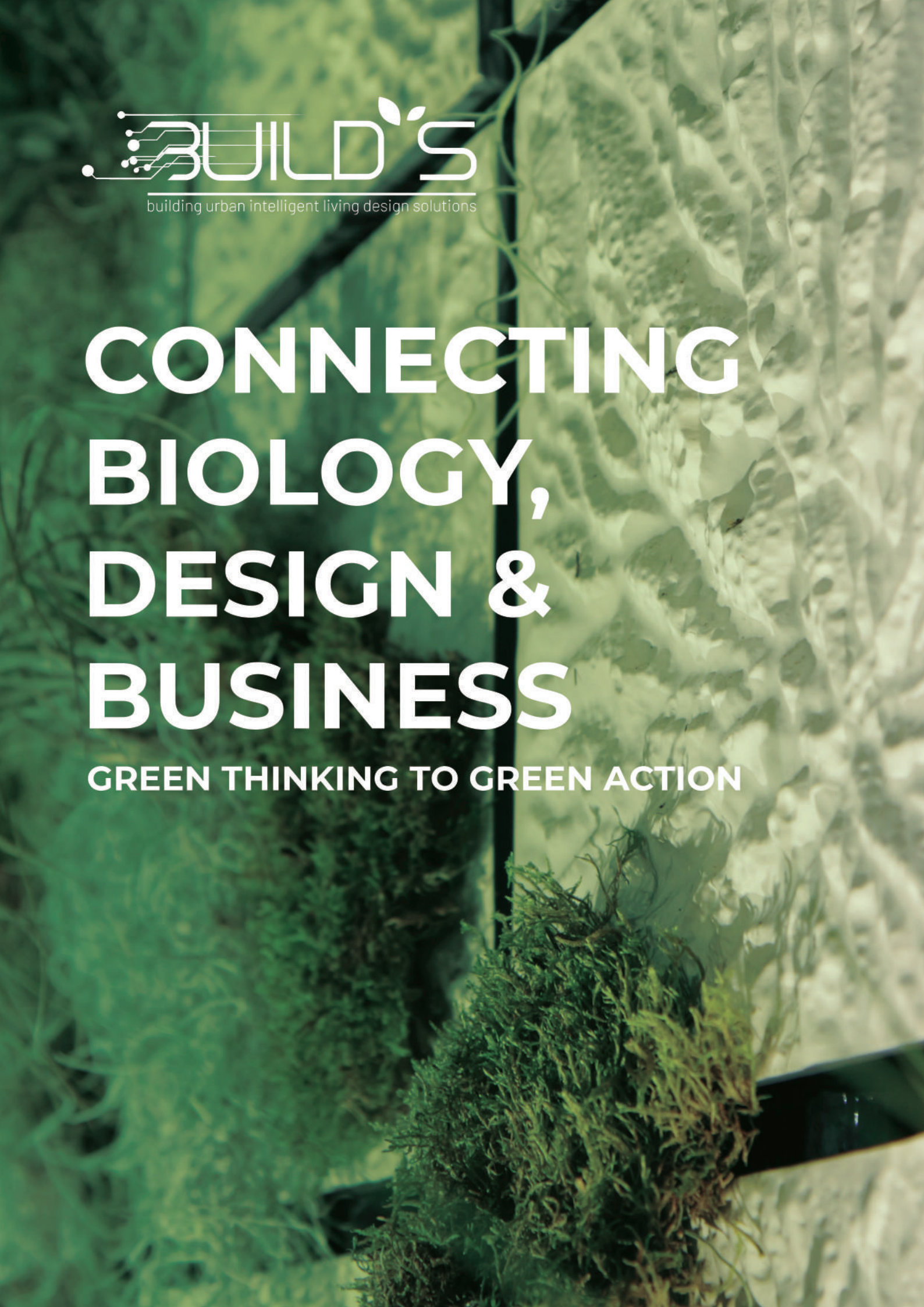
BUILD'S
building urban intelligent living design solutions
CONNECTING BIOLOGY, DESIGN & BUSINESS
GREEN THINKING TO GREEN ACTION

BUILD SOLUTIONS
CONNECTING BIOLOGY, DESIGN & BUSINESS
Green Thinking to Green Action

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FOREWORD

Nature-based solutions (NBS) is a term commonly heard today across different disciplines and has gained attention from large institutional bodies. 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. Prominent city challenges include indoor and outdoor air pollution, the urban heat island effect, and decreased levels of biodiversity. 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 instils the knowledge in students to research and find tangible solutions with the possibility of implementation.

Building Urban Intelligent Living Design Solutions (BUILD Solutions) set up an experimental transdisciplinary educational model focused on Learning by Doing and bringing together the disciplines of biology, design and business. Students, teachers, researchers and businesses collaborated to develop intelligent living solutions and bring them to the market. This was achieved through investigating biological systems, creating smart design prototypes, business plans, plans for start-ups and working with accelerators.

This book compiles the BUILD Solutions experience with ideas shared by professionals in the fields of biology, design and business, more specifically on the importance of transdisciplinarity. Building Urban Intelligent Living Design Solutions (BUILDs) project is 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).

INTRODUCTION

As defined by the European commission, nature-based solutions (NBS) are considered “Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions” (EC). NBS did not become common in literature until after 2009 and the term only emerged in the early 2000’s (Snep., 2020).

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.

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, the implementation of their discoveries stumble due to a lack of personal experience in entrepreneurship and cooperation with industry leaders (Fritsch 2010).

The Building Urban Intelligent Living Design Solutions (BUILD Solutions) project set up a transdisciplinary cooperation among universities and businesses by engaging students, teachers, and researchers. It provides them with the necessary entrepreneurial skills and connections to create and bring intelligent living solutions to the markets, through the investigation of biological systems, the development of smart design prototypes, business

plans, plans for start-ups and working with accelerators.

The project's objective is to develop an experimental transdisciplinary educational system linking biology, intelligent design and business through several kinds of activities. These include courses for students and trainers, symposiums, development of educational resources, the set-up of an accelerator programme, launching an international call for ideas and creating new networks. The results of these activities, specifically the educational programme can be found throughout this book, with insights from experts that have participated in the activities. BUILDs has led to key results that demonstrate the importance and need to implement such educational programmes.

Cooperation among Institutions, Inclusiveness and Access to Excellence
Effective interdisciplinary collaboration set up through the BUILDs Programme has facilitated an easy exchange, flow and co-creation of knowledge across the three Higher Education Institutions and disciplines - biology, design and business. In addition, the same level of knowledge transfer was achieved with the entrepreneurial world and across borders - Spain, France, Austria, Denmark, and the Netherlands. BUILDs has allowed for the latest and most innovative research and market products in the field of nature-based solutions to be brought into the academic discussion. These solutions demonstrated how nature-based solutions can holistically address the most pressing urban and global challenges and inspired several new solutions which will be further explained in the book.

Digital Green Transitions and Online Learning
In order to promote a holistic educational model in the face of the current societal challenges, BUILDs developed the One-Year Programme, organised in a collaborative way that allowed 30 international students to work remotely in 5 start-ups, composed by 2 students coming from each of the three Higher Education Institutions (biology, design, business). Using a start-up model allowed students to work within interdisciplinary groups with peer colleagues from other European Universities, and receive high-level

coaching by experienced entrepreneurs of the green sector. By working towards the same goal - to develop groundbreaking Nature-Based Solutions (NBS) - each team's diversity brought a consciousness and perspective on the same challenge to address it holistically. Fast prototyping tools allowed the groups to create 1:1 prototypes of their projects, test them and show them to potential clients. By using the latest online platforms of communication and a set of regular programmed activities, BUILDs has been able to create an effective comprehensive platform that allows multidisciplinary co-creation and continuous knowledge sharing across the three Higher Education Institutions, with the support of the business partners.

Figure 1: Trainers in Corserolla National Park, Barcelona

Internationalisation and Opportunities for Competitiveness

A key objective of the BUILDs Programme was to stimulate entrepreneurial skills in higher education. The One-Year Programme pushed students and trainers to think out-of-the-box and work in a transdisciplinary manner from a result-driven approach. The proof, five nature-based solution start-ups, with one being selected by an external jury to participate in a one month Accelerator Programme in Bloxhub, Copenhagen. Continuing their ideas, several start-ups participated in international events and contests, winning several prizes. These included Entrepreneurship Avenue Contest, Climate Launchpad 2020, 2020 University Start-up World Cup, Dubai Design Week, and many more!

Strengthening Collaboration between Academy and Business

BUILDs has demonstrated an efficient collaboration between European Higher Education Institutions and business specialists is possible. A solid cooperative framework has been established between teachers, researchers and businesses with expertise in the green sector. Through their connections with both public administration and private sector stakeholders, they have ensured a wide and effective dissemination of the ongoing project results to reach a wider audience. This model can serve as a best practice model for future replication.

BUILDs is an example of a successful, replicable, interdisciplinary higher educational programme, through incorporating an innovative business mindset at its centre with the aim of addressing the current urban challenges by promoting more sustainable and greener cities. Connecting Biology, Design & Business brings together perspectives from the consortium partners and professionals working with nature, as well as key insights from the BUILDs experience with the intention to inspire the next generations of entrepreneurs to work in interdisciplinary groups to find viable and forward-thinking nature-based solutions.

SECTION 1

TRANSDISCIPLINARITY

TRANSDISCIPLINARITY FOR MULTI SPECIES CO-EXISTENCE AND COLLABORATION

The Urban Environment has developed over the centuries into a complex machine to host human beings and their activities, actively excluding external factors that disturb anthropogenic activities. Part of this process consists of excluding “nature” (with the exception of a few selected species) from cities. Today a new consciousness of the effects of anthropogenic activities on our planet and the regulating properties of nature is causing us to reconsider the introduction of nature in cities. A discussion has begun in recent years on the process of rethinking cities as environments which can encourage multispecies co-existence and collaboration. Studies performed in different fields such as biology, ecology, urbanism and design agree that emphasizing the agency of life-forms and their ability to set goals may foster local and global sustainability (Lenton and Latour, 2020). The example of natural ecological systems reveals that mutualistic attitudes between living beings help to shape their ecosystems, making them stronger, longer-lived and more resilient (Mancuso S. et al, 2018).

How can we foster mutualistic multispecies attitudes in cities that are designed to exclude nature? The integration of nature in cities requires thinking beyond inherited categories (Haraway, 2016) and capacities as today co-existence and collaboration are mainly conceived and planned for a single space environment. The development of cities designed for multispecies habitation requires imagining environments able to attract and host different living organisms, which can foster dynamic processes of exchange.

Marcos Cruz (2019) refers to the idea of designing and creating scaffolds for inhibition not only for humans, but also for an entire surrounding biota as bio-integration, moving from thinking about tectonics, performativity and materiality in buildings to the understanding of architecture as an integrated system of inert and biological matter. He affirms that the external surfaces have the potential to be bio-receptive, being bio-colonized in time, and that if we implement bio-receptivity on a very large scale, we could really shift our cities from being the biggest polluters to becoming active agents. Cities designed for multispicies co-existence and collaboration stop being just a container of programmes and functions (Pasquero, 2019) and become an

inclusive space that fosters dynamic processes of exchange.

Most natural organisms require specific conditions to live (e.g. specific temperature, humidity, light exposure, etc.) and the process of creating or re-creating habitats requires high precision and accuracy. The ultimate technologies in the field of construction have the potential to help us to manage this complexity: advanced softwares helps to simulate growing systems, while digital manufacturing gives us the possibility to build specific, complex and unique pieces. These innovations open the possibility to reach a design sophistication that wasn't dealt with before.

In order to convert our current cities into biocities it is needed a wide range of expertise from architecture, to ecology, botany, social sciences, technology, governance, business, etc. This section explores how to set up a transdisciplinary education programme, bringing together students with different backgrounds to shape the city of the future, a city that fosters let us imagine the city of the future, where new encounters enhance resilience and boost diversification and evolution.


RESPONSIVE CITIES
DESIGN WITH NATURE
SYMPOSIUM
PROJECT PARTNERS:
UNIVERSITÉ DE LORRAINE

VOICES FROM THE FIELD: LIVING SYSTEMS & LIVING CITIES

DESIGN WITH BAMBOO

AUTHOR: Elora Hardy
Founder and Creative Director of IBUKU

Everything that is done at IBUKU grew out of a choice to use bamboo. Over the past two decades, over 200 unique structures have been created across Bali and beyond. In the absence of what you could call a tried and true vocabulary or even precedent of bamboo architecture, we had to invent our own rules, our own processes, our own systems. We learned to listen to the material and understand what the material wants to become in the world. We had to set up a whole new industry motion to harvest, to test, to treat, and then to design for permanent structures. Bamboo lets us reach for bounty, rather than aspiring to scarcity. One thing that is clear, is that this material itself is a simple marvel of nature engineering. Its tensile strength can be compared with steel; its compressive strength with concrete; and some measures are actually most similar to carbon fiber as stated by Neil Thomas of Atelier One. In addition, bamboo is incredible for its unusual flexibility, a trait that in recent years we have had to have, as designers, builders and as people. We had to be ready to unlearn our training in order to reinvent our own rules.

First, we had to understand bamboo. These are curving, tapering, hollow poles - no two poles alike, no straight lines, no 2x4's. Sketching has been essential to keep thinking in 3 dimensions, and increasingly in our process we use technology, CAD, Rhino, Grasshopper, exploring these technologies to bend it to our possibilities with bamboo. Not everything can happen on a flat paper or screen and thus, model making is where much of the design thinking happens. The physical model has been key in creating communication and dialogues with the craftsman who are building it. It has also guided us in how we approach the build and has given us insight into how the users will view the space. On site, that structural model rules, it is the blueprint. Every whittled stick represents a part of that structure at scale.

As technologies and engineering systems are developed that do not require or rely on the local craftsmanship, it creates a situation where there is replicable scale, and that potential broadens as to what is possible internationally.

The abundance of the material is undeniable. Imagine you could grow the materials for a whole home, or a whole skyscraper, or even a whole city within four years.

Wherever we are, or whatever materials we surround ourselves with, we humans seek shelters as comfort. The form of a building can hold us, it can hug us in the right balance of connection and protection of being enclosed while still being in nature. We remember tradition to bring the past into the future. Especially in the cities of Europe, we see this strength in a beauty inherent in old structures. How have we departed from that? How can we find our way back to it? To be part of it?

In Bali, we still love our bamboo. These columns are familiar, their form is friendly, and as a product of nature, they are varied, unique, individual, even scarred from their journey from jungle to our structure. Do natural materials with their texture and their uniqueness, give us humans permission to be our own flawed and perfect selves? Humans and natural materials are not made up of perfections, right angles or measurable details. In the world, change is inevitable, the impact on the world is inevitable. We wonder if it is possible to make that impact positive, so human presence can add value to how we live with nature as part of nature because are we not also nature after all?

With less freedom to choose where we are and where we want to go, we are more in touch than ever with the power of space. We relate to the forms around us, they inform our sense of self, they essentially become layers of ourselves. When we create new spaces, we can reinvent them. Have you ever woken up from a nap in the park, looked up into the branches of the tree? Is there something that we have forgotten, what we need?

We have spent at least several hundred years, if not several thousand, building to protect ourselves and as a default began to shut ourselves off. The texture is missing. The texture of a floor, it can ground us, it can give us a closeness. How does that affect your sense of texture in the world? How does that affect your footprint on the world? There is an element of mystery to the future and adventure being in new spaces makes something new possible in ourselves. How can a place move you? How can a structure help you become who you need to become, who you want to become? All of this comes back to remembering that we are nature and it is in our hands to create our future, to create our own future memories, experiences, our future selves.

DESIGN WITH SPECIES

AUTHOR: Feifei Zhou
Artist and Architect // Co-editor of Feral Atlas: The More-than-Human Anthropocene

Feral Atlas is a digital project on the Anthropocene, studying the non-human entanglements with human-made infrastructure projects. Through integrating first-hand field reports and artistic interventions, we created a complex, playful, and experimental Atlas that studies the Anthropocene from a more-than-human perspective. The Atlas is a transdisciplinary project by more than 200 collaborators, edited and curated by Anna Tsing, Jennifer Deger, Alder Keleman Saxena and I. To be able to study the intricacy of the Anthropocene, it is important to listen to different voices and perspectives, and to approach from different angles and methods.

An Anthropocene Atlas of Ferality

The "ferality", or feral effects, indicates the undesigned, unexpected and out-of-control effects that imperial and industrial infrastructures have been creating and spreading to the ecological world. Feral has neither a negative or positive connotation, but the effects are all around us and these can be wonderful or terrible. Flora and fauna reproduce and follow their own cycles and rhythms beyond human activities all the time. For example, an apple tree thrives after the first core is tossed, or a jellyfish invades the black sea causing ecological disasters after being accidentally introduced. Feral Atlas studies the infrastructure projects that upset formally stable non-human cycles and lead to ecological state changes. In Feral Atlas, infrastructure refers to human-built landscape modification projects that emerge within social and political programs, including plantations, deforestation, urbanisation, global transportation routes etc.

Anthropocene Detonator Landscapes

The creation of four large-scale illustrations (Anthropocene Detonator Landscapes) are experiments in visualising the Anthropocene using fantastic juxtapositions of landscape modification projects across time, scale, and location, but with historical references. They tell horrible stories in beautiful

ways. Each Anthropocene Detonator Landscape is named Invasion, Empire, Capital and Acceleration. The Anthropocene is patchy and uneven, therefore scale is crucial for observing the patchiness of the feral effects that proliferated through infrastructures. Architects, through our training, offer a particular set of skills of noticing, representing, and analyzing, especially relating to the built environment and the structures that humans have observed, designed and occupied over time.

The development of Feral Atlas has highlighted the importance of transdisciplinary collaborations to facilitate knowledge exchange. It is crucial to notice before designing, and think in advance of the long-term social, ecological and political effects that technological interventions may create. The Atlas encourages a shift in ways we, as architects, to see and understand architecture as more-than-human co-habitation.

Figure 1: Feifei Zhou Presenting at the Responisve Cities Symposium 2021

JANE JACOBS AND LEWIS MUMFORD IN SANT MIQUEL DE BALENYÀ

AUTHORS: Maria Teresa Guevara, Andreu Ulied

Renaturalisation as remedy to modern towns and cities

Lewis Mumford published an article in The New Yorker, December 1, 1962 P. 148 criticising Jane Jacobs, then a rising figure on urbanism: THE SKY LINE Mother Jacobs Home Remedies. In spite of their differences, Lewis and Jane were social scientists who shared many values, however they had reservations about the likely efficacy of the other's policy prescriptions[1].

Small renaturalisation projects and co-creation processes are very effective ways to improve conviviality and communitarian values (as Jacobs´ prescriptions favoured); on the other hand, renaturalisation projects challenge existing planning regulations and laws (it is likely Mumford would agree in favour to begin by updating existing regulations to deal with global problems such as Climate Change).

While Jane strongly advocated in favour of decentralised small projects coming from social mobilisation and social activism, as a key driver for change, Lewis thought that towns and cities need "master plans", more centralised planning regulations and public institutions to make radical changes possible and sustainable overtime. We can easily dismiss renaturalisation as "just gardening" (a "home remedy" in Mumford words) if we do not pay attention to the social dimension involved in it[2].

Jacobs believed that the essence of urban form was "self-organised complexity", with just a few and clear regulations avoiding chaos. There was a sort of "unplanned casualness" at the core of urban life. She focused on the street - how to make it safer, how to enhance human contacts on it, how to make it a place for assimilating children. As for parks, squares and other "planned" urban forms, or large housing or infrastructural projects, Jacobs expressed guarded scepticism at best, or just opposition. Jacobs derisively summed up her distaste for early 20th century attempts at enhanced urban design and pretentious technocratic modern urbanism with the term "Radiant Garden City Beautiful".

“It was a question of order versus disorder, of disciplined, or well-planned urban development versus a more haphazard, hit-or-miss approach,” according to Donald M. Miller, Mumford’s biographer and editor of The Lewis Mumford Reader (1986). Mumford was against the idea that “small is beautiful”. The end result of successive good small projects can be chaotic, unsustainable, Mumford thought, if there is no an overall guide and public leadership on the process. Mumford accused Jacobs of “aesthetic philistinism”, not caring for planned large open spaces or networks of infrastructure that are necessary to provide public services such as waste management and energy. For Jacobs, however, the existing street grids were the focus. She wanted shorter blocks, a greater mix of uses to enhance pedestrian activity. Mumford was a proponent of the superblock - rebuilding cities on the basis of exclusive pedestrian areas separated from traffic.

Small renaturalisation projects and co-creation processes are very effective ways to improve conviviality and communitarian values (as Jacobs´ prescriptions favoured), but on the other hand, renaturalisation projects challenge existing planning regulations and laws (are often require Mumford’s advice to modify plans).

Which prescription is more efficient to treat the well-known problems of contemporary cities, towns or megalopolis, from social segregation and lack of conviviality to poor environmental quality, unsustainability, increasing risks? If towns and cities are not just collections of buildings and infrastructure, but communities, it must be considered a community-building policy in itself. We have witnessed in many places all over the world how renaturalisation projects, such as transforming a wasteland into a park, can contribute significantly to the mobilization of groups of neighbours, strengthening not just the environmental resilience but the community conviviality and the inclusiveness.

In spite of their differences, Lewis and Jane were social scientists who shared many values, however they had reservations about the likely efficacy of the other’s policy prescriptions.

Renaturalisation according to Jacobs's prescriptions

The town we will be referring to illustrate Jacobs and Mumford debate is Sant Miquel de Balenyà, an small town with 1,200 inhabitants in the middle of Catalonia near the Montseny mountain. The town was formed around a railroad station known as Balenyà from 1875. The church of Sant Miquel was built later, in 1956, when most houses were built following a grid structure. Because of its history, the town is very open and enjoys an intensive social vitality, people mobilise themselves easily. The town was small but still divided into four different municipalities until 1995, when the whole town was integrated together in the same municipality with Seva, a town of similar size. Then the town took as official name Sant Miquel de Balenyà. The first land-use master plan was designed in the late sixties, and successive updated plans always confirmed its initial car-orientation, the latest from 2006.

We will report in the section three projects and initiatives in Sant Miquel de Balenyà following Jacobs´ prescriptions.

Figure 1: Participatory process to co-create the Ellipsis Park

Núria Prat[3], the youngest lady in the picture, wearing a red shirt, town resident and social activist, professor at the University of Barcelona, helped to mobilise her neighbours to design and build a public park as a community garden, something that she thought was imperative in a town with poor liveability. The town is crossed by a road carrying about five thousand cars and heavy trucks every day, and streets, most of them 10 metres width, have just 1 metre sidewalks. With the participation of the neighbours and a landscape architect, they co-created and built Ellipsis Park together. The park is characterised by 7 ginkgo trees (or Buddha trees) bought by neighbours themselves, the trees were planted in an ellipse-shape, a form that evokes movement and energy flow. The project did not require any investment from the municipality.

Today, the Ellipsis Park is a quiet, cosy and beautiful place in the middle of the town where residents can enjoy the town views. Since its creation, the park has been the scene of numerous cultural and social activities, thus building community cohesion and contributing to the physical and mental health and well-being of the community. The park is next to the church, connected through Sant Miquel Street to the railway station. The three centres that give meaning to the town.

After the positive experience of Ellipsis Park Núria welcomed the idea of recovering the town streets for pedestrians, not just to walk but just to stay, play or talk. Most streets have no trees, so it was an objective to increase urban vegetation and biodiversity. The idea was to use a “tactical urbanism” approach, building a pilot, a short-term, low-cost and scalable, reversible intervention.

Núria work began by interviewing neighbours to gain knowledge about their needs. Without observing the community’s relation with the space, there is a risk of creating a project that failed to serve the original purpose, even if expensive. To start with, Villarrubia Street was chosen, and in several meetings some design solutions were designed together with neighbours. All seemed to agree with the idea. However, some neighbours complained about the project to the town mayor because some of them were afraid of

losing the comfort of parking just in front of their doors, or having a slightly more difficult way to enter the car in the garage. So the town major decided that a referendum had to take place, even before implementing a pilot project.

Figure 2: Renaturalisaton project (Passeig de Lladoners)

But a referendum always implies to divide neighbours in two sides, with winners and losers. There is a natural tendency for many people to vote against change, if the benefits for all are not clearly visualised. Moreover, some people don't like others to get more positive impacts from a public project, even if the project is also positive for them. All of these complexities were already described five hundred years ago by Machiavelli, in the Prince (1532). If urbanism is about enhancing conviviality, as Jacobs understood, then it is better no to provoke further disputes among neighbours and just wait for a future occasion.

Reclaiming streets remains necessary in a car-oriented town. The municipality will soon begin a PMUS (Sustainable Urban Mobility Plan) that will further develop these ideas and discuss them with neighbours through a formal participatory process. While the Villarrubia street experience is a precious experience, in Jacobs's terms, the PMUS can become a relevant experience in Mumford terms.

The third experience is the Passeig de Lledoners[4], former Edison Street. By changing the name, the municipality already welcomed the renaturalisation process of the former Edison Street.

According to current legislation, a street project is a standard urbanisation

project. All streets have to have standard dimensions and use standard materials, and need to be designed and constructed according to standard regulations. However, neighbours in the street decided to shift from conventional engineering to landscaping to renaturalise the mountain along the side of the street, creating a green corridor that surrounds the small mountain, called Muntanyeta, where there are sport and educational facilities built by the municipality.

The project started years ago, and it has been gradually implemented, as most renaturalisation projects have to be. First by planting trees (lledoners) and placing a small wall with rocks to contain the soil and water that comes down from the mountain. The street is not paved to absorb the water, sidewalks are grass but given the extremely low traffic people walk in the middle of the street, that is actually becoming a lovely path. Trees, shrubs, aromatic plants have been planted. Some have died, others have grown. Other plants have appeared naturally, and now some parts of the mountain already look like a Mediterranean garden, where you can find butterflies, bees and worms, and hear the sound of crickets. During summer time the trees bring some shadow to a place that is hot like a desert. The process is not finished, will never be finished. It will always require care.

