban environment, improving the mobility experience and the living conditions of citizens.

Figure 2:
Proposals for urban facilities based on NBS.

The transport nodes include structures that use natural materials, such as wood, and enclosures covered with vegetation that improve their energy performance since they provide natural cooling avoiding heat loss in winter and cooling it in summer. This guarantees energy savings and an improvement in the air quality of the urban environment, but they are also attractive elements for the enjoyment of citizens. The integration of vegetation also absorbs CO2, mitigates the urban heat island effect, acts as an acoustic barrier and favours the naturalization of spaces, promoting their use and enjoyment by citizens.

Along with these design parameters, the proposals have also proposed the use of permeable pavements around the transport nodes, that contribute to the improvement of surface runoff by improving urban drainage. Permeable pavements increase the degree of aesthetic and environmental quality of public space and are especially viable in pedestrian streets, squares and even bicycle lanes.

Finally, green furniture elements designed with sustainability criteria have also been proposed, which also contribute to the adaptation of cities to climate change by improving the energy efficiency of the neighbourhood. Thus, the use of biomaterials in canopies, benches and shade houses, as well as the placement of flowerpots and planters improves the urban environment. In this sense, people with functional diversity especially appreciated the inclusion of green urban elements, stating that they generate more welcoming, more legible and recognizable spaces in the city.

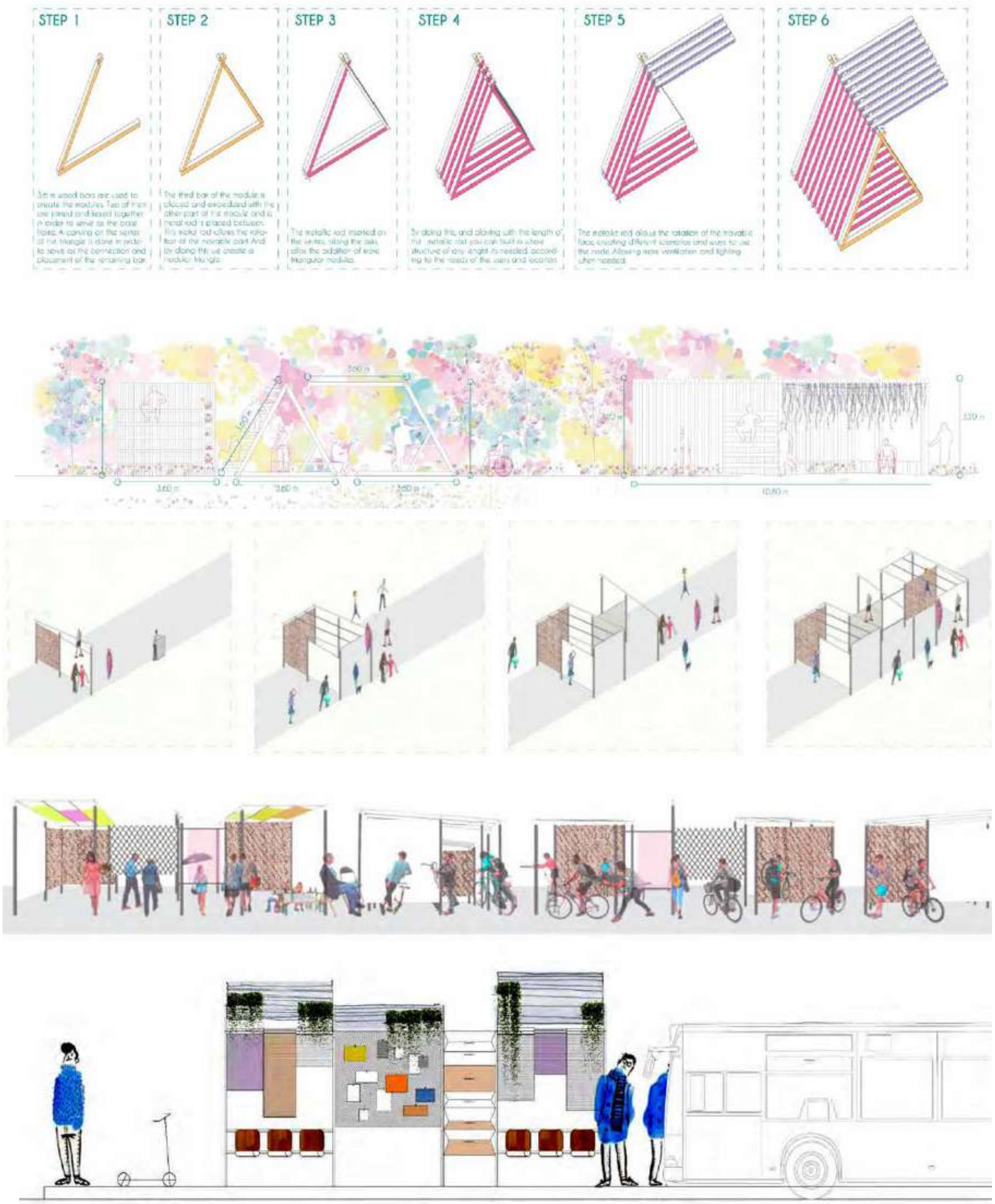


Figure 3:
Proposals for urban facilities based on NBS.

5. CONCLUSION

Environmental sustainability has been the premise in all the proposals, always keeping in mind the NBS approach and with actions such as the design of urban elements made with sustainable and recyclable materials, seeking to extend the life cycle of urban interventions, the use of permeable pavements that allow establishing safe routes for people with different types of functional diversity, the inclusion of green urban furniture that would allow improvement air quality and the use of strategies that limit CO2 emissions and favour a responsible use of the resources used. Our goal was to reflect on the current guidelines of urban mobility to design collaboratively to promote innovation in cities, in order to progressively change them in favour of healthier, safer and more sustainable urban environments.

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HEALING FLOWS
Towards healthy mobility flows

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ABSTRACT
In recent years, healthy mobility has been an increased focus of urban policies worldwide. However, street design is yet to be a fundamental tool in the challenge of creating healthier cities. This project tackles a more holistic understanding of healthy street design by providing an analytical design tool to urban planners and stakeholders through a combined evaluation of health risk and mobility flow. Starting from the area of Poblenou in Barcelona, the project provides a transferable framework that can be applied to different scenarios and cities. By understanding the indicators related to health, such as air pollution, noise, accessibility and analyzing their data, the project allows designers and city planners to identify risk areas in the network and design specific interventions that can address each of these risks with consideration to citizen's needs.

1. INTRODUCTION

1.1 IDENTIFYING THE CHALLENGES

The effect that mobility systems have on people's health has become one of the most urgent concerns of cities. New kinds of strategies in terms of design and policy-making are being pushed to reframe the connection between mobility and wellbeing (Rosenberg et al. 2016). Indeed, the way we move can have either a positive or negative impact on our health. Our daily mode of transport not only affects us personally -such as by improving our physical health status by walking - but also indirectly affects the habitability of cities. It has been widely acknowledged that urban populations are continuously exposed to a series of negative factors related to transport modes. According to the World Health Organization (WHO), nine out of ten people breathe air with high levels of pollutants (World Health Organization 2018), with motorized vehicles being one of the main causes of air pollution in large urban settlements. This type of environmental exposure promotes cardiovascular and respiratory diseases that generate enormous extra costs for health systems. Yet, policies that try to involve urban health as one of the main mobility drivers tend to focus only on physical benefits. Since 1946, health has been defined as "the complete state of physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization 1946). Understanding people's behaviour is an opportunity to encourage change through design strategy and to ensure sustainability, comfort, and inclusion.

1.2 STATE OF ARTS

After research, we identified new methods of mobility simulation that are becoming a powerful tool for researchers. Some of the main techniques are:

- agent based algorithms (Shafiq 2018)
- space syntax (Hillier et al. 1984)
- graph neural networks (Jiang et al. 2021)

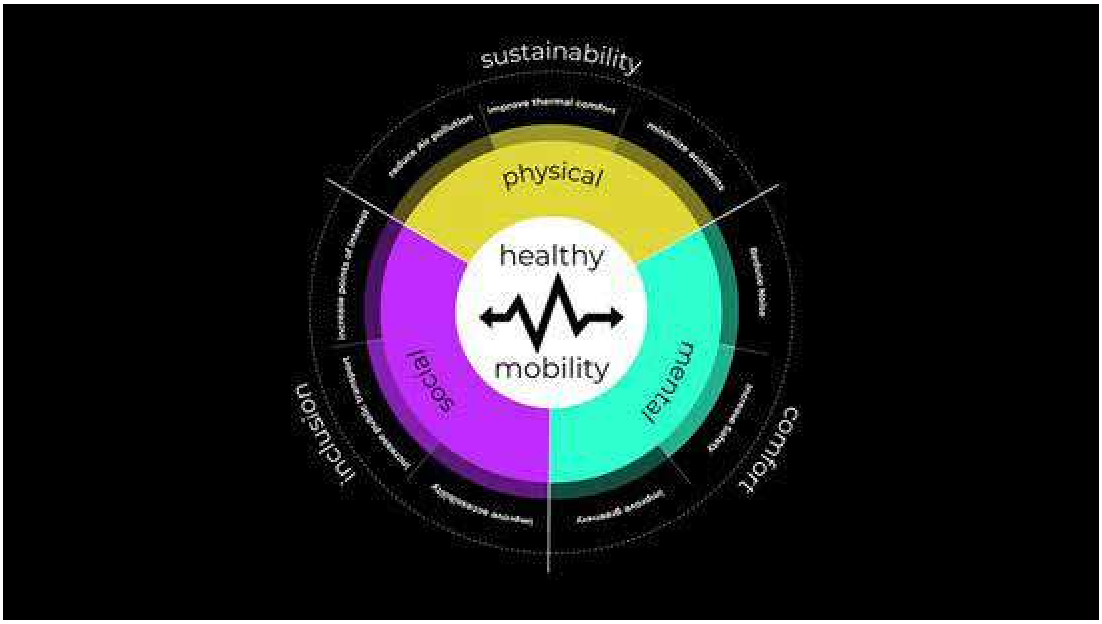
These new technologies and processes solve problems by handling multiple layers of data at once. They enable us to receive predictions about future scenarios such as in the cases of traffic forecasting (car, subway, etc.) and accident prediction (Zhou et al. 2020). In this project, we work with an agent based algorithm in order to simulate the behavior of people and understand the network's connectivity and accessibility.

1.3 ADDRESSING THE CHALLENGES

‘Healing flows’ offers a data-driven process to street health analysis. The focus is to break down what constitutes the built environment in our street into measurable indicators such as the amount of air pollution, level of accessibility, and percentage of sociability - which in turn can be objectively tested against specific Physical, Mental, and Social health outcomes. In this way, it encourages steps to be taken by the government and citizens alike to improve the health of their neighborhoods. It provides the necessary data visualization for highlighting the potential value in the implementation of the new projects.

This project acknowledges that top-down approaches that use data are important in providing insights on the existing street network at its issues. At the same time, it highlights the importance of the back and forth, or the codesign process. The need for stakeholders' participation, city planner, architects, and citizens' inputs, becomes crucial, as it increases the sense of placemaking and belonging of the people and communities involved. This type of approach establishes more empathy to all the actors included, regarding the space they occupy and provides an additional driver for changing their future behavior - such as by opting to take the bike to work instead of the car. Hence for citizens, it provides a feeling of higher responsibility by involving people in decisions affecting their own health. Also, by treating each segment separately, focused solutions can be provided allowing better allocation of resources and management of project fundings.

Figure 1:
Challenge focus.

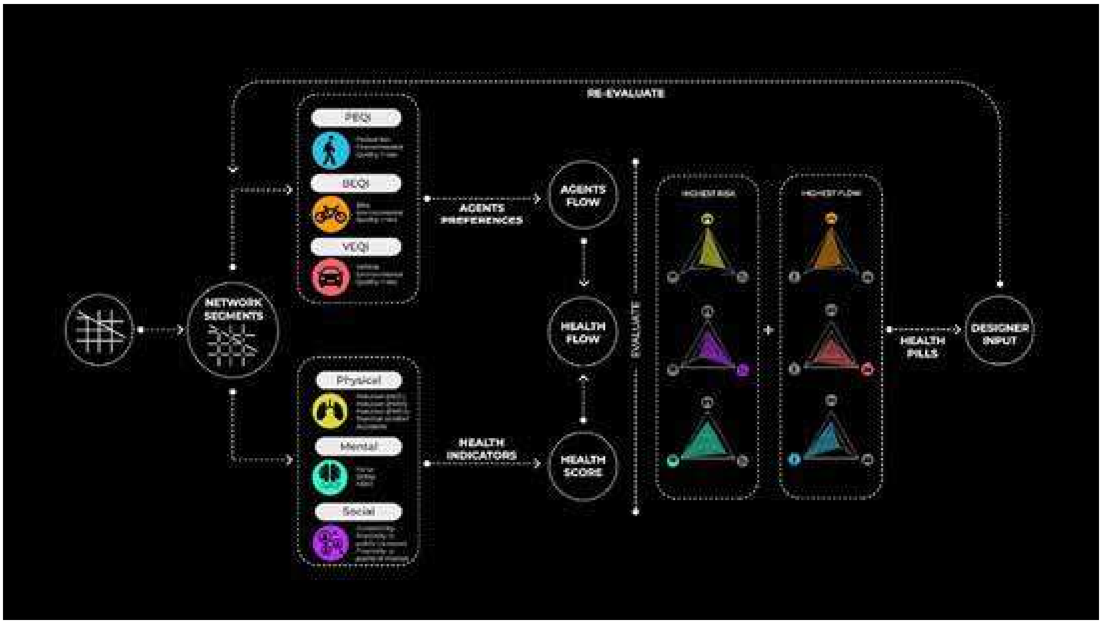


1.4 SITE SELECTION & DATA

Figure 2:
(top)
Site Location.

Figure 3:
(bottom)
Methodology diagram.

The small area of El Poblenou, in Barcelona, was considered as an example to test this analysis tool and design methodology. Located in Sant Marti district, the area has been one of the most transformed places in the city. Its urban development is part of the 22@ project which aims to bring a new model of innovation and digitalization to the citizens. Hence, it was the perfect location to carry out the project and test the indicators across the small sample of the inner-city area.



2. METHODOLOGY

2.1 OVERVIEW

To respond to the ambitious goal of this project, we designed a unified methodology consisting of several steps that start with data and end with design. The method is structured into three main clusters and starts by segmenting the existing street network into smaller units. In the first cluster, two aspects of the given network are analyzed: agent flows and network health. In this part, each street segment is scored based on 3 agent preferences (Pedestrian, Bike, and Car) and 3 health indicators (Physical, Mental, and Social). The data for these layers are collected through municipality portals and other open data sources then aggregated and combined in the necessary process. The resulting scores provide the 'Agent flows' and the 'Health scores' respectively. In the next cluster, both measures are combined and evaluated to identify risk areas (areas with the highest agent flows and lowest health scores). The risk scores are based on benchmarking with international standards such as the ones established by WHO for maximum air and noise pollution and so on. Once the final map of combined scores is achieved, the tool proposes a set of 9 health pills that are designed to answer the resulting health of flows from the analysis. The process is explained in more detail below.

2.2 AGENT PREFERENCES

Based on combining a set of indicators we achieve the first results of the analysis: the 'PEQI, BEQI, and VEQI' . These refer to the Pedestrian/Bicycle/Vehicle Environmental Quality Index respectively. They were created taking into account the research done by the San Francisco Department of Public Health (Sanders et al. 2013).

- The Pedestrian Environmental Quality Index (PEQI) consists of 21 layers such as crosswalks, intersections, sidewalk obstructions amongst others. These layers are clustered in 5 categories: Intersection Safety, Traffic, Street Design, Land Use, and Perceived Safety and in combination reveal which streets are more "walkable" or in other words, preferred by pedestrian users.

- The Bicycle Environmental Quality Index (BEQI) consists of 13 layers such as intersections, bicycle lane markers, and street slope. These layers are clustered in 5 categories: intersection design, street design, vehicle traffic, safety, and adjacent land use. These layers reveal which streets are mainly preferred by cyclists.

- The Vehicle Environmental Quality Index (VEQI) consists of 5 main layers, type of road, number of lanes, two way traffic, speed limit and traffic volume

These three indexes evaluate the street features that make it preferred by one of the 3 modes of transport. For example, while a person might prefer to walk on a street that is wider, another might prefer to cycle on a road with safe buffer zones and easy access to bike rentals. So based on these scores we can identify which street is more walkable, which ones are more cyclable and even the ones that are more drivable.

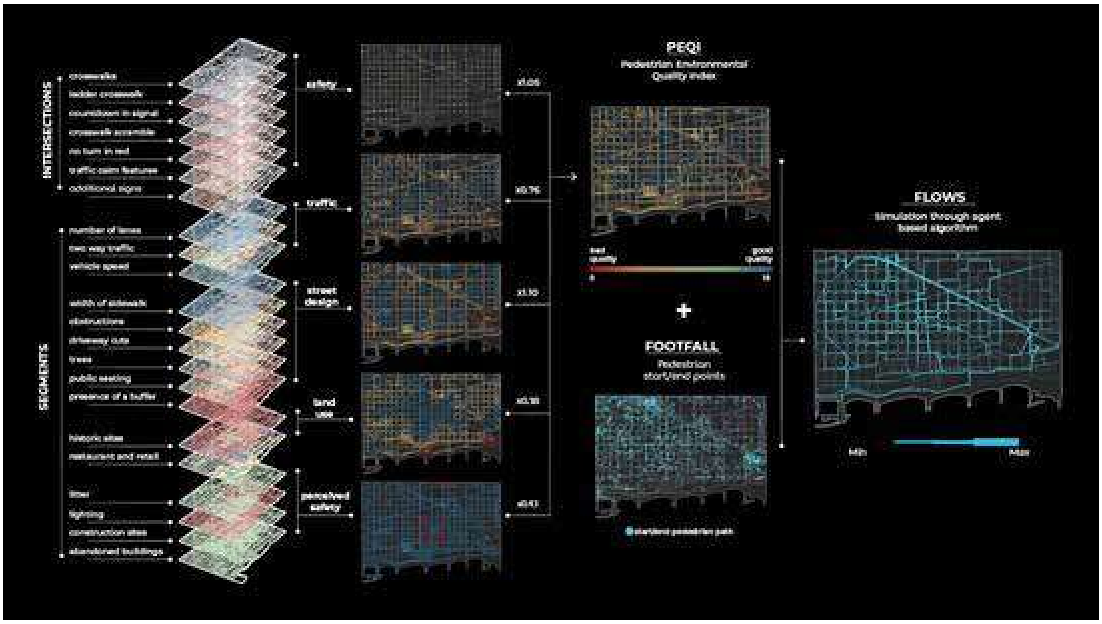


Figure 4:
Agent preferences indicators.

2.3 AGENT FLOWS

Then, to identify which street segment has a higher flow of pedestrians, bikes and vehicles respectively we designed an agent-based algorithm. The algorithm simulates the path of the population, where each person is an agent. Our algorithm requires two types of geolocation: origin and destination of each agent, and a street network. The agent geolocations are extracted from a smartphone geolocation tracking dataset. We extracted their transport mode and their origin and destination. The street network contains the PEQI, BEQI, and VEQI index that instructs the agents' pathfinding process (Muhammad Shafiq 2018). From this analysis, we simulated 8,439 flows of people divided into pedestrians, bikes, and vehicles networks. These 3 flow attributes are then transferred to an integrated network to calculate the dominant agent type passing through a street segment. In the end, the algorithm processed the flow score, which is the number of times a street segment is crossed by an agent.

Figure 5:
Agent flows.

2.4 HEALTH SCORE

Once we established the flow, we evaluated how different agents' health is affected on the street based on the three categories: physical health, mental health, and social health .

- For Physical health, we used indicators that are related to levels of physical comfort. More specifically, the layers that were considered were Air quality (considering NO2, PM10, and PM2.5 pollution), Thermal Comfort, and the Number of accidents.

- For Mental health, we used indicators related to stress and psychological issues. In this case, the layers considered were Noise pollution, Visibility, and NDVI (Normalized Difference Vegetation Index).

- Finally, for social health, we included indicators related to inequality. These layers were Accessibility, Proximity to Amenities, Proximity to Public Transport, Proximity to bike and car parking.

All these indicators provided a valuable data source and by processing and aggregating these layers we arrive at results that reflect the health of the street network. With the superposition of these 3 layers we could understand how people's movement is affected by their health and vice versa. The final map depicts the road segments with the lowest health scores for each category.

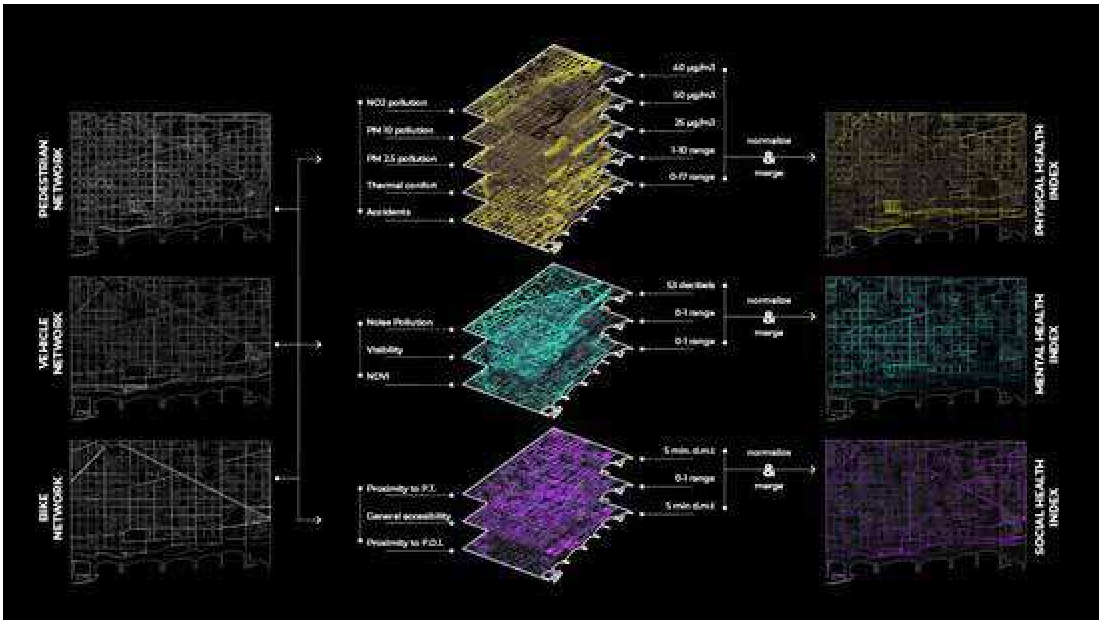


Figure 6:
Health scores.

2.5 EVALUATION

Obtaining the final layers of the health risks and flows of our area, enables us to evaluate and highlight high risk areas. More specifically, we can identify the street segments with the highest health risk and their dominant flows. These street segments would be the first ones to go through our intervention process. For example, in the map of physical health one can notice the predominant health risk of the highway both on the south and north of the Poblenou.

We can draw summaries about the main issues on site from the supporting spider graphs. In relation to health, we see that the network suffers mainly from issues related to mental health. In relation to the flows, we find that vehicles and bikes are more evenly distributed on the network, while pedestrians are more concentrated in areas of the central areas. This means that planners should give priority to interventions that deal with noise, visibility and greenery and adapt these solutions to the peripheries of the site.

2.6 HEALTH PILLS

To address the identified health risks, we defined three lines of actions: Sustainability, Inclusion, and Comfort. Each line of action is associated with a health score and dominant agent flow. Thus, nine "Health pills" are proposed for our network. These include a collection of guidelines and focus on the predominant transport mode of the segment. The aim, in the end, is to promote walking and cycling and discourage the use of cars.

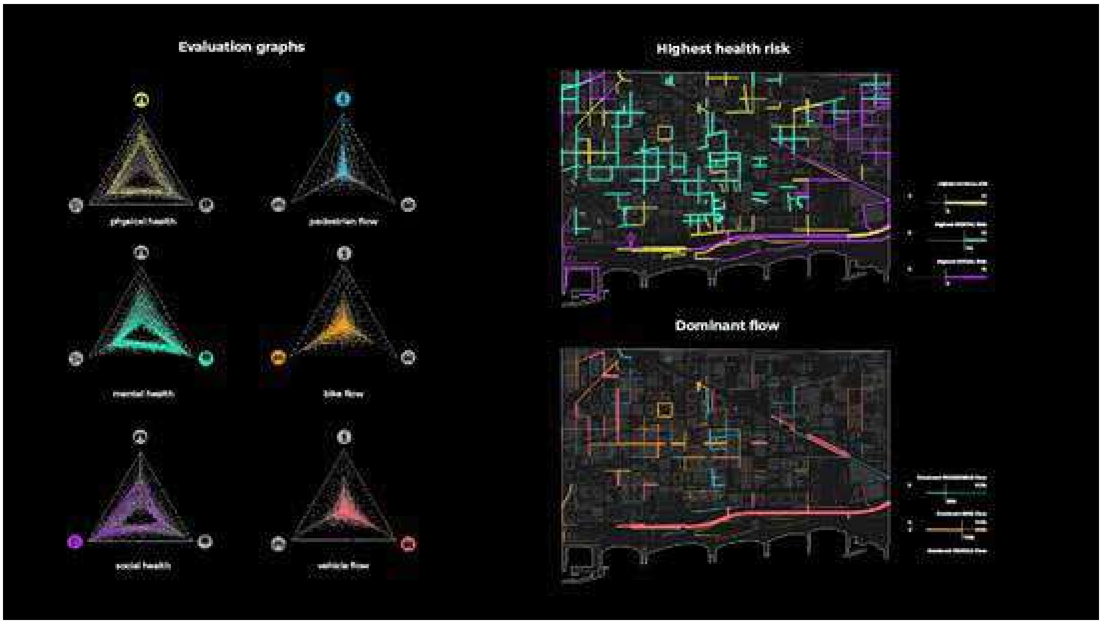
- Health pills A to C (Figure 8) target sustainability in segments with low physical health. A focuses on the pedestrian network, B on bikes, and C on the vehicle. For example, pill B increases greenery to improve thermal comfort and increases bike lane width to reduce accidents for bikes.
- Pills D to F (Figure 9) aim to increase comfort levels in the segments with low mental health. The main actions involve improved greenery, noise reduction, and safety.
- Pills G to I (Figure 10) deal with social inclusion by providing improved infrastructure for accessibility and public transport.

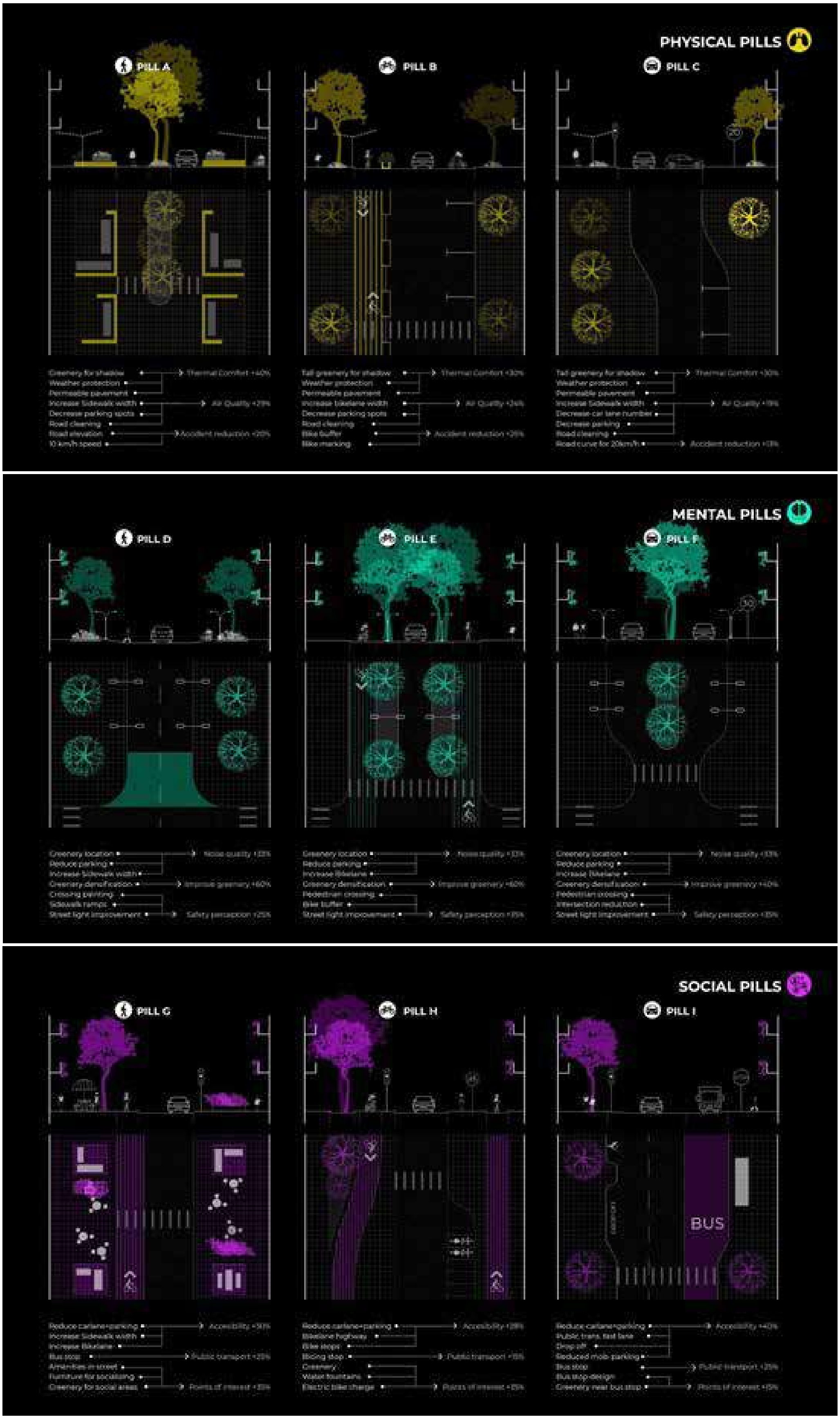
Figure 7:
Segment evaluation.

Figure 8:
(top of next page)
Physical Health pills.

Figure 9:
(center of next page)
Mental Health pills .

Figure 10:
(bottom of next page)
Social Health pills.



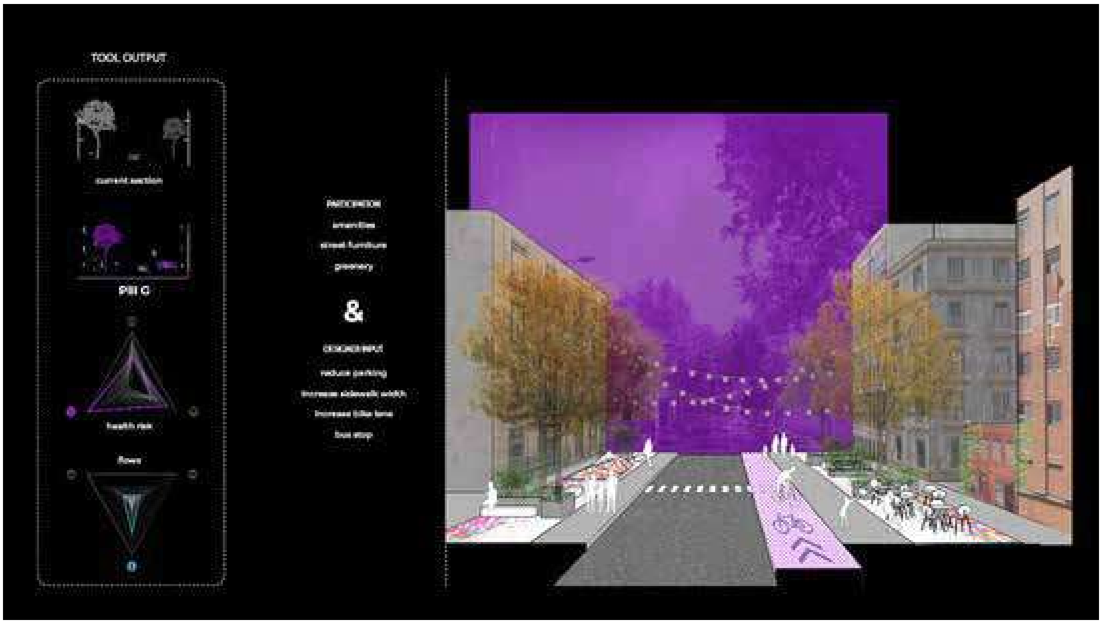


PHYSICAL PILLS
PILL A
PILL B
PILL C
Greenery for shadow
Weather protection
Permeable pavement
Increase Sidewalk width
Decrease parking spots
Road cleaning
Road elevation
10 km/h speed
Thermal Comfort +40%
Air Quality
Accident reduction
Tall greenery for shadow
Weather protection
Permeable pavement
Increase bikelane width
Decrease parking spots
Road cleaning
Bike buffer
Bike marking
Thermal Comfort +30%
Air Quality
Accident reduction
Tall greenery for shadow
Weather protection
Permeable pavement
Increase Sidewalk width
Decrease car lane number
Decrease parking
Road cleaning
Road curve for 20km/h
Thermal Comfort +30%
Air Quality
Accident reduction
MENTAL PILLS
PILL D
PILL E
PILL F
Greenery location
Reduce parking
Increase Sidewalk width
Greenery densification
Crossing painting
Sidewalk ramps
Street light improvement
Noise quality
Improve greenery +60%
Safety perception
Greenery location
Reduce parking
Increase Bikelane
Greenery densification
Pedestrian crossing
Bike buffer
Street light improvement
Noise quality
Improve greenery +60%
Safety perception
Greenery location
Reduce parking
Increase Bikelane
Greenery densification
Pedestrian crossing
Intersection reduction
Street light improvement
Noise quality
Improve greenery +40%
Safety perception
SOCIAL PILLS
PILL G
PILL H
PILL I
BUS
Reduce carlane+parking
Increase Sidewalk width
Increase Bikelane
Bus stop
Amenities in street
Furniture for socialising
Greenery for social areas
Accessibility
Public transport
Points of interest
Reduce carlane+parking
Bikelane highway
Bike stops
Biking stop
Greenery
Water fountains
Electric bike charge
Accessibility
Public transport
Points of interest
Reduce carlane+parking
Public trans. fast lane
Drop off
Reduced mob parking
Bus stop
Bus stop design
Greenery near bus stop
Accessibility +40%
Public transport
Points of interest

2.7 PARTICIPATORY DESIGN

Identifying the suitable health pill for each case is only the first step. While these pills provide guidelines with measurable results, it is crucial to carry out a full design process including citizens and city planners. From that point the designer's input is considered important to adjust the given example to the actual street section in a meaningful way and drive behavioural change to ensure placemaking in the neighborhood.

Figure 11:
Participatory Design process.



3. CONCLUSIONS

3.1 FINDING & LIMITATIONS

Through the geo-spatial mapping of the health parameters and mobility patterns, the project provides insights into the existing urban street network in the area. Most importantly, we were able to identify the street segments with the highest health risk and understand the dominant mode of transport in each of them. This approach to mobility allows for a targeted street design. Solutions to improve citizens' health and safety can be prioritized where needed most and even save money and time in the process. Our agent-based simulations provided us with insights into the dominant mode of transport on each street and allowed us to simulate flows in different scenarios. This was a key element in being able to promote healthy living and safety.

However, the process does not come without its limitations. The large amounts of data layers required for the creation of the indicators can limit the process in sites or cities where this data is not available. In addition, we have to understand that by inputting fixed layers we lose part of the dynamism of mobility. Mobility flow can be temporal and fluctuate according to times of the day or year. A certain festival, holiday, or weekday, for example, can alter the way people behave on the street. These different fluxes can be linked to different health risks identified and the assistance of these temporary fluxes can alter the reliability of the data. Hence, it is important to take into account that several evaluations will need to be made with footfall data of different days and times to achieve a more comprehensive result.

3.2 FUTURE POTENTIAL

In the future, we would like to expand this research further by exploring ways to ‘hack’ the pills: provide tools and ability in which to combine solutions and offer a more ‘open’ approach to the design of the health pills. In this way, citizens can accommodate their specific needs into the design and enable the pill to be completely contextualized to each segment in the network. In addition, this data can be linked in the future to the general health status of the society all the way from social inequalities to cardiovascular and respiratory diseases. Using those studies to also conclude important information about the impact cost on municipalities.

Another thing we would like to push further is the process of re-evaluation that gives the tool its ability to restore the global network. We are completely aware of the complexity of mobility networks in the sense of how they are interconnected and interdependent. The idea is to be able to implement a solution in one area of the city without causing a catastrophic effect in another part. For example, by creating a slow street in an area that suffers from noise pollution, we want to avoid creating a traffic jam in another segment. Hence, further study needs to be carried out to expand the tool and enable it to also identify potential risks to the city network as a whole and not only on specific isolated sites.

4. ACKNOWLEDGEMENT

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"The project cited within the body of this paper known as HEALING FLOWS was developed as part of the Master in City & Technology 2020/21 of the Institute for Advanced Architecture of Catalonia, as part of the Internet of Buildings Studio, Faculty: Angelos Chronis Faculty Assistant: Iacopo Neri, Mahsa Nikoufar, Androniki Pappa; Students: Adriana Aguirre Such, Diana Roussi, Dong Xuan Zhu, Hebah Qatanany, Tugdual Sarazin."

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URBAN (AI)D

Aligning Urban Development with UN Sustainable Development Goals using Machine Learning

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KEYWORDS
UN Sustainable Development Goals, Urban Analytics, Urban performance, Sustainable development goals Indicators, Lisbon, Online Interface, Machine learning, Rhino.Compute App Server

ABSTRACT

According to the UN, the projection of shifting from rural to urban areas has increased over the years and it is expected that two-thirds of the world's population will be living in cities by 2030. (UN SDG, 2011). Not least because of their population density and climate changes, cities have now become a huge focal point when it comes to sustainable development.

By 2008, more people were living in urban areas than in rural settings (3.3 billion) leading to the so-called Megacities. (UN SDG, 2011). These are not the only signs of increased urbanization with the numbers of small and medium-sized cities also growing steadily. This phenomenon brings limited access to land in cities, high costs of food, water, electricity, transportation, housing, education and healthcare, as well as contributing to urban poverty and inequality. Rapid urbanization growth requires vision and responses, like the ones defined in the Sustainable Development Goals (SDGs).

To realise the promise of the Sustainable Development Goals (SDGs), governments and international organizations need to improve the way to identify and support the urban poor and we as architects should be in the lead of that understanding.

Our project aims to explore processes for a network of metrics for urban analysis using AI and open available data, that could lead to possible interventions directly associated with the UN sustainable development goals in a certain built environment not based on just environmental analysis but rather focus on social and infrastructural needs.

1.1 INTRODUCTION

Urban(AI)D follows the research by design methodology and aims to explode processes for evaluating urban indicators with a network of metrics using different types of data directly associated with the UN sustainable development goal.

With well-known processes for energy and radiation analysis in the urban environment, our focus for exploration goes especially for social and infrastructural needs and how AI can contribute to Sustainable development goals.

Making use of the capacities of Machine learning processes, we intend to identify and classify metrics based on the SDGs which can give us existing metrics, predict future tendencies that allow better responses and visualise changes.

The aim of Urban(AI)D is to identify and classify urban metrics based on the SDGs not based on just environmental analysis but rather focus on social and infrastructural needs which can predict future tendencies of a city and can help in generating targeted urban interventions and responses and also visualise changes in a city based on the SDGs.

1.1.1 OBJECTIVES

- Explore the potential of quantizing and predicting the UN SDGs based on the social and infrastructural needs of a city

- Unveil the possibility and efficiency of using web interfaces as a means of sharing the data analysed to various stakeholders in developing a city - policymakers and real estate developers

1.2 RESEARCH PROCESS AND METHOD

1.2.1 UNDERSTANDING SDGS + CITY DATA

As our first approach, we tried to understand the difference between the SDGs and their indicator and how they are divided. With a total of 17 goals and 247 indicators, they can be grouped into 3 main areas - Social, Environmental and social. Starting from there, and as shown on the next page, we have collected a sample of SDG`s that could be applied to the Lisbon study case.

Table 1:
Some of the UN Sustainable Development Goals related to the built environment.

SOCIAL

- Proportion of schools with access to electricity, Internet and computers for pedagogical purposes
- Proportion of urban population living in slums, informal settlements or inadequate housing
- Indicator of food price anomalies
- Health worker density and distribution (2,5 Medical workers per 1000 inhabitants)
- Proportion of population that feel safe walking alone around the area they live
- Proportion of children and young people in 2 and 3 grades.
- Proportion of children and young people in 2 and 3 grades.
- Proportion of teachers
- Renewable energy share in the total final energy consumption
- Renewable energy share in the total final energy consumption
- Proportion of population that has convenient access to public transport
- Proportion of Urban solid waste collection and air quality
- Average share of the built-up area of cities that is open space for public use for all
- Employment status

ECONOMICS

- Annual growth rate of real GDP per capita
- Reduce the proportion of youth not in employment, education or training
- Research and development expenditure as a proportion of GDP and Researchers/ per 1000 inhabitants
- Proportion of people living below 50 per cent of median income.
- National recycling rate, tons of material recycled.

ENVIRONMENTAL

- Proportion of population using safely managed drinking water services
- Proportion of population using safely managed sanitation services
- Operationalization of an integrated policy/ strategy/plan which increases their ability to adapt to the adverse impacts of climate change
- Progress towards national targets established in the Strategic Plan for Biodiversity

Figure 1:
(top)
UN Sustainable Development Goals divided into Social/ Economical/Environmental Criteria.

Table 2:
(bottom)
Part of the dataset in CSV used for the ANN Regression to predict Lisbon's infrastructural needs.

1.2.2 DATA PROCESSING USING PCA

After choosing the 23 Sustainable development goals that could be more relevant to our location, the next step was to correlate them with different open data available from the city of Lisbon and run a Principal Component Analysis (PCA) to narrow it down to the most relevant datasets PCA. The procedure of PCA is usually used to reduce the dimensionality of multivariate datasets, which can be an important step when in our Indicators data processing - as we have 247 SDGs that relate to the urban environment. In our case study, we analyse SDG indicators from the Lisbon open dataset to understand the correlation between the different indicators. By doing it we can understand which ones are most relevant (less correlated) to be used in our machine learning training process.

Year	Population	Newborns	Mortality_rate	Price_Index	Public_transportation_metro	Solid_waste_collection	Poverty_rate	Early_school_leavers_rate	Air_quality_management	Waste_management	Clean_water_system	Hospital_beds_per_1000	Road_Accidents_yr	Green_Energy_prod	Inv_Health_GDP
2001	563312	9.9	14.4	4.4	144586	454.4	4.8	35.9	0	44.14	90	13.8	2132	34.6	0.234
2002	562308	10	14.5	1.6	145734	441	4.5	36.4	0	61.79	91	12.9	2712	22.1	0.239
2003	540022	9.9	14.8	2.3	179650	448.7	4.8	33.3	0	54.3	92	13	2666	38.5	0.256
2004	534754	9.5	13.6	1.1	185444	445	4.7	31.8	0.1	52.7	93	13.1	2501	27.9	0.268
2005	524640	9.5	14.5	-0.6	166887	451.8	5.6	31.5	0	56.9	92	13	2381	15.5	0.273
2006	514772	9.2	13.6	2.3	172697	465.5	6.8	31.1	0	60.8	91	12.4	2282	33	0.265
2007	504726	8.9	13.9	2.4	178432	471.1	7.3	29.5	0	65.49	92	12.6	2268	35.1	0.262
2008	489562	9	13.9	3.6	178726	516.3	8.5	28.3	0	69.8	94	12.5	2186	32.9	0.271
2009	550466	11.5	13.3	-3.9	178720	522.1	10	24.8	0	90.8	95	12.4	2285	37.9	0.295
2010	548210	11.4	13.8	0.1	182781	516.1	10.25	22.3	0	83.4	95	12	2451	53.2	0.279
2011	540217	10.6	12.2	1.4	180182	480.4	8.1	22.8	0	100.2	94	11.6	2284	47.1	0.267
2012	530847	10.2	13.3	2.6	154005	453.3	7.6	19.9	0.1	90.9	95	11.2	2233	43.9	0.312
2013	520549	10.2	13.4	2.5	135712	439.7	6.2	16.2	0.1	86	95	11.1	2295	59.2	0.248
2014	514064	10.8	13.2	-1.1	135013	452.9	5.6	14.8	0	75.6	95	10.8	2378	65.5	0.238
2015	520592	11.4	13.3	3.4	142704	460	4.7	10.7	0	59.9	96	10.9	2544	46.7	0.229
2016	504718	11.9	13.3	0.2	153191	473.5	4.4	12.2	0	57.3	96	11	2687	55.5	0.229
2017	505526	11.7	13.1	1.4	161490	486.1	4.5	10.6	0.1	73.6	96	10.7	2813	40.9	0.221

1.2.3 ML USING ANN REGRESSION

Our workflow starts from the SDGs goals, total of 247 and find correlations to the available data, geolocated or non-geolocated. The geolocated will be used mostly for measuring features and amenities while non geolocated to measure social, economic and environmental ratings in the city. After gathering the data in an evaluation metric, we use it to predict different performances over the time, as a tool for urban planners and decision makers using ANN regression.

Using the results of the PCA, we have then built our Indicators dataset for the city of Lisbon using open data available between 2001 and 2019. The Lisbon indicators dataset was then used to train our machine learning model.

We have created 3 different sets of correlations corresponding to Social, Economic and environmental themes and trained our Linear regression model. In the end, the model trained can be used to obtain the existing evaluation for the current year, as well as our predictions through Rhino.Compute App Server and Flask Application.

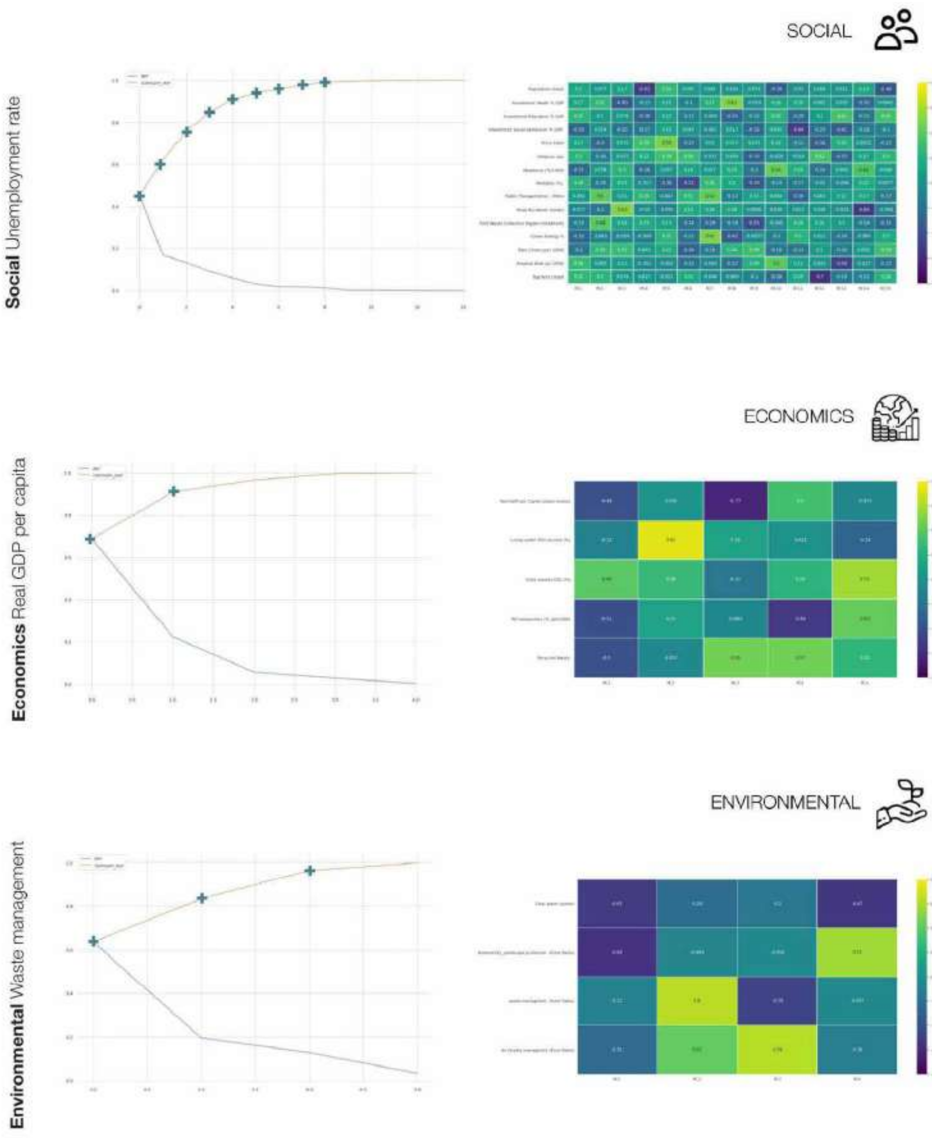
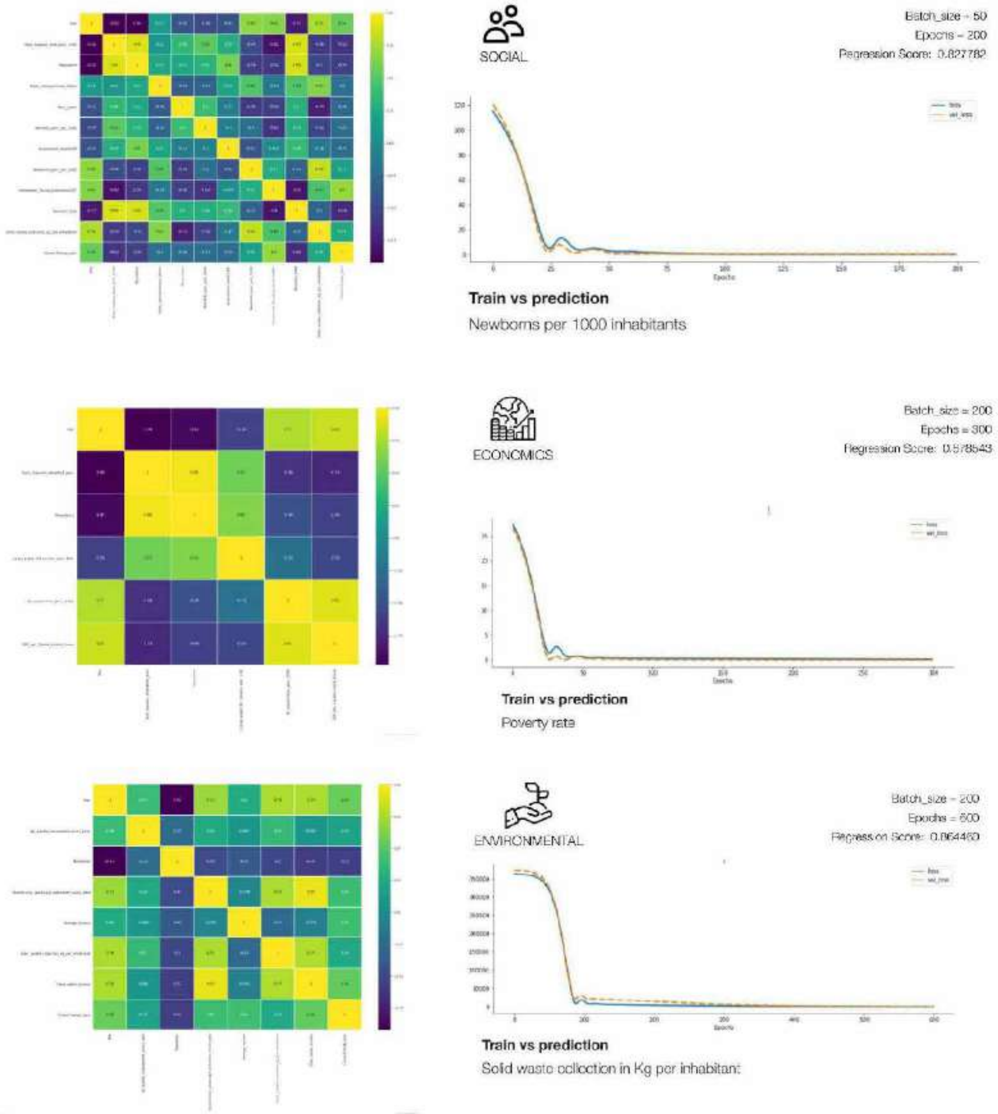


Figure 2:
Running PCA analysis to extract the most relevant features in the dataset using the elbow method.

Figure 3:
Running ANN Regression and training the model to predict the needs of the city such as Predicting Requirement of Green Open space in m2 // Predicting Population overtime // Predicting Requirement for number of Amenities // Predicting Requirement for Public Transportation Nodes // Predicting requirement for the number of Education Facilities // Predicting the solid waste generation in tonnes



	GENERAL CITY METRICS (non geolocated)		GEOLOCATED METRICS (spatial / coordinates)
Source :	From OECD / OPEN DATA LISBON / BIPZIP		From OSM/GEOJSON
Info :	Data over the last 15 years		Data of the current year
Aim :	Calculate the metric for 10 - 20 years in the future	ANN Regression →	Needs required by the city in the future

Table 3:
Schematic workflow of correlating the non-spatial metrics with the geolocated metrics.

1.2.4 INTERFACE DEVELOPMENT WORKFLOW

The workflow consists of 2 types of datasets - one from the OSM which is open source and the closed source data of BIPZIP by Lisbon city. OSMx library is used to extract the open-source data. Flask App is used to push the ML predictions to the cloud and the data is visualized using Node.js and rhino compute app server for interaction with users to display the data.

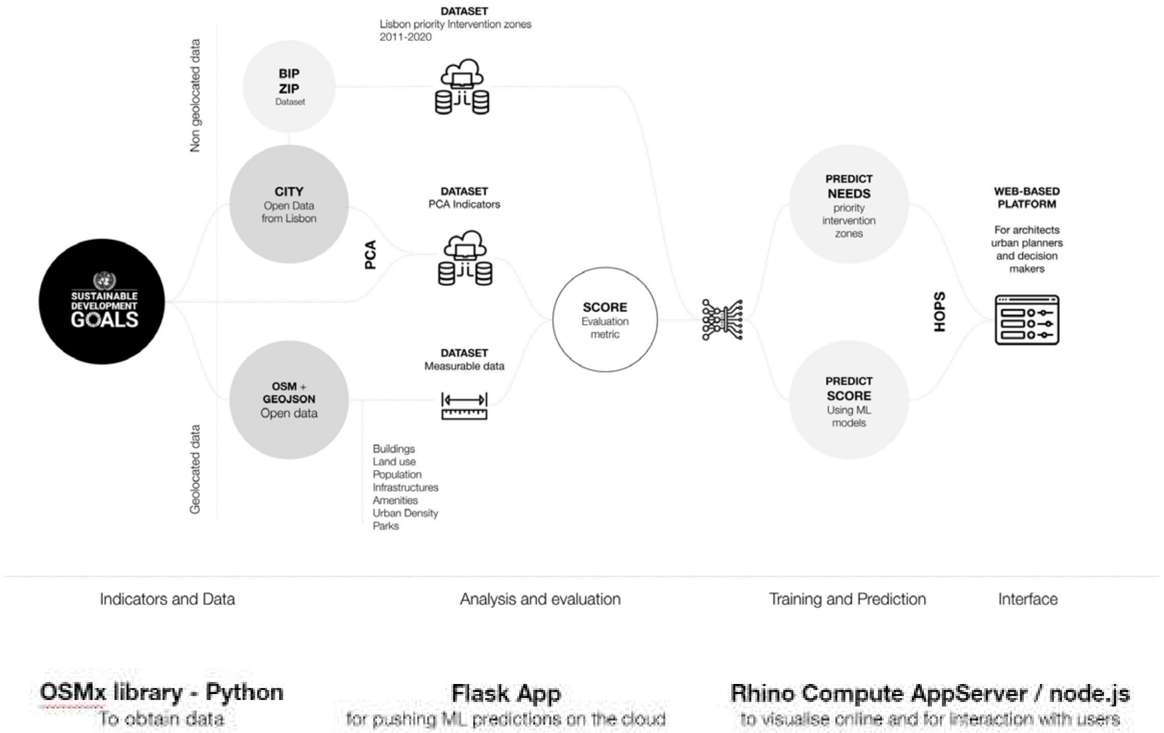
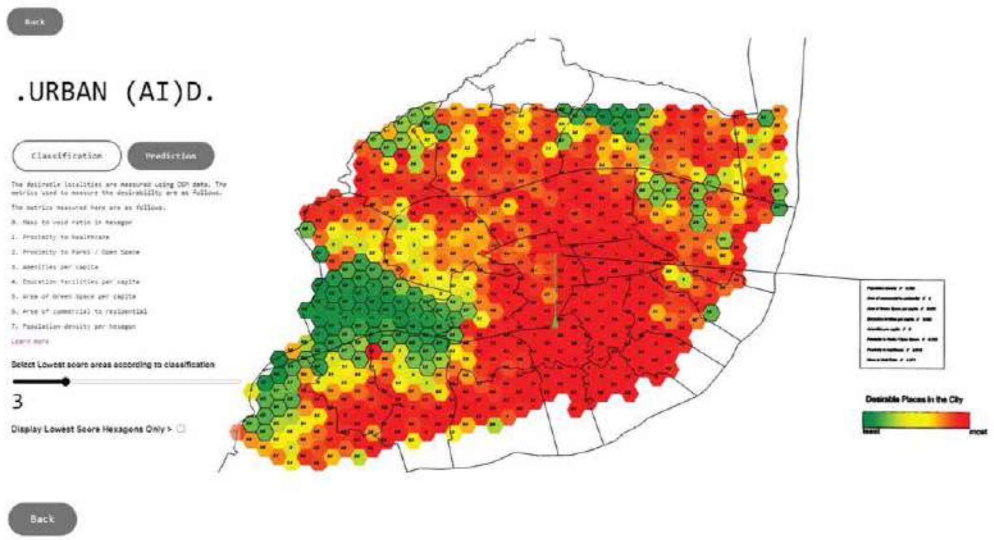


Figure 4:
The city of Lisbon with the most desirable parts of the city shown in red and the least desirable parts of the city shown in green.

