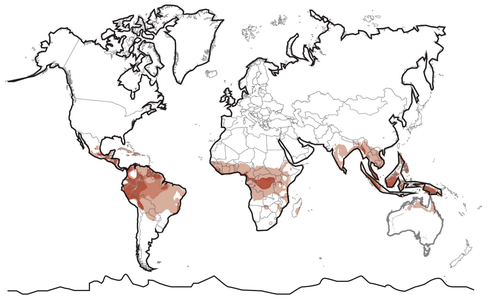
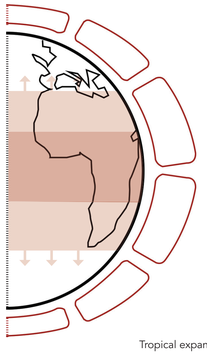
A Future Threat for the Tropics



Tropical countries clasification (Koppen)



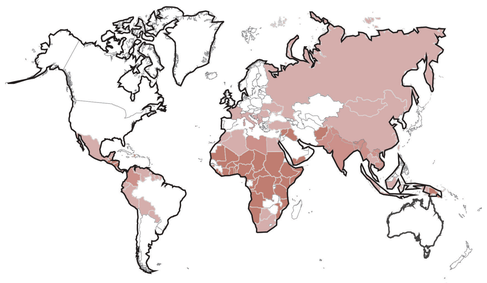
Tropical expansion

Tropical expansion

The Earth's tropical belt is defined as the region between the Tropic of Cancer (23.5 degrees north latitude) and the Tropic of Capricorn (23.5 degrees south latitude). Global warming, which causes an increase in the Earth's average temperature, triggers various alterations in the atmosphere and oceans. These changes lead to shifts in weather patterns and result in the expansion of the tropics.

The main driver of tropical expansion is the modification of the Hadley circulation, a large-scale atmospheric circulation pattern that significantly influences the configuration of the Earth's climate zones. As the Earth's surface warms, the temperature contrast between the equator and the poles decreases. This temperature contrast is a key factor in shaping atmospheric circulation patterns. As this contrast decreases, the Hadley circulation tends to extend poleward, resulting in the widening of the tropical belt.

Tropical expansion has several consequences, such as alterations in rainfall patterns, ecosystem changes, and the potential to influence weather patterns in mid-latitude zones. These transformations can substantially impact agriculture, water availability, biodiversity, and human communities in tropical and temperate zones.



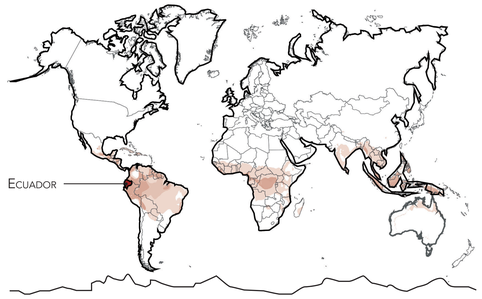
Tropical countries clasification (Science Direct 2022)

Climate change = Risk for tropical communities

According to the Fifth Assessment Report of the IPCC, in tropical countries, extreme events can have particularly pronounced effects due to the region's vulnerability to climatic changes. This vulnerability is due mainly to poverty, inadequate infrastructure, and limited resource access. The report emphasizes that these vulnerabilities can exacerbate the impacts of extreme events and hinder effective adaptation. The report says that many tropical regions are experiencing an increase in the frequency and intensity of extreme weather events.

- Heatwaves
- Tropical Cyclones
- Heavy rainfall and floodings
- Droughts
- Environmental damages

Site selection



Tropical countries clasification (Koppen)