Figure 3: Booklet produced by engineering students (University of Lorraine) describing NBS to tackle erosion and floods

The use of nature-based solutions is more part of a process than a final design. Design concepts are tested iteratively, moving back and forth from design to implementation while observing how nature unfolds. Sometimes there are difficulties, in the case of the green corridor the mountain soil is marl, which is prone to erosion, with the risk that some parts of the mountain slope are almost vertical and support urban infrastructures as schools. In addition to erosion, some parts of the green corridor are prone to water retention during floods. To face these challenges and in the context of the BUILD'S project, three engineering students[5] from the University of Lorraine gave advice on how to integrate NBS during urban planning to limit natural risks such as soil erosion and water floods. They suggested different nature-based solutions ranging from low to high-tech, considering their affordability, erosion efficiency, flood efficiency, aesthetics, ease of implementation, and need for maintenance.

Figure 4: Booklet produced by engineering students (University of Lorraine) describing NBS to tackle erosion and floods

Nature follows its course as does the erosion, so the execution of one or various solutions cannot be eternally postponed. The project is still questioned by some people, some of them prefer an artificial solution. A project that does not need maintenance and that could be quickly completed.

Renaturalisation according to Mumford's prescriptions

Concrete projects developed by neighbours themselves are precious but, according to Lewis, not enough to change towns or cities as a whole, thinking in the long-term or in new generations; for this to happen, there is a need to change actual planning regulations and carry on large projects. In the case of Sant Miquel de Balenyà, the municipality has begun to change the actual plan to enlarge and connect all public spaces, as a necessary step before actually carrying on projects.

Figure 5: System of parks in Sant Miquel de Balenyà. (1) sport facility, (2) garden near social facility, (3) Ellipsis park.

Implementing nature-based planning solutions is inherently complex, since there are continuing gaps in terms of legislation and governance. For instance, according to the law the total surface of green spaces below 20% slope have to be maintained, a reasonable standard that is however taken as mandatory. In the 19th century debates between Reinhard Baumeister and Camilo Sitte, already Sitte complained against the rigidity and simplicity of this standard that do not take in consideration the ecological value of land, neither if the town is a dense urban area or in a rural setting.

Zooming in the zone 3 considered in the proposal to change land-use regulations, it was proposed to transform excessive space devote to streets and cars to enlarge public gardens. A small triangle classified as public facility (D5) was transformed into green area (C9) and enlarged. A car-oriented plan is therefore proposed to be modified both for social and ecological reasons. These are places very much used by neighbours, meaningful because of the history behind; ecologically to desurbanise these areas, removing asphalt, will be a good remedy to reduce flood risk avoiding expensive investments to enlarge the sewer system.

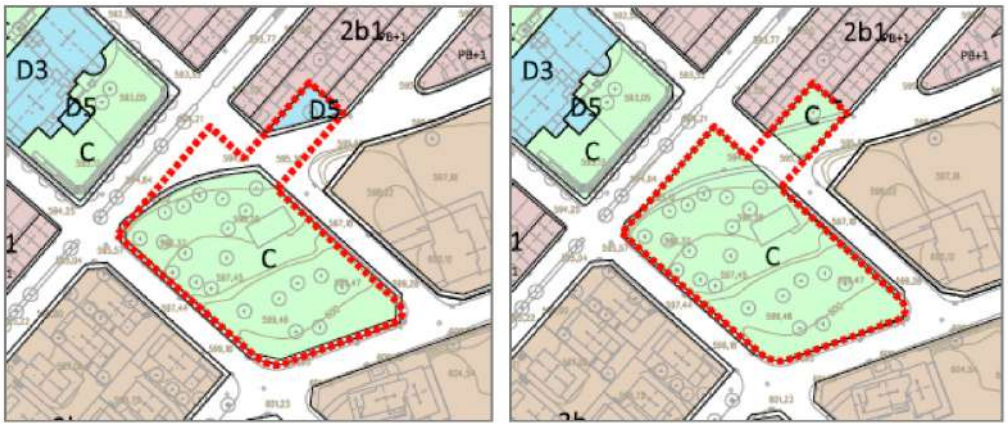

Figure 6: Actual Land-use plan, and proposal to modify the plan to enlarge two parks (Ellipsis and Bons Records)

Figure 7: Regular floods on the streets around the parks, to be removed in the parks are extended and water infiltration increases

Renaturalisation is a "home remedy for urban cancer"?

Are renaturalisation projects a kind of "home remedy for urban cancer", as Mumford once said in relation to Jacob's prescriptions? Is renaturalisation "just gardening"? Is the "Luxurious Ecology" of Singapore successful sample of renaturalisation? Can we reintroduce wild nature, and exotic animals, in our towns and cities? It is renaturalisation the right planning strategy to face global challenges such as Climate Change? To what extent can we get rid of zoning and hard engineering projects and renaturalisation is mere "aesthetic philistinism"?

Cities all over the world rush to become "Digital Green" or "Smart". Gasoline and noisy vehicles are being removed from streets, and at the same time sensors and cameras to monitor weather and environmental conditions and people activities are placed at every corner to get massive online data useful to feed intelligent algorithms that decide how to manage the optimal irrigation of gardens, or how to implement circular economy processes, for instance. What will it be like to live in a town free from human errors? An efficient, sustainable, resilient, and safe city? Is it a rational and controlled environment, liveable, after all? The Smart City often looks like the world of the "Green Leviathan" imagined by Mark Coeklbergh[6], a world populated by people that –like the "Last Man" by Nietzsche, the "Tourist" by Bauman or the "Productive Self" by Han, people that feel happy living standard lives because they do not have to make any existential decisions.

What it has been defined as Advanced Urbanism by many authors, particularly by the KAAU research project (2018)[7] is closer to Jacobs than to Mumford, since it is emphasising the social and cultural dimension involved in the process of building cities. Advanced Urbanism is about planning and designing green and digital cities, yes, but by engaging citizens, business and government into sustainable processes; by placing citizens at the core of urbanism, focusing on processes instead of end products, buildings or infrastructure, and avoiding having a final ideal destination in mind. It is the Jacobs approach to decentralisation, muddling through, accepting non perfect, even unpredictable outcomes, is a feasible strategy.

Successful renaturalisation processes are close to Jacobs "home remedies'', communitarian projects. Big plans and regulations, large projects advocated by Mumford are still needed but should not drive the process but provide structure, an "autopoietic structure", in the sense of Humberto Maturana[8], a frame that changes overtime, that do not prevent spontaneity and social activism. Paradoxically, emerging technologies can provide for the tools to support both bottom up self-organised networks and communities, and top-down centralised plans. Jacobs was rather pessimistic in her latest days, since he imagined a future populated just by standardised productive selves. Her latest book was "Dark Age Ahead" (2004). Let's take this negative vision for the future as a warning.

ENDNOTES:

[1]. Among others thinkers, David Cohen, in Jane and Lewis (2006) explored the differences on Mumford and Jacobs views, as well as James G. Mellon in Visions of the Livable City: Reflections on the Jacobs–Mumford Debate, Ethics, Place & Environment (2009).

[2]. Among others thinkers, David Cohen, in Jane and Lewis (2006) explored the differences on Mumford and Jacobs views, as well as James G. Mellon in Visions of the Livable City: Reflections on the Jacobs–Mumford Debate, Ethics, Place & Environment (2009).

[3]. Núria Prat is professor at the School of Social Work at the University of Barcelona. Her field of teaching and research are the processes of community development, social and interpersonal communication.

[4]. The English translation of Passeig de Lledoners is Nettle Trees Promenade

[5]. In the context of the BUILD'S project the University of Lorraine (France) offered in April 2021 an intensive course titled "Science et Génie de l'Environnement". Students were asked to bring answers from a biotech perspective to different challenges exposed by BUILD partners and start-ups.

[6]. Mark Coeklbergh is author of "Green Leviathan or the Poetics of Political Liberty Navigating Freedom in the Age of Climate Change and Artificial Intelligence" (2021)

[7]. We understand "Advanced Urbanism" as the sensitive integration of ICT in cities. "Advanced Urbanism" is about merging technology and culture, focusing on planning processes –instead of just designing concrete artefacts, and engaging citizens, business and government into sustainable urbanism. "Advanced Urbanism" has a transdisciplinary nature. It requires changing traditional design and planning practises towards more open and collaborative practises (KAAU, 2018).

[8]. Humberto Maturana was author of Autopoiesis and cognition: the realisation of the living (with Francisco Varela) in 1980

Figure 8: Marite Guevara Presenting at the Responisve Cities Symposium 2021

Figure 9: BUILDs Partners Participating in a Round Table Discussion


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VOICES FROM THE FIELD: LIVING SYSTEMS & TECHNOLOGY

DESIGN WITH LIFE

AUTHOR: Mitchell Joachim
CoFounder Terreform ONE // Associate Professor NYU

There is a new movement which focuses on biology and architecture eventually becoming one. In reality everything on this planet is made by cells. Biology is technology and architecture is morphing into a very new kind of field, certainly in its methodology. Terreform ONE designs against extinction. Every 9 minutes another species on this planet disappears forever, that includes every bird, fish, mammal, insect. Since the 1970's we have lost 60% of all species. We are heading towards the equal of the pre Triassic period, known as the great dying. During this period, 60% of all ocean life and 71% of all terrestrial life died off, mostly due to carbon loading in the atmosphere from volcanoes. Architects have always been worried about a crisis, every decade architects need a crisis to face. This pandemic is the mother of all crises'. We need to be accountable. We are all complicit. We probably have to do more because nothing is changing and nothing is slowing down.

42nd Street is an idea one needs to argue for, which Terreform ONE does with its clients, patrons, and institutions, so that a version of this future can be achieved through collaborations. It speculates the future of our cities, working with technologies and nature, incorporating the gardens into the facades of buildings and creating a sense of automation to help maintain the civic spaces.

Design for Extinction
The United Nations along with the TED Countdown gives us around seven years before the effects of the permanent rise in temperature makes it impossible for oceans and coral life to survive. There is a massive movement to communicate this issue of biodiversity loss to the public. Terreform ONE produced eggs called Anti Extinction Libraries which have been placed in social spaces. They contain cryogenically frozen eggs of endangered species or species on the edge of extinction which are surrounded by seed bombs of potential flora that it will need to survive. The egg slowly melts and erodes, returning to the earth and releasing the fertilized eggs, giving the species a

chance to reset its population. It educates the public and gets them on board with the problem.

The Monarch Sanctuary produced for a building in the city of New York aimed to stop the extinction of the Monarch Butterfly. Integrated into the skin of this building, in the facade, is a vertical meadow that looks at the lifecycle of those butterflies and gives them the chance to rewild New York. There has to be a relationship between biodiversity and the occupants of the building. The butterflies do not have a voice, but we as architects can give them a voice.

Food & Waste

Working with waste, food, water, energy, air quality and mobility are fundamental in Terreform ONE's work. Cricket Shelter works with crickets as an alternative food source, making our insect powder protein inside urban areas. Flavorful foods are created through working with Michelin rated chefs to make bagels, bonbons, and pasta. By eating cricket powder, you save about 2000 gallons of water and around 3000 times the amount of greenhouse gas emissions per gram of protein. Plugin Ecology is another project focusing on pasture to plate. It serves as a cabin and can grow food on the interior and exterior such as spirulina, arugula, mint, herbs and spices. It combines different programs so that where food comes from, is not foreign to us.

Styrofoam is one of the most difficult materials to get rid of on this planet. The Amazonian mealworm is an amazing technology that is able to eat and digest the Styrofoam through an enzyme in their body, producing frass. Eventually, the frass turns into garden mulch and the worms turn into beetles that can be fed to lizards and birds. Anything we can do to increase biodiversity, that is the goal in how we can stop extinction.

Engineered Living Materials

Another idea that I have been working on is structures built from ELMs (engineered living materials). One example is using clusters of willows that are grafted together through scaffolding which controls their geometry, growing the building into the landscape so that there is no distinction between house

and landscape. Another ELM project we are working on, combines CLT and mass timber to produce a centerpiece for the largest urban park in the world. Ficus Sycomorus is grafted into a specified geometry through computer driven scaffolds that grow on the surface and integrate into the gardens. Inside focuses on growing food, food for the people of Riyadh and giving an educational tour about how we can change the way we farm or how we can do it sustainably.

How do we conceive what 11 billion people on the planet might look like? What are we going to eat? How are we going to live and move? We produced a biocity map with transgenic E Coli, an analogue, computational system, to show the growth of cities over time, and to explain and visualize population growth in our 50 largest cities. Everything that we do at Terreform One has been working with living organisms.

Figure 1: Mitchell Joachim Presenting at the Responisve Cities Symposium 2021

DESIGN WITH BIOMIMETICS

AUTHOR: Petra Gruber
CEO transarch, office for transdisciplinary architecture // Adjunct Associate Professor, The University of Akron, USA // Expert, Austrian Research Promotion Agency FFG

My work is meandering between Biomimetics, which I understand as the translation of principles derived from biology or from nature in general to technology, to a more bio-hybrid approach where we actually use or implement organisms to design. My favorite work environment is in nature, and my travels have led me to amazing places such as the jungle of French Guiana with its Cathedral tree for example. I have a strong interest in biology and design, specifically construction, structures, materials. I try to work at this intersection, and it turned out that with my professional architectural education and with my interest in biology, I became a translator between those fields, something that we will need more of in future.

In my PhD thesis I investigated what living systems are and how life is defined, and how this framework relates to the built environment. What are the characteristics of life that we look at? We are talking about living architecture and more like dynamic responsive systems. What does growth mean in biology and how can we translate this into architecture and the arts? We do not have self-propagating buildings yet, do we?

In biomimetic design we try to abstract knowledge from biology with the goal to translate it to a completely different context in technology, that has nothing in common with the biological environment of our so-called role models. Biomimetics as an innovation strategy does not automatically produce sustainable design. If we want to design sustainably, this needs to be consciously pursued in the product development stage.

In the project GrAB, Growing as Building (funded within the PEEK program for arts-based research of the Austrian Science Fund FWF) we had the opportunity to research how growth in biology can inform architecture and the arts. We had the opportunity to install our own biolab at the University of Applied Arts.

This was very radical when we started the project and has become a very common infrastructure in architectural faculties. It is interesting how fast the field of biodesign has advanced, how rapidly those ideas were taken up by many research groups.

At the University of Akron, Ohio US, I established a Biodesign Lab, where we followed several research avenues. In a root research project, we explore tree root morphologies as structural systems that deliver solutions for engineering. We are abstracting the morphology of coarse tree root systems to designing new foundation systems and to improve engineered solutions for coastal resilience. Through photogrammetry, we have managed to image nine different root wad models from three different local specimens. The root data was recorded using a high-resolution camera and processed with several sophisticated softwares, among them Agisoft Metashape. Statistics are used to analyze the roots and we are now at the stage of creating algorithms for Rhino and Grasshopper to let us design further. The goal of the project is to create a multifunctional foundation system that is adaptable to different situations in the built environment.

The second project I present here is plant leaf research, specifically the work of my PhD student Dr Ariana Rupp. We researched the thermodynamics of plant leaf shapes, and how leaves evaporate water. Ariana discovered an inherent connection between the shape of the leaves and evaporation efficiency. At the Biodesign Lab we have created ceramic tiles that we tested in the lab and outdoors, using an infrared camera, thermosensors and a digital scale to visualize the tradeoff between evaporation and the cooling effect. Using morphological data, our interest is to translate this efficiency into technical systems.

A newly started research project at the University of Applied Arts, Biocool, translates this shape-function relationship found in plant leaves into building facades made of ceramic material for cooling envelopes. A lot of our built environment on a global scale requires cooling for the interior to be comfortable for inhabitants, so this work paves the way for more energy

efficient building.

This short glimpse into my work shows that it is more research than architecture focused. I hope that the publishing and prototyping we do inspire people to take the work further to product stage, more development of knowledge and new more sustainable solutions.

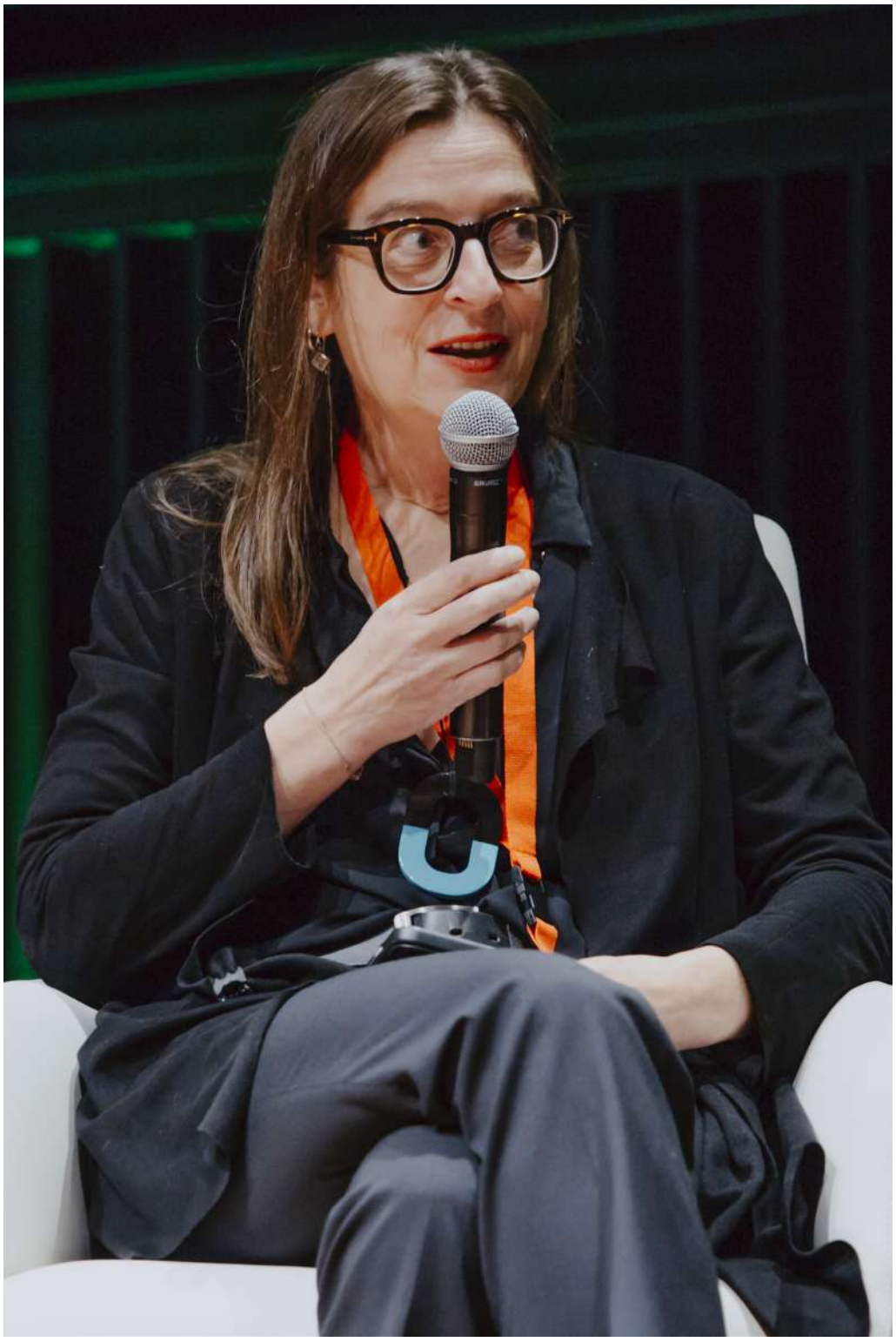


Figure 1: Petra Gruber Presenting at the Responisve Cities Symposium 2021

DESIGN WITH LIVING SYSTEMS

AUTHOR: Chiara Farinea
AAG Head of Building with Nature Based Solutions Research

How can we design with Digital Technologies to integrate living systems into the urban environment? Which are the main principles? To answer these questions I will share with you projects developed at IAAC over the last years. Food Voltaic is a project designed to serve, to provide ecosystem services like food, energy production, water saving, flood mitigation and oxygen production. The tile brings the water below the surface avoiding evaporation and aiding plant growth. It also hosts a Bio Photovoltaic system where the energy produced from the bacteria near the roots of the plants is invested in the system. We are hosting humans, bacteria, plants and machines, trying to create an unexpected collaboration between these different systems to help our cities to perform better in terms of sustainability. Through an app and embedded sensors, our system can be monitored in terms of how much energy is produced, and what is the state of our plants.

Transforming Food Voltaic into a vertical system led to the Comida project. It is intended to implement this system in the city and then to codesign the system with the citizens in Passatge Trullàs. We choose the plants to be embedded in the system with the citizens focusing on butterflies and providing herbs to the people that are eating lunch in this space. They wanted to create a collaboration between humans providing food for butterflies and for the other species. The citizens are working with us to provide workshops and maintain the system.

Based on the learning from Passatge Trullàs, the next iteration of the project is being implemented. The idea with these people, who manage the gardens, was to create a new system for vertical cultivation, but we are using all its parts to host different kinds of species. For example, some structures are meant to host bacteria and to be populated by moss. We have different morphologies and modules. Some host food for humans, some are houses for birds or houses for bats. We have modules that are only meant to be colonized by nature spontaneously, creating an interspecies project. Through collaborations with

different people, we are opening to the city and providing the city with the technologies that enable change. A flexible technology like 3d printing allows us to create any kind of structure in a quick and specific way, in any kind of environment. How can we design and how can we use technology for living systems for new kinds of integration of living systems and a new collaboration of living systems?

The city is not just a human centered design, it's starting to be a non-human centered design, a collaborative species center of design. We are trying to grow mushrooms in the cities and exploit all their possibilities. We are growing mushrooms to eat, but also producing materials. In the project Mutualism, students designed a tile with a collaborative system, growing mushrooms on one side and herbs on the other side. The herbs reduce the temperature creating a better environment for the mushrooms to grow. MYCOScape is an evolution of the latter, using design to create a microclimate simulating the forest to grow mushrooms and create building materials. The city has to be a permeable living organism, where we can create facades for cultivating nature, for hosting nature and also for a different collaboration. We can use these kinds of structures to produce, to share, and to create business models. Several kinds of business models can be associated with these kinds of structures.

The BUILDs project is a collaboration between universities and disciplines, setting up transdisciplinary groups of students that together were developing elements for the city. Projects include Epiclay, a tile system to grow epiphytic plants on build facades, and C:aire, a column using biocatalytic materials to depurate the air, coupling it with biofiltration and plants. We were also collaborating with several companies working in the fields that were advising our students on how to develop these complex projects with a new vision for the future city.

The Poble Joc project is a project developed for the opening of the Superilla Project. These are structures on wheels where people can cultivate, they can move and they also have digital support to share information about the project.

This is the end point of one project, but the starting point of a new project, collaborating with 6 schools in Porto. We have been developing prototypes with the children, working on how to accommodate animals, bees, flowers and their relationship. We are going to create structures through design and technologies for these 6 schools. Our challenge will be to translate the ideas from the kids and to create structures where they can accommodate animals and where they can interact with different living beings.

Superbarrio is a tool to codesign the public space. This tool was developed a few years ago to accommodate living systems. While developing the URBiNAT project, a European project in several cities where we are co-designing the living corridors with nature-based solutions. Through this system the people can choose and also see the impact, simulating the solutions and where they want to have them in the city. Through collecting data and a technological ecosystem collecting ideas, it is helping us to design structures.

Can we generate cooperative environments and enhance coexistence through design and technology?

Figure 1: Chiara Farinea Presenting at the Responisve Cities Symposium 2021

PLANT-E: SPARK OF NATURE

AUTHORS: Marjolein Helder, Paulien van Straten, Sharon Polman

Imagine a world in which nature can provide us with electricity. Sounds magical, doesn't it? But it's actually possible! Plant-e, a company located in Wageningen, The Netherlands, has developed the technology to harvest electricity produced by living plants.

So how does this work? It all begins with the plant, which under influence of sunlight produces organic matter through photosynthesis. This organic matter is transported throughout the plant. Some of this matter, however, is not used by the plant, and this matter is excreted into the soil through the roots. In the soil around the roots, bacteria use the organic matter excreted by the plant to grow. In this process they release electrons, which are captured in an electrode. The electrons are then transported through a wire, through a smart chip that enables us to use the electricity, to a counter-electrode. Once the electrons reach the counter electrode, they react with oxygen and protons, and water is formed (Figure 1).

This technology, once integrated with nature, will provide electricity without harming the environment. The technology takes sustainability a step further. Because it captures CO2 while producing electricity, it is actually carbon-negative! The electricity that is provided by the plants can be used to power different applications. At this point in time, Plant-e technology can be used to power small LED-lights and Remote Sensing applications.

First, the plant-powered lighting experience was developed. For this experience power from the plants is used to light up LED-lights. The LED-lights have been programmed to fade in and out, creating an effect that is quite magical. Thus far, this form of Plant-e technology with application has been installed on a large scale at several locations in the Netherlands and abroad.

Once the lighting system was developed, Plant-e shifted its research focus to Remote Sensing applications. This was done because there is a clear need for

clean and sustainable power sources for IoT devices used all over the world. Currently, most of the IoT devices are powered by Lithium batteries, which are a source of pollution, and need to be replaced on a regular basis. Plant-e technology can negate both of these disadvantages, because it is both sustainable and has a 50+ years lifetime. The aim for the future is to make the technology available for a multitude of different sensors.

Using energy from plants to power both remote IoT devices and lighting experiences is one small example of how living systems and technology can successfully be combined. At Plant-e we are excited to continue to dedicate ourselves to improve the technology to contribute to a sustainable society.

