GREEN SKILLS 4 CITIES

Training for Trainers : Design Dimension

Institute for Advanced Architecture of Catalonia
April 2022

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Iaac

TABLE OF CONTENTS

SECTION 1

DESIGN WITH/FOR NATURE, BASIC CONCEPTS

Integrating nature in cities
Technologies supporting the integration of nature in cities

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SECTION 1A

INTEGRATING NATURE IN CITIES THROUGH DESIGN

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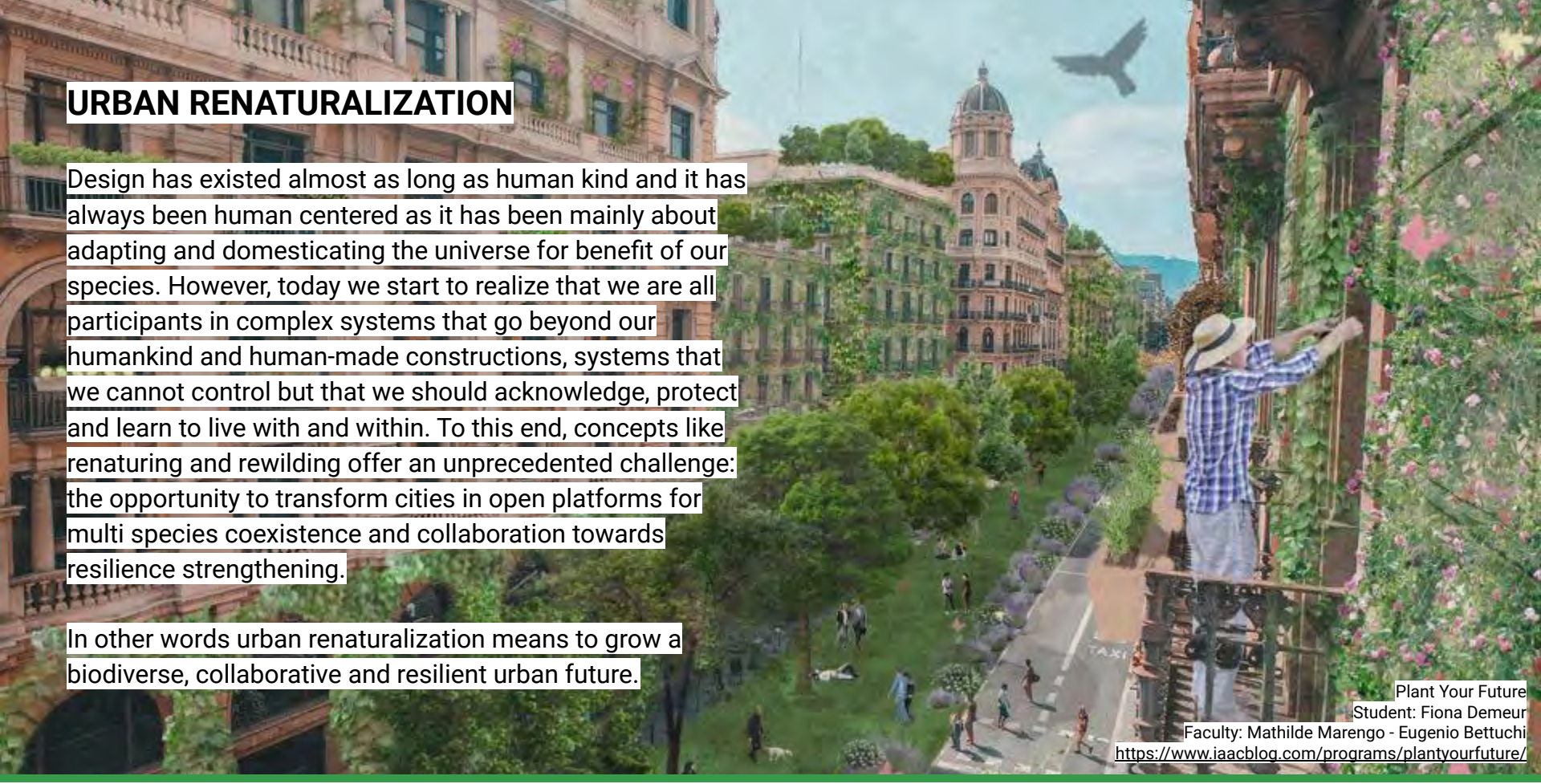
Even though the example of natural ecological systems reveals that **mutualistic attitudes can help to shape the ecosystems**, ultimately making them stronger, longer-lived and more resilient, up to now multi species co-existence and collaboration has not really been planned or embedded in the development of our cities.

What if we start to design spaces not centered only on humans, but on the future of the whole biosphere? What if we embed humans-flora-fauna and bacteria collaborations in the morphology and materials of our cities fostering collaborations towards resilience strengthening?

URBAN RENATURALIZATION

Design has existed almost as long as human kind and it has always been human centered as it has been mainly about adapting and domesticating the universe for benefit of our species. However, today we start to realize that we are all participants in complex systems that go beyond our humankind and human-made constructions, systems that we cannot control but that we should acknowledge, protect and learn to live with and within. To this end, concepts like renaturing and rewilding offer an unprecedented challenge: the opportunity to transform cities in open platforms for multi species coexistence and collaboration towards resilience strengthening.

In other words urban renaturalization means to grow a biodiverse, collaborative and resilient urban future.



Plant Your Future
Student: Fiona Demeur
Faculty: Mathilde Marengo - Eugenio Bettuchi
https://www.iaacblog.com/programs/plantyourfuture/

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DESIGN WITH/FOR NATURE

The Urban Environment has been developed through centuries as a complex machine excluding factors disturbing anthropogenic activities. Part of this process consisted in excluding the so-called “nature” (except a few selected species) from cities.

The result is that today cities, due to phenomena as for example the heat island effect, are hostile environments for nature. Reintroducing nature means to create the conditions for nature to grow, designing urban morphologies and using materials that creates microclimates adapt to host life.