By using OSM we can extract a large amount of geolocated information and some of it corresponds with some parameters defined in the SDG's. The distances to Health care, Urban parks or Educational buildings are some of the examples of parameters to measure and follow up life quality in the urban scene. Proximity to public transportation or urban open parks, as well as the number of research institutions around us, are some of these indicators and can help to evaluate, for example, our quality of life or innovation status.

The city map is divided into a hexagonal grid of 1 sq.km and devised a way to come up with an evaluation score showing the most desirable parts of the city shown in red and the not so desirable parts of the city according to the criteria shown in green.



1.2.5 PREDICTIONS

Since we have data for the past 20 years it was possible to predict the needs of the city in the future. For that, we had to correlate the non-spatial metrics for the past 20 years with the spatial metrics.

For example, we realised that the percentage of newborns is directly related to the healthcare amenities as the number of newborns increases the number of healthcare amenities required to take the load has to be more. Similarly, population density is directly proportional to the solid waste produced. In a similar manner, we have defined 5 correlated metrics as shown. In the figures below, the darker colour shows the increased requirement whereas the lighter colour shows less requirement of each of the metrics shown.

Figure 5:
The city of Lisbon with the parts of the city with the maximum requirement in dark colours and the least requirement in lightercolours.

1.2.6 PREDICTION SAMPLES

- Predicting Requirement of Green Open space in m2
- Predicting Population over time
- Predicting Requirement for number of Amenities
- Predicting Requirement for Public Transportation Nodes
- Predicting requirement for the number of Education Facilities
- Predicting the solid waste generation in tonnes

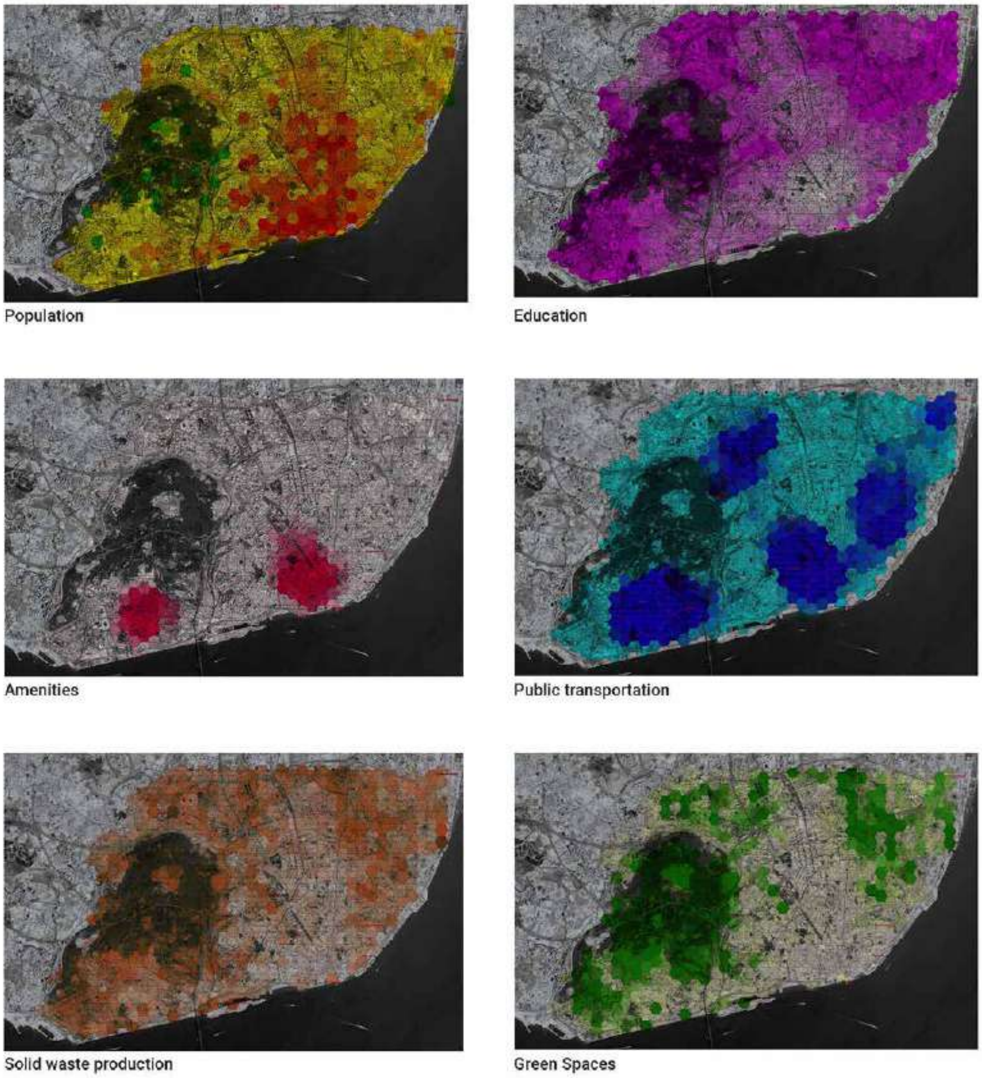


Figure 6:
The Urban(AI)D interface developed as a way to share the source knowledge developed as a part of the research.

1.2.7 URBAN(AI)D INTERFACE

With the goal of helping policymakers, architects and urban planners to evaluate and understand the needs of the city better, Urban (AI) has its own WebAPP. This app can be used in Planning & Design, Cities & Public Agencies and Real Estate.

The Urban(AI)D interface is live at https://urbanaidlisbon.wixsite.com/urbanai

1.3 FINDINGS/CONCLUSIONS

1.3.1 WORKFLOW

We believe that this research has presented very positive results in breaking down the workflow between urban indicators analysis and machine learning and it can, in our opinion, be considered as a workflow for further exploration.

The workflow methodology seems to translate well the SDGs indicators and it shows that machine learning methods along with pure statistical methods such as Principal Component Analysis (PCA) can help to narrow down the complexity that sustainable development goals represent.

With the final goal of output performance metrics of the urban environment that can guide architects and decision-makers to informative interventions, the Urban (AI)D workflow seems to respond positively not only in its results but also in its capability to be replicable.

1.3.2 SDG INDICATORS AS DATA

The direct translation from indicators to data cannot be done directly. The choice of indicators is quite dependent on how much a city is developed. While some indicators gain meaning, others lose.

In addition, the use of only public open data can limit the final results, which makes us believe that collaborations with institutions with direct access to official data can be an advantage.

1.3.3 APP

The deployment of the application made us understand that there is a possibility of making AI accessible for urban planners, real estate developers and policymakers. However, sufficient back end work was done by us to integrate the data with the predictions and display it in a visually understandable manner. Since the data used now is completely open-source and the workflow completely established, the next step is to make this available for every city with minimal human / developer intervention. For eg extend the app for various cities like Mumbai / Moscow / Barcelona with the click of a button.

1.4 ACKNOWLEDGMENT

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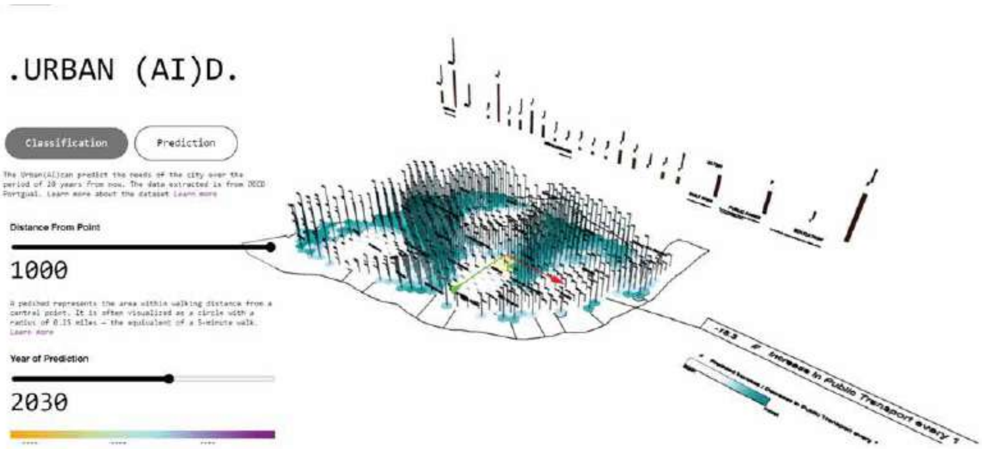

Figure 7:
The Urban(AI)D interface where the Policymakers and real estate developers can understand the city with respect to the UN SDGs and plan the city further by understanding its demands.

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TREEHOPPER

A tool development for identifying potential areas for roadside tree planting

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KEYWORDS
participation, environmental impact, tree planting, microclimate predictions, web application, Augmented Reality

ABSTRACT
This research proposes a novel way of utilizing technologies for identifying potential areas for roadside tree planting. Urban greenery as a resource should be decided through participatory approaches that involve citizen engagement and empowerment. Therefore, the research focuses on proposing inclusive and data- informed tools in engaging both citizens and municipal authorities in collaborative decision-making processes. The solution is a web platform called “TreeHopper” enabling and guiding stakeholders towards data informed decisions. Tree planting is observed from two perspectives – the bird’s eye strategic view and from an augmented reality view where citizens can make local proposals for possible tree locations. The project’s impact can be pinpointed into three aspects, important for urban design and participatory practices - feasibility, environmental and social impact.

1. INTRODUCTION

European cities are living organisms consisting of residents, local stakeholders, the sum of functional building stock, and all interactions and processes that take place between them. As the city is predominantly a man-made ecosystem, urban components are continuously shaped and formed based on decision-making processes that constantly adapt to local and global conditions.

Current developments in ICT technologies provide a framework that has the potential to challenge the way we decide, design, and experience public space. As a direct outcome, the sheer volume of data generated by urban users and infrastructure provide an unprecedented volume of accessible information, that can help develop new tools and resourceful insight towards more engaging, inclusive, and meaningful decision-making processes in order to tackle pressing challenges of the 21st-century city, like climate action, sustainable and effective urban forestry.

2. RESEARCH

2.1 LITERATURE REVIEW

Urban greenery and the means to foster citizen engagement have been an ongoing subject for researchers. Most of the research focuses on three fields: finding ways to engage citizens in ad hoc problem solving, raising climate awareness, and providing intelligent computational tools processes.

“Trees AI” (Gillett et al., 2020) is one of the recipients of “Google’s Impact Challenge on Climate” and aims to address the critical problem of facilitating and financing urban tree restoration at scale, helping to address the gap between urban tree-planting targets, their sustainable delivery and long-term maintenance of urban forests. Trees AI platform has been already adopted from the Glasgow City Council, in order to contribute to the pledge to plant 18 million trees and provide input that will help reverse the notion of viewing trees as cost and instead provide tools to consider them as assets. The platform’s value lies in finding ways to monetize positive impact climate action in order to unlock novel financial streams to reduce the cost of urban tree maintenance.

“Treepedia”, is a platform developed by “MIT Senseable City Lab”, that uses “Google street view” data in order to measure and compare the green canopies of major cities across the world. The interactive website gives local stakeholders the chance to “view the location and size of their cities' trees, submit information to help tag them and advocate for more trees in their area."

On the subject of raising awareness towards urban greenery and providing design standards to be used by policymakers, the "Trees and Design Action Group TDAG" brings together a diverse group of stakeholders from academia, the private and public sector, in order to improve knowledge and good practice to support the role of urban trees in design, planning, construction, management, and maintenance practices. The main task of "TDAG" is the development of guidelines with evidence-based information, practical advice, and case studies to inform decision-making on urban trees.

Another critical issue is to provide collaborative tools, bringing diverse stakeholders together in order to reach consensus, or as it is known in game theory, a zero-sum game, where everybody wins and everybody loses. The issue of tree planning is often considered at the city-wide scale, however to make it acceptable, it needs to be addressed in a hyperlocal design scenario, where urban residents will acknowledge the value and the need and take ownership of the project, ensuring its sustainability.

Towards that goal, based on the 15-minute city initiative, a hyperlocal variation arrives from Sweden, piloted by Swedish national innovation body "Vinnova" and design think tank "ArkDes", named the "one-minute city", focusing on the scale of a single street-level, paying attention to "the space outside your front door". The project promotes collaborative practices in order for urban residents to be able to co-design their streets.

Another project enabling mobility, relying on a tablet application, is the "SuperBarrio" Video game, which was developed by "IAAC", in order to engage citizens in the design of their public space using gamification strategies. The users, by navigating space in three dimensions, can modify their neighborhood by adding elements, functions, and services for the public space or empty buildings, with modules relating to the topics of ecology, energy, mobility, and culture.

On the issue of providing a framework for stakeholder engagement, the "Play the city" initiative proposes a toolkit for applying games to complex multilayer city challenges. The key steps that researcher Ekim Tan proposes in her manual are, firstly identifying the urban question, then identifying who is already involved in the situation, and finally, who is willing to get involved. For the purpose of facilitating interactions, the toolkit implements a board game approach that consists of almost 2000 pieces.

The idea of a discrete architectural framework based on parts, is strongly advocated by researcher Jose Sanchez, due to the fact that parts have social value. Furthermore, the patterns that parts are organized upon, we could claim that represent the embodied intelligence gained by the collaborative process (Sanchez, 2020). Furthermore, in his game "Block'hood", Sanchez highlights the value of entropy in any ecosystem, let alone an urban ecosystem that is primarily artificial. In the game, the players are given the means to design a neighborhood out of 200+ building blocks with the goal of maintaining an ecological balance, as each block produces and consumes resources. Therefore, by constantly trying to balance between natural and man made elements, the users become aware of the need for positive climate action in their own local micro-environment.

2.2 STATING THE CHALLENGE

The challenge that our project "TreeHopper" aims to tackle is to contribute to the goal set by the municipality of Vienna, who, as part of its climate strategy, plans to issue a climate action policy by planting 25.000 trees (City of Vienna). "TreeHopper" contributes, by finding innovative and inclusive solutions in deciding on the most suitable locations for urban tree planting, and finding efficient ways of engaging citizens along with municipal authorities in order to create a decision-making process that is data-driven, and has the potential of achieving broad acceptance among competing stakeholders.

However, based on an article by "Dark Matter laboratories", the key reasons that municipalities are struggling to increase urban forest growth is that "urban forestry is framed as a cost rather than a resource" since they need to be handled by a contractor and also requires maintenance. Furthermore, urban greenery metrics focus on planting rather than maintaining. Finally, it is pointed out that, there is a need to simplify the financial returns of trees, by creating monetary benefits for non-municipal stakeholders in maintaining trees, thus reducing the load in the municipal budget. Therefore, we can identify a pressing need for "councils to start understanding success beyond planning and consider a suite of different metrics that are more granular and greatly entwined with the science of climate".

Before proceeding further into "TreeHopper" 's solution to the challenge, we need to identify the three key reasons behind the necessity of engaging local stakeholders in urban decision-making processes with intelligent tools. Firstly, "cities lack competence in understanding digitization, experimenting with technologies, and approaching challenges flexibly. Business models, funding models and procurement practices are underdeveloped, do not support technological innovation and are often unsuitable for multi-stakeholder strategic collaboration" (De Lange & De Waal, 2019).

Furthermore, Manuel DeLanda states that "Before we can generate buildings themselves" (or sustainable public spaces), "we must model the decision-making processes that give rise to them. And in order to do this, we must be able to devise intelligent decision-making agents that can influence others and reflect upon their own decisions" .

In addition, there is a shift towards a new type of urban centrality based on local urban residents and stakeholders. Antonio Negri, explains that the "Polis" of the 19th and 20th century or the imperial center of the top-down hierarchical model, needs a new definition. As over half of the world population lives in cities, as supported by data by "The United Nations Population Division's World Urbanization Prospects report", the urban experience points toward an emergent centrality, based on the sheer volume of urban dwellers and their interactions between them and not by an imposed "imperial" centrality defined by institutional and authoritarian norms.

Therefore, we can safely assume that technological innovations that promote the engagement of local residents, giving them a data-driven and data-informed say in how and what is decided in their city, is vital in this urban paradigm. Furthermore, the issue of deciding, managing, and maintaining cannot and must not only be a municipal concern. Local stakeholders need to take ownership of the urban greenery and their neighborhoods and actively acknowledge it as a common resource that must be nurtured and maintained.

3. IMPLEMENTATION

3.1 OUR SOLUTION TO THE CHALLENGE: THE TREEHOPPER PLATFORM

Our solution to the task at hand is to develop a tool for identifying potential areas for roadside planting. "TreeHopper" is a data-informed participatory digital solution that incorporates into the final application participatory practices in order to help reach consensus on the issue of roadside tree planting, taking into account municipal action, stakeholder engagement, and hyperlocal environmental impact assessment.

Coming upon the "what?" and "how?" of our proposal and how it tackles the challenges presented above, our project "TreeHopper" is a platform that consists of two critical parts, a front- end user facing web app and a backend platform, doing all the "heavy lifting" in order to provide the user a seamless user experience. The backend platform is underpinned by a web server that exposes endpoints where the pre-trained deep learning microclimate models can be accessed through a GraphQL API. The user-facing web app front-end combines data externally gathered from open data sources (like OSM), with the results returned from the API, consisting of the microclimate predictions, relevant to the user's input.

By focusing on maximizing user experience, by transferring to the backend, unnecessary (for the average user) options and adjustments, we offer a seamless, efficient and easy to use user experience, requiring very little to no effort to understand how it functions. Therefore, the user is offered a combined and holistic perspective, resulting in a seamless data informed decision making process, enabling the average non expert user to arrive at informed decisions.

The core functionality of the front- end user interface offers the user the possibility to place trees within their neighborhood and see the impact of their decisions in almost real time. Furthermore, the web interface uses a bird's eye view representation of the city, traditionally used by architects and planners alike, as a method of representation to understand urban elements, relations and effects in the strategic scale. However, "birds eye view" lacks granularity and context, since it is unaware, by-design of the intricacies and phenomena that take place within the micro-scale of the neighborhood, since it is more attune with the top-down decision making perspective.

To account for that "limitation" and to provide the user an "urban wanderer"-like experience- a "Flâneur", "TreeHopper", provides also the possibility to switch over to the integrated augmented reality view. By incorporating this feature, we set the users of the app at the "urban wanderer's" perspective, which is most importantly locally aware of their surroundings, influencing their view, their perspective, their psychological and emotional condition, as they are content and context aware of their urban micro- environment. By allowing the users to experience the tree placement process from within, "TreeHopper'' aims to capitalize upon the "urban bias" that each local resident has, as there are no better experts to identify local problems and conditions, than the urban dwellers themselves. Thus, by enabling this feature, users can see their streets through the app, place trees by simply touching the screen, which are then rendered in view, providing ad hoc, onsite, locally relevant impact assessment.

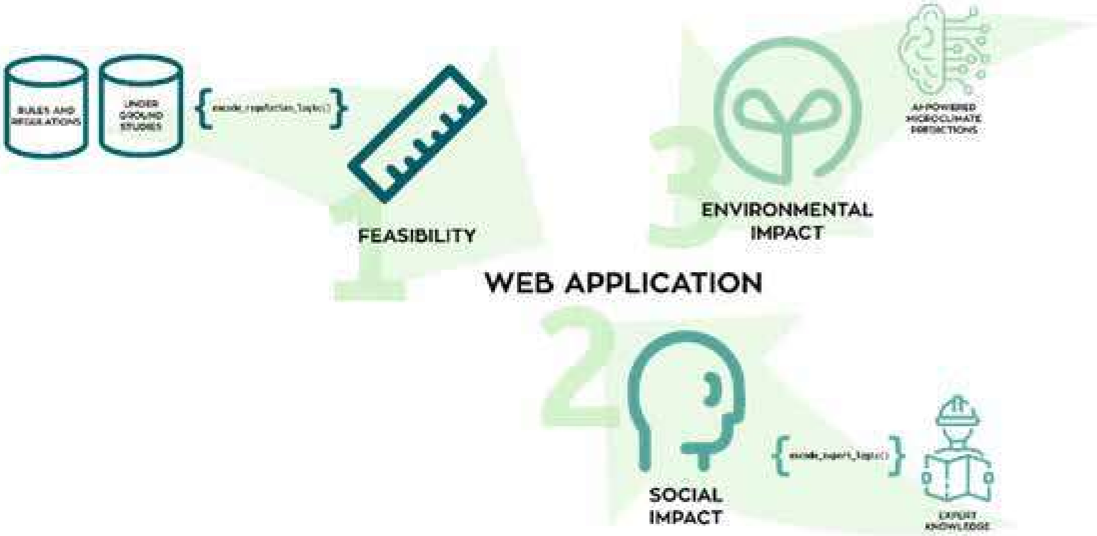
RULES AND REGULATIONS
UNDER GROUND STUDIES
1
FEASIBILITY
3
ENVIRONMENTAL IMPACT
AI-POWERED MICROCLIMATE PREDICTIONS
WEB APPLICATION
2
SOCIAL IMPACT
EXPERT KNOWLEDGE

Figure 1:
(top of previous page)
Three aspects of the web application.

Figure 2:
(center of previous page)
An AR application enables the user to choose a tree location in the city by using their tablet/mobile.

Figure 3:
(bottom of previous page)
AR applications give the possibilities for mutual discussions between citizens.

3.2 IMPACT

As already presented, "TreeHopper" offers a seamless integration between, computational, visualization and decision-making tools, compiled in an easy to use and engaging toolkit. This is a novel approach, as previous attempts, examined in the literature review, were constrained by the interface, either using only a web interface, a tablet interface, a board game, or a videogame. Furthermore, previous contributions about planning the placement of trees offer only limited feedback on existing government regulations (Jan Peters-Anders et.al., 2016). TreeHopper aims to extend beyond this approach and involve other aspects that are relevant for the participatory process.

All of the above points are brought together as embedded data informed features, guiding the decision making process, or as active functionalities accessible to the user. We can pinpoint three specific attributes in measuring impact, feasibility assessment, social impact and environmental impact. By embedding and aggregating these attributes, the average citizens are empowered to co-identify, and co-decide potential planting areas in their neighborhoods.

On the issue of feasibility assessment, "TreeHopper" can incorporate on the backend platform, when evaluating a certain spot for planting suitability, different design rules and infrastructure regulations about urban forestry. There are 2 main aspects that need to be considered, regulations and design restrictions for above and below the ground. These design restrictions include aspects such as specific distances that need to be followed from the crown of the tree to a building facade, as well as from the root of the tree to the surrounding canals underground, thus preventing future damage to critical infrastructure.

On the issue of social impact, "TreeHopper" 's dual interface (strategic view and Augmented Reality), offers the possibility of a seamless transition from the decision making board, situated within a municipality meeting room, towards the organization of an ad hoc collaborative workshop in the area in question. By making the process locally aware and socially relevant, competing groups, such as policy makers, stakeholders, and local residents, disputing on the subject of where the trees should be planted, are brought to the same level and are facilitated towards consensus. As the city model can be viewed from a smaller scale and through different devices, citizens and along with expert consultants, designers and policy makers, share the same view. (Figure 3).

Capitalizing on the possibility of bringing the decision making process to the place of dispute, "TreeHopper " allows for almost real time impact assessment analysis such as wind comfort and solar radiation, based on the provided user input. Through the functionalities made available from the backend of the platfrom, simulations that would usually take hours, are replaced by AI-powered microclimate predictions generated within a few seconds

(Galanos & Chronis 2021) (Figure 4). The solar and microclimate analysis of the urban space in question, provides to the user insightful understanding of the impact urban forestry has to its surrounding urban locale. (figure 5).

Finally, "Treehopper" is actively contributing in the implementation of important Sustainable Development Goals (SDG) which are part of the 2030 Agenda for Sustainable Development (Federal Chancellery, Republic Austria). Included SDGs are the promotion of good health and well-being that would be ensured through tree planting. The project is further concerned with building a resilient infrastructure for the city and promotes climate action as a participatory approach.

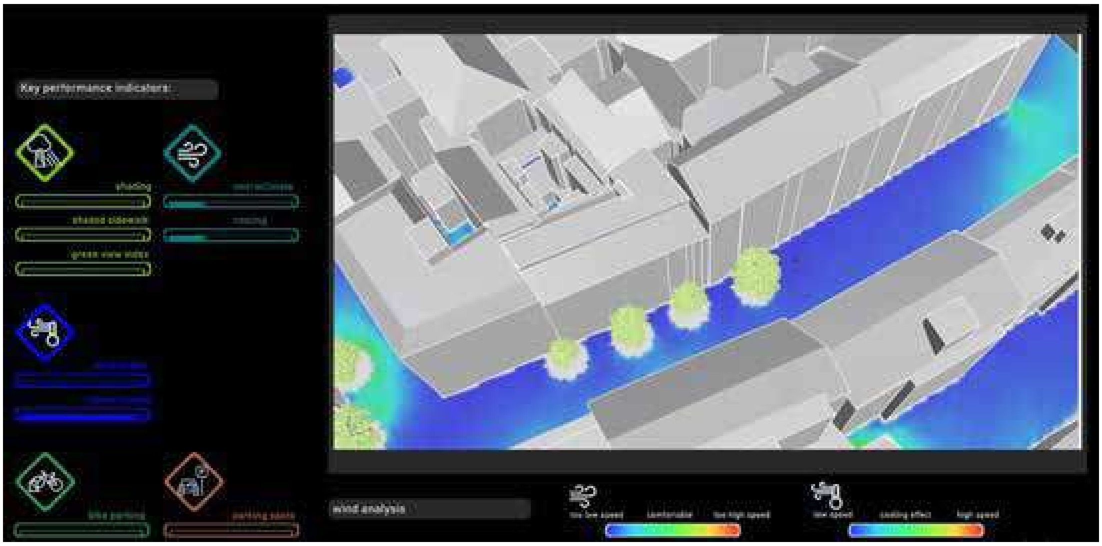

Figure 4:
(top of previous page)
Wind analysis results: increase of cooling effect by locating more trees.

Figure 5:
(bottom of previous page)
Solar analysis results: increase of shading effect by locating more trees.

4. CONCLUSION

“TreeHopper” project tries to capitalize upon new developments in ICT technologies and focus them towards contributing in urban innovation digital solutions. The research identifies a data-informed participatory methodology as a solution to tree planting in the City of Vienna. By offering a more efficient user experience the platform provides a multiple perspective tool that eases municipal action and stakeholder engagement.

The preliminary tests and results point out that real time analyses on microclimate data along with visualizing and estimating the positive impact of tree planting, have the potential to enhance and inform decision-making processes between competing stakeholders. The novelty of “Treehopper” ’s approach to the problem can be seen in the incorporation of both a web interface along with multiple visualization features, actively incorporating AR tools, providing a seamless user experience. This could be practically utilized in various scenarios from a small municipality meeting room to a larger collaborative workshop that includes more stakeholders. With all of the embedded knowledge and expertise, citizens are empowered to meaningfully contribute towards a better city and a better neighborhood.

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PERFROM

Within the "Perform" Section a selection of research papers seek to answer to questions such as:

How can increased livability be achieved in cities and rural environments?

How can ecosystem services be extracted and enhance the benefits of the design solution?

How can living systems positively impact the built environment?

DESIGN & ADAPT

BUILD

SHARE & LEARN

PERFROM

POSTERS

TOWARDS THE IMMUNOLOGICAL CITY

Protecting citizens against escalating environmental harm

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KEYWORDS
Immunological principle, Danger Theory, urban bioremediation, microbial technologies, “smart” infrastructure

ABSTRACT
A new immunological principle for mitigating urban harm is proposed as the foundations for establishing the Immunological City. Drawing together the “nervous system” capabilities of “smart” infrastructure with the electroactive, bioremediating capabilities of “living” technologies, a new bio-digital platform for urban bioremediation is proposed that defends citizens against the increasing risks posed by our ever-changing and environmentally-stressed cities.

1. INTRODUCTION

As we line up to be vaccinated against the coronavirus pandemic, the issue of immunology is very much in the public eye, but we cannot immunise ourselves against the harmful effects of the environmental crisis. While it has been down staged by the pandemic, urban pollution is an ongoing worldwide emergency posing an increasing danger to human health—from air (Jantun et al., 1998; EEA, 2020) to noise pollution (Oyedepo, 2013), particle accumulation (Gern, 2010), social stress (Lederbogen et al., 2011) and altered circadian rhythms (Dominoni et al., 2013). Set against a changing hazard condition in cities caused by urban expansion and the ongoing climate emergency, the need for healthy urban environments is now a major policy priority and a coordinated, coherent strategy to protect citizens against the growing problem of toxic urban environments is pressing. This paper proposes a bio-inspired view of the urban environment, which defends citizen health against environmental harm by virtue of an immunological principle that combines "smart" infrastructure with "living" systems powered by microbes that are simultaneously capable of providing ecosystem services and producing bioelectricity.

2. THE CITY AS RISK TO CITIZEN HEALTH VIA TOXIC ENVIRONMENTS

More people than ever are living in cities. The UN estimates that by 2050, 68% of the world's population will live in urban areas. Cities are, therefore, important in determining the quality of life for citizens and the health of the broader environment (UN, 2004). Unfortunately, urbanisation itself actively produces a range of harmful agents that negatively affect citizen health and the natural systems around them including: i) pollutants (nitrous gases, sulphur dioxide, methane, (ground) ozone, Volatile Organic Compounds (VOCs), lead) (WHO, 2021); ii) physical events (changes in pressure, lux, temperature, humidity, noise etc.); iii) noxious agents (pollen, pathogens, black carbon, microplastics, particulate matter, toxic changes in exposomes etc.); and iv) harmful microbes (altered microbiome composition, pathogens) (Brodie et al., 2007; King, 2014). Set against a changing hazard condition in cities, i.e., urban expansion and the ongoing climate emergency; healthy urban environments are now major policy priorities. Present approaches towards environmental monitoring generally search for a narrow range of environmental risks with an emphasis on one, or a few hazards that do not correlate this data with other variables. For example, the Air Quality Index (AQI) measures ground-level ozone; particle pollution; carbon monoxide; sulphur dioxide; nitrogen dioxide but is not compared with e.g. traffic density, or local industry activity, so solutions do not anticipate expansion of the system's organisation as needs change. This means that rather than quickly identifying mitigating actions and innovation opportunities (Huang & Morawska, 2019), the next appropriate steps to take with respect to this data are unknown (Bithal, 2015; Mayer et al., 2019).

3. URBAN IMMUNITY AS FIRST-LINE DEFENCE OF ENVIRONMENTAL HEALTH

Bio-inspired (using biology as an organisational model) approaches in architecture and urban studies have expanded progressively to address challenges posed by complex adaptive systems typical of the living realm (Barabási, 2007) toward a dynamic engagement with cities (Speck et al., 2017). The Urban Immune System (UIS) model uses the concept of the biological immune system to establish ways of mitigating environmental harm (Bristow & Mohareb, 2019), by combining the principles of urban Risk Management (RM) systems with Urban Metabolism (UM)—an established systems-oriented model of energy and resource consumption, with material flow analysis that draws together the physical and social urban realms (Kennedy, Cuddihy & Engel-Yan, 2007). Enabling urban sustainability to be understood as a metric, or resource demand so the key sources of greenhouse gas emissions can be quantified and, therefore, regulated alongside other sustainability measures (Kennedy & Hoornweg, 2012) UIS strengthens the relevance of UM concepts through their deployable relevance to RM in response to a range of anthropogenic factors e.g. rapid urbanisation, technological advances, malicious acts etc. Taking a coarse-grained approach to the concept of "immune system" where, for example, "skin behaves like flood barriers, whereas new construction and emergency response could be compared to aspects of the lymphatic system and T-Cells which likens hazards that activate emergency responses to pathogens" (Bristow & Mohareb, 2019, p. 301), UIS lacks integrated "smart" mitigation strategies, which are needed to defend the health of citizens in a responsive and coordinated manner, while tracking environmental remediation.

4. SMART INFRASTRUCTURE FOR AN EFFECTIVE IMMUNE SYSTEM

Smart city solutions are frequently likened to urban "nervous systems." For example, Huawei proposes their Smart City approach comprises a "brain" (the control centre) and "peripheral nerves" (the network and sensors), which are gathering real-time information about the status of the city. By transmitting the data, "smart" infrastructure enables the “brain” to analyse and make informed decisions, delivering feedback commands, and ultimately carrying out intelligent actions, enable real-time situation reporting and analysis that unites the powers of cloud computing, AI, IOT and big data to improve the environment for all citizens (Huawei, 2017). These “neurological” principles of “smart” infrastructure provide live data about the distribution of a whole range of harmful environmental agents using clusters of different sensor types e.g. (sound, air, physical parameters etc.) that can be correlated using cloud computing so that patterns and relationships emerge (Gubbi et al., 2013). Enabling a joined-up relationship between cause and effect means that appropriate mitigation responses (Lobo et al., 2020) can be further modulated by digital collaboration tools, such as mobile phone applications and web portals, where citizens with access to real-time information can help train the immunological memory of a place (Monfaredzadeh & Kruger, 2015). By comparing new data with past experience, “neurologically” enabled cities can prepare for future threats (Mayer et al., 2019).

5. URBAN IMMUNITY AS FIRST-LINE DEFENCE OF ENVIRONMENTAL HEALTH

Since the 1940s, the immune and nervous systems have been shown to share many commonalities in their developmental and evolutionary origins (Kioussis & Pachnis, 2009) and cellular dimensions can be added to the established “neurological” infrastructure by incorporating microbial technologies (such as the Microbial Fuel Cell, an organic battery powered by microbes), which are of growing importance to urban studies (Figure 1). The biggest contributors to urban biodiversity, microbes occur in associations with building surfaces, roads, streets, and other passages; surface and sub-surface soils; the phyllosphere of plants; animal and human waste; water distribution systems, streams, drainage systems and other aquatic habitats. Comprised from groups of symbiotically interacting populations that form interacting and interdependent networks, these organic systems are sensors that constantly “read” the character of their surroundings. Through their rich and varied metabolisms they also act as effectors, converting their surroundings into energy for microbial “life” and producing a range of metabolites that become food and nutrients for other microbes and plants. Notable also for their critical contributions to biogeochemical functions, e.g., decomposition and nutrient cycling (Fenchel et al, 2012) microbes have multiple, and often beneficial roles in urban systems, contributing to the overall environmental dynamics of urban systems by performing critical “ecosystem services,” at little, or no resource cost within the urban context (Bell et al, 2005; Balvanera et al, 2006; Fenchel et al, 2012). For example, nitrification and denitrification are microbial processes that are extensively used in urban wastewater treatment (Bitton, 2011), providing food for plants, and removing toxins respectively, with

Figure 1:
Microbial Fuel Cells formed by "hacking" vernacular Venetian bricks. This simple configuration of an electroactive biofilm attached to a semi-permeable membrane (in this case a ceramic) enables the harvesting of bioelectricity. Courtesy of the Living Architecture project, 2019.[i]

substantial "health" benefits to the local environment. Sensitive to both natural and anthropogenic disturbances, these networks, and the services they provide, can change according to their context, thereby becoming "living" sensors and effectors within the urban landscape (Yeager et al, 2005; Wittebolle et al, 2006). The bioremediation potential of natural microbial communities that make up the Urban Microbiome (UMi)—the sum diverse microbial communities that inhabit a city (Bahcall, 2015), the Microbiome of the Built Environment (MBE)—the sum diverse microbial communities that occupy buildings (Kembel et al., 2012), and their orchestration within a range of bioprocessors

(such as the MFC) are, therefore, set to shape our understanding of the environmental health of the built environment (King, 2014).

6. "THEM" AND "US"

To trigger an appropriate mitigation response, the Immunological City must discriminate between harmful and non-toxic agents. This highly contextualised response that interprets the significance of a diverse range of parameters, is initiated by antigen-presenting cells (APCs). This heterogeneous group of immune agents mediate the cellular immune response by processing and presenting antigens for recognition by certain lymphocytes (white blood cells) such as T-cells. Classical APCs include dendritic cells, macrophages, Langerhans cells and B-cells. Owing to its complexity, our understanding of the immune system is still evolving but early theories of "self/non-self" recognition (Burnet & Fenner, 1949; Burnett, 1969) do not universally account for its specificity and nuances. In the 1990s Danger Theory (DT) (Matzinger, 1994; 2001; 2002a; 2002b) proposed that the trigger for an immune response was by detecting "harmful" signals, rather than by "othering" the range of actors it encountered. When applied to the principles of an Immunological City, DT correlates with healthy environmental factors being recycled (by microbes) into the urban fabric, enabling sites to remain stable and healthy. However, should a site become contaminated, damaged, or polluted by "harmful" factors then, it releases signals that are detected by the APCs to start an appropriate immune response. For example, the microbial composition of pollen is correlated with altered allergenicity due to microbial stress (which is, in turn a response to environmental pollution, namely nitrogen dioxide, ammonia, and ozone) (Obsersteiner et al, 2016), so one approach to mitigating the harmful effects of pollen may involve increasing the number traffic-free zones, especially around arboreal areas. Importantly, DT does not recognise foreignness as a trigger and provides a theory of immunity that does not pathologise "difference" by default. When transposed to the urban environment DT implies a condition of mutuality where unlike agents invite equal treatment unless they cause actual "harm" to one another. Recognised as a feminist model of the immune system "DT leads us to a new viewpoint that turns out to have enormous explanatory and predictive power" (Matzinger, 2001, p. 7), while providing important epistemological value in changing narratives about the health of urban environments from being at war with "foreign invaders" (Weasel, 2001, p. 29) (the "harmful" antigens), to outlining a value system that is based on an agentised view of mutual care (Tronto, 1993; Puig de la Bellacasa, 2017). By acknowledging the non-neutrality of the language encoded within descriptions and narratives associated with scientific models—particularly those that seek exclusion or eradication measures—notions of an Immunological City can be constructed and communicated in inclusive terms—which is particularly important where cultural factors also play a role in shaping theories into

Figure 2:
Screen shot of the active display of the Active Living Infrastructure: Controlled Environment (ALICE) prototype, a digitally-enabled microbial technological platform that enables "conversations" with microbes by feeding and warming them to manipulate their activity and establishing the principles for a bio-digital platform. Courtesy of the ALICE project, 2020. [ii]

practice. Avoiding metaphors of "self" and "other" at this time of global pandemic and heightened nationalism, resists characterising immunological agents as being at war with foreigners, so that conflict does not become imbedded and accepted in scientific theory as a "natural" state of affairs. Such nuanced responses necessitate a more detailed and qualitative understanding than is appropriate for chemical and physical variables alone, which can be detected by sensors typical of "smart" infrastructure and raises important issues of quality when defining notions of "harm" as a trigger for an appropriate immune response. Systems are, therefore needed, that can appropriately recognise some microbes as "antigens" (as in the case of SARS-CoV-2, Hepatitis B, and other pathogens), while also recognising others as part of a mitigating system response (99% of environmental microbes). Such distinctions can be made through the deployment of "living" microbial technologies (Ieropoulos, Pasternak & Greenman, 2017) (Figure 2).

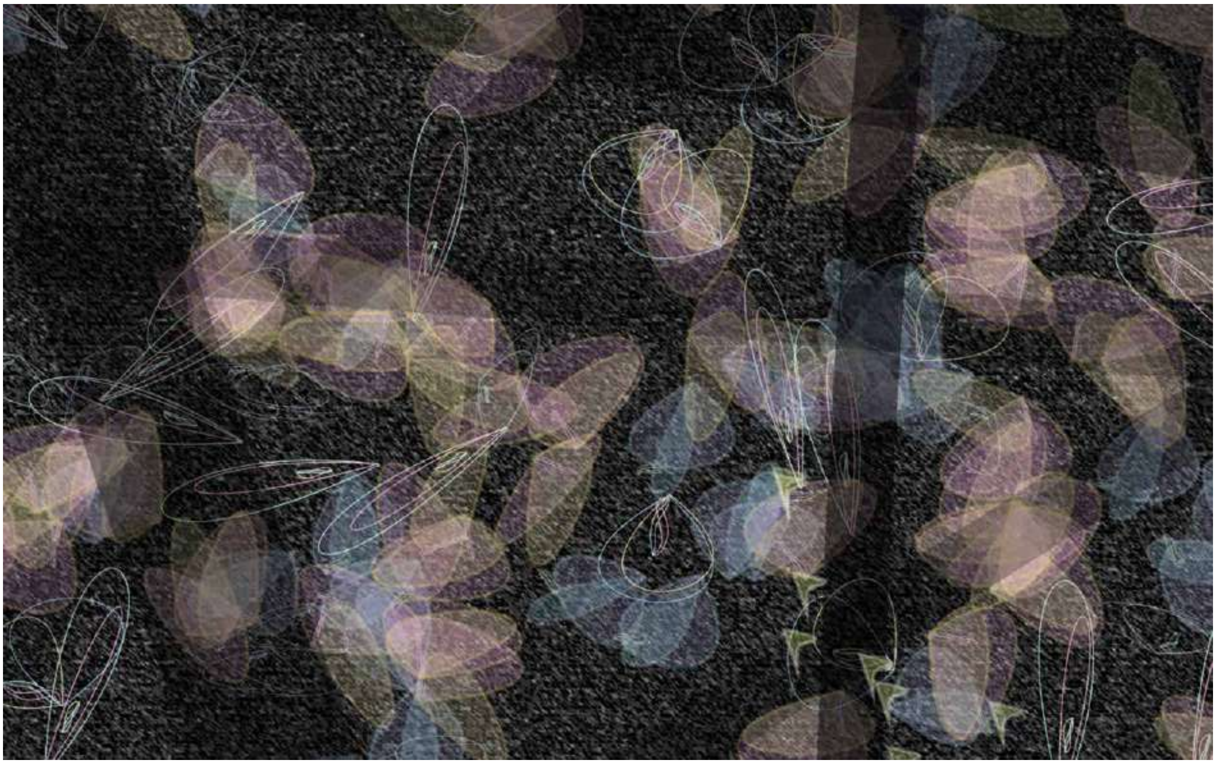

Figure 3:
999 years 13sqm (the future belongs to ghosts) installation by Rachel Armstrong and Cecile B. Evans for the "Is This Tomorrow?" group exhibition at the Whitechapel Gallery, London, demonstrates how bioelectricity generated by microbes can enliven a space conferring it with an "inner life" that is vital for an active urban immune infrastructure. Photograph courtesy Rolf Hughes, 2019.[iii]

7. MICROBIAL TECHNOLOGIES AS URBAN IMMUNE ACTORS

I have been working with biologically-agentised infrastructure such as "living" technologies (Bedau, 2009), for more than a decade which comprise a spectrum of agents that range from "protocells" (dynamic droplets formed by smart chemistries) to activated soils and the bioremediating actions of microbes (Armstrong, 2015; 2018; 2019a; 2019b; 2021; Hughes & Armstrong, 2020). Importantly, some "living" technologies like the MFC also produce bio-electricity. Not only are these apparatuses self-powering but through their electroactivity, generate "data." Positioned at the nexus of coupling together "smart" digital systems with organic approaches, these technologies provide a bio-digital interface that enables an organic Internet of Things (IoT) based on sensor data that understands and prepares for the growing risk posed to citizens by "harmful" city environments. Maintaining its relevance by incorporating emerging new data and areas of science into its framework the Immunological City, therefore, has important implications for environmental remediation, energy production, and resource circularity, establishing the innovation framework for next-generation development of "sustainable" and "smart" urban platforms through their seamless and timely integration in an organic IoT (Figure 3).

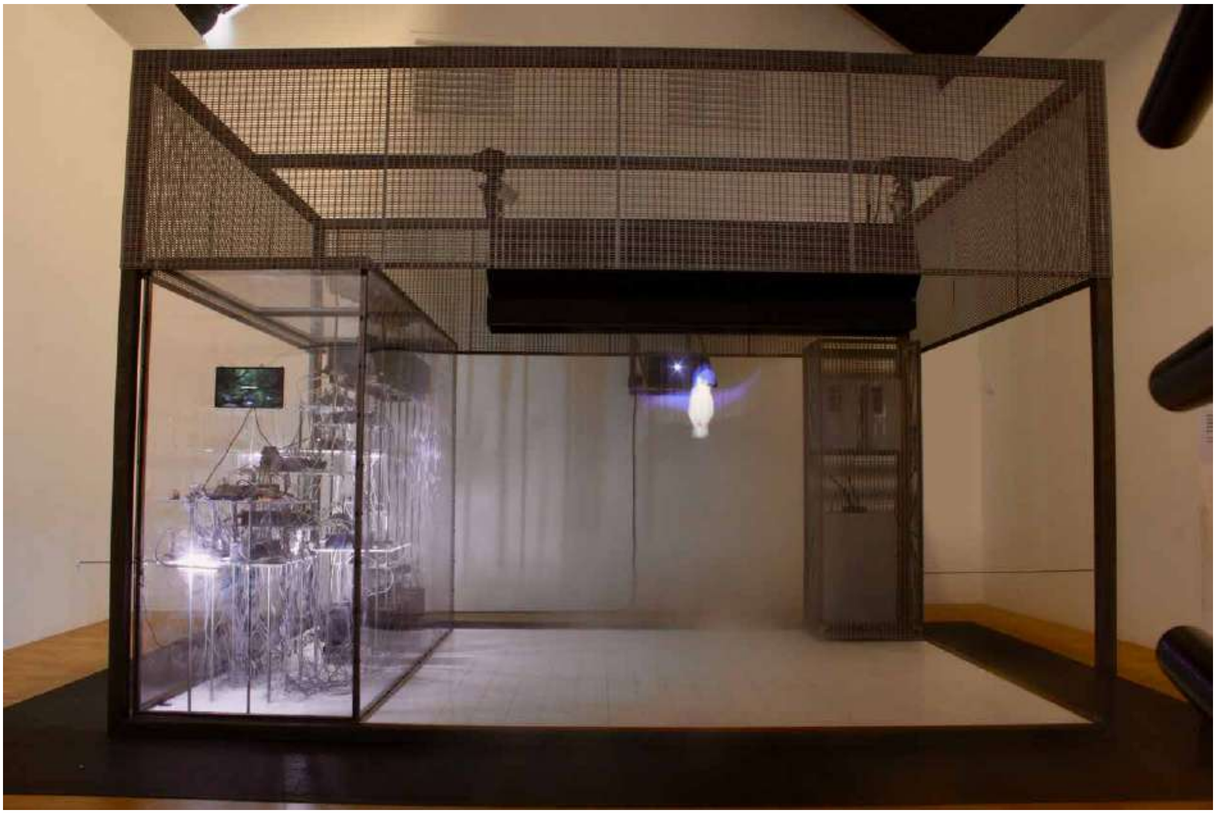

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IMAGE REFERENCES

[i] Living Architecture is Funded by the EU Horizon 2020 Future Emerging Technologies Open programme (2016-2019) Grant Agreement 686585 a consortium of 6 collaborating institutions—Newcastle University, University of Trento, University of the West of England, Spanish National Research Council, Explora Biotech and Liquifer Systems Group.

[ii] The Active Living Infrastructure: Controlled Environment (ALICE), is a collaboration between the University of Newcastle, University of the West of England, and Translating Nature. This EU funded Innovation Award and grant agreement 851246 prototypes the construction of a novel bio-digital interface using Microbial Fuel Cells and augmented reality experience for “living” bricks developed in the Living Architecture project.

[iii] 13sqm, 999 years (the future belongs to ghosts), installation by Cecile B. Evans and Rachel Armstrong at the Whitechapel Gallery at the group exhibition "Is this Tomorrow?", London (2019) was possible with contributions by: Bioengineering team: Ioannis Ieropoulos (lead; University of the West of England), Simone Ferracina (University of Edinburgh), Rolf Hughes (Newcastle University), Pierangelo Scravaglieri (Newcastle University), Jiseon You (University of the West of England), Arjuna Mendis (University of the West of England), Tom Hall (University of the West of England), Patrick Brinson (University of the West of England); Microbial Fuel Cell Bioreactor Brick Installation Design: Pierangelo Scravaglieri and Jiseon You, under the guidance of Ioannis Ieropoulos; Structure Designer: Dominik Arni; Structure Fabricator: Weber Industries; Contributing Writer: Amal Khalaf; Animator: Tom Kemp; Composer: Mati Gavriel; Research and production assistance: Anna Clifford; Installation team: Richard Hards, Hady Kamar; Sponsorship from Personal Improvement Ltd. and Living Architecture (EU Grant Agreement no. 686585). In-Kind support provided by Andrew Hesketh; Audioviz (UK FogScreen); the Bristol BioEnergy Centre at the Bristol Robotics Laboratory and their research into alternative, sustainable sources of power for the home and infrastructure.

FLOWERPOWDER

A new ecological corridor for pollinators

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ABSTRACT

The following paper discusses the development of a codesign strategy aiming to implement an ecological corridor, with a focus on insect pollinators, using abandoned crops as structural elements. The ecological corridor is designed as a performative pathway of ecosystemic stepping stones between habitats of species, connecting not only the corridor in itself, but also the surrounding areas due to the relevance of pollination.

To select an area that ensures ecological connectivity, a methodology is developed using the Circuitscape simulation tool that allows to measure and visualize this connectivity, based on electronic circuit theory. Simulating and then taking into account the transformation that can be achieved by restoring degraded landscapes, the methodology implements a data-driven approach to model favorable ecological connections. This methodology is tested in the area of El Vallès (Barcelona, Spain), surrounded by natural areas and suffering from the abandonment of agricultural practices, functioning as an experimental case study. With this new layer of information, advanced

computational analysis tools were used to select the areas with higher potential of ecological performance as a starting point for a transition process.

In parallel, potential stakeholders and possible interventions were identified to create a co-design strategy to support its implementation. Through different starter-kits based on different scales of economy, the agents involved are enabled to take an active role in a distributed implementation strategy. This process allows large scale ecological transition through distributed and small scale interventions, in a constant circular loop based on a new land use.

1. INTRODUCTION

The United Nations General Assembly has proclaimed the next decade as "The Decade for Ecosystem Restoration" in order to prevent, arrest and reverse the degradation of ecosystems worldwide, and help in the healing process of nature (UNGA, 2019) . These actions include landscape restoration, with the goal of reducing human control to allow ecological and evolutionary processes to reassert themselves through the introduction of keystone species. The focus of this study are pollinator species, specifically insects, due to the crucial ecosystem service they provide (Vanbergen, 2013). Indeed, multispecies pollination is solely responsible for the provision of reproductive faculties of many crops, as well as the majority of wild plants. As a result, pollinators play a key role in the proliferation of flowering plants and plant-based food supplies, necessary for our survival (Klein et al. 2006).

Over the last few decades, several natural pollinator habitats have disappeared with intensive agricultural practices and urbanization being two of the main reasons for this loss. The massive growth of intensive cropping practices since the "Green Revolution'' has created major changes in terrestrial land use. More specifically, pollution, pesticides, and different anthropogenic land use, among others (Vanbergen, 2013), are the main risks related to the loss of habitat and biodiversity regarding insects. As a result, natural habitats for these wild species have been degraded, and fragmented. This fragmentation has created loss or dissociation of important resources for the provision of food and spaces for nesting of pollinators (Klein et al. 2006), consequently leading to their decline in agricultural lands, and the reduction of their habitats to disconnected patches without sufficient resources necessary for their survival.

Ecological connectivity has been widely recognised as a key factor to reverse habitat fragmentation, imperative to preserving biodiversity and ecosystem functions (Hilty et al. 2017). Recent papers published on the Circuit Theory (McRae et al. 2008) introduced ecologists to a set of new perspectives oriented to evaluating multipath routes for gene flows among habitat patches. This approach offers the possibility of analysing diverse possibilities of ecological connectivity between the habitat patches without establishing only one optimal route. This process has already been used in ecological studies (Peng et al. 2018), but also in studies with regards to pollinator travel paths (Lander et al. 2013). After the contribution of Circuit Theory to ecological connectivity, the Circuitscape open-source program was developed to create an accessible tool for different disciplines, to measure and visualize the performance of ecological connectivity. In this sense, Dickson et al. state that "in the future, outputs from Circuitscape will see more frequent use as hypotheses to strategically inform the design of habitat use studies" (2018). Taking this into account, this paper explores a possible methodology to create a draft modeling of landscape connectivity for insect pollinators based on the application of Circuitscape. Using degraded landscapes as an opportunity for natural restoration, potential ecological performance can be measured and high performative areas can be identified as key starting, and connector points to mend the fragmented territorial condition and create natural corridors through distributed design.

According to the Landscape Observatory of Barcelona, there are three areas of main interest for landscape restoration (Observatori del Paisatge, 2014). One of these is the Agroforestal area of the El Vallès, where the number of abandoned crops has increased, particularly during recent years. This area is a divided territory, where urbanization is intersected with large cultivations and industrial districts, surrounded by protected natural highlands. These in-between spaces have for years been considered an opportunity for ecological connection by different public stakeholders. Abandoned crops have a high potential to reverse habitat loss and fragmentation, providing fertile ground to implement pollination corridors. By using non-productive vacant lands, such as abandoned crops, stepping stones to reinforce biodiversity and ecological connectivity between core habitat areas can be created (Saura et al. 2014). The potential to cross-read this with the connectivity analysis of Circuitscape can further enhance the implementation process by creating diverse scenarios in identifying the most performative ecological connections. Furthermore, the lack of activity in these abandoned areas is an opportunity to restore not only the ecology, but also enhance productivity and promote new localised and circular economies. This integrated approach creates a new circuit where anthropogenic and natural ecosystems can work together, in symbiosis (Korman et al., 2016).

2. METHODOLOGY

With the support of ecological connectivity simulations, big data analytics, and advanced computational tools, a methodology is defined to implement a data-driven design approach capable of managing complex living systems. Through the engagement of local stakeholders, which can be adapted according to each specific fragment of the territory, the approach allows to activate circular economy processes applied to design, retrofitting the fragments with new land uses, oriented to restoring pollinator habitats. The methodology is structured in the following main blocks: Data gathering, Data Simulation, Data Analysis, and Co-design Strategy identification.