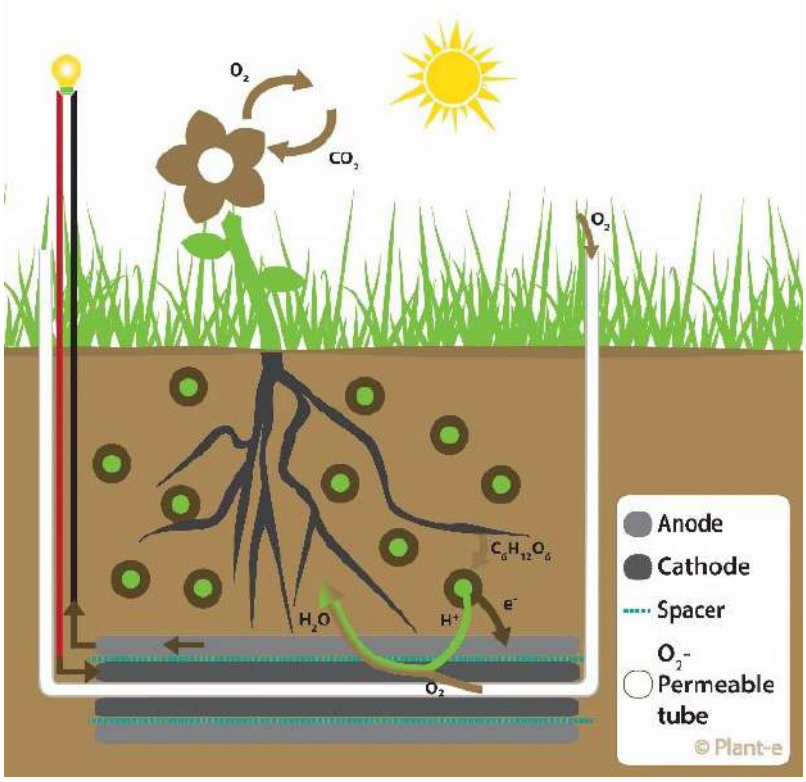


Figure 1: Schematic of the Plant-Microbial Fuel Cell

SECTION 2

ACCELERATING ACTION INNOVATIVE EDUCATIONAL & BUSINESS MODELS

STATE OF THE ART OF TRANSDISCIPLINARY EDUCATION

Transdisciplinary Teaching and Learning in Bio-design Education

AUTHORS: Institute for Advanced Architecture of Catalonia

Nature and design have a long history that has evolved over time from concepts like the Primitive Hut by Laugier to designing with microorganisms to create facade systems like the work of Claudia Pasquero and Marco Poletto. Historically, we have been following the route of specialisation, but now there is a need for relational knowledge. To deal with the complex challenges the world is facing, we cannot educate in a discipline-bound way as this will only limit the solutions that can be found. Instead, knowledge should be hybridised to spark innovative ways of thinking and thus, solutions. Basarb Nicolescu, a theoretical physicist described transdisciplinarity as the following (Doucet and Janssens, 2011):

"Transdisciplinarity is nourished by disciplinary research, in turn, disciplinary research is clarified by transdisciplinary knowledge in a new and fertile way. In this sense, disciplinary and transdisciplinary research are not antagonistic but complementary."

Transdisciplinary research follows three clear steps:

- Identify the problem- What is the main challenge your idea or solution will overcome?
- Analyse the problem- What is the data behind your problem? What solutions already exist and did they have any problems?
- Bring the idea or solution to life- This is often achieved through prototyping and simulations to back up the idea.
-

Transdisciplinarity creates new knowledge beyond the boundaries of the discipline or in between the different disciplines (Derry and Fischer, 2005). When we attend university and begin to specialise, in many educational systems, you only focus on your chosen subject, resulting in opportunities missed. When you design for a plant, it is important to understand the plant's requirements, and this information can be obtained from a biologist or botanist.

“If the world of working and living relies on collaboration, creativity, definition and framing of problems and if it requires dealing with uncertainty, change, and intelligence that is distributed across cultures, disciplines, and tools—then graduate programs should foster transdisciplinary competencies and mindsets that prepare students for having meaningful and productive lives in such a world.” (Derry and Fischer, 2005)

Bioinspired design is a field that has gained particular attention especially in terms of biomimetics which was first coined in 1957 by Otto Herbert Schmitt (Ng, Elgar and Stuart-Fox, 2021). Even though design and biology have a close relationship, at the educational level the two fields have been kept quite segregated over time. However, now, we are beginning to see initiatives at the educational level to bring biologists and designers together and provide them the platforms and the tools to work together.

Biodesign Challenge is an example of an educational programme and competition platform with a focus on biotechnology. Daniel Grushkin (Executive Director) vision for this platform was to create interdisciplinary thinkers who understand the impacts of biotechnology and that can design with biotechnology in a thoughtful and ethical way. Biodesign Challenge has 3 main goals they are striving towards (Grushkin, 2022):

- “To create a community of collaboration among artists, designers, and biologists.”
- “To seed the first generation of biodesigners.”
- “To build meaningful public dialogue about biotech and its uses.”

The intention of the BUILD Solutions programme was to take this relationship between biology and design one step further, introducing the business minds to be able to take nature-based solutions to the market. This programme and initiative proved to be very successful as understanding the business perspective adds to the success of reaching a feasible solution.

Transdisciplinary teaching and learning in start-up education

AUTHOR: Christian Rammel, WU

Tackling the great challenges of the Anthropocene needs a new wave of young entrepreneurs, which are driving socio-ecological transformations and whose ideas are far from business as usual (Fernandes et al, 2021). This need to support, train and educate entrepreneurial change-makers poses major challenges to traditional start-up education. These challenges correspond with the strong demand to incorporate interdisciplinary approaches into the very heart of start-up education.

In general, a transdisciplinary approach shall: "(a) grasp the complexity of problems, (b) take into account the diversity of life-world and scientific perceptions of problems, (c) link abstract and case-specific knowledge, and (d) develop knowledge and practices that promote what is perceived to be the common good" (Pohl & Hirsch Hadorn, 2007). For establishing a transdisciplinary learning environment, there are three fundamental preconditions which reflect its dynamic setting (Biberhofer & Rammel, 2017):

- Transdisciplinary teaching and learning is ideally driven by the interconnections between and beyond disciplines
- Transdisciplinary teaching and learning is ideally built on problem-based learning
- Transdisciplinary teaching and learning is ideally allowing and strongly enhancing "real-life" feedback and the co-creation of knowledge due to the integration of (non-academic) stakeholders from outside the classrooms

Transdisciplinary education supports learning processes that integrate different disciplines in a cooperative way. This is not only to create new knowledge, rather it is to enable learners to acquire new skills to actively shape the intersection between science and society. This goes hand in hand with an approach to curriculum integration that dissolves the boundaries between conventional disciplines and focuses teaching and learning on the

construction of meaning in the context of real problems or issues (Moallem et al. 2019)

The enormous importance of transdisciplinary learning processes for start-up education is obvious. Against the background of the multidimensionality of the market, it is crucial for start-ups to be able to think and work not only in an interdisciplinary, but also in a transdisciplinary way. Entrepreneurs recognize the importance of linking their entrepreneurial expertise with others, but underline the cooperation with universities in order to give an additional scientific value to their work (Schaltegger et al., 2013).

When it comes to the training and support of a sustainability oriented start-up or start-ups with a clear focus on “green tech”, the importance of a transdisciplinary learning environment is even higher. Transdisciplinary learning allows us to explore sustainability challenges from the perspectives of various disciplines while applying an integrative focus to find effective solutions (UNESCO 2012). Thus, transdisciplinary learning is a well-adapted form of learning in any kind of sustainability education to tackle real, complex and socially relevant problems. Transdisciplinary learning environments can have a positive impact on the motivation of learners (start-ups), and allows an active imparting of practice-based and problem-oriented knowledge (Merck & Beermann, 2015). Considering the emergence of new modes of science on the one hand, and the growing need to deal with sustainability problems on the other, it becomes apparent that a transdisciplinary approach is well-suited for start-up education, especially when it comes to sustainability-driven entrepreneurship and green tech.

Figure 1: Training for
Trainers Business Workshop

Figure 2: Trainers
Kicking Off the One Year
Programme at IAAC

STATE OF THE ART OF TRANSDISCIPLINARY GREEN BUSINESS

AUTHOR: Green Innovation Group

Transdisciplinarity in a Green Business Setting

Transdisciplinarity is not often heard in business contexts these days. It is widely acknowledged within the private sector that companies need to integrate different disciplines to accomplish business targets, whether it is a matter of product development, lean production or strategic development. However, cross sector collaboration and new partnerships are highly relevant to private companies as well, regardless of which area they are working in. Silo thinking is an issue that especially large organisations struggle to break out of. Important knowledge and knowhow get stuck in one silo and do not flow to other silos, how crucial it may be.

So even though transdisciplinarity is not an outspoken matter of concern in business, it is certainly relevant to innovate and create new business opportunities. Especially the area of innovation screams for transdisciplinarity, as it is vital to innovation processes to break out of status quo, norms, and routines.

It is far from easy to activate transplicinary thinking, though. The area is complex and demands a high level of empathy, involvement and system thinking. If the aim is to construct a school that challenges barriers between natural and built environment, a system thinking mindset is needed. That means to be able to see the value of the knowhow of the carpenter, the knowledge of the architect, the background information from the office worker, and the insight of the anthropologist, one needs a system thinking mindset. One needs to see beyond the specific project and the obvious disciplines required. It is a matter of seeing the bigger picture, which is a skill in itself. It requires both an understanding of different disciplines, empathy for different professionals, and the skills to involve and engage different people. Transdisciplinarity requires human qualities.

One useful framework for applying transdisciplinary thinking to green innovation in the business sector is circular economy. Circular economy is a

key area, where different disciplines must intersect. It requires you to think of every aspect of the innovation – from cradle to cradle – within a green setting. How should you handle the design process without the use of scarce resources and with the possibility of regeneration by the end of use? Which competencies do you need to manage the product development, the building process or the production in a way that respects nature, environment, humans, and other species? The circular economy model takes into account much more aspects than the traditional approach: The wear and tear of the consumer or the reintegration of the materials after end usage (be it recycling or refurbishment), to name a few examples.

Circular economy opens up a variety of questions that drive innovation and draw on sustainability aspects. One specific model is the butterfly model that takes into consideration renewable energy, recycling, regeneration, biochemicals, and more when developing products and processes that make life easier for consumers and citizens.

Why Aspire to Transdisciplinarity?

Green transition is mandatory. Those businesses that do not feel the pressure to make a green shift yet, will feel it soon enough. New regulations from local governments or the EU require businesses to take in sustainability concerns and to be able to describe and report them as well. Customers, end users, business partners, and other partners from the supply chain call for a sustainability focus, while more and more even demand it. Furthermore, circularity will be a competitive advantage in future markets.

But businesses are fundamental to the green transition as well. There will be no green transition without green businesses. Companies are big polluters and they emit CO2 to a great extent. On the other hand, they are the frontrunners of green innovation and sustainable solutions, transforming the energy sector, transportation, construction industry, food industry, and much more, with a speed and an adaptability that is crucial to the green transition. While the increased interdependence between stakeholders makes business processes very complex, circular economy presents a framework to handle

the complexity. Out of sight is not out of mind, and the specific company needs to know where its resources come from, who handles them, and how. Not only with respect to lowering CO2 emissions, but to preserve biodiversity, scarce water resources, rare materials, and the like.

Innovation is indeed happening in business today. Many startups are born with a sustainability mindset and more and more companies see the potential in circular economy. The small startups develop new products and concepts rapidly, while larger companies deploy and scale the solutions. Many companies try new ways of doing business, where the possibility to thrive as an employee (and a human being) is a real concern of the company, and nature is being integrated rather than excluded. If transdisciplinary thinking applies only to universities or as a small experiment in a business setting, the green transition is too many years away from now. Therefore, transdisciplinary green thinking also needs companies to deploy and scale solutions.

The How: 7 Principles for Approaching Circular Business
By adapting to the following principles, it might be easier to get a grasp of how to approach a circular business model leading to green innovation and driving the green transition.

Be a green visionary. Allow yourself to aim high and be visionary. Ask questions like: What impact is your business creating? What is your impact potential? By introducing positive impact as your main focus, your goal is to change or improve X – instead of producing X – paving the way for innovation.

Implement transdisciplinarity and a business model in the design phase. It is never too soon to introduce transdisciplinary thinking. By applying it as a requirement in the design phase and insisting on a business model from the very beginning, you are one step closer to making your innovation scalable.
Sell before you build. If your idea does not gain buy-in with real people, the time and money are better spent on further development or shifting track, rather than building something that has no target group and no business model.

Start small, think big. Do not start building a sustainable village, where the city of London used to be. Start small by creating a showcase for your visions. It is easier to sell, build, scale, and improve. Make sure to think big, though. A product without a vision is worthless.

Build Partnerships. Transdisciplinarity is clearly not a solo project. Make sure to involve others at an early stage to bring in more perspectives and different disciplines. This makes your solution more robust and betters the conditions for scaling later on.

Review point 2. How do you scale your idea? What is your business model? Are you still on track, or is it time for alteration?

Scale. It is time to scale and move from innovation to solution. Do you have the right partners onboard? Do you have the funding? Is the business model set up for scaling? Is the time right? Then go do it.

These seven principles are just one way to approach an innovation, while taking sustainability into concern from the very beginning. Many other approaches are applicable, but there will always be pitfalls.

The Pitfalls in Approaching Circular Business

When one builds without selling at first, the risk of ending up having a product or a solution that nobody wants to use or pay for is high. At the same time it is a real struggle to sell an idea without a good showcase that oftentimes needs to be built at first. One of the pitfalls in approaching a circular business model, therefore, is to assure that the right conditions are in place in order to bring your nature-based solution to life.

Another pitfall that many fall into, is forgetting the end-user. It is easy to fall in love with a beautiful solution that blends in with the surrounding nature. But is it practical? Is it functional? Is it desirable? Too often, innovations never take form in reality, because the idea is too far from what the end-user needs. It is also important to make the idea as simple as possible. This makes it far

easier to create the product, making the business model manageable as well. The risk of having a too complex solution or business model is higher, the more stakeholders involved. This is especially relevant when working with transdisciplinarity, as this by default often involves more people.

One last pitfall worth mentioning is not making a real impact. Nature-based solutions, green innovation, circular economy and sustainability all rely on real impact. If your incentives are not aligned, the risk of working in different – or wrong – directions and ending up with a solution that has no real impact is high. If your trucks run on electricity, but transport concrete, you are missing the bigger picture. Sustainable building and nature-based solutions need to be sustainable from the very beginning – and generate a new beginning at the end of use.

Team Building Exercise during the One Year Programme Kick-off in Barcelona

BUILDS EDUCATION CASE STUDY

METHODOLOGY

BUILD Solutions offered a combination of good education, good science and good business, adopting a transdisciplinary strategy. The approach facilitates an active flow of information and ideas among universities, businesses, students, teachers and researchers, providing them with the necessary entrepreneurship skills and connections to bring a nature-based solution to the market. Through a Learning by Doing educational programme, a blended training in biology, architectural design and entrepreneurship allows cross-border teams of students, teachers and practitioners to co-create solutions that contribute to urban re-naturalisation and resilience. By being part of the programme, and participating in competitions, the students are able to unleash their talents and enhance their employability prospects.

The educational programme was designed to interrelate and enable interdisciplinary and transdisciplinary approaches to knowledge production. This was achieved through bringing together architecture, biology, environmental, technology and business experts, and graduate students to design, test and implement a new educational programme on entrepreneurship and design for urban re-naturalisation and resilience.

The Trainers for Trainers Programme provided the educators and professionals with knowledge of the different fields - biology, design and business, to be able to support the students during the One Year Programme. These trainings took place in the form of three trainer workshops, where each discipline shared basic knowledge, concepts and educational methodologies commonly used in their respective fields. This allowed all the trainers to get familiarised with the content and terminology before testing their knowledge internally through peer learning sessions.

The One Year Educational Programme began with the biology teachers, researchers and students developing the scientific concepts and compiling case studies which were then transferred to the architecture and business students. A one-week intensive course took place in Barcelona that brought the 30 students together along with their teachers and business experts. During this week the students were able to get to know each other and

work together to start developing ideas. By the end of the intensive week the students had formed 5 start-ups consisting of two students from each higher education institution. For 6 months they continued to develop their concepts and start-ups under the guidance of various experts across the different disciplines. Moreover, the students were provided with training on digital fabrication methods such as large scale 3D-printers and CNC Milling machines, that allowed them to develop 1:1 prototypes. During the final month, each start-up pitched their idea to possible investors and the best-case idea was selected to undertake a month long Accelerator Programme.

The Accelerator Programme's aim is to further develop the best start-up idea into a start-up business. The winning start-up, Epiclay, headed to BLOXHUB in Copenhagen, Denmark, where they were able to further develop their ideas, prototype and receive tailored guidance on how to develop their business further. The incubator helped Epiclay in developing their start-up business idea with the aim of commercializing a real product and service that could contribute to city resilience and its re-naturalisation. At the end of the month, they were able to pitch their idea and start-up in front of many experts and investors, receiving invaluable feedback.

"Most of the program has been designed to meet potential customers, potential partnerships, potential investors. The most important criteria to make it successful is to follow the startup from the beginning and be in a constant dialogue to design and to customise the program and so I've been personally in dialogue with EPICLAY from day one to figure out where they are in their start-up stage."
Tanya Jørgensen- City Facilitators (BUILD partner)

The educational methodology has been carefully developed to provide the students with the tools and knowledge to transform what they learn in an academic setting into a business opportunity to drive change. BUILDs has demonstrated the importance of embedding these opportunities into educational systems to find solutions that could truly have an impact and do not remain at the concept level.

HOW LIVING SYSTEMS CHANGES BUSINESS AS USUAL

AUTHOR: Martin Andreas Petersen, Senior Research Analyst, City Facilitators

ABSTRACT:
The BUILD Solutions project aimed from its inception at using the process of commercialization of Nature-Based Solutions (NBS) to further trans-disciplinarity amongst students and trainers alike. Another goal was to allow the students of one discipline to gain further mastery of their own discipline through the transdisciplinary interaction. To the students, later entrepreneurs, and educators from Vienna University, the first major change to business as usual happened when the startups had to find suitable markets for their solutions. Using living systems as a core product of one's offering requires integrating environmental parameters (rather than i.e., only demand parameters) when identifying, planning for, and executing market entry.

Figure 1: Training for Trainers: Eco-business Workshop

HOW LIVING SYSTEMS CHANGES BUSINESS AS USUAL:

The BUILD Solutions project focused on creating an immersive experience that would further trans-disciplinarity between business, biology, and architecture students and trainers. This goal was reached by using the creation of Nature-Based Solutions startups as a vehicle; a common purpose that would unite the disciplines and allow them to synergise.

Using Nature-Based Solutions as an integral part of the startups' offerings fundamentally changed how the startups approached commercialization and market entry. It became apparent that these changes to commercialization and market entry were necessary as soon as the BUILD students formed their teams and started exploring how their company should look. The team members joined one another in the different startups based on a shared understanding of which urban challenge was the most important to tackle. Air and noise pollution ended up being the dominant theme (shared by 3 startups) with one of the remaining startups focusing on environmental awareness (addressed by a Nature-Based Solution for a playground with interactive learning elements), and the last startup focused on plastic waste (to be consumed by worms).

With the problem identified, the startups would now normally try to identify where there was a market for addressing the problem: who was willing to pay to have the problem solved?

Using living systems made this approach less linear, since willingness to pay had to be matched with a suitable climate for the solution. At times, the change of the length of day, temperature and humidity would necessitate a change in plants used, other times, it would increase maintenance and/or installation costs.

When the BUILD startups had to change their offerings according to these environmental parameters, they ended up expanding their potential product portfolio. Suddenly markets were just as much identified by environmental factors as economic factors. Choosing the right product to develop first,

hence became a much more strategic choice since, i.e., each outdoor NBS scaled more easily along the East-West axis than North-South axis. To the BUILD students it meant that markets that would normally be attractive due to high spending power (i.e., Norway) were a lot less interesting due to the low number of similar markets that could be addressed.

The indoor solutions encountered similar issues but concerning different types of built environment rather than geographical locations. The plants used by Epiclay to reduce noise and improve indoor environments could not be used by aeroSQAIR for example when they addressed the massive amounts of air pollution in subway systems. Humidity levels and especially levels of wind flow were too drastically different for the two companies to use the same composition of plants.

The BUILD startups had learned to use a very iterative approach to product development and sales. Development was as far as possible constantly aligned to what the market needed. Without this iterative approach and the insights from biology and architecture, the startups very well might have followed a more linear and traditional approach to market entry, solely or mostly based on demand and willingness to pay. An approach that would have led them to failure.

Instead, the startups showed that they were agile and able to change approaches based on insights from other disciplines. Instead, the students showed that like their solutions, they could adjust organically. Instead, the students succeeded in creating solid startups AND in showing that new approaches to learning can grow into great results.

Figure 2: Martin Petersen Presenting the Work of City Facilitators at the Responsive Cities Symposium 2021

WHERE ARE THEY NOW?

Out of the five transdisciplinary BUILD start-ups, three are currently still operating: two of them as start-ups, and one as a funded research project. One of the teams dropped out immediately after the project ended, whereas another one continued their business ambitions for another 6 months. Beneath, a short overview of the individual start-up developments is provided, including insight on the major learnings, challenges and take-away. These insights are based on the information shared by members of each team in a reflection carried out 1,5 years after the official project ended.

NAME	STATUS	OTHER COMMENT
aeroSQAIR	Continuing	Funded research collaboration & pilot planned in Vienna in Summer 2022
C:aire	Continued for 1 Year, then dropped out	Dropped out due to not enough time & commitment in the long run
Epiclay	Continuing	Winning team of the BUILDs startup competition
Play Jungle	Immediate drop out after the project ended	Team and idea were the greatest challenge
Worm Generation	Continuing as research	Idea was not feasible for a business case: pivot from startup to funded research project

Worm Generation: Karolina Sliwa, Madhavi Ojha, Eve Nnaji, Malte Pasche, Myriam Planque, Vincent Heurtel

C:aire: Mario Sequeira, Ninon Dell'Acqua, Jasmo Nickol, Melanie Bascon, Sophia Keyner, Xhilda Kulla

aeroSQAIR: Nastia Martinet, Harsh Vora, Chloe Sachot, Bharath Lakshmesh, Patrick Frank, Esther Hummel

Play Jungle: Veronika Nesterenko, Vinay Prabhakar, Anastasia Meshkova, Alexandra Martin, Juliette Gravis, Sauraub Singla

Epiclay: Melanie Kalman, Christoph Hornik, Sumit Nemmanivar, Maurico Casian, Alice Ubleman, Mary-Eve Henrotte

Reflection Exercise during
the One Year Programme
Kick-off in Barcelona

INTERDISCIPLINARY STARTUPS

AEROSQAIR

Patrick Frank (WU), Esther Hummel (WU), Harsh Vora (IAAC), Bharath Lakshmesh (IAAC), Nastia Martinet (UL), Chloé Sachot (UL)

KEYWORDS
Moss, Bioremediation, Indoor Air Pollution, Automated Panels, Metro Stations

ABSTRACT
aeroSQAIR is an international team of students and graduates taking on the indoor air pollution market. The interdisciplinary team has backgrounds in business, architecture and design, engineering and biology. Their love for nature and the outdoors brought the team together to find nature-based solutions for the often forgotten issue of indoor air pollution. The goal is to reduce harmful pollutants like particulate matter and carbon dioxide in the underground and indoor environment. All this is achieved through a sustainable approach based on the principle of bioremediation – hidden champion moss. Working with digital fabrication techniques, the moss panels are able to be fabricated with unique designs. aeroSQAIR continues to work under the new name eiria, designing fully automated moss walls that can be implemented in various internal environments such as metro stations, offices and shopping malls.

Figure 1: aeroSQAIR Panel Visualisation by Mahesh Dubey

Figure 2: aeroSQAIR Prototype

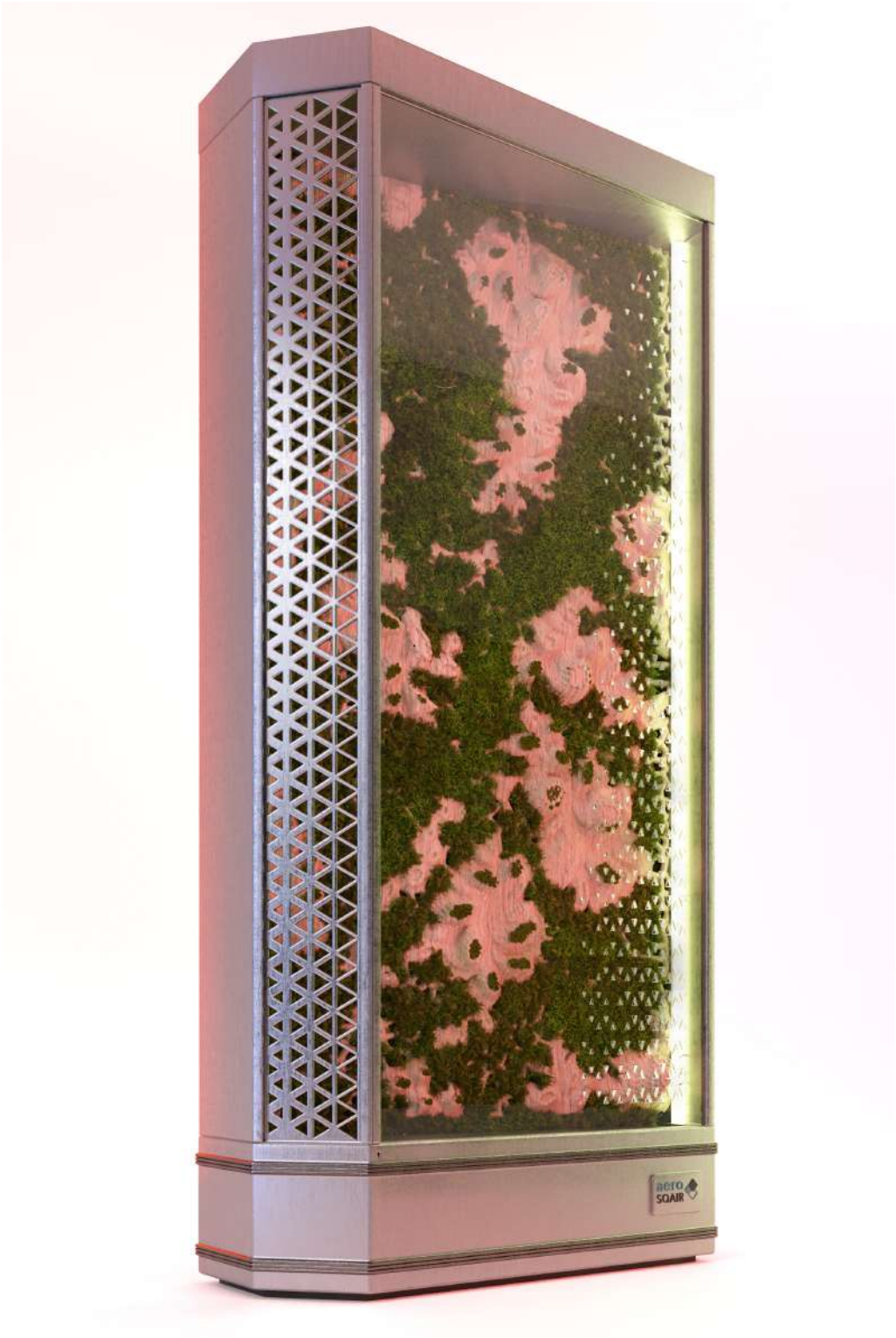

aero
SQAIR

Figure 6: aeroSQUAIR Details

WHERE ARE THEY NOW?