MYCOScape
Advanced Architecture Group

SECTION 1B

TECHNOLOGIES SUPPORTING THE INTEGRATION OF NATURE IN CITIES

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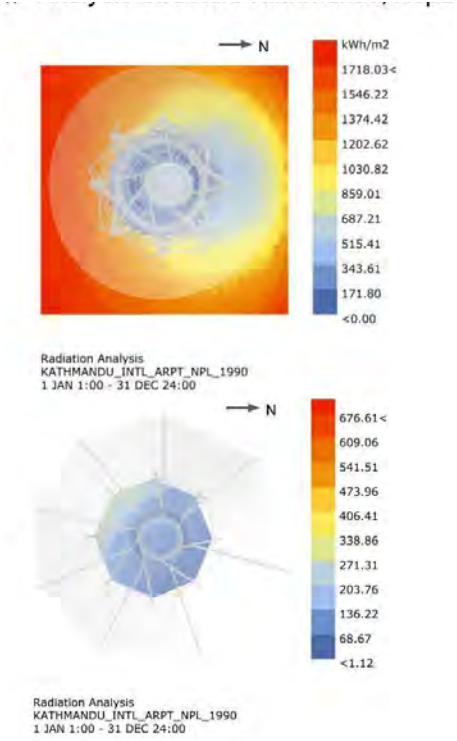
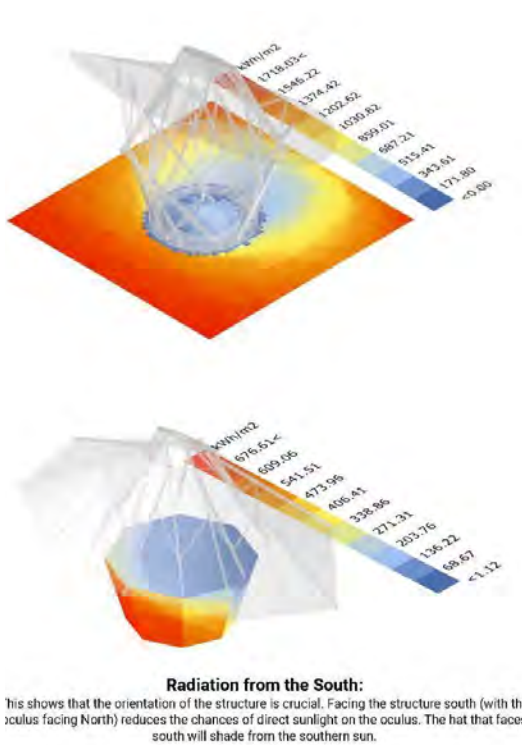
How can **digital technologies** support us to design cities where we **integrate living systems** making the urban environment more **resilient** and **ecosystems stronger**? The process of nature integration in the design of the city can be supported by several digital technologies as illustrated in the following slides

DATA DRIVEN DESIGN

Data driven design refers to using data as an input to define the final design or improve the design solution, better embedding the project/plan in its context. This information can include a wide range of inputs from solar, wind, shadows, rain, etc. inputs. The data-driven design in the framework of integrating nature in cities uses computational logics exploited in environmental studies to foresee ecological patterns and behaviours. It can be applied form the macro scale, as for example the simulation of the territorial dynamic of river flooding patterns, to the micro scale, as for example simulating animal and insect movements on a green facade.



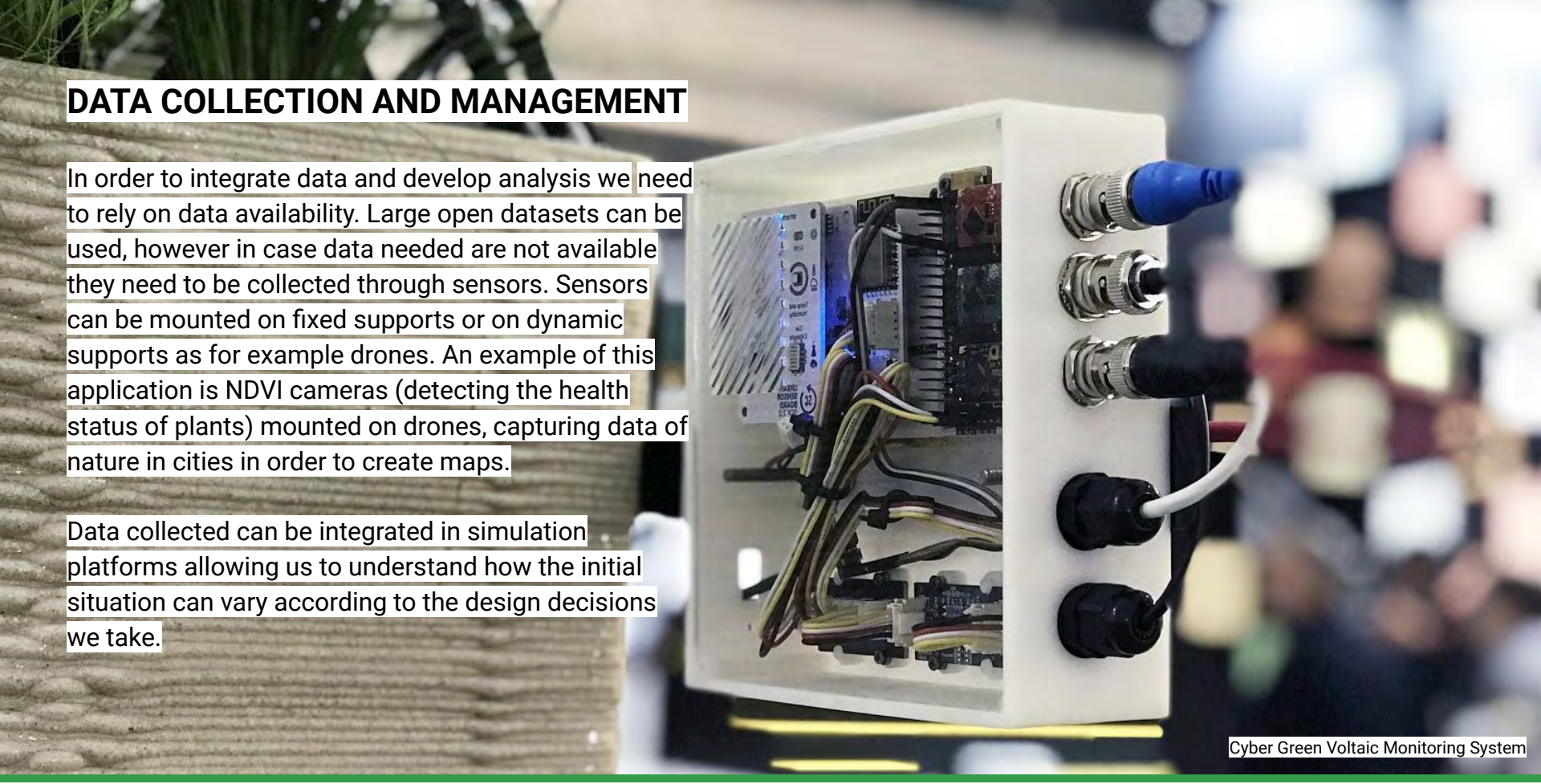


Nest 2.0 – Climate
Students: Brenda Freitas -Frank Shirying Feng - Hanna Lepperod - Ilaena Napier
Faculty: Manja van de Worp - Raimund Krenmueller
https://www.iaacblog.com/programs/data-informed-structures-nest-2-0-bamboo-shading-hat/

DATA COLLECTION AND MANAGEMENT

In order to integrate data and develop analysis we need to rely on data availability. Large open datasets can be used, however in case data needed are not available they need to be collected through sensors. Sensors can be mounted on fixed supports or on dynamic supports as for example drones. An example of this application is NDVI cameras (detecting the health status of plants) mounted on drones, capturing data of nature in cities in order to create maps.

Data collected can be integrated in simulation platforms allowing us to understand how the initial situation can vary according to the design decisions we take.