2.1 DATA GATHERING

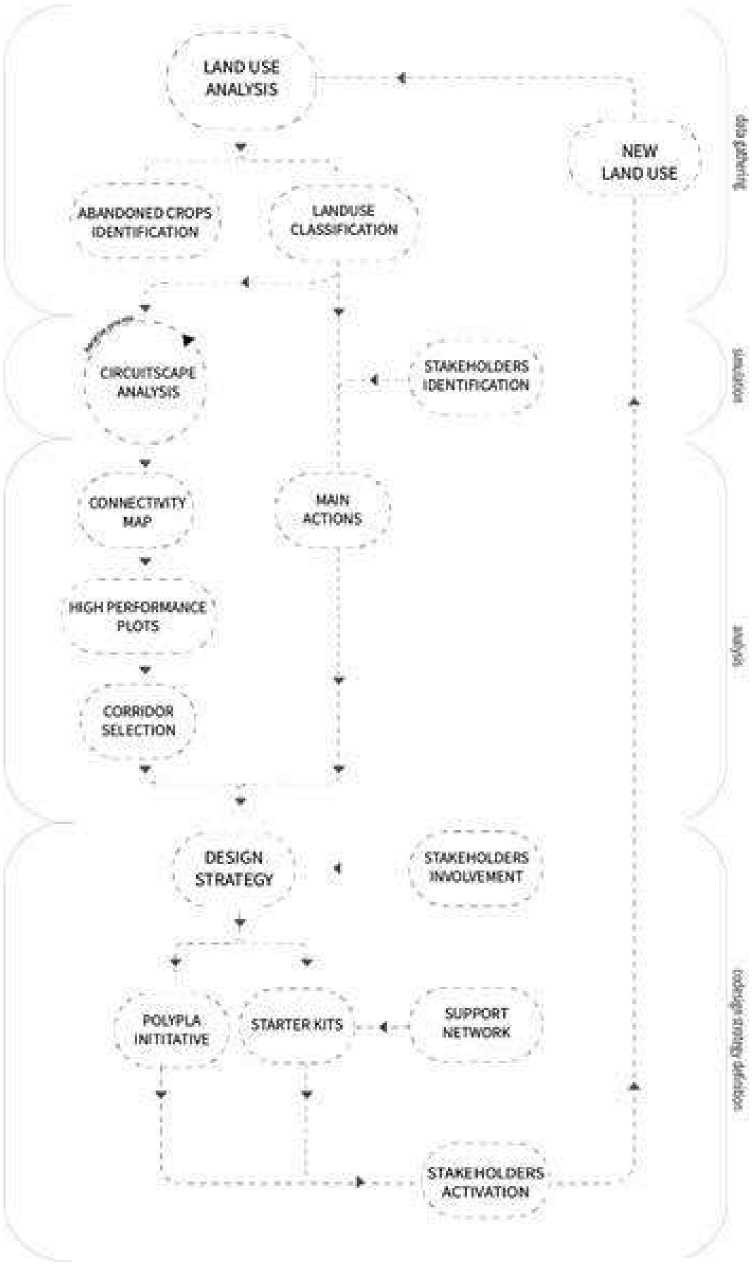


Figure 1:
Methodology diagram.

The entire process is initiated with the collection of land use data in order to generate a comprehensive land use map of the El Vallès area. The land use categorization includes natural, agricultural, infrastructural and urban use areas. This data was cross-read with the available open data (agricultura.gencat.cat) on historic crop production. The main focus of this process is to identify all the abandoned crops, their surface area, and location with respect to the surrounding land uses, allowing to identify pertinent stakeholders.

2.2 DIGITAL SIMULATIONS

Once the data gathering process is concluded, an analysis of landscape connectivity is run using the abandoned crops as ecological structural elements. To run the simulation and identify the ecological performance of the area, the collected data-layers are cross-read as raster cells with different values depending on their land use categorization. These values are later converted into degrees of ecological resistance in Circuitscape, where the lowest resistance is determined for natural areas and the highest one for urban and industrial areas. These simulations play a key role for the consequent design process, as they allow the forecasting of different scenarios for the abandoned crops, through the modification of their resistance value, and consequently, their potential ecological performance. In this sense, Circuitscape is used for both the analysis and validation of the proposed interventions. Through this process, the areas with a higher potential connectivity are identified and selected for design in order to foster new connections between the focal habitat patches, located in the current natural areas around the site. This process generated a large number of corridors with different lengths and intensities through the area of study, resulting in two comparative maps showing the current and potential ecological connectivity. Orange areas on the right image indicate the abandoned crops that were modified in terms of resistance in order to create stepping stones (Figure 3).

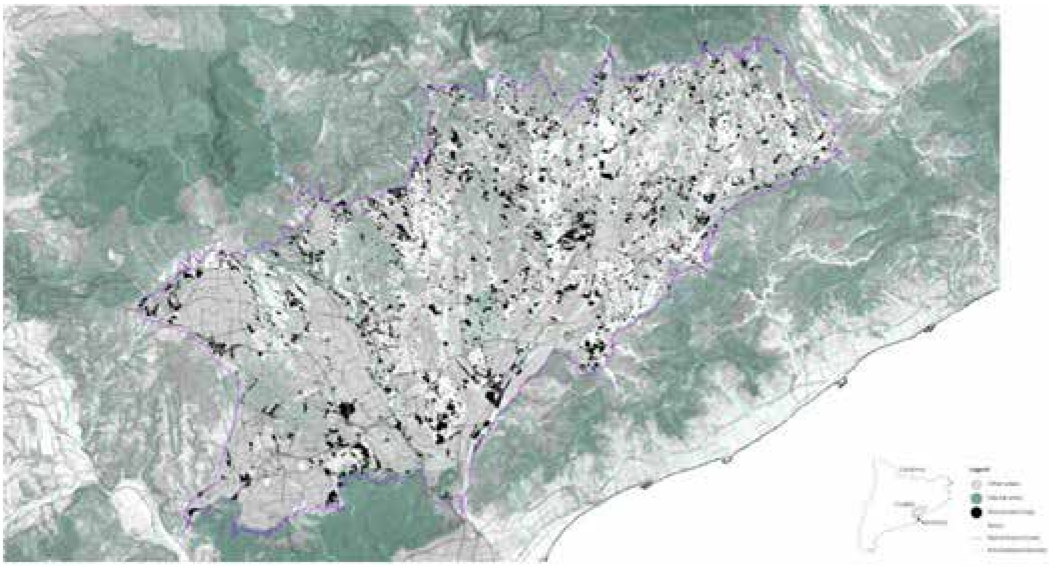
2.3 DATA ANALYSIS

Figure 2:
(top of next page)
Abandoned Crops in El Vallès.

Figure 3:
(center of next page)
Circuitscape Simulation without and with abandoned crops.

The data analysis was based on two parallel processes providing the necessary insights to define a transition strategy: the first one analyzes the simulation output with the aim of identifying the crops with higher performance in terms of connectivity, the second focuses on the identification of stakeholders that can be involved in the co-design and actuation processes.

Regarding the output of the simulation, advanced computational analysis tools such as GIS and Grasshopper3D were used for the preparation of a geospatial scatter graph that measured the intensity of potential connectivity. This connectivity map shows what are the potential stepping stones of the corridor that connect abandoned crops with the rest of the uses with a resistance level that allows the



flow of pollinators. Based on these connections and their intensity, the best 8 abandoned crops for the creation of an ecological corridor were selected, capable of connecting and restoring different habitats.

The second part of the analysis was oriented to identifying the stakeholders, where their location also determines their involvement in the codesign strategy. The main stakeholder categories defined were the following: municipalities, farmers, schools, citizens, and industries. At the same time, potential typologies of activities are identified, focussing on enhancing the pollination within the ecological corridor. These were clustered in four main blocks, as follows:

- Adequation of the environment: elimination of the adverse effect such as management of invasive species or chemical pesticides reduction.
- Plantation: selection of wild autochthonous vegetation species that are suitable for the corridor and pollination, divided into three types (trees, high bushes, and wildflowers).
- Nesting: creation of nests for pollinators that go from more artificial ones (like insect hotels) to more natural ones (cleaning areas for bare soils in sunny spots)
- Beekeeping: establishment of new productive areas for honey production.

2.4 CODESIGN STRATEGY DEFINITION

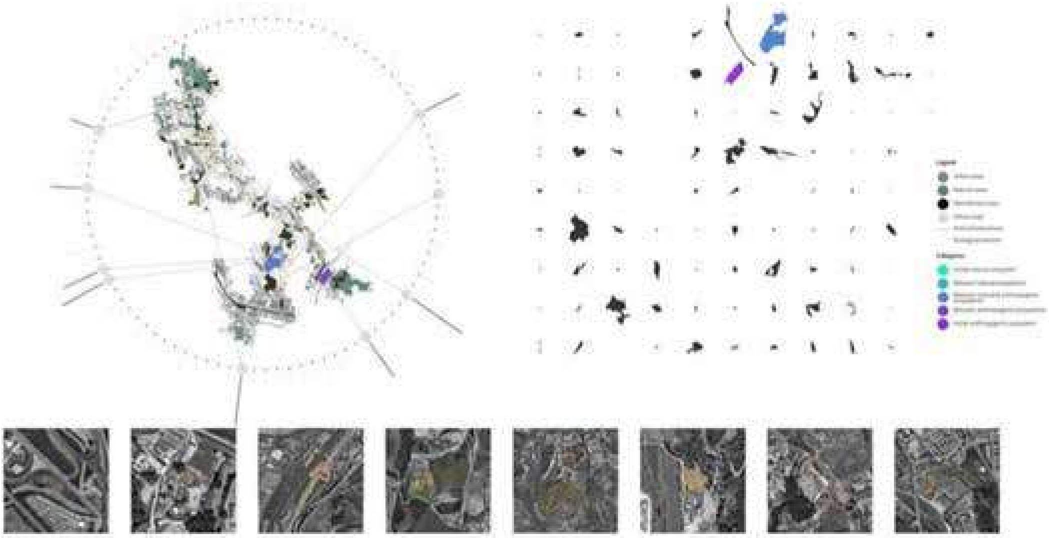


Figure 4:
Abandoned crops with higher ecological performance.

Figure 5:
Catalogue for abandoned crops.

The final stage of the methodology consisted of a catalogue of co-design interventions that weave specific land uses to selected stakeholders, within the abandoned crops with the highest performance potential.

- Natural areas: The type of forestry in el Vallès is characterized by a large number of invasive species and non-pollination trees and bushes that don't promote pollination in our territory.

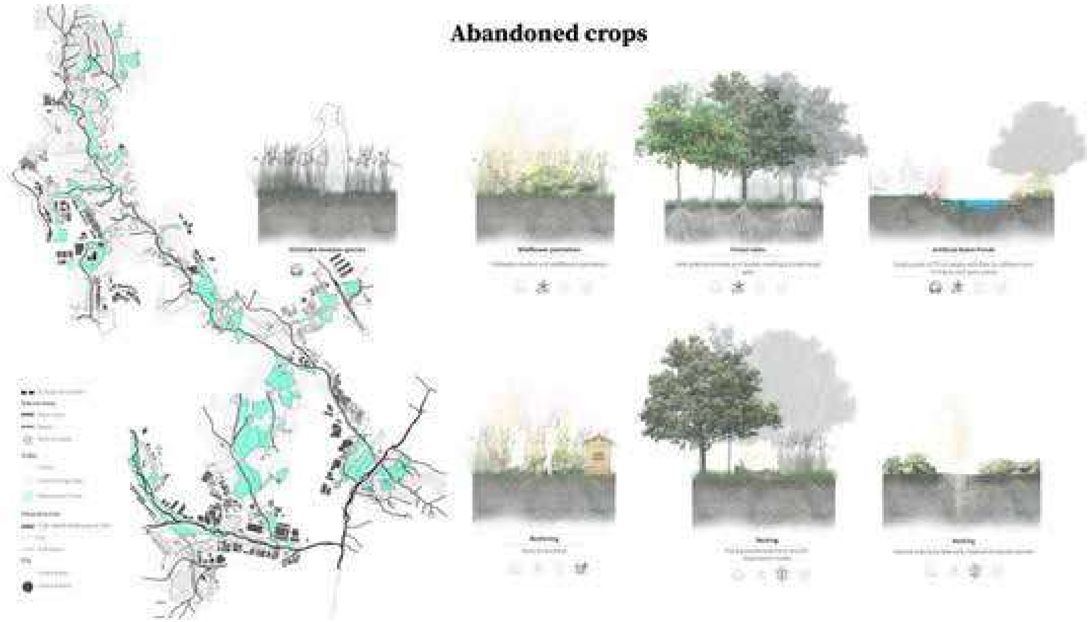
- Functioning crops: in order to stop the spread of chemical pesticides and herbicides and create more biodiverse friendly agriculture, the main actions involved promoting pollination on the edges of crops and creating pollination patches inside them.

- Infrastructure: Borders of infrastructure (such as roads or railways) are an opportunity to create a territorial pollination connectivity infrastructure in their edges.

- Urban areas: Self-sufficient parks with low maintenance need to be promoted by accepting natural wilderness into them. Buildings also can introduce the vertical plane (with facades) and a new elevated horizontal layer (the rooftops). Citizens can be enhanced to add small patches in balconies such as flower pots.

- Abandoned crops: These degraded areas are the ones that ensure ecological connectivity. The areas should have the implementation of the 4 kinds of actions, including the beekeeping activity due to its condition of unproductiveness as a new way of giving economic value to the ecosystem service.

In order to apply the catalogue of interventions, the involved



stakeholders are required to be active and activate the implementation and maintenance of the ecological corridor. To achieve this activation, diverse pollination starter kits were designed, each targeting specific stakeholders and counting on the help of a support network. This allows to also promote the initiative between different communities as well as enhancing the design through participation. The network was proposed based on different already existing stakeholders in El Vallès, and the surrounding areas, and its main purpose was to ensure the call for action through the starter kits. These were categorized to achieve different purposes: diffusion and engagement, knowledge and support and research. The strategy also proposes a municipal initiative with a specific starter kit for nonprofit organizations and associations, also proposing temporary uses for abandoned crops that further ensure the ecological restoration of these structural elements.

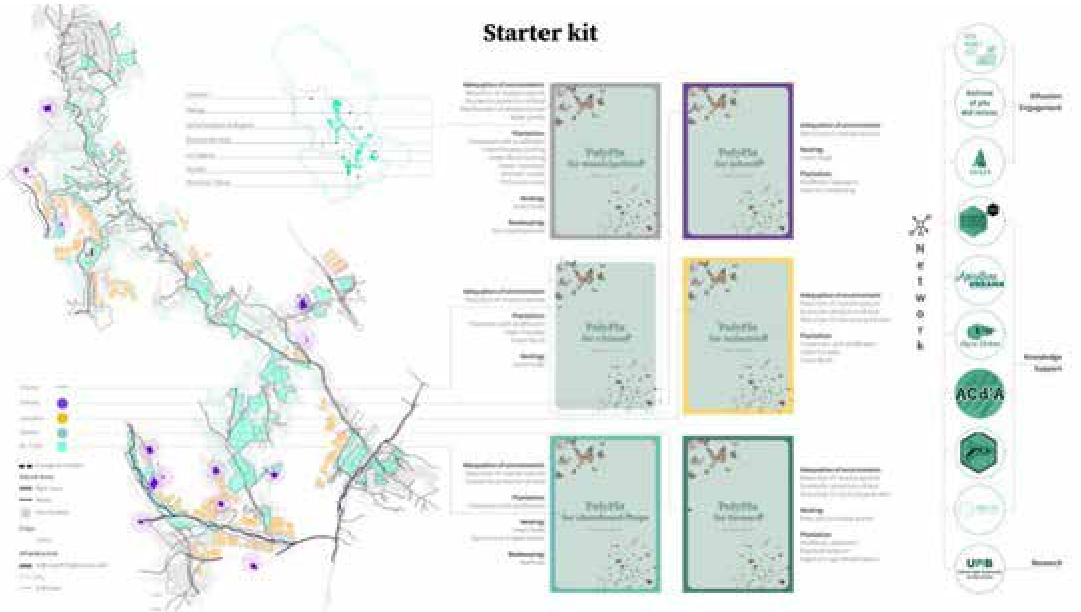


Figure 6:
Stakeholder map for activation through starter kits and Pollination Network.

Figure 7:
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School Starter Kit.

Figure 8:
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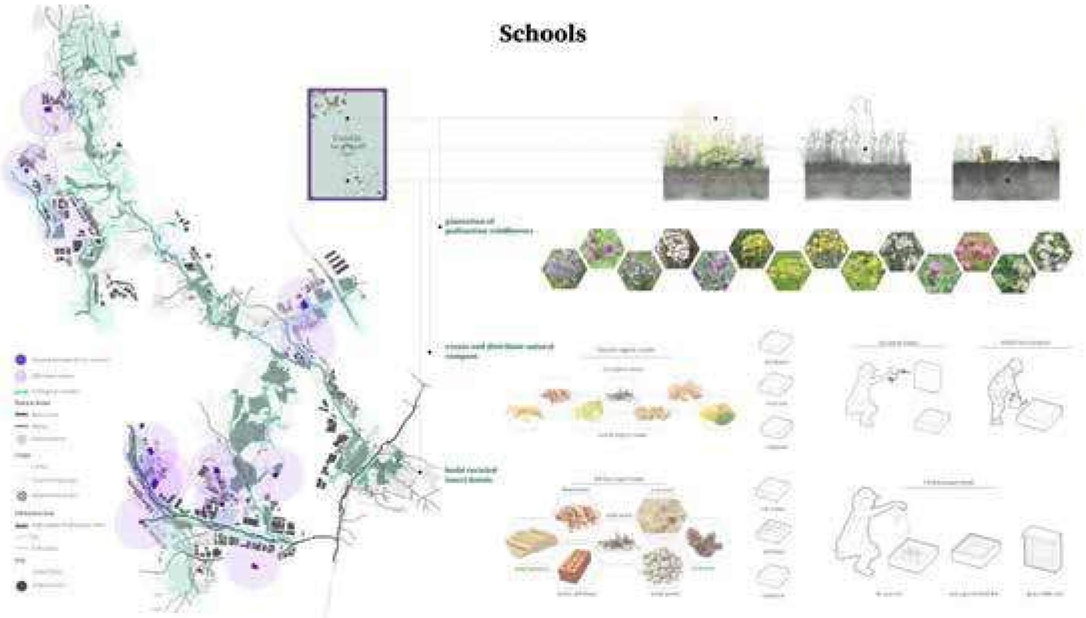
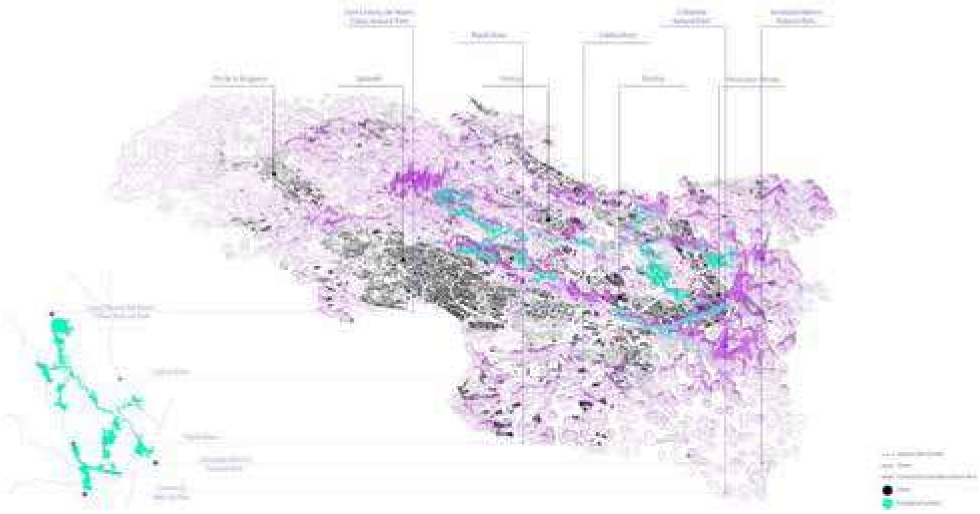
3D heatmap with the corridor maximum performance.

To conclude the methodology, a case study selecting schools as stakeholders is implemented. Schools that are at a maximum of 500 meters distance to the nearest abandoned crop were identified, proposing actions that children can do with the support of their teachers, such as: creating their own insect hotel and composter, filling it with the waste of the canteen, and learning the plant species suitable for pollinators. Additionally, by proposing a tour activity, the students could distribute these elements along the route, which includes different land uses, abandoned crops being one of these.

Once the implementation phase has been activated within the first



strategic areas, the corridor begins to change its performance and land use, as well as positively impacting the surrounding area. A new cycle can then start with the new land uses as an input, in turn suggesting new transformations and developments. The co-design strategy can also be revised and adapted to improve its success rate. Thanks to this feedback process, the maximum performance and continuity of the corridor can be achieved.



4. FINDINGS/CONCLUSIONS

The tool discussed in the paper allows to select degraded landscape plots with high ecological potential, as structural elements for ecological transition (in the case study, abandoned crops). The transition is activated, based on different scales of economy, and supported through the use of tailored starter kits for stakeholders and initiatives. This approach allows a high level of flexibility enabling the implementation of diverse scales of intervention, with different time periods of actuation, implemented by both individual and collective actions as well as institutionalized or private interventions. The corridor becomes a flexible platform for the establishment of a variety of non-exclusive solutions where the cooperation among stakeholders is valued and supported.

One of the main limitations for the implementation of environmental plans is the large scale of change that is based on. Moreover, the involvement of a wide range of stakeholders can also generate further lag or complexity. It is important to understand the approach discussed as a process instead of a final and fixed output. Rather than a closed design system, it enables users to take action within an open ecosystemic platform. It establishes a hierarchy of importance to identify key starting points that allow transition, where location and actions can be chosen according to the desired ecological performance in achieving larger impact through distributed strategies. Finally, a feed-back loop process is established where new land use systems can be continuously retrofitted.

Critical points within the methodology can be the lack of involvement of selected stakeholders, meaning the activation of plots in a lower hierarchy of performance, consequently affecting the potential global impact of the strategy. It is therefore important to ensure in this feedback loop in order to redefine the codesign strategies, if needed, through the evaluation of the results of earlier iterations of the methodology.

The result is a distributed co-design strategy to enhance the performance of pollinator habitats within the broader scope of ecological connectivity, where managing their transition is of primary importance. It merges natural and anthropogenic ecosystems by proposing a new perspective: humans are not only receivers of a certain amount of ecosystem services, but they also play an active role in protecting and preserving the natural environment, beyond the direct benefits they can obtain. It proposes an approach that is not human-centered but life-centered, where anthropogenic and non-anthropogenic habitats are no longer isolated thanks to the cohabitation, support, and feedback between wilderness and humans.

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FARMSCAPES

Macro-level approach for urban farming

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KEYWORDS
Food production, Urban farming, Rooftop, Urban data, Machine learning

ABSTRACT
By 2050, 68% of the world population will be living in cities. In order to best accommodate this rapid urbanization growth while making cities more sustainable, designers must find creative solutions for the big challenges that are going to arise from this reality. Food production, as highlighted in the SDG by the UN, is one of the most pressing challenges that we need to address within the next 10 years. This study focused on the hidden potential that traditional and informal roof surfaces can have for urban farming in a third-world environment to help alleviate the food production crisis, as well as to create micro economy opportunities for the low-income communities.

The approach of this study spans across three different scales: macro, meso, and micro. This methodology helped us discover the potential applications at a city level, connected with meso realities of each area, and finally implemented and tested at a micro-level on a real-case rooftop of Kampala, Uganda. This research explores the use of existing GIS and open databases to register and map the quantity and quality of the existing rooftops and couple this with the latest computer vision technology to alleviate the man-powered need it to complete these datasets.

1. INTRODUCTION

The world around us is rapidly changing, affected by multiple factors like climate, politics, technology, and demographics. These factors are not just introducing new dynamics to which we need to adapt but also creating new sets of challenges and problems we need to face. Governments, policymakers, regulatory bodies, etc, have mostly, for the past decades, turn a blind eye to these matters in regards to more pressing short-term issues.

Thanks to a series of recent developments like the Sustainable Development Goals (Fig.1), driven by the United Nations, these major global issues have been addressed, explored, and communicated at an international level. This has led the global community to start openly discussing the current and future challenges and put together a comprehensive agenda that serves as a guiding manual to navigate them.

Since then, we as designers, have had the opportunity to focus our efforts on new and alternative ideas that can help us get closer to these goals. Because of this, we have decided to use this thesis to research and explore the possibilities within the architectural and urban design field to alleviate some of these pressures.

Figure 1:
SDG diagram - United Nations.

2. PROBLEMATIC

We narrow the research to the intersection of three major components: Architecture, food production, and increased population.

Beyond the obvious challenges, cities need to be able to find a new way to produce, distribute, commercialize and process up to 10 times more the amount of food. This also needs to be done sustainably, without compromising food quality, diversity, and most importantly, carbon footprint. Cities will have to face major issues like the lack of available land for food production where most than 80% of the city area is occupied by buildings; the need for quality infrastructure to support centralized growth as 70% of global water consumption is used for farming; the need for a well-connected distribution network to get the fresh product to different regions as on average vegetables travel approximately 2,400km from farm to the consumer; and finally, a circular way to deal with wastage, as 33% of the world's food goes to waste every year (Rajkumar, Paulrajan, 2010).

3. OBJECTIVES

Based on these challenges, we want to research and explore, from an urban and architectural scale, different approaches to achieve the following:

- Explore, from a macro level, the potential of a city to produce all the vegetables it produces based on its population growth.

- Understand how can we make use of existing elements like roofs surfaces, residual areas or abandon spaces to re-activate by giving them a new function

- Understand how more advanced farming techniques, like hydroponics and aeroponics, help us to incorporate farming into the cities.

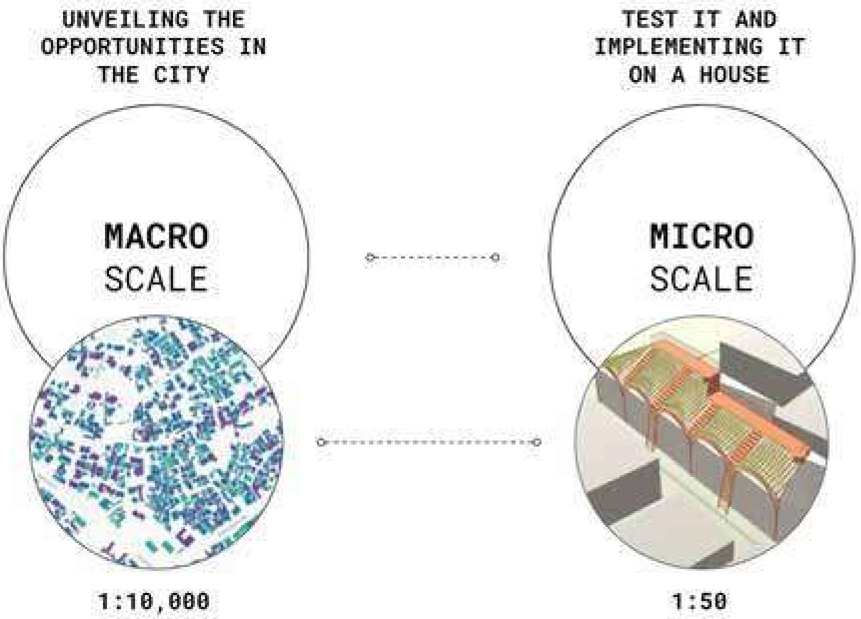
- Prototype new systems that can be retrofit into existing buildings within the city to enable rooftop farming

4. PROJECT METHODOLOGY

Based on the objectives specified above, we decided to phase our project onto a two-stage approach that goes from a macro to a micro implementation (Fig 2). This approach allowed us to explore and understand the global possibilities, opportunities, and constraints of an urban area and then jump onto the microscale where we can prototype real-case solutions that can fit the built environment.

Figure 2:
(top)
Research methodology between the Macro and Micro scale.

Figure 3:
(bottom)
Selected area for the research: Gabba - Kampala City - Uganda.



AREA OF STUDY:

We choose the neighborhood of Gabba, located on the southeast side of the city of Kampala, Uganda (Fig 3). Despite its growing economy, it is one of the poorest countries in the world. In 2012, 37.8 percent of the population lived on less than $1.25 a day and in 2009 24.5 percent of the population lived in poverty. Farming is one of the most common sources of income for most Ugandans and as far as 90 percent of all rural women work in the agricultural sector (Sabiiti et al., 2014).

In addition to agricultural work, rural women are responsible for the caretaking of their families. The average Ugandan woman spends 9 hours a day on domestic tasks, such as preparing food and clothing, fetching water and firewood, and caring for the elderly, the sick as well as orphans. This city is already having a crisis in food production and lacking empty farming spaces on the ground level, and this is what makes it a perfect candidate to test and explore our theory.

Figure 4:
Selected area for the research: Gabba - Kampala City - Uganda.

5. MACRO SCALE

The macroscale was focused on creating a live database of all the existing structures and buildings within the study area. This database was created by merging multiple existing sources onto a unique set that managed to capture position, area, levels, roof condition, structural condition, roof type, population, and the roof slope. Once we have identified the characteristics and unique conditions of each building within the study area, we then proceed with the next scale.

5.1 WORKFLOW

Once we established the overall approach, we mapped and developed the data workflow (Fig 4). The first step was to start gathering all available data related to the site and its context. We make use of three different sources: Building shapes and positions extracted from OpenStreetMap website service, roof conditions and materiality from Open Cities Africa, and population factors extracted from the Uganda Open Map service. Once the data was collected, we used both QGIS and Grasshopper to consolidate and map the ids of each source onto a combined database. This allowed us to have a centralized data source that can be queried for multiple purposes.

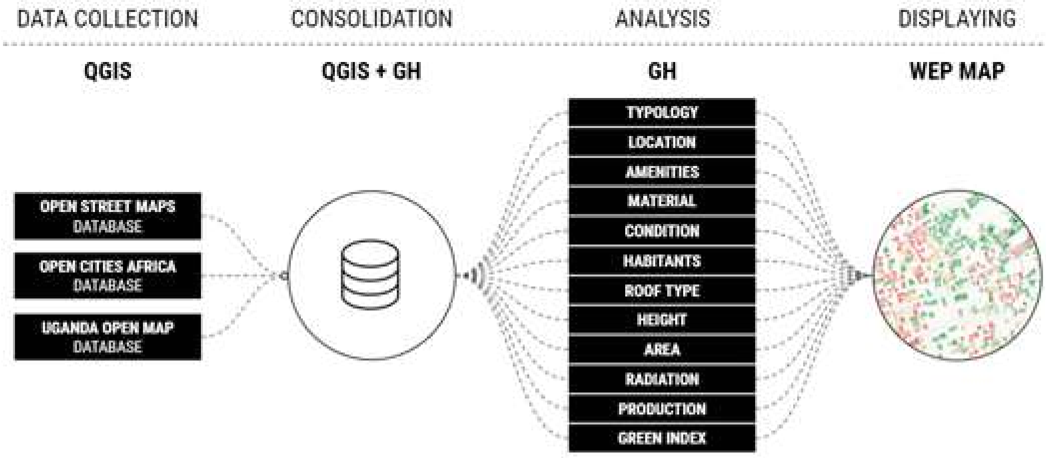


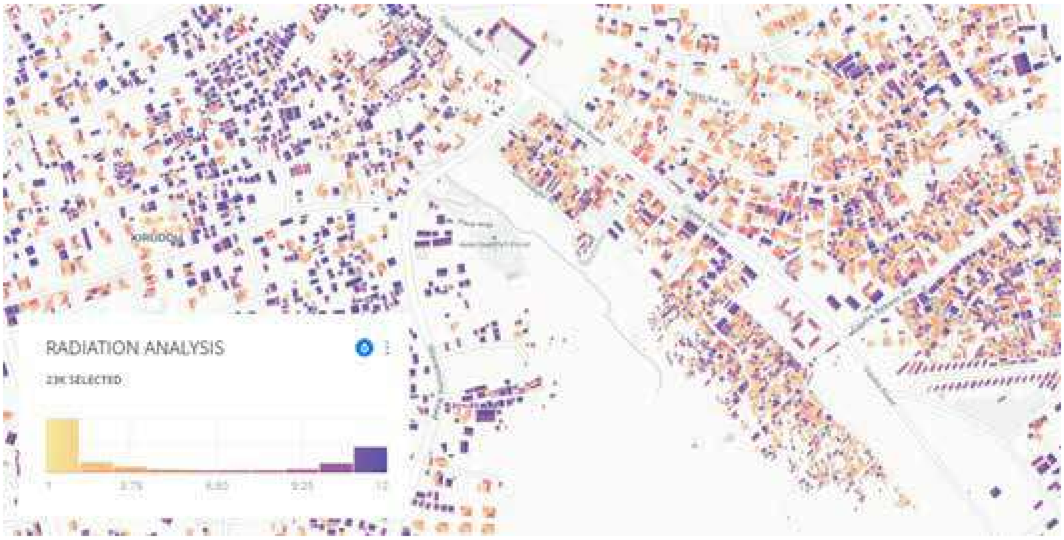
Figure 5:
(top of next page)
Radiation analysis of all roof surfaces.

Figure 6:
(center of next page)
Typology analysis of existing buildings.

Figure 7:
(bottom of next page)
Analysis of existing building conditions.

5.2 ANALYSIS

We used Grasshopper to analyze and process all the different fields available to us and to create a series of environmental and structural analyses, such as wind, radiation (Fig 5), materiality, typology (Fig 6), and condition (Fig 7). This allows us to understand the current conditions and characteristics of each roof panel across the entire area of study.


RADIATION ANALYSIS
23K SELECTED


BUILDING TYPOLOGY
21 CATEGORIES
RESIDENTIAL
KIOSK
COMMERCIAL
COMMERCIAL/RESIDENTIAL
TOILETS
OTHER
Auto Spot Fish Pond


ROOF CONDITION
40,729 ROOFS PANELS
ROOF CONDITION
AVERAGE
POOR
GOOD

5.3 GREEN PRODUCTION CAPACITY

Once we have understood the existing conditions of the area, we then proceed to calculate the GPC index. This is an index calculated based on the following parameters:

- Location: Proximity to the center of the neighborhood
- Amenities: Amount of amenities within a 100 mts radius
- Roof Materiality: Type of roofs
- Roof condition: Current condition of the roof structure
- Roof Type: Flat - Skillon - Gabled - Hipped
- Area: Size of the usable roof for farming

All the existing roof panels within the study area were scored based on these parameters from a 1 to 5 scale. As a result, we had 40,729 roof surfaces scored across 6 different categories.

5.4 K-MEANS CLUSTERING

To group all the existing roof surfaces based on 6 different categories, we used an unsupervised machine learning algorithm called K-Means clustering. This allowed us to cluster them based on the following criteria:

1. Not Possible: All roof surfaces that are not suitable for roof farming due to their materiality, poor condition, small area, etc.
2. Not Optimal: All roof surfaces that, with intervention, can be used in the future for farming.
3. Suitable: Surfaces with suitable existing conditions but with low performance.
4. Good: Surfaces with good conditions and average performance.
5. Best: Roof surfaces that have the best qualities for an efficient urban farming system.

The k-means clustering was run in a python environment in visual studio and connected with Grasshopper using Hops. All the final values were packaged and presented onto a web-based map application (Fig 8) using Mapbox and Carto systems where the user can navigate through all the available roofs and check their suitability for urban farming.

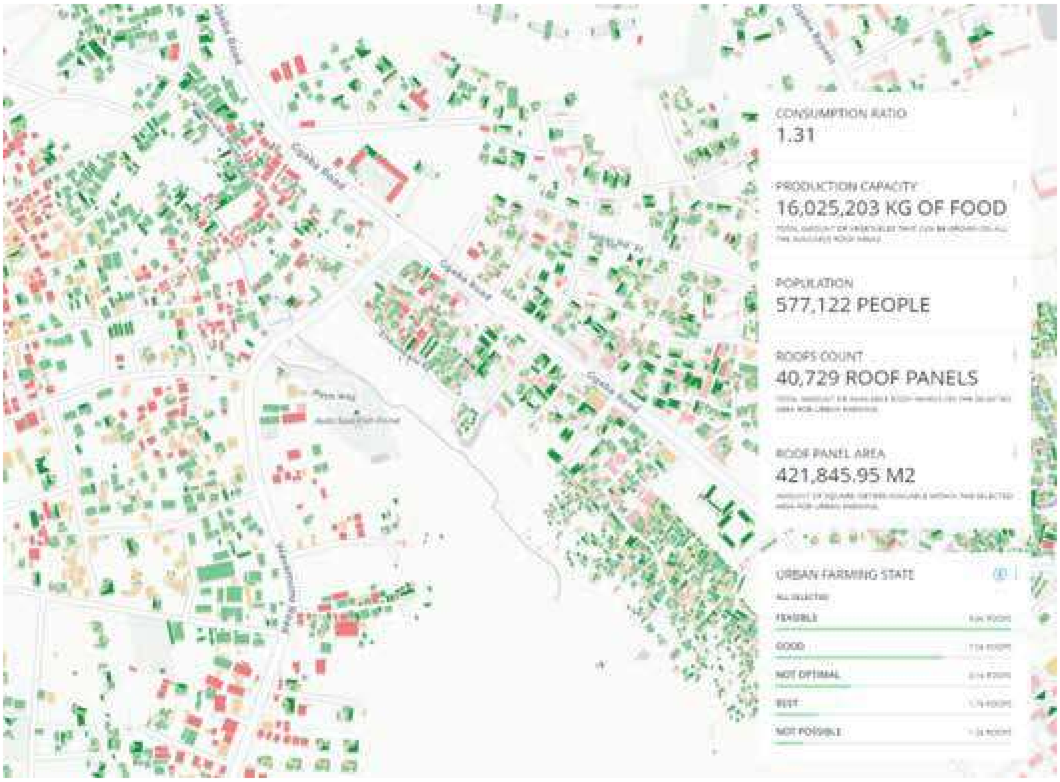


Figure 8:
Selected area for the Web map showing the Green Production Capacity index for each roof in the area of study.

Table 1:
A comparison between traditional farming, greenhouse, and urban farming systems and their requirements, advantages, and disadvantages.

6. FARMING SYSTEMS

Farmers in Uganda, as well as across the world started to use the advantages of hydroponics. This is the technique of growing plants without soil, where the roots receive a balanced nutrient solution that contains water and all the nutrients essential to the development of the plant (Rajkumar and Paulrajan, 2010). This system has many benefits, such as producing high-quality plants, occupying less space, and consuming fewer resources (Table 1).

	TRADITIONAL	GREEN HOUSE	URBAN FARMING
Growth process	70 days	40-45 Days	21 Days
No. of crops/m2	18	25	25-300
Crop cycles	seasonal	Seasonal	365 Days
Water usage	35 L	15 L	1.5 L
Pesticides	Often	Less often	Never
Location	Open Field	Open Field	Everywhere
harvest handling	High	Medium	Low

Figure 9:
Diagram showing the different requirements needed for rooftop farming.

6.1 ROOFTOP FARMING

Urban rooftop farming is the development of farming activities on the top of buildings by taking advantage of the available spaces on roofs or terraces and it is part of the building-based urban agriculture that has recently occupied built infrastructures (Sanyé, Mengual, and Esther, 2015). Farmers in Uganda started to use their rooftops, towards a vertical resilient farming approach, whether for their daily use or commercial farming (Fig 9).

6.2 HYDROPONIC CROPS

The most commonly grown crops in Kampala city are banana (cooking, beer, and sweet types), cassava, maize, beans, vegetables (leafy greens, cabbage, tomatoes, onions, bitter Tomatoes, etc.), spices, potato, cocoyam, mushrooms and fruit (jackfruit, avocado, pawpaw, mango, etc.). The studies show an approximate plant density of 24 plants per square meter where the mass of edible lettuce per plant was averaged from two sources to get an average mass of 144.6 grams per plant. Using the estimates for plant density, the number of harvests and plant mass, the average yield of hydroponic lettuce per year was calculated in units of kg/m2/y. This equation calculates the production of the annual crop per roof area (Rajkumar and Paulrajan, 2010).

7. MICRO SCALE

On this scale, we evaluate the different rooftop surfaces within one building to choose the best fit surface based on the orientation, area, slope, and sunlight access. Our proposal explores the concept of building a lightweight structural system made of natural local materials where load forces directions could be optimized by the structure shapeshifting techniques and by utilizing active bending properties of natural local materials such as bamboo. A parametric model is designed for such an adaptive structure to be able to fit the complex geometries of the different rooftop surfaces.

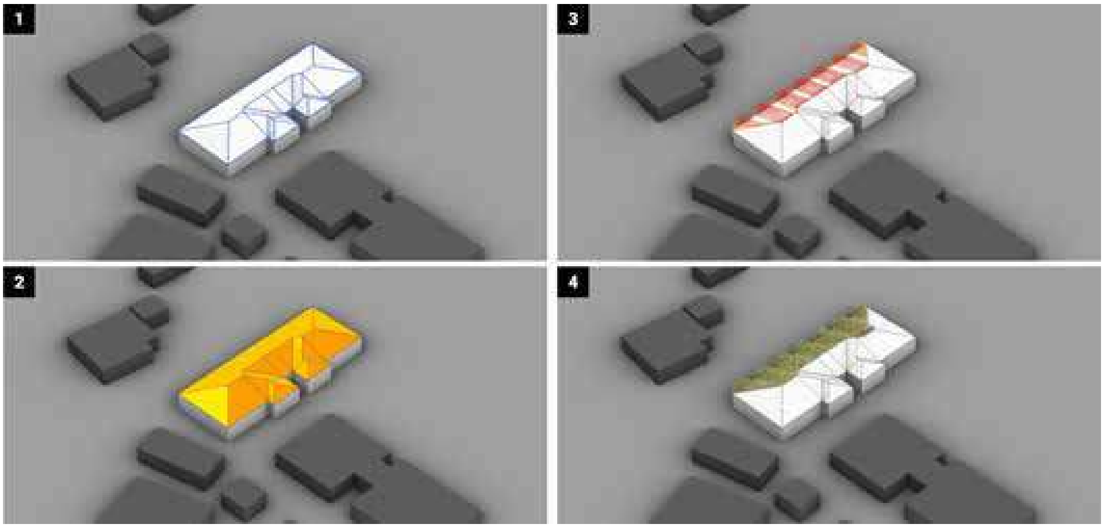


Figure 10:
Environmental, structural, and farming ergonomics analysis.

7.1 DESIGN WORKFLOW

As shown in (Fig 10) the microscale design workflow is divided into the following phases:

1. Importing the polygon of a building from open street maps into Grasshopper3d using SHAPE files.
2. Analyzing the structural system of the rooftop geometry to evaluate the loads' flow to the ground level using the Karamba3d Grasshopper plugin.
3. Analyzing the sunlight hours of the rooftop to evaluate the sun access within the surroundings.
4. Applying farming ergonomics based on the needed movement between farming lines, and the required slope to accommodate the water flow within the structure using gravity forces.
5. Optimizing the farming system geometry to enhance the structural performance and the water flow cycle within the sloped water tubes.
6. Deploying the parametric model on the web using Rhino Compute and THREE JS to allow public users to access and evaluate different housing prototypes rooftops.

Figure 11:
(top)
A diagram shows the rooftop farming system metrics.

Figure 12:
(bottom)
Different attempts of importing buildings from open street maps and applying the script of the parametric rooftop farming prototype.

7.2 OSM TO GRASSHOPPER3D WORKFLOW

Each building was given an ID and imported to Grasshopper3D using shapefiles. A recursive system was developed to parse one building each loop and analyze its rooftop. The purpose of this process is to create our rooftop farming system metrics extracted from OSM buildings (Fig 11). At each step, we were able to extract roof area, max number of crops, annual food production, and structural features.

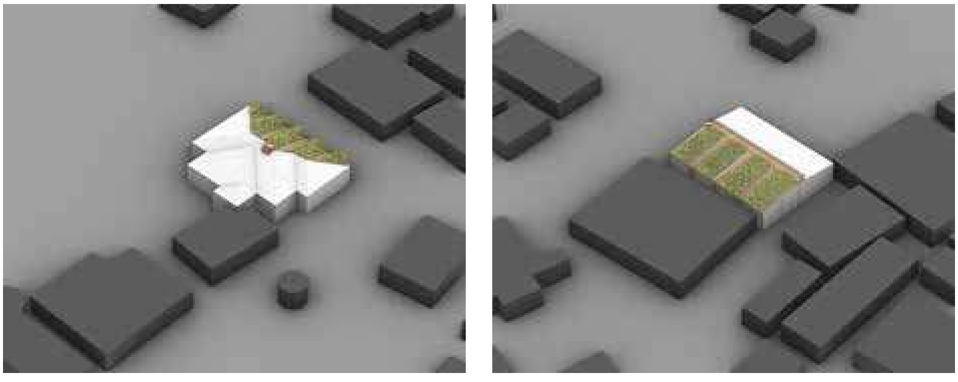
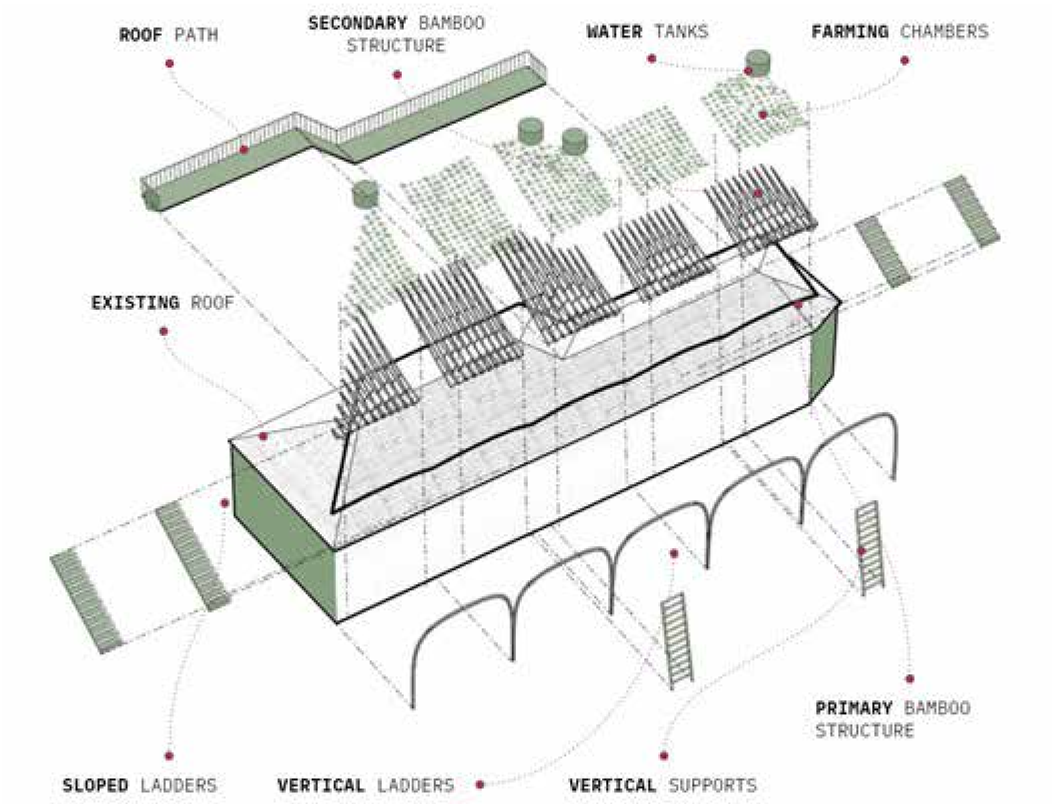


Figure 13:
(top)
Rooftop hydroponic structure elements.

Figure 14:
(bottom)
Rooftop hydroponic system layers.

7.2 FARMING SYSTEM COMPONENTS

As shown in Figure 9, the proposed hydroponic farming system could be fabricated using local materials and traditional assembling techniques. The irrigation water system should be integrated with the existing house infrastructure and by adding a water pump at the ground level. The vertical staircases are enhancing the bottom-top connectivity for local farmers. Two water tanks are added to the highest level to store water, and the sloped pipes should be enough to carry water down to the crops. Finally, the main arcade structure system is taking care of carrying the load shared with the existing house structure (Fig 13,14).



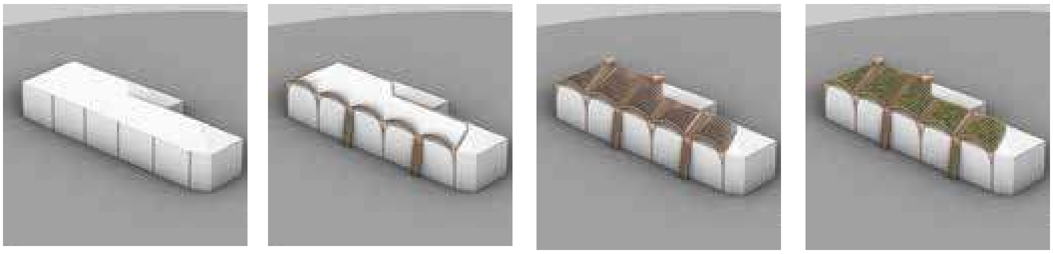
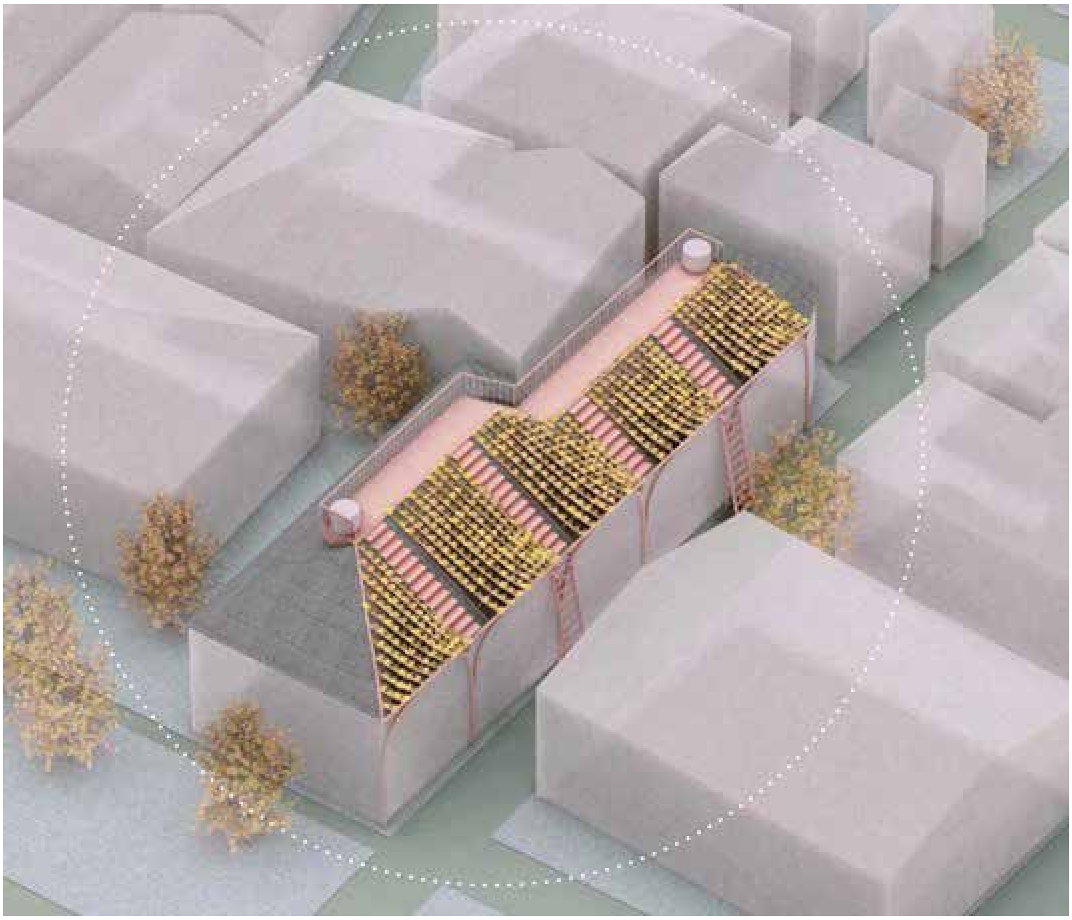


Figure 15:
Empty rooftop utilized to construct a hydroponic system.

8. FARMSCAPES WEB INTERFACE

In this last step of our research, we created a web application to give the public users and farmers in Kampala city the opportunity to evaluate their rooftop space at the macro scale, and to build their rooftop farming system at the micro-level.



8.1 2D MAP - 01 URBAN ANALYSIS

Figure 16:
(top of next page)
Urban Analysis Map.

Figure 17:
(center of next page)
Green Capacity Map.

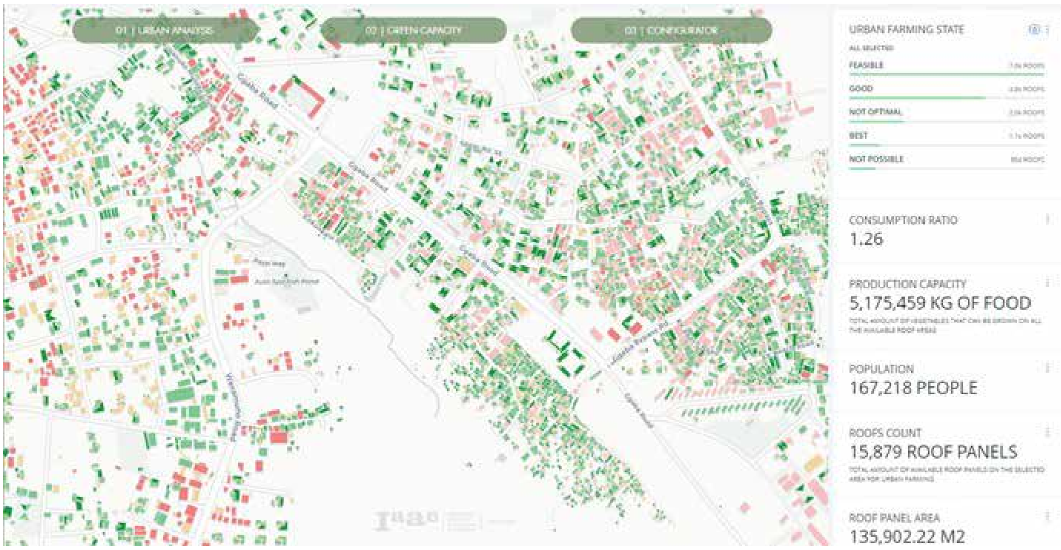
Figure 18:
(bottom of next page)
3D Configurator.

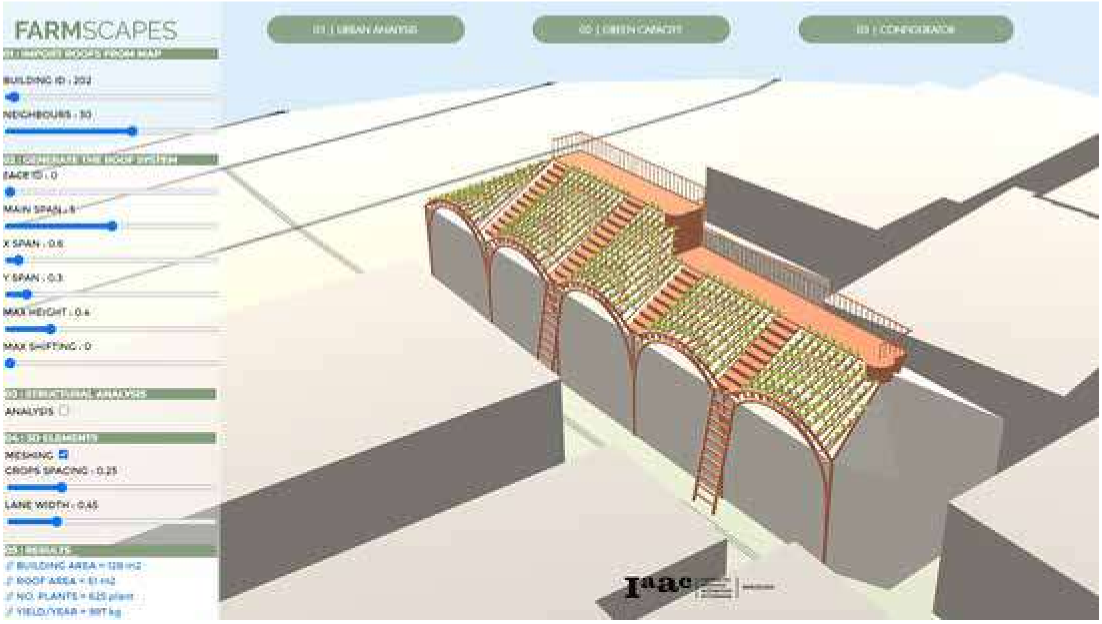
The user can access a web map of Kampala, where the user can navigate through the different features. The user will also have access to the building's rooftop condition, roof material, and building type (Fig 16).

8.2 2D MAP - 02 GREEN CAPACITY

The user can access a web map of Kampala, where the user can navigate through the different features. The user will also have access to the building's rooftop condition, roof material, and building type (Fig 16).


01 | URBAN ANALYSIS
02 | GREEN CAPACITY
03 | CONFIGURATOR
KATUSO
BUZIGA
BUZIGA HILL
GGABA
ROOF MATERIAL
INFORMAL
WOOD
METAL ROOF
CERAMIC TILES
CONCRETE ROOF
OTHER
BUILDING TYPE
RESIDENTIAL
KIOSK
COMMERCIAL
COMMERCIAL/RESIDENTIAL
TOILETS
OTHER
BUILDING LEVELS


01 | URBAN ANALYSIS
02 | GREEN CAPACITY
03 | CONFIGURATOR
URBAN FARMING STATE
FEASIBLE
GOOD
NOT OPTIMAL
BEST
NOT POSSIBLE
CONSUMPTION RATIO
1.26
PRODUCTION CAPACITY
5,175,459 KG OF FOOD
POPULATION
167,218 PEOPLE
ROOFS COUNT
15,879 ROOF PANELS
ROOF PANEL AREA
135,902.22 M2


FARMSCAPES
01 | URBAN ANALYSIS
02 | GREEN CAPACITY
03 | CONFIGURATOR
BUILDING ID : 202
NEIGHBOURS : 30
X SPAN : 0.6
Y SPAN : 0.3
MAX HEIGHT : 0.6
MAX SHIFTING : 0
ANALYSIS
MESHING
CROPS SPACING : 0.25
LANE WIDTH : 0.65

8.3 3D CONFIGURATOR

Finally, the user will be able to select a specific building from the 2D map and access the 3D web configurator. The parametric environment will allow the user to change many parameters to manipulate the rooftop farming systems based on their needs like the maximum farming span, minimum farming span, structure height, spacing between crops, and structural system. The configurator will show the user the system metrics in real-time, such as roof used area, number of plants, yield per year, and structure weight (Fig 18).