Eiria (during the BUILDs programme called aeroSQAIR) is still actively working on the start-up, starting their pilot project in collaboration with the Viennese subway provider in summer 2022, and then planning on entering the DACH region as beachmarket. They still have 3 out of the 6 original members working in the project and currently count 8 team members. On top of their local partnership with the Wiener Linien, they initiated a research project with a local university and received a major research grant. Additionally, they participated in another incubation programme and won prize money in an idea competition and a pitch event. Eira got this far, as they were able to foster a common language and a team culture where they could communicate openly despite their different backgrounds and distinct working styles.

MAJOR LEARNINGS

1. To make progress, you have to align goals, follow a clear division of work tasks and practice open and frank communication.
2. Leading a company sometimes also requires tough, yet necessary, decision to bring the team and idea forward.
3. Leadership requires trust: despite clear overarching working structures and procedures, it is crucial to leave flexibility and decision-making to the individual team members in the fields of their expertise.

CHALLENGES TO OVERCOME

1. Commitment to taking it to the next level: changing a student project into a running startup.
2. Establishing functioning structures across national and thematic borders, including necessary digital tools for remote working settings.

C:AIRE

Sophie Keyner (WU), Jasmo Nickol (WU), Xhilda Kulla (IAAC), Mario Sequeira Valadez (IAAC), Ninon Dell'Acqua (UL), Mélanie Bascon (UL)

KEYWORDS
Indoor Air Pollution, Health & Well-being, Air Filtration, Bacteria, Epiphytes

ABSTRACT
C:aire is an international and diverse university spin-off combining knowledge in the fields of biology, architecture, and design as well as business development and innovation. Their story begins in Barcelona, where extreme heat and dust from the streets, in combination with the indoor air-conditioning dominate urban living. Thus, they chose the path of fighting indoor air pollution and the related consequences on health and well-being. The solution: a natured-based air filtration system incorporated in an aesthetically pleasing 3D printed column. The biofiltration system is hidden inside the parametrically designed column which also houses plants on the exterior. In addition, the material used for 3D printing the column further aids in purifying the air. C:aire went on to win several prizes in Entrepreneurship Avenue 2020 and the StartupLive competition to further develop their ideas.

Figure 1: C:aire 3D Printed Column

Figure 2: C:aire 3D Printed Column

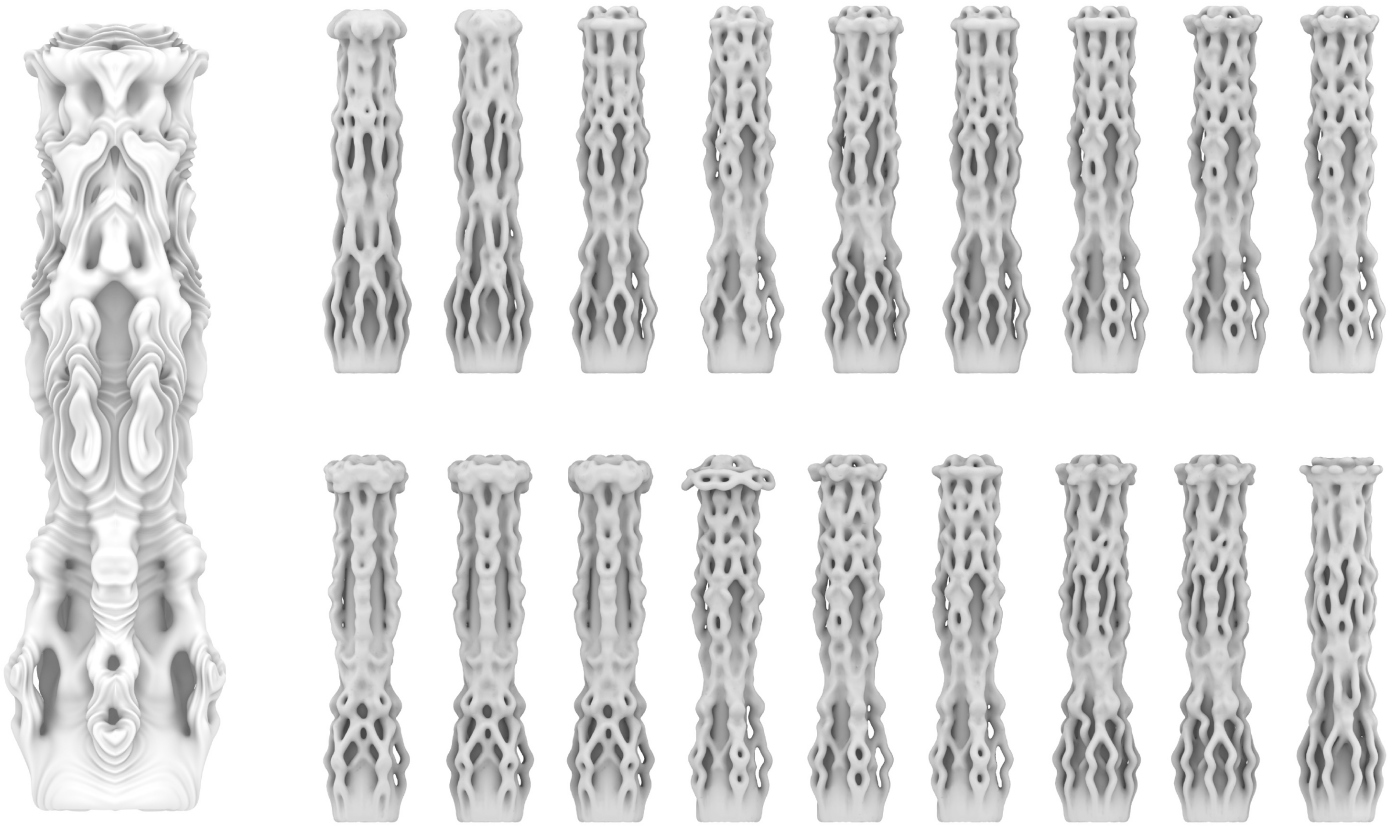


Figure 3: C:aire Column Variations

Figure 4: C:aire Column Render

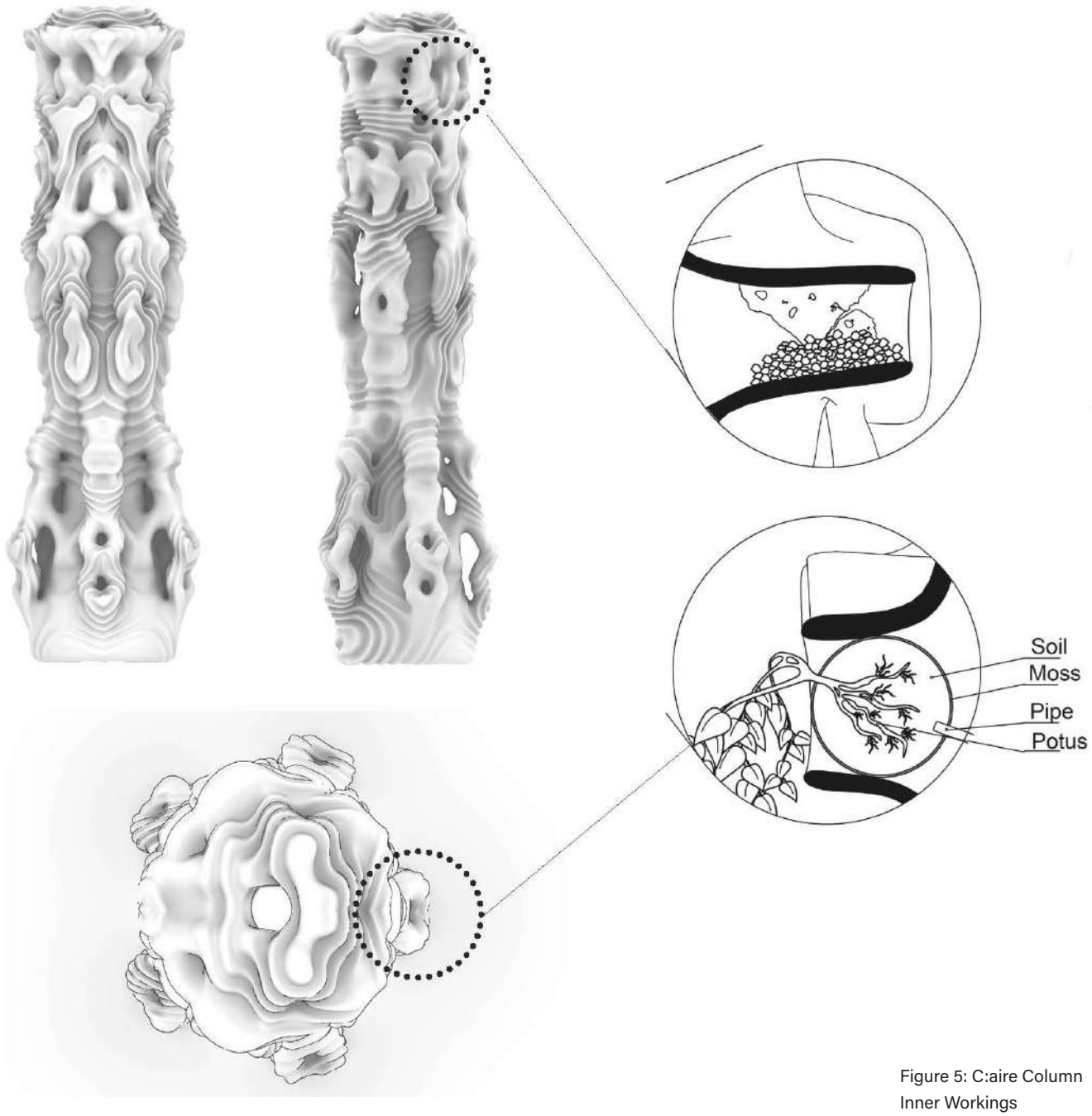


Figure 5: C:aire Column Inner Workings

Figure 2: C:aire 3D
Printed Column

WHERE ARE THEY NOW?

C:aire continued their journey for another 6 months after the BUILD programme ended, where they also participated in another start-up programme, added new team members and won several prizes. Nonetheless, in the beginning of 2021, the team decided to not continue further as the required time commitment as well as financial resources, given the complexity of their product, conflicted with personal career plans. Even though they were seeing a clear USP in their product, the actual product development (including the needed infrastructure for building and testing a functioning prototype) caused many fall-backs and integrating the biological components into the design and business case marked a repetitive challenge. Despite working in remote settings, the team succeeded in developing a fruitful working culture and enhanced their personal communication skills.

MAJOR LEARNINGS

1. Soft skills such as mutual trust, respect and motivation mark the basis for any interdisciplinary work setting.
2. Remote work settings require clear communication and additional commitment by all team members.

CHALLENGES TO OVERCOME

1. Work remotely and being located in different places.
2. A business idea that is great in theory can still fail when being put into practice.
3. Only with enough priority and time commitment can a project really turn into a startup.

EPICLAY

Christoph Hornik (WU), Melanie Kálmán (WU), Mauricio Casian (IAAC), Sumit Nemmaniwar (IAAC), Mary-Eve Henrotte (UL)

KEYWORDS
Green Wall, Epiphytes, Modular, Clay based, Soil Free

ABSTRACT
Epiclay's objective is to make urban areas more liveable and healthy for its inhabitants by creating a modular green wall system that tackles issues related to air pollution. The clay tiles are designed to house moss and epiphyte plants, and have an integrated irrigation system which all aid in minimising the maintenance of the wall. Through a carefully designed structural system, the tiles can easily be implemented on any facade or indoor wall providing additional thermal insulation for the building. The tiles have been parametrically designed, creating a surface texture that allows the epiphytes to grow as well as trapping moisture to encourage moss growth. Through digital fabrication techniques, the molds for the tiles were created, allowing them to be reused and identical.

Figure 1: Epiclay Visualisation by Mahesh Dubey

Figure 3: Epiclay Ceramic Green Wall

Figure 3: Epiclay Plant Variations based on Climatic Factors

Figure 4: Epiclay Final Tile Design Render by Mahesh Dubey

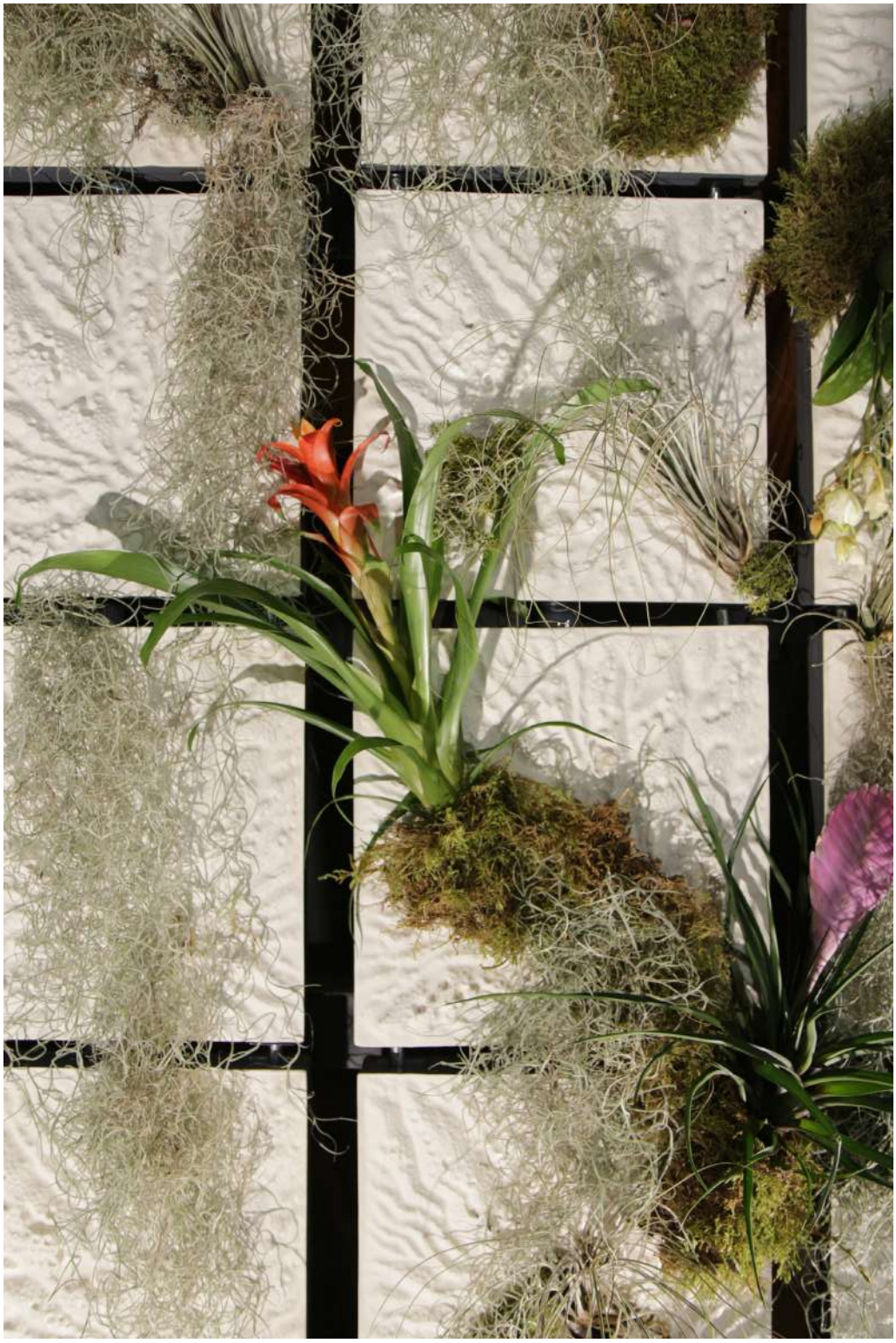


Figure 5: Epiclay Ceramic Wall

Figure 2: Epiclay Wall Details

WHERE ARE THEY NOW?

Epiclay is still successfully continuing today, after having won the BUILD Startup competition and receiving a full month of support in an accelerator programme in Blox Hub Copenhagen. After the official programme ended, they engaged in a great number of competitions winning many renowned local and international prizes such as the University Start-up World Cup 2020 where they were nominated as the “best early stage university start-up in the world”. Their product not only convinces through the solution it is providing per se, but also in the design itself which was selected as part of the Global Grad Show of the Dubai Design Week 2020. Hence, at the current stage, it can be seen as the most successful BUILD start-up with a fully functioning prototype.

MAJOR LEARNINGS

1. Great team spirit, even if not shared among all, can lead to great outcomes as long as a core team is fully committed.
2. Efficient task splitting and clear, honest communication from the very beginning help to encounter upcoming challenges more efficiently.

CHALLENGES TO OVERCOME

1. Not all disciplines understand the approach of entrepreneurship: selling an idea before being able to prove the real feasibility can be a difficult concept to grasp.
2. Different expectations and different overlapping responsibilities.

PLAY JUNGLE

Anastasia Meshkova (WU), Veronika Nesterenko (WU), Saurabh Singla (IAAC), Vinay Prabhakar (IAAC), Juliette Gravis (UL), Alexandra Martin (UL)

KEYWORDS
Playground Equipment, Education, Increased Biodiversity, Modular System, Parametric Furniture

ABSTRACT
Play Jungle focuses on creating a nature-based solution for play spaces in urban environments; a playground for children composed of eco-friendly materials like wood, cork and ropes instead of plastic. The playground equipment serves the purpose of play, but also education by incorporating different aspects of nature into the design of the modular elements. The structure includes spaces and panels dedicated to aromatic herbs such as basil, mint and rosemary which create a sensory experience; educational zones where children can learn about plants and biodiversity, especially friendly insects; elements of shade to relieve the children from the hot summer days. Through parametric design, modules and elements were created that could be amalgamated in different compositions to create unique structures. Through the implementation of these playgrounds, the goal is to reconnect people, specifically children with nature.

Figure 1: Play Jungle Playground Render

Figure 2: Play Jungle Playground Render

Figure 3: Play Jungle Playground Render

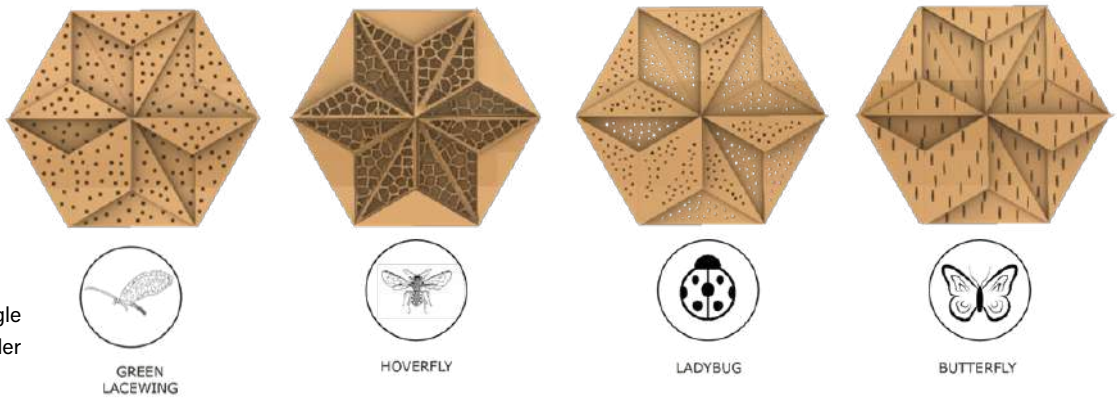


Figure 4: Play Jungle Playground Render

Figure 5: Play Jungle Insect Panels

Figure 6:
Play Jungle
Playground
Render

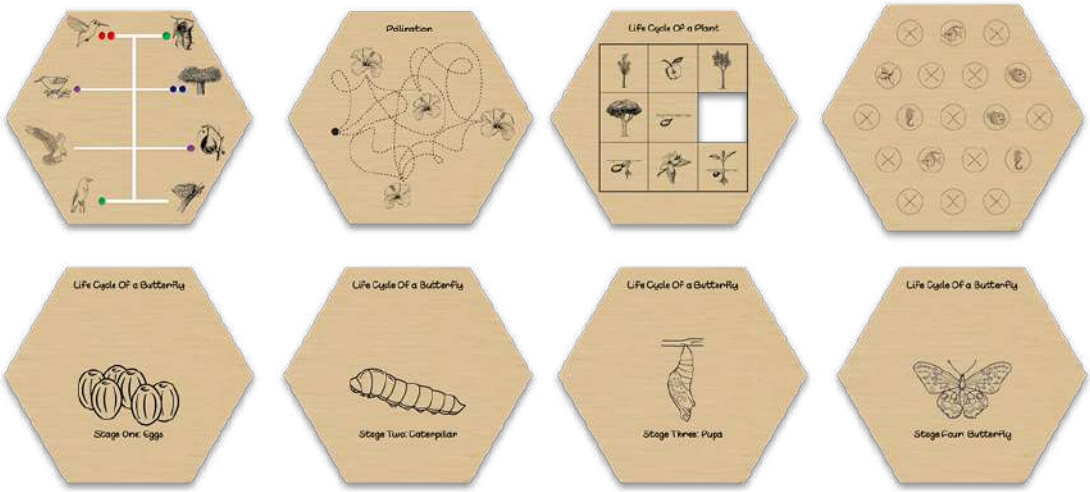


Figure 7: Play Jungle Insect Panels

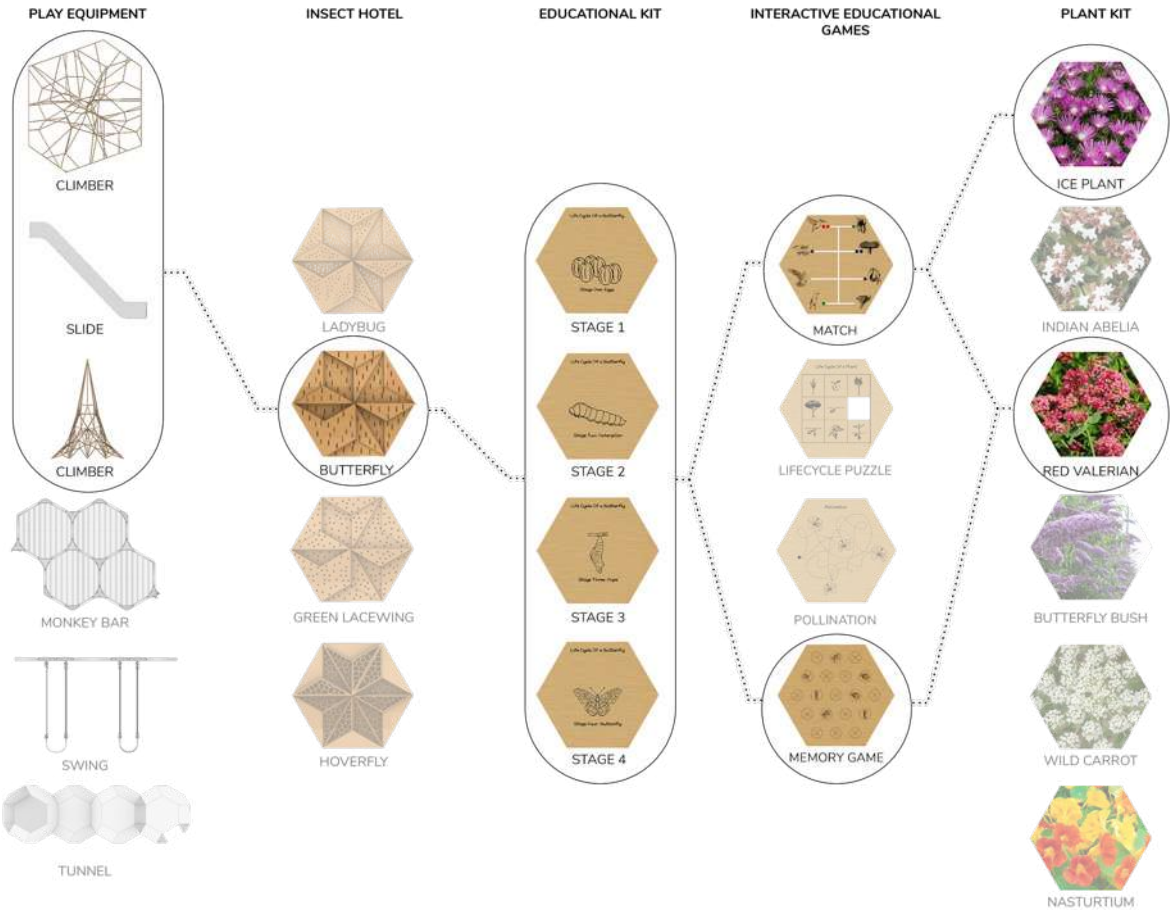


Figure 8: Play Jungle Selection fo Parts

WHERE ARE THEY NOW?

Play Jungle was the first startup to finish their journey, right after the programme ended. This however is not as surprising, if it is taken into account, how the team was formed. They had a very difficult starting point: Like most team building and -forming exercises, there usually ends up a group of people who are undecided which topic they lean for or which persons they prefer to work with. This was the case in BUILD as well. The remaining students hence formed their own group 'Play Jungle' with very different interests and no instant connection towards each other. This difficult team dynamic, even after pivoting on the initial idea, could never be overcome, showing how the interplay of a team with a common vision and an idea they are passionate about is crucial for succeeding. Nonetheless, the BUILD journey was a fundamental learning journey for them, as -despite the mentioned difficulties - all of them became aware of the importance of engaging in such transdisciplinary settings and how to overcome the encountered challenges in future working environments.