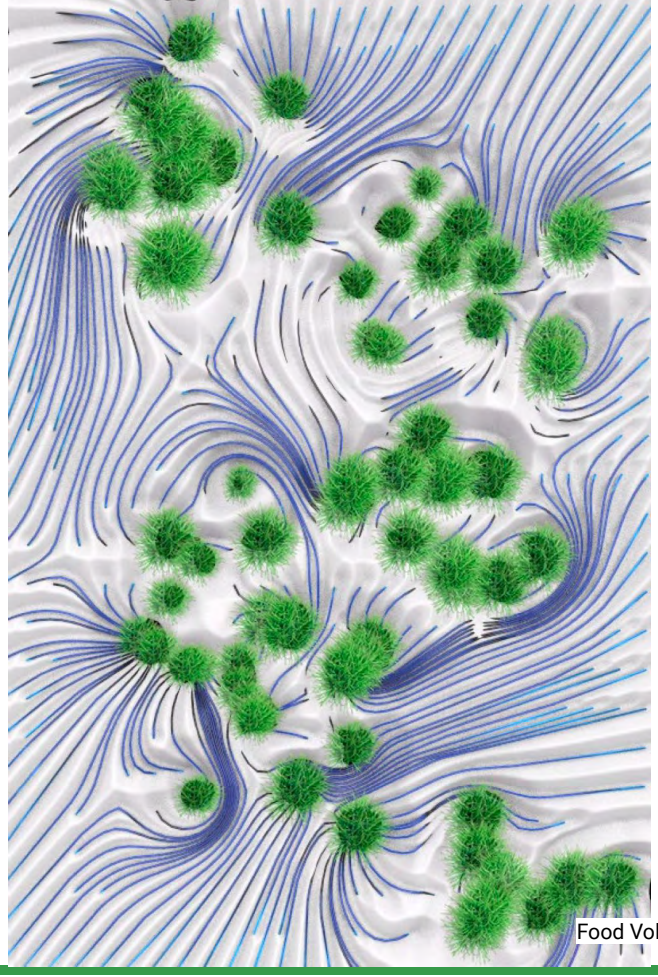


Cyber Green Voltaic Monitoring System

COMPUTATIONAL AND PARAMETRIC DESIGN

The use of computers using algorithms to develop shapes and morphologies is called computational design. Through computational design, we can create complex geometry using a mathematical approach and hence play with possibilities through parameters and constraints.

In the framework of integration of nature in cities, an example of the application of computational design is the development of a floor tile directing water towards holes containing plants. The floor morphology is developed based on the analysis of the data of precipitation patterns in a certain area and the parameters applied to the floor design optimise how to direct a certain amount of water towards the holes.



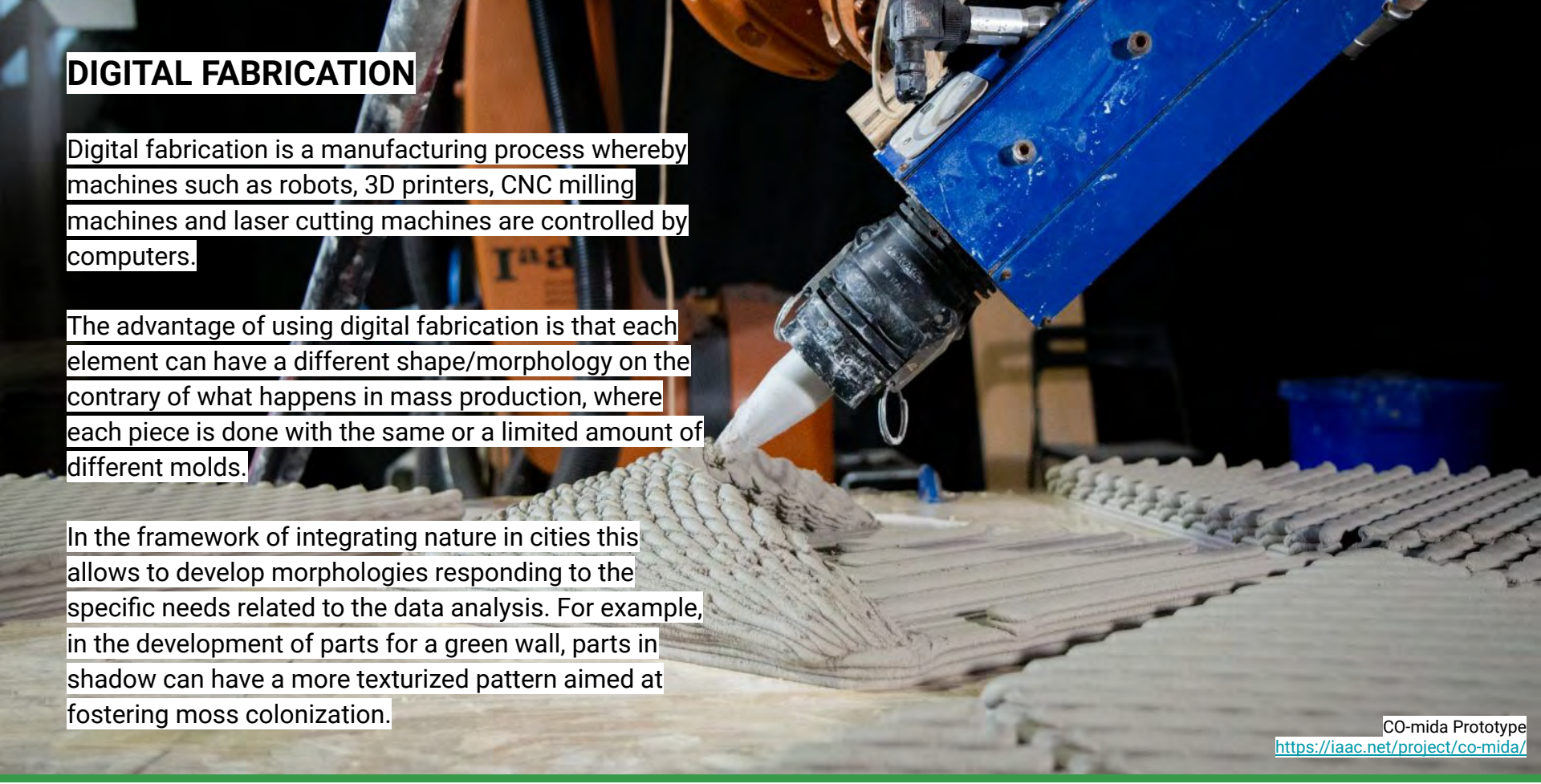
Food Voltaic Water Analysis

DIGITAL FABRICATION

Digital fabrication is a manufacturing process whereby machines such as robots, 3D printers, CNC milling machines and laser cutting machines are controlled by computers.

The advantage of using digital fabrication is that each element can have a different shape/morphology on the contrary of what happens in mass production, where each piece is done with the same or a limited amount of different molds.

In the framework of integrating nature in cities this allows to develop morphologies responding to the specific needs related to the data analysis. For example, in the development of parts for a green wall, parts in shadow can have a more texturized pattern aimed at fostering moss colonization.



CO-mida Prototype
https://iaac.net/project/co-mida/

PRETOTYPING

Pretotyping is a method to quickly test an idea or solution. This is usually done by building an extremely simple mockup or virtual model to test. It allows us to gather data and validate the idea before building the prototype.