9. CONCLUSIONS

Despite the overwhelming technical and political challenges related to developing a mature urban farming culture, we strongly believe that even in the toughest conditions this can become a viable approach to alleviate the food production crisis.

Based on our research, we have discovered that in the neighborhood of Gabba, as much as 80% of the existing roof areas are good or optimal for a hydroponic farming system. This means that they can produce up to 16,025,203 Kg of vegetables each year for a population of 577,122 people. Based on these projections, the citizens of Gaba can produce 130% of what they need over a year, not just covering their consumption but also creating a surplus that can be commercialized.

This showcases not just the feasibility of such an endeavor but also the huge potential to become a future model to follow in all our cities. This process, coupled with the latest innovations on AI, can help us to leap from some of the biggest challenges in the process like data capturing.

Computer vision can be used to recognize and map existing buildings and their condition (Chen & Li, 2019); mobile apps can be used to feed extra site information from their users, and blockchain networks can assist to manage the micro-transactions related to the commercialization of the products.

Urban farming is not an idea anymore but rather the vehicle to a sustainable future for all.

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THE ADAPTATION OF A COASTAL COMMUNITY IN COSTA RICA TO CLIMATE CHANGE

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KEYWORDS
Participatory processes, Lanscape adaptation, Landscape resiliency, Ecosystem services, Co design

ABSTRACT

The Anthropocene as a new geological stage is distinguished from any other era by having rapid changes in ecosystems around the world, marked by the acceleration of climate change. In the Costa Rican coastal village of El Cocal, these alterations have affected the community not only by changing the morphology and ecosystems of the island but also the dynamics of the families that are affected by these transformations. To address these challenges, an academic project is proposed, but one of direct involvement with the inhabitants of El Cocal, for which a series of participatory processes was carried out with people from the community with the purpose of knowing the culture, to analyze and preserve local traditions, creating landscape design and how these could be adapted to different scales and temporalities in the face of climate change. The project will use ecosystem-based adaptation, which is defined as the use of biodiversity and ecosystem services, as part of a broader adaptation strategy, to help people to adapt to the adverse effects of climate change; with the aim of developing a set of different interventions (reefs, living coasts, housing, mangroves) that promote the relationship and protection between humans, marine ecosystems and coastal dynamics.

1. INTRODUCTION

Figure 1:
Damas Island floods, Quepos Costa Rica.

The project seeks to develop the adaptation of a community in coastal areas to the Anthropocene, offering an alternative to be able to adapt to the challenges of the place and take advantage of it to create new opportunities for habitat restoration and sustainable progress. Currently coastal erosion and floods destroy ecosystems and infrastructure that will force millions of people to adapt or move. These processes have been identified on the coasts of Costa Rica in both the Pacific and the Caribbean (Omar Lizano, 2013). In Costa Rica by the year 2100, rising sea levels will cause more than 1,000 floods a year in the Central Pacific. It is the country with the most people vulnerable to sea level rise in Central America, with a number of 27,900 people directly affected by these natural events (Kulp, S.A., Strauss, B.H. 2019).

For communities that depend on a good week of fishing or on the conservation of coastal ecosystems and ecotourism, the rise in sea level complicates the sustenance of their work. The map (Figure 1) shows Isla Damas areas most affected by floods from 2050 and 2100 in blue.

So we wonder how disaster planning can incorporate multipurpose

infrastructure, without going back to the traditional norms of solving a problem and ignoring related problems. Design thinking is not enough, for resilient architecture and urban planning to face the challenges of climate change, what is needed is systems thinking; with a deep and interdisciplinary approach that recognizes that change is constant; trying to live together and accept these realities and not see them as problems but as transforming conditions and opportunities.

The project seeks new design strategies that create a spatial relationship between the different ecosystems in the area and take advantage of their ecosystem services. At the same time, work is being done on the rehabilitation of the area in order to create spaces that facilitate economic, environmental and social development (Figure 2).

Figure 2:
Rehabilitation of children's area with reused materials.

The program has a focus on the construction of generative landscapes based on the cycles, processes and flows given by the same area. These are landscapes that are also sources and resources for new synergies between the community and its environment. This was followed by a series of investigations, architectural and landscape design guidelines, with a focus on strengthening the relation between human and nature, managing these territories so that they can offer ecosystem services and develop the identity of the community.

2. PROBLEM STATEMENT

It begins by analyzing the current geological epoch in which we live, we come from a time called the Holocene, which was characterized by having constant climates but some geologists propose that we have already entered to the Anthropocene; which is defined by the rapid changes in ecosystems around the world. At this stage, the human footprint in the biosphere has turned us into agents that shape the earth and into inhabitants of a world increasingly created by ourselves. These changes in the Anthropocene have been generating different transitions in coastal forms and processes; generating different modifications in marine ecosystems, marine biodiversity, coastal morphology and impact on infrastructures, societies and the economy of these regions. (Fernández, W. 1991).

In the community of Cocal (Figure 3) founded in 1956, located on the coast of Costa Rica and with an area of 8246 m2 where 1000 families live, which are totally defenseless against these changes.

These alterations have affected the community not only by changing the morphology and ecosystems of the island but also the dynamics of the families that are affected by these transformations. This condition requires an alteration in the way in which we approach the problems related to climate change with the design. Therefore, we conclude that the community and the ecosystems of the area are in vulnerability, so an adaptation to climate change is needed to make natural and social systems less vulnerable to its effects, the reduction of exposure through sensitivity, increasing its adaptive capacity.

Figure 3:
Location of El Cocal.

3. OBJECTIVE

Generate a resilient architecture with a series of territorial design strategies, whose adaptability to the environment affected by climate change, helps a community to mitigate the effects of the Anthropocene, especially floods.

4. THEORETICAL / CONCEPTUAL FRAMEWORK

To address these challenges, an academic project is proposed, but with direct involvement with the people of El Cocal, for which a series of participatory processes were carried out with people from the community (Figure 4). With the purpose of understanding the culture of the users, their lifestyles, jobs and tastes, to analyze and preserve local traditions. We analyze how the capacity of people, communities, societies and cultures can adapt or even transform into new ways of development in the face of dynamic change. It is about how to navigate the journey in relation to various paths and the thresholds and turning points between them. Deliberate transformation involves breaking the specific resilience of the old and building the resilience of the new (Folke, C. 2006).

Figure 4:
Cocal Communal Committee.

Together with these on-site managers, the approach to design strategies to adapt or mitigate these effects is done in multi-scale projects and 3 main scales were identified from high to low (Quepos, Isla Damas, the community of Cocal) and 3 different main ecosystems were identified (sea, coast, mangrove), which work together for the evolution and nutrition of the coast (Figure 5).

The relationships between the layers must be analyzed to ensure a complete understanding of the ecology of the site, its biodiversity, state of succession, energy and material flows, etc. It is essential not to lose sight of the fact that limits and internal ecological functions are dynamic and constant change will be limited to the limits of their legal ownership (Ken Yeang, 2009).

Therefore a master plan was developed which differs from planning conventional for trying to maintain the integrity, connectivity and functioning of ecosystems; seeking to adapt, restore and repair damaged ecosystems, while facilitating our human-built development within ecologically acceptable limits. One of the main challenges of master plan design in coastal areas is to be able to induce what nature takes years to develop, all to put coastal areas back into a balanced zone where ecosystem services are developed, so a ecosystem-based adaptation strategies were used throughout the area; with the aim of developing a set of different operations that promote the relationship and protection between humans, marine ecosystems and coastal dynamics.

Each design strategy generated an environmental and social opportunity for the community. All the adaptations are in relation to the training of the local workforce, where the environment and economies are regenerated. The design strategies are divided in : mobilization, recovery, protection, accessibility and community projects (Figure 6).

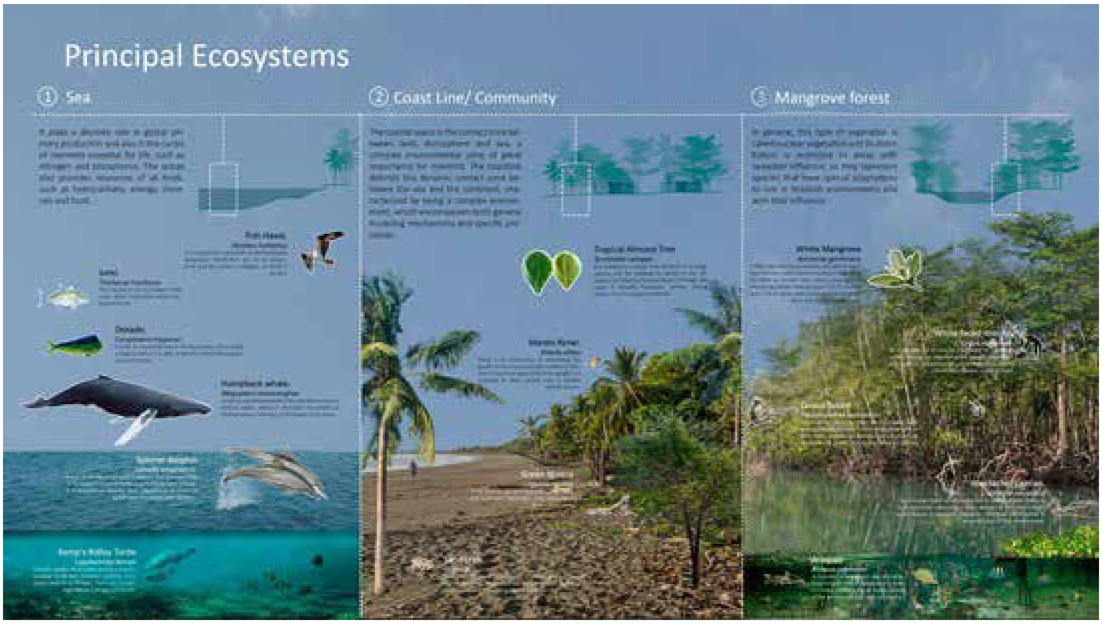

Figure 5:
(top)
Ecosystems.

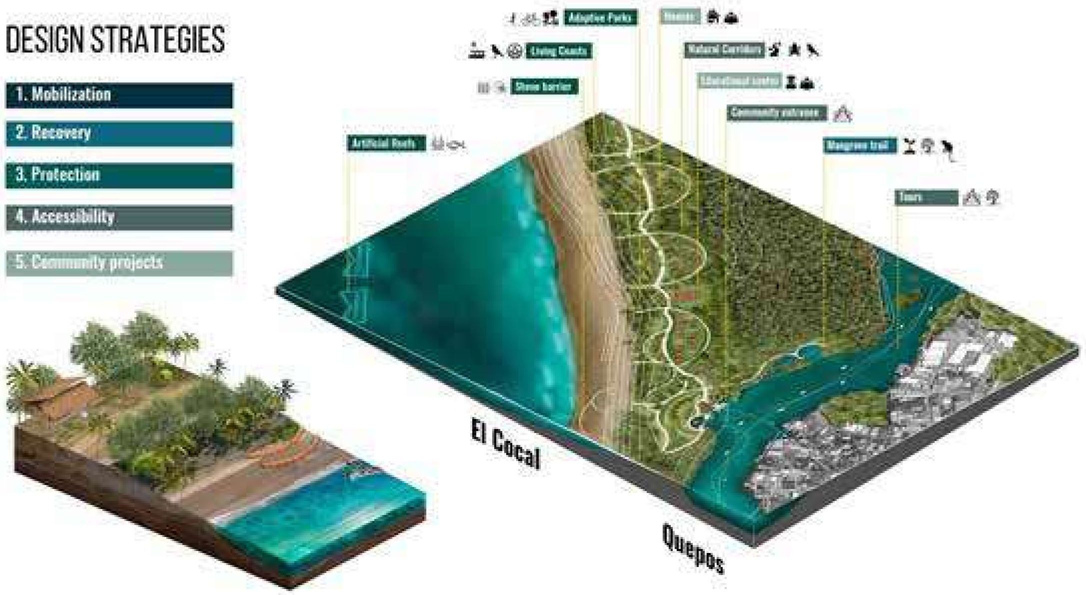

Figure 6:
(bottom)
Design Strategies.

Figure 7:
Structure in coastline.

4.1 MOBILIZATION (STRUCTURES IN RISK ZONE)

The coasts are in a constant process of metamorphosis as an adaptive response to both internal and external disturbances, the way in which we have designed we have generated that our cities, infrastructures, coasts in a way of closed or static systems; These closed and static systems have paralyzed the very ability of systems to adapt.

Certain structures were mobilized in the area to try to recover mangrove areas and generate certain changes in those spaces to activate resilience processes (Figure 7).

Figure 8:
Evolution in mangrove areas.

4.2 RECOVERY (MANGROVE / GREEN AREAS)

The mangroves are one of the most threatened ecosystems in the tropics mainly due to anthropogenic causes; In this area of Quepos, the Damas and Boca Vieja mangroves have lost part of these forests, in 1957 having 456 hectares and in 1974 having 284 (Lizano,Omar 2013).

In the Cocal naturally the mangrove cannot recede to the rise in sea level due to the development of urbanizations, streets and mainly cultivated areas, this leads to the loss of these forests; therefore the mangrove and the community are exposed to the alterations of climate change (Figure 8).

That is why an ecological restoration of the mangrove was carried out, which allows facing social challenges such as adapting to climate change and recovering services for human well-being and the conservation of biodiversity (Figure 9). For the recovery of the mangrove, restoration strategies that integrate social, economic and ecological aspects were used.

Figure 9:
Restoration of the mangrove.

In ecological restoration, different spatial and temporal scales are considered from its implementation to its evaluation. The perception and participation of the community are fundamental for the continuity of the project through the conservation and maintenance of the actions carried out and the results of the site (Teutli Hernández, C., Herrera-Silveira, J.A., Cisneros-de la Cruz, D.J., Roman-Cuesta, R.M. 2020). Social integration is considered from the beginning of the project, considering uses and customs, land tenure, knowledge of the site and the current management of the natural resources of the ecosystem.

4.3 PROTECTION (BREAKWATERS / LIVING COASTS)

Within the protection, restoration and rehabilitation measures of coastal ecosystems, artificial reefs and certain interventions on the coastline appear as management and protection tools from an environmental, social and economic perspective. Although artificial reefs do not build a natural landscape, rather an artificial landscape is still an intervention that activates processes of ecological resilience within the system; The materials are not natural but they are modified in ways so that they can work with natural processes and that is where an adaptive response to climate change can be. Coconut fiber logs were used along the shoreline to provide better erosion control while generating new habitats (Figure 10).

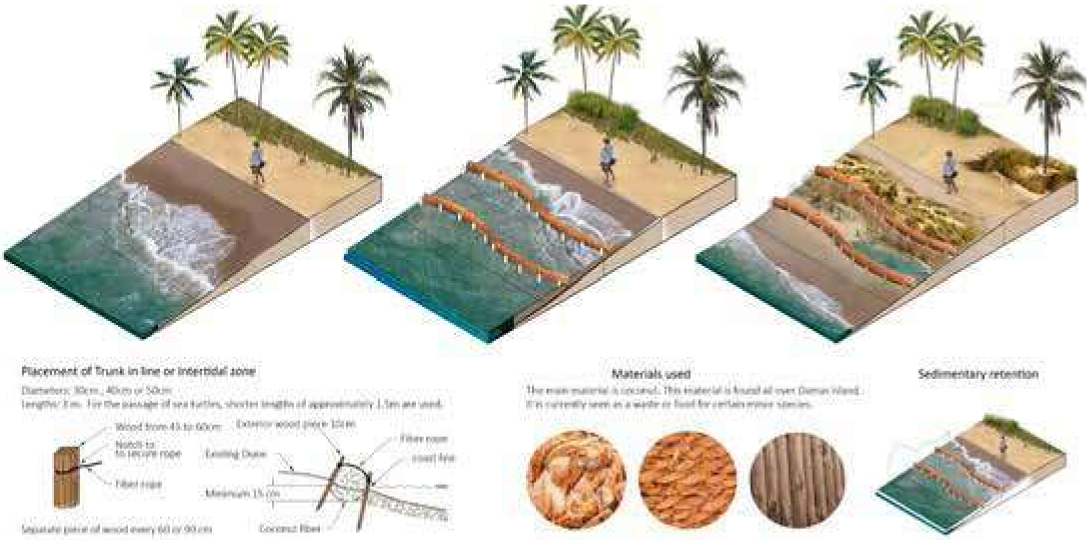

Figure 10:
(top)
Fiber Logs.

Figure 11:
(bottom)
Fiber Logs and Roads.

In this intervention it is related to the retention of certain sediments when the tide is high, which is the moment when the sea water reaches its maximum height. This retention of sediments allows an accumulation of nutrients that manages to provide a growth of natural space and helps in a certain time in the mitigation or protection of the waves. A series of roads or trails were proposed between the coconut fibers and the restoration of the natural edge to publicize the processes that would be taking place in the same community (Figure 11).

4.4 PROTECTION (BREAKWATERS / LIVING COASTS)

The design begins with the identification of the site's existing routes and the potential for new connections. These new paths become nature trails, linking new green spaces with larger habitats such as mangroves. The main routes are taken to give access to the different spaces, both marine and land. The beach accesses are marked every 100 meters since the area is also used for turtle nests in the dune area of the beach, for which certain areas of the coastline are protected and another is used to give access to other areas.

Materials reused by the community of the cocal itself are used to signal the spaces or restore some natural parts between the trails and finally, multi-habitat structures are placed, which helps to provide spaces dedicated to different animals, especially birds (Figure 12).

Figure 12:
Fiber Logs and Roads.

4.5 COMMUNITY SUPPORT PROJECTS (HOUSING / PUBLIC SPACES)

Before designing the houses, the typologies of the Quepos area were studied. In this case houses of the United Fruit Company were found; these were normally built in what were called “ciudades bananeras” (banana cities), which had an architecture that represents an adaptation to tropical climates taking into account the context in which it is located. This adaptation to the climate tries to strengthen the community and culture through local materials and strategies or traditions that have been passed down through generations, where contemporary architecture emerges from them (Bruno Stagno,1997).

Figure 13:
Houses linked with the environment.

Seeking to establish character and identity through a link with the environment, without making it vernacular (Figure 13). Therefore, it is essential to study and investigate the history of the site, understanding its direct environment, reaching the universal from the local, which can be achieved through an architectural practice in which a message of adaptation and coherence with the environment is transmitted (Bruno Stagno, Jimena Ugarte 2006).

The configuration of the house responds to the lifestyle of the population and its environment, without forgetting the local values which can become an expression for the strengthening of the identity of the area. Depending on the temporality or the current state of the place, different wave dissipation strategies are proposed. The houses allow a connection for a future bridge. In case it was flooded for long periods of time, the bridge is supported in the same way with the columns of the houses, which offers habitats for different species (Figure 14).

There are also shared spaces between houses that are used as playgrounds or cultural activities in the same area, these areas are transformed depending on external factors such as floods. Of course, it is also important to recognize the limitations of these landscapes, inherent in a changing nature; Since not even scientists are capable of predicting in detail the speed or magnitude of these changes, a constant process of research through design is necessary. Each one having a variable resilience and certain limits to be able to accept and in some way coexist with the tensions imposed by any form, system and activity built by humans, for which it is necessary to analyze these limits in order to understand the systems or programs that can be use without stopping the resilient and adaptive capacities that coastal ecosystems themselves have.

Figure 14:
Temporality and adaptation to change.

5. CONCLUSIONS

In a certain way, several of these strategies can be replicated, bearing in mind that existing conditions must be accepted as realities on which to intervene and always working with adaptive natural processes; likewise, the incorporation of an active citizen is important to promote a culture of prevention of risks to disasters, in the individual and in the community.

One of the roles of designers or planners is to serve as interlocutors between the environment and society, focusing the objective not only on environmental and aesthetic values, but also on the capacity for self-management and learning, derived from their implementation processes. This perspective where the landscape becomes the tool, from which to face the Anthropocene perspective and the relationship of man and the city with nature. It is important to understand the experiences of the communities and see that there are historical roots where there is tradition, history, and people identify with the place. If these habitats are left, they would end up disappearing just like these coastal communities. People have the opportunity to be administrators of these ecosystem services, making it possible for design strategies to be sustained for long periods of time.

These design strategies work together to form the master plan as a territorial strategy that integrates the conservation and restoration of ecosystems, to provide services that allow people to adapt to the effects of climate change, while increasing resilience. The landscape is worked on as a collective process where the community participates in the design process, the person is not seen as a user but rather they become project managers.

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ECOLOPES

A multi-species design approach to building envelope design for regenerative urban ecosystems

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KEYWORDS
Ecological Restoration; Biodiversity; Multi-species Design; Computational Modelling; Cohabitation;

ABSTRACT

Urban areas are facing significant challenges regarding degradation of environments and ecosystems, species loss, and increased vulnerability to climate hazards, all of which impact negatively upon human health and well-being.

Focusing on building envelopes can offer an effective approach to the regeneration of urban ecosystems, by providing new spatial opportunities in dense urban environments.

The H2020 FET Open project ECOLOPES - ECOlogical building enveLOPES aims to develop a game-changing design approach for regenerative urban ecosystems. An Ecolope is a building envelope designed as a multi-species living space for four types of inhabitants: plants, animals, microbiota, and humans. ECOLOPES adopts a holistic multi-species approach, going beyond the provision of ecosystem services (i.e., benefits provided by nature to society and the economy). The goal is to develop the technology to plan and design urbanization with an integrated approach that addresses the requirements of the urban ecosystem. The paper presents an overview of the first steps towards this approach with focuses on data selection and integration, algorithmic modelling, and on developing an urban classification system that will be used for the project development.

1. INTRODUCTION

Urban ecosystems are complex, fragmented, heterogeneous habitats that are densely populated (European Commission. Directorate General for Environment., 2021; Groffman, 2017) that can provide a wider range of regulating, provisioning, and cultural ecosystem services (Millenium Ecosystem Assessment, 2005) to benefit humans. Urban growth is strongly related to a significant reduction and fragmentation of vegetation and green networks that do not only impact upon urban and natural balance but also on human health (Mitchell et al., 2016).

Currently, more than half of the world's population lives in urban areas and this condition is projected to increase to 70%worlwide by 2050 (United Nations, 2018). This trend and the destruction of natural ecosystems due to urbanization (Bernardo et al., 2021) causes local species' extinction and significant reduction of ecosystem services. To limit urbanisation effects, one of the most promising solutions is to foster climate change adaptation measures by adding vegetation and green spaces to improve microclimate, human health as well as increase biodiversity (Lee and Maheswaran, 2011).

These actions can help reducing green fragmentation and improving local biodiversity and foster multispecies design approaches on a building scale. The potential role that architecture can play in this context has been stated (Hensel, 2013). For example, the great amount of building in need of refurbishment could be used to experiment with new envelope designs, that consider the needs of urban ecosystems. This will require the setting of standards for individual and collective behaviour (policies, codes, rules, and regulations). So far, few examples of wildlife-inclusive urban design were able to incorporate provisions for multiple species into architecture (Apfelbeck et al., 2020) and a systematic approach is still missing.

This paper introduces and discusses the "ECOLOPES - ECOlogical building enveLOPES: a game-changing design approach for regenerative urban ecosystems" (https://www.ecolopes.org), as well as first steps toward its implementation.

2. ECOLOPES VISION

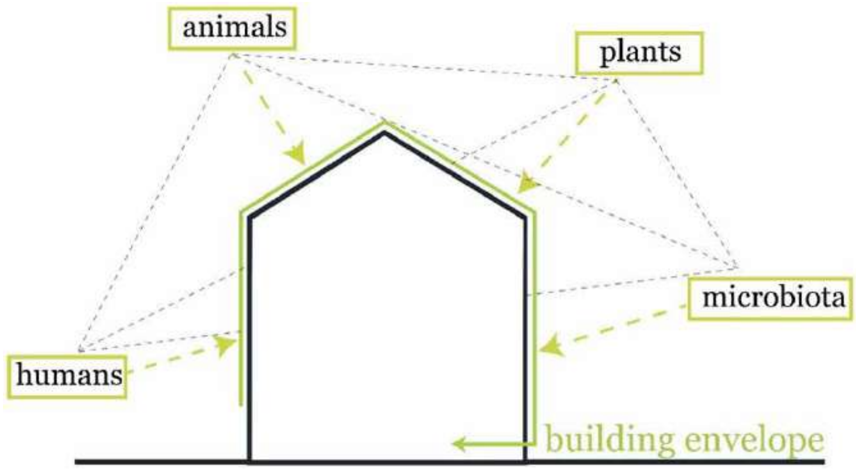
2.1 MAIN OBJECTIVES AND COMPONENTS

The project ECOLOPES adopts a radically new integrated ecosystem approach to architecture. This is done with the aim to enable nature to co-evolve with the city to support biodiversity and human well-being. Building envelopes, that is the enclosure of new and existing buildings, are proposed to be designed as ecolopes, multi-species living space for four types of inhabitants: humans, plants, animals, and microbiota (i.e., microbes living in or on the inhabitants). Indeed, an ecolope is new key concept for building envelope that include architecture, soil and different inhabitants. To make this possible it is necessary to develop a suitable design approach with a computational framework and workflow that includes a range of expert data-bases, an information model and a range of algorithmic processes and tools, and most critically, a data-driven design recommendation system. More specifically this includes the ECOLOPES Information Model (EIM Ontology) that defines the relationships between the inhabitants, architecture and the abiotic environment. A tailor-made computational framework will make the knowledge embedded in the information model available for design. This includes front-end tools for design, modelling and visualisation, and a computational simulation environment that enables iterative design development integrated with multi-criteria decision-making strategies. The ECOLOPES design approach will be validated through design cases, located in different urban environments.

Figure 1:
ECOLOPES Multispecies approach.

2.2 MULTISPECIES APPROACH

Since soil, microbiota, plants, animals, and humans play significant roles in natural dynamics, a wildlife-inclusive design is required within cities (Garrard et al., 2018; Snep and Opdam, 2010). Within an ecolope, a multitude of species can be hosted. Plant and animal dynamics and their interspecific multitrophic interactions and relations with soil and abiotic environment, microbiota and humans can thus become key elements of building envelopes. Subsequently, the ecological data obtained from multiple species in the ecolope will feed into an information model that enables design decision support.



2.3 MULTI-CRITERIA DECISION-MAKING APPROACH

The integration of multi-species cohabitation into building envelopes requires a holistic data-driven design process informed by ecological factors. The inhabitants of the ecolope require specific environmental conditions to function. Therefore, it is important to consider how an ecolope can contribute to maintaining and regulating these conditions. Key performance indicators (KPIs) derived from expert knowledge, will be assigned to each of the inhabitants to evaluate the ecolopes' impact on the KPIs and vice versa. Multi-criteria decision making (MCDM) strategies will be employed to understand the trade-offs and hierarchies of the KPIs in relation to the design of the ecolope.

MCDM processes can be understood in two distinct ways depending on the problem definition (Penadés-Plà et al., 2016; Yazdani et al., 2019). The first approach entails Multiple Attribute Decision Making (MADM), where weights are assigned to discrete criteria and the strategy results in a ranked list of solutions. The second approach entails Multiple Objective Decision-Making (MODM), which allows for the generation of a continuous set of solutions using two or more criteria.

In architectural design Multiple Objective Optimization (MOO) algorithms can be implemented to identify optimal solutions and the co-benefits or trade-offs between conflicting criteria that need to be simultaneously adjusted (Gunantara, 2018; Hamdy et al., 2016).

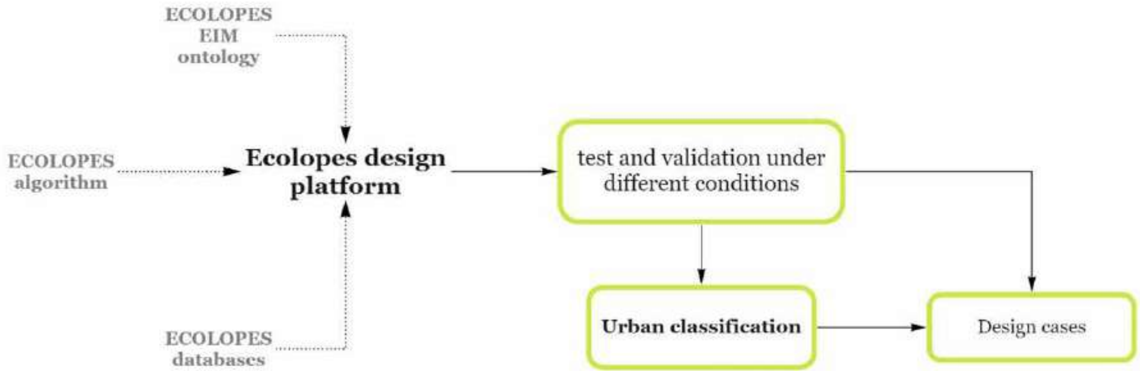
In ECOLOPES weights will be assigned to the KPIs to establish a hierarchy that informs the design outputs of the MOO strategy. The KPIs will then be optimized through an iterative design process. In this way the process enables analysis of the design of a building envelope in relation to plants, animals and humans (KPIs for these three stakeholders with high and equal weight) compared with one that is developed for humans and plants (high weight to human and plant KPIs, low weight to animals), or one just designed for humans. MADM strategies will also be implemented to rank design iterations based on weights assigned to the KPIs, as well as their optimized performance values resulting from the MOO. This serves to assess and formulate KPIs under different sets of conditions.

2.4 ECOLOPES FRONT-END TOOLS

ECOLOPES' front-end tools are part of the ECOLOPES design platform and make the ECOLOPES Information Model (EIM Ontology) available to architects and planners. Built as plugin in a standard CAD environment (Rhino and Grasshopper), they enable the design of ecolopes, provision of support in the decision-making process and systemic coordination of planning actions of multi-species environments. Furthermore, ECOLOPES front-end tools visualise the output of the EIM ontology (spatio-temporal data from multi-species dynamics) as a 3D model, which is be useful for ecologists and architects. In order to foster the collaboration between several disciplines in the design process, ECOLOPES web tools will be accessible through a standard web browser, without prior knowledge using CAD software.

The tools are made from different sets of algorithms compiled as Grasshopper (https://www.grasshopper3d.com/) components allowing the user to analyse, evaluate, and optimise their 3D models based on the developed ECOLOPES approach.

Figure 2:
Role of urban classification in the ECOLOPE development.



3. FIRST STEPS TOWARD IMPLEMENTATION

3.1 ECOLOPES INFORMATION MODEL (EIM) ONTOLOGY – FIRST STEPS TOWARD DATA INTEGRATION IN A 3D MODEL

The ECOLOPES Information Model (EIM) Ontology defines the relationships between architecture, the abiotic environment and all the inhabitants (soil, plants, animals, microbiota, and humans).

The EIM Ontology is a central component of the decision support system. It is tailored to guide design generation and to bring ecological and engineering knowledge into the early phase. The ontology links with the expert database that structures volumetric spatio-temporal data for query and is represented as voxel model, and will be reasoned to capture instructions that are selectively executed in a recursive, iterative and generative algorithmic process. This process will generate a voxelized 3D model at various levels of resolution. Selected data will be translated into a CAD model for the design generation. The voxel model provides an interface between interdisciplinary datasets incorporating expert information and parametric design methods. Voxel models are collections of values assigned to a three-dimensional grid with precisely defined resolution. Different tools in open-source GIS packages serve to analyse geophysical traits, such as geomorphons, slope analysis, water run-off, etc. Expert knowledge from the field of soil science contributed by the soil scientists will be integrated into the analytical framework. Currently we are reviewing existing tools for terrain modelling integrated into the Grasshopper environment including Bison, GHopperGIS, Lands Design, Docofossor, Ibex and ShrimpGIS. GDAL library integrated in GHopperGIS or .asc file format originally developed by ESRI are currently integrated as input format for Ibex and Docofossor plugins. Still, mMost of the currently existing tools are not integrated to the necessary extent, nor designed to exchange information. Hence, while there exists potential for integrating geospatial analysis tools and parametric design processes, there is a need to create interfaces which allow for systematic data exchange that preserves the information content represented by the data. In a second step data and models pertaining to plant and animal ecology will be integrated.

3.2 URBAN CLASSIFICATION

The ECOLOPE design platform will be tested and validated by means of selected design cases. A method for urban classification is being developed to select design cases in a systematic way, and to facilitate the comparison of the performances achieved by an ecolope under different sets of environmental and architectural conditions.

The urban classification will serve to identify urban areas characterised by similar conditions, i.e., similar in term of constraints for, and drivers of biodiversity (i.e., our four inhabitants) and architecture. Biodiversity and architecture are indeed directly and indirectly influenced by a large diversity of biotic and abiotic factors that will be integrated into the urban classification. The urban factors driving biodiversity can be grouped into three categories (Li et al., 2019): the biophysical conditions (e.g., climate and topography), the social–economic environment (e.g., the socio-economic level of the population and the social-economic orientation of the block), and the built and natural environment of the city (e.g., land-use and building height) (Mimet et al., 2020; Pellissier et al., 2012) (Figure 2). For the sake of simplification, the variables used to describe the built and natural environment are usually thematically quite coarse (e.g., based on coarse land-use information). In ECOLOPES, we go further than existing urban classifications (Cadenasso et al., 2007; Li et al., 2019), by considering two different scales and thematic resolutions, for the role of the landscape (variables computed at 100m resolution) and detailed local architectural features (variables computed at 10 m resolution), which are known to be very important for biodiversity (Weisser and Hauck, 2020) and play an important role in driving the architectural design.

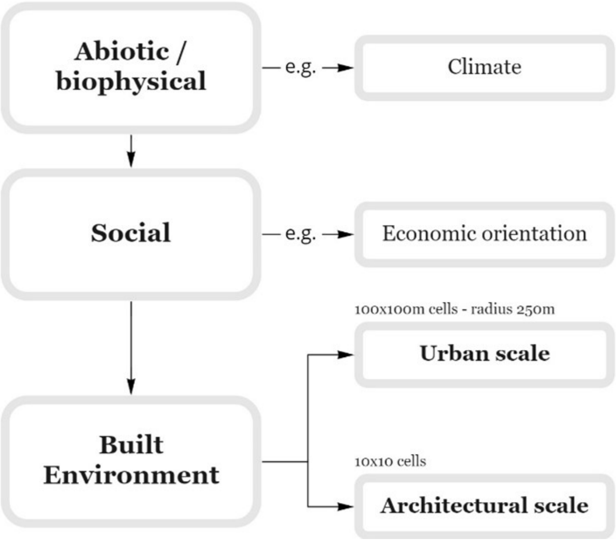
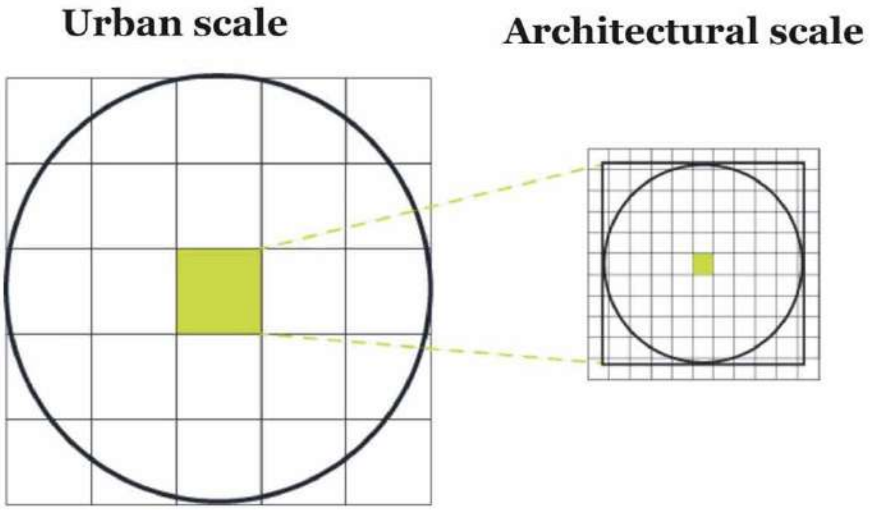


Figure 3:
ECOLOPES Urban classification categories.

Figure 4:
Scale of the urban classification: 1. for urban scale the grid is made by 100x100m cells, 2. For architectural scale the grid is made by 10x10 m cells. Their radiuses are, respectively, 250m and 50m.



The classification will be implemented to identify and further describe the features of a given cell in a 100m x 100m resolution, for urban scale, and 10m x 10m resolution for architectural scale as well as their radius of, respectively, 250m and 50m.

4. RESULTS

In this section we provide an overview of the initial results and of some expected results that are related to the data integrated design approach and on the urban classification for design cases selection

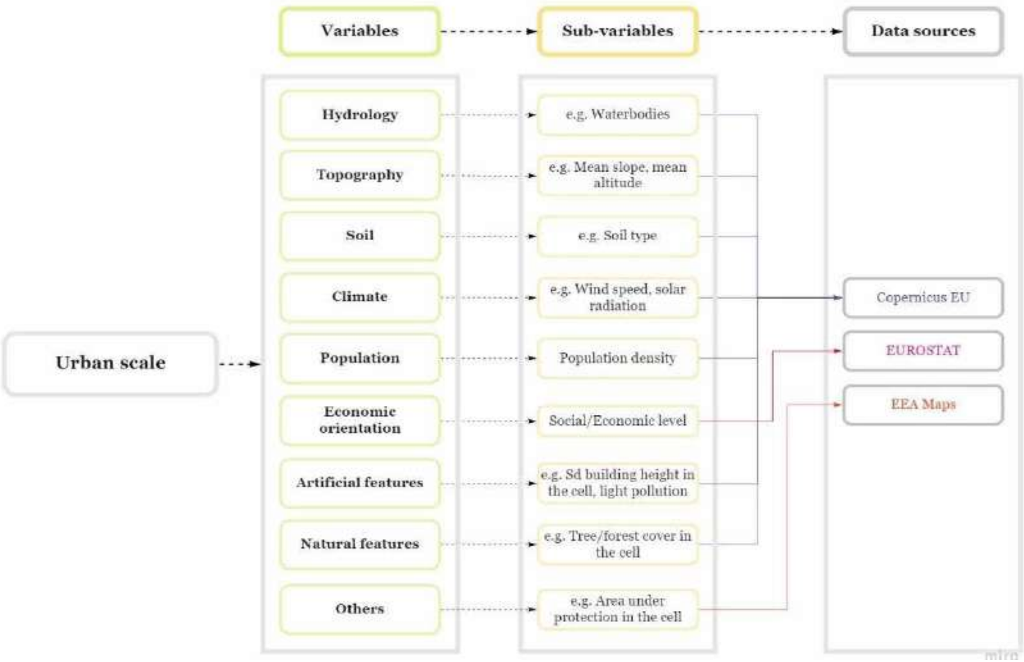
4.1 DATA INTEGRATED DESIGN APPROACH – CURRENT AND ANTICIPATED RESULTS

Ontologies have long been used in the domains of architecture, engineering, landscape and ecology. However, the pursuit of using ontologies for turning agent-based modelling into an intelligent system for simulating the dynamics and form of an ecolope constitutes a new approach. Regarding voxel models we focus on applications related to volumetric particle simulations (e.g., OpenVDB) and to the application of Computed Tomography (DICOM and NIfTI). At the current stage a more general implementation is considered to simplify the creation of interfaces with the required range of disciplinary tools and methods. Regarding the algorithmic tools, an overall service-oriented software architecture (SOA) is anticipated that structures coherent algorithms into independent services and enables a flexible and scalable implementation of various datasets. The functionalities of the algorithmic tools are specified by the definition of different use cases combined with user requirements. We are currently developing algorithmic tools and methods that address the correlation between ground and building structures, with both components forming a terrain with specific soil-related parameters as an underlying resource for the multi-species approach. Initially we focus on tools which are related to terrain and slope modification and evaluation of terrain related parameters such as slope, aspect, surface water flow and soil stability. The intended combination of terrain related modelling and evaluation tools enables feedback on the environmental impact of different designs on the projected terrain from the early design phase onward with the aim to ensure adequate conditions for plants, animals, and microbiota.

4.2 URBAN CLASSIFICATION: PRELIMINARY RESULTS

Within the context of the ECOLOPES, it is important to consider the building characteristics, as well as variables in the surrounding environment that can inform design and planning decisions. Using open-source databases such as, at urban scale, Copernicus, EUROSTAT, EEA, and at architectural scale OpenStreetMaps as well as Google Maps and Google Earth, enables a comprehensive data pool of 2D and 3D information for characterization on a 10m scale. Figures 4 and 5 show the variables and main sub-variables at the urban and architectural scales.

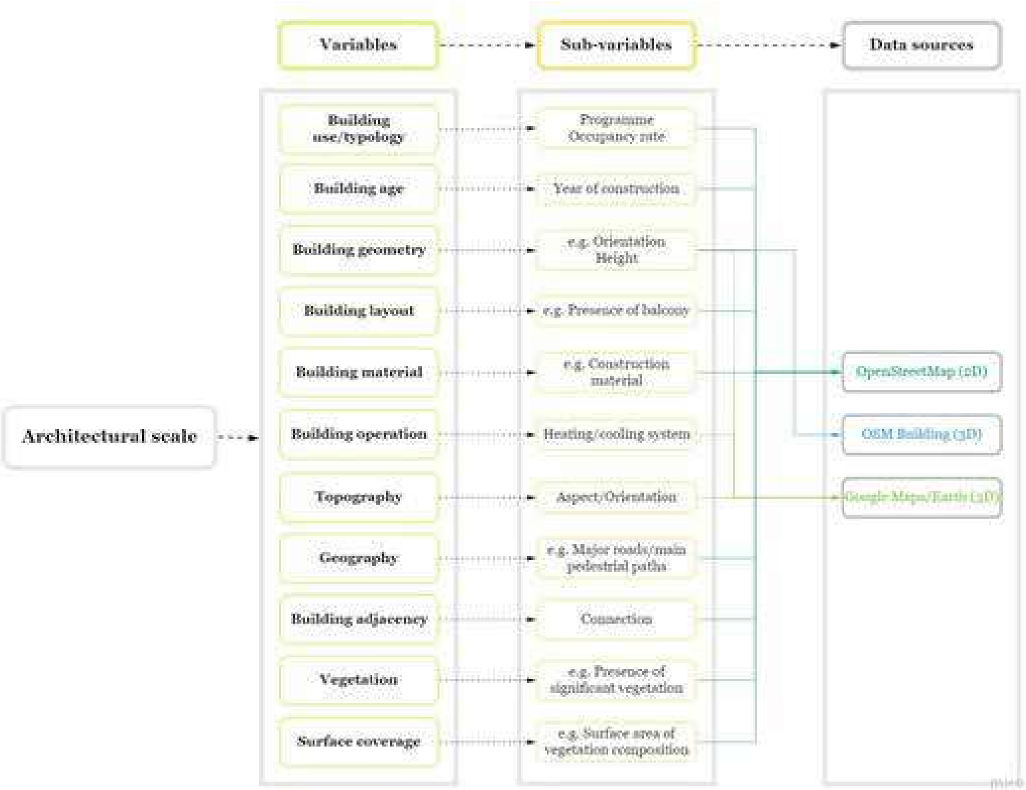
Figure 5:
Urban scale variables, sub-variables and data sources.



The urban classification system will be based on the identified variables and sub-variables that allow the selection of suitable design cases in different cities in different countries. Clusters will be generated and organised in such way as to allow description of selected areas for design and the surrounding features and conditions.

Machine learning strategies such as Hierarchical Clustering Analysis (HCA) provides a systematic overview of variations within clusters (Araldi et al., 2021) and facilitates an integrated classification workflow from the urban scale to the architectural scale.

Figure 6:
Architectural scale variables, sub-variables and data sources.



5. CONCLUSIONS

The paper describes the ECOLOPES radically new integrated ecosystem approach to architecture and provided an overview on the holistic data-driven design process informed by ecological factors.

The activities of ECOLOPES implemented so far led to promising results regarding depth studies on multi-specie interactions through the EIM Ontology. This also includes methods that explore how the expert database that structures volumetric spatio-temporal data for query can be represented as a voxel model.

Concerning the urban classification, the workflow will be further developed, to be applicable for strategic site selection in an urban planning perspective. This will enable the identification of prospective areas for design and implantation of an ecolope, for example, for improving habitat connectivity. Furthermore, the urban classification provides knowledge of urban conditions that will make it possible to extend the results of different ecolopes to analog urban areas in different contexts.

The next steps within the ECOLOPES project include the further development of the ECOLOPES Information Model, to define the relationships between the inhabitants, architecture, and the abiotic environment, and of the computational tools for modelling and visualizing the ecolope, the set-up of the computational simulation environment and the validation of the ECOLOPES' overall design process through specific design cases, selected thanks to urban classification methodology presented in the paper.

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WATER WE TALKING ABOUT?

River Dialects: A city, citizen, and water dialogue Natural flood management in Lagos, Nigeria, through participatory river strategies

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KEYWORDS
Flood Risk Management, Natural Urban Solutions, Lagos, Nigeria, Metabolic Urban Design, Environmental Architecture

ABSTRACT

This thesis illustrates the issues resulting in the environmental problem of urban flooding in Lagos, Nigeria in order to propose solutions that encompass democratic flood risk management. The solutions proposed in this thesis focuses on practical applications that can be implemented in the study region. This thesis is a combination of theoretical approach and applied research that combines a holistic vision of the insertion of the research in a broader scenario with a specific description and analysis of the own research process and the results obtained. This research was developed with the intention of delivering a phased project implementation program to be for Lagos, Nigeria.

Lagos, Nigeria and rapidly developing cities like it are destined for a life spent largely underwater unless reformational measures are put

in place. Lagos is undergoing rapid urbanization with a 13 million population growing at 3.2%. This leads to environmental problems such as poor infrastructure and increased flooding. Urbanization has led to a 35% increase in flood economic risks and €500 million euros in economic damage (Komolafe, Adegboyega and Akinluyi, 2015).

Water we talking about? reconnects a dialogue between the city, the citizens, and their water by creating natural, democratic flood risk management systems perpetuated by the inhabitants of Lagos, Nigeria. How can the understanding of hydrological aspects and the decentralization of this information be used to transcend recurring problems plaguing the region's ecological systems.

This research was developed with the intention of delivering a phased rehabilitation program to be implemented in Lagos, Nigeria. The implementation of natural environmental rehabilitation, environmental control, and cultural integration strategies for flood mitigation in Lagos, Nigeria was developed to serve as a model for the neighboring cities facing the same problem in the country.

01 - INTRODUCTION- Climate Change; rapid urbanization _

1.1 - Climate Change and water risk

Less than 1% of all freshwater available for people to use is about 12,500 km3 of water, amounting to 6,600 m3 per person/year. Only 48% of the inhabitants of the urban and semi-urban areas of Nigeria and 39% of rural areas have access to potable water supply.

Global water demand for all uses, presently about 4,600 km3 per year, will increase by 20% to 30% by 2050, up to 5,500 to 6,000 km3 per year. By 2050 the global population will increase to between 9.4 to 10.2 billion people. Most of the population growth will occur in Africa (Boretti and Rosa, 2019).

Climate change is an increasingly acute issue with impacts devastating some of the most vulnerable regions worldwide.

Lagos, Nigeria is undergoing rapid urbanization with a 13 million population growing at 3.2%. This urbanization has led to a 35% increase in flood economic risks and 5.3 billion euros in economic damage (Komolafe, Adegboyega and Akinluyi, 2015). Approximately 70% of the city's population lives in lower income areas characterized as slums (Adelekan, 2010). These vulnerable areas consisting of structures composed with temporary and second-hand elements suffer the most during floods.

Severe storms and flooding have come both expededly and unexpectedly. Flooding has altered the landscapes, in particular the rivers and water transportation systems, hindering the environment from draining built up silt, sediments, chemicals, and solid obstructions. These elements in turn are dispersed all over the urban and rural areas, contaminating natural resources. Not only are surface water resources compromised, but this dispersal of contaminants also affects the groundwater resources. With increasing floods, an increasing population, and decreasing water stability, there is a clear water disconnect and an imminent water crisis.

02 - REGIONAL STUDIES - Nigeria's water network

2.1 - Lagos State

Lagos State can be divided into Lagos Mainland, Lagos Island, and Lekki. With a population of 14,368,000, Lagos Mainland receives 2000mm of rainfall per year from flows through its elevation from north to south spanning from 71 to 0m above sea level. The Ogun River, Osun River, Aye waterway, Owo waterway, Yewa waterway, and Iju waterway all flow through Lagos mainland and outlet into the Lagos and Lekki Lagoon. This rapidly urbanized city with an economic focus on oil and commerce has expanded to a size of 3,577 square km. The growth of Lagos has led to heavy rains, poor environmental conditions, and unplanned, seemingly unstoppable urban growth which all contribute to its severe flooding.

2.2 - Regional Flood Causes Conclusions

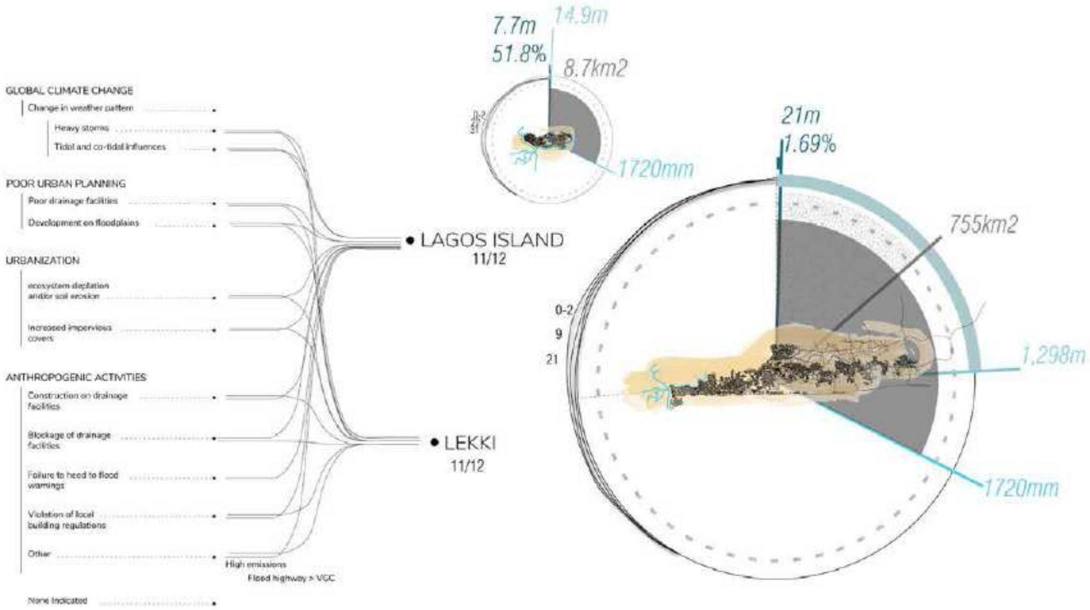
In his paper, 'A review and critical analysis of the efforts towards urban flood risk management in the Lagos region of Nigeria,' U. C. Nkwunonwo listed the major causes of urban flooding in Lagos and categorized each item under climate change and meteorological events, poor urban planning, urbanization, or anthropogenic activities (Nkwunonwo, Whitworth and Baily, 2016). Though this list presents an appropriate categorization method, the last category, anthropogenic causes, should be placed as an overarching category because it emcompasses the others.

Rapid urbanization created inadequate infrastructure, impermeable surfaces, and cripples a city's natural drainage systems, the rivers, from functioning. The urbanization of Lagos led to the solidification of waterways that need room to transform and accommodate for changes in flow velocity. Straightening of these waterways has disabled this ability. A river needs to constantly transform by meandering as sediment is moved from side to side due to the velocity of the flow. The development of impermeable surfaces have solidified the shape of the river, creating hard edges that disable the river from adapting to the flow of the water. The river then spills beyond flood plains in urban areas resulting in the inundation of these vulnerable spaces.

03 - LAGOS URBAN ANALYSIS - Identification of the contributors to urban flooding

3.1 - Water as a resource (city and citizen water relationship)

Vulnerable citizens, in vulnerable economic circumstances, find themselves in areas vulnerable to urban flooding.



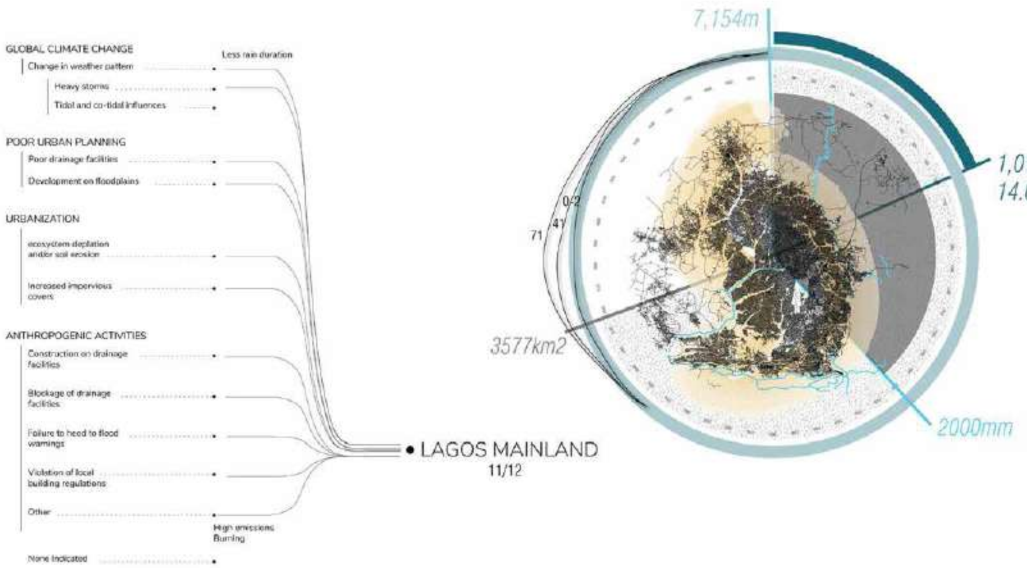


Figure 1:
Flood causes in Lagos State

This disconnect is the ironic narrative of the city being overwhelmed by excessive amounts of water yet not having enough access to improved drinking water.

In Lagos Mainland the Adiyan, Iju, Isashi, and Odomola waterworks supply pipe-borne (70% of water usage), whereas boreholes, wells, tankers, and disposable water sachets supply 30% (Oyebod, 2018). This is a stark difference to Lagos Island and Lekki which have no governmental water supplier. The households rely on boreholes, tankers, and sachets for their water supply.

This independence of water supply extraction using boreholes and wells creates unaccountable variables for the city's water supply. In terms of surface water, Lagos does not consume it due to extremely low quality. The waterways and rivers are polluted enough to produce very discernable signs of its poor quality. This is enough to deter the citizens as well as the city from depending on surface water which in turn puts extreme pressure on groundwater.

3.2 - Urban activities along the waterway (city and citizen water relationship)

It is evident that groundwater is the most dependable source of water; however, this does not disqualify the fact that the surface water resources, the rivers and waterways, are being used by the citizens.