MAJOR LEARNINGS

1. Networking: not only the benefit of it per se, but also on how to expand and use it properly.
2. Understanding the bigger picture of how a company works, no matter the actual field/task you are working in.
3. Closing the gap between theory and practice: how to translate academic/ theoretical solutions into practical and realistic outcomes.

CHALLENGES TO OVERCOME

1. Dedication of time towards the startup and finding common slots where all could participate.
2. 'Kill your darling': being able to reshape or also 'kill' your idea, even if you love it, as soon as you see that it does not work or there is no need for it.

WORM GENERATION

Malte Paschen (WU), Karolina Sliwa (WU), Eve Nnaji (IAAC), Madhavi Ojha (IAAC), Vincent Heurtel (UL), Myriam Planque (UL)

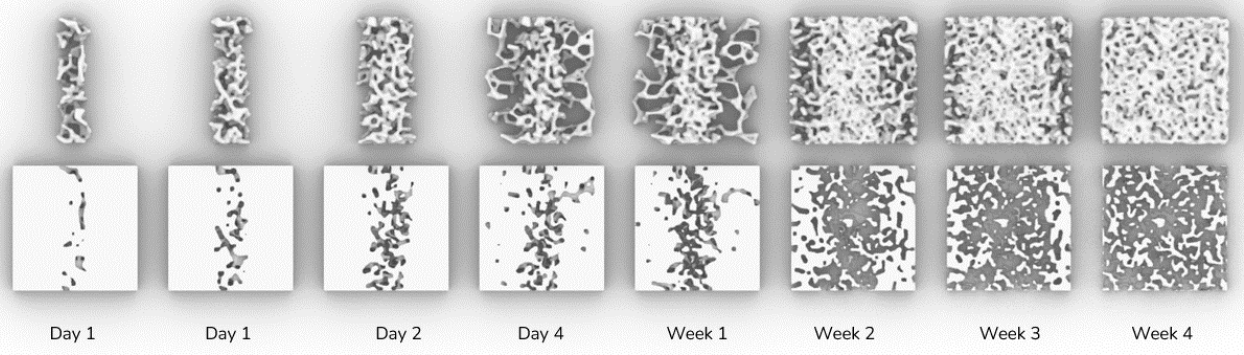
KEYWORDS
Mealworms & Superworms, Polystyrene, Worm Farms, Installation, Recycling

ABSTRACT
The current narrative of the World's plastic consumption, promiscuously sprawls at the shores of economically competitive coastal regions, in the streets of vulnerable developing nations, and in the digestive tracts of the native animals that depend on the dwindling resources of their environment. Since plastic waste production increasingly proliferates in almost all known and unknown regions of the planet, many methods and efforts to degrade, eliminate, and convert these compounds are being investigated. Worm Generation investigates the use of biological agents, mealworms and superworms, to directly convert plastic into organic matter using their natural digestive process. Their start-up focused on the idea of creating worm farms to process the polystyrene and convert it to frass which could be used for other purposes such as compost.

Figure 1: Worm Generation Installation Render

Figure 2: Worm Generation Worms at Work

Figure 3: Patterns
Generated by the Worms



Eating pattern timeline (**Superworms**)

Figure 4: Eating Patterns
Generated by 100 Worms
Through Grasshopper

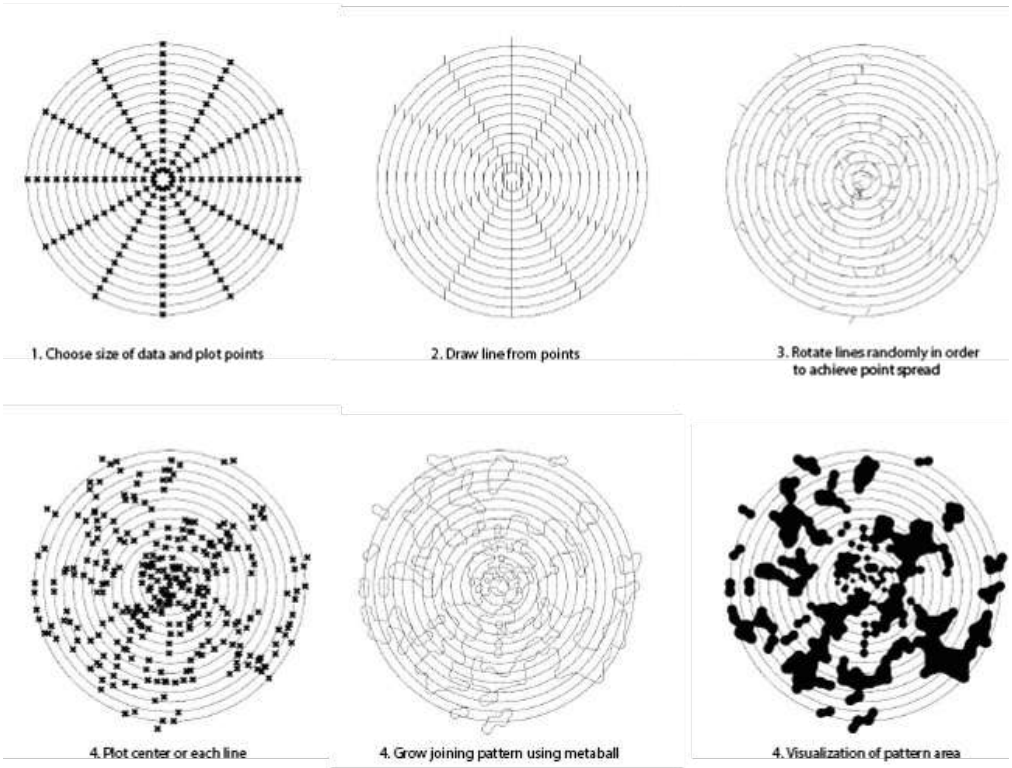


Figure 5: Workflow to Predict the Patterns Generated by the Worms

Figure 6: Worm Frass Generated

Figure 7: Final Installation Prototype

Figure 8: Inital Prototype Tests

WHERE ARE THEY NOW?

Worm Generation as a project itself is still successfully ongoing, however it went through one monumental change as it shifted the focus of being a startup towards a research project. The main reason behind it was the difficulty of 'laws' standing in the way to turn it into a profitable business case. In total, the startup worked together for one year until one teammate took over and is still carrying it out as a funded research project. He on his own managed to raise additional fundings of 15 000 euros by winning more than 9 regional and national prizes and competitions.The first mealworm farms are planned for April 2022, allowing further research and development as well as the proof of concept.

MAJOR LEARNINGS

1. How to pitch an idea convincingly and in a manner that it is easy to understand for externals.
2. Taking time to really include all disciplines at the beginning of the process will make sure more robust and sustainable outcomes are the end results.

CHALLENGES TO OVERCOME

1. Team dynamics in a remote setting are difficult and need time and creativity.
2. Include all the disciplines and to see the value of a transdisciplinary business idea.
3. Finding a common language, understanding other disciplines and explaining one's own.

STUDENT INTERVIEWS

The students who participated in the One Year Programme were asked to reflect on their experience with BUILDs and how BUILDs has impacted them personally or professionally. The transdisciplinary approach to education was a new experience for most students and it is clear that this programme opened their eyes to new ways of working and sharing ideas.

Why did you choose to be part of the BUILDs 1 year programme?

Alice Ubelmann: I was very interested in having the chance to discover innovative urban biotechnologies.
I was also curious to know what kind of approach and initiative we can develop thanks to nature-based solution for urban environmental issues in a team (with the Institute for Advanced Architecture of Catalonia and Wien University).

Esther Hummel: I found the basic idea of developing sustainable solutions for the cities of the future very appealing. Furthermore, for me the interdisciplinary and multifaceted nature of the program were very interesting. Also, the perspective of continuing the project beyond the duration of the program was an important aspect for my participation.

Vinay Prabhaker: The broader exposure it provides and the opportunity to build a startup along the guidance of experts.

Vincent Heurtel: I like entrepreneurship and it was the perfect opportunity to start on this subject. The topic was wonderful, related to nature, biology, and positive impact. A fully English programme was a perfect challenge for me to improve my language. And, I was sure that interdisciplinary work is the best and wanted to test it.

What did you learn during the 1-year programme working with different disciplines?

Harsh Vora: My biggest takeaways would be from the business perspective. I learned about how marketing pitches are conducted, business modules are planned out, revenue streams generated, all in all how to set-up and run a business from scratch. Hopefully I will be able to set up my own architectural practice someday and utilize the learnings to set-up and run it.

Figure 1: One Year Programme - Team Building Week in Barcelona, Spain

Jasmo Nickol: If the team is built on mutual trust and respect, it's very much possible to work together even if you have very different educational and cultural backgrounds. I would say it's even inspiring and offers great opportunities to expand the horizon and learn how much can be achieved if you team up with motivated people.

Patrick Frank: To align goals from the beginning, have clear responsibilities for different areas of work (although this takes time to settle in), as well as to communicate openly with everyone. Also, the importance of making difficult decisions that may not be popular or feel challenging.

Vinay Prabhaker: Having a strong core idea is very essential to build any start up. But being the most difficult part, one has to be very critical of it before starting up.

What challenges did you face working with different disciplines and how did you overcome them?

Esther Hummel: We quickly realized that there were different working methods and communication styles. In order to collaborate productively, we agreed on clear structures and common goals. Within the individual areas, however, we left it up to the teams themselves to organize themselves, structure their tasks and find their own mode.

Eve Nnaji: The only challenge was not being able to convey the design process in a way that would make the team understand how iterations work. It was a bit hard to balance doing all that you can for the project and knowing when to say no to requests from teammates.

Jasmo Nickol: Our biggest challenge was that we were located in different places, which made it more difficult to apply for funding and to work on the physical aspects of the startup.

Figure 2: One Year Programme - Team Building Week in Barcelona, Spain - Group Discussions

Figure 3: One Year Programme - Team Building Week in Barcelona, Spain - Quick Prototyping Challenge

Vinay Prabhaker: Developing ideas was the most challenging part. As designers, we see a problem from a different perspective, but coordinating with various disciplines requires a much wider perspective. And any solution to be thought of has to fit and work in all the 3 disciplines. Finding better alternatives to conventional ones aided a lot in overcoming these hurdles.

Have the skills you developed and knowledge you acquired during the 1 year programme aided in your future endeavours or career? If so, please explain.

Jasmo Nickol: I am sure that the skills I acquired already help me in other group projects as we were working together very intensely, which required us to develop a good working culture, for instance, using tools, rules and enhancing personal communication.

Patrick Frank: Yes, helped a lot. The skills of leading a company, creating and deploying strategies as well as to pitch in front of a jury/crowd helped a lot in self-development.

Saurabh Singla: Yes, It has enhanced my skills. Now, working as a principal architect of a firm, I can relate to the business part. Also it has helped me understand how a company functions from an idea stage to final operations.

Vincent Heurtel: I think I developed more indulgence toward the other collaborators I work with. I understand that we have different motivations and beliefs, and so we have different perspectives on a point. I now try to listen and understand the point of view of others before saying something.
I am also curious about everything, understanding that every discipline has an influence on our work and our project. And for that, I want to learn more about other disciplines.

Please share your thoughts on transdisciplinary education and whether you think it should be a fundamental methodology included in education.

Alice Ubelmann: Transdisciplinary education is essential, all the more when it comes to global issues (global warming, environment and ecosystems).
Working on such complex and cross-disciplinary subjects requires an understanding of the multiple workings of the various disciplines and the

unique, yet necessarily complementary, expertise involved in their proper functioning. It is necessary to create the link between all the complex components that make up each future engineer, architect, economist, literary scholar, historian, lawyer, etc., in order to create fertile ground for the growth of tomorrow's society. Without this fertile ground, we cannot hope for great advances.

Patrick Frank: Transdisciplinary education is a MUST, makes you see how fast and powerful teamwork can be and you can achieve things you couldn't do on your own.

Vinay Prabhaker: A unidisciplinary world is almost nonexistent. Learning to tackle multiple aspects of problems during education will help us develop solutions which are ready to use and practically perform better.

Vincent Heurtel: The importance of the design is fundamental.
We now see that it is important to take into consideration every aspect of a project. If one side is missing, it can cause huge damage, such as our climate crisis. Taking time to include diverse disciplines from the beginning will save time after all, during the development and certainly and most importantly, lead to a more sustainable idea.

Do you think that the BUILDs Programme created a relevant difference in your education? If yes, please explain how/why.

Esther Hummel: Absolutely! The program made an entrepreneur out of me, or rather brought out the entrepreneur in me. :) Through the hands-on work on a concrete project and the support within the framework of the program, we were always able to develop our idea further and finally turn it into reality.

Eve Nnaji: Yes, I was able to engage in a project that went beyond Iaac itself. Dealing with real-world participants like company managers and start-up advisors helped diversify my routine as well as remind me of the importance of applying what I've learned rather than continuously focusing on meticulous design details that disappear in application.

Vincent Heurtel: It is difficult to judge this part and imagine how I could be different without this programme. However, I think the awareness and the broad vision that BUILDS gave me has a major impact. Open-mindedness

Figure 4: One Year Programme - Team Building Week in Barcelona, Spain

creates more collaborations and permits to build stronger projects. We all interact with other disciplines in our daily work and life. I better communicate with others for work. Moreover, BUILDs gave me a nice impression on the entrepreneurship world. I learnt a state of mind of development, of growth.

Do you think that the BUILDs Programme has been relevant for your future career? If yes, please explain how/why.

Alexandra Martin: Yes, it was a first step to international career I hope!

Patrick Frank: Yes, it changed the way I am, how I trust myself and my perspective on the future. Also, it made me have my own start-up, which pretty much changed my whole life.

Vincent Heurtel: BUILDs programme is completely relevant for my career. Because firstly, I would have never started an entrepreneurship journey and have this idea of business. After the BUILDs programme, I continued to learn and develop new competences, far from my area. Thanks to this idea, I integrated incubators, did an entrepreneurship master, met many people, and developed myself while following my dreams.

Entrepreneurship has given me inestimable knowledge, marvellous moments, and an incredible mindset.

If you could give one advice to future students that would take part in transdisciplinary programmes, what would it be?

Alexandra Martin: Stay open minded and say it when something bother you, it is really important to understand why you learn something.

Alice Ubelmann: Do not hesitate to make your opinion known and to make yourself understood, repeat and exchange without ever abandoning your idea without a good reason, but knowing how to listen and question yourself when the time comes. Working in a multidisciplinary group is difficult in the sense that one can feel illegitimate within the group. No one is illegitimate, everyone has something to say, the most important thing is to manage to make a sentence with everyone's word.

Esther Hummel: I think the most important thing is open communication.

Figure 5: One Year Programme - Team Building Week in Barcelona, Spain

One should openly address what drives the individual team members, what goals they are pursuing and where they want to develop with the project and also personally. This is not a one-time thing, but should be repeated at regular intervals. If everyone has a shared understanding, it will always be possible to find ways and means to turn the idea into reality.

Eve Nnaji: Communicate

Harsh Vora: Be compassionate about the project and have some empathy while working with your teams, you will go a long way then and will possibly end up with your own start-up.

Jasmo Nickol: Take part!

Patrick Frank: Stay curious. Everyone knows something or can do something way better than you can. You just have to find out what it is :-)

Vinay Prabhaker: Always have an open mind in all interactions but be critical when required.

Vincent Heurtel: Let your judgement at home and bring your open-mindedness.Try to integrate the vision of others and explain every side of yours: communication is crucial.
And let's go!

SECTION 3

RADICAL INNOVATION CASE STUDIES

NEW TECHNOLOGIES FOR MULTI SPECIES CO-EXISTENCE AND COLLABORATION

BEYOND HUMAN CENTERED DESIGN

According to the Gaia hypothesis by Lovelock and Margulis, living things are part of a self-regulating mechanism on a planetary scale that has preserved habitable conditions for the past three and a half billion years. It is based on the premise that the oceans, seas, the atmosphere, the earth's crust and all the other geophysical components of the planet earth remain in suitable conditions for the existence of life thanks to the behavior and action of living organisms, plants and animals (Lovelock, 2009). Many scientists have analyzed and described the Earth's dynamics in line with the Gaia hypothesis during recent years. Anna Tsing (2015) describes the activities of life-forms as making words, stating that we are surrounded by many world-making projects, human and not human. World-making projects emerge from practical activities of making lives, that in multispecies populated environments overlap creating collaborations: for example bacteria make our oxygen atmosphere, and plants help maintain it, while plants live on land because fungi make soil by digesting rocks. Collaborations between living forms maintain the earth in a state of equilibrium, and based on this principle Gaia worked without foresight or planning on the part of organisms for millions of years, but the evolution of humans is changing that.

This change has been described as the starting of a new epoch called the Anthropocene, the epoch in which human disturbance outranks other geological forces endangering the existence of all life forms.

During the last decades we have begun to gain awareness of the global implications of our actions and as a result, intentional self regulation—from personal action to global geoengineering schemes—is either happening or imminently possible. Making such conscious choices to operate within Gaia constitutes a fundamental new state of Gaia, which Timothy M. Lenton and Bruno Latour call Gaia 2.0. Operating within Gaia means emphasizing the agency of life-forms, their ability to set goals and their collaborations, fostering global sustainability (Lenton and Latour, 2020). Even though the example of natural ecological systems reveals that mutualistic attitudes can help to

shape the ecosystems, making them stronger, longer-lived and more resilient, up to now co-existence and collaboration has been mainly conceived and planned only as a single spice environment, some examples are cohousing, coworking, community allotments and ethical purchasing groups (Mancuso S. et al, 2018). What if we start to design spaces to host and foster multispicies co-existence and collaboration? What if the design of our cities and objects has the objective of maintaining or restoring the environment's state of equilibrium through exchange?

Design has always been human-centered, as it has always been about adapting and domesticating the world for the advantage of our species. Human Centered design has been defined in the '90 by IDEO, the design company that popularized the term, as a "creative approach to problem solving that starts with people and ends with innovative solutions that are tailor-made to suit their needs". Human Centered design focuses clearly on an old anthropocentric perspective. However designers can help people realize that we are all participants in complex systems that go beyond our human made constructions, systems that we cannot control, but that we should acknowledge, protect, and learn to live with and within: design should not be cantered only on humans, but on the future of the whole biosphere as well (Antonelli, 2019).

Designers can help people realize that we are all participants in complex systems that go beyond our human made constructions, systems that we cannot control, but that we should acknowledge, protect, and learn to live with and within. "These underrepresented systems, such as the microbial system and the environment, have suffered and still present significant challenges for designers. While these systems are self-adaptive, complex systems, our unintended effects on them will most likely cause unintended negative consequences for us", writes Jiochi Ito, director of MIT's Media Lab. (Ito, 2017).

This section presents disruptive projects working with nature, where new technologies, morphologies and materials are used to foster multispecies

collaborations. It presents radical innovations with the potential to be mainstreamed. In order to strengthen our planet's sustainability and resilience, using the words of Donna Haraway (2016), we require each other in unexpected collaborations and combinations.

CO-mida Green Wall

CASE STUDIES: RESEARCH TO IMPLEMENTATION

CYBER GREEN VOLTAICS

Barcelona, Spain
Advanced Architecture Group, Institute for Advanced Architecture of Catalonia

KEYWORDS:
Bio Photovoltaic System, Food Production, Community Participation, 3D Printing, Ceramic

ABSTRACT:
Cyber Green Voltaics is a system designed to build green walls through 3D printing techniques as well as generating renewable energy at the urban scale. The power generation technology used is based on the photosynthesis process of the plant (bio photovoltaic technology. The surplus of organic matter, generated by the plants during the process of photosynthesis, is transferred to the soil through its roots. This generates an entire ecosystem of microorganisms around it that feed on this matter releasing electrons. These electrons are collected by placing electrodes next to the roots to obtain electricity.

The ceramic pots were 3D printed and house edible herbs and plants to attract butterflies. The community is maintaining the plants and enjoying the benefits of the plants. Sensors help to monitor the whole system including irrigation and energy production.

Figure 1: CGV Prototype

Figure 2: CGV Prototype

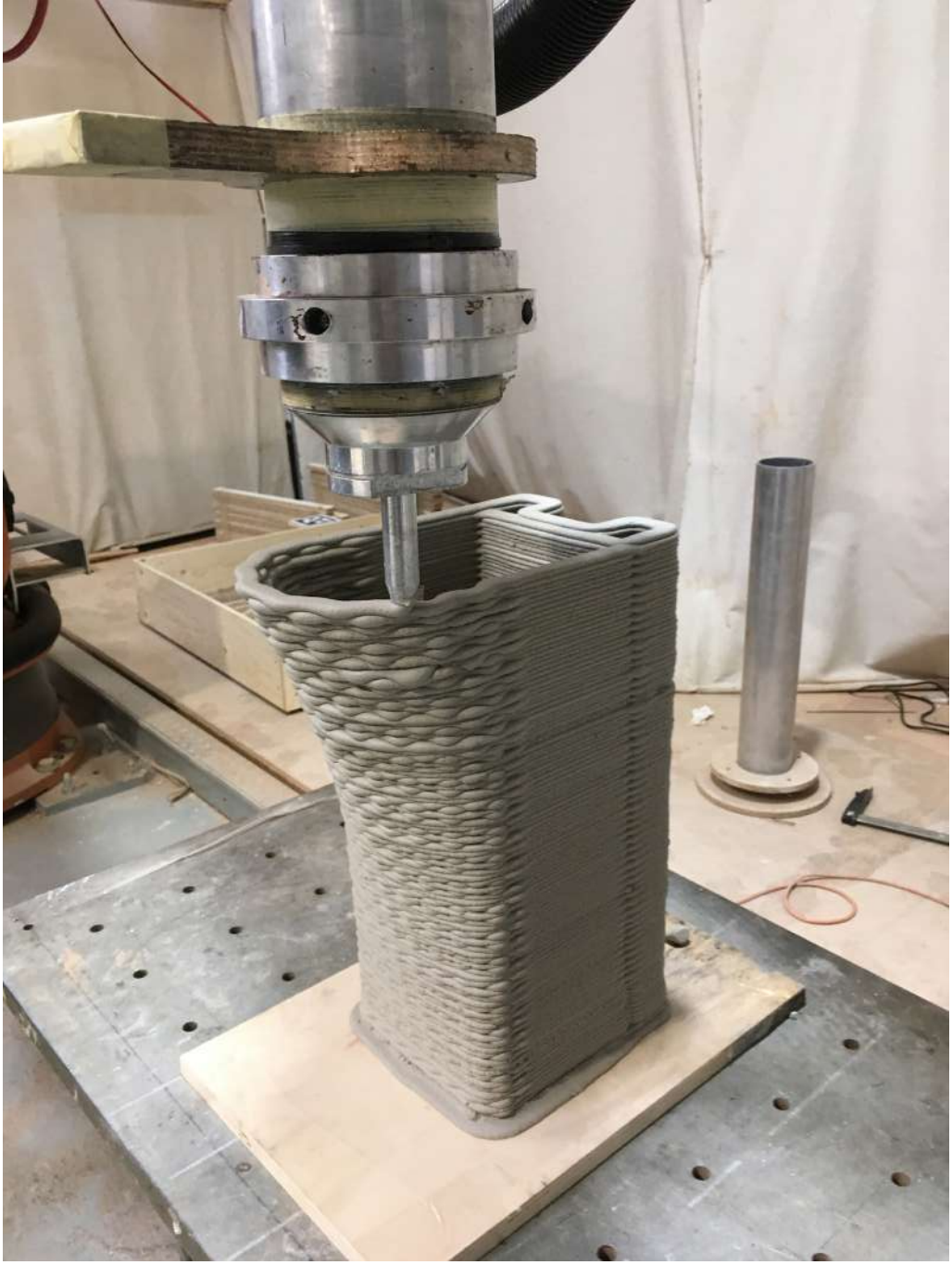


Figure 3: 3D Printing Ceramic

Figure 4: Ceramic Pots Glazed and Ready for Assembly

Figure 5: Testing the Biovoltaic System

CO-MIDA

Barcelona, Spain
Advanced Architecture Group, Institute for Advanced Architecture of Catalonia

KEYWORDS:
Bio Photovoltaic System, Food Production, Robotic Fabrication, 3D Printing, Ceramic

ABSTRACT:
CO-mida combines nature-based solutions with robotic 3D printing technology and digital technologies to create an automated green wall. Installed in a community garden, the wall will be maintained by the community with each person taking care of a pot. The wall is aimed at growing food, providing homes for birds, bats, and insects, and generating electricity through a bio photovoltaic system.

The tiles and pots were parametrically designed, and textures were applied to the surfaces to encourage moss and microbial growth. They were fabricated from ceramic which could be 3D printed by the robotic arm, before being fired in a large kiln. The pots and tiles are mounted on a structure with an automated watering system, triggered by humidity sensors in the soil. In addition, there are sensors incorporated in hubs that measure the air temperature and the amount of energy produced by the bio photovoltaic system. CO-mida has been developed with the community, horticulturalists and designers for the community and demonstrates how the community can play a fundamental role in the maintenance of projects.