PROTOTYPING

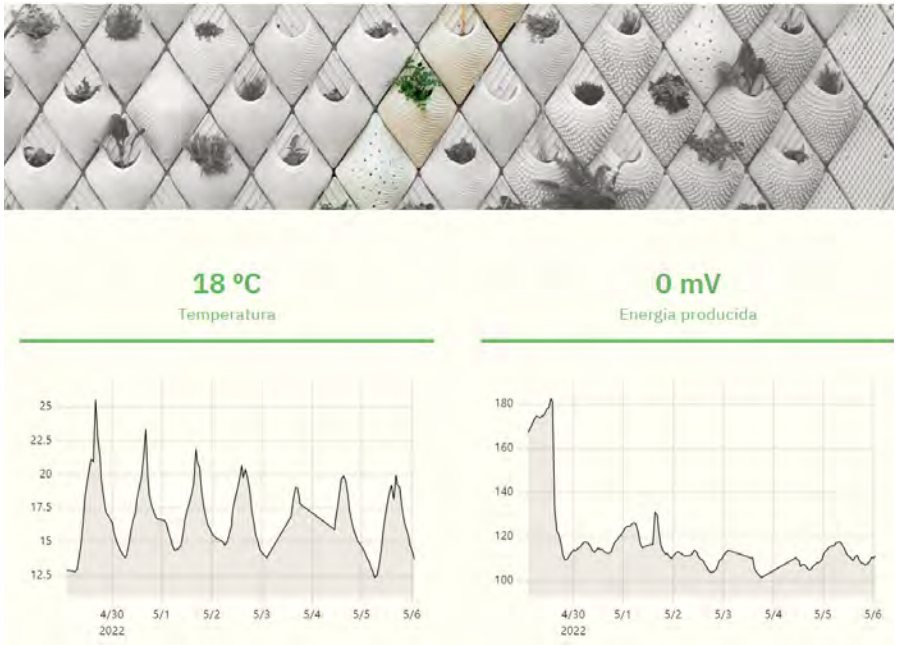
The preliminary version of a device. The prototype can help to evaluate different aspects, from the overall design to the structural design, to the device performances. It can be reworked until the optimal solution is found, satisfying all aspects. Prototypes can be made through digital fabrication methods, or by hand.

CGV Prototype
Finalised design and fabrication

MONITORING SYSTEMS

Monitoring systems allows us to monitor the performances of a project once implemented. It is normally constituted by a system of sensors, a platform collecting the data captured and a visualization system / visualization interface (as for example a web page or an app).

In the field of nature implementation in cities, for example, a system of sensors collecting soil moisture can be installed, data collected can be visualized on a platform and eventually a water irrigation system can be automatically activated each time the sensors detect a value of moisture under a certain value.



CO-mida Platform
https://iaac.net/project/co-mida/

SECTION 2

DESIGN WITH/FOR NATURE CASE STUDIES

Urban design with/for nature case studies
Building and public space design with/for nature case studies
Co-design with/for nature case studies

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SECTION 2A

URBAN DESIGN WITH/FOR NATURE CASE STUDIES

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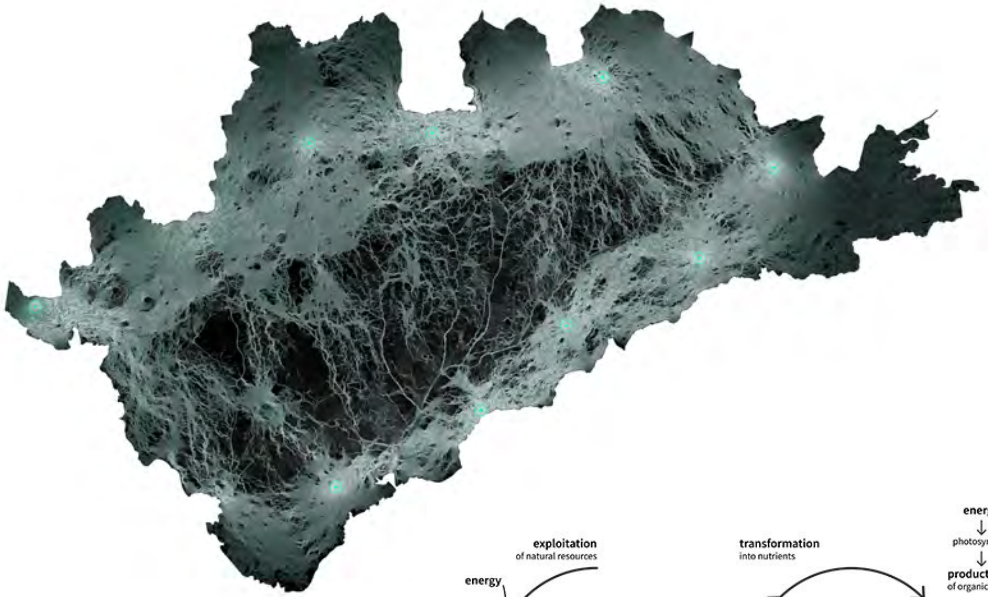
Flower Powder - Rewilding Barcelona

Flower Powder focuses on the **creation of green corridors** specifically for pollinators. The interventions are proposed for *El Vallès* plain, near Barcelona, using the **existing abandoned crops** as structural elements to improve the ecological connection between the North and the South of this region. The process starts from the **land use analysis**, it continues with the generation of a **connectivity map** and with the categorization of the abandoned crops and it concludes with the identification of the **ecological corridor**. A catalogue of interventions was created for different depending on the actions required.



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Students: **Adriana Aguirre Such, Simone Grasso, Matteo Murat, Riccardo Palazzolo Henkes**
https://www.iaacblog.com/programs/new-ecological-corridor-for-pollinators/