There are various economic activities taking place in and around these waterways. A section of the Osun River harbours an animal farm, nestled between the chaos of the city. This animal farm most likely takes advantage of the river as a drinking water source for the animals or even a water source for cleaning the pens. Though animal farming is prevalent, crop farming is the most common economic

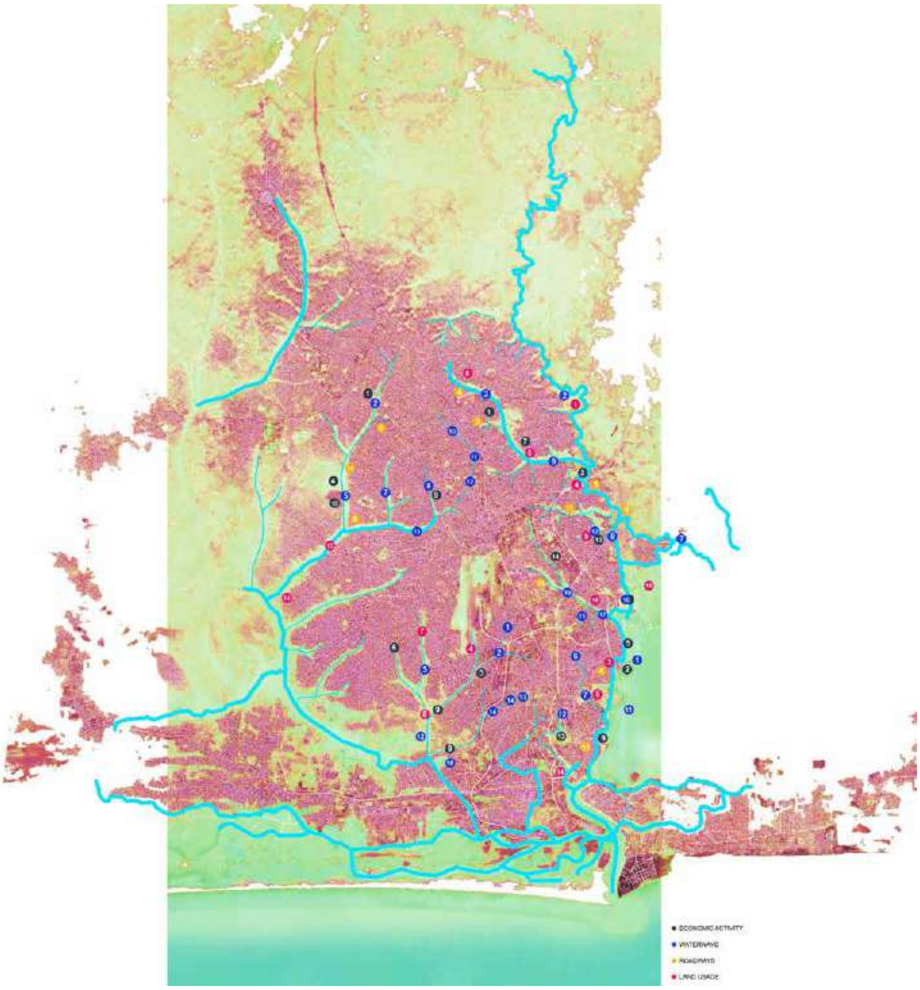


Figure 2:
Lagos Urban Analysis

activity taking place around the waterways, due to a free source of irrigation water. Fish farming is also a common economic activity around the waterways. The farmers carve our small rectangular pools next to the waterway which fill up with water due to the saturation of the soil.

Less economically profitable activities taking place around the river are landfills. Sanctioned city landfills are placed close to the river which is an extreme health hazard. The chemical leachate from these landfills make their way into the waterways as well as the groundwater which also releases into the waterways. Another hazardous, yet more profitable activity taking place is the dredging of soil. Heaps of silt and sand can be seen lined up along the waterways. Canoes are used to venture into the middle of the waterway and anchored while the diver swims to the channel bed with a bucket to retrieve the sediments.

The activities around the river such as animal farming, landfills, and dredging for soil, revealed that the river was being used as a miscellaneous resource simply because of its openness. The river has become the backyard of the city, making it susceptible to an uncoordinated range of activities, while the Lagoon is the end recipient of the harsh effects of this unchecked discoordination. The waterways blend from gutter to canal to river through the facade of solid waste, making it hard to connect it as one functioning body. The dysfunction of the waterways has offset a chain of environmental problems ultimately leading to devastating flood impacts in the urban landscape.

3.3 - Impact analysis and an identity crisis; the river as a residual space

The river and waterways today hold the same conversation as they did less than 60 years ago, yet tell a very different story. What was once the forefront of economic responsibility has become the background of economic damage. Fishing, lumber, and farming were once fostered in a manner that was easily sustainable due to the scale at which they operated. Today, these industries have been outcompeted by commerce and oil, leaving the trades to be adopted by low socio-economic citizens who can seek to make a profit using the free resources.

The waterways have been left out of the jurisdiction of city planning and regulation, becoming a residual space. From the perspective of the individual, there’s a clear identity, but from the perspective of the city, there's an identity crisis, a dysfunction leading to flooding. Perhaps the way we have designed and built our waterways were actually inappropriate for young countries and cities facing rapid urbanization.

The major question now becomes how do individuals create a collective identity that restores the function of the waterways and river?

04 - STRATEGY _

4.1 - Democratic Flood Risk Management

For many tribes the river was a deity, one body, able to give, take and communicate. Most of these forms of communication were actually just signs of a healthy ecological system. We can use this strategy to restore the river by restoring the communication between the man and the river. This is the strategy of democratic flood risk management, the restoration of the river's function through the development of the river's identity by the city and citizens.

The lack of a collective structure to govern and guide the development of the city and coordinate citizen participation in the urban development is the root of the problems that have led to extreme urban flooding. Democratic flood risk management is split into two goals; restoration of the function of the river and definition of identity of the river.

The restoration of function can be achieved through the renaturalization of the river. These goals, in a nutshell, aim to maximize water retention, prevent obstruction, and filter waste in order to maintain an hydro ecological balance. The definition of identity can be achieved through the reculturalization of the citizens. There needs to be a clear medium that will serve as the infrastructure to direct the citizen's engagements with their water.

4.1.1 - Renaturalization strategy; quality, quantity, hydromorphology

The natural functionality of a river can be redeveloped by focusing on three parameters; water quantity, water quality, and hydromorphology. The quantity of water being discharged by the channel needs to be appropriate for its size, roughness, location, and so forth. Several parameters can be used to keep a balanced quantity in order to prevent flooding, excessive quantities. The focal parameters are a.) sediment control, b.) planform flexibility, c.) obstruction control, and d.) flood plain porosity.

a. Sediments are particles that are broken down from rock and land formations which make their water into the river through streams. Sediment build-up can create natural dykes, which can act as a natural elevated barrier wall, preventing flooding. Sediment build-up can also elevate a river's floor, making it more shallow, thus decreasing its capacity to hold more water which could lead to flooding. The control of sedimentation in the floodplain is essential to allowing a gradual rather than a rapid flow of sediments into the waterways.

b. A river alters its planform, shape and sinuosity, in order to

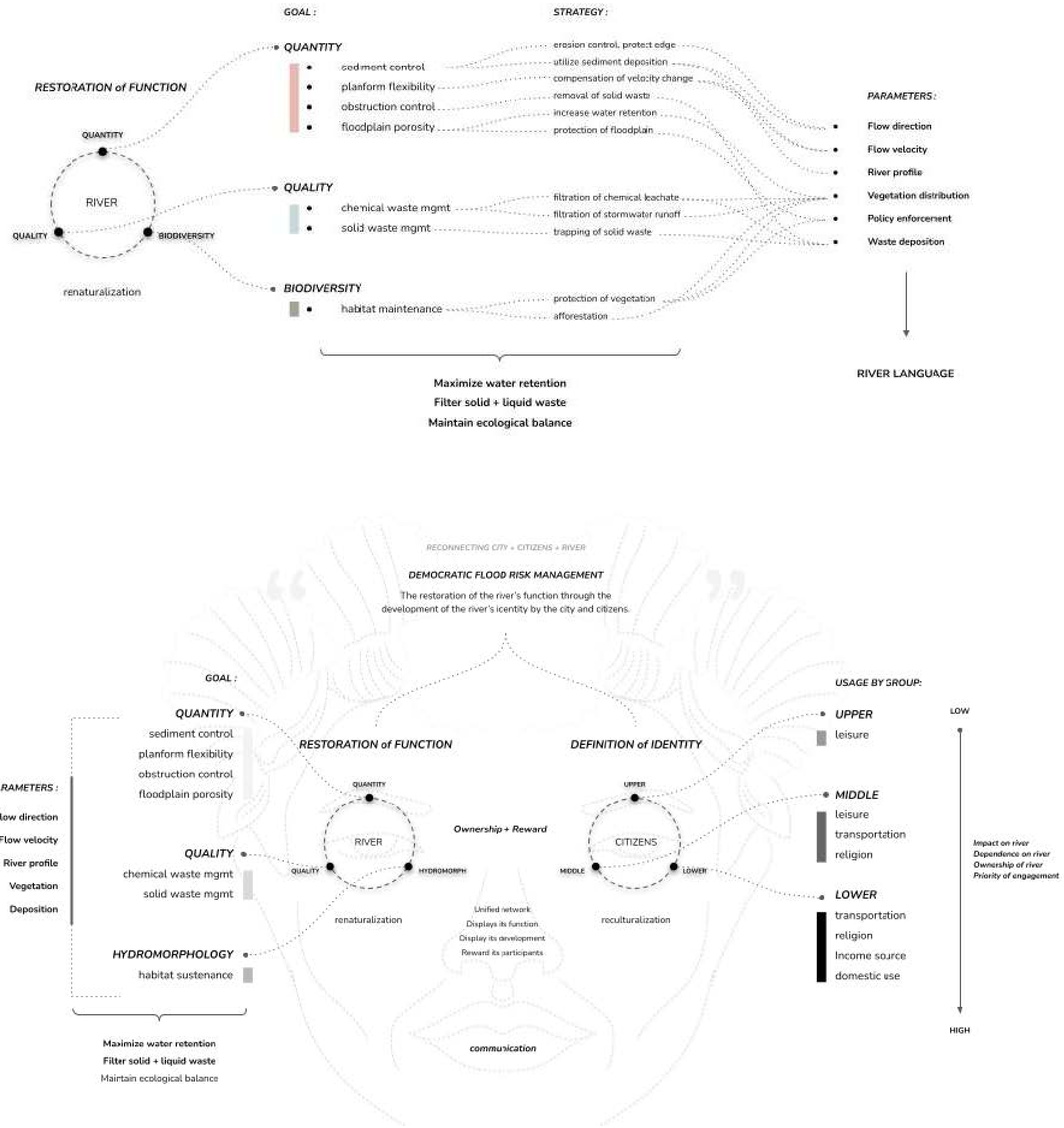


Figure 3:
Democatric flood risk management strategy

accommodate for changes in water discharge amount and velocity. The urbanization of Lagos has led to the solidification. The river needs to maintain its malleable edges in order to transform its planform. Using soft, natural solutions in and around the floodway is essential to maintaining the natural transformation of a planform.

c. Obstruction control is essential for allowing water to flow through a channel. If the channel is obstructed, water will accumulate and overflow, causing the surrounding areas to flood. Obstruction control not only refers to solid waste created by urban waste, but to solid organic matter such as branches and fibrous debris. Controlling obstruction in the floodplain will reduce obstructions in the floodway.

d. Floodplain porosity refers to the floodplain's capability of retaining water. The retention of water is dependent on factors such as the soil type, vegetation type and dispersal, as well as ground cover of the floodplain and surrounding environments. The floodplain needs to be able to maintain its water balance along with retaining incoming water from rain, surface runoff, and river overflow.

These parameters were chosen because they can be translated into a formal design that can then be implemented as a design strategy towards the renaturalization of the river. Controlling water quality, quantity, and hydromorphology in the river sustains a healthy ecosystem which in turn facilitates the renaturalization of the river.

4.1.2 - Reculturalization (deifying the river to create an identity)

Mami Wata, meaning mother of water, is a popular water deity that is known by most of the tribes in Nigeria. She controls the river and uses the water and ecology in order to reward or punish participants. The anger of Mami Wata can be expressed through the drying up of the river, the hunger of alligators, and flooding, while her affection can be expressed with the abundance of fish, the steady flow of fresh water, and lush vegetation. These expressions are indications of a river's health. The message is that man gives to the river, by taking care of it, and the river will give back to man by taking care of him.

The river must be reestablished as a living entity by creating a unified network that is able to directly display its function, display its development, and reward its participants.

What was once governed by a deity, today does not even have a name. Most of the rivers and waterways in Lagos have not been named due to the rapid growth of the city. The simple act of giving the rivers a name is a strategy towards deification and reconnection. Giving the waterways multiple forms of personification, such as deification and naming, can create a connection to the citizens in a manner that allows them to understand the river as a body and a living entity.

4.2 - Establishing a dialect using flows

4.2.2 - Mapping the hydrological processes of the waterway and

floodplain

Reconnection of the river means reconnection to the land itself. The river is essentially the bloodstream of the environment, as it delivers the nutrients and resources necessary for the development of life; flora and fauna. Understanding how this bloodstream is fed and distributed is essentially mapping the convergence and dispersal of water; pressure points and relief points. Pressure points are areas with high activities that can be used to implement high-impact solutions because they focus on extreme points rather than deploying solutions evenly through an environment. The pressure points are the starting point of intervention towards the location for implementing interventions for the quality, quantity, and hydromorphology goals in an optimal manner.

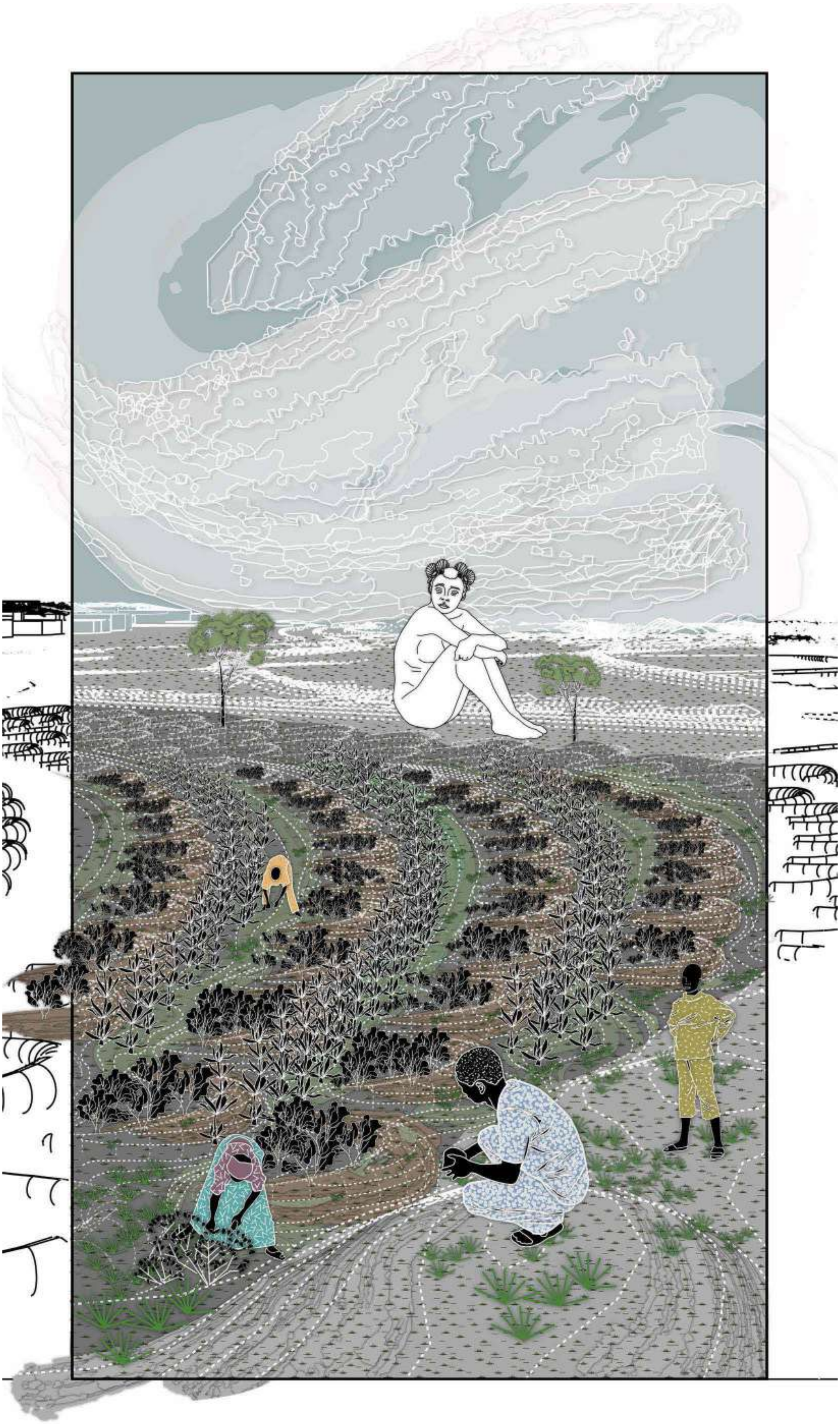
By giving a formal language to the series of water flows in the lateral direction, the floodplain, the pressure points can be identified well before they converge with the flows in the linear direction, the floodway. In order to do this, the hydrological process that constructs the floodplain needs to be understood. Typically, the floodplain can be split into zones; zone 0 being the floodway and zone 1, 2, and 3 being the flood fringes. In these zones, inland water needs to make it to the nearest floodway through runoff, infiltration and percolation, and interflow. As water flows, it has to make a decision; to infiltrate or to runoff, to percolate or to be absorbed, retained by soil and vegetation, to move forward into the next zone through interflow or to percolate downwards into the baseflow. Each of these forks in the roads decreases the time it takes for water to reach the floodway in zone 0. Currently, impermeable surfaces in and around the floodplain have hindered infiltration, thus decreasing percolation, interflow, and baseflow. The water has only one decision to make, to runoff surfaces and converge in the floodway, causing flooding; therefore, surface runoff becomes the major flow we need to map in order to identify our pressure points. This creates a silver lining because surface runoff, unlike percolating and interflow, is a visible process. It can be tracked and controlled using natural, low-cost, interventions that simply redirect runoff towards relief areas. This combination of retention, filtration, and distribution strategies are called micro-catchments.

05 - PROPOSAL

5.1 - Designing for bund microcatchments

Micro-catchments redirect runoff through surface alterations. Bunds are a type of micro-catchment that optimize surfaces by using coordinated mound formations to direct runoff, allowing water to infiltrate the ground before it reaches the floodway. They dismantle large quantities of water and maximize surface retention quality.

Bunds are composed of small mounds and barriers, surface alterations, that are able to divert surface runoff water coming from other catchments along with precipitation. They are able to reduce



the speed of water flow and allow it to flow on the ground surface in a manner that encourages infiltration and soil water absorption. The advantage of bund systems is that their effectiveness relies mostly on their location and general design. They do not require heavy specifications that leave a tight margin of error in order to be operable and can be used to divert runoff from areas with high peak runoff rates into areas with low peak runoff rates by simply creating a linear axis from and towards the high and low peak runoff area using the surface mound.

The system of bunds offers many design variations that can adhere to the distributive guidelines of the zones. While distribution is achieved through the geometric formation of the bund, retention is achieved through vegetation and ground cover. Vegetation also increases percolation as well as provides another avenue for water to travel, this is through the root system of the plant and eventually through evapotranspiration. As the water flows through each zone, it can pass through ground covers and vegetation that moves from a rapid absorption and percolation rate to a more gradual rate as it reaches the center of the zone, the retention point. This bund micro-catchment strategy essentially plots a land rehabilitation and flood mitigation scheme. This is the layered information that needs to be decentralized and democratized. It is crucial for this information to be visibly communicated to the community in order for them to carry out and further develop this strategy within their environment.

5.2 - Application and implementation strategy

How do we communicate these micro-catchment schemes that can maximize retention in heavy inundated areas, disperse and moderate flows in areas with high discharge velocities, create interventions that confront water quality issues before they reach the floodways, and most importantly, engage the community in the restoration of their environment?

This is where the city comes in as a platform of communication. The city has the opportunity to establish a formal language that serves as a guideline from catchment to catchment, using a spatial framework that communicates these schemes and can be populated by each community. Bunds are appropriate for this implementation because they are that visually simplistic.

Simplified geometries can be used to indicate the direction in which water needs to travel and the destination it is trying to reach. By demarcating pressure and relief regions using bund geometries, the city informs, “this is where water needs to go”, the citizens engage the implementation, and the water follows these directions. This partnership is the restoration and definition of the floodways and floodplains by the city and citizens.

Figure 4:
This is what we are talking about

In order to successfully execute this project, the implementation can be broken down into 3 phases. The first phase is dedicated towards identifying a pilot location and implementing the first bund framework. The community residing in the immediate environment must be engaged in the implementation of the bund framework. By educating a handful of stakeholders, the community is empowered to carry out further development and maintenance independently.

The second phase focuses on the development of multiple channels towards monitoring the health of a catchment area. Parameters such as solid waste amount, precipitation, water discharge amount, and even sedimentation can be recorded. The goal of recording is not necessarily to control these parameters, but to initiate the development of a digital environment that can learn and provide large scale environment analysis. The third phase focuses on the entire water network of the city. By implementation, the combination of data, and the development of a digital environment of Lagos, flood mitigation can be controlled at a level capable of relieving the city from disasterous scenarios.

06 - CLOSING

What if we changed our linear ideas of our impacts, acknowledging that we are an extension of our environment?

We'll find that as we exercise control that doesn't try to fight water, but invites it into a meeting place, we create temples for nutrients, flora and fauna that serve beyond the immediate region. As we find our place within this framework in a continuously changing landscape, We collectively build a body that exemplifies a strong social ecological connection between our immediate selves and our extended selves, our environment.

The communities and individuals that will benefit from this strategy are the ones that acknowledge the river, investigate its changes, and participate in the development of its new identity. Giving to the river, will give to the citizens, creating a narrative where function and identity are present not only in the environment, but in the culture.

This is democratic flood risk management.

This is the new dialogue between the city, the citizens and their water.

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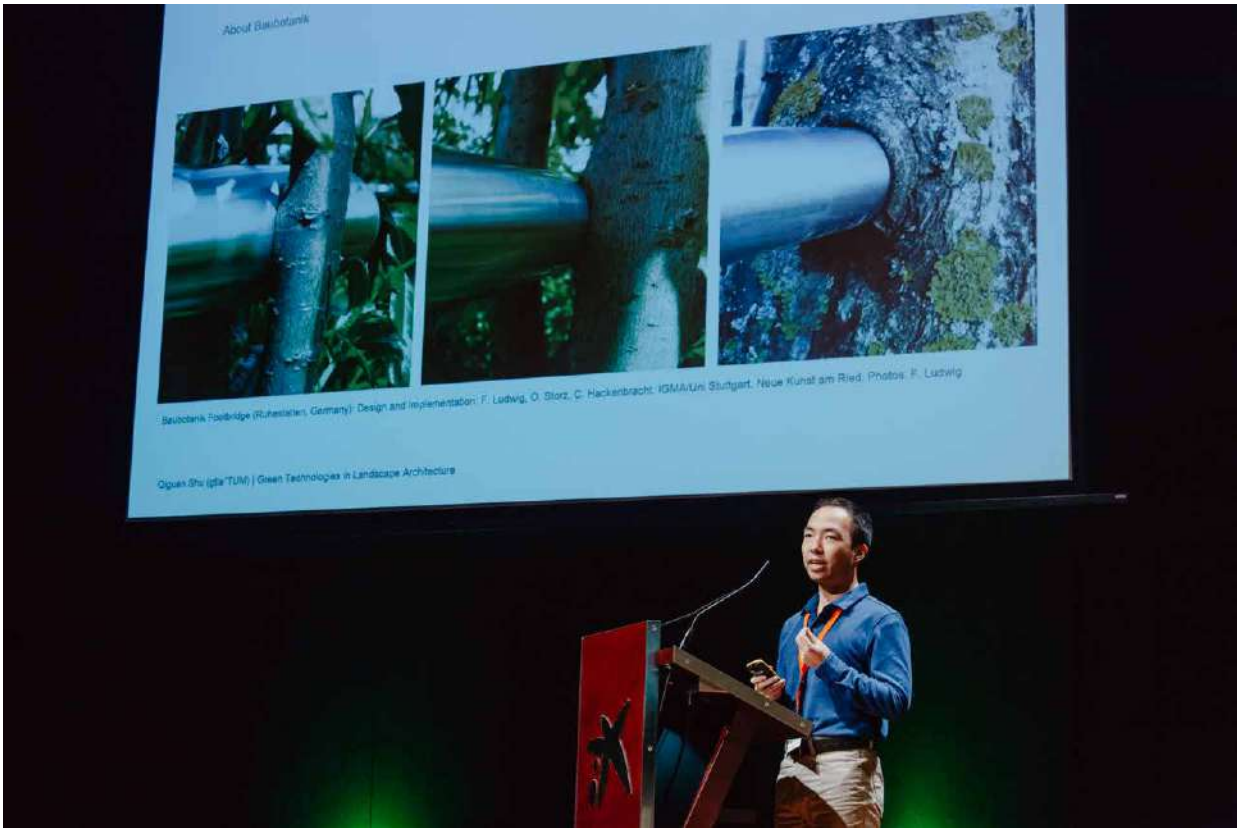
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PLANT & EDUCATE IN PORTO ALEGRE

Brazil

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KEYWORDS

Urban Agriculture, Resilience, Industrial Heritage, Social Reintegration, Vertical Farm

ABSTRACT

Plant&Educate in Porto Alegre is a project that develops an urban vertical farm combined with a restaurant-school and a republic for the reintegration of former homeless people in the 4th district of Porto Alegre. Urban agriculture (UA) is already known as a strategy for food security, bringing consumers closer to production, reducing costs with transportation and creating an environmental conscience. The urban vertical farm allies technology with more efficient and sustainable production. Moreover, this project also proposes to create a space of discussion regarding the environmental issues, climate change and the preservation of natural ecosystems. It is situated in the 4th District of Porto Alegre, the old industrial area of this Brazilian city that entered a degradation state after the departure of many factories in the 70's. Today the area has abandoned buildings and a wide socially vulnerable population. Therefore, it was chosen to intervene in a very characteristic lot, the old Wallig Stoves Factory deactivated in the 80's. Today we see the ruins of the sheds and the historical facades of 1921, which are considered historical heritage. This project aims to ally nature, quality food production, food security, technology and social support, generating jobs, offering training classes at low costs and temporary shelter for people without homes. In addition, it aims to have a close relationship with schools and the general public, creating an example of resilient food production. Finally, it was thought to be a democratic space with quality open areas that benefit the microclimate and the population.

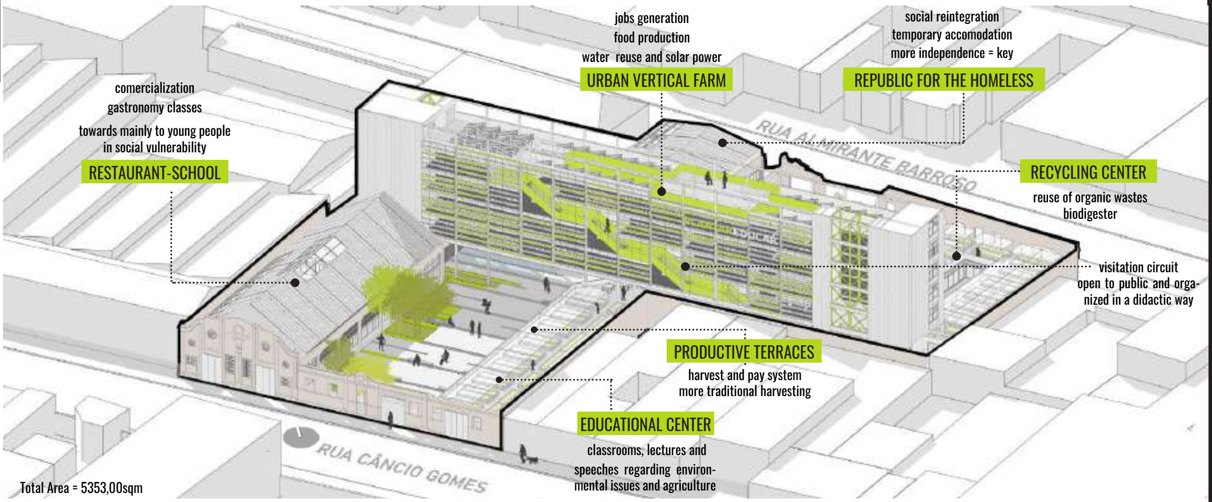
PLANT&EDUCATE IN PORTO ALEGRE

a new productive system for the old industrial dristrict

WHAT. This project will develop the program of an urban vertical farm combined with a restaurant-school and a republic for the reintegration of former homeless people in the 4th district of Porto Alegre. Urban agriculture (UA) is already known as a estrategy for food security, bringing consumers closer to production, reducing costs with transportation and creating an environmental conscience. The vertical farm is a modality of UA that uses technology to make production more eficient and sustainable. Moreover, this project also proposes to create a space of discussion regarding the environmental issues, climate change and the preservation of natural ecossystems. **WHERE.** This project is situated in the 4th District of Porto Alegre, the old industrial area that entered a degradation state after the departure of many factories in the 70's. Today it's noticed as place of abandonned buildings and a wide social vunerable population. Therefore, it was chosen to intervein in a very characteristic lot, the old Wallig Stoves Factory, it was deactived in the 80's and today it is perceived by the ruins of the sheds and the historical facades, that were project of the eclectic architect Theo Wiederspahn, in 1921. The buildings and facades are considered historical heritage within the city hall. **WHAT FOR.** The project aims to ally nature, quaility food production, food security, technology and social support. A percentage of production will be available for social vulnerable communities nearby, generating jobs, offering training classes at low costs and temporary shelter for people without homes. Beyond that, it aims to have a close relationship with schools and the general public, creating an example of a resilient food production. Finally, it is thought to be a democratic space with quality open areas that bring people togheter and benefit the microclimate.


CÂNCIO GOMES ST. INTERIOR VIEW
ALMIRANTE BARROSO ST. INTERIOR VIEW
CÂNCIO GOMES ST. FACADE
ALMIRANTE BARROSO ST. FACADE


ILLUSTRATIVE IMAGE | ALMIRANTE BARROSO ST. FACADE




01. EXISTENT OLD FACTORY STRUCTURES IN RUINS
02. DEMOLISH/BUILD MOST DETERIORATED STRUCTURES AND BUILD A DELIMITATION TO THE INTERVENTION
03. STRUCTURING FACADES AND PRESERVING THE ORIGINAL SPACIALITY
04. BASE CONCENTRATED IN THE BORDERS/ CONECTION OF STREETS/ DIFFERENT OPEN SPACES
05. BASE PRESERVATION OF THE FACADE'S SCALE

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

PE4POA

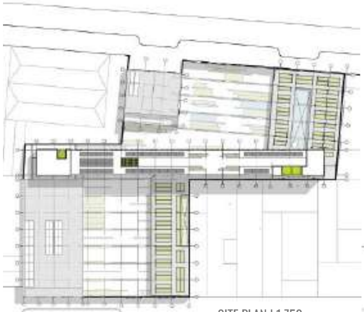
06. MAIN VOLUME BACKGROUND TO THE OLD BUILDINGS

07. MAIN VOLUME MODULATED BUILDING WITH STEEL STRUCTURE

08. ORGANIZATION MORE "TRADITIONAL" FUNCTIONS IN THE PRE-EXISTING BUILDINGS

09. ORGANIZATION AQUAPONIC FARM IN THE MORE VERTICAL VOLUME

10. VISITATION CIRCUIT THROUGH THE COMPLEX INFRASTRUCTURE



SITE PLAN | 1:750

01. REPUBLIC FOR THE HOMELESS
Ground floor - reception, living area, shared kitchen, storage, bike locker, accessible bedroom and bathrooms; 2nd floor - family, double and colective bedroom, studies area; 3rd floor - family, double and colective bedroom, studies area, colective garden, kitchen with barbecue uni.

02. RESTAURANT-SCHOOL
Ground floor - comercializing area, main kitchen, locker rooms, gas central, residual storage; 2nd floor - research area, comercializing area, classrooms.

03. STORES
Stores focused on sustainable and organic products.

04. EDUCATIONAL CENTER
Multipurpose spaces, classrooms, restrooms.

05. FARM BASE
Composting center, biodigester room, fish tanks, storage, charge-discharge.

06. PRODUCTIVE BUILDING (AQUAPONIC FARM)
Laboratories, production, sanitation areas, support areas, germination.

REPUBLIC 2nd FLOOR PLAN

GROUND FLOOR PLAN | 1:500

RESTAURANT-SCHOOL 2nd FLOOR PLAN PAVTO

REPUBLIC 3rd FLOOR PLAN

PRODUCTIVE BUILDING 3rd FLOOR PLAN

INTERIOR VIEW OF RESTAURANT-SCHOOL (GROUND FLOOR)

INTERIOR VIEW OF A RESTAURANT-SCHOOL'S CLASSROOM (2nd FLOOR)

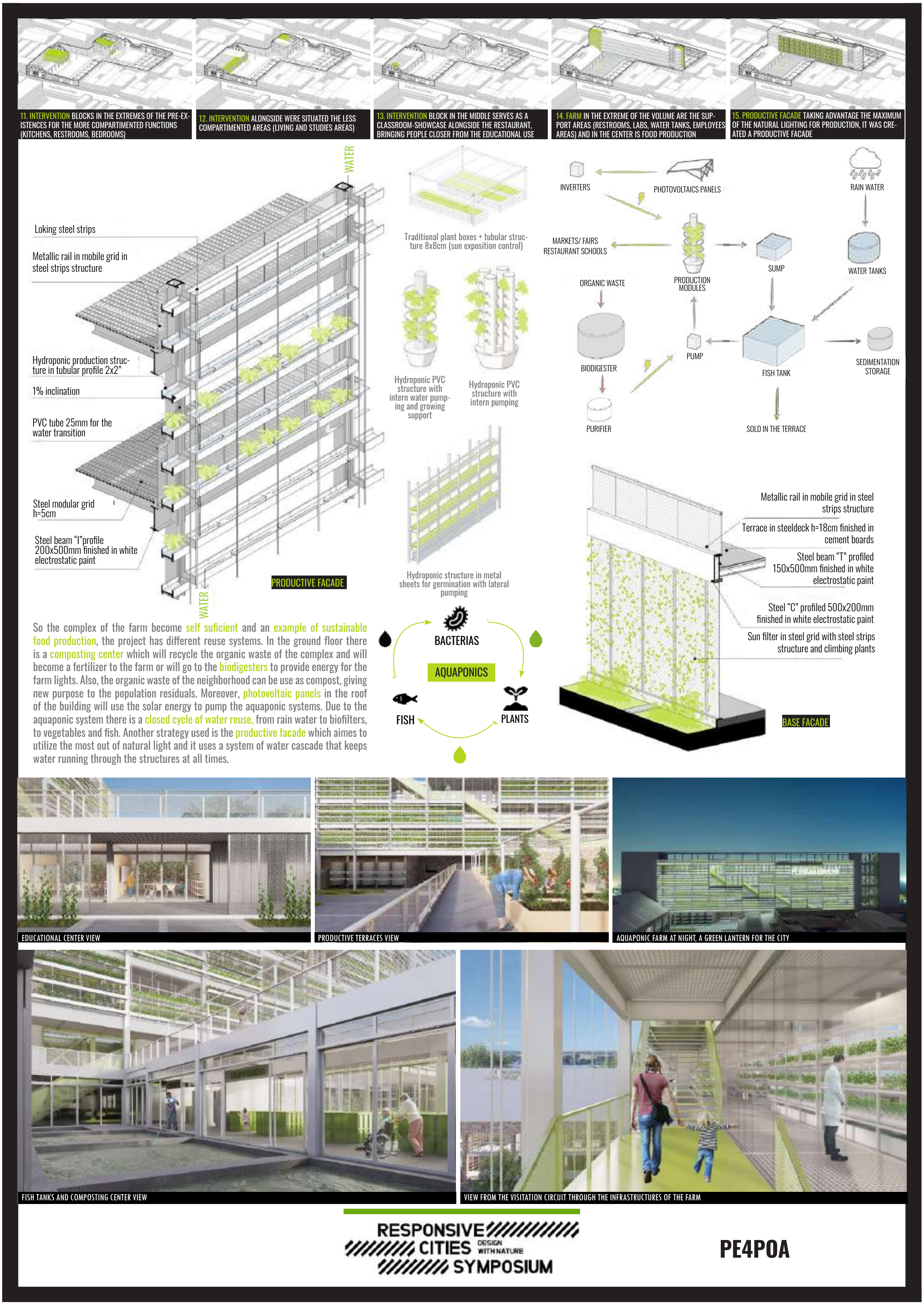
INTERIOR VIEW OF THE REPUBLIC FOR THE HOMELESS' COMMON AREA (GROUND FLOOR)

VIEW OF THE ARRIVAL FROM CANCIO GOMES STREET

VIEW OF THE ARRIVAL FROM ALMIRANTE BARROSO STREET

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

PE4POA



11. INTERVENTION BLOCKS IN THE EXTREMES OF THE PRE-EXISTENCES FOR THE MORE COMPARTIMENTED FUNCTIONS (KITCHENS, RESTROOMS, BEDROOMS)
12. INTERVENTION ALONGSIDE WERE SITUATED THE LESS COMPARTIMENTED AREAS (LIVING AND STUDIES AREAS)
13. INTERVENTION BLOCK IN THE MIDDLE SERVES AS A CLASSROOM-SHOWCASE ALONGSIDE THE RESTAURANT, BRINGING PEOPLE CLOSER FROM THE EDUCATIONAL USE
14. FARM IN THE EXTREME OF THE VOLUME ARE THE SUPPORT AREAS (RESTROOMS, LABS, WATER TANKS, EMPLOYEES AREAS) AND IN THE CENTER IS FOOD PRODUCTION
15. PRODUCTIVE FACADE TAKING ADVANTAGE THE MAXIMUM OF THE NATURAL LIGHTING FOR PRODUCTION, IT WAS CREATED A PRODUCTIVE FACADE
WATER
Loking steel strips
Metallic rail in mobile grid in steel strips structure
Hydroponic production structure in tubular profile 2x2"
1% inclination
PVC tube 25mm for the water transition
Steel modular grid h=5cm
Steel beam "I"profile 200x500mm finished in white electrostatic paint
PRODUCTIVE FACADE
WATER
Traditional plant boxes + tubular structure 8x8cm (sun exposition control)
Hydroponic PVC structure with intern water pumping and growing support
Hydroponic PVC structure with intern pumping
Hydroponic structure in metal sheets for germination with lateral pumping
INVERTERS
PHOTOVOLTAICS PANELS
RAIN WATER
MARKETS/ FAIRS RESTAURANT SCHOOLS
PRODUCTION MODULES
SUMP
WATER TANKS
ORGANIC WASTE
BIODIGESTER
PUMP
FISH TANK
SEDIMENTATION STORAGE
PURIFIER
SOLD IN THE TERRACE
Metallic rail in mobile grid in steel strips structure
Terrace in steeldeck h=18cm finished in cement boards
Steel beam "T" profiled 150x500mm finished in white electrostatic paint
Steel "C" profiled 500x200mm finished in white electrostatic paint
Sun filter in steel grid with steel strips structure and climbing plants
BASE FACADE
So the complex of the farm become self suficient and an example of sustainable food production, the project has different reuse systems. In the ground floor there is a composting center which will recycle the organic waste of the complex and will become a fertilizer to the farm or will go to the biodigesters to provide energy for the farm lights. Also, the organic waste of the neighborhood can be use as compost, giving new purpose to the population residuals. Moreover, photovoltaic panels in the roof of the building will use the solar energy to pump the aquaponic systems. Due to the aquaponic system there is a closed cycle of water reuse, from rain water to biofilters, to vegetables and fish. Another strategy used is the productive facade which aimes to utilize the most out of natural light and it uses a system of water cascade that keeps water running through the structures at all times.
BACTERIAS
AQUAPONICS
FISH
PLANTS
EDUCATIONAL CENTER VIEW
PRODUCTIVE TERRACES VIEW
AQUAPONIC FARM AT NIGHT, A GREEN LANTERN FOR THE CITY
FISH TANKS AND COMPOSTING CENTER VIEW
VIEW FROM THE VISITATION CIRCUIT THROUGH THE INFRASTRUCTURES OF THE FARM
RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM
PE4POA

REMODELLING AND SYMBIOSIS
China

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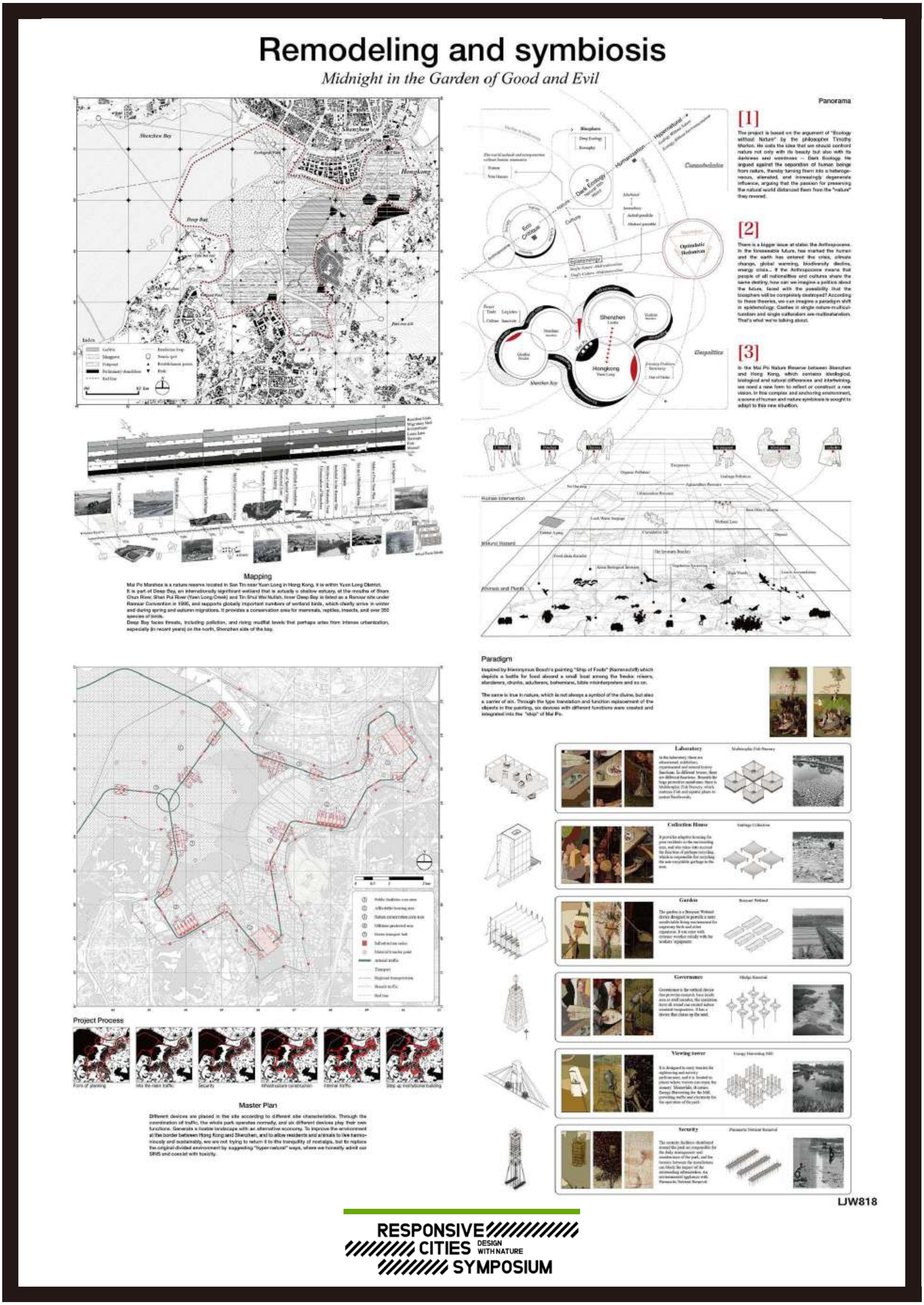
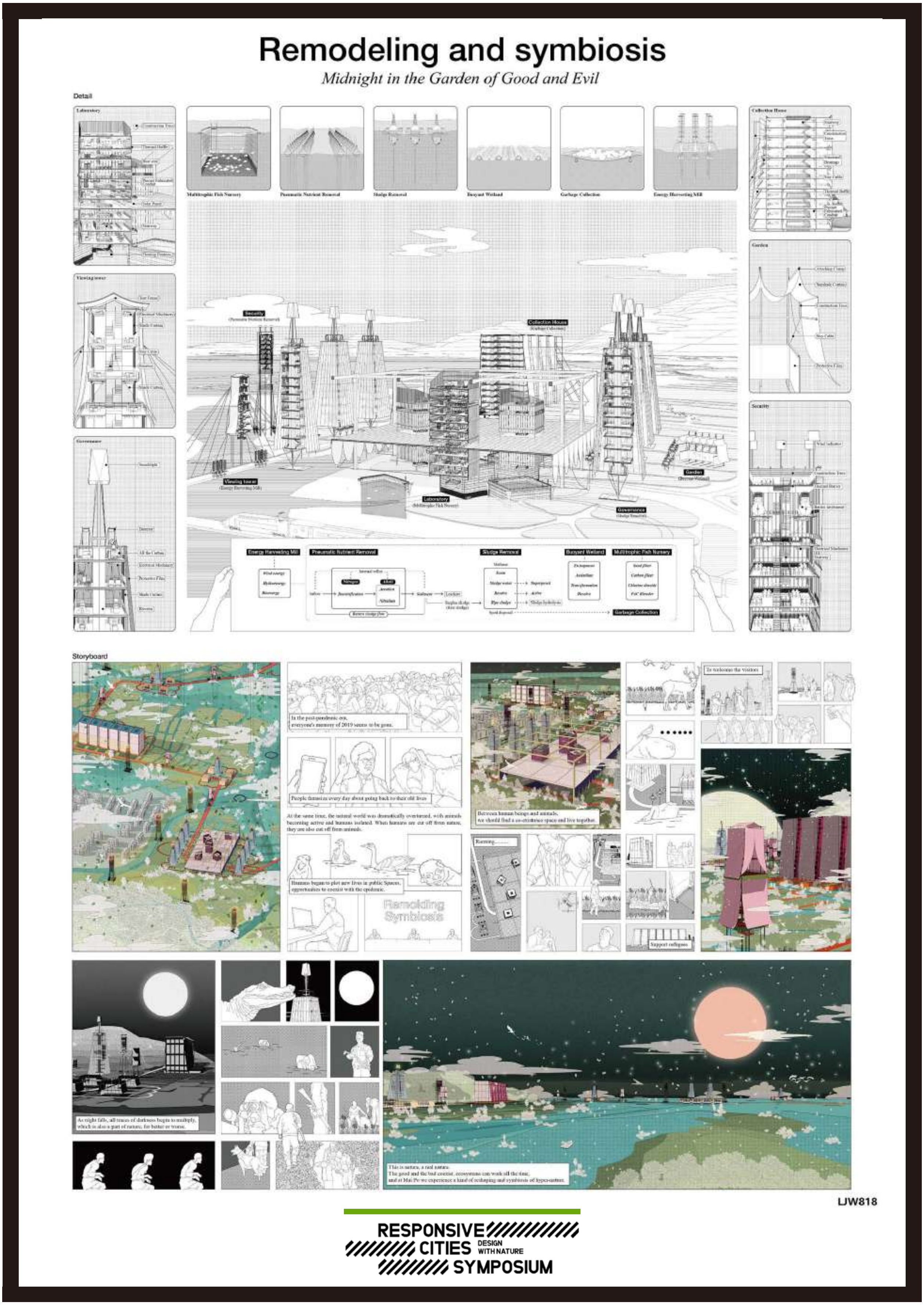
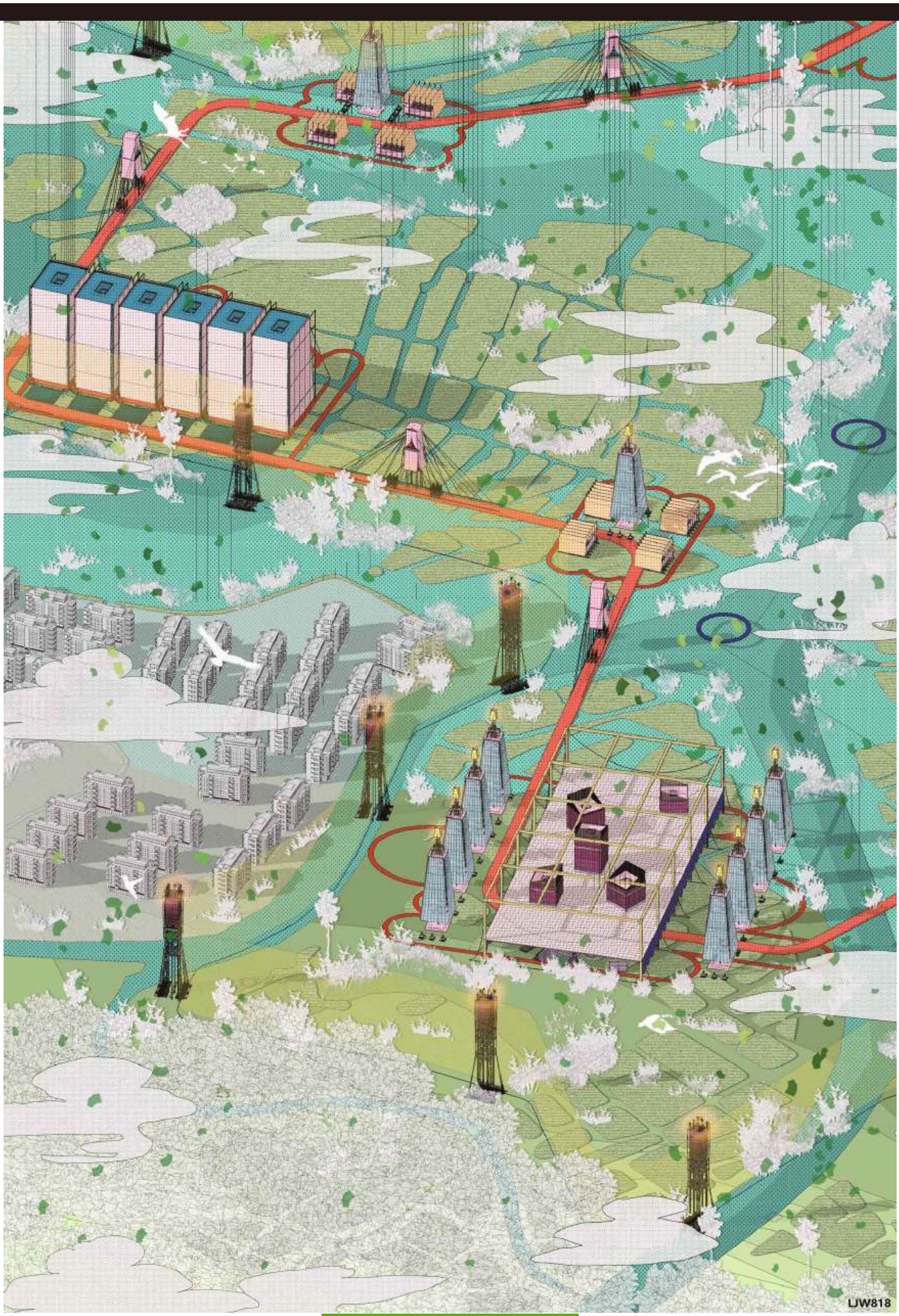
KEYWORDS
Dark Ecology, Local Construction,Inhabitable Landscape, Remodeling, Symbiosis

ABSTRACT
Timothy Morton, a philosopher at Rice University, argues that we must confront nature not just with its beauty, but also with its darkness and weirdness -- an idea he calls "Dark Ecology." The point of ecology is to "disenchantment" human load on nature's infinite significance, To restore nature itself and admit that "natural filth" is the real existence of the natural world. In fact, we are intimately connected to everything else. "Humans" as a complex combination of human and non-human, the world is not fixed on the human scale.

In Timothy Morton's philosophical view, we can observe that under the capitalist ideology, simple environmentalism forms a binary opposition relationship between nature and human beings, and separates human beings from nature. Now we need a new form to reflect or construct a new vision. Using Dark Ecology theory and local construction to create an Inhabitable Landscape for an Alternative Economy in Mai Po, Hong Kong. While improving the environment of the border between Hong Kong and Shenzhen, allowing residents and animals to live in harmony and sustainable development, we are not trying to return it to the tranquility of nostalgia, but by implying the "hyper-natural" to replace the original separated environment, where we honestly admit our SINS and coexist with toxicity. Remodeling and symbiosis reflect an ideal vision, but it is also about destroying nature/human dichotomy, changing and confronting the current narrow consumer culture and environmentalist view of nature, and representing a better form of ecological criticism in the post-pandemic era.


Remodeling and symbiosis
Midnight in the Garden of Good and Evil
Panorama
[1]
The project is based on the argument of "Ecology without Nature" by the philosopher Timothy Morton. He calls the idea that we should confront nature not only with its beauty but also with its darkness and weirdness — Dark Ecology. He argued against the separation of human beings from nature, thereby turning them into a heterogeneous, alienated, and increasingly degenerate influence, arguing that the passion for preserving the natural world distanced them from the "nature" they revered.
[2]
There is a bigger issue at stake: the Anthropocene. In the foreseeable future, has marked the human and the earth has entered the crisis, climate change, global warming, biodiversity decline, energy crisis... If the Anthropocene means that people of all nationalities and cultures share the same destiny, how can we imagine a politics about the future, faced with the possibility that the biosphere will be completely destroyed? According to these theories, we can imagine a paradigm shift in epistemology. Castles in single nature-multiculturalism and single culturalism are multinaturalism. That's what we're talking about.
[3]
In the Mai Po Nature Reserve between Shenzhen and Hong Kong, which contains ideological, biological and natural differences and intertwining, we need a new form to reflect or construct a new vision. In this complex and anchoring environment, a scene of human and nature symbiosis is sought to adapt to this new situation.
Shenzhen
Hongkong
Shenzhen Bay
Deep Bay
Dark Ecology
Eco Critique
Epistemology
Geopolitics
Human Intervention
Natural Hazard
Animals and Plants
Mapping
Mai Po Marshes is a nature reserve located in San Tin near Yuen Long in Hong Kong. It is within Yuen Long District. It is part of Deep Bay, an internationally significant wetland that is actually a shallow estuary, at the mouths of Sham Chun River, Shan Pui River (Yuen Long Creek) and Tin Shui Wai Nullah. Inner Deep Bay is listed as a Ramsar site under Ramsar Convention in 1995, and supports globally important numbers of wetland birds, which chiefly arrive in winter and during spring and autumn migrations. It provides a conservation area for mammals, reptiles, insects, and over 350 species of birds.
Deep Bay faces threats, including pollution, and rising mudflat levels that perhaps arise from intense urbanization, especially (in recent years) on the north, Shenzhen side of the bay.
Paradigm
Inspired by Hieronymus Bosch's painting "Ship of Fools" (Narrenschiff) which depicts a battle for food aboard a small boat among the freaks: misers, slanderers, drunks, adulterers, bohemians, bible misinterpreters and so on.
The same is true in nature, which is not always a symbol of the divine, but also a carrier of sin. Through the type translation and function replacement of the objects in the painting, six devices with different functions were created and integrated into the "ship" of Mai Po.
Laboratory
Collection House
Garden
Governance
Viewing tower
Security
Project Process
Security
Internal traffic
Master Plan
Different devices are placed in the site according to different site characteristics. Through the coordination of traffic, the whole park operates normally, and six different devices play their own functions. Generate a livable landscape with an alternative economy. To improve the environment at the border between Hong Kong and Shenzhen, and to allow residents and animals to live harmoniously and sustainably, we are not trying to return it to the tranquility of nostalgia, but to replace the original divided environment by suggesting "hyper-natural" ways, where we honestly admit our SINS and coexist with toxicity.
LJW818
RESPONSIVE
CITIES
DESIGN WITH NATURE
SYMPOSIUM


Remodeling and symbiosis
Midnight in the Garden of Good and Evil
Detail
Storyboard
LJW818
RESPONSIVE
CITIES
DESIGN WITH NATURE
SYMPOSIUM



RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

LIVING ARCHITECTURE: FORMULATING URBAN FARM SYSTEMS THROUGH NATURE BASED SOLUTIONS

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KEYWORDS

Urban Farm, Algae, mycelium Architecture, Circular Design, Bioplastics

ABSTRACT

'Living Architecture: Formulating Urban Farm Systems Through Nature Based Solutions' explores the potential for urban based farming systems designed and constructed by new technologies in conjunction with natural matter (Mycelium) and waste to tackle high levels of pollution in our environment. The proposed scheme sets out to eliminate waste through the implementation of a circular system that creates viable products (orange peel bioplastics planting pods) through the collection of waste to real time repurposing into new products through 3D printing pavilion towers. The scheme explores a new form of architecture- not one that is static and unresponsive, but one that is alive and growing, one that utilises natural resources, recognises and tackles pollutants.

The scheme will create a rich urban ecosystem, communicating flows of information from one tower to another, it will become a living membrane that will feed on our waste and in turn produce a living food system. The 3d printers constructed within the mycelium towers create proactive behaviours within the system by turning waste products and food waste into continued needs for the consumers, thus the consumer is supplying their own demand creating a sustainable urban system.