Figure 1: A Gradient of Textures

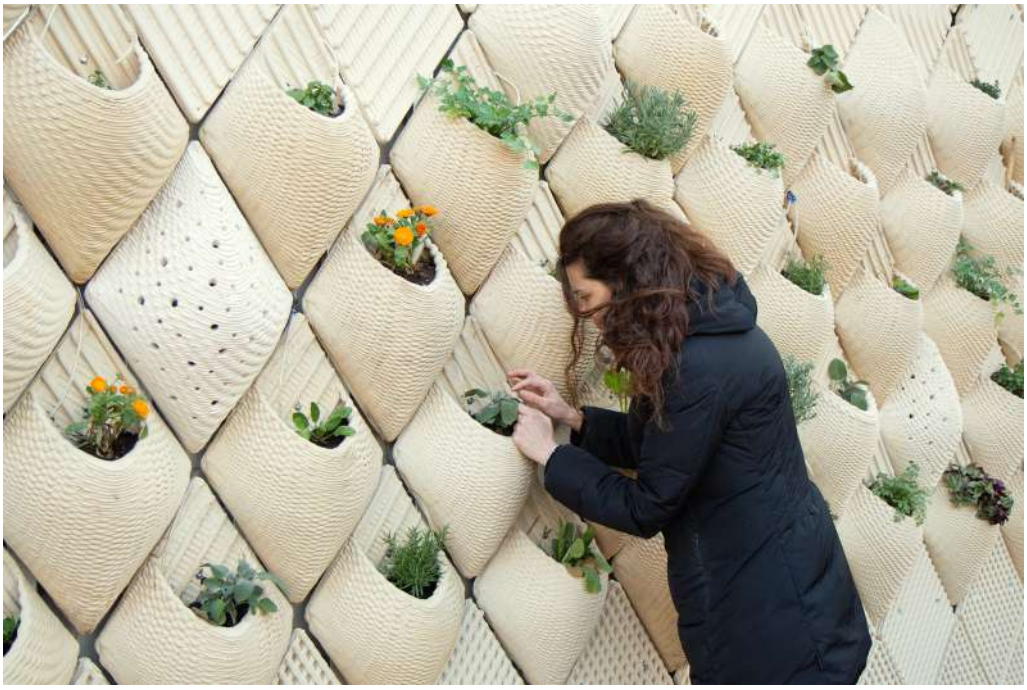


Figure 2: Varied Textures to Encourage Microorganisms to Grow

Figure 3: CO-mida Installation at Connecthort, Barcelona

Figure 4: COmida Green Wall at Connecthort

ROOT MEMBRANE

Barcelona, Spain
Advanced Architecture Group, Institute for Advanced Architecture of Catalonia

KEYWORDS:
Plant Roots, Fabric, Digital Fabrication, Parametric Design, Membrane

ABSTRACT:
Inspired by the work of Diana Scherer, Root Membrane was developed to cultivate food, but also harvest the roots in the form of a textile. This textile can then be used in the construction industry as a facade system or shading device.

Using digital technologies and fabrication techniques a mold was created for the plant roots to grow into. As the plants are watered, the water seeps into the patterns created by the mold and attracts the roots seeking water. Once the root network is well established, the roots are cut away from the plants, and the root fabric is left to dry.

Figure 1: Root Membrane Mold

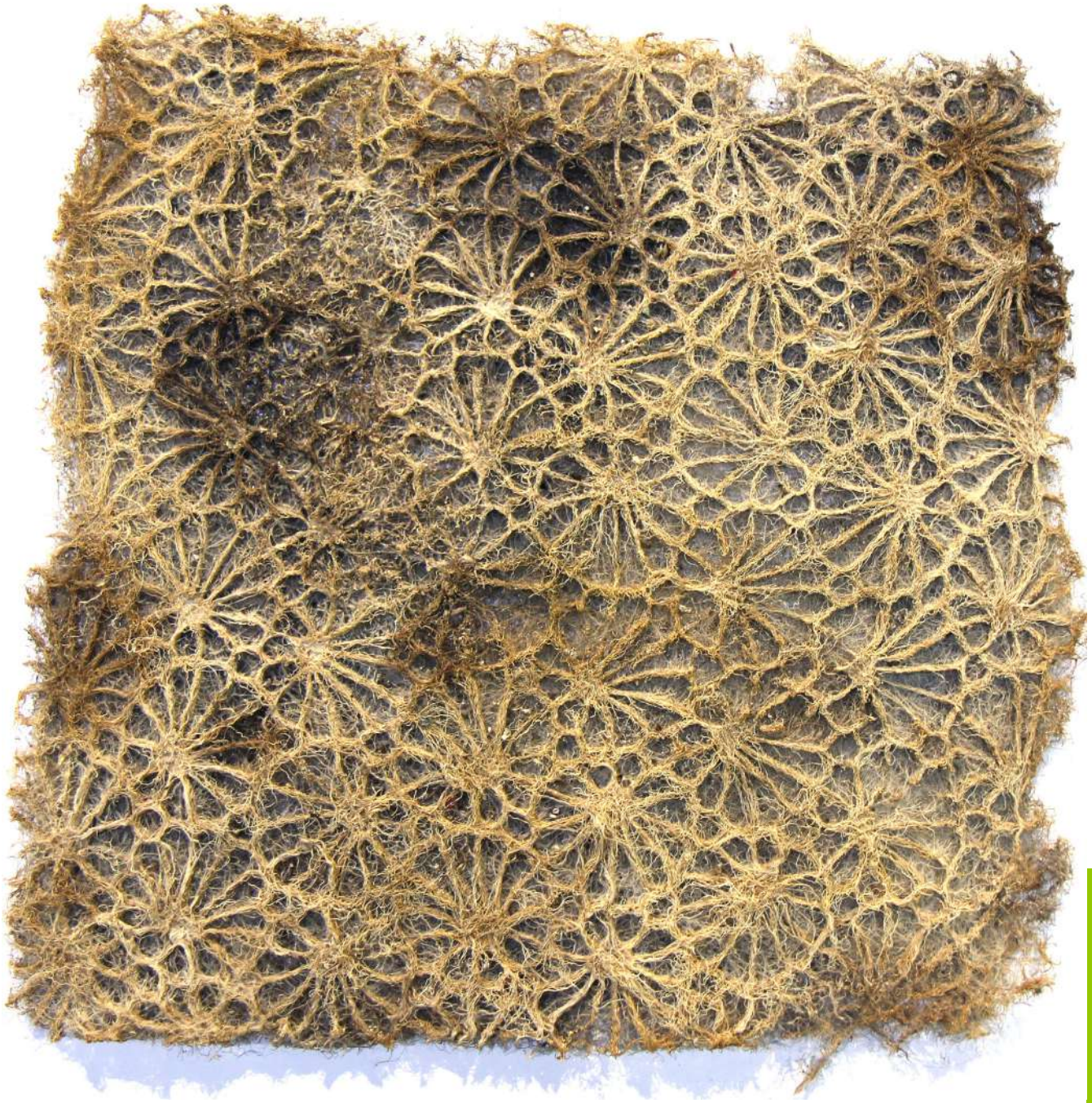


Figure 2: Root Membrane Textile

Figure 3: Root Membrane
Textile Details

FOOD VOLTAICS

Barcelona, Spain
Advanced Architecture Group, Institute for Advanced Architecture of Catalonia

KEYWORDS:
Bio Photovoltaic System, Nature-based Solution, City Resilience, Parametric Design, Digital Fabrication

ABSTRACT:
Food Voltaic consists of an urban infrastructure targeted to enhance the cities resilience. This is achieved by increasing food production, producing renewable energy, purifying the air, mitigating flooding, trapping water and informing the citizens about environmental conditions. Through digital technologies and advanced manufacturing techniques the system enhances and exploits the properties of living materials.

The Food Voltaic system consists of tiles associated with an app which can be implemented on vertical and horizontal surfaces, in public spaces, facades, and rooftops. The external surface has been designed using parametric programs and can be adapted to the local conditions. For example, larger holes for the plants are designed for wetter climates to collect more water. The tile sits in a box that is equipped with a bio photovoltaic system, collecting the electrons emitted by bacteria near the roots of the plants, as well as sensors to monitor soil moisture, temperature, humidity, air quality and quantity of energy produced by the system.

Figure 1: Food Voltaic Detail for Capturing Water

Figure 2 & 3: Integration of Plants in Food Voltai

Figure 4: Food Voltaic Prototype

MYCO-SCAPE

Barcelona, Spain
Advanced Architecture Group, Institute for Advanced Architecture of Catalonia

KEYWORDS:
Mushroom Production, Parametric Design, Digital Fabrication, Modular System, Urban Cultivation

ABSTRACT:
MYCO-Scape is a modular system which supports the growth of edible mushrooms in the urban environment - public spaces, facades and rooftops. The structure's modules allow for both food and construction materials to be produced. The modules house the substrate, straw and mycelium spores, for 3 weeks to allow for the mushroom formation which forms the construction material. The external surface is parametrically designed and tailored to control the environmental conditions such as shading and humidity. It is designed to mimic the texture and function of tree bark where mushrooms naturally grow and flower. Digital fabrication processes were used to mill the plywood panels using a CNC machine. Developing the project in a sustainable manner was key and thus, wood was selected for the realisation of the panels and frame structure. In addition to the production of food, MYCO-Scape demonstrates how to create a 'culture of caring' for locally sourced and produced food.

Figure 1: MYCO-scape Prototpe Details

Figure 2: MYCO-scape Prototype

Figure 3: MYCO-scape Implemented on a Building Facade Render

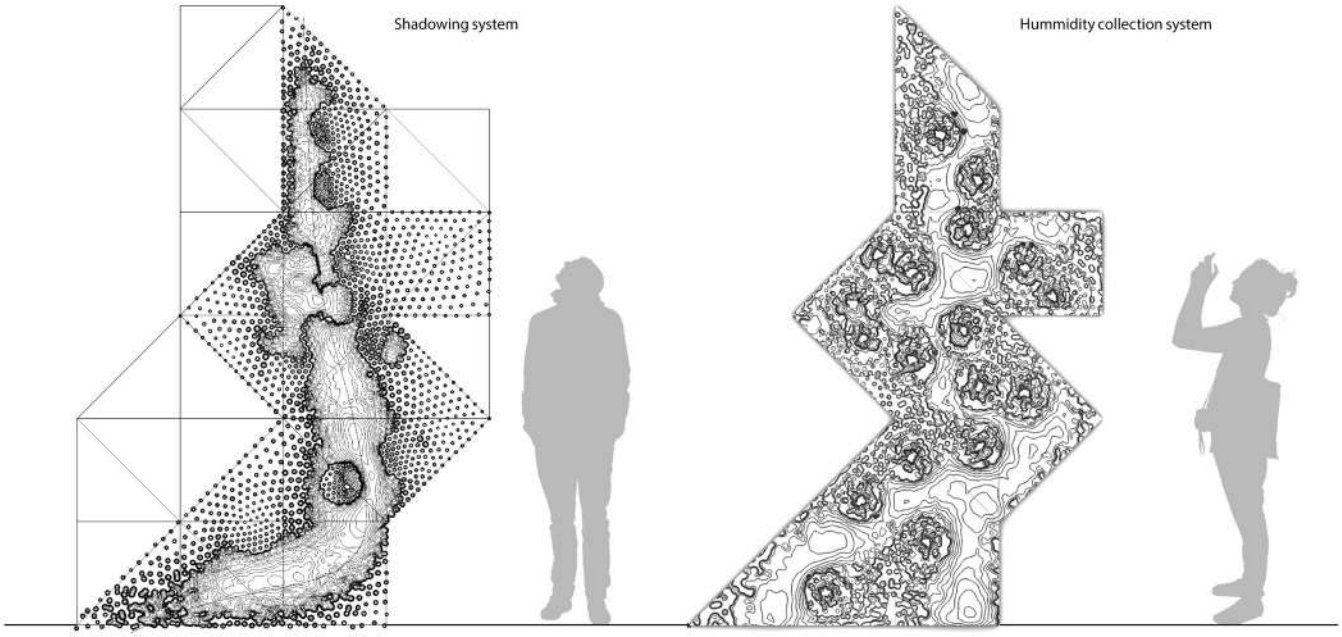


Figure 4: Design Parameters

Figure 5: MYCO-scape Prototype

Marjolein Helder
presenting the work of
Plant-e

CASE STUDIES: BUSINESSES IN THE FIELD

ØSTERVOLD BASIN, RANDERS, DENMARK

Plant-e, Municipality of Randers, Denmark, LA Arkitekter

KEYWORDS
Energy, Sustainable lighting, Plant-power, Plant-e technology, Green future

ABSTRACT
The effects of climate change can be seen all around the globe. One place where this is painfully clear is the city of Randers, in Denmark. Randers is experiencing increased rainfall events and seawater intrusion due to a changing climate. In order to mitigate these effects of climate change, the municipality decided to replace all the city drainage systems. While doing this, they chose to incorporate several measures to increase their sustainability as a city. They aim to be the most climate neutral city in Denmark by 2030.

Not a small challenge, and one Plant-e got to contribute to by installing one of our systems in their new rainwater collection basin. Plant-e technology has been installed in the banks of the basin, and lighting was attached to it, contributing to the locals' and tourists' sense of safety during the evening and night. Since plants capture CO2 while Plant-e technology produces electricity, this power is actually carbon-negative. And in addition the power for the lights originates from Plant-e technology installed in the basin itself, a mere meter away. This means that long and expensive power cables can be avoided. Altogether, the system provides for a safe and stunning environment, with the lighting giving off a fairy-tale like effect to the basin and surrounding land.

Østervold Basin at night, Randers, Denmark

SOLAMET

Nancy, France
Econick

KEYWORDS
Agromining, Hyperaccumulator plants, Soil remediation, Biotechnology, Research and development

ABSTRACT
Plants that are able to accumulate metals from soils: a nature-based solution developed by Econick. As many soils have been polluted by human activities (farming, metal ore mining and smelting, coking plants, glass factories...), this has resulted in health and environmental issues. In the recent decades, environmentally-friendly solutions to mitigate pollution and to remediate contaminated soils have been developed. Such plants used by Econick are called hyperaccumulator plants. Phytoextraction, a biotechnology based on the use of these metal hyperaccumulator plants, can help extract trace metal elements from a wide range of contaminated soils (industrial wastelands, mine tailings, or even soils naturally rich in metals). Econick grows these plants, but also goes one step further by developing a hydrometallurgical process that enables the production of bio-sourced metals, such as nickel, from the hyperaccumulator plant ashes. The whole chain from crops to bio-sourced metals is called agromining.

SOLAMET is a hybrid project situated between research and large-scale application of agromining on a wasteland of the glass industry. This site is rich in various trace metal elements such as cadmium, lead and zinc, on which several hyperaccumulator plants are cultivated. Different associations of hyperaccumulator crops are being tested to observe and understand the interactions between their shoots and their roots. The knowledge acquired on these trials helps us to define, what are the best associations of hyperaccumulator plants to improve phytoextraction, and so, what is their agromining potential. In this way, Econick designs a circular economic technology by considering recycling and re-valorization of metals, with the production of bio-sourced compounds through the hyperaccumulator

crops. Such bio-sourced metals are sought-after by various industries, from pharmaceutical, cosmetics or stainless-steel industries to glass industries. Today, through the SOLAMET project, Econick is creating knowledge, while mitigating metal pollution on a wasteland of the glass industry, and providing bio-sourced metals for manufactured products, such as the leatherback turtle, made of crystal and colored by Econick's bio-sourced nickel.

Figure 1: Steps from the hyperaccumulator plant (left-side tube) to one bio-sourced metallic product (here nickel sulphate on the right-side tube)

Figure 2: Hyperaccumulator crops on a crystal industrial wasteland

Figure 3: Leatherback turtle sculpture (Copyright: Daum, a French crystal factory) colored by bio-ore from Econick

Gabrielle Michaudel
Presents the Work of
ECONICK at Responsive
Cities 2021

SLOW FOREST COFFEE

Copenhagen, Denmark
Slow

KEYWORDS
Coffee, Deforestation, Agroforestry, Biodiversity, Regeneration

ABSTRACT
Slow is a nature-positive coffee company providing corporate coffee solutions with high transparency and impact accounting. Their mission is to protect and regenerate forests while improving the livelihoods of smallholder farmers, creating a community-based forest business.

Slow has people “on-the-ground” in Laos, where the coffee is grown working with 37 households and 208 people globally to achieve their mission. They work directly with micro-farmers, encouraging them to preserve and plant more varied tree species in their plantations, turning monoculture farms into agroforests. Furthermore, Slow provides better prices, advance payments, an emergency fund, training, better equipment, and the like for their farmers.

Depending on the business’ coffee needs, Slow provides two options. The first being ordering directly from a Slow family’s coffee plantation, or for large coffee orders, investing in a monoculture coffee farm and transforming it into a agroforest. These strategies aid in creating a stable market for the coffee farmers and reduces their financial uncertainty. In addition, the customers are able to use Slow’s well documented sustainability efforts in their own reporting.

Figure 1: Coor Mono Plot to be Converted into an Agroforest

Figure 2: CEO Sebastian Nielsen

Houay Wai with Slow Coffee

Mr Oudom and Mrs Pherg
from Houay Way Village

slow
OUT OF THE FOREST

HARMLESS HOMES

Calgary Canada
Just BioFiber

KEYWORDS
Hemp, Building Blocks, Biofiber, Co2-Reduction, Homes

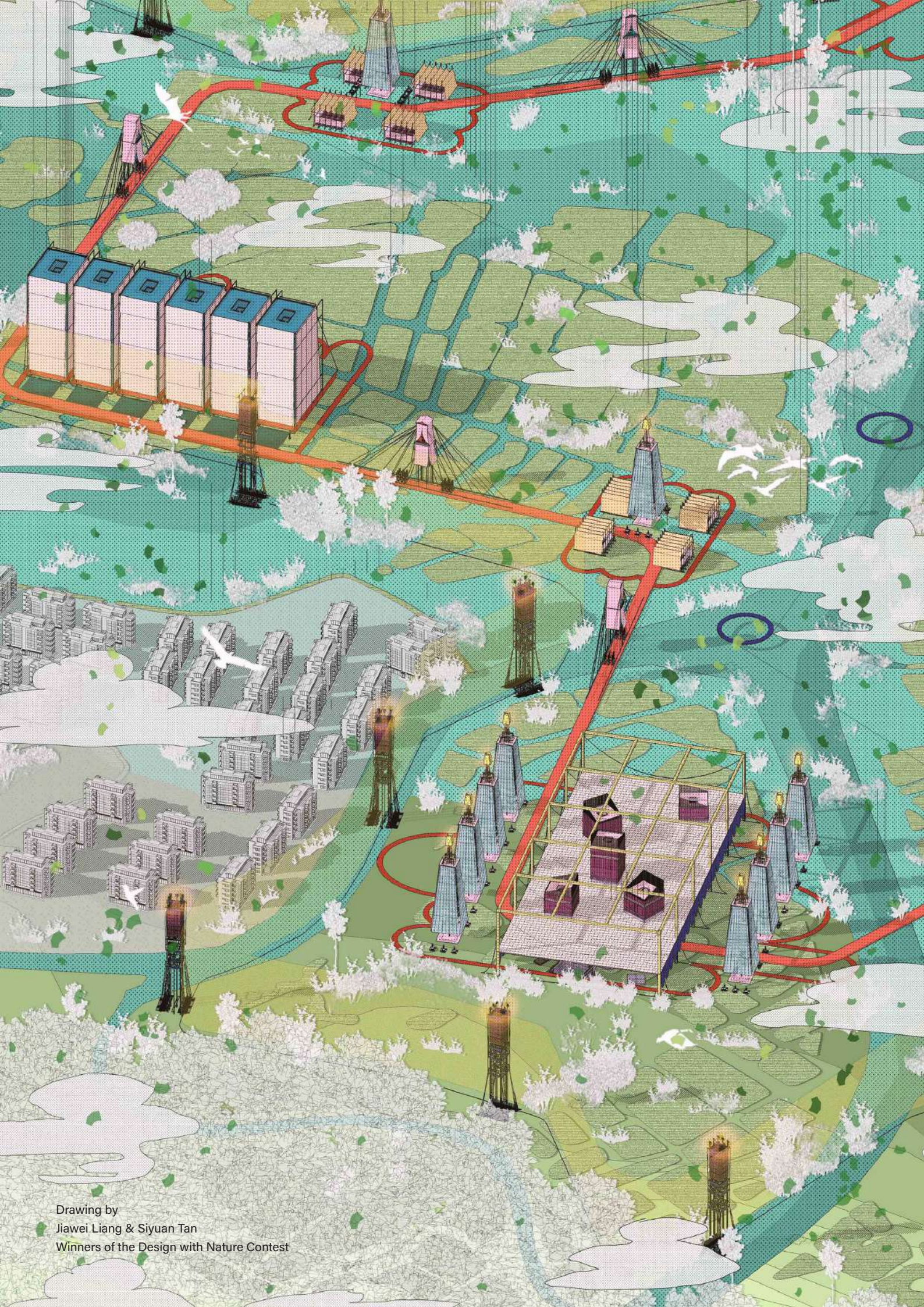
ABSTRACT
Just BioFiber produces sustainable building blocks from industrial hemp fibre that save energy and create “harmless homes”. The vision of the company is to bring a sustainable building system to the market, improving the quality of living, lowering costs and waste, and for the system to be easily constructed.

The construction system has a low embodied energy as during the production of the product, the system captures and reuses waste heat and water from flue gases. Furthermore, the water collected from the drying process is recycled into the blocks, and 10 percent of the structural frame can be recycled. In the end, the building construction system has sequestered more greenhouse gases than it has emitted during production.

Cities all over the world have committed to net-zero carbon emissions in all new buildings by 2030. The buildings constructed using the Just BioFiber block will use less energy to heat and cool, and will contribute to healthier indoor air quality for the occupants.

Homeless Homes
Construction with Hemp
Blocks

Homeless Homes
Construction with Hemp
Blocks



Drawing by
Jiawei Liang & Siyuan Tan
Winners of the Design with Nature Contest

CASE STUDIES: VISIONS FOR THE FUTURE

PLANT&EDUCATE IN PORTO ALEGRE

Brazil
Yasmin Feijó Jaskulski
Design with Nature Contest Winner

KEYWORDS:
Urban Agriculture, Resilience, Industrial Heritage, Social Reintegration, Vertical Farm

ABSTRACT:
Plant&Educate in Porto Alegre is an urban vertical farm proposal combined with a restaurant-school and a republic for the reintegration of former homeless people in the 4th district of Porto Alegre. 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. Today, in the 4th district of Porto Alegre, 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.

Figure 1: Facade Visualisation

Figure 2: Fish Tanks
Interior Render

Figure 3: View from the Interior Courtyard

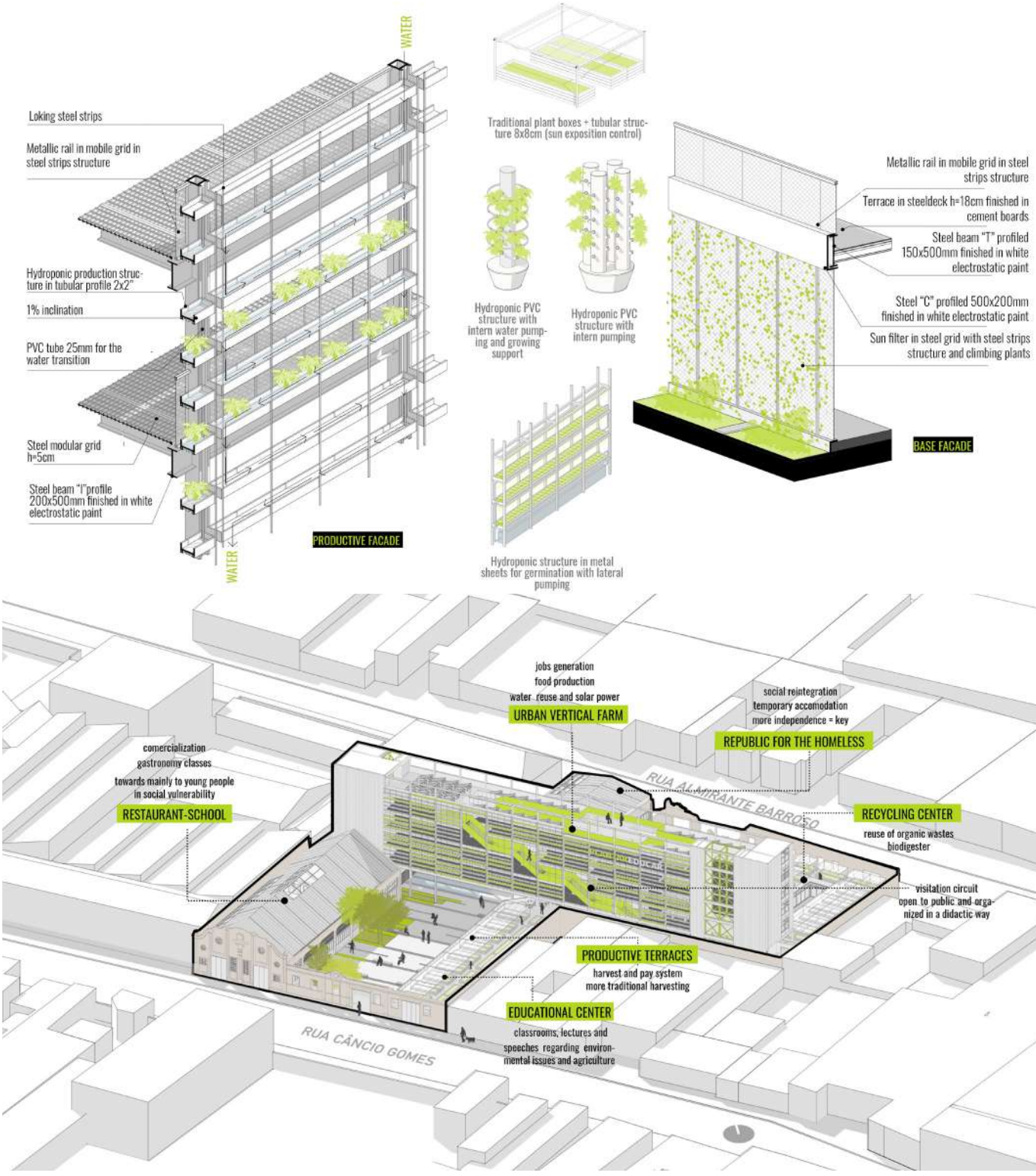


Figure 4: Details of the Productive Facade and Algae Production

Figure 5: Axonometric Diagram

REMODELING AND SYMBIOSIS

China
Jiawei Liang & Siyuan Tan
Design with Nature Contest Winner

KEYWORDS:
Dark Ecology, Local Construction, Inhabitable Landscape, Remodeling, Symbiosis

ABSTRACT:
Based on 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 reflects 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.