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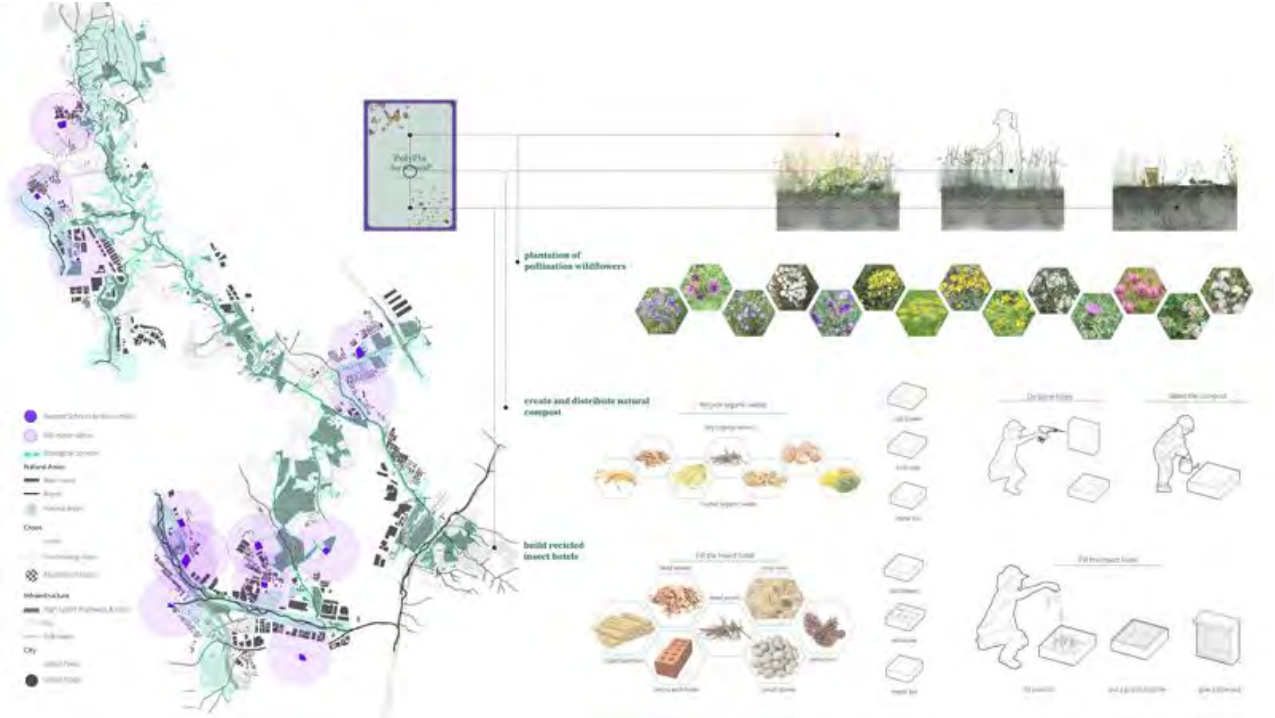
RELATION TO GLOSSARY TERMS:

Computational Design / Urban Renaturalization / Data Driven Design / Data Collection and Management / Design with/for Nature

ECOSYSTEM SERVICES:

Increased biodiversity (pollinators) / Creation of Green Corridors



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SECTION 2B

BUILDING AND PUBLIC SPACE DESIGN WITH/FOR NATURE CASE STUDIES

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Food Voltaic

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 external surface has been designed using **parametric programs** and can be adapted to the local conditions. 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.

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RELATION TO GLOSSARY TERMS:

Computational & Parametric Design / Data Informed Design / Urban Renaturalization / Digital Fabrication / Prototype

ECOSYSTEM SERVICES:

Food production / Biophotovoltaic energy production / Storm-water runoff collection

URBiNAT

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Cyber Green Voltaic

Cyber Green Voltaics is a wall composed of **3D printed ceramic pots** that host soil, plants and a **bio photovoltaic system**. This system harvests the energy produced by bacteria living near to the plants' roots. The system is equipped with **automatic irrigation** and includes sensors detecting the moisture in the soil, minimizing irrigation when not necessary.

This prototype was developed with a variety of herbs and plants used to attract butterflies.

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RELATION TO GLOSSARY TERMS:

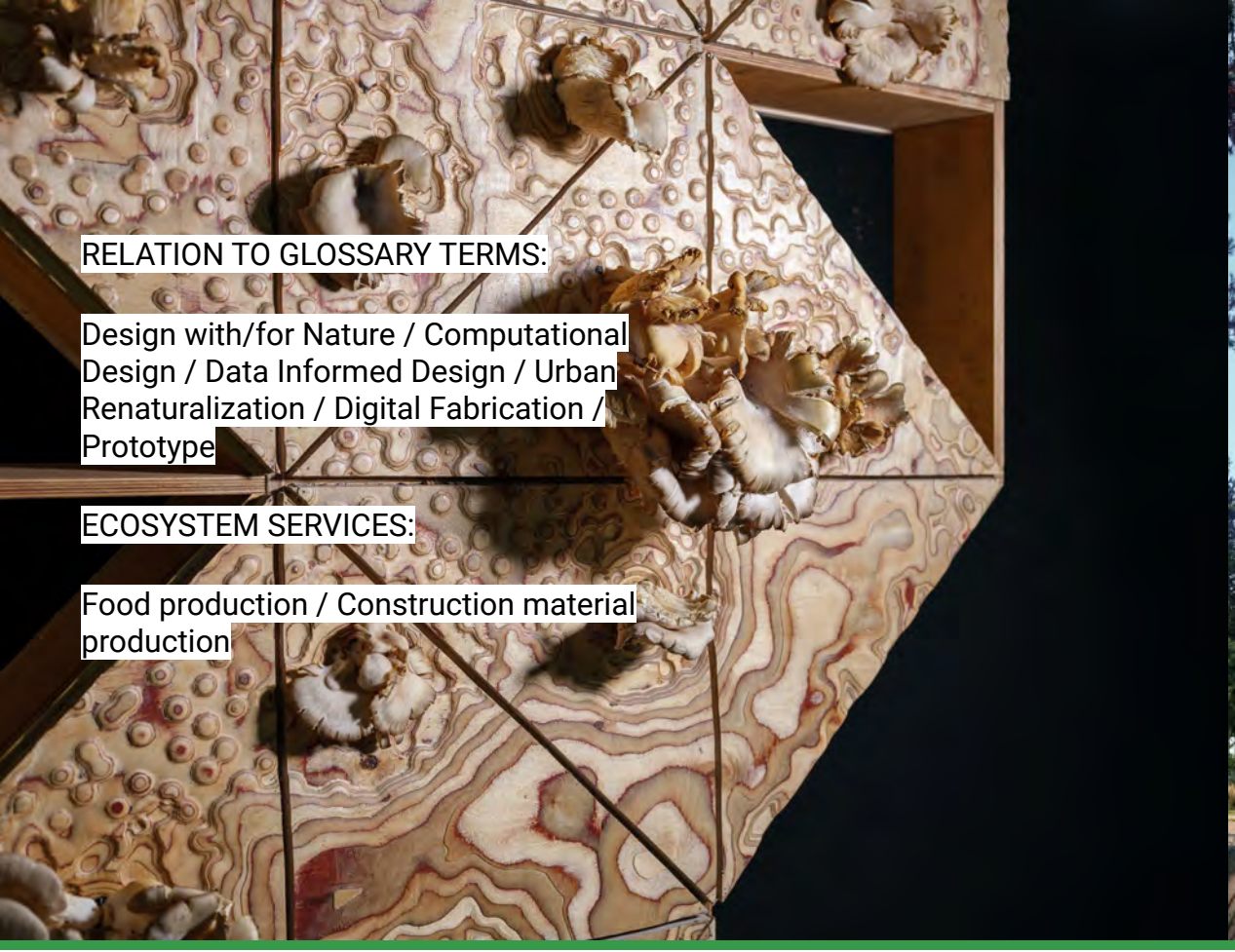
Design with/for Nature / Computational Design / Data Informed Design / Urban Renaturalization / Digital Fabrication / Prototype

ECOSYSTEM SERVICES:

Food and energy production, Flood mitigation, Oxygen production

MYCO-Scape

MYCO-Scape is a **modular system** which supports the growth of 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 mushrooms to grow, after this time it is possible to eat the mushroom flower and use the roots as insulation panel. 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**.