This proposal explores the implementation of future systems within the existing built environment in order to tackle widespread pollution. It allows us to face the realities of our waste and the effects it has on our environment by accepting that we demand, we use and we waste but we can also learn, we can create, we can heal.

black water getting treated in the sector through wetlands - providing nutrients for fish farming or compost for growing food. A relationship loop that contributes to resilience and environmental sustainability.

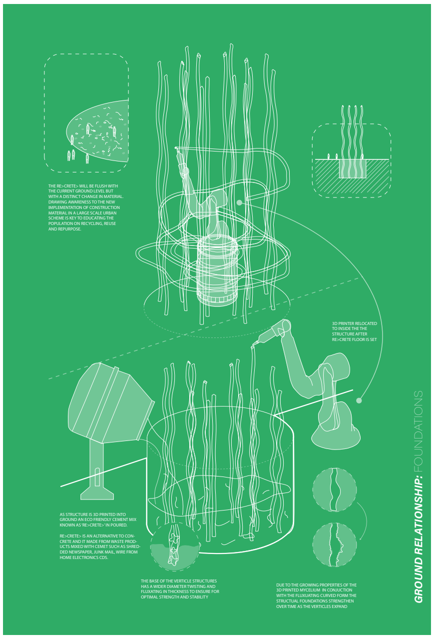
LIVING ARCHITECTURE: FORMULATING URBAN FARM SYSTEMS THROUGH NATURE BASED SOLUTIONS

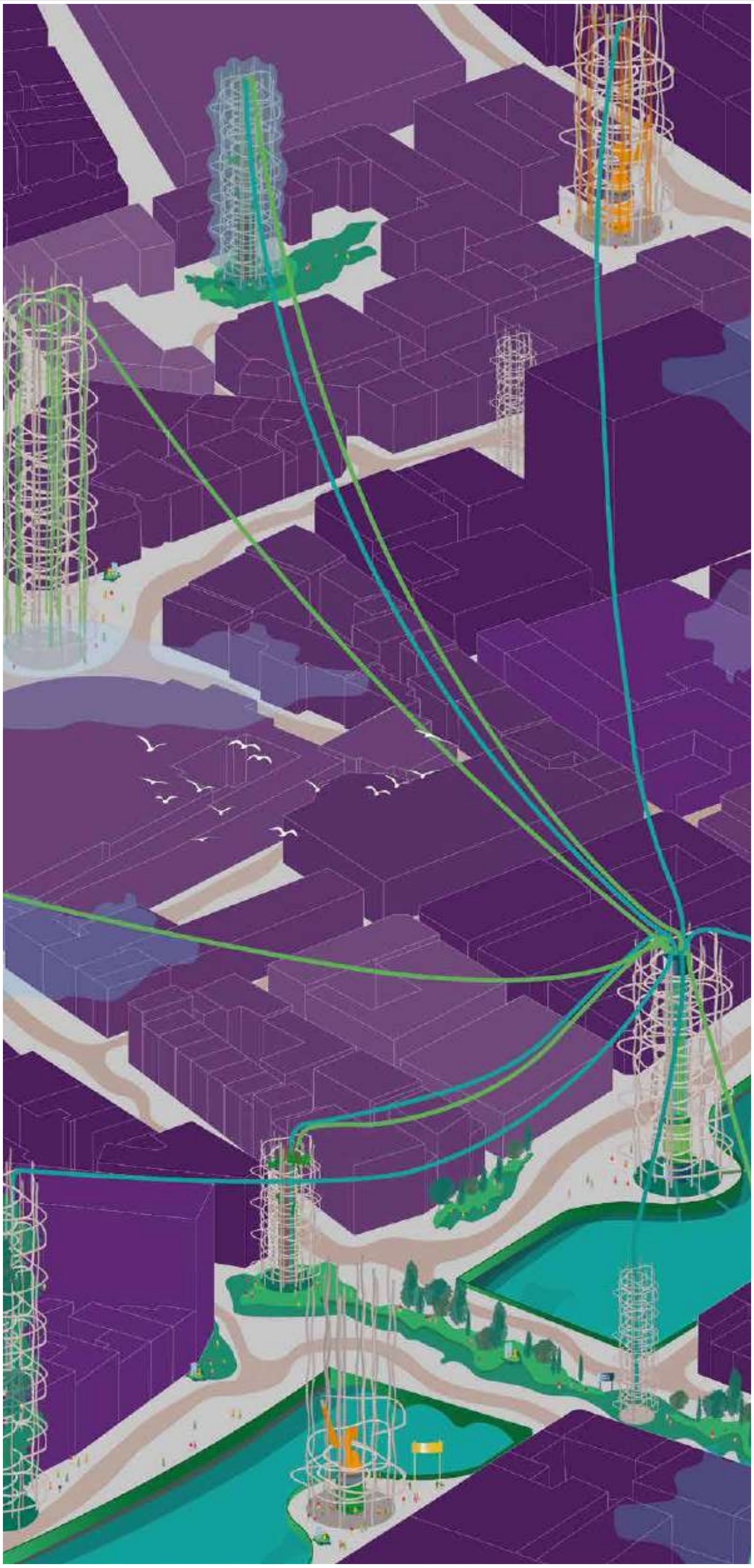
'Living Architecture: Formulating Urban Farm Systems Through Nature Based Solutions' explores potential for urban based farming systems designed and constructed by new technologies in conjunction with natural matter and waste to tackle high levels of pollution in our environment. The proposed scheme sets out to eliminate waste through the implementation of a circular systems that creates viable products/ food products. This proposal explores the use of new construction technologies through the use of robotics i.e.. 3D printing. Through this method new materials can be created, formed, and controlled with the use of computational design and BIM softwares. This scheme forces us to recognise our contribution to climate change by taking back our waste. Exploring the active environmentally positive properties from organically sourced building materials in collaboration with computational design and emerging technologies allows us to approach urban design in the right way. This proposal also aims to explore a new form of architecture. Not one that is static and unresponsive, but one that is alive and growing, one that utilises natural resources, recognises and tackles pollutants in the air. With a mixture of natural matter and technology not only can a new form be designed but a new urban system. This project offers a large scale urban solution to an even larger global problem with the key to the scheme being human interaction. This proposal delves into eradicating waste in the area that we produce it the most- our cities.
The scheme will create a rich urban ecosystem, communicating flows of information from one tower to another. It will become a living membrane that will feed on the waste of the land (our waste) and in turn producing a living food and product system. The living architecture of this scheme is its ability to react to its surrounding, the smart material uses allow the structure to clean the surrounding pollutants in the air. The 3d printers constructed within the towers create proactive behaviours within the system by turning waste products and food waste into continued needs for the consumers. Thus the consumer is supplying their own demand creating a sustainable urban system.

The large purple illustration (right of page) showcases the 'farming towers' in an urban setting (Dublin city centre), it represents the beginning of a new city life, one of health, healing, and education.

The black line drawing explores the twisting 3d printing mycelium structure of one vertical. The science behind this design is to encourage mycelium growth by creating dark moist areas within the structure, thus holding stronger air purifying properties.

The green drawing below begins to explore the Tower's ground relationship, how the mycelium will thrive and grow within the foundations to create a stronger structure with the use of REcrete materials.





RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

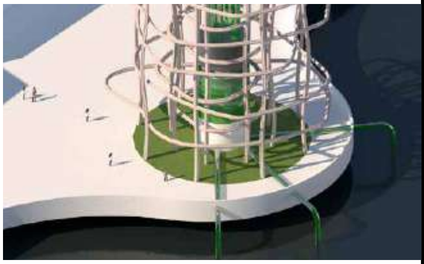
C0A9S5

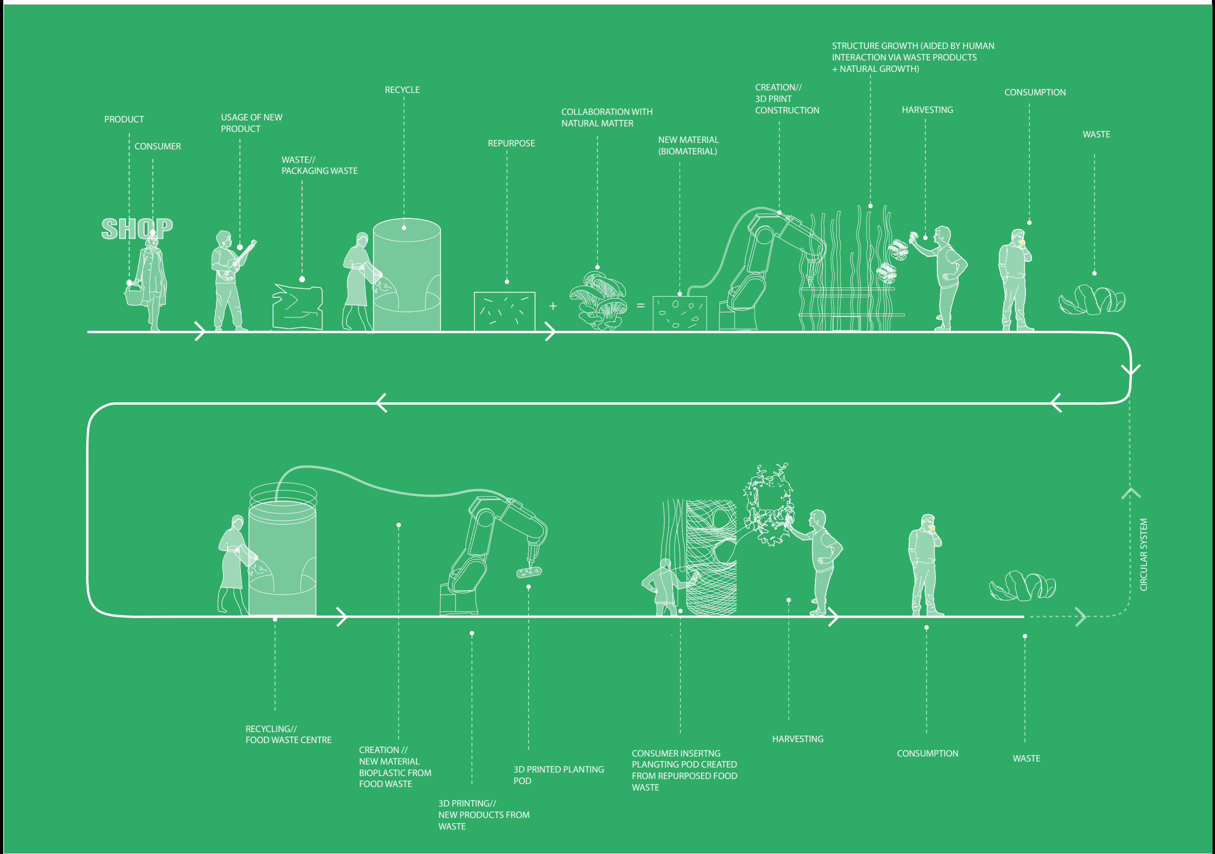
URBAN/ HUMAN INTERACTION

With the vast number of imports, the demanding consumer disregards the importance of supply and demand, and the realities of not appreciating how far a single piece of fresh fruit has travelled for them to buy, not use, and then throw away. The average household wastes 117kgs of food a year. When not disposed of properly the food waste goes to landfill and produces methene gas, a greenhouse gas that is 25 times more potent than co2 and a lot more harmful to human health. The food companies that supply these fresh produce follow strict guidelines so that the fruit and vegetables we purchase look good on the shelves, because we wouldn't purchase anything that doesn't look perfect as there may be something wrong with it, when in fact it's perfectly fine to consume. Our relationship with fresh produce can be uneducated. We must create a system where we understand the time, effort and resources that go into the growth of these produce and the cycle of what happens when left over food and food waste get disposed of. What would a system look like that eradicates food waste and tackles the co2 pollutants?

The render on the top half of this page illustrates the farming towers in an urban setting, showcasing fresh food farming towers to algae extraction towers which are used to fertilise crops in surrounding towers and contribute to the creation of healthy new food products.
The diagram below illustrates the process of integrating current consumer habits into the farming tower proposal showing of vital human interaction is in each stage of the scheme.

The implementation of a living system within an urban setting offers a new lifestyle concentrated around health for humans and our environment, it looks to natural resources that cause damage to our atmosphere and uses new technologies to repurpose them into useful matter. Out of sight out of mind behaviours can be no longer, this scheme allows us to face the realities of our waste and the effects it has on our environment by accepting that we demand, we use and we waste but we can also learn, we can create, we can heal. The use of modern robotic technological systems allows us to create intelligent systems through nature based solutions. Here we can create new living materials that react and proactively change our air qualities. We can design new product materiality through food waste and new construction materials through product waste.





RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

C0A9S5

STRUCTURE & MATERIALITY

The sourcing of building materials has arrived at a new milestone- sourcing from nature with the help of technology and design. we can no longer look to our traditional manmade production line of brick, concrete, and timber. we must explore the possibilities of 3D printing with reproposed 'shell nutrients' and food waste to creature strong structures that will last forever and if deconstructed can dissolve back into nature, both land and water. we can't afford to make any more non-biodegradable, chemical emitting materials that we bury within our planet once we are done with them. This proposal looks at creating living architectural structures that react to their surroundings, contributing positively to the environment.

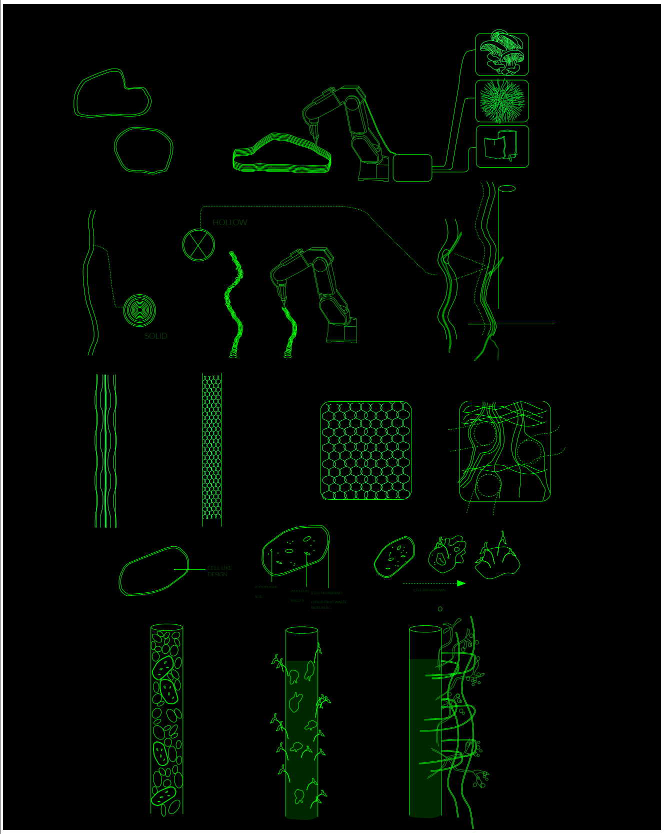
To further explore the design of my project I used 3d printing software to construct a physical model of my design. I began this process through visual coding design on Grasshopper where I was able to adjust height, thickness and radius of structure. I then brought the model into Sketch up to scale and explode components suitable for printing. This printing process took 8 hours and 42 minutes. I was then able to construct the components to make the Farming Tower. Here I was able to mimic the planting core were I planted and watered cress seeds.

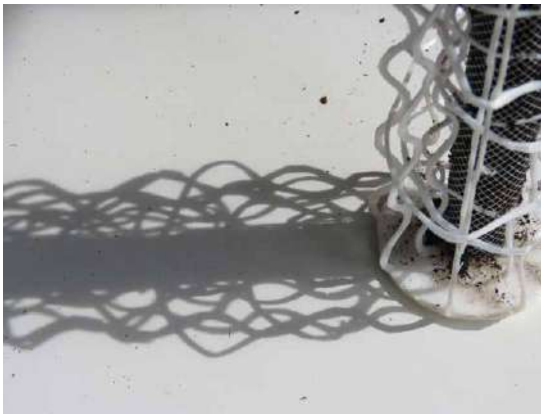
the primary use of the trunk like structure is to grow fresh produce. taking inspiration from the anatomy of trees through displacing the rings in shape and scale begins to shape a flexible scaffold structure allowing for maximum growth. The sensory system of plants allows them to search for surrounding forms to grow around. This design offers a range of alternative growth paths to encourage growth of plants. The illustration below explores the construction and growth of the mycelium towers.

Another element within this proposal looked at the smaller scale areas- but equally important. The creation of new nature based materials. The photographs to the right of this page showcase several first-hand experiments creating orange peel bioplastics. These material experiments were carried out to explore how easy it is to incorporate our food waste into new materials and repurpose them for use again. With the farming tower scheme this material would be 3d printed as a skin for 'planting pods' which when placed in the core of the towers would eventually open up releasing the seeds to allow for controlled growth whilst aiding plant health with no waste.

To build with materials that have active environmental positive properties is a growing sector within the design and the built environment. Designers, researchers and architects explore the possibilities of new material construction through 3d printing organic matter and applying these to structural designs.

This proposal explores the implementation of future systems within the existing built environment in order to tackle widespread pollution. I propose a nature-based solution crossed with new robotic technologies to create a zero waste co2 free lifestyle.





RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

C0A9S5

SVA: A VISION OF SELF SUSTENANCE

India

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KEYWORDS

Sva, Self-Sustainable, Nature-based solutions, City for all, SDGs

ABSTRACT

Cities contribute more than 70% of the world's CO2 emissions. Cities have a long flow network which contributes the most to the Co2 emissions. Systems like Wastewater treatments, Solid waste to landfills, food supply, energy production and many more depend on a long supply chain and non-sustainable industrial methods, and these are the major leaders in the environmental degradation in and around the cities. While I understand the need for these city-level systems, I think there is a need to look at more stable, short and local networks that can reduce the overall carbon footprint.

So, my bold vision is to integrate nature-based living systems into the everyday life of the people and design an ideal sector that is self-sustainable. My design premises include:

1)Food

2)Water

3)Energy

4)Waste

5)Biodiversity

In Ideal Sector each household has their own productive landscape which includes a compost pit, farms and solar panels whereas on the sector scale it has food towers that could cater to the overall need for food in the sector. This sector also has its own systems which are interconnected and interdependent on the citizens of the sector where imagine, instead of waste going to landfill, it becomes the input for farms. Instead of Greywater from households going to STPs begin to feed into bioswales around the street and recharge groundwater. Imagine black water getting treated in the sector through wetlands - providing nutrients for fish farming or compost for growing food. A relationship loop that contributes to resilience and environmental sustainability.

Sva:
A vision of self-sustenance

'Growing your own' by nature based solutions- norms for food, energy, Waste and biodiversity

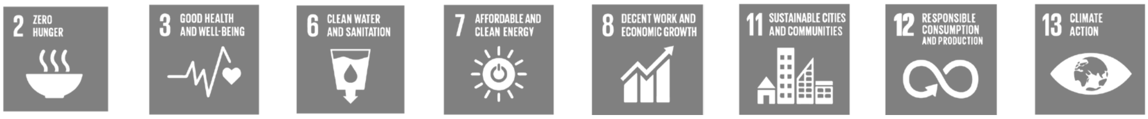
Cities contribute more than 70% of the world's CO_2 emissions. Cities have long flow network which contributes the most to the Co_2 emissions. Systems like Wastewater treatments, Solid waste to landfills, food supply, energy production and many more depend on a long supply chain and non-sustainable industrial methods, and these are the major leaders in the environmental degradation in and around the cities. While I understand the need for these city-level systems, I think there is a need to look at more stable, short and local networks that can reduce the overall carbon footprint.

So, my bold vision is to integrate living systems in the urban enviroment and combine it in the everyday life of the people. To design an ideal sector that is totally self-sufficient, only include nature base solutions and defies the existing long supply chain systems in the cities. My design premises include:

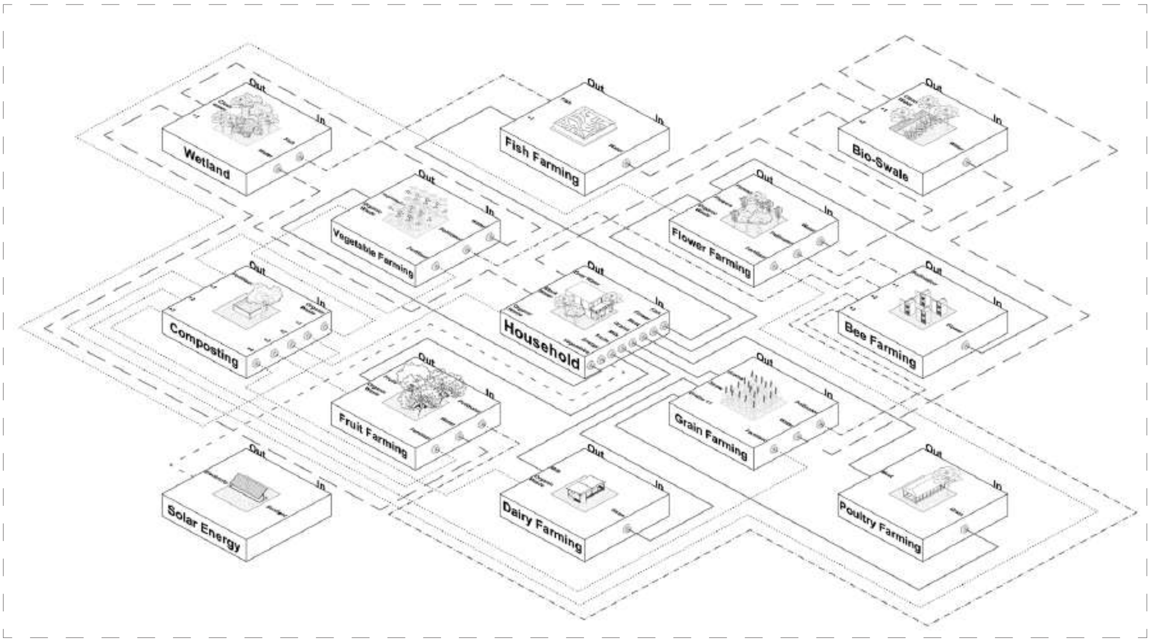
1)Food 2)Water 3)Energy 4)Waste 5)Biodiversity

In Ideal Sector each household has there owned productive landscape which includes compost pit, farms and solar panels whereas on the sector scale it has food towers that could cater to the overall need for food in the sector. This sector also have its own systems which are interconnected and interdependent on the citizens of the sector where imagine, instead of waste going to landfill it becomes the input for farms. Instead of Greywater from households going to STPs begin to feed into bioswales around the street and recharge groundwater. Imagine black water getting treated in the sector through wetlands - providing nutrients for fish farming or compost for growing food. A relationship loop that contributes to resilience and environmental sustainability.

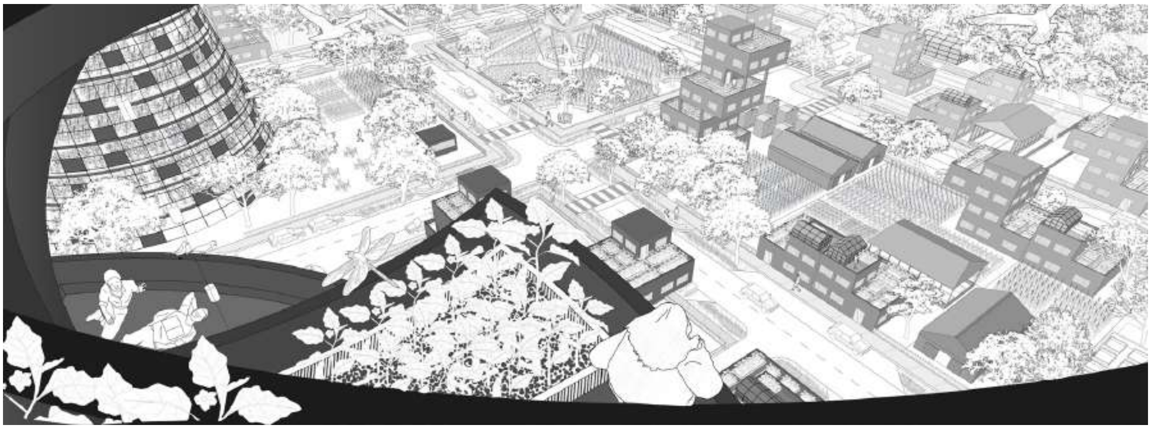
// Catered SGDs //



// Self-sustenance system diagram //



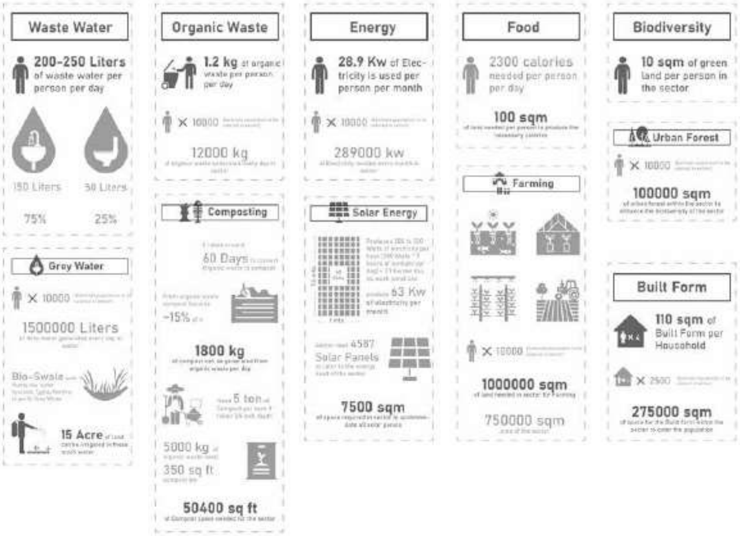
// View to Sector - from highrise building //



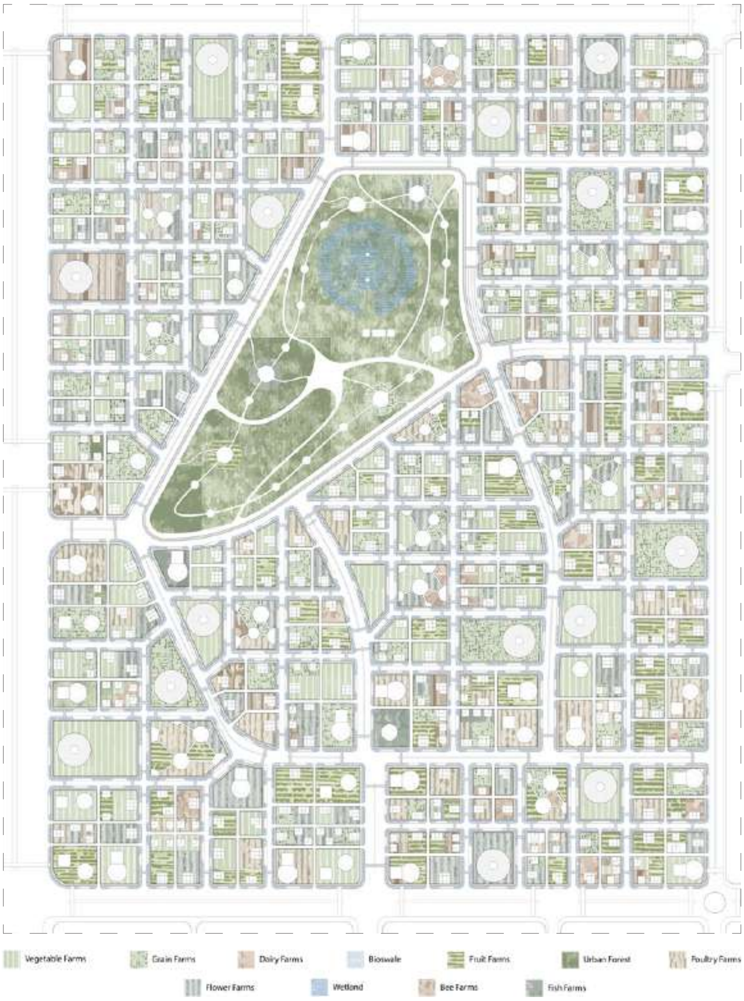
RESPONSIVE CITIES SYMPOSIUM DESIGN WITH NATURE

SON008

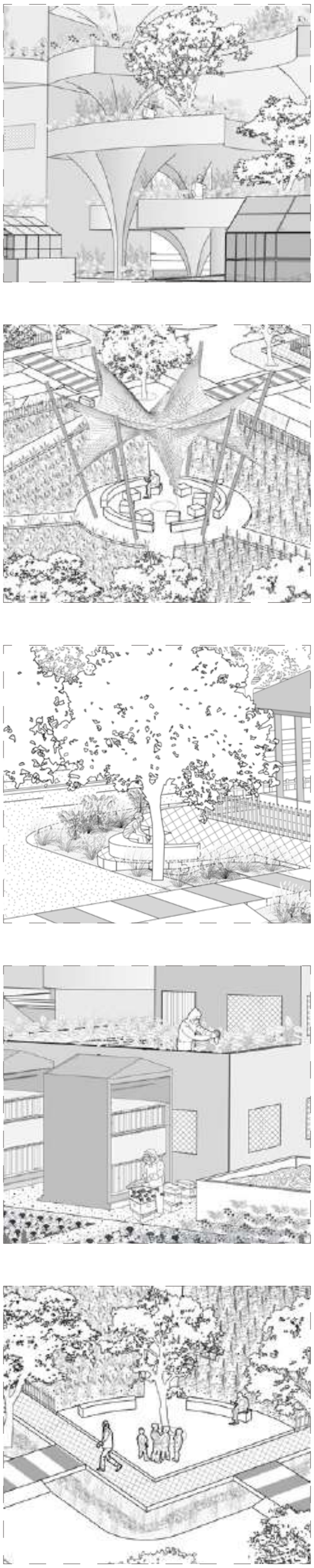
// Calculations for Self-Sustenance //



// Plan for Self-Sustenance //



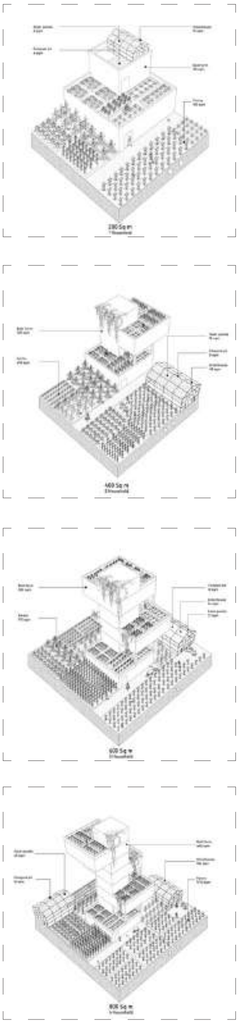
// Everyday life in sector //



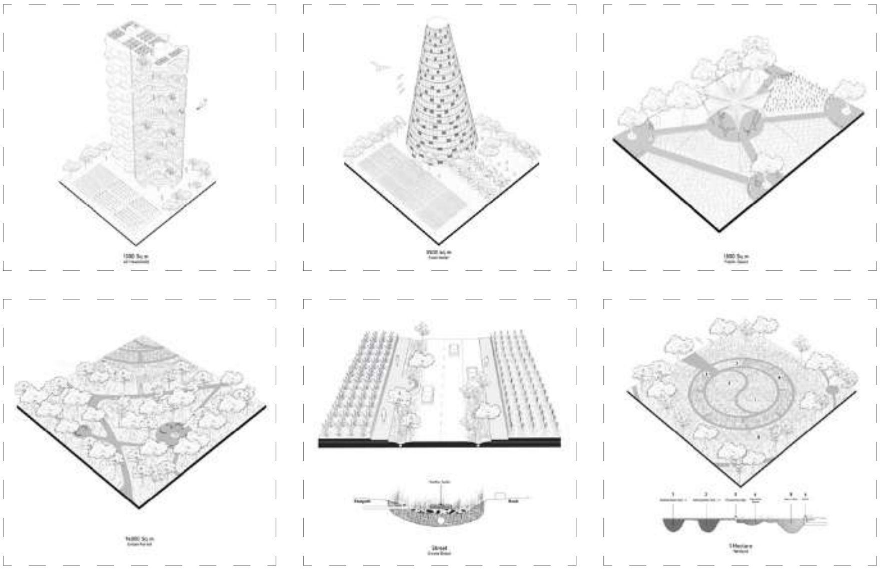
RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

SON008

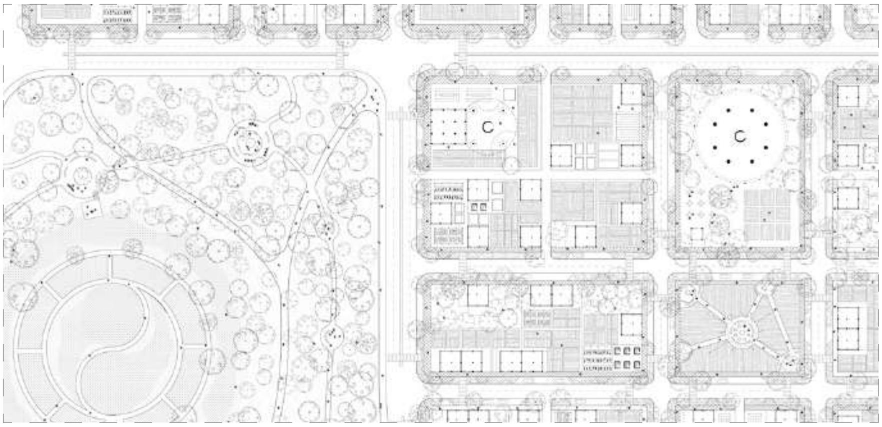
// Household Typologies //



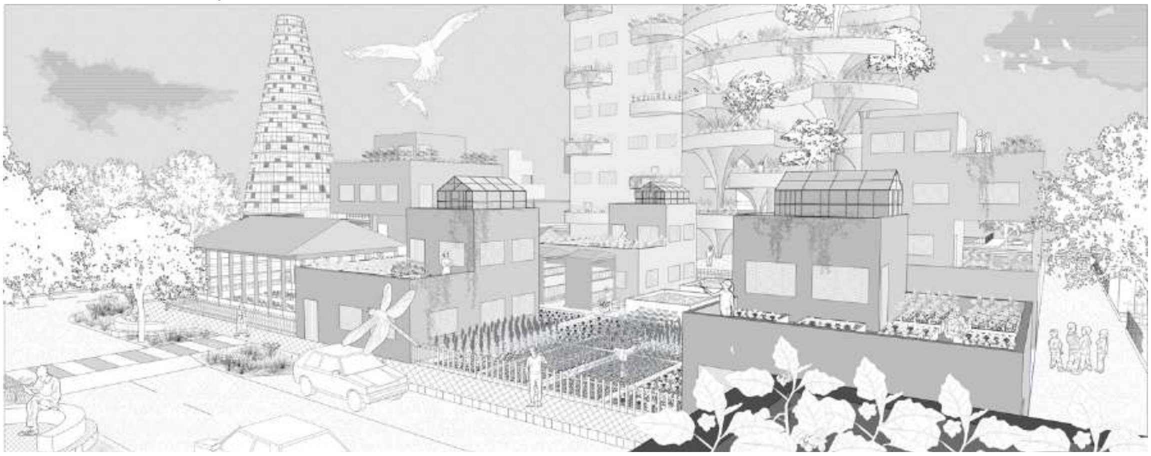
// Kit of parts //



// Part plan - Living Systems //



// View to Sector - from balcony //



This proposal aims to integrate living systems in the everyday life of the people in the city. Where you can see the housing typologies with farming areas, food towers, wetlands and forests as leisure spaces for citizens. An environment where barter system and community dining is an everyday thing. Where seeing and living with other beings is as normal as the outer greens of the city. And to me, **this defines the next century's urban living where you have food security and access to nutrition at your doorstep and not just for humans but for other beings as well.**

SON008

BAIRA - FLOATING GARDENS

Bangladesh

Anahita Jafar Abadi & Florian Opitz

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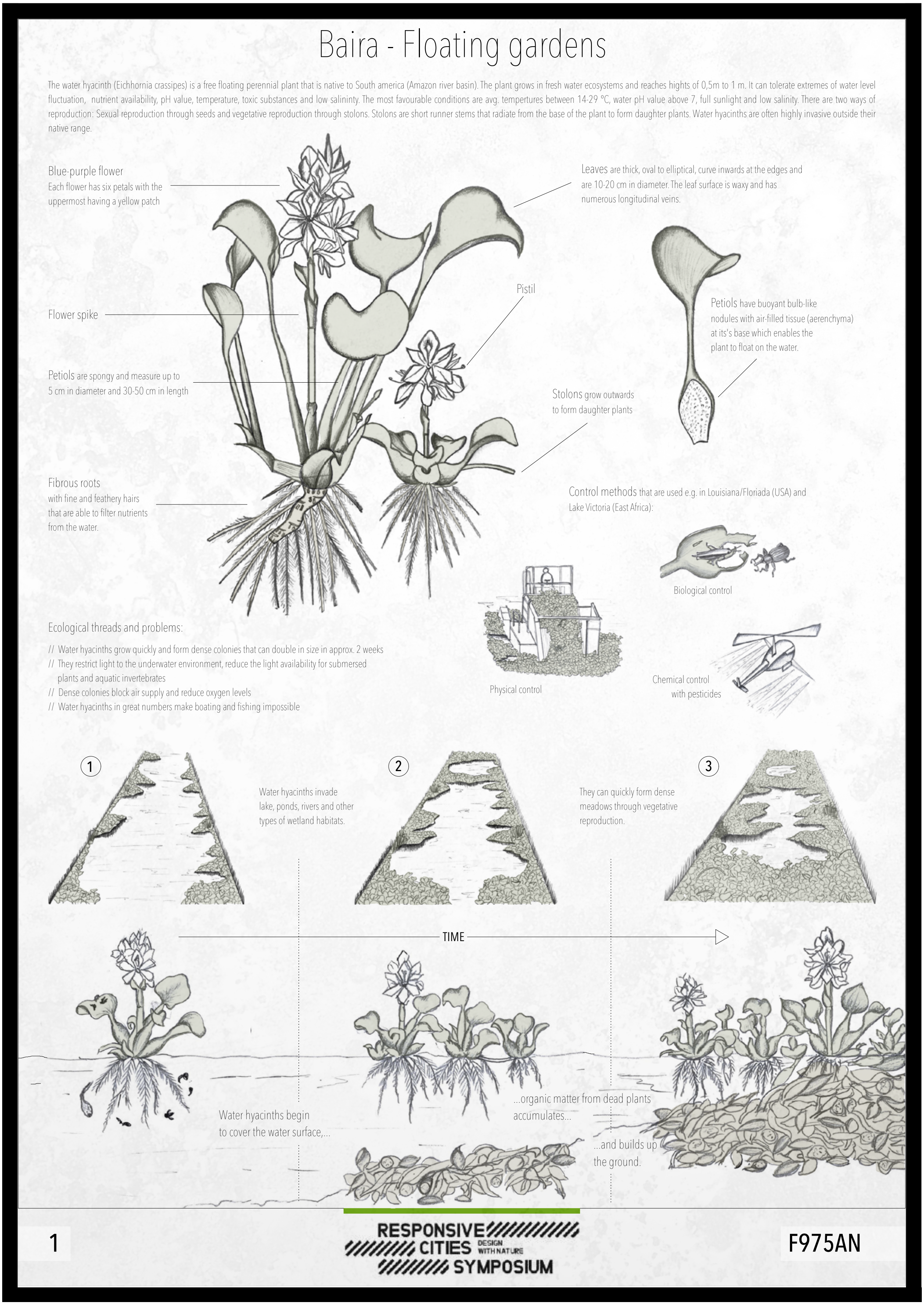
KEYWORDS

Floating Gardens, Traditional Ecological Knowledge (TEK), Bangladesh, Water hyacinth, Repurpose

ABSTRACT

Flooding is the norm in Bangladesh. During the monsoon and typhoon season, flooding occurs for as long as 8 months a year and makes farming very challenging. From these circumstances the technique of building Floating Gardens, called Bairas, emerged 300 to 400 years ago in the south of Bangladesh. By using layers of water hyacinths, farmers are able to build Floating Gardens which allow them to be independent of their farmland and grow vegetables and more during flooding.

This project explores the traditional ecological knowledge of the construction process of Bairas and focuses especially on the building material, the water hyacinth. Water hyacinths are highly invasive and can quickly form dense colonies that cover lakes and streams and greatly alter their biological function and usability. Therefore a common practice is to control their spread through physical, biological or chemical interventions, for example through the application of pesticides. Using water hyacinths as a resource by building floating rafts out of them opens up a whole new perspective. Suddenly their rapid production of biomass which is commonly perceived negatively turns into an great advantage and provides even more possibilities: Water hyacinths can help to clean water, woven together into rafts they provide habitat for birds and aquatic life, they can be used as a resource to generate biogas, as feedstock, weaving material or for land reclamation and erosion protection.

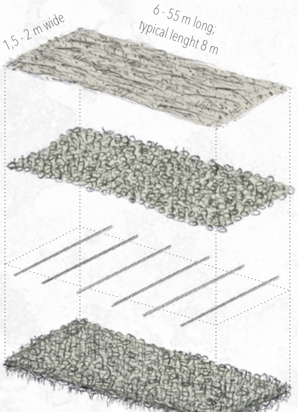


Baira - Floating gardens
The water hyacinth (Eichhornia crassipes) is a free floating perennial plant that is native to South america (Amazon river basin). The plant grows in fresh water ecosystems and reaches hights of 0,5m to 1 m. It can tolerate extremes of water level fluctuation, nutrient availability, pH value, temperature, toxic substances and low salininty. The most favourable conditions are avg. tempertures between 14-29 °C, water pH value above 7, full sunlight and low salinity. There are two ways of reproduction: Sexual reproduction through seeds and vegetative reproduction through stolons. Stolons are short runner stems that radiate from the base of the plant to form daughter plants. Water hyacinths are often highly invasive outside their native range.
Blue-purple flower
Each flower has six petals with the uppermost having a yellow patch
Leaves are thick, oval to elliptical, curve inwards at the edges and are 10-20 cm in diameter. The leaf surface is waxy and has numerous longitudinal veins.
Pistil
Flower spike
Petiols have buoyant bulb-like nodules with air-filled tissue (aerenchyma) at its's base which enables the plant to float on the water.
Petiols are spongy and measure up to 5 cm in diameter and 30-50 cm in length
Stolons grow outwards to form daughter plants
Fibrous roots
with fine and feathery hairs that are able to filter nutrients from the water.
Control methods that are used e.g. in Louisiana/Floriada (USA) and Lake Victoria (East Africa):
Biological control
Physical control
Chemical control with pesticides
Ecological threads and problems:
// Water hyacinths grow quickly and form dense colonies that can double in size in approx. 2 weeks
// They restrict light to the underwater environment, reduce the light availability for submersed plants and aquatic invertebrates
// Dense colonies block air supply and reduce oxygen levels
// Water hyacinths in great numbers make boating and fishing impossible
1
Water hyacinths invade lake, ponds, rivers and other types of wetland habitats.
2
They can quickly form dense meadows through vegetative reproduction.
3
TIME
Water hyacinths begin to cover the water surface,...
...organic matter from dead plants accumulates...
...and builds up the ground.
1
RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM
F975AN

Baira - Floating gardens

Flooding is the norm in Bangladesh. During the monsoon and typhoon season flooding occurs for as much as 8 months a year and makes farming on land mostly impossible. Adding to that a lot of areas are still waterlogged even when the floods recede. From these circumstances the technique of building floating gardens, called "baira", emerged 300 to 400 years ago in the south of Bangladesh, most common in the districts Gopalganj, Pirojpur and Barisal. In this way farmers are not dependant on dry land anymore. This page explores how bairas are made and what use they have in the local culture.

1



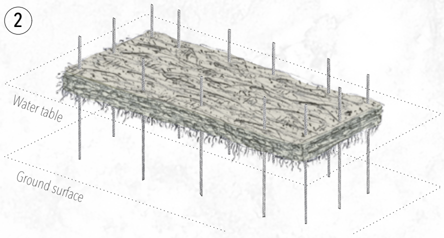
A top layer is spread over the raft. It can consist of soil, cow dung, compost, coconut husk etc.

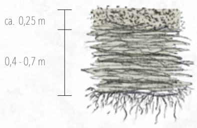
In intervals of 8 to 10 days more layers of water hyacinth are added

Bamboo rods stabilise the raft in this phase and are removed later

Water hyacinths (*Eichhornia crassipes*) are gathered and compacted into raft

2



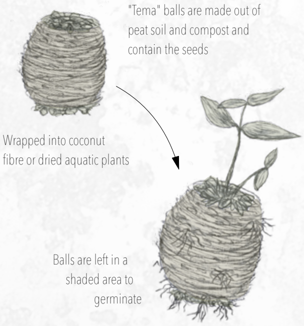


The "baira" is anchored by sticking bamboo poles around it into the ground

Then the construction is allowed to rot for 15-30 days in the water to release nutrients as a preparation for growing crops on it

5 Vegetables are harvested and serve as food for the family or is sold at floating markets

3 Prepararing the seedlings:



"Tema" balls are made out of peat soil and compost and contain the seeds

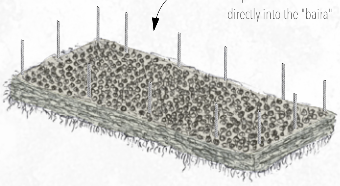
Wrapped into coconut fibre or dried aquatic plants

Balls are left in a shaded area to germinate

4

After 7 days when the seedlings are big enough they are planted on the raft

Some plants are also sawn directly into the "baira"



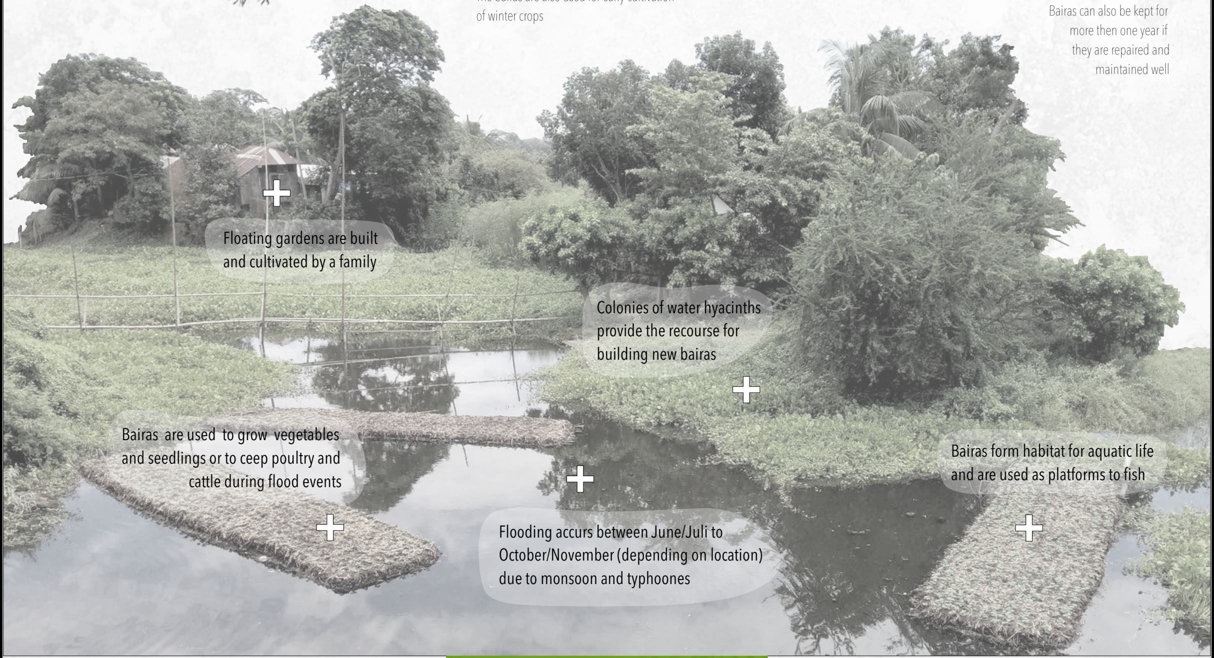
Plant species:
Cauliflower, tomato, okra, bitter/snake gourd, spinache, tumeric, ginger, beans, eggplant, carrots, radishes, squash, (red) amaranth, pumpkin etc.

The bairas are also used for early cultivation of winter crops

6 Late autumn when floodwater recedes:

Bairas are either broken up and used as a fertiliser for growing wintercrops like turnip, cabbage, cauliflower, tomato, red amaranths etc.

Bairas can also be kept for more then one year if they are repaired and maintained well



2

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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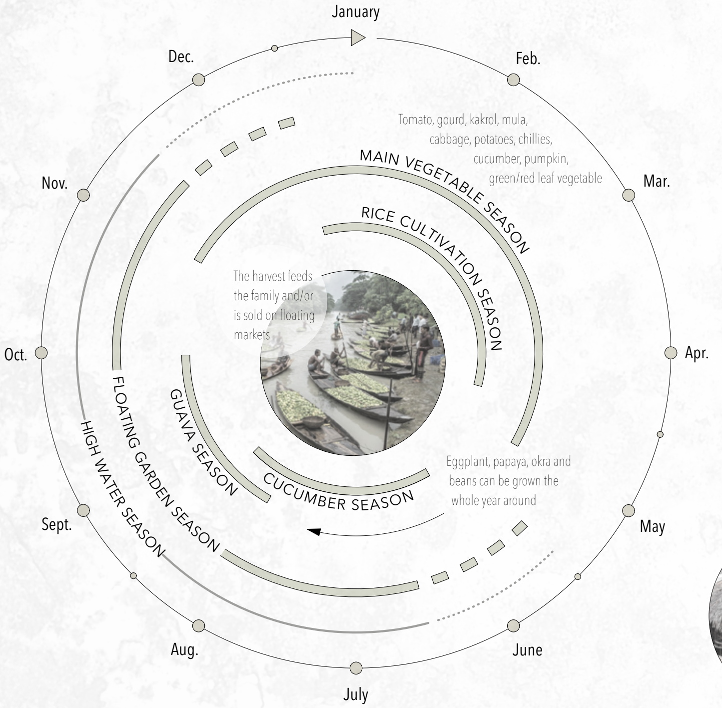
Baira - Floating gardens

The seasonal farming cycle in the Barisal district in southern Bangladesh is very diverse. The upper part of the page shows how the year and life of the people is influenced by the high and low water season. The down part of the page explores possible applications of the concept of the floating gardens in different contexts and possible uses of the water hyacinth in general. The aim is to show the positive aspects of this plant when invasion has already happened as an antithesis to the control methods that are shown on page one.



Floating gardens from above

The economy in southern Bangladesh is based on farming and fishing.

Bangladesh is criss-crossed by rivers like in the Barisal district, which lies in the delta of the Padma (Ganga) and Jamuna river. Due to the regular flooding floating gardens are a strong part of the local culture.

Rice farming

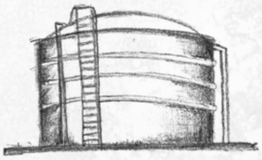
Flooded village

In the Barisal district, flooding occures 2-4 times a year, submerging 30-50 % of the villages and staying 3-10 days in the houses. Every few years "abnormal" floods take place where 100 % of the villages are under water and building and roads are destroyed.

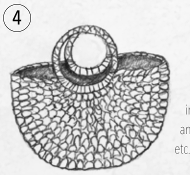
(1) **Waste water treatment and clean-up of polluted environment.** Water hyacinth has the potential to clean up various contaminated waters. The plant can absorb into its tissues large quantities of heavy metals from the water column.

(2) **Habitat for aquatic and bird life.** Large, thick floating islands of water hyacinth and its feathery roots can form habitats for birds and animals.

(3) **As alternative fuel and energy source.** Water hyacinths found in various water ways can be harvested and serve as an alternative energy source. Water hyacinth biomass can be processed into convenient solid fuel pellets using briquetting technology or used to generate biogas.



(4)



Semi-industrial uses and household articles. Water hyacinth can be used in making ropes, baskets, mats, shoes and sandals, bags, wallets, vases, furniture etc.

(5)

Animal feedstock and agricultural use. Water hyacinth can be used as fodder for farm animals and as supplementary feed in fish farming. It can also be used as an organic fertilizer and in mushroom cultivation.

(6) **Land reclamation and erosion protection.** As shown on page one, water hyacinths close up the water surface and accumulate huge quantities of dead organic matter that builds up the ground over time. Also they slow down wave energy and can act as a berrier between land and open water.

3

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

F975AN

LA CEIBA

Mexico

Lucila Aguilar de la Lama, Daniela Lujan Menchaca, Raúl de Villafranca Andrade

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KEYWORDS

Sustainability, Architecture, Industrial, Bamboo, Design

ABSTRACT

La Ceiba is a social infrastructure project developed for Uumbal, an agroforestry company located in the southeast of Mexico. The project introduces materials and design strategies that have a low environmental impact and high aesthetic quality while also meeting the needs for safety and operation. It demonstrates that industrial buildings can be in harmony with the environment. The project consists of 16 replicable prototypes such as warehouses, homes and guardhouses, among others.

During the construction process, the design team faced many challenges regarding the bamboo handling for construction. We realized that even though bamboo is abundant in the region and easy to use, there are not many workers qualified to build with bamboo. To address this problem, we made several detailed bamboo construction manuals that would not only help the workers build this particular project, but could reach many people in different parts of the country and make it easier for them to start exploring the possibilities of building with bamboo.

With La Ceiba we seek to generate a positive social impact. Natural materials such as earth and bamboo are mixed with conventional materials in an attractive and functional design, which responds to a bioclimatic strategy for warm-humid temperatures, and the constructions are strategically oriented to benefit from the winds and the position of the sun. In addition, they have a bamboo roof and vegetable cover that provide shade, comfort and harmony, and respect the dignity of the work of the Mexican countryside.

LA CEIBA

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RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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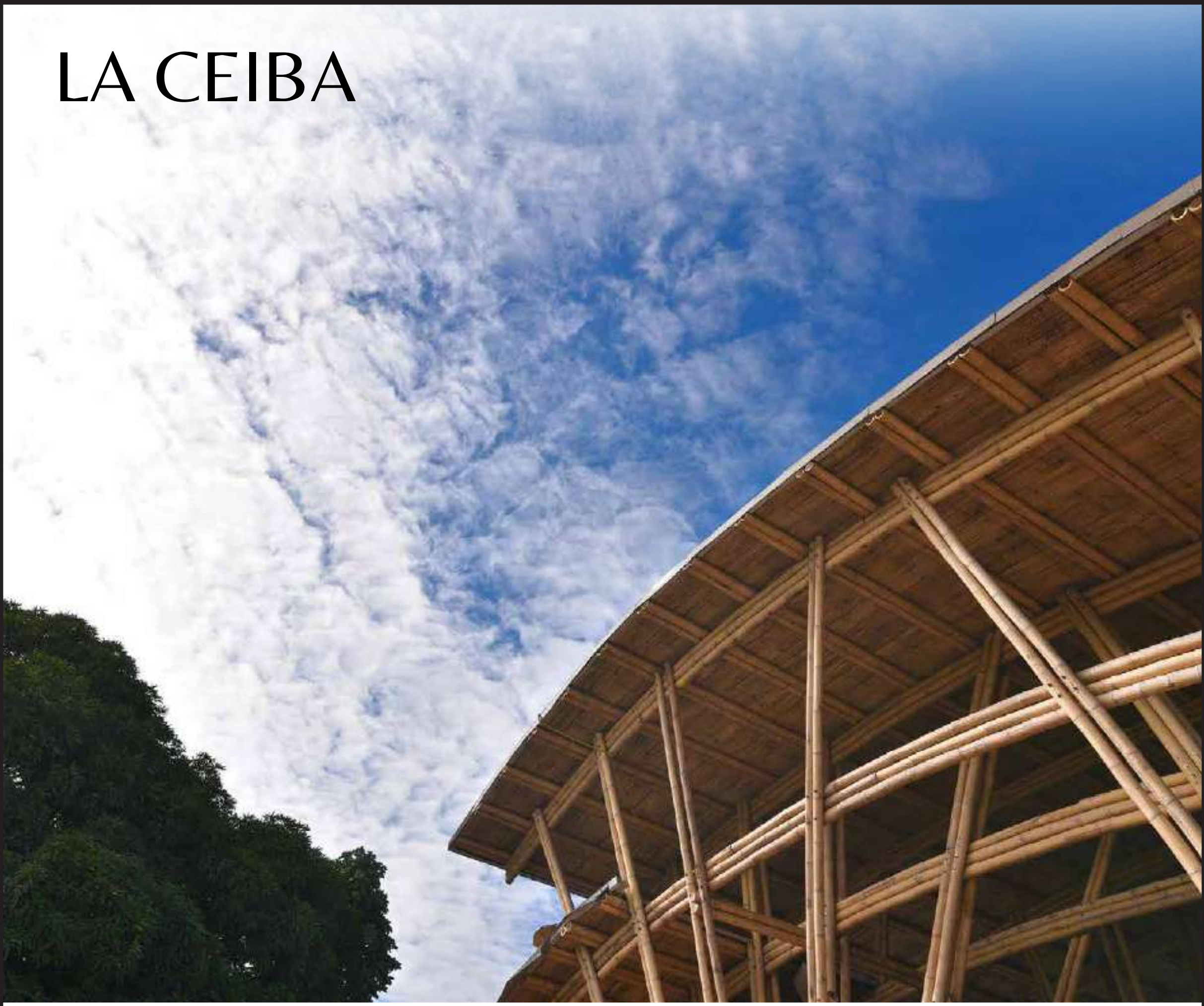
LA CEIBA



During the construction process, the design team faced many challenges regarding the bamboo handling for construction. We realized that even though bamboo is abundant in the region and easy to use, there are not many workers qualified to build with bamboo. To address this problem, we made several detailed bamboo construction manuals that would not only help the workers build this particular project, but could reach many people in different parts of the country and make it easier for people all around to start exploring the possibilities of building with bamboo.