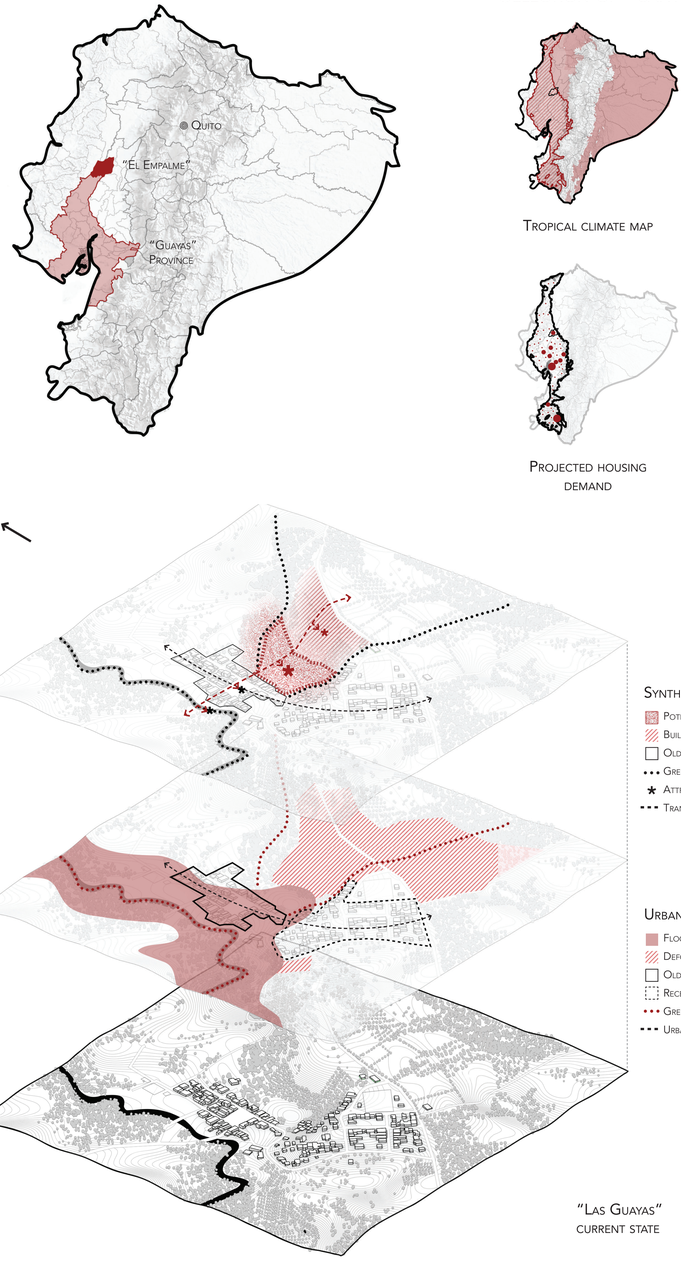
Selection criteria

A specific site had to be selected to develop a project in detail. Among the tropical countries mentioned before, Ecuador offered an excellent diversity of climatic conditions which could lead to a more versatile project concerning the rest of the candidate entities. Moreover, Ecuador has a reasonable data basis for territorial and climatic research, enriching the outcomes of this work. The following are the main criterion that were used to select the site in this country. From the existing Köppen Classifications for tropical climates, the "Tropical Savanna (Aw)" was selected since it is the one with the most significant extension over inhabited areas.

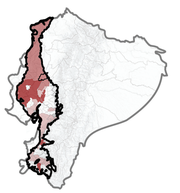
This first criterion brought attention to the western plains of the Andean Mountain range. This vast basin spans the provinces of Santo Domingo, Los Ríos, Manabí, and Las Guayas. Since the purpose of this thesis is to develop a project for a housing system, the following criterion consisted in identifying the "Cantones" (an administrative delimitation in Ecuador) that presented the most unfavored conditions in housing availability, as well as the most urgent need for decent housing according to the local demographic growth.

- Tropical climate
- Climatic risk
- Housing deficit
- Demographic growth
- No disposal management serv
- Lack of water infrastructure

Selection of "canton"

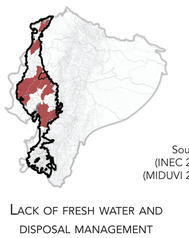


Tropical climate map



Housing deficit

Projected housing demand



Lack of fresh water and disposal management

Of these areas with housing necessities, the one selected was the "canton" of "El Empalme" because of its socioeconomic and infrastructure concerns. According to local data, "El Empalme" communities suffer predominantly from poverty and the lack of sewage and water supply. Since the present thesis aims to approach sustainability in architecture through the concept of circular economy, which among other benefits, it offers a more affordable way to produce architecture simultaneously to a certain degree of self-sufficiency, it was considered that "El Empalme" could be the ideal area to find the site of the project. Las Guayas is a small town in the canton, located amid the dense rainforest and crossed by a stream from the Saiva estuary.