RELATION TO GLOSSARY TERMS:

Design with/for Nature / Computational Design / Data Informed Design / Urban Renaturalization / Digital Fabrication / Prototype

ECOSYSTEM SERVICES:

Food production / Construction material production

COmida

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 is **maintained by the community** with the aim of **growing food**, **providing homes** for birds, bats, and insects, and **generating electricity** through a bio photovoltaic system.

The tiles and pots were parametrically designed, with textures to encourage moss and microbial growth. They were **3D printed in ceramic** using a robotic arm before being fired. 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.

More info: iaac.net/project/co-mida/

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RELATION TO GLOSSARY TERMS:

Computational & Parametric Design / Data Informed Design / Digital Fabrication / Prototype

ECOSYSTEM SERVICES:

Food production / Increased Biodiversity / Energy Production / Education

More info: iaac.net/project/co-mida/

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SECTION 3

TEACHING DESIGN WITH/FOR NATURE

Urban design with/for nature case courses
Building and public space design with/for nature courses

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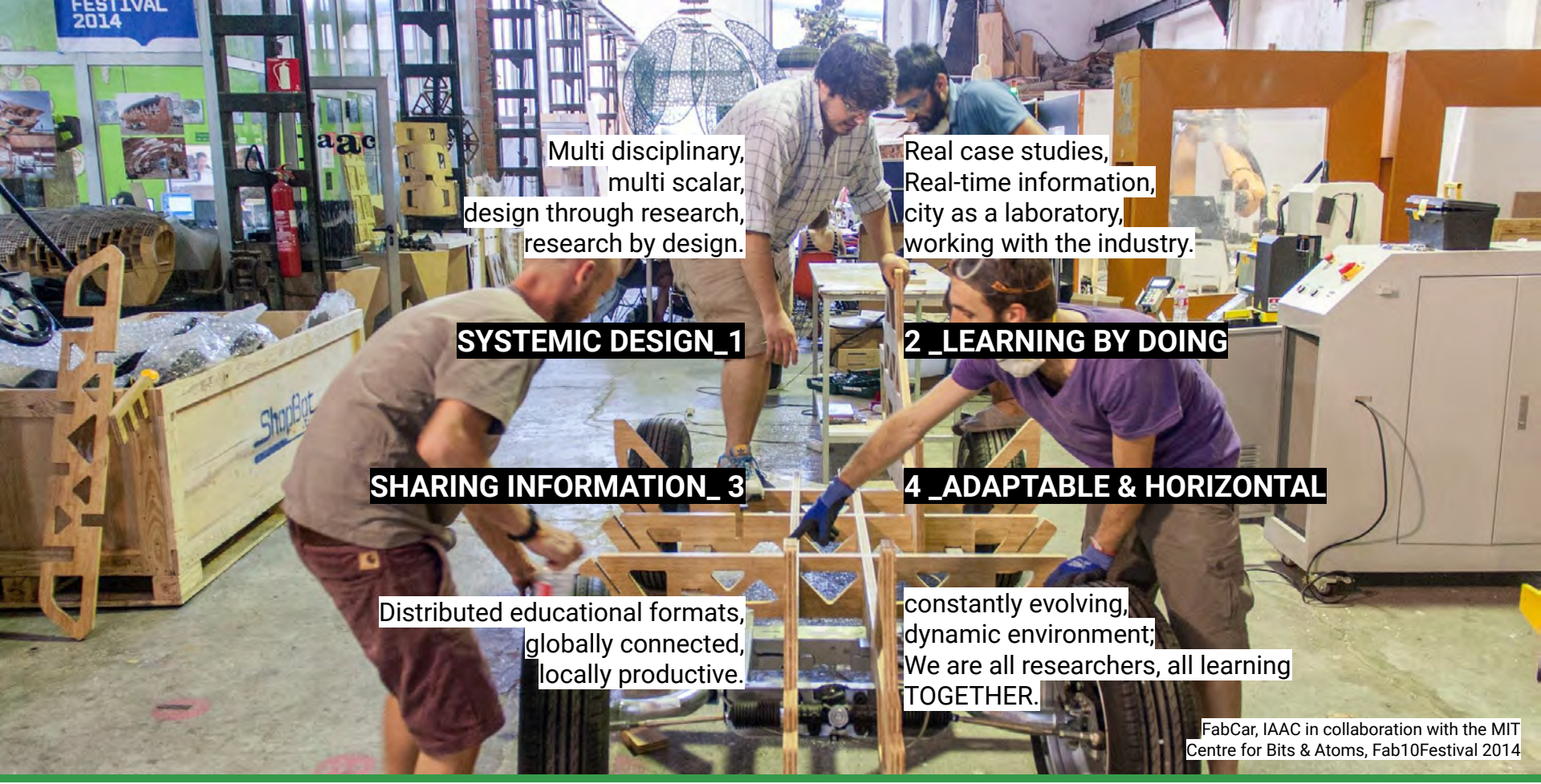

Multi disciplinary,
multi scalar,
design through research,
research by design.

Real case studies,
Real-time information,
city as a laboratory,
working with the industry.

SYSTEMIC DESIGN_1

2 _LEARNING BY DOING

SHARING INFORMATION_ 3

4 _ADAPTABLE & HORIZONTAL

Distributed educational formats,
globally connected,
locally productive.

constantly evolving,
dynamic environment;
We are all researchers, all learning
TOGETHER.

FabCar, IAAC in collaboration with the MIT Centre for Bits & Atoms, Fab10Festival 2014

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SECTION 3A

URBAN DESIGN WITH/FOR NATURE COURSES

Methodology
Course structure
Example of a student project

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COURSE STRUCTURE EXAMPLE: MaCT Studio

Clear Brief

1.

Analysis & Research

- Land-use analysis
- Connectivity between areas
- Simulations

2.

The Proposal

- Catalogue of interventions
- Proposed Interventions

3.

Impact Analysis

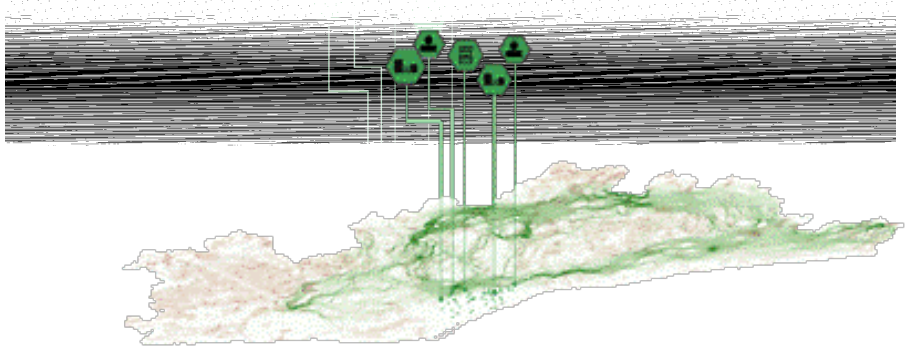
- How can the system be monitored
- Simulations