Through this manuals, that we shared though our website, we aspire to reach a large number of people and theach the world about the benefits of this wonderful material.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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LA CEIBA

With La Ceiba we seek to generate a positive social impact. Natural materials such as earth and bamboo are mixed with conventional materials in an attractive and functional design. The proposal promotes dry construction and the use of resources that can be useful beyond the life of the building. The design responds to a bioclimatic strategy for warm-humid temperatures, and the constructions are strategically oriented to benefit from the winds and the position of the sun. In addition, they have a bamboo roof and vegetable cover that provide shade, comfort and harmony, and respect the dignity of the work of the Mexican countryside.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

C31BA4

URBAN OASIS

Brazil

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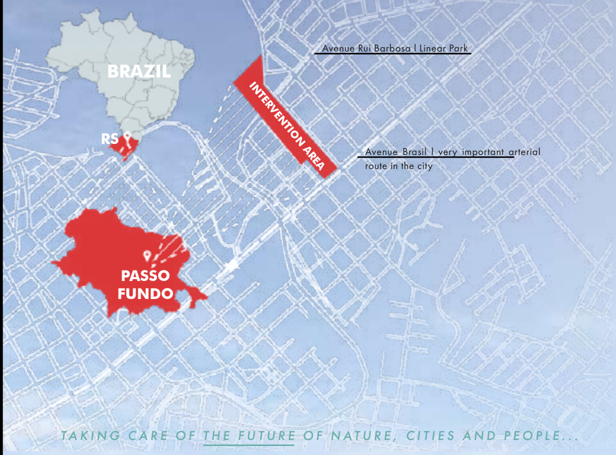
KEYWORDS
Degraded Spaces; Urban Development; Sustainable Development; Regenerative Landscape, Reuse

ABSTRACT
Urban Oasis is an investigation of the potential for degraded urban spaces to become catalysts of the changes needed for the future of humanity. The Project proposes a transformation on the area of Company of Silos and Warehouses (CESA) located in Passo Fundo, Rio Grande do Sul – Brazil, currently deactivated and unoccupied, into a park, a green laboratory for the city, that provides a place for practical and sustainable activities, that involves three aspects: social, environmental, and economic. Therefore, the Silo, which conserved grains in its industrial past, will become a space that conserves the environment and the future. The area has a strong connection with the city center of Passo Fundo, and it is easy to access, and there are attractive views of the skyline of the urban center. So thinking globally and acting locally, it was considered pertinent to use a degraded and abandoned space, which has been part of the urban landscape for 60 years. Therefore, both the area and the built heritage are regenerated, recycled and reactivated through programs that combine sustainability with community, transforming it into a living space, rich in social and environmental biodiversity, an Oasis in the middle of the city.

URBAN OASIS

A GREEN LABORATORY FOR THE CITY

PROPOSAL LOCATION



TAKING CARE OF THE FUTURE OF NATURE, CITIES AND PEOPLE...

INTERVENTION AREA

Top views of the Silo and surroundings. Silo window overlooking the city. Silo side view.

SILO - CESA I TIMELINE

1961 START OF OPERATIONS IN THE SILO

2011 CLOSURE OF SILO ACTIVITIES

2021 REQUALIFICATION PROPOSAL

HOW CAN ARCHITECTURE SHAPE A BETTER FUTURE?

Improve citizens self-organization in communities and their relation with the environment

AN URBAN SPACE RICH IN SOCIAL AND ENVIRONMENTAL BIODIVERSITY!

THEME

The proposal investigates the potential of degraded and abandoned spaces in the urban fabric, as catalyzing spaces for the future we want, in balance with social, environmental and economic dimensions. The space called Urban Oasis intends to explore the area mainly with regard to the construction of a sustainable space, with the use of preexistence, energy generation, knowledge, information, research and regeneration of fauna and flora, also being concerned with the dynamics of space and its surroundings, creating a space for everyone.

FUNCTION

The project is an epicenter of sustainable practices that aims to make Passo Fundo a greener city for everyone. A planning model for sustainable development is about meeting the needs of the present, without compromising the capacity of future generations according to their needs. It's planning today so that tomorrow still exists. Thus, this space, located in the urban center, intends to change the logic of thinking, living, producing and consuming, as the change must start from the inside out, starting from the cities.

CONCEPT

Exploring the capacity of abandoned spaces to capture the transformation needed today, the proposal brings the force of subversion, of an industrial space into an environmental space. The intervention area, which is currently degraded and abandoned, is transformed into an Urban Oasis, a space rich in biodiversity, social and environmental, an oasis in the middle of the city. The space takes care of the needs of the present, without compromising the needs of the future, with sustainable actions. This is the mark the space wants to leave for future generations. The presence of the nature and character of the project, implemented in the central area of the city, aims to be an epicenter of sustainable practices, which guide Passo Fundo and the Region towards sustainable development, and thus serve as an example for other measures that rethink the human impact on nature. The purpose of the program is the immersion and reflection of the community, for awareness, and in this way, joint alternatives are built for a better future.

WHAT IS THE FUTURE WE WANT TO BUILD? WHICH MARK WILL WE LEAVE?

TARGET AUDIENCE

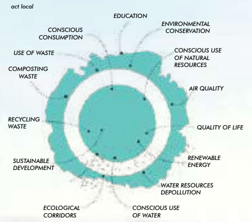
The project serves the entire Passo Fundo community and region in order to raise awareness, as well as offering a public space rich in experiences connecting with nature and the city of Passo Fundo.

PRE-EXISTENCE

The presence of the project will be a constant reminder of the capacity for change that industrial spaces can provide in cities, in this case, the space that previously conserved grain will conserve the environment.

HUMAN IMPACTS ON EARTH

FUTURE WE WANT - OUR MARK



AN OASIS IN THE MIDDLE OF THE CITY...

URBAN OASIS

A GREEN LABORATORY FOR THE CITY

PROJECTUAL INTENTIONS / terrain and surrounding considerations

VOCATION - IMMERSIVE

The proposal takes into account the vocation of the project's surroundings. Thus, Sector A, which has the greatest connection with Avenue Brasil, and will be the entrance to the Park, will start by inserting activities involving immersion in the environmental theme, such as education, research, exhibition and space for discussion of ideas, in order to raise awareness among users.

VOCATION - CONTEMPLATIVE

At the center, contemplation activities are proposed, which are already linked to the existence of a much-visited spot for the beautiful views of the city. It is in this sector that the Lake and the Educational Nursery are located, with the park's landscape species, the Playground and Academy, which intend to offer support to the user.

VOCATION - COMMUNATIVE

At the other end, there are activities that engage the community that lives in Petropolis in practice spaces, such as the vertical community garden, the waste space, which handles all the waste from the Park and Ecopoints, and the Multiuse space, which intends to make room for the most varied outdoor activities.

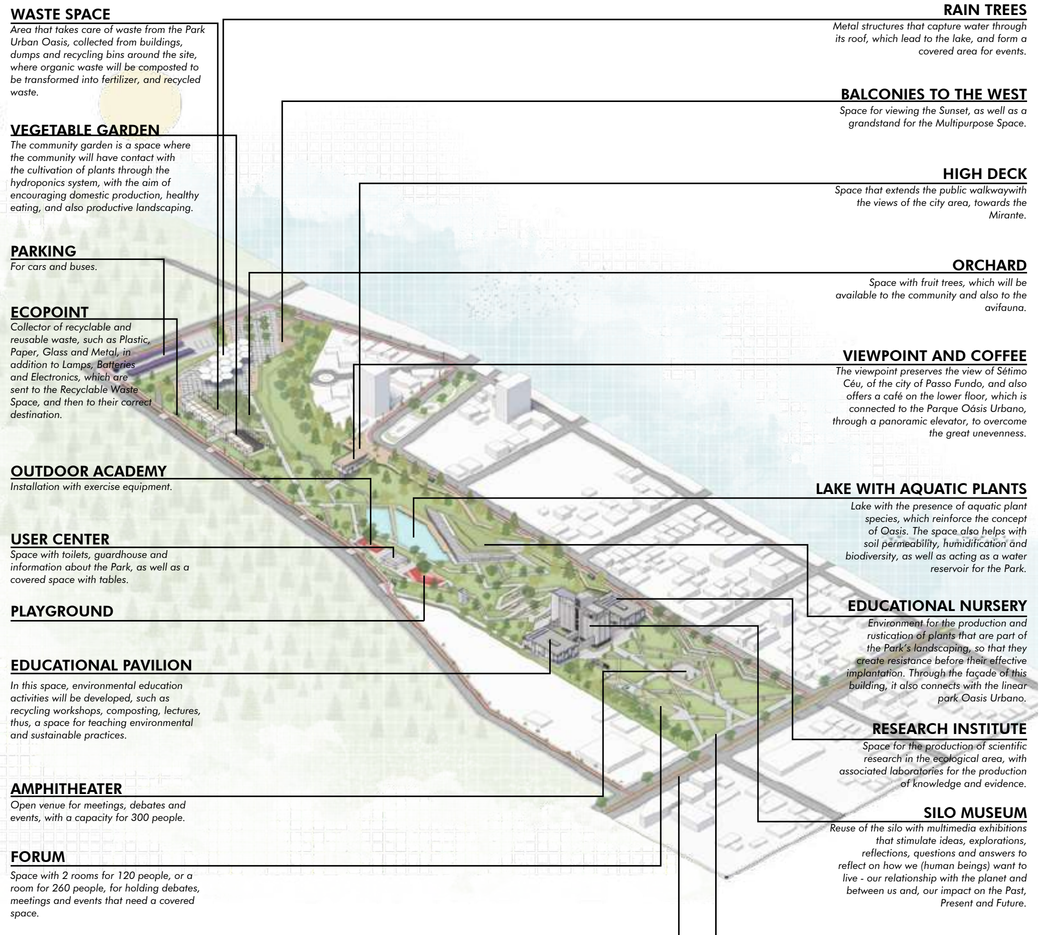
PERMEABILITY

The park intends to please connections with the existing urban fabric, which the area does not have today. Thus, the highlights are the connections with users in the surroundings, favoring walkability, in order to expand access through the topography, the relocation of occupation and the connection of the Linear Park.

VISUALS

The Park preserves the urban landscape present in the intervention site in relation to the pre-existence and also to the city of Passo Fundo. Thus, the buildings and paths keep the view, and provide others, as they extend across the land. Thus helping to create a common identity with the city's space.

THINK GLOBAL ACT LOCAL!



WASTE SPACE
Area that takes care of waste from the Park Urban Oasis, collected from buildings, dumps and recycling bins around the site, where organic waste will be composted to be transformed into fertilizer, and recycled waste.

VEGETABLE GARDEN
The community garden is a space where the community will have contact with the cultivation of plants through the hydroponics system, with the aim of encouraging domestic production, healthy eating, and also productive landscaping.

PARKING
For cars and buses.

ECOPOINT
Collector of recyclable and reusable waste, such as Plastic, Paper, Glass and Metal, in addition to Lamps, Batteries and Electronics, which are sent to the Recyclable Waste Space, and then to their correct destination.

OUTDOOR ACADEMY
Installation with exercise equipment.

USER CENTER
Space with toilets, guardhouse and information about the Park, as well as a covered space with tables.

PLAYGROUND

EDUCATIONAL PAVILION
In this space, environmental education activities will be developed, such as recycling workshops, composting, lectures, thus, a space for teaching environmental and sustainable practices.

AMPHITHEATER
Open venue for meetings, debates and events, with a capacity for 300 people.

FORUM
Space with 2 rooms for 120 people, or a room for 260 people, for holding debates, meetings and events that need a covered space.

AVENUE BRASIL
Main arterial road in the city of Passo Fundo and main pedestrian access to the Park.

RAIN TREES
Metal structures that capture water through its roof, which lead to the lake, and form a covered area for events.

BALCONIES TO THE WEST
Space for viewing the Sunset, as well as a grandstand for the Multipurpose Space.

HIGH DECK
Space that extends the public walkwaywith the views of the city area, towards the Mirante.

ORCHARD
Space with fruit trees, which will be available to the community and also to the avifauna.

VIEWPOINT AND COFFEE
The viewpoint preserves the view of Sétimo Céu, of the city of Passo Fundo, and also offers a café on the lower floor, which is connected to the Parque Oásis Urbano, through a panoramic elevator, to overcome the great unevenness.

LAKE WITH AQUATIC PLANTS
Lake with the presence of aquatic plant species, which reinforce the concept of Oasis. The space also helps with soil permeability, humidification and biodiversity, as well as acting as a water reservoir for the Park.

EDUCATIONAL NURSERY
Environment for the production and rustication of plants that are part of the Park's landscaping, so that they create resistance before their effective implantation. Through the façade of this building, it also connects with the linear park Oasis Urbano.

RESEARCH INSTITUTE
Space for the production of scientific research in the ecological area, with associated laboratories for the production of knowledge and evidence.

SILO MUSEUM
Reuse of the silo with multimedia exhibitions that stimulate ideas, explorations, reflections, questions and answers to reflect on how we (human beings) want to live - our relationship with the planet and between us and, our impact on the Past, Present and Future.

BUS STOP
Access to public transport at the main access in the area.

12S2V9

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

URBAN OASIS

A GREEN LABORATORY FOR THE CITY

BRINGING NATURE TO THE CITY...

REGENERATIVE LANDSCAPE */ expanding diversity*

Landscaping is important for the production of social welfare, recreation, and also, for its functional capacity, being a source of food for birds, absorbing carbon dioxide, and other polluting gases. Vegetation is like a lung in cities, reducing the effect of heat islands, as green areas produce photosynthesis and can still reduce 85% of solar radiation, in addition to improving air and water quality. In this way, Regenerative Landscaping acts by reinforcing these characteristics, as it proposes the regeneration of a degraded space through native plants, natural from the insertion site, which are already inserted in every ecosystem, from fauna to flora. In the case of the project, the corresponding Biome is the Atlantic Forest and the objective of the trees is to generate green spaces for people. These plants are easy to grow, adapt to the region's rainfall, do not need much irrigation, and are already part of the fauna, maintaining the ecological balance of the place and environmental preservation. Exotic species are also used, but they are much more aimed at the ornamentation of the Park.

SECTORES */ CONSTRUCTING LANDSCAPE*

With the division of Urban Oasis Park into sectors, with the objective of working in the linearity of the land, in order to progressively immerse users in the environmental theme and in the Park's activities, Landscaping also offers differentiation between sectors. Sector A - Immersive, is the beginning of the user's journey, and where the Silo (imposing preexistence) is concentrated, so we opted for a more permeable landscaping, with low height and slender trees, such as the Alamo and the Herb - Mate. In Sector B - Contemplative is where landscaping begins to present a greater presence in the landscape, with colorful trees, with denser and more open crowns and with aquatic plants in the lake. In Sector C - Communativa, the focus is on productive landscaping, from the orchard, for the community, and the landscaping of the degraded hillside area, with native species.

SECTOR A - IMMERSIVE

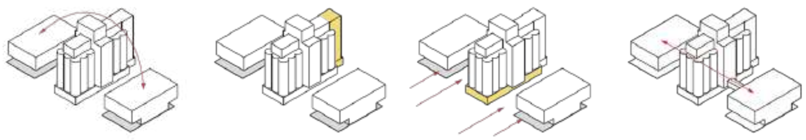
SECTOR B - CONTEMPLATIVE

SECTOR C - COMMUNATIVE

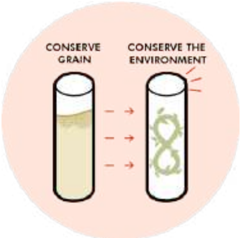
SILO MUSEUM | *helping society to review its priorities*

The buildings that are inserted in this sector A - Immersive, such as the Silo, the Educational Pavilion and the Research Institute, intend to immerse the user in the context of sustainability. The Silo is recycled and becomes a Science Museum, adapted to rethink the Past, Present and Future. Outwardly, it conserves its materiality and brutality, adding only vegetation. The two buildings beside it stand out for their counterpoint, they are symmetrical, permeable and light.

The silo is a Science Museum, focusing on digital media, and exhibitions that rethink our Past, Present and Future. To demonstrate the intent of the transformation proposal, users are invited to explore the space through the Central Atrium, where several cells were joined to build a space for everyone. From there, the walkways and the panoramic elevator distribute the visitors between the exhibitions. On the top floor, there is the coffee shop of the city where everyone can enjoy beautiful views of the city of Passo Fundo.



SYMMETRIC VOLUMES — ANNEX - EMERGENCY LADDER — PERMEABLE AND FREE GROUND FLOOR — CONNECTION



12S2V9

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

IXUA - PALENQUE VILLAGE

Mexico

Lucila Aguilar, Miguel Ruiz Velasco, Miguel Ángel Vargas, Cassandra Esteve, Fabián Tron

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KEYWORDS

Sustainability, Architecture, Urban, Bamboo, Design

ABSTRACT

Ixua is a magical village that intertwines with the jungle at the foot of the Mayan Train tracks, the tourist route that connects the southeast of Mexico. The visitors, arriving in Palenque, suddenly find themselves in the first community built entirely out of bamboo. With its magical markets, restaurants and hotels, Ixua envelops travelers and inhabitants in the ancestral colors and flavors of the region.

More than just an architectural project, Ixua is the seed of a scalable movement towards a more sustainable planet, which guarantees natural wealth, economic prosperity and social justice for current and future generations. Bamboo is central to this vision: it grows quickly, and in the process, it cleanses the water and fertilizes the soils. It regenerates after being harvested and continues to capture CO2 from the atmosphere. Its abundance in many different environments and the simplicity of its use in construction makes bamboo an accessible material.

Ixua exposes to the world the structural and ecological value of bamboo, while nourishing the area with economic vitality. It harmonizes our enormous natural and cultural wealth with the desire for an inclusive Mexico that looks responsibly towards the future.

IXUA - Palenque Village

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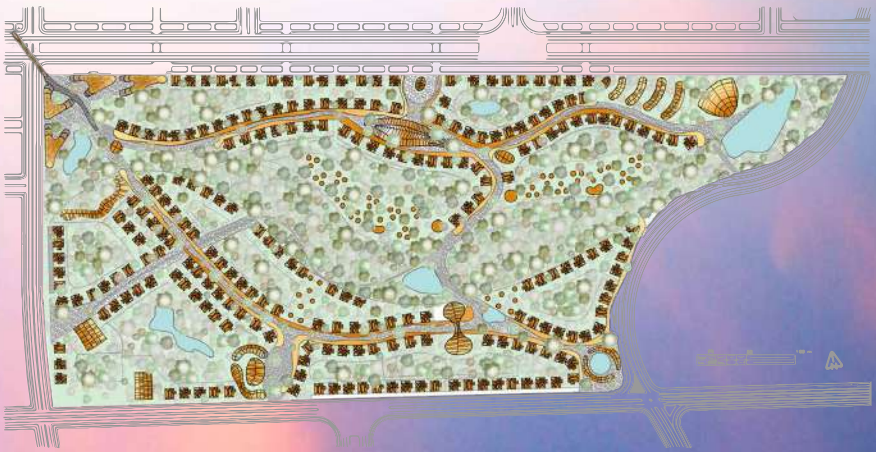
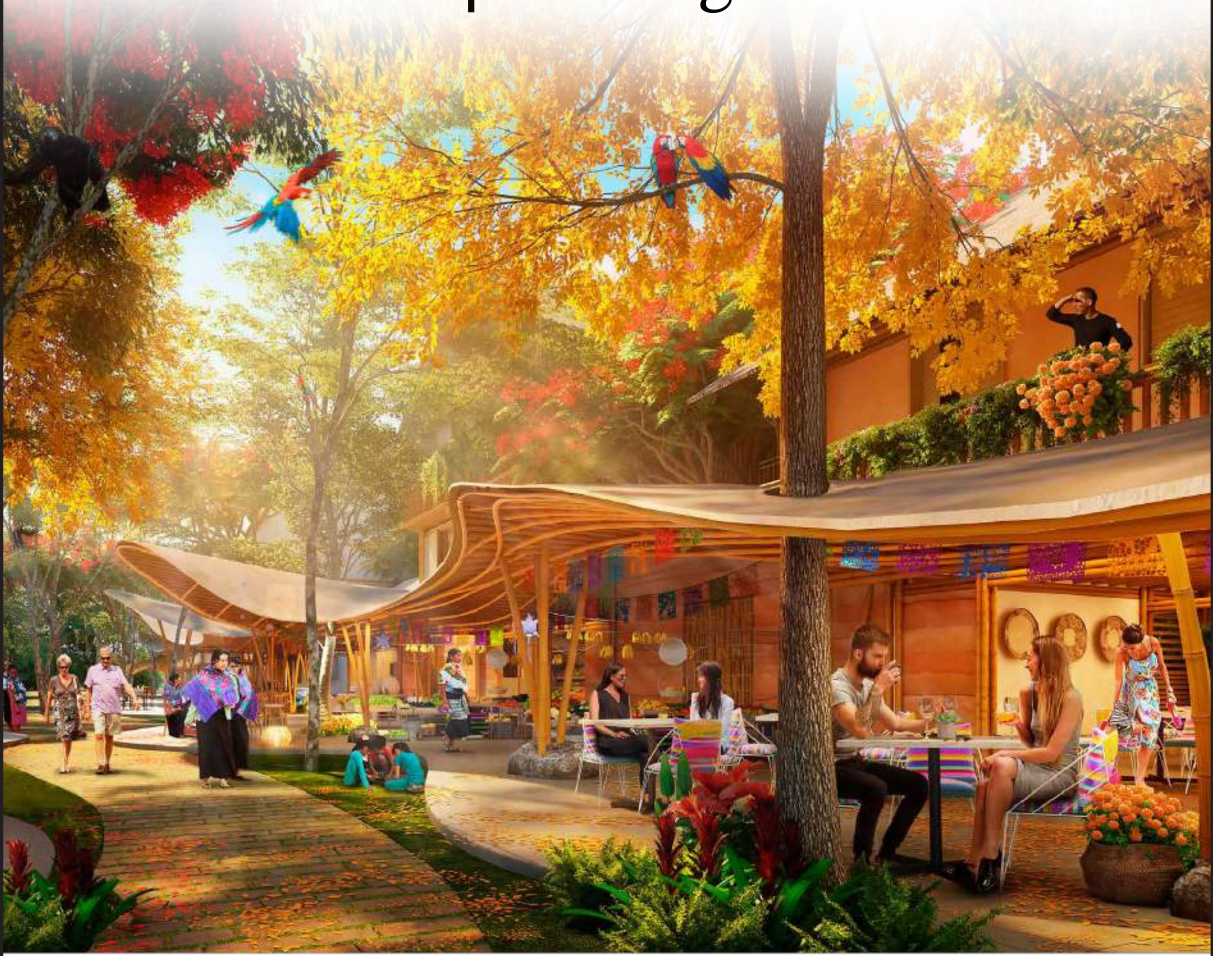


RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

B4MB00

IXUA - Palenque Village



More than just an architectural project, Ixua is the seed of a scalable movement towards a more sustainable planet, which guarantees natural wealth, economic prosperity and social justice for current and future generations. Bamboo is central to this vision: it grows quickly, and in the process, it cleanses the water and fertilizes the soils. It regenerates after being harvested and continues to capture CO_2 from the atmosphere. Its abundance in many different environments and the simplicity of its use in construction makes bamboo an accessible material.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

B4MB00

IXUA - Palenque Village

Ixua exposes to the world the structural and ecological value of bamboo, while nourishing the area with economic vitality. It harmonizes our enormous natural and cultural wealth with the desire for an inclusive Mexico that looks responsibly towards the future.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

B4MB00

META DELTA _ BOTANICAL GARDEN 2.0

Romania

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KEYWORDS

Urban Nature, Wetlands, Research Center, Transitions

ABSTRACT

The project is a reflection on how to create a synergy between nature and technology and change the way people relate to nature in the city. It addresses a more advanced understanding of the human-nature relationship in which architecture has the opportunity to integrate into an ecosystem by proposing an artificial object.

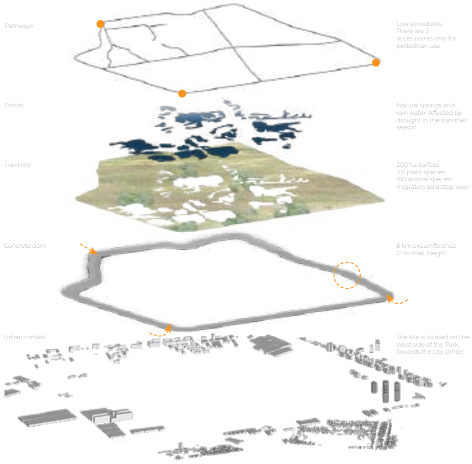
The case study is a protected natural reserve in the city of Bucharest, Romania. The issue was how to preserve urban nature while integrating it into the urban system.

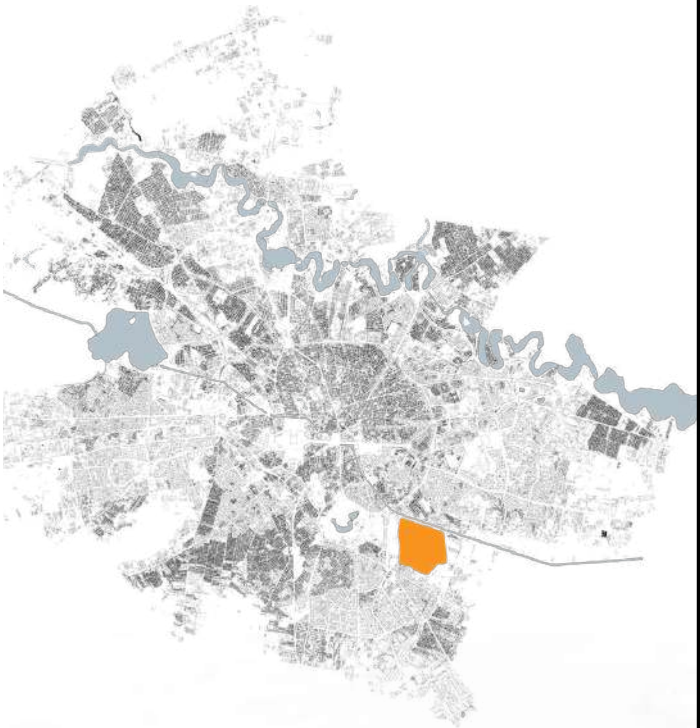
The project was built around the concept of the terrain vague - the intermediate, undifferentiated, unused space that exists in the urban fabric of post-industrial cities.

Vŭcŭreŭti Natural Park in South-East Bucharest is an abandoned artificial lake built in the ’80s as part of the communist hydro-technical projects on the Dâmboviŭa River. It is enclosed by a concrete dam that discouraged human presence for 40 years, so nature reclaimed the territory and created a diverse ecosystem of wetland flora and fauna.

The project reinterprets the typology of the botanical garden, which traditionally combines science and leisure, and is comprised of a landscaped planted area and various buildings, including green-houses, pavilions, and follies. In this case, the green area is a man-made space reclaimed by wild nature, which is to be left untouched. The program is inserted into a building that grows from the former lake’s infrastructure and houses a wetland research center and visiting center.

transition between nature and the city





Meta Delta _ Botanical Garden 2.0

The project adresses the issue of ecosystems in the city environment on urban scale. The case study is a protected natural reserve in the city of Bucharest, Romania. The issue was how to preserve the urban nature while integrating it into the urban system.

The site
Văcărești Natural Park in South-East Bucharest is an abandoned artificial lake built in the 80's as part of the communist hydrotechnical projects on the Dâmbovița River. It is enclosed by a concrete dam that discouraged human presence for 40 years, so nature reclaimed the territory and created a diverse ecosystem of wetland flora and fauna.

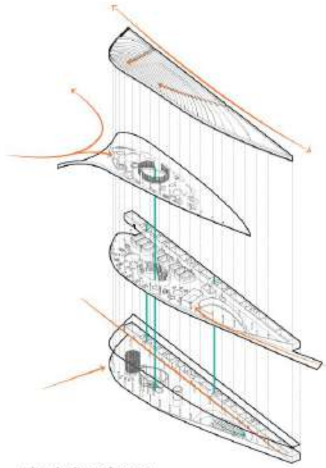
The Terrain Vague
The project was built around the concept of the terrain vague - the intermediate, undiferentiated, unused space that exists in the urban fabric of post-industrial cities.

The Botanical Garden of the 21st Century?

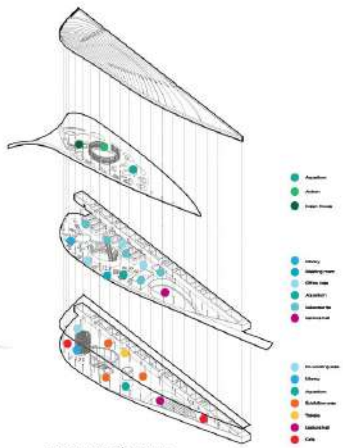
In a moment of dramatic environmental transformation and permanent economic uncertainty, the project is a reflection on how to create a synergy between nature and technology and change the way people relate to nature in the city. It addresses a more advanced understanding of the human-nature relationship in which architecture has the opportunity to integrate into an ecosystem by proposing an artificial object.

The project reinterprets the typology of the botanical garden, which traditionally combines science and leisure, and is comprised of a landscaped planted area and various buildings, including green-houses, pavillions and follies. In this case, the green area is a man-made space reclaimed by wild nature, which is to be left untouched. The program is inserted into a building that grows from the former lake's structure and houses a wetland research center and visiting center.

The strategy is shaped by introducing the relationship of audience and actor into the site by creating as many visual connections as possible. A reinterpretation of the Romantic vision of wandering and grasping for the spectacle of nature.



Circulation Diagram



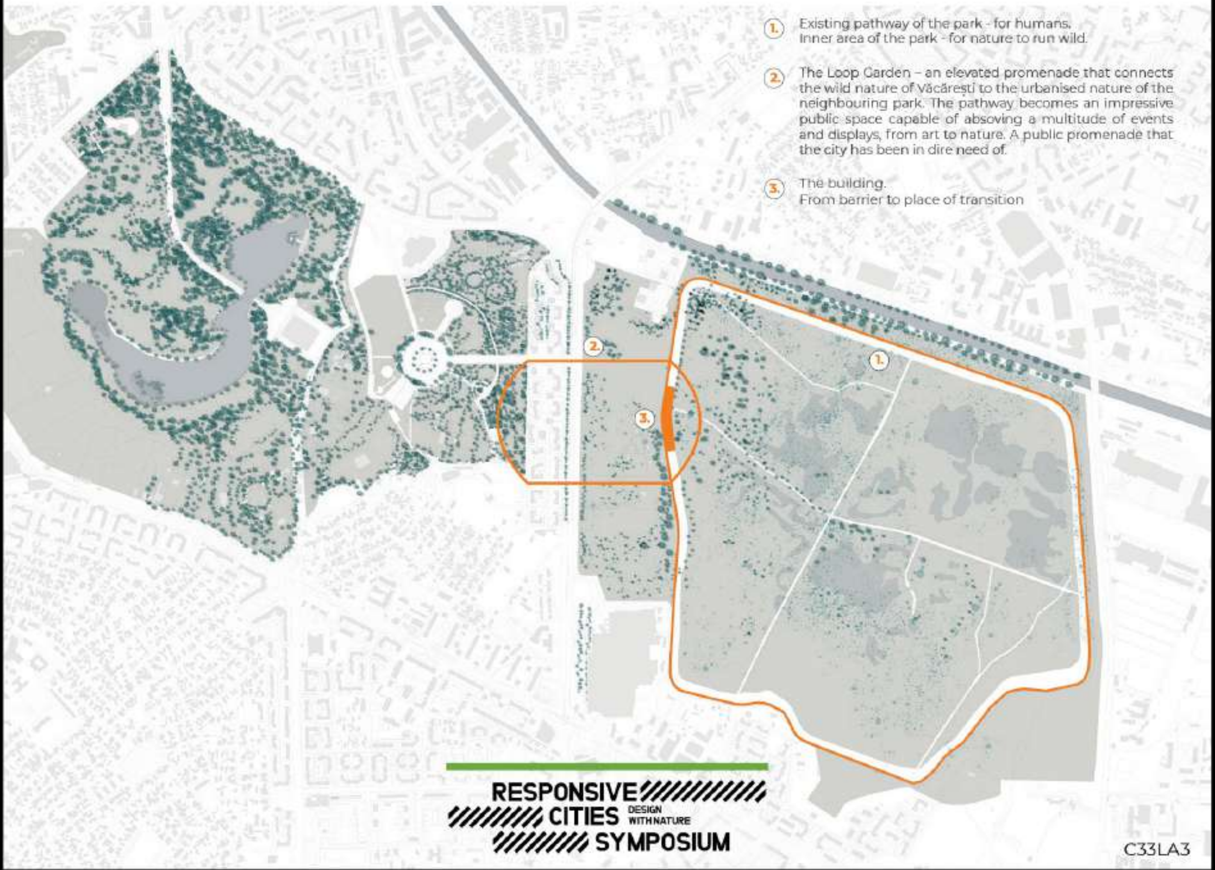
Program Diagram

The Urban Strategy

Vacărești is located in the periphery of the city, isolated by its close context, although it is at a short distance from other big parks of the city.
In this master plan, I proposed a way of connecting these two green areas via a elevated pathway called The Loop Garden - between two types of attitude towards nature: the urbanised park of the 70's and the wild nature of the 21st century city.

The Building

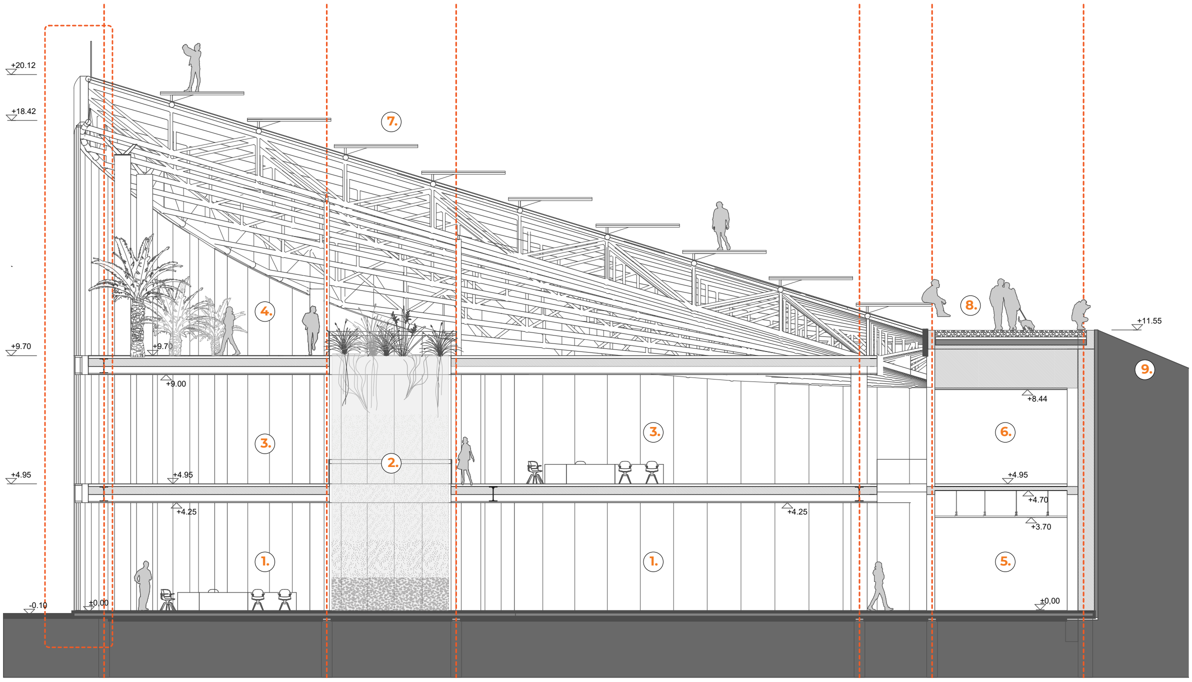
The projects aim is to create the opportunity for the public realm to get activated and transformed through **a delicate and intricate architectural intervention** that connects, enhances, and cherishes the special qualities of the environment.
The building is a subtle alteration in the shape of the landscape, a lifting of the surface that creates **a space of transition between nature and the city**. Its goal is to accommodate function inside while being crossed and surrounded by public space. The building morphs and intersects with the landscape. It's complex roofing system houses three stories. It is rooted in the dam and reveals itself towards the city through a generous transparent facade.



The green-house is the core of the project: Science, education and leisure.

The program is clearly divided between the three floors, the ground floor is the place of engagement, exhibition and study dedicated to the public, the everyday visitors; the second floor positioned inbetween the greenhouse and the public level serves as the space dedicated to the research centre and specialized laboratories. The three levels are perforated by three circular assets, the first is represented by the cylindrical library a place of rendez-vous between the academia and the public, the second one is the central atrium which allows the public to transition towards the greenhouse; the third one is a circular section of the actual layers of the Delta, presenting to the public the strata's that allow this natural reserve to function.

1. Lobby/ Exhibition area
2. Aquarium showcasing wetland layers
3. Labs/ Workspace/ Library
4. Green-house
5. Ticket area/ technical spaces
6. Technical spaces
7. Roof Terrace
8. Dam promenade
9. Interior Dam



RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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JELI-JELI

Senegal

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KEYWORDS

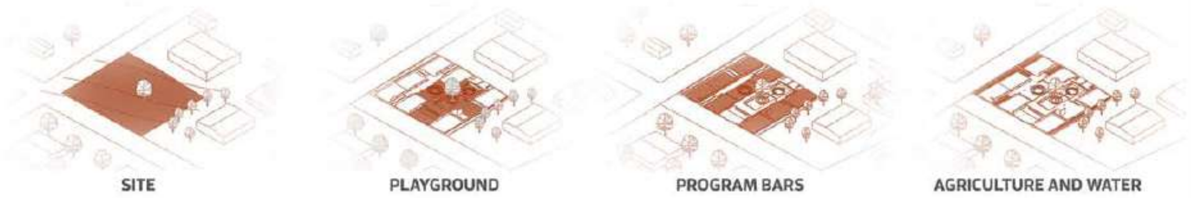
Learning By Doing, Local Construction, User's Empowerment, Community, Collective Intelligence

ABSTRACT

The Jeli-Jeli is a project inspired by Senegal and takes place in the city of Marssasum. Inside this Islamic community, there is a form of art that has flourished throughout the country which is based on the transferring of knowledge and culture from elders to children and adolescents by telling stories. Since its people come from a very poor social strata, they value the teaching of daily chores instead of letting kids going to school having an 80% of school dropout rate. Understanding this context, the project mixes the importance of studying and the local traditions of trading presenting a place where the community can join together and learn; the countryside lifestyle has been brought to the school adding vegetable gardens and green areas to encourage the know-how of learning.

The project has innovated traditional construction techniques using walling, foundation with tires and cyclopean concrete, columns, wooden beams, cut cane panel, zinc roofs, thermal conditioning, water collection, reuse of waste and food production. Besides, to keep the connection with nature, it was built around an existing tree with a simple composition of 3 programmatic strips, it has closed and semi-open spaces for 7 classroom modules with greenhouse gardens all connected by a drip irrigation system, the interior space is flexible and can be used for workshops, fairs, shelters, communal assemblies, etc. It articulates spaces and knowledge through collective actions and the community is empowered by the school program.

EXTERIOR FACADE-CONTEXT

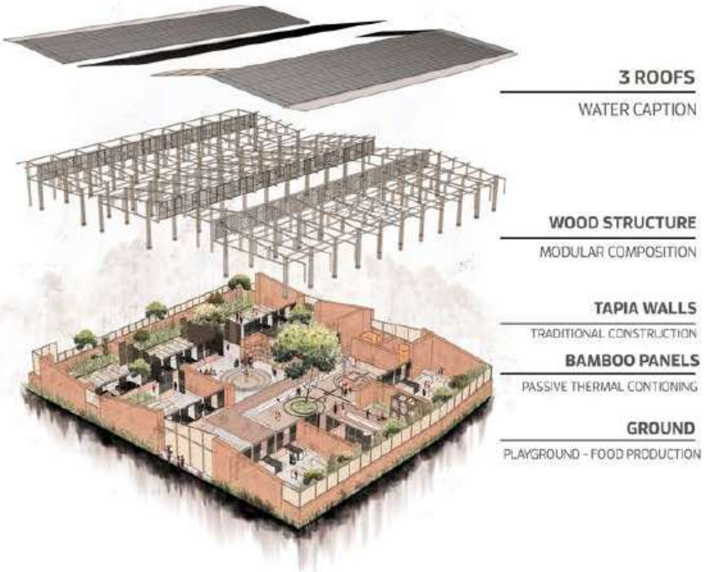


JELI-JELI Jc_pdge`wbmge

This project is not just as a school, is the Jeli-Jeli, a storyteller, the place inside the community where children, teachers, seniors and mothers meet to learn and experience together. The idea of Jeli-Jeli is of great importance to Senegal for its customs; here elders are the ones who transmit knowledge and the culture to children and adolescents through stories, this is a collective effort and an art form that has flourished throughout the country.

The project is located in the city of Marssasum. In this place the majority of the community is Islamic and has a variety of customs marked by a very poor social stratum. For this group of people, it is more important to teach daily chores to children over letting them go to school; this fact results in an 80% of school dropout rate.

CONSTRUCTION MODEL



RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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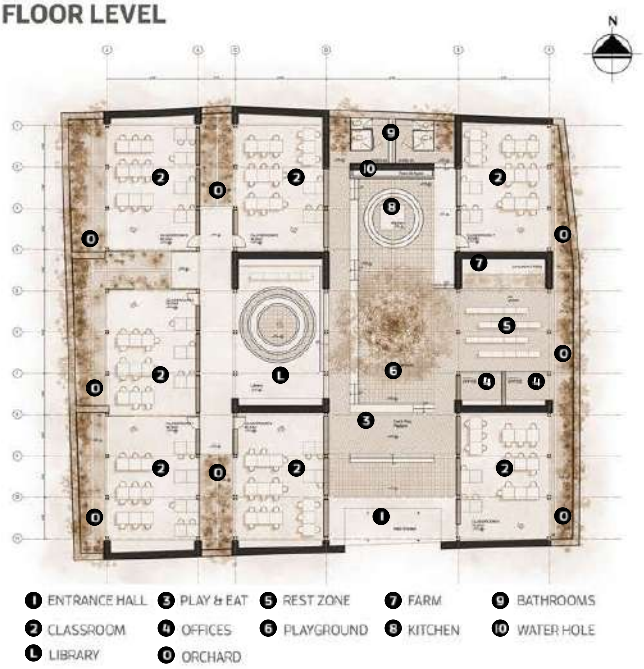
This background allowed us to understand that any institution in this context must have an added value, it must include the community and focus on a program based on practicing traditions and trades. For this reason, this work aims to transport the countryside's life to the classrooms, adding vegetable gardens and green areas to encourage the know-how of learning.

FLOOR LEVEL



TRANSVERSAL SECTION

LONGITUDINAL SECTION

Furthermore, in its structure, the vegetation seeks to protect and filter the natural light and it will refresh and liven up the interior of the school.

FRONT FACADE

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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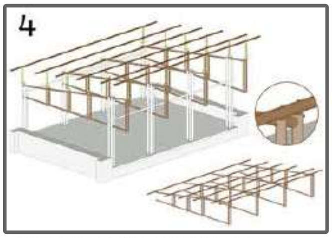
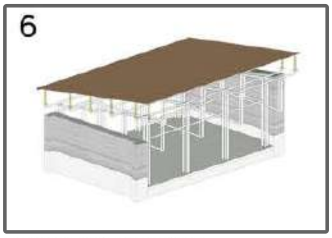
CONSTRUCTION MANUAL

SQUARING, LAYOUT AND
CONSOLIDATION OF FOUNDATIONS

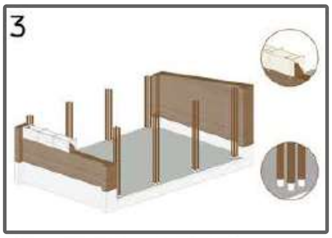
CASTING OF CONCRETE SLAB AND PLACEMENT
OF METAL ANCHORS FOR COLUMNS



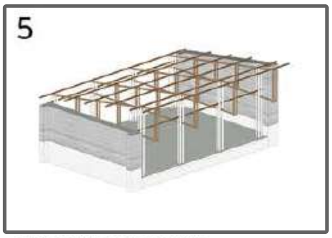
ARMING AND PLACEMENT OF BEAMS
VI WOOD Ø10 CM



PLACEMENT OF ZINC COVER



BOLTED FIXATION OF COLOMUNAS



PLACEMENT OF WOODEN V2
BEAM Ø10CM

CONSOLIDATION OF WOODEN ENCLOSURE
PANELS 2"X0.90CM AND 6MM BAMBOO

RESPONSIVE
CITIES DESIGN WITHNATURE
SYMPOSIUM

HCC456

PELLIS

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KEYWORDS

Responsive Facade, Algae Based BioFuel Cells, Self Sufficient System, BioPhilic Envelopes, Sustainable Architecture

ABSTRACT

PELLIS is a conceptual study focused on the benefits of implementing a secondary building envelope to high rise buildings in extremely high temperature environments as a replacement to typical renovation practices. The aim of the added envelope is to provide two distinct functions; the first is to provide exterior accessible platforms that can be farmed and used by the public as gathering spaces. The second is to provide control over the harsh environmental characteristics of the environment applied on the architectural space by affecting the direct radiation input, the localized temperature, and the local humidity. The system also incorporates algae-based biofuel cells that passively generates an electrical output that self-sustains the motorized parts of the envelope reducing the projected carbon footprint of the added envelope.

The topology of the design is inspired by the local fauna's circulatory system as it aims to create a closed circulatory system of water that is cooled underground and then pumped throughout the system. The system then uses the cooled water on its surface within enclosed translucent ETFE pockets to reduce the local temperature via heat exchange. The ETFE pockets also change size based on the sun radiation input applied to minimize the direct sun exposure on the façade. Specific pockets are also selected to function as biofuel cells generating the systems requirement of electricity from the photosynthetic properties of algae species enclosed within.

The system was simulated on a building facade in the UAE and produced an estimated ~50% reduction in temperature, ~40% reduction in humidity and a sufficient production of electricity to sustain the function.


[PELLIS]
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RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM
[Bio-Inspired Building Envelopes for Extreme Temperature Climates]

[CONCEPT & ABSTRACT]

THE OBJECTIVE OF THIS FACADE STUDY IS TO PROVIDE A BIO-INSPIRED FACADE SYSTEM THAT WILL BE INCORPORATED ONTO OLDER FACADES OF ANY BUILDING THAT RESIDES WITHIN THE DESERT BIOME. THE SYSTEM WOULD SERVE AS A SHADING DEVISE DEVICE AND CLIMATE CONTROL WHILE PROVIDING A PUBLICLY ACCESSED GREENARY PLATFORMS THAT SERVE TO LOWER THE IMMEDIATE HUMIDITY AND PROVIDE AN AETHSETIC UPGRADE TO THE MONOTONE DESIGN LANGUAGE OF A TYPICAL METROPOLITAN. THE ADDITION OF THE GREEN ELEMENT ALSO IS INTENDED AS A METHOD TO HIGHTEN THE HUMAN INTERACTION WITH THE MONOTONE TYPICAL FACADE SYSTEM AS THE GREEN PLATFORM PROVIDED WOULD INCORPORATE FARMABLE ZONES WHERE HABITANTS CAN INVOLVE THEMSELVES WITH THE NEW FACADE SYSTEM AND THE EFFECTS IT PROVIDES FOR THE BUILDING.

THE DESIGN INTENT WAS CONSIDERED FOR THE TYPICAL METROPOLITAN OF DUBAI, UNITED ARAB EMIRATES AS THE HIGHER TEMPERATURE AND HARSHER CLIMATE PROVIDED A CHALLENGING ADAPTATION POSSIBILITES, WHILE THE TYPICAL DUBAI URBAN FABRIC AND DESIGN LANGUAGE DOES NOT TYPICALLY ALLOW FOR ANY HUMAN INTERACTION WITH THE BUILT ENVIRONMENT. FURTHER TO THAT, THE CITY HAS GONE THROUGH A MASSIVE EXPANSION CYCLE ON AN URBAN SCALE, WHILE THE OLDER PARTS OF THE CITY THAT WAS BUILT WITHIN THE PAST 50 YEARS ARE PRIME FOR RENNOVATION WORKS, THUS ALLOWING US AN ENTRY POINT TO EASILY INTEGRATE THE SYSTEM INTO THE URBAN FABRIC RATHER THAN FORCEFULLY INTRODUCE IT.

AS FOR THE SYSTEM ITSELF, IT WILL BE A MODULAR INFLATED AND MESH REINFORCED ETFE SYSTEM THAT IS RESPONSIVE TO THE SUN RADIANCE, DIRECT RADIANCE AND TEMPERATURE INPUT AND THE IMMEDIATE HUMIDITY. THE SYSTEM WILL INCORPORATE A FUNCTIONAL BIO-FUEL CELL UNITS THAT UTILIZES THE HIGH SUN EXPOSURE TO GENERATE ELECTRICITY AND BIO-MASS. THE BIO-MASS GENERATE CAN BE THEN FURTHER UTILIZED AS FERTILIZER FOR THE FARMABLE GREEN PLATFORMS OR AS CONSUMABLE FOOD SOURCE FOR THE HABITANTS OF THE BUILDING SUBJECT TO THE SELCETION OF THE ACTIVE ALGAE SPECIES WITHIN THE FUEL CELL.

THE SYSTEM IN ESSENCE FUNCTIONS ON THE BASICS OF FLUID (WATER) CIRCULATION TO COOL THE FACADE SYSTEM. THIS IDEOLOGY OF DESIGN WAS INSPIRED BY STUDYING THE BIOMES FLORA THAT HAVE ADAPTED TO THE HARSH CLIMATE. AN EXTENSIVE STUDY OF THE FLORA REVELAED A TENDENCY OF THE FLORA TO HAVE LARGE SPREAD NARROW ROOT SYSTEMS THAT EXTEND AROUND THE PLANT BODY. THIS SYSTEM ASSISTS MAINLY IN STRUCTURAL SUPPORT OF THE PLANT AND NUTRIENT GATHERING, ALONG SIDE THE MINIMAL FUNCITON OF DIFFUSING THE TEMPERTATURE OF THE INTERNAL PLANT'S FLUIDS DUE TO THE HIGH EXCHANGE OF HEAT WITH THE RELATIVELY COOLER SOIL. THIS CONCEPT IS WHAT INSPIRED THE DESIGN INTENT FOR THE COOLING CIRCULATORY SYSTEM OF PELLIS.

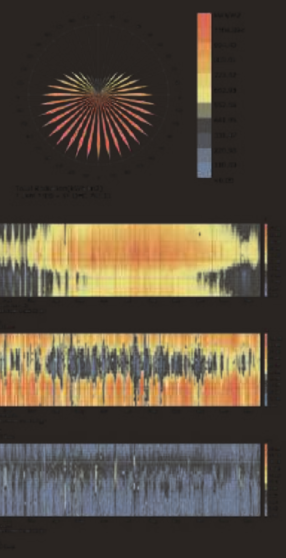

DIAGRAM -1 DUBAI CLIMATE STUDY.

THE CLIMATE STUDY ALLOWS US TO UNDERSTAND THE CHALLENGE POSED BY THE TEMPERATURE. WE NOTICE A HIGH EXPOSURE OF HEAT AND RADIANCE ON THE SOUTHERN, SOUTHERN EAST, AND SOUTHERN WEST DIRECTIONS ON MOST OF THE YEAR'S DURATION PEEKING BETWEEN MARCH AND NOVEMBER. WE ALSO NOTICE CONSISTENT HIGH HUMIDITY YEARLONG THAT PEEKS AROUND THE SAME DURATION OF THE RADIANCE PEEKS.

[DESIGN IDEOLOGY DEVELOPMENT]

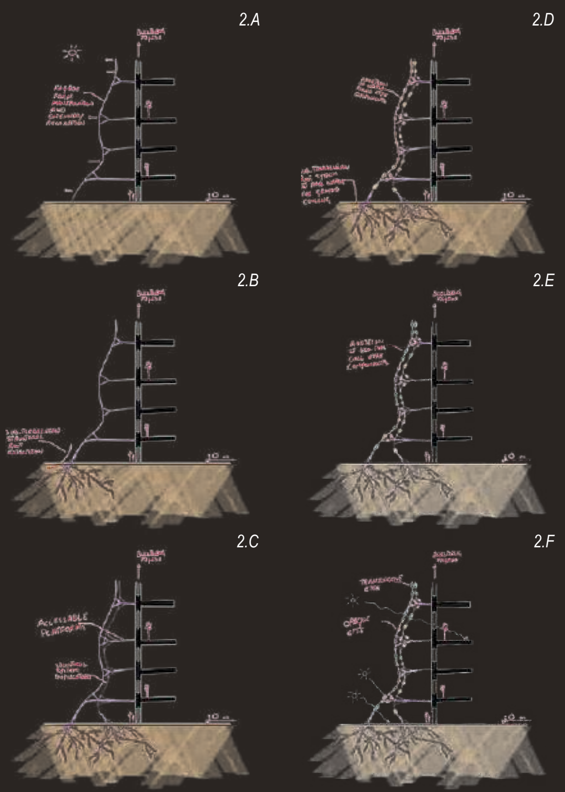

DIAGRAM -2 DESIGN IDEOLOGY DEVELOPMENT

THE SYSTEM WAS GENERATED BASED ON THE TYPICAL DETAIL OF EXTERNALLY ATTACHED FACADE SYSTEMS USUALLY USED WITHIN THE INDUSTRY OF DUBAI. THE TYPICAL RENNOVATED FACADE SYSTEM CONSISTS OF METALLIC STRUCTURES THAT FOLLOW THE FACADE TYPICAL FORM AND HOLDS THE CLADDING UNITS SELECTED.

(2.A) BASED ON THE TYPICAL FACADE SYSTEM, PELLIS SYSTEM IS OFFSETED AWAY FROM THE EXTERNAL STRUCTURAL FACADE OF THE BUILDING TO GENERATE A SEPERATION ACCESSIBLE VOID AND PLATFORMS. THE FORM ALSO WAS DEFORMED TO ALLOW FOR MAXIMUM INTERCEPTION OF SUN RADIATION.

(2.B - 2.C) THE SYSTEM'S ELEMENTS WERE INSPIRED BY THE NEEDLY SHAPES OF THE LOCAL FLORA, THUS THE ELEMENTS IN GENERAL ARE HOLLOWED STAINLESS-STEEL PIPING THAT SPREAD BELOW GROUND LEVEL INTO A ROOTING SYSTEM STABALIZING THE STRUCTURE AND ALLOWING FOR MAXIMUM HEAT EXCHANGE BETWEEN THE ENCLOSED WATER CIRCULATORY SYSTEM AND THE SURROUNDING SOIL.

(2.D) THE SYSTEM THEN WAS DUPLICATED TO ALLOW FOR MORE STRUCTURAL STABILITY.

(2.E) THE ETFE POCKET SYSTEM WAS THEN SPREAD ALONG THE STRUCTURAL ELEMENTS. THE ETFE SELECTED WOULD ALL BE MESH REINFORCED ETFE TO ALLOW FOR MORE STRUCTURAL INTEGRITY OF THE SYSTEM WHEN THE POCKETS ARE HOLDING LIQUID WATER. THE ETFE POCKETS ARE ALSO CONNECTED TO A PULLY SYSTEM EACH TO CONTROL THE SIZE OF THE POCKET THUS ALLOWING FOR RADIATION PENETRATION CONTROL INTO THE INTERMEDIATE VOID.