Figure 1: Illustration

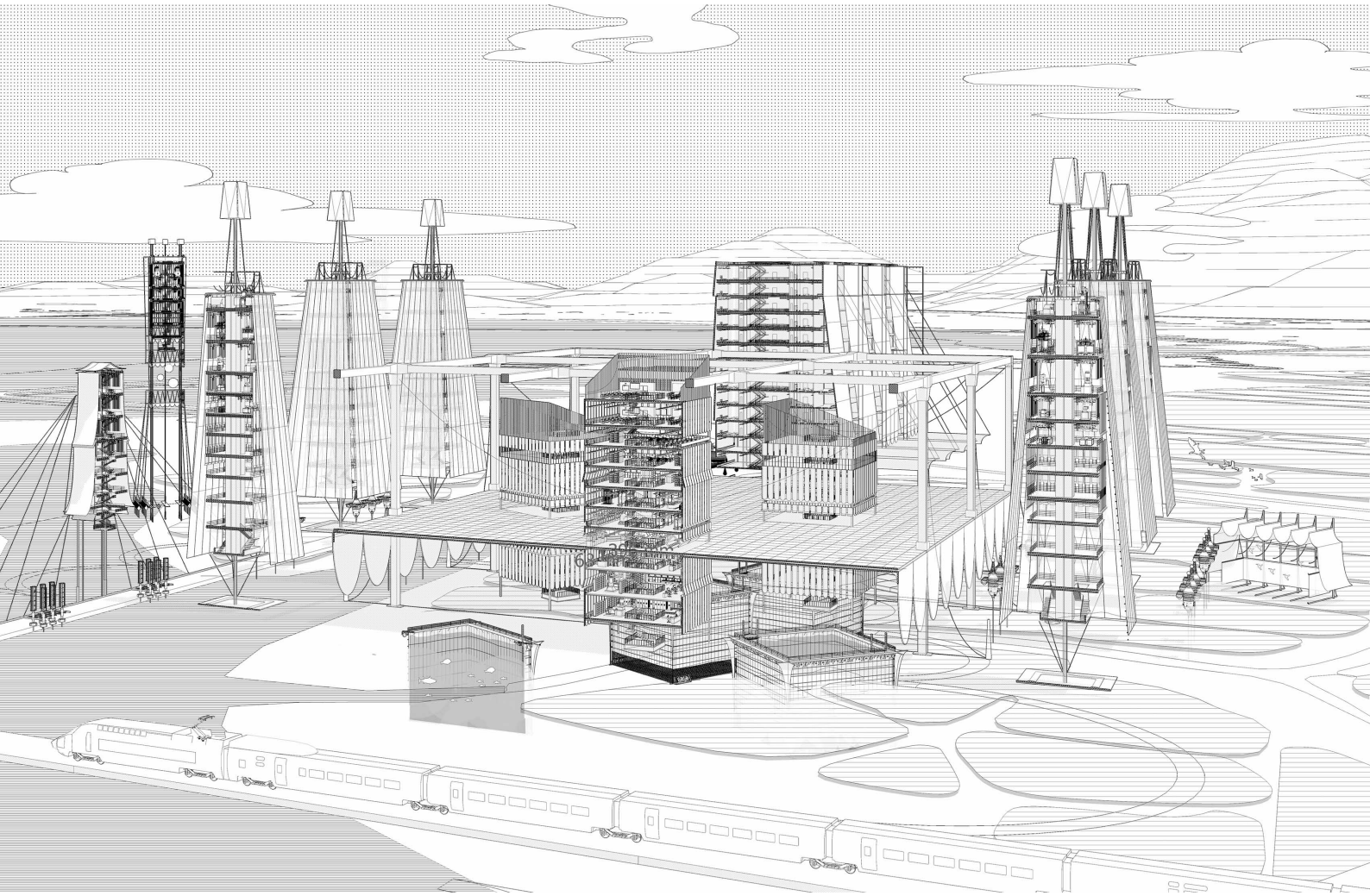


Figure 2: Sectional Perspective

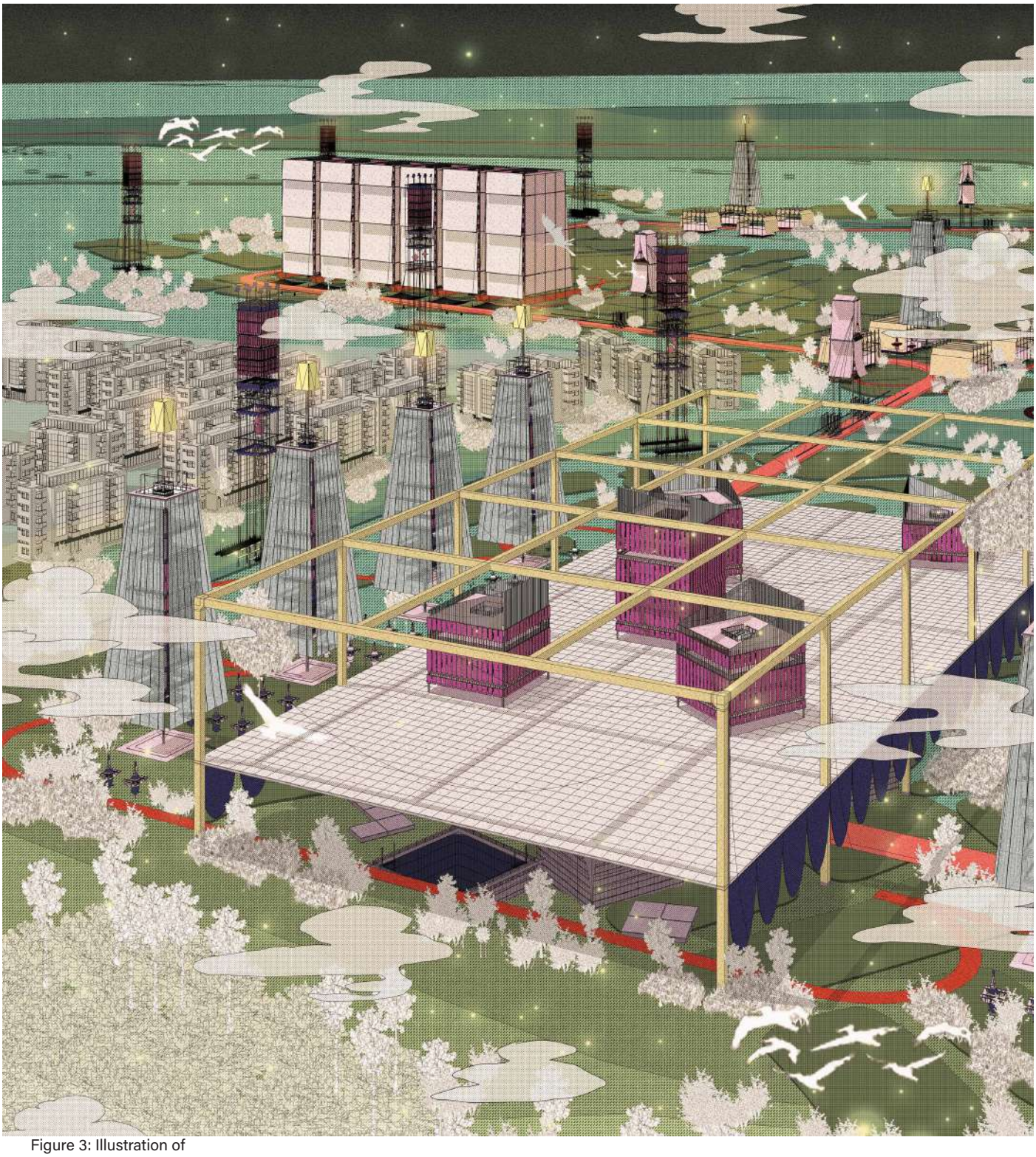


Figure 3: Illustration of System

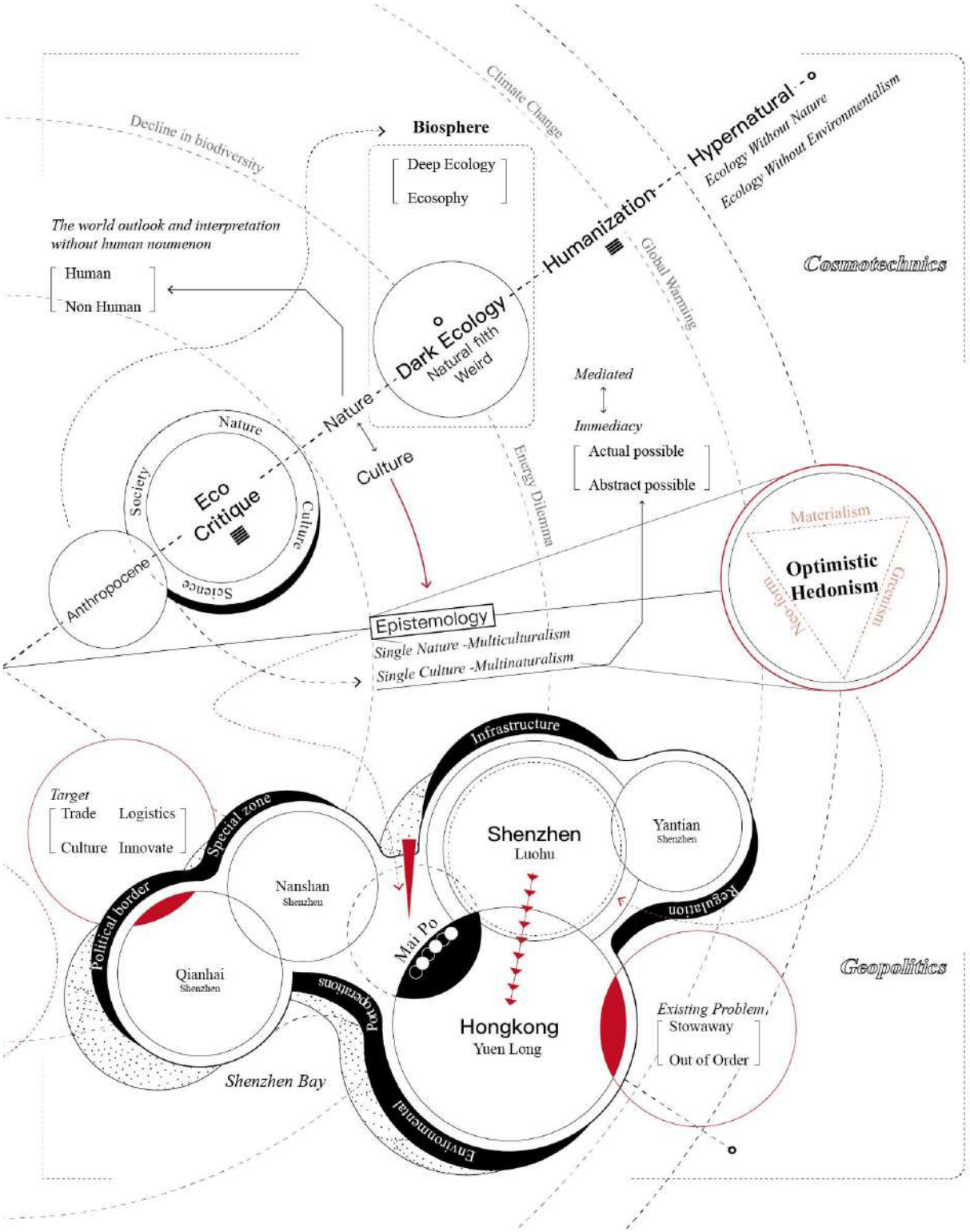


Figure 4: Project Panorama

LIVING ARCHITECTURE: FORMULATING URBAN FARM SYSTEMS THROUGH NATURE BASED SOLUTIONS

Northern Ireland
Orlagh Casey
Design with Nature Contest Honourable Mention

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.

Figure 1: Bio-plastic Material Tests

Figure 2: 3D Printed Column

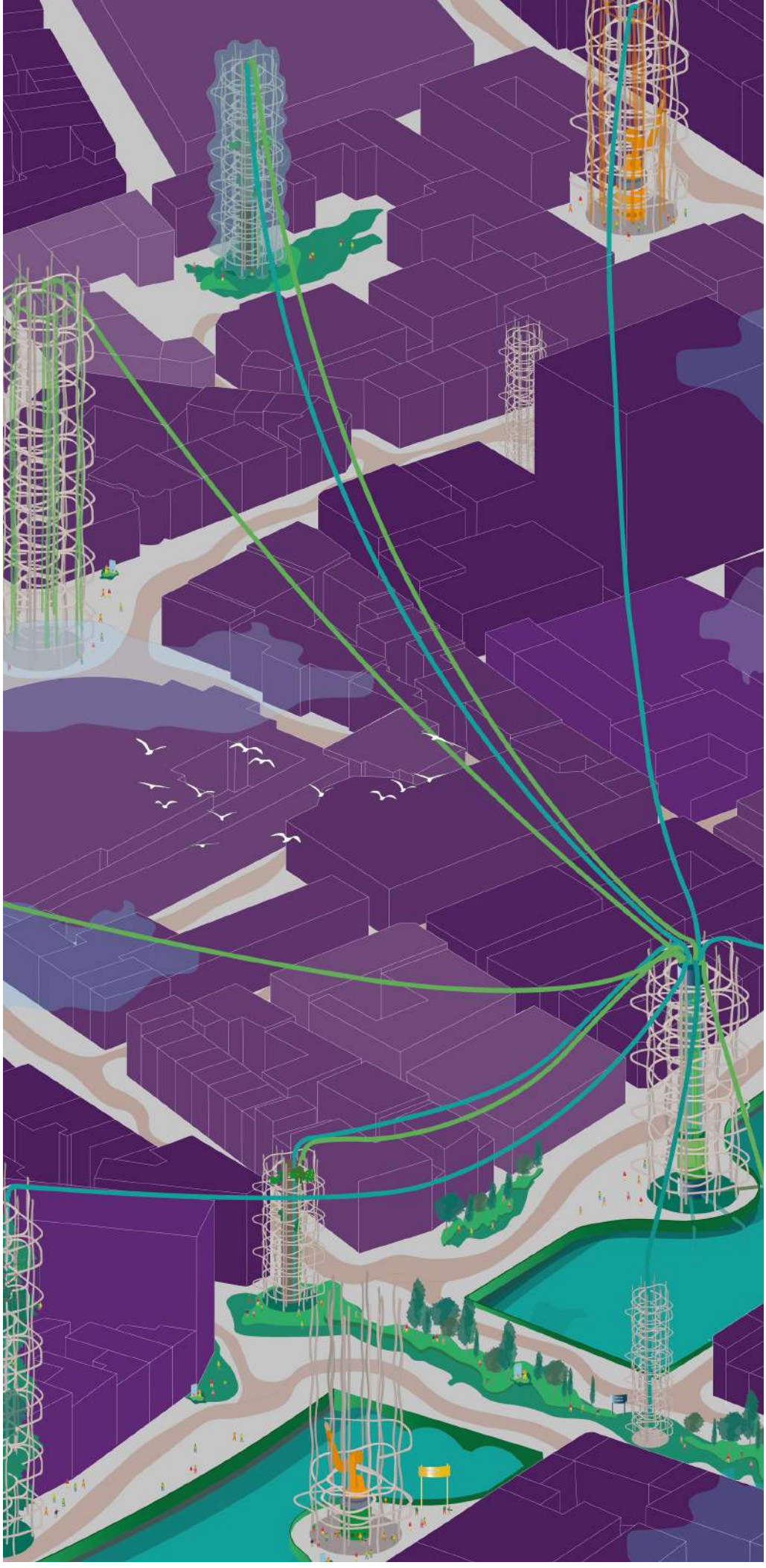


Figure 3: Visualisation of the 3D Printed Towers

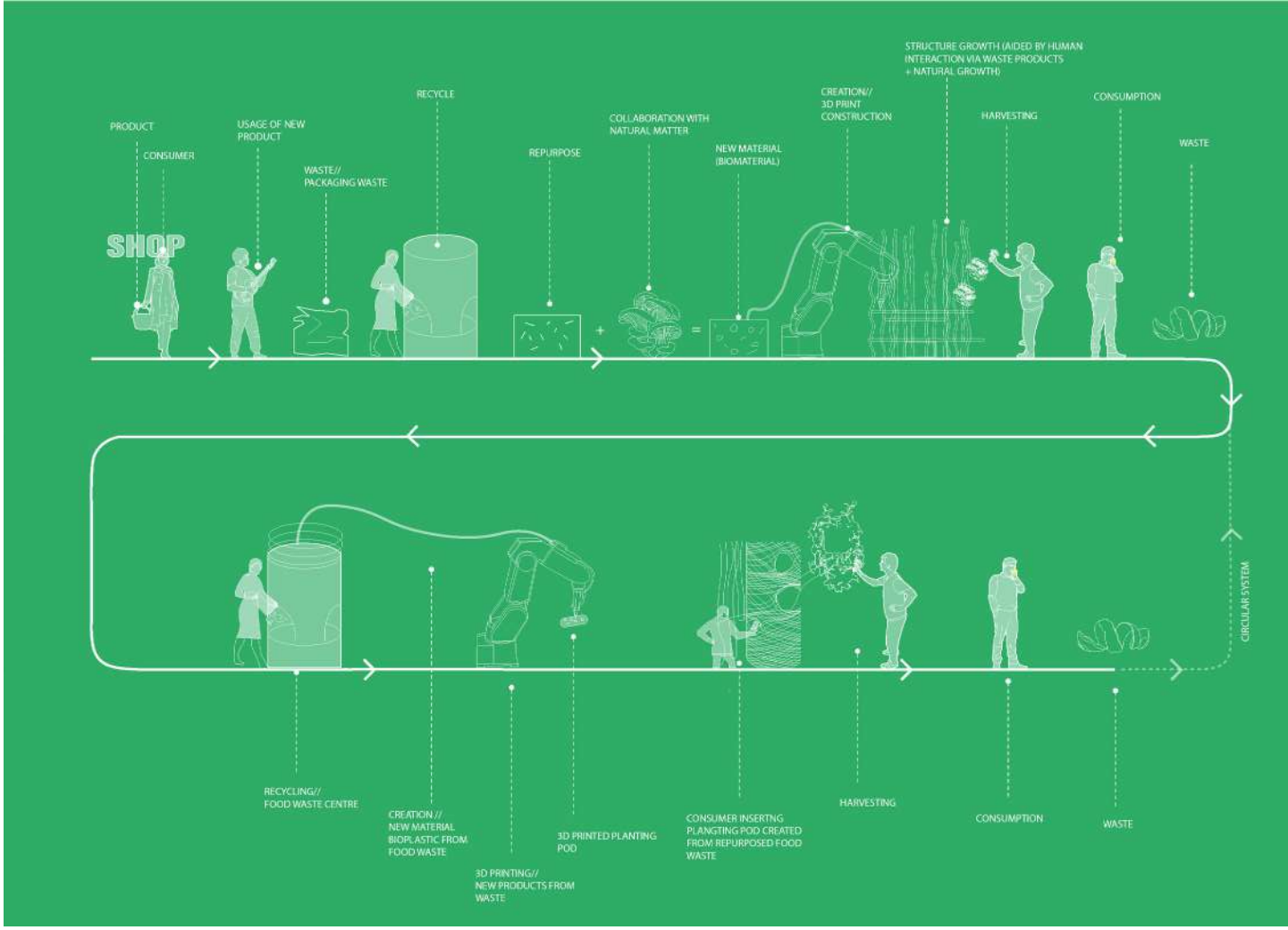


Figure 4: The Fabrication Process

Figure 5: Render of the Implemented Towers

SVA: A VISION OF SELF-SUSTENANCE

India
Dharan Koruduvar
Design with Nature Contest Honourable Mention

KEYWORDS:
Sva, Self-Sustainable, Nature-based solutions, City for all, SDGs

ABSTRACT:
Today, as large numbers of people live in cities, the resource network is invariably extensive and invisible. Furthermore, the needs and lifestyles of our growing cities put enormous stress on environmental systems and natural cycles, and these challenges are accelerated with climate change. This proposal puts forward an innovative approach to enhance the urban environment through decentralised and nature-based solutions. 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. Imagine, instead of waste going to the landfill, it becomes the input for farms. Instead of greywater from households going to STPs, they 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.

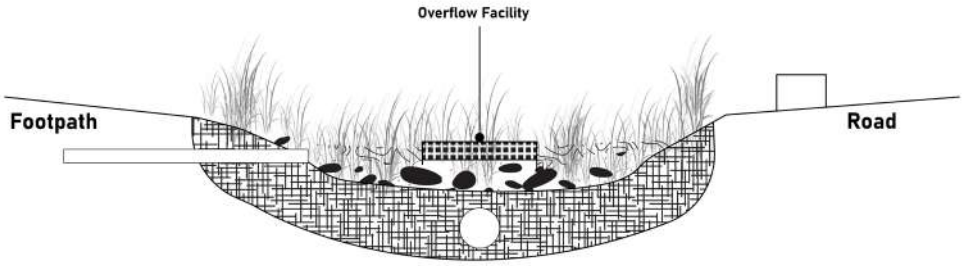


Figure 1: Street Swale Detail

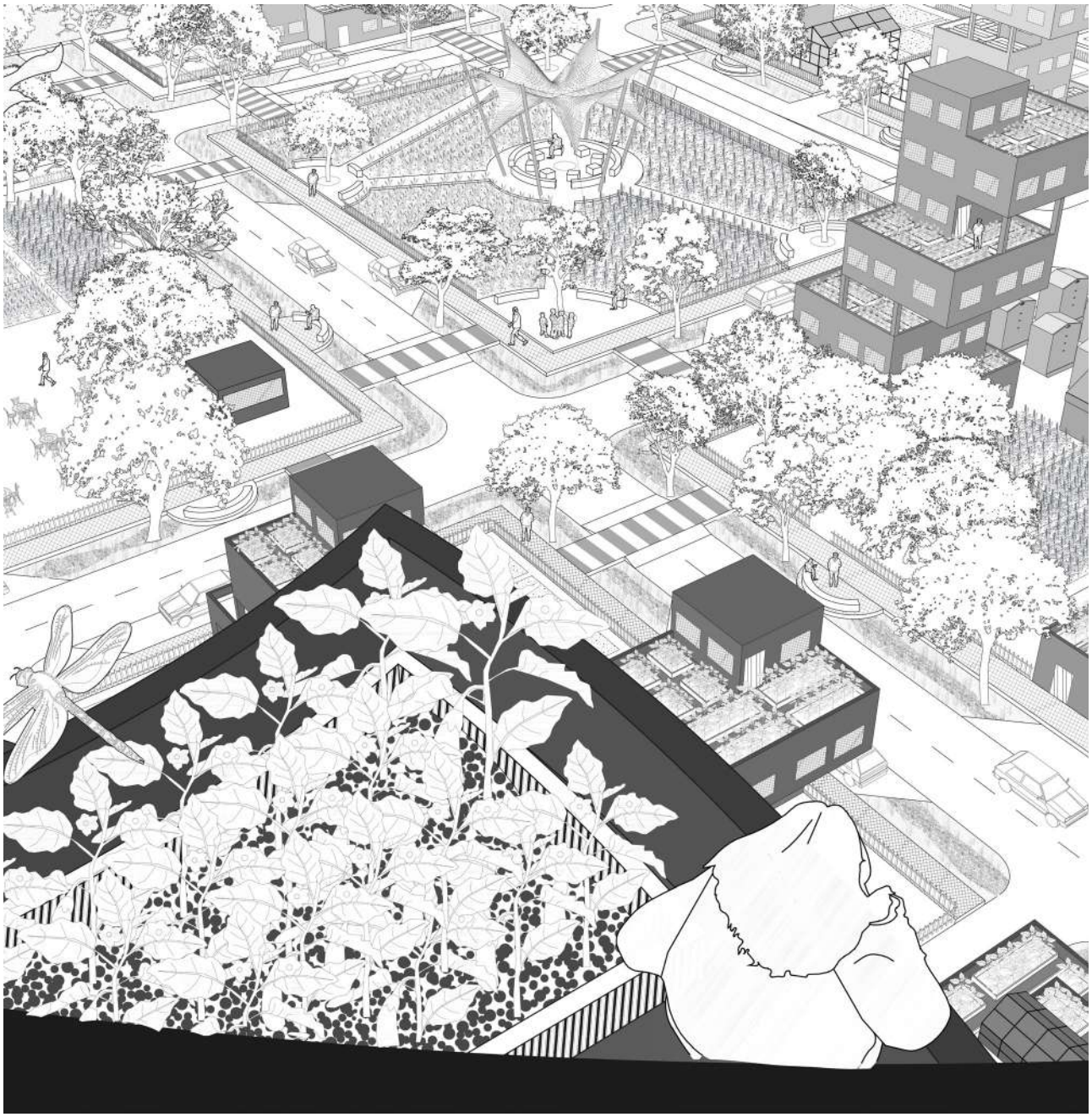


Figure 2: Visualisation of the SVA Model

Figure 3: Masterplan

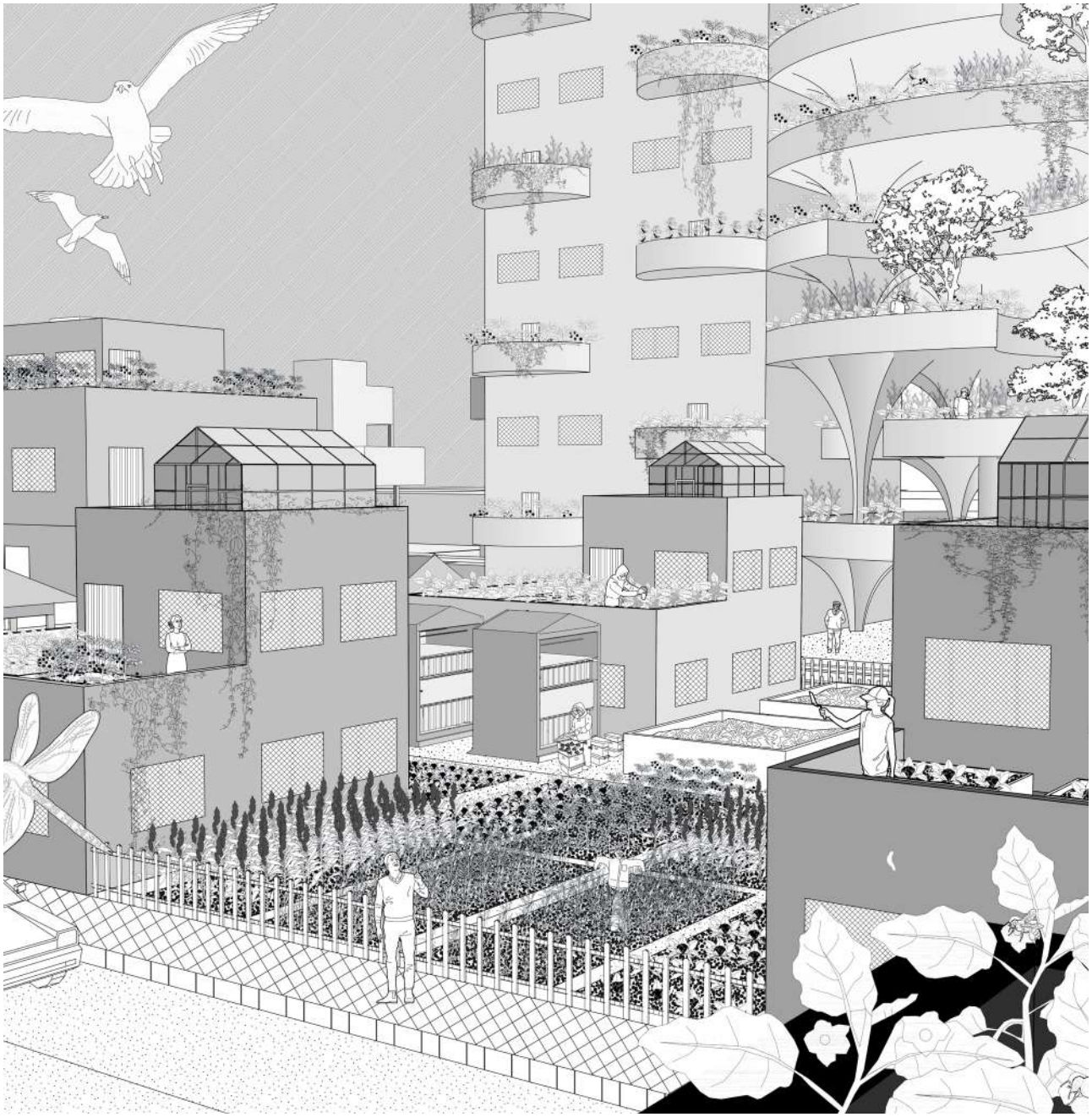


Figure 4: Visualisation of the SVA Model

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CONCLUSION

BUILDs developed a pioneering educational experience across disciplines, sectors, and countries by engaging business students, teachers, researchers and business professionals with biotech and architecture to boost innovation, entrepreneurship and subsequent market uptake of intelligent living, biotech and biomimicry solutions to help green cities.