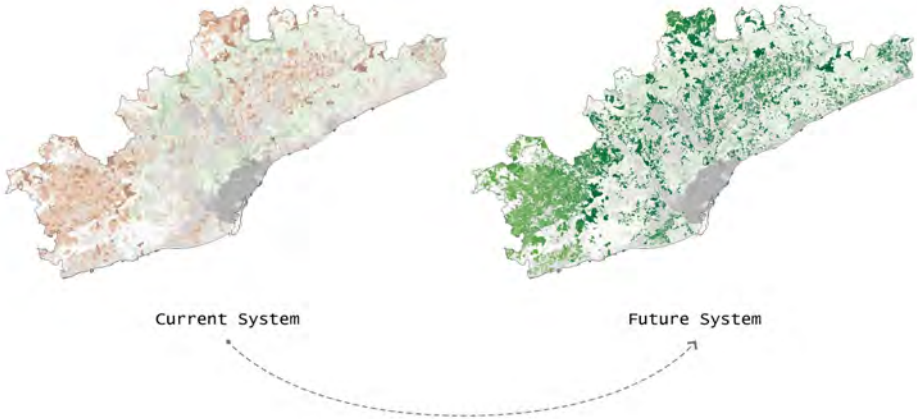
Barcelona Breath

Carbon Capture for Breathing

Barcelona Breath is a project where the soils are utilised as a means to increase the **carbon capture** in the area of Barcelona. The proposal considers **converting conventional farming to regenerative agricultural lands** through a network of U-Pick farms. Additional benefits include organic food production as well as general health and social benefits.

The transformation of the territory is based on the natural behaviors of the system. Thus, the natural connections were analysed and the circuitscape software was used to simulate the animal paths.





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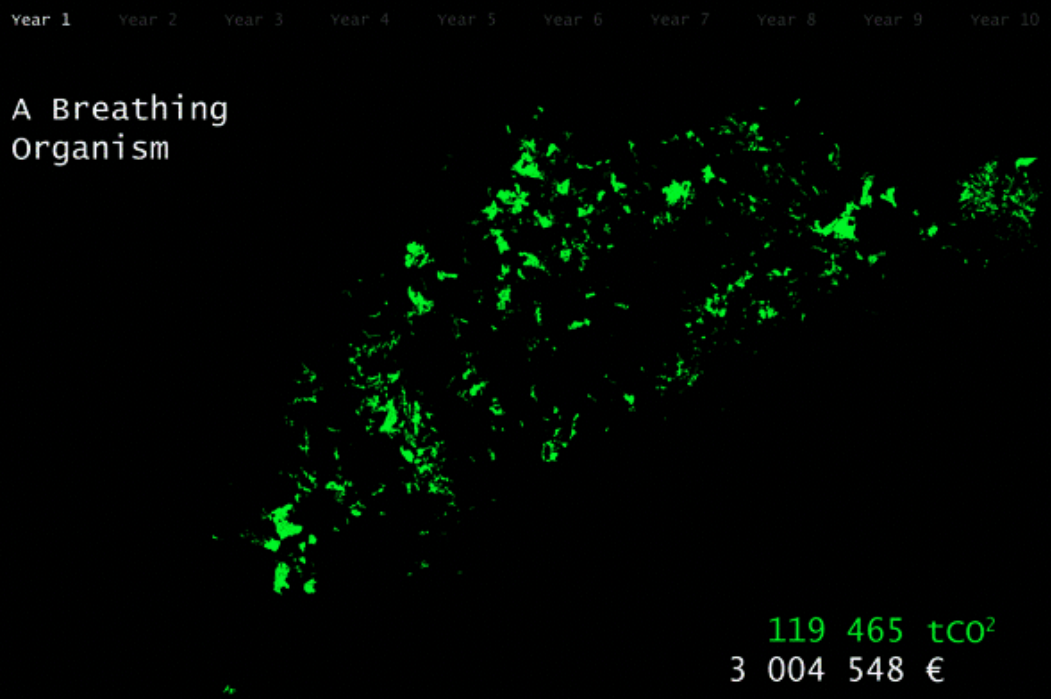
RELATION TO GLOSSARY TERMS:

Computational Design / Data Driven Design / Data Collection and Management / Design with/for Nature

ECOSYSTEM SERVICES:

Carbon sequestering / Food production / Health benefits / Increased social activities



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SECTION 3B

BUILDING AND PUBLIC SPACE DESIGN WITH/FOR NATURE COURSES

Pedagogy
Course structure
Example of a student project

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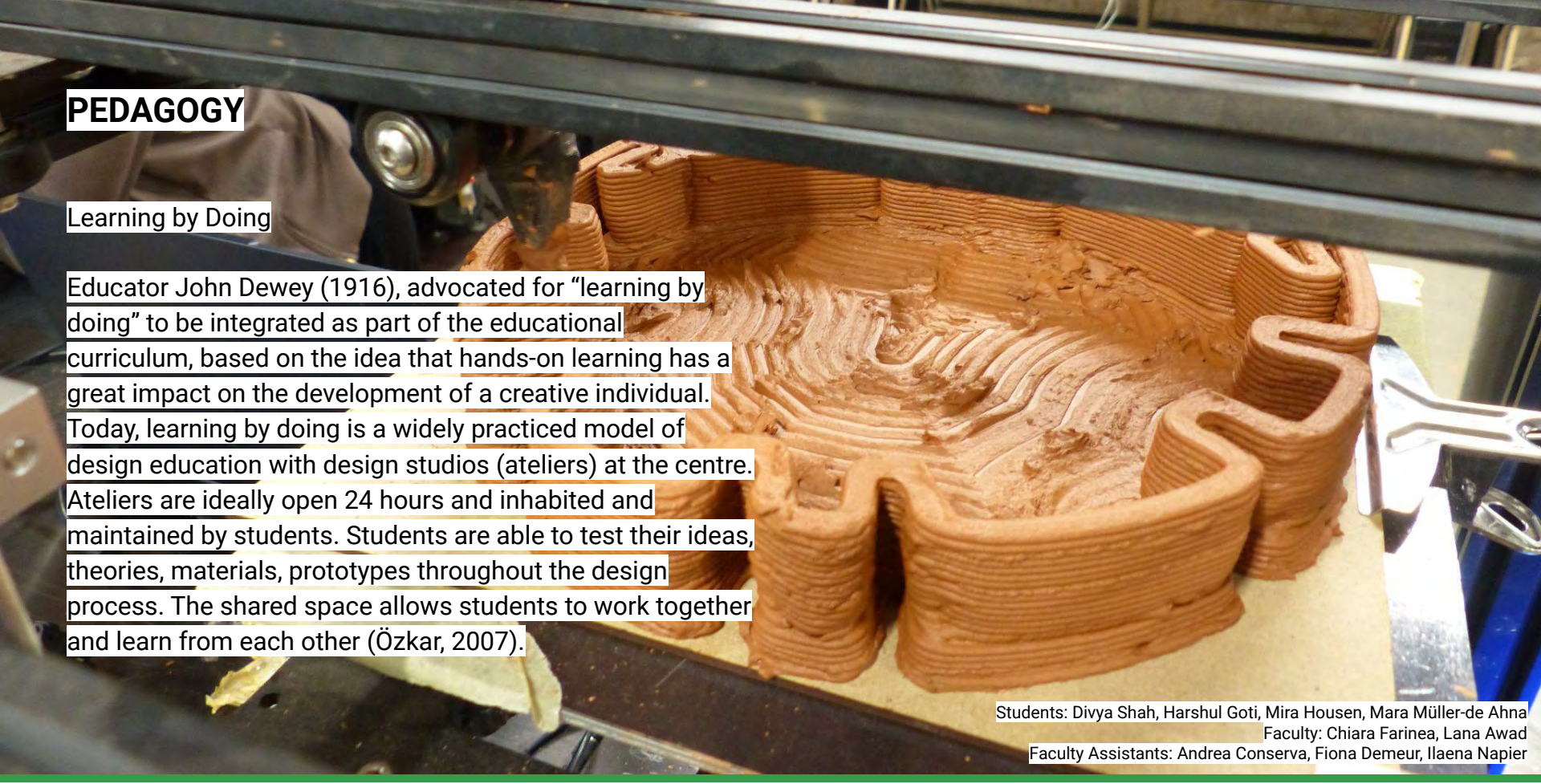
PEDAGOGY