(2.F) THE POCKETS ARE ALSO SPLIT INTO TWO DISTINCT SYSTEMS, AND OPAQUE POCKET SYSTEM THAT WILL BE SPREAD ON THE HIGH RADIATION ZONES OF THE FACADE, AND A TRANSPARENT SYSTEM THAT WOULD BE SPREAD ON THE MEDIUM TO LOW RADIATION AREAS OF THE FACADE AS PER THE RADIATION STUDY PERFORMED. THE SYSTEM WOULD FUNCTION IN GENERAL AROUND THE BASIC HEAT EXCHANGE CONCEPT BETWEEN THE SOIL COOLED WATER THAT IS CIRCULATED WITHIN THE OPAQUE ETFE POCKETS, AND THE SURROUNDING AIR. FURTHER TO THAT, THE TRANSPARENT ETFE POCKET SYSTEM WOULD HOUSE THE ALGAE SPECIES ALLOWING FOR MORE RADIA-TION PENETRATION INTO THE INTERMEDIATE VOID AND ALLOWING THE SUN TO ACTIVATE THE ALGAE ENCLOSED TO PHOTOSYNTHESISE AND GENERATE ELECTRICITY WHILE GROWING.

[PELLIS]

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RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

[Bio-Inspired Building Envelopes for Extreme Temperature Climates]

[SYSTEM DETAILING]

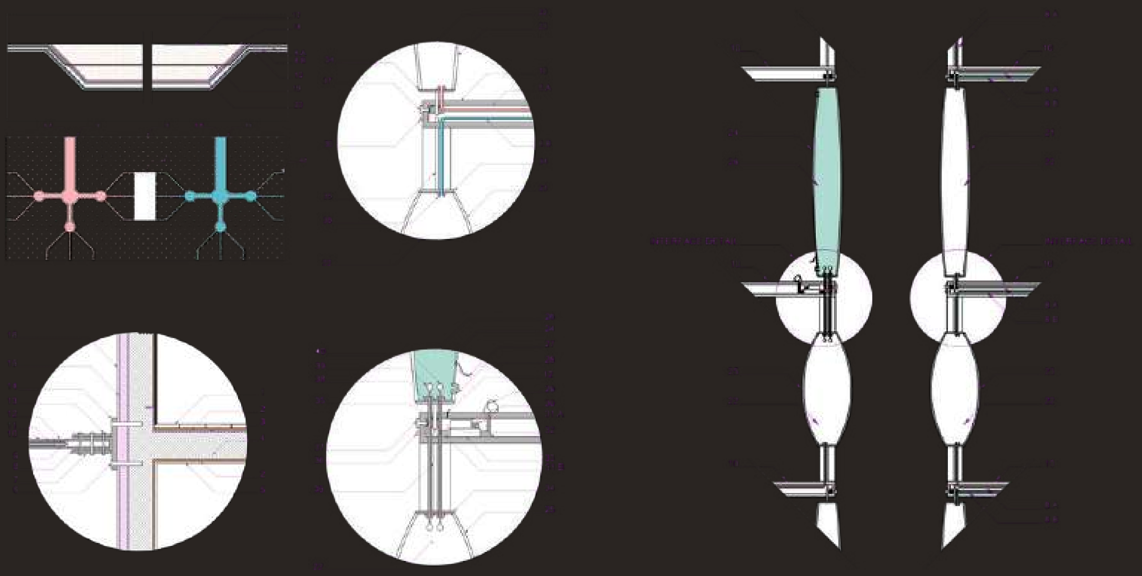

DIAGRAM 3 - SYSTEM DETAILS

1- Interior floor finish 2- Interior floor and wall mortar 3- Interior floor water proofing 4- Building structural Envelope 5- Interior wall finish6- Chemical fixing anchor 7- PELLIS structural interface wall bracket glossy white stainless-steel finish 8- Flexible and stretchable water pipe dia 20mm (A- water output pipe feeding the system, Bwater input pipe feeding the system) 9- PELLIS circulation secondary water pump 10- PELLIS horizontal structural element ~150x150 mm cross section, 25mm thickness white stainless steel 11- Neoprene seating block and filler 12- Water pump compartment and hinged opening 13- Mechanical fixing nut and bolt 14- PELLIS structural interface with wall – base plate ~150x150x25mm stainless steel glossy white 15- Exterior façade thermal insulation ~30-45mm 16- Exterior façade renovated finish glossy white 17- PELLIS platform's walkable stone path, white sandstone. 18- PELLIS platform's soil and planter 19- Water intake pipe penetration into the platform's soil to assist in cooling 20- Planter water proofing 2x layers of 2mm bitumen membrane. 21- Reinforced ETFE membrane with embedded metallic mesh-opaque, white-relaxed state 22- Refined water enclosed system 23- Reinforced ETFE membrane with embedded metallic mesh-opaque, white-stressed state 24- Reinforced ETFE membrane with embedded metallic mesh-transparent- relaxed state 25- Reinforced ETFE membrane with embedded metallic mesh-transparent- stressed state 26- Algae medium 27- Sealed and waterproof sipping system embedded within the ETFE membrane to allow access for unit maintenance and cathode / anode replacement. 28- Corked drainage points top and bottom of the ETFE pocket to allow for media replenishment and cleaning. 29- Light fixture 30- Responsive system computer terminal 31- Electric cable (A-computer / battery, Bbiofuel cell cathode / anode) 32- Data cable 33- Battery and system fuse box 34- ETFE pocket rigid interface base with the motorized pully system 35- Pully system cabling ~10mm dia threaded elastic rope 36- Radiation intensity sensor 37- Pully system rotation motor and rope spool 38- Waterproof and leakage proof ETFE penetration interface 39- Cathode, metallic in nature (copper) 40- Anode, metallic in nature (Aluminum)41- Below ground level main pump substation 42- Copper capillary piping

[CASE STUDY]

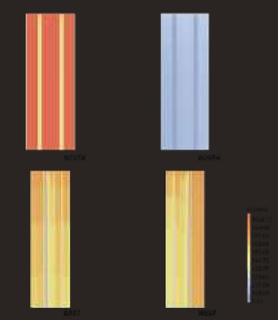

DIAGRAM 4- ORIGINAL STATE

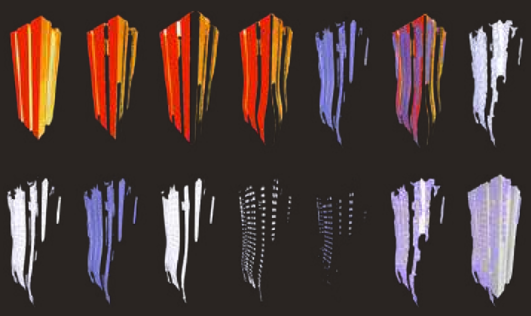

DIAGRAM 5- SYSTEM APPLICATION

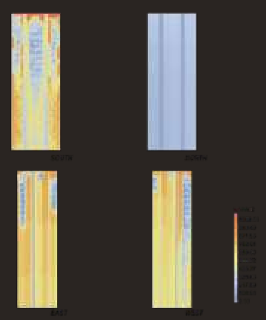

DIAGRAM 5- RESULT

THE PELLIS SYSTEM WAS APPLIED ON THE FACADE OF A NATIVE DUBAI BUILDING (THE PALLADIUM TOWER) AND SYMULATED TO A SUCCESS. THE ORIGINAL STATE OF THE FACADE HAD A DIRECT RADIATION UPWARDS OF 1100 KWH/M2 WITH A 2700+ HOURS OF ANNUAL DIRECT SUNLIGHT HOURS FOCUSED ON THE SOUTHERN, SOUTHERN WEST, AND SOUTHERN EAST FACADES. THE APPLICATION MANAGED TO PROVIDE A ~65% DIRECT RADIATION IMPACT ON THE INTERIOR BUILDING ENVELOPE. FURTHER TO THAT, THE DIGITAL SIMULATION PROVIDED A ~35% DECREASE IN HUMIDITY. THEY SYSTEM FUEL CELL ARRAY ESTIMATED AN AVERAGE OUTPUT OF 1 KILO VOLT IN PEEK HOURS OF THE DAY THAT WOULD BE USED AND SAVED BY THE BATTERY ARRAY ACCOMPANYING THE SYSTEM ITSELF.

[PELLIS]

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RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

[Bio-Inspired Building Envelopes for Extreme Temperature Climates]

REWILDING THE URBAN FABRIC

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KEYWORDS

Rewilding, Urban Green Infrastructure, Ecosystem Services, Health, Urban Farming

ABSTRACT

Built urban environments minimally retain natural ecosystem origins. Nature can be found in the city parks, trail systems, riparian zones, public gardens, and streetscapes. However, the wildlife and ecological corridors have been broken and removed for city growth, resulting in a patched mosaic urban landscape. Utilizing Nature-Based Solutions (NBS) as an urban design and planning tool allows recultivation of the urban landscape at a large scale. Rewilding our cities with native vegetation will increase biodiversity, improve air and water quality, reduce flood risk, while strengthening and rebuilding our urban ecologies. The economic, social, and environmental benefits are described through sharing the uncultivated, unmanicured, wild landscapes that attract the pollinators, birds, and wildlife back into the city. NBS results in positive landscape performance measures by cooling cities, absorbing pollutants, and recharging groundwater. The COVID-19 pandemic has imminently redefined our city streets for human health, access to nature, and urban farming. Urban agriculture improves food security for those in financial need. Having access to a variety of nutritious foods enhances the nutritional balance of the neighboring communities. The produce could also be an economic driver where those in lower income communities could profit by selling the produce. There are ecological and human benefits of replacing traffic and vehicles with native urban landscapes. Changing policy, to set the stage for nature to reemerge, will reap local, regional, and global benefits for the health of our natural world and human nature.

rewilding the urban fabric

Barcelona

Built urban environments minimally retain natural ecosystem origins. Nature can be found in the city parks, trail systems, riparian zones, public gardens, and streetscapes. However, the wildlife and ecological corridors have been broken and removed for city growth, resulting in a patched mosaic urban landscape. Rewilding our cities with native vegetation will increase biodiversity, improve air quality, reduce flood risk, improve water quality, in addition to strengthening and rebuilding our urban ecologies. The economic, social, and environmental benefits are seen through sharing the uncultivated, unmanicured, wild landscapes that attract the pollinators, birds, and wildlife back into the city. Nature-based solutions (NBS) result in positive landscape performance measures by cooling cities, absorbing pollutants, and recharging groundwater. The COVID-19 pandemic has imminently redefined our city streets for human health, access to nature, and urban farming. There are ecological and human benefits of removing traffic, vehicles on the street, with rewilding and replanting streets. Changing policy to definitively set the stage for nature to reemerge will display local, regional, and global benefits to the health of our natural world and human nature.

Stormwater Basin in Sheffield's Grey to green project, Nigel Dunnett

New York City

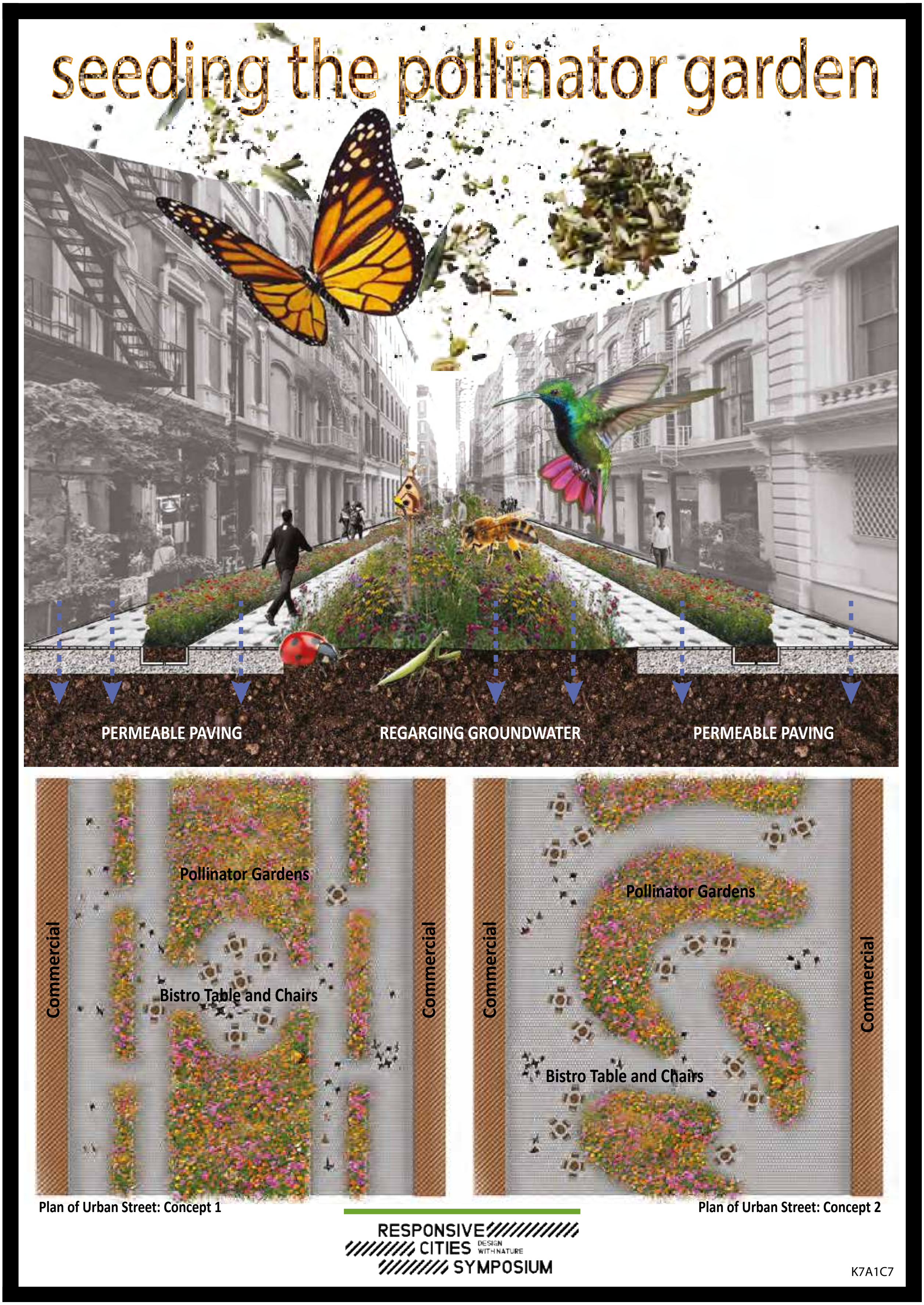
Beech Gardens and The High Walk, Barbican Estate, Nigel Dunnett

San Francisco

Piazza Vecchia as Green Square, Piet Oudolf in 2018

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

K7A1C7


seeding the pollinator garden
PERMEABLE PAVING
REGARGING GROUNDWATER
PERMEABLE PAVING
Commercial
Pollinator Gardens
Bistro Table and Chairs
Commercial
Plan of Urban Street: Concept 1
Commercial
Pollinator Gardens
Bistro Table and Chairs
Commercial
Plan of Urban Street: Concept 2
RESPONSIVE
CITIES DESIGN WITH NATURE
SYMPOSIUM
K7A1C7

Food Security: Farm the Streets

Urban agriculture improves food security for those in financial need. Having access to a variety of nutri ous foods enhances the nutri onal balance of the neighboring communi es. The produce could also be an economic driver where those in lower income communi es could profit by selling the produce.

Urban trees can be a major contributor to **climate change** by ac ng as a CO_2 sink and reduc on of energy use. Vegetated streets will add beauty and **improve human health** and wellbeing. Vegeta on will reduce air and noise pollu- on, improve air quality, reduce street temperatures, **conserve water** and reduce soil erosion. Overall, the vegetated streets will provide more leisure access to the commercial spaces and will increase **economic stability**. Crea ng wildlife and plant **diversity** also provides ecological educa on for city dwellers.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

K7A1C7

TO DA LOO

United States

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KEYWORDS

Humanure, Reuse, Public Health, Water Quality, Biomimicry

ABSTRACT

The current way we manage human waste is unsustainable. Outdated and failing waste infrastructure in cities overflow into the built environment and leach into the natural world, causing disease, illness, water and environmental degradation, and draining financial and human resources. Our current waste infrastructure often diverts fresh, clean, potable water to flush away our waste. In the face of climate change, these issues will only worsen. But if we design with nature, **our waste doesn't have to be so wasteful.**

Utilizing biomimetic design, we can learn from nature, our ancestors, and indigenous populations around the globe to solve a crucial part of our waste problem. **TO DA LOO** is a portable, clean, hygienic, and user-friendly way to turn human waste into **humanure**: combining multiple waste streams into a productive asset, decreasing stress on our water systems, improving public health and hygiene awareness, providing easily accessible sanitation to those in need, and enhancing environmental and social relations.

TO DA LOO uses lessons learned from prairie dogs, fan palms, cicada wings, and the millennia-old practice of composting to create a clean and comfortable composting toilet that turns human waste into productive fertilizer cleanly and efficiently. **TO DA LOO** can fit seamlessly into the urban fabric and be placed near community gardens, farms, or at any public gathering to take waste from those places and turn them into a productive resource in as little as 8-12 months. Unlock the poo-tential of human waste with **TO DA LOO!**

TO DA LOO

Turning Poop into Potential

TO DA LOO is the urban composting toilet that turns human waste into an environmental asset. Biomimetic design reduces the stress on our cities' sewer systems, water pollution, and increases access to public bathrooms.

TURN HUMAN WASTE STREAMS INTO NEW PRODUCTS

REDUCE WATER USAGE AND CONTAMINATION OF WATER WAYS

INCREASE PUBLIC ACCESS TO BATHROOMS

The Problem with Our Waste

The current way we manage human waste is unsustainable. Outdated and failing waste infrastructure in cities overflow into streets and leach into drinking water, causing disease and gastro-intestinal illnesses, and cost millions of dollars after nearly every rainstorm. Our current waste infrastructure often diverts fresh, clean, potable water to flush away our waste, draining aquifers and poisoning our rivers, lakes, and oceans. In the face of climate change, these issues will only worsen. But if we design with nature, ***our waste doesn't have to be so wasteful.***

Why Compost Human Waste?

Indigenous populations around the globe have been composting human waste for millenia. Chinese farmers used to apply the famous 'night soil' on rice paddies after collecting human refuse from the cities. They understood that people have a direct relationship with the land, and fertility taken from the land must be given back.

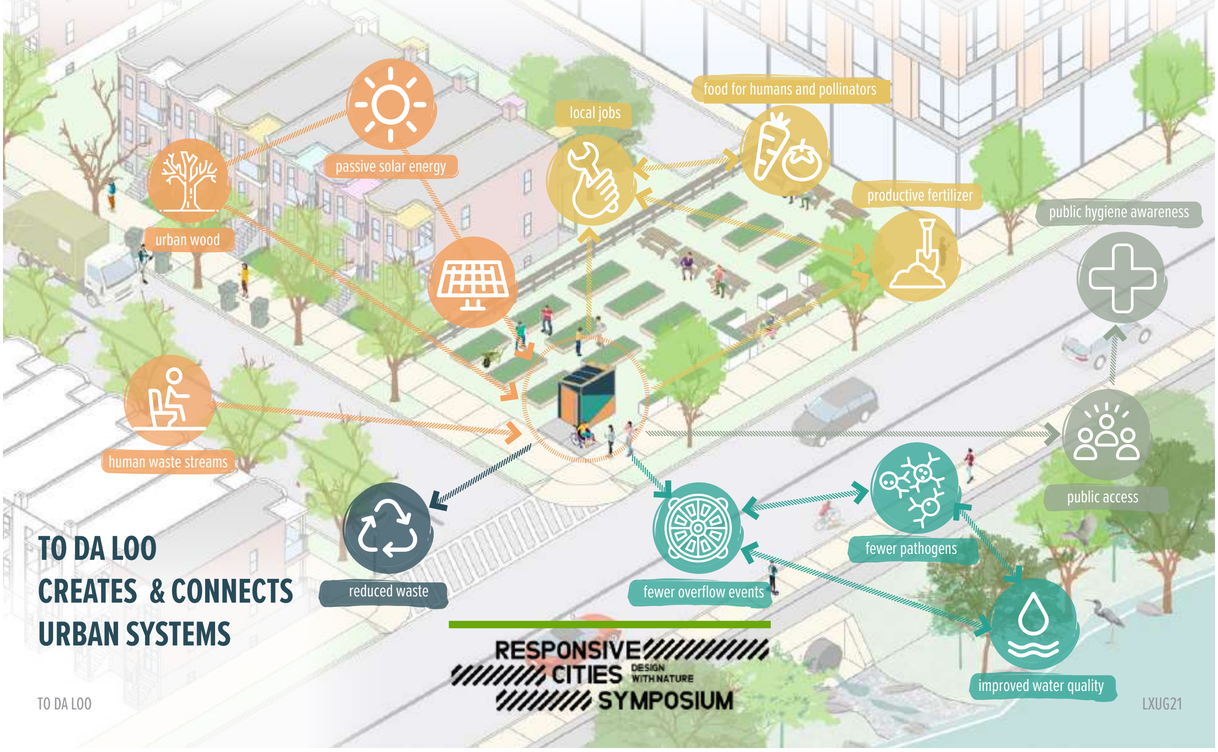
Well designed composting toilets can solve multiple problems at once:

- Combine multiple waste streams and turn them into a productive asset
- Decrease stress on our water systems
- Improve public health and awareness of hygiene
- Provide easily accessible sanitation to those in need
- Enhance social relations

800 +	U.S. cities with combined sewer systems (CSS)
23,000 +	CSS overflow (CSO) events annually in the U.S.
27 billion	gallons of raw sewage released into New York harbor alone
5,000 +	CSO-related illnesses annually in the U.S.
2.3 billion	people lack access to basic sanitation globally

Meeting U.N. Sustainable Development Goals

- 3 Good health and well-being
- 6 Clean water and sanitation
- 9 Industry, innovation, and infrastructure
- 11 Sustainable cities and communities
- 12 Responsible consumption and production
- 13 Climate action
- 14 Life below water



TO DA LOO CREATES & CONNECTS URBAN SYSTEMS

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

TO DA LOO

LXUG21

TO DA LOO

The Urban Composting Toilet

passive ventilation system
Provides airflow to the solids storage tank to keep composting process aerobic. This reduces odors and hastens decomposition. A solar-powered fan may be activated when sensors detect low levels of oxygen in the tank to ensure constant air flow in all climates.

perforated ventilation panel

bulking agent storage
Bulking agents are added to the solids to absorb moisture and create air pockets to encourage the aerobic activity needed for the solids to property convert to usable humanure. **TO DA LOO uses recycled paper and wood chips from urban wood.**

weather-proof monitor center & solar inverter
Sensors are used to detect when the bins are full. A thermometer also monitors the temperature, as certain temperature ranges are necessary to maximize decomposition. Inverter for solar panels is also located here.

removable solid collection tank

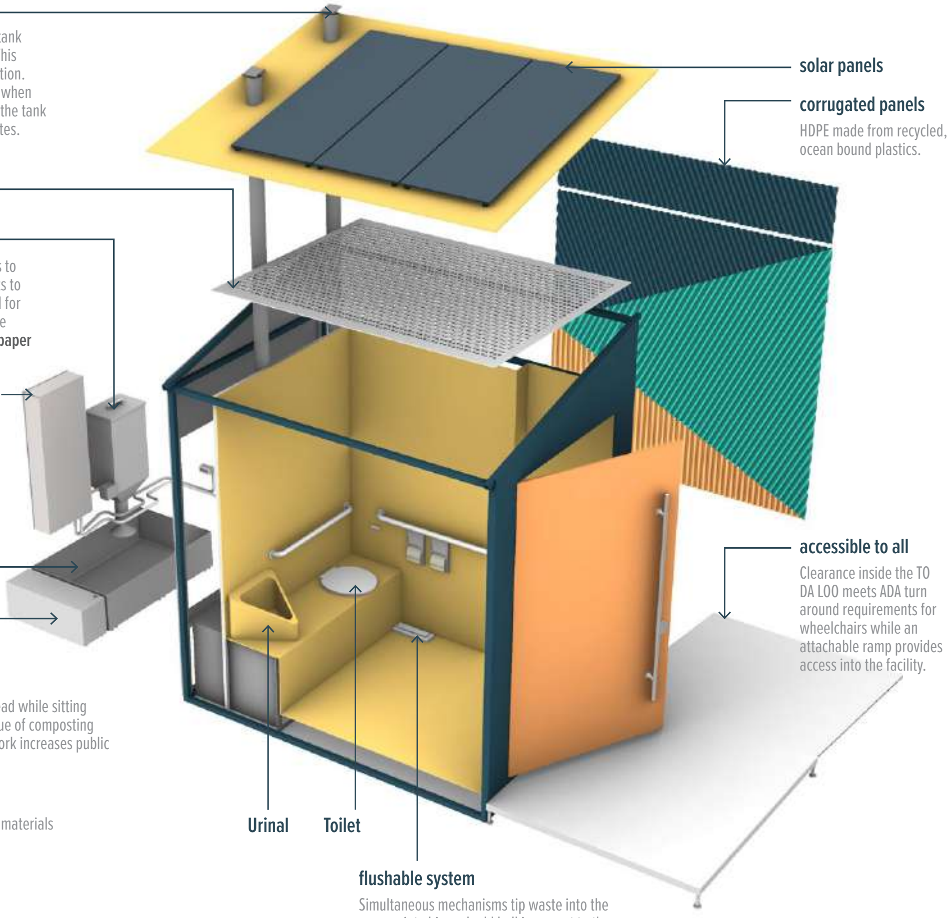
removable liquid collection tank

informational signage
Graphic on back of door that can be read while sitting on the toilet educates folks on the value of composting toilets in urban areas and how they work increases public awareness and understanding.

toilet paper
Made from recycled and compostable materials

weight sensor with automatic locking system
Locking door triggers toilet lid lifting to limit compost exposure

human by-product separator
For efficient composting and to allow resulting humanure to be more widely applicable, solids and liquids are diverted into separate containers.



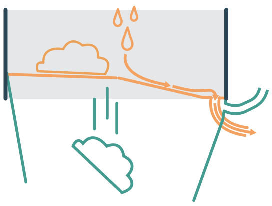
solar panels

corrugated panels
HDPE made from recycled, ocean bound plastics.

accessible to all
Clearance inside the TO DA LOO meets ADA turn around requirements for wheelchairs while an attachable ramp provides access into the facility.

flushable system
Simultaneous mechanisms tip waste into the appropriate bin and add bulking agent to the solids when activated by the floor or wall pedal.

Back of House
Houses all maintenance and electronics behind lockable panel doors. Solid and liquid collection tanks are in a separate compartment to confine any odors.



1. Liquids flow down the slanted trap door (closed), toward a tube that directs liquid into a separate container. Solids rest on the closed trap doors.

2. When flush pedal is activated, traps open, dropping solids into collection tank below.

WHERE DO YOU TO DA LOO?

Farmer's markets
Public parks
Outdoor parties
Pop-up events
City areas where public restrooms are limited

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

TO DA LOO LXUG21

TO DA LOO

Designed by Nature

Black-Tailed Prairie Dog

Passive Ventilation & Aeration

The asymmetrical turrets of the Black-Tailed Prairie Dogs create a pressure differential that directs air into the lower tube, causing directional airflow. Oxygen is key to the aerobic activity necessary for efficient and odorless decomposition. **TO DA LOO's dual pipe ventilation system mimics the passive ventilation created by the Black-Tailed Prairie Dog's asymmetrical turret construction.**

Australian Fan Palm

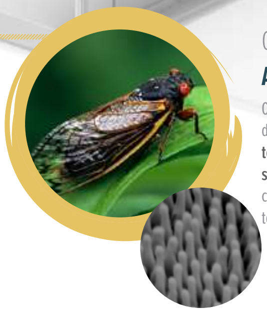
Cladding that Cools

The corrugated cladding on the sides of the structure mimic the Australian Fan Palm, which directs air through the channels created by the corrugation, and blows off heat. **TO DA LOO's cladding is high-density polyethylene made of recycled, ocean-bound plastic.**

Composting

Turning Waste into Resource

There is no such thing as waste in nature. **TO DA LOO uses nature's model of handling excrement by passively turning it into compost**, which can be used for many applications, including urban farming, and amending soil for landscapes.

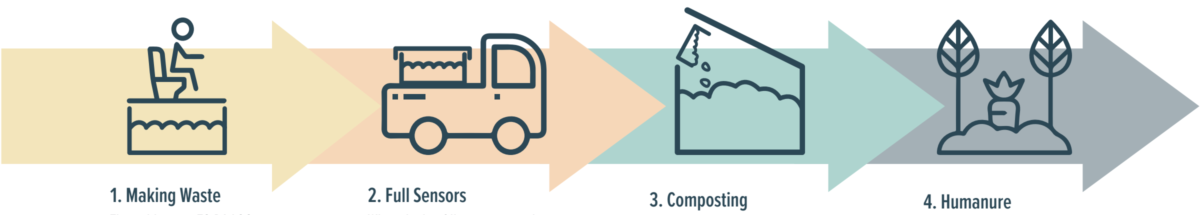


Cicada Wings

Anti-Bacterial / Superhydrophobic Surfaces

Conical nano-structures on the wings of a cicada allow the passive destruction of bacteria that land on the wing surface. **On the toilet seat, the conical nano-structures create an antibacterial surface.** On the human by-product separator, the conical field creates a superhydrophobic surface that allows solids and liquids to easily slide into the appropriate basins.

TO DA LOO's Compost Process



1. Making Waste

The public uses TO DA LOO. Solids and liquids collect in their appropriate containers.

2. Full Sensors

When the bin fills, sensors within notify the responsible city or private department to pick up the bin and put an empty bin in it's place.

3. Composting

Full bins are taken to a yard waste facility where they are emptied into a dedicated composting area to fully compost into humanure. Urine can be used for fertilizer.

4. Humanure

In 8-12 months, humanure will be ready to use as a compost amendment for urban farms, gardens, and landscapes.

RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

TO DA LOO

LXUG21

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KEYWORDS

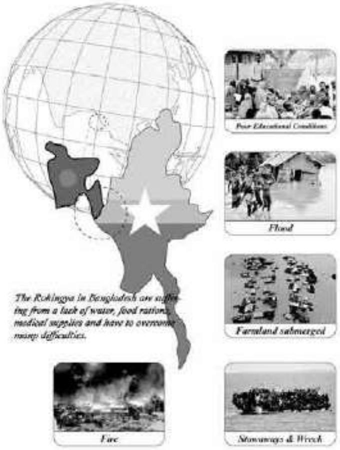
ecological, intelligent, in-site, modular, anti-disaster

ABSTRACT

Although technology and science are developing rapidly, there are still many people who live difficultly under the threat of violence and natural disasters. That is the case in The Nayapara refugee camp in Bangladesh, where many Rohingya who fled Myanmar now live with limited resources. Refugees have nowhere to hide from natural disasters such as floods and rising sea levels. During the floods, Nayapa refugee camp was like an "open air prison," where undocumented Rohingya stayed. The hope is to build smart city models in a economic, positive and optimistic way to help them live a better life during and after natural disasters and provide them a platform at peace with local people. In order to achieve this goal, we adopted the idea of modularity, with functions such as education, medical care, storage, planting and event center, making the building more flexible and sustainable. The modular setting is in normal mode during normal times, but in the event of a disaster, it automatically switches to emergency mode, with some functions shifting to provide disaster relief, transportation and shelter. In terms of technology, salting-out technology to improve the ecological environment, heat-sensing technology to save mankind and early warning system to forecast disasters have been adopted. Our design mimics similar styles of local houses, trying to intervene in this area in a conciliatory way, as a catalyst, not only to heal their wounds and provide a new way of life, but also to broaden their horizons and even light up their lives.

Ribs of Cypress

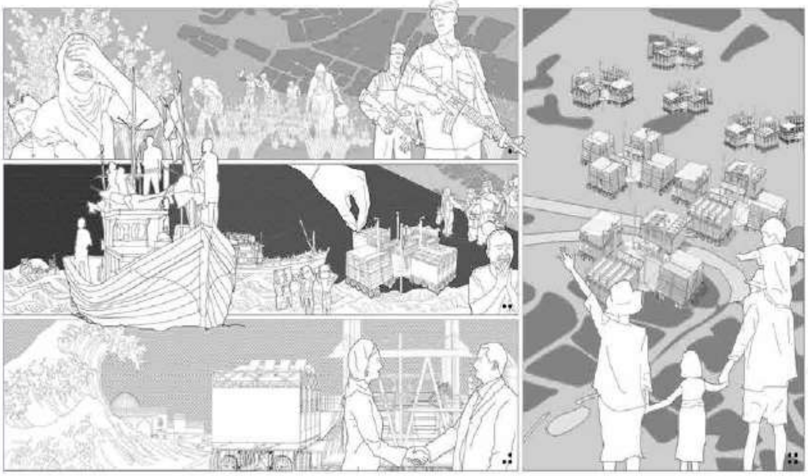
—Focused on environment and citizens interation in public spaces of refugee camp



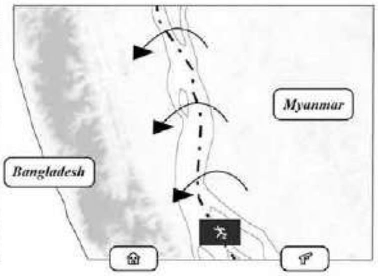
Before the waters of the flood came upon the earth, The Maker said to Noah, "Make yourself an ark with Ribs of Cypress."

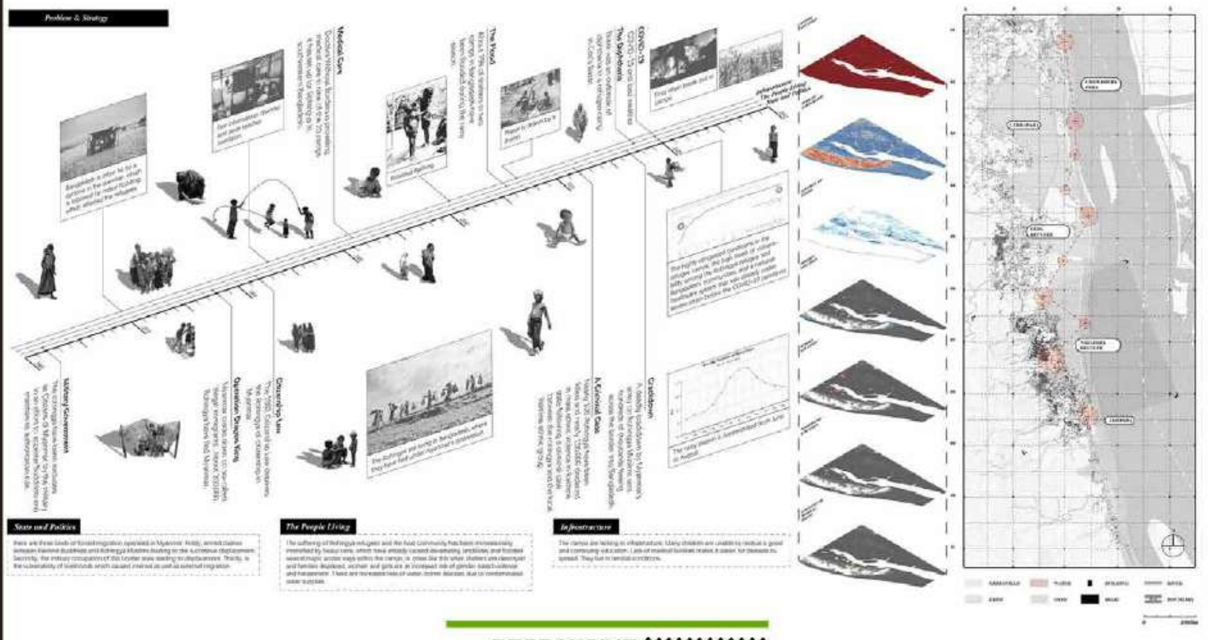
Although both technology and science are rapidly developing, there are still many people living a hard life threatened by violence and natural disasters. It's exactly the case of the Nayapara refugee camp of Bangladesh, where many Rohingya people who escaped from Myanmar now live with limited resources, that have sprung up. The refugees have nowhere to hide from natural disasters such as floods and rising sea levels. During the floods, the Nayapara refugee camp was like an "open air prison," with undocumented Rohingya staying put. As William Gibson said, 'The future is already here –it's just not very evenly distributed.' It's hoped that to build a model of Smart City in an economical, positive and optimistic way may help them live a better life during and after some natural disasters occur and provide a platform of peace with the locals.

To achieve the goal, designers adopt the thought of modularization, setting some important functions like education, medical treatment, storage, plantation, activity centre, to make the building more flexible and sustainable. The modular settings are in normal mode at the usual time, while if disasters come up it turns to emergency mode automatically, in which some functions change to providing disaster relief, transport and sanctuary. When it gets down to the technical side, salting-out technology for improving eco-environment, heat sensing technology for saving people and pre-warning systems for forecasting disasters are utilized. Imitating a similar style of local 'houses', our design tries to intervene in the field in a conciliatory way, which is also expected to act as catalysts not only healing their wounds, providing a new lifestyle but also broadening their horizons, even brightening their life.



Journalists and news media have described the Rohingya as one of the most persecuted minorities in the world. Since the 1940s, most Rohingya have faced a military crackdown and been driven out of Myanmar into neighboring Bangladesh.





RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM

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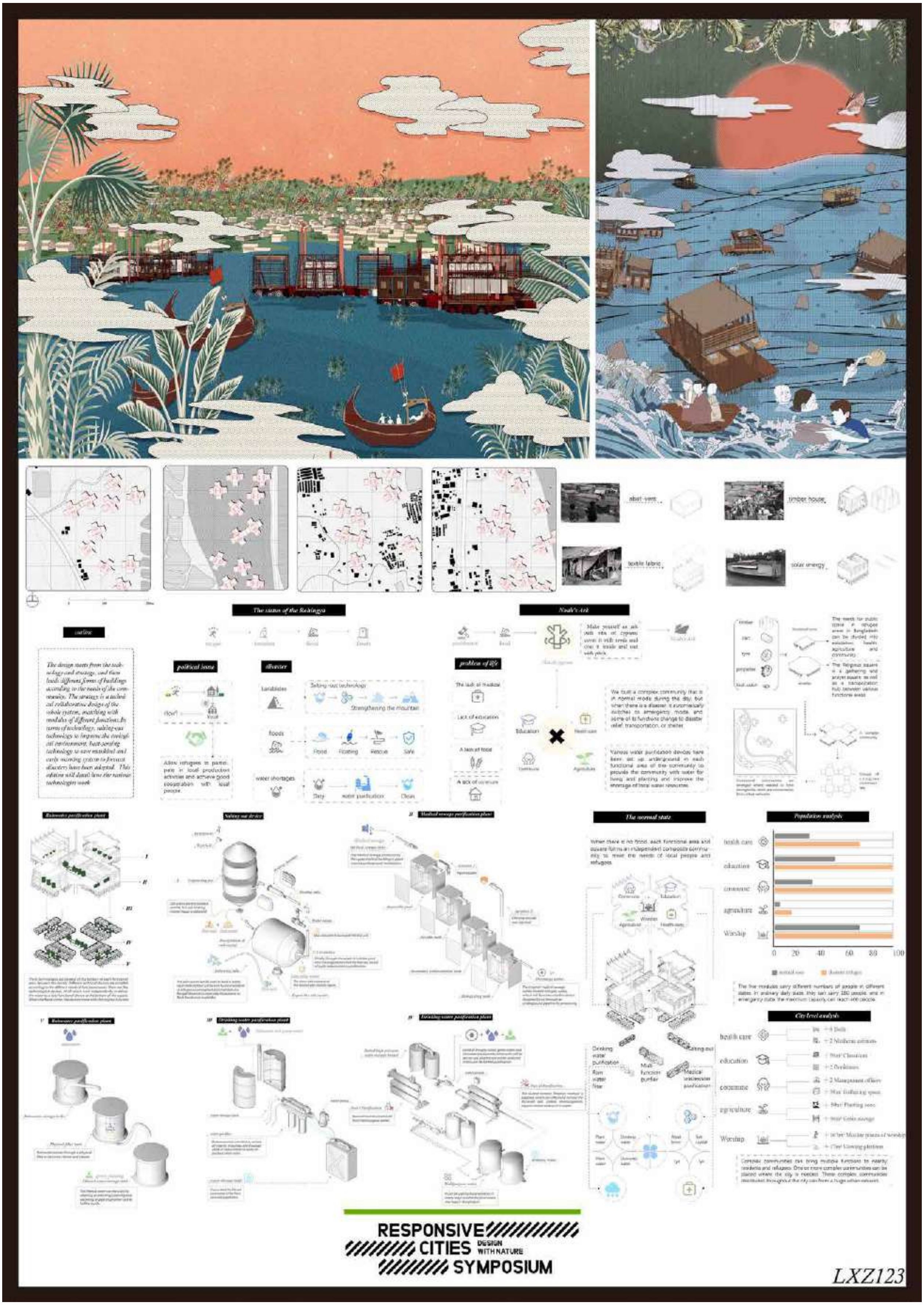
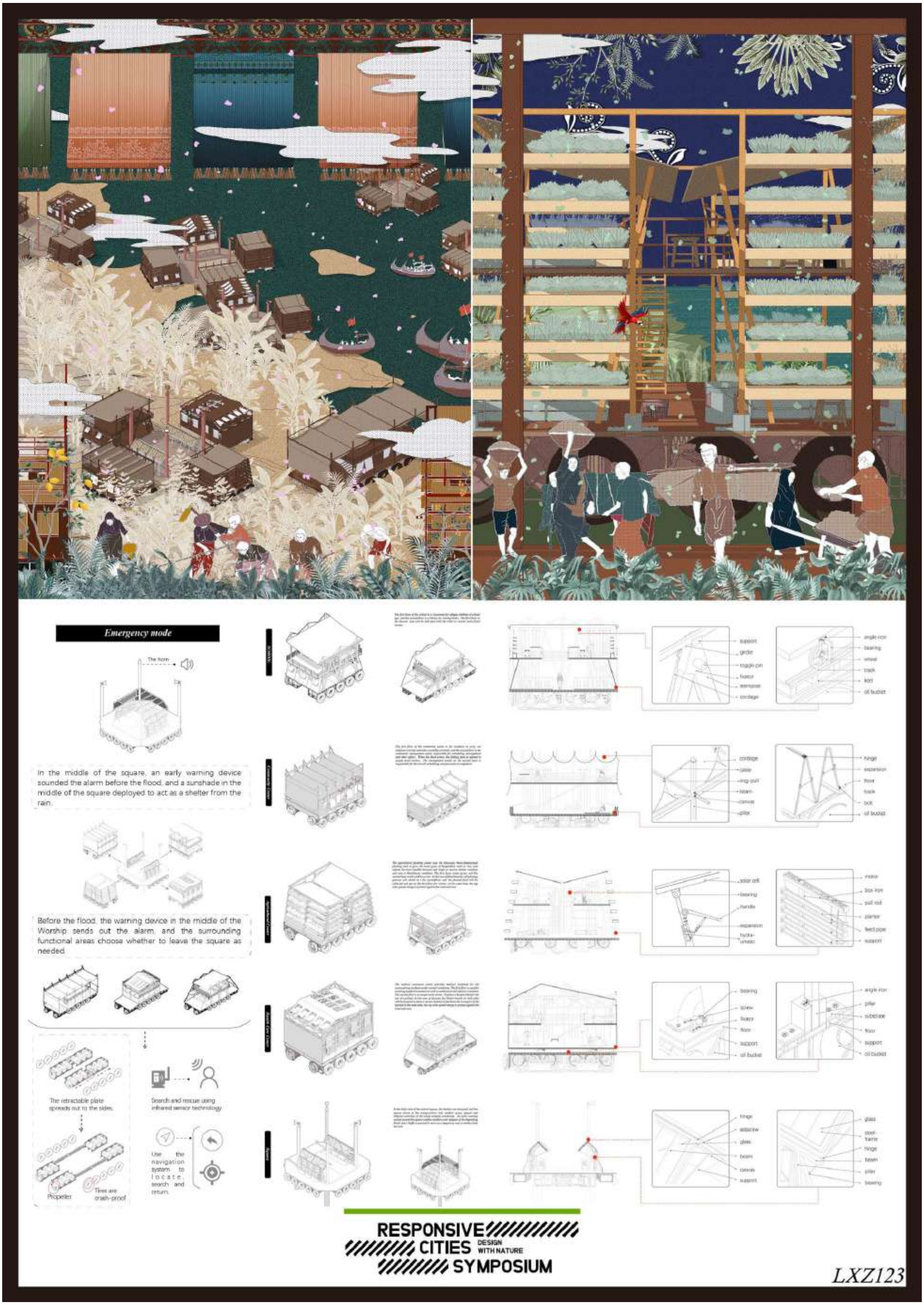


RESPONSIVE CITIES DESIGN WITH NATURE SYMPOSIUM
LXZ123


Emergency mode
The horn
In the middle of the square, an early warning device sounded the alarm before the flood, and a sunshade in the middle of the square deployed to act as a shelter from the rain.
Before the flood, the warning device in the middle of the Worship sends out the alarm, and the surrounding functional areas choose whether to leave the square as needed.
The retractable plate spreads out to the sides.
Search and rescue using infrared sensor technology
Use the navigation system to locate, search and return.
Propeller
Tires are crash-proof
RESPONSIVE
CITIES
DESIGN WITH NATURE
SYMPOSIUM
LXZ123

BOOK BOKK

Senegal

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KEYWORDS

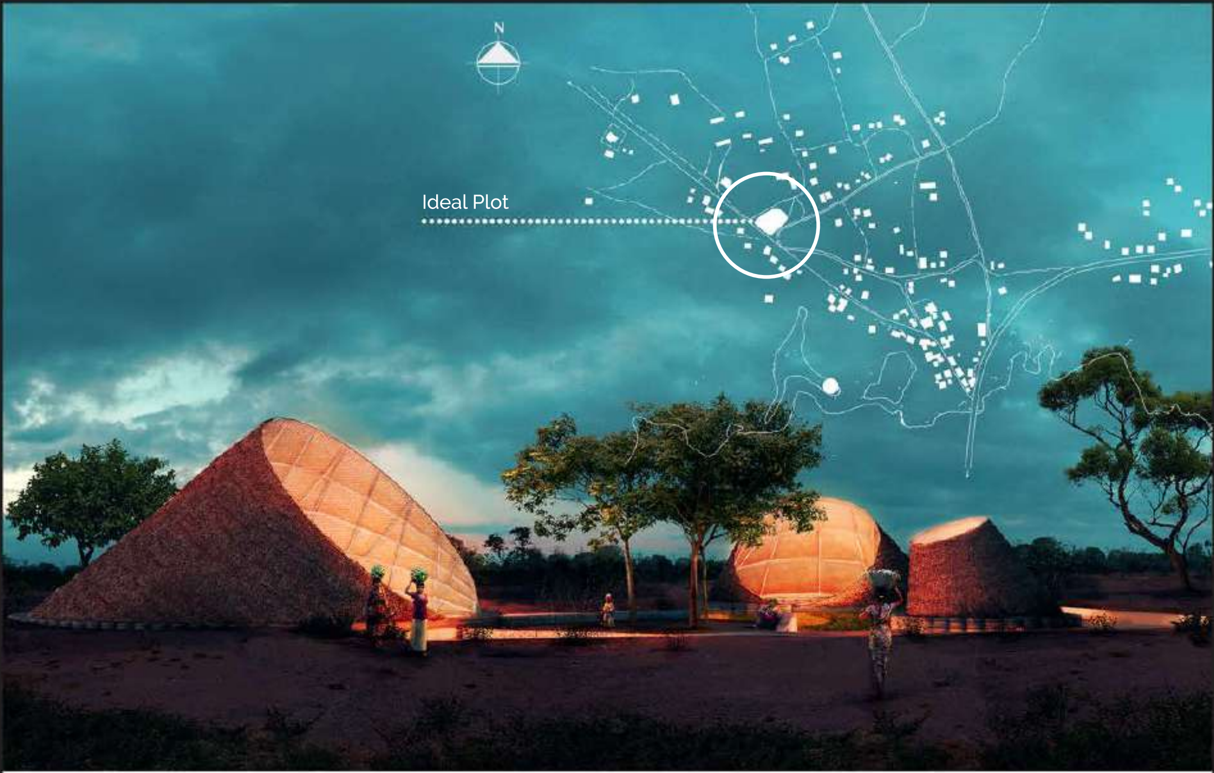
women's house, reintegrating nature, user's empowerment, participatory design, collective intelligence

ABSTRACT

This project was inspired on Bagheri and the gender inequality, abuses, oppression, and low visibility women have every day. In this place, people live in a precarious situation and deal with a lot of social problems, this is why it is proposed a construction to be used as a tool for the members of the community to share solutions, participate in activities, protect all the members, but most important, where women who have directly identified inequalities can make everyone aware.

The distribution and form of the project arises from the abstraction of Senegalese housing typologies, which are based on dispersed settlements installed in the shape of a village. The houses are similar to huts and are organized around a tree or well taking into account the direction of the monsoon. The walls are built with vegetable fibers or cement blocks and the cone-shaped roofs are covered with thatch.

The project has three different layers and, above these spaces, three circular roofs are located on a central square where the ground, vegetation and water meet and take the center stage. The architecture considers the woman's relationship with soil and agricultural work through an approach that symbolizes an encounter with their roots and their rebirthing. This project is a simple intervention that articulates spaces and knowledge through collective actions, a tool that offers protection and integration to women and a place where everyone has the opportunity to express themselves, be present, be seen and heard.



bOOk bOkk share & participate

The architectural proposal "bOkk bOOk" planned to the "Women's House" competition that will be implemented in Bagheri aims to be a material and symbolic contribution to the collective´s dream of reducing gender inequality gaps in the community. The project is conceived as a tool that allows women to share, participate, protect and integrate members of the community, and where women who have directly identified inequalities can raise awareness among others.

The architecture takes up the woman's relationship with soil and agricultural work through the approach of an architecture that is born below the natural level of the ground; it symbolizes the encounter with the roots and rebirthing from them.


KNOWLEDGE FROM WOMEN


TRADITIONAL CONSTRUCTION


LEARNING BY DOING


WOMEN ENGAGEMENT

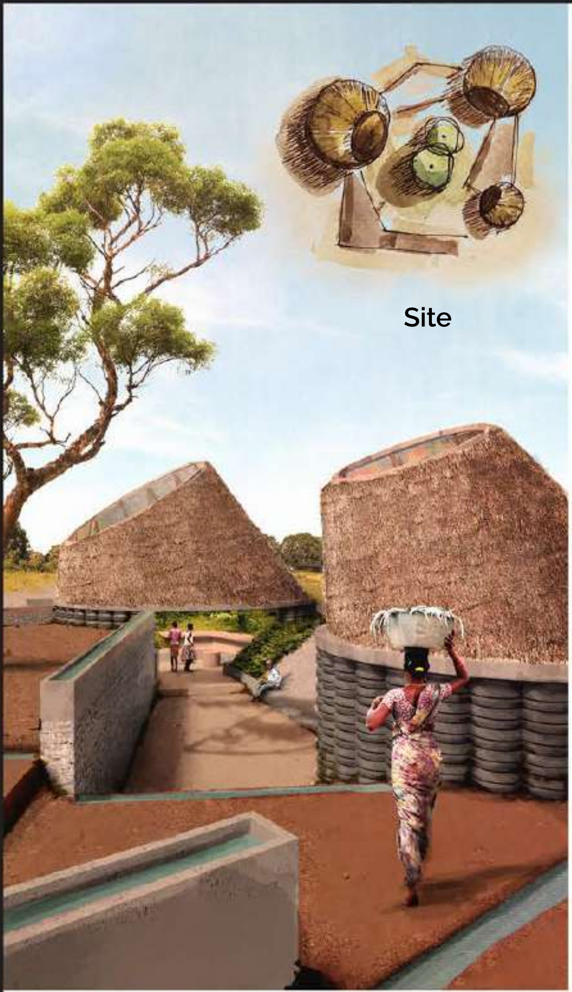

PROJECT IDEA


Facade

PROCESS OF CONTRUCTION
AS A RITUAL

RESPONSIVE CITIES DESIGN WITHNATURE SYMPOSIUM

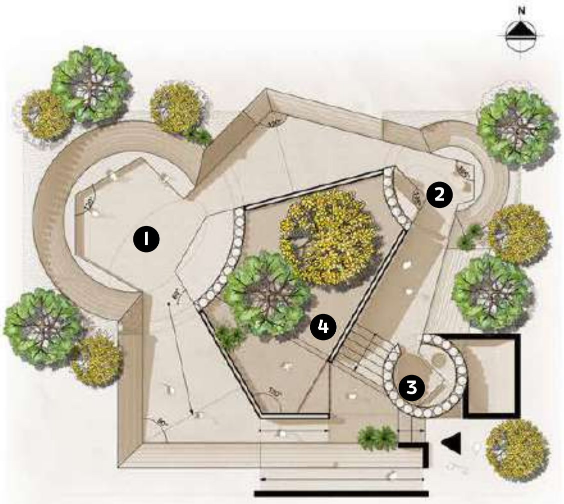
XYZ789



CIRCULAR TYPOLOGY

MATERIALS AND CONSTRUCTION TECHNIQUES

The distribution and form of the project arises from the abstraction of Senegalese housing typologies, which are based on dispersed settlements installed in the shape of a village. The spaces of these houses are organized around a tree or well (common space) which form a central square. These are made up of circular, square or pentagonal huts; the walls are built with vegetable fibers or cement blocks and the cone-shaped roofs are covered with thatch.



Underground level

0.5 1 2 4 6

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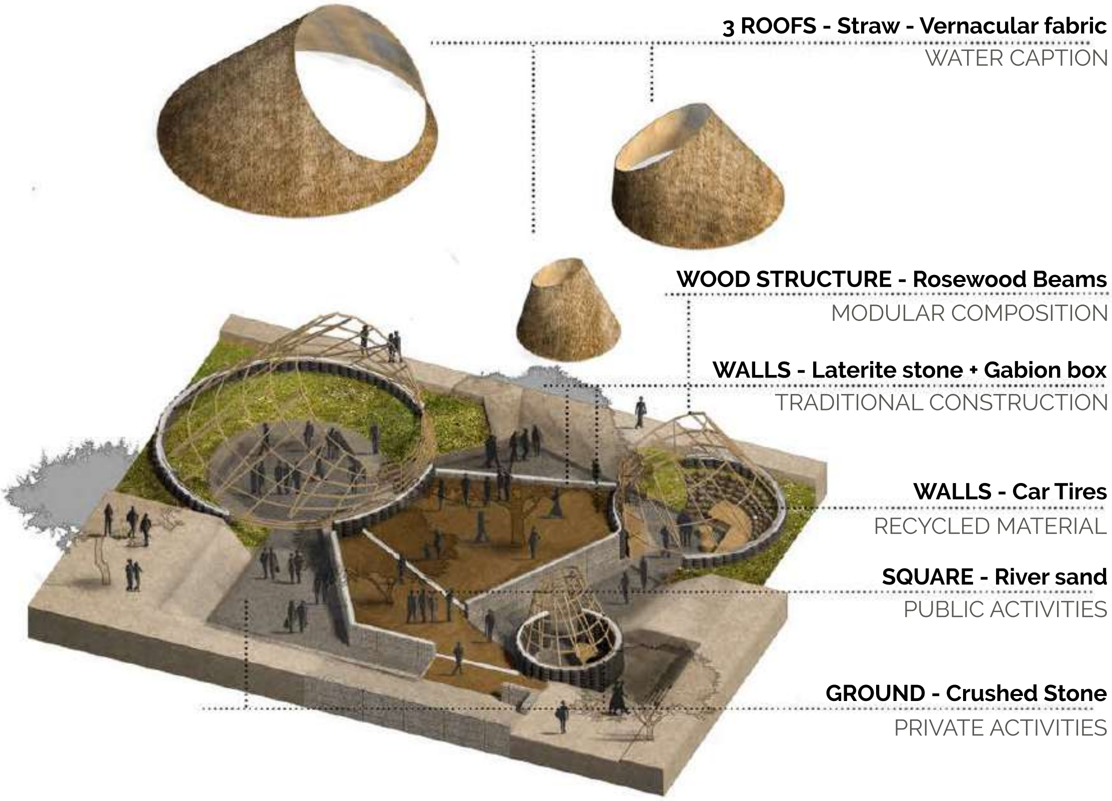
Construction model



The project is built in different layers: it starts from the underground (protection) where 3 spaces with different levels of privacy are formed (personal hygiene, organization and dialogue) to a stage to display femininity, revalue women and admire the work made by their hands (collective activities).

Longitudinal section

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2050 SCENARIOS FOR CITIES
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PERFORM

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