This multidisciplinary partnership has allowed us to jointly develop an innovative educational model targeted at teaching students to work in a transdisciplinary environment towards the development of marketable products that integrate living systems in the urban environment through the creation of groundbreaking start-ups. Each discipline brought its own expertise for fruitful results: scientific questions and biotechnological solutions from the biology UL students, design and implementation solutions from the architecture IAAC students and identification of business opportunities as well as development of start-ups from the business WE students. Business partners brought their experience and expertise in the green economic sector.

From a trainer's perspective, BUILDs has offered an outstanding opportunity for academics and researchers to go beyond their University silo structures, bureaucracies, and research trajectories in the search of new platforms of concepts, methods, and knowledge exchange. They have familiarised themselves with content from other disciplines and, more importantly, with other learning methodologies. Business partners have gained a broader perspective on the market potential of nature-based solutions and have benefited from networking opportunities, allowing for new partnerships with various organisations. From the students' perspective, BUILDs allowed them to experience a transformative learning process that has enabled them to venture out of the traditional parameters of their disciplines and adapt their knowledge, becoming entrepreneurial agents of sustainable change, capable of collaborating between different disciplines and sectors.

The experimental and hands-on environment created through BUILD's methodology, proved to be effective, surprisingly students demonstrated

a high level of ownership and dedication in the implementation of their startups. This experience provided students with the tools and skillset to build a powerful holistic system by first finding the most sustainable and resilient living design solution, then creating transdisciplinary startup teams equipped to implement these solutions, and lastly, in the true sense of sustainability, ensuring the continuation of the startups after the BUILD´s project ends.

Working with living systems pushed students to embrace a holistic perspective, welcoming diverse disciplinary knowledge, skills and viewpoints and analysis of the full complexity surrounding real-urban challenges. It has also facilitated the understanding that the integration of living systems in a design project not only requires a transdisciplinary approach, but also permanent monitoring in conjunction with continuous care to adjust the initial design, considered barely as a framework.

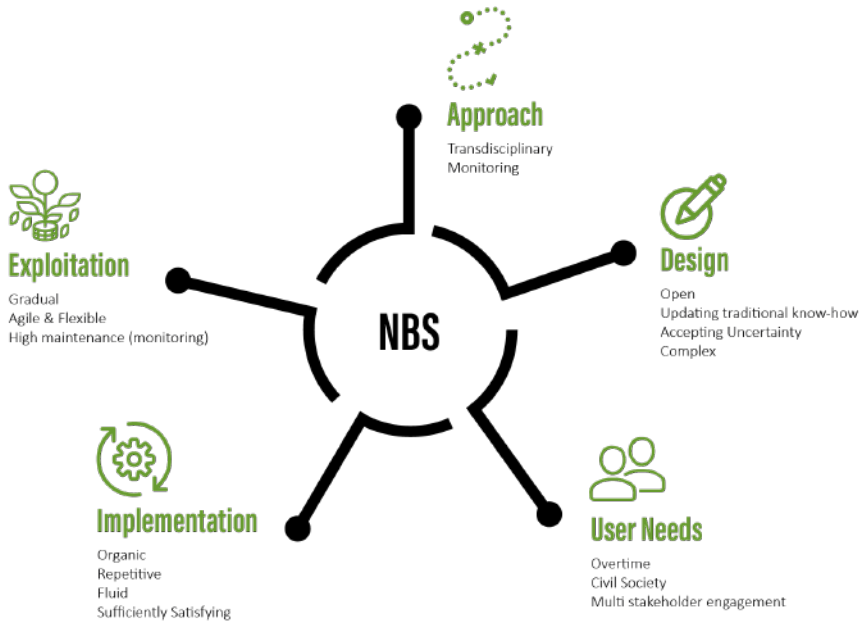

Figure 1: Learning from Nature based solutions

In this sense, BUILD startups ideas were conceived as part of an open and iterative process involving a wide range of stakeholders, potential users and investors. The lean startup methodology used in BUILD enabled students to develop products and business models that addressed real-urban environmental problems by learning from failures early on and changing direction when necessary, while simultaneously wasting the least amount of resources.

Feedback at the early stages of the startup concept was incentivised throughout the programme. Connecting the innovative research to the market structure helped to ensure that the best ideas didn´t remain in the laboratories but rather were tested in real life in hopes of making a difference. With the application of an agile and flexible management business, students developed and updated the projects and startup business plans according to the marketability of the product and it´s prototype development.

BUILD Solutions educational programme has facilitated a transformative learning experience by bringing new perspectives and fostering new start-up initiatives to address sustainability challenges in our cities more broadly.
The programme has proven to be very successful in driving innovation, entrepreneurship and the consequent market uptake of nature-based solutions to help green cities. Proof of this is that four out of the five startups have presented their pioneering ideas for living solutions at international events, competitions and trade shows, all with great success.
Hopefully this innovative transdisciplinary experience can serve as inspiration to other HEIs and business partners, encouraging them to work collaboratively for the benefit of urban sustainability.

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APPENDIX
COMMON VOCABULARY

Agromining: Agromining involves cultivation of selected hyperaccumulator plant species ('metal crops') on low-grade ore bodies or mineralized (ultramafic) soils, or anthropogenic metal-rich materials (e.g. contaminated soils, mine spoils, industrial sludge), prior to harvesting and incineration of the biomass to recover target metals or salts.

Biodiversity: Biodiversity (ies) is the variability among living organisms from all sources at different scales: genes, cells, species, populations, communities, in all managed and unmanaged ecosystems (terrestrial, aquatic). This includes a high quantity of organisms (visible and invisible) in interaction with one another with different needs, different functions, and a high range of tolerance and adaptation abilities in relation to human disturbances, especially in cities. Biodiversity is still moving through space and time. Finally, biodiversity is functional and can provide benefits to humans (ecosystem services).

Biology Project: From the biology perspective, a project is the organization in terms of: i) definition of milestones; ii) scheduling; iii) division of work that aims at answering a request/question.

Biomimicry: Biomimicry is the copy of the models, living systems, and elements of nature for the purpose of solving complex design problems. We used Biomimicry in BUILDs with the aim of taking inspiration from nature and translating the natural selection solutions found in nature into the process of design and manufacturing of the start-up products. By mimicking nature and its biological systems in the design process, we end up having products that are more efficient, resilient and sustainable

Business Angel: Investor angels, or business angels, are people who invest their money in the initial phase of startups, in exchange for a participation in capital. They also usually carry out the role of a mentor and offer their consent and experience to entrepreneurs.

Business Model Canvas: The Business Model Canvas is a very popular tool for

a startup to create a new business model. While filling out it gives the startup a valuable insight about the customer and the value proposition of their product or service. The Business Model Canvas consists of 9 building blocks: Key Partners, Key Activities, Key Resources, Value Proposition, Customer Relationship, Channels, Customer Section, Cost Structure and Revenue streams. It was a strategic management tool that the BUILD students used. Usually you start with filling in the sections with post-its, especially in the brainstorming phase, in order to be able to shift and change content easily. Alex Osterwalder created the Business Model Canvas. The Business Model Canvas can be downloaded from Strategyzer, an online platform also offering explanation videos and further valuable materials.

Business Sustainability 3.0: The "Business Sustainability Typology" was developed by Dyllick and Muff. They cluster sustainable business performance in four stages, enabling a practical distinction between early, intermediate and advanced stages of business sustainability in practice. They herein determine three different shifts away from 'business as usual' towards Business Sustainability 1.0, 2.0 and 3.0.4 Business sustainability 0.0 - business as usual, based on purely economic interest. Business sustainability 1.0 - mostly CSR activities, where businesses recognize and embrace challenges and opportunities that occur from societal and environmental concerns and incorporate them into given practices and processes "without changing the basic business premise and outlook" (Dyllick/Muff 2016:392).5 In this stage, creating economic value remains the main target while addressing sustainability issues results in benefits for the business itself. Business sustainability 2.0 - following the triple bottom line approach, hence balancing the social, environmental and economic impact of the business activities. In practice, this means to broaden the value of shareholder value by the addition of social and environmental values and by implementing particular programmes and actions to reach intendedly set-up sustainability goals. Business sustainability 3.0 - considered as truly sustainable business performance. Characterized by its outside-in perspective, where businesses start by looking at the external world and related challenges first, before developing the actual business idea. Emphasis is not on minimizing or

outbalancing negative business performance but rather on creating positive impact for the greater good.

Challenge Based Learning: BUILDs aimed to boost innovation, entrepreneurship and subsequent market uptake of intelligent living, biotech and biomimicry solutions to help greening cities. In this regard, a CBL approach provides an efficient and effective framework for learning while solving real-world challenges. A CBL experience is defined as "a learning experience where the learning takes place through the identification, analysis and design of a solution to a sociotechnical problem. It is typically multidisciplinary, takes place in an international context and aims to find a solution, which is environmentally, socially and economically sustainable" (Malmqvist et al., 2015).

Computational Design: Computational design is the application of computational strategies to the design process. Computational design aims to enhance design strategies using a computer language. The goal is not to document the final result necessarily, but rather the process required to create a new approach of designing. We used computational design methods to facilitate the development and fabrication of several start-up product designs.

Crowdfunding: Crowdfunding explains the method of raising money from a large number of people (crowd) giving smaller amounts of financial contributions than a larger investor would and often combined with an online campaign to raise this money to a desired goal. Within BUILDs, some startups were interested in crowdfunding and an Austrian platform that was suggested was green rocket.at, having a strong focus on sustainability.

Digitally Fabricated Prototype: A prototype is the simplest form of a designed product that can be digitally manufactured and used for testing, instead of putting a lot of resources into a fully designed and manufactured product. At BUILDs we built several prototypes for the start-ups and continuously improved them through many iterations. Therefore, experimentation and

testing of the product, as well as speed, are the essence for a project's success.

Discounted Cash Flow (DCF) Forecasting Methodology: DCF usually involves estimating the value of an investment today based on the predictions of how much cash the investment will generate in the future and discounting for risk and opportunity cost (what could your money have earned in a risk-free investment).

Ecological Resilience: Ecological resilience is the ability of an ecosystem to maintain its normal patterns of nutrient cycling and biomass production after being subjected to damage caused by an ecological disturbance. The resilience concept was interesting for the sustainability of BUILD solutions.
Ecosystem Services: "Ecosystem services are the ecological characteristics, functions, or processes that directly or indirectly contribute to human wellbeing: that is, the benefits that people derive from functioning ecosystems". Ecosystem services were expected to face the major environmental issues in urban areas; ecosystem services are provided by living systems in BUILDs.

Entrepreneurship Ecosystem: Support systems are crucial in the development of a startup, starting from the early stage onwards. The concept of 6 domains in an entrepreneurship ecosystem derives from Isenberg (2010) and are: Finance, Capital, Policy, Markets, Supports, Human Capital. According to Mason and Brown (2014), "The Entrepreneurial Ecosystem is a set of different individuals who can be potential or existing Entrepreneurs, organizations that support Entrepreneurship that can be businesses, venture capitalist, business angels, and banks, as well as institutions like universities, public sector agencies, and the entrepreneurial processes that occur inside the ecosystem such as the business birth rate, the number of high potential growth firms, the serial entrepreneurs and their Entrepreneurial ambition." The BUILD startups were encouraged to insert themselves in the entrepreneurship ecosystem, using already existing support structures to their advantage and getting to know other startups outside of the BUILDs network.

Five Whys: Five Whys , which has its origins in the Toyota Production System,

and posits that behind every supposedly technical problem is actually a human problem. Applied to a start-up, here is how it works:
1. A new release broke a key feature for customers. Why? Because a particular server failed.
2. Why did the server fail? Because an obscure subsystem was used in the wrong way.
3. Why was it used in the wrong way? The engineer who used it didn't know how to use it properly.
4. Why didn't he know? Because he was never trained.
5. Why wasn't he trained? Because his manager doesn't believe in training new engineers, because they are "too busy."

Green Infrastructure: Green infrastructure is defined as engineered environmental design features built in interconnected natural and urban spaces to provide multiple ecological functions. The innovations developed in the BUILDs program are intended to be inserted in the urban green infrastructure.

Hyperaccumulator Plants: Hyperaccumulator plants have the ability to grow on metalliferous soils and to accumulate extraordinarily high amounts of heavy metal in the aerial organs (leaves, stems, flowers). They are used by Econick (partner of the BUILDs project) to develop agromining.

Interdisciplinary: An approach to curriculum integration that generates an understanding of themes and ideas that cut across disciplines and of the connections between different disciplines and their relationship to the real world. It normally emphasizes process and meaning rather than product and content by combining contents, theories, methodologies and perspectives from two or more disciplines (UNESCO). In BUILDs we also used Jo Bailey's analogy and visualisation of interdisciplinary as a stew. "In a stew, ingredients mix/much into each other and are only partially distinguishable. In interdisciplinary collaboration integration of disciplinary contributions is required".

Lean Startup Methodology: Developed and popularized by Eric Ries in his blog and book "The Lean Startup" (2011), the lean startup method has brought many startups to success. It is based on ideas and principles that are not entirely new and resonate with some of the principles of Lean Manufacturing, which derives from the Toyota manufacturing revolution (McFarlane, 2020). The Lean Startup provides a scientific approach for any "human institution designed to create a new product or service under conditions of extreme uncertainty" to navigate the many challenges of new product development and real value creation while accelerating growth to a maximum and reducing resource waste to a minimum (Ries, n.d.). The lean startup method enabled BUILDs students to develop a product and business model that solve real problems and match real needs by quickly learning from failures while producing the fewest waste of resources in the process. The methodology was applied to the second semester part of the one-year programme, when business students developed and constantly updated the project and startup business plan according to the marketable product and its prototype development.

Learning by Doing: Learning-by-doing is the pedagogy firstly articulated by the educator John Dewey (1916) based on the general idea that hands-on experiences leave deeper marks towards the development of the creative individual than those induced by uniform second-hand knowledge. Today "Dewey's legacy and learning by doing is at the core of a widely practiced model of design education with the design studio at its centre. A design studio is ideally an atelier, open 24 hours, inhabited and kept by the students. It is an environment where students test out theories, ideas, materials, constructions, and similar productions as part of their design processes. Because it is a shared space, students are able to work together, and follow each other's processes" (Özkar, 2007). Thanks to recent developments in digital fabrication, architecture schools are now equipped with fast prototyping tools, such as, for example, 3D printers, laser cutters, CNC machines and robotic arms. These artefacts enable students to develop working prototypes, through which it is possible to test project performances. A Learning-by-doing approach was included in BUILDs methodology in order to engage learners in more

hands-on, creative modes of learning and to develop functioning prototypes, testing the performances of their marketable project throughout the second semester of the One-year Programme.

Living Design: Living design is defined as “the use of forces and possibilities given by natural living organisms to help and build low-cost and sustainable construction. Achieving real living design requires not only using nature as it is but also shaping it to the required form” (Vallas & Courard, 2017). Living design, through Nature Based Solutions (NBS), can provide sustainable, cost-effective, multi-purpose and flexible alternatives to today’s global urban challenges. In BUILDs, we used living design in the process of using and shaping nature in the design and manufacturing of the start-up products.

Modular Design: Modular design is a design approach that creates things out of independent parts with standard interfaces. This allows designs that can be aggregated in different shapes, forms, and orientations. A very well-known example of modular design is LEGO plastic construction toys.

Multidisciplinary: As defined by UNESCO is an approach to curriculum integration which focuses primarily on the different disciplines and the diverse perspectives they bring to illustrate a topic, theme or issue. A multidisciplinary curriculum is one in which the same topic is studied from the viewpoint of more than one discipline. In BUILD Solutions, we found very useful Jo Bailey’s analogy and visualisation of multidisciplinary as a salad. “As in a salad, bowl ingredients remain intact and distinguishable”. In a multidisciplinary collaboration, several different disciplines provide different perspectives, approaches, tools and methods.

Nature-based Solutions: Solutions that are inspired and supported by nature, which are cost-effective, simultaneously providing environmental, social and economic benefits and helping to build resilience. Such solutions bring more, and more diverse nature, natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. (EC)

Pitch: A pitch is a presentation of a business idea to potential investors. People pitch a business idea because they need resources. If the goal is to raise startup cash, the target of the pitch is an investor. Other businesses pitch to potential customers to sell their product. Finally, some organizations pitch because they need a partner or resource to help them accomplish their mission. Very popular is the term 'elevator pitch' depicting the imagery of only having a short elevator ride to convince someone of the idea and having to present all the important facts in a concise and convincing manner.

Phytoextraction: Phytoextraction is one of the methods of phytoremediation that uses plants that absorb and concentrate in their aerial parts the pollutants contained in the soil. It is the main mechanism responsible for agromining, the process developed by Econick, partner of the BUILDs project.

Pretotyping: The basic idea is simple: sell it before you build it. Furthermore, as you build and design your solution, constant market feedback ensures market uptake once the solution is complete. By using pretotyping as a design and development methodology companies, in this case the student startups, potentially save years and years (and bucket loads of money) on research and development since the risk of designing and developing a solution for which there is no market is drastically reduced (Savoia, n.d.). In practice, pretotyping aims at finding out whether people are interested in a product, whether they use it as expected and whether they will continue to use it as opposed to prototyping which aims at answering the question if something can be build, for what price and at what speed and if it will work as expected. To summarize, pretotyping looks at the appeal of a project whereas prototyping looks at the feasibility of a product.

Shareholders' Agreement: A shareholders' agreement is a private contract between all shareholders of a company with the aim of regulating their relationships, rights, and obligations, as well as the daily operations of the company.

Socio Ecosystem: From the biology perspective, the socio ecosystem is defined as all the stakeholders that need to be taken into account in the development and implementation of a project.

Spin-off: A spin-off is the creation of an independent company through the sale or distribution of new shares of an existing business or division of a parent company.

Start-up: "A startup is a company working to solve a problem where the solution is not obvious and success is not guaranteed". A start-up counts as a startup if it is younger than 5 years (definitions vary from 3-7 years) and differentiates itself from a small enterprise by starting up a new business idea, driven by force of innovation and scalability. As a startup does not have to be a legal entity yet, it does not necessarily mean profit is being made (yet). Generally speaking, 7 out of 10 startups fail to establish themselves properly and long-term on the market. Compared to conventional startups, sustainable startups may face more obstacles, as the supporting ecosystem is not as established yet.

Start-up Accelerator: Start-up accelerators support early-stage, growth-driven companies through education, mentorship, and financing. Start-ups enter accelerators for a fixed-period of time, and as part of a cohort of companies. The accelerator experience is a process of intense, rapid, and immersive education aimed at accelerating the life cycle of young innovative companies, compressing years' worth of learning-by-doing into just a few months.

Sustainable Business Model Canvas: The Sustainable Business Model Canvas is a version of the Business Model Canvas. It adds two categories that especially focus on the sustainability of a business: eco-social costs and eco-social benefits. Adding these two categories to the financial section in a business model is beneficial to define and elicit the advantages and disadvantages the startup has on society and the environment.

Sustainable Cities: Building sustainable cities requires investment in (a) renewable energy sources, (b) efficiency in the use of water and electricity, (c) design and implementation of compact cities, (d) retrofitting of buildings and increase of green areas, (e) fast, reliable and affordable public transportation and (f) improved waste and recycling systems. Cities in poor countries need resources to support green technology transfer, and capacity development, and to improve access to soundly constructed housing, water and sanitation, electricity, health and education.

Sustainability Driven Entrepreneurship: Sustainability driven entrepreneurs act as agents of sustainable change. They counter current sustainability problems with entrepreneurial answers. At the core of their business models is their objective of making a positive social or/and ecological impact.

Transdisciplinary: BUILD Solutions aimed to experiment with a transdisciplinary approach. According to Formas (2006), the definition of transdisciplinary "is not a process that follows automatically from the bringing together of people from different disciplines or professions, but requires an ingredient that some have called 'transcendence', principle that implies the giving up of sovereignty over knowledge, the generation of new insight and knowledge by collaboration, and the capacity to consider the know-how of professionals and lay-people on equal terms" (cited in Dunin-Woyseth, 2010). In BUILDs, we used Jo Bailey's analogy and visualisation of transdisciplinary collaboration and design production as a cake, "where the ingredients are no longer distinguishable and the final product is a different kind". In BUILD Solutions, students work in a transdisciplinary manner crossing over the disciplinary boundaries when pretotyping their start-ups. By working each startup towards the same goal, the team diversity brought consciousness about the different lenses and perspectives of a same challenge and therefore the sensitivity to address it holistically.

Transformational Learning: The process of transformative learning is characterized by a quality shift in perception and meaning making, which brings the learner to the crucial point of questioning and reframing his/her

world views, assumptions, and habits (Mezirow, 2000). In line with this process, BUILDs sought to provide a programme where students could venture out of the traditional parameters of their disciplines and adapt their knowledge becoming entrepreneurial agents of sustainable change, able to collaborate across different disciplines and sectors. An increasing body of literature already exists that highlights the efficacy and benefits of transformative learning and the abilities it imbues into its students. Abilities such as participating in interdisciplinary teams, cooperative and creative problem solving, bridging theories with practice or actively dealing with conflicting values, knowledge domains and legitimated interests are recommended to be enhanced during the learning process (Thomas, 2009; Taylor and Cranton, 2012). In BUILD the arrangement of the learning setting was of particular importance as it addressed the substantive challenges of the students, such as collaboration in interdisciplinary teams and the translation of theoretical approaches, into the dynamic and applied environment of the marketplace.

Urban Agriculture: Urban and peri-urban agriculture occurs within and surrounding the boundaries of cities. It includes products from crop and livestock agriculture, fisheries and forestry. It also includes the provision of multiple ecosystem services that are beneficial to urban areas. Some BUILD Solutions could be integrated in urban agriculture.

Urban Ecosystem: "Any ecological system located within a city or other densely settled area or, in a broader sense, the greater ecological system that makes up an entire metropolitan area. Urban ecosystems are composed of biological and physical components that interact with one another within a specified area. The biological complex includes human populations. The physical complex includes buildings, transportation networks, modified surfaces, and the environmental alterations resulting from human decision-making. The physical components of urban ecosystems also include energy use and the import, transformation, and export of materials". The complexity of urban ecosystems were taken into account to create sustainable NBS in BUILDs.

Urban Heat Island Effect: Urban Heat Island (UHI) is an urban area or metropolitan area significantly warmer than its surrounding rural areas due to human activities. It is caused by anthropic production of energy, lower albedo of urban building materials, urban morphology, air pollution and lack of vegetation and permeable soils. There are multiple consequences of UHI such as health issues, consumption of energy for air-cooling, degradation of urban water quality. Green infrastructures implemented in BUILD, such as green walls and green roofs, are expected solutions to mitigate UHI.

Urban Ecology: Ecology is the science that is studying interactions between organisms (biodiversity) and between organisms and their environment at all spatial and temporal scales. In this way, urban ecology is an adaptation of ecology to urban areas. Increasing our knowledge in this science might help in designing sustainable projects in BUILDs.

Urban Soil: All soils under human influence that can be found not only in urban areas, but also in a wider range of locations. NBS that are developed during the BUILDs program partly or totally rely on urban soils, which are the central compartment of the urban ecosystem.

Value Proposition: A value proposition refers to the value a company promises to deliver to customers and why they should choose to buy their product. Hence, it is crucial for a startup to be very clear about what their value proposition is and to be able to communicate it to the customers. It clearly identifies what the customer gets for the product or service they pay. For a startup, this usually is a process and not instantaneously clear. However, it is very important as it identifies the advantage and what differs you from the competition. To understand your customers better, BUILDs students worked with the Value Proposition Canvas and focused on their customers' needs, pains and gains. The Value Proposition Canvas can be downloaded from Strategyzer: https://www.strategyzer.com/canvas/valueproposition-canvas.

https://www.build-solutions.org/

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