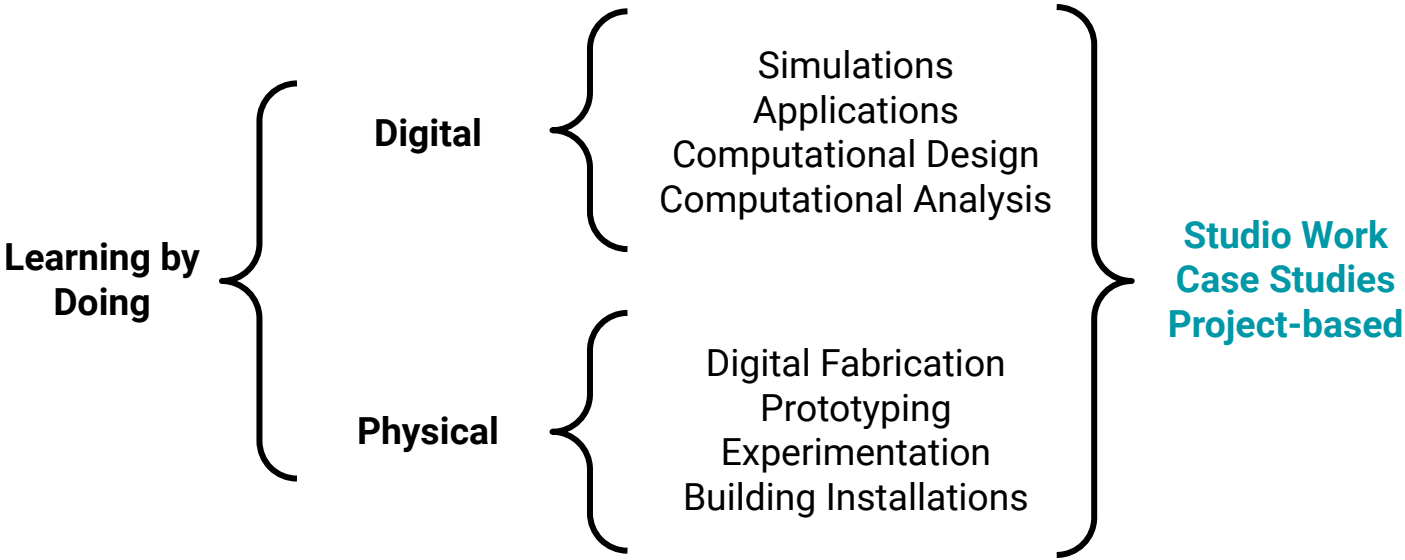
Learning by Doing

Educator John Dewey (1916), advocated for “learning by doing” to be integrated as part of the educational curriculum, based on the idea that hands-on learning has a great impact on the development of a creative individual. Today, learning by doing is a widely practiced model of design education with design studios (ateliers) at the centre. Ateliers are ideally open 24 hours and inhabited and maintained by students. Students are able to test their ideas, theories, materials, prototypes throughout the design process. The shared space allows students to work together and learn from each other (Özkar, 2007).



Students: Divya Shah, Harshul Goti, Mira Housen, Mara Müller-de Ahna
Faculty: Chiara Farinea, Lana Awad
Faculty Assistants: Andrea Conserva, Fiona Demeur, Ilaena Napier

LEARNING BY DOING AT IAAC



COURSE STRUCTURE EXAMPLE: IDEA TO PROTOTYPE

Clear Objective

1.

Development of the project idea

- Consideration of social, economic & environmental factors
- Application at the urban scale

2.

Development of one module

- Design
- Functioning Prototype

3.

Simulation Analysis

- Solar Analysis
- Water Flow Analysis

4.

Development of scalability & replication strategy

EPICLAY

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.

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RELATION TO GLOSSARY TERMS:

Design with/for Nature / Computational Design / Urban Renaturalization / Prototype

ECOSYSTEM SERVICES:

Air Filtration / Regulating the Buildings Temperature / Increased Biodiversity (insects)

SECTION 4

FURTHER READING MATERIAL

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FURTHER READING MATERIAL

- Video (1.5h) IAAC Roundtable - Nature Based Solutions – transitioning towards resilient cities
  https://www.youtube.com/watch?v=F5EO8jzhX2w&ab_channel=IAAC
- *Building urban resilience with nature-based solutions: How can urban planning contribute?* Judy Bush & Andréanne Doyon
  https://www.sciencedirect.com/science/article/pii/S0264275119313976
- *Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action*
  Nadja Kabisch, Niki Frantzeskaki, Stephan Pauleit, Sandra Naumann, McKenna Davis, Martina Artmann, Dagmar Haase, Sonja Knapp, Horst Korn, Jutta Stadler, Karin Zaunberger and Aletta Bonn
  https://www.ecologyandsociety.org/vol21/iss2/art39/
- *Moving beyond the nature-based solutions discourse: introducing nature-based thinking*
  Thomas B. Randrup, Arjen Buijs, Cecil C. Konijnendijk, Tom Wild
  https://link.springer.com/article/10.1007/s11252-020-00964-w
- *The role of Nature-Based Solutions in architectural and urban design*
  Elena Mussinelli, Andrea Tartaglia, Luca Bisongni, Sergio Makcevschi
  https://oaj.fupress.net/index.php/techne/article/view/5003/5003

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  Available at: https://www.build-solutions.org/book/
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- *Design with Life*, Mitchell Joachim, Maria Aiolova / Terreform ONE (2019)
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- *IaaC BITS 9 Black Ecologies*, Manuel Gausa, Areti Markopoulou, Jordi Vivaldi (2020)
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- *The Mushroom at the End of the World*, Anna Tsing (2021)

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GREEN SKILLS FOR CITIES

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Or check out our website:
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