Sources:
(INEC 2010)
(MIDUVI 2015)

The alternative: Sustainable and resilient architecture

Design for circularity

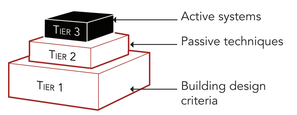
The Circular Economy, 100 innovation programs published a report where the ReSOLVE framework is presented as a guideline and evaluation tool. The framework consists of six forms in which circularity can be approached by public and private institutions: Regenerate, Share, Optimize, Loop, Virtualize, and Exchange (CE100, 2016).

- **RE** GENERATE — Renewable energies; Recovery of resources
- **S** HARE — Colective housing
- **O** PTIMIZE — Bioclimatic design; Natural materials
- **L** OOP — Design for disassembly; Upgradable design
- **V** IRTUALIZE — Smart systems
- **E** XCHANGE — Long-lasting materiales

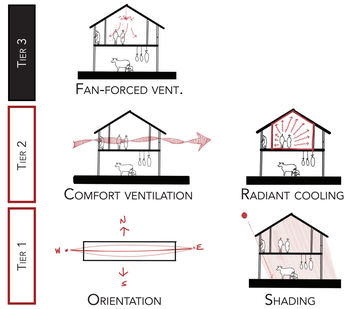
→ Building with natural materials: Bamboo guadua (GaK)

Following the design for circularity guidelines, the building systems considered for the project were those based on natural materials and renewable sources. GaK has been used as a construction material for various structures since pre-Hispanic times. Even now, structures erected over a century ago using Guadua angustifolia Kunth

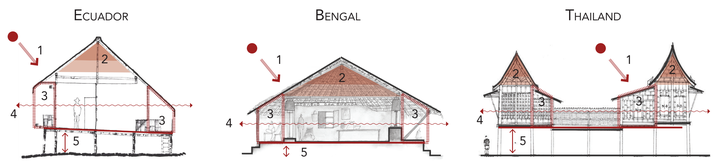
Bio-climatic design



According to Norbert Lechner, the sustainable design of buildings can be accomplished by the logic of the three-tier approach. The first tier stands for basic design of the building, the second involves the use of natural energies and passive techniques, whereas the third represents the use of active systems to provide the comfort that was not possible to achieve by the two first.



Learning from Vernacular Architecture

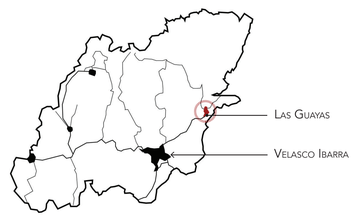


The following is an analysis of vernacular architecture case studies, which can be found in the tropical stripe of the planet, focusing on the bioclimatic solutions that archaic builders used to enhance living conditions. These cases have been selected due to existing studies on their successful bioclimatic performance and constructive local wisdom.

1 Shading: Large overhangs
2 High ceilings: air stratificat.
3 Porticoes and verandas
4 Comfort ventilation
5 Lifting space from ground

"Las Guayas" current state

"Las Guayas"



16,947 inhabitants

1.54% Year growth (1.90% Ec.)

4 People average per home

15% are retailers

40,60 are farmers

Cacao producer town.

Sources:
(Gob. El Empalme 2015)

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

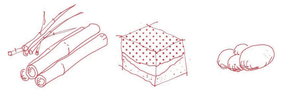
Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

October 2023

The Prototype

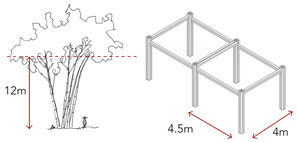
Local natural materials



Bamboo and reed | Earth | Local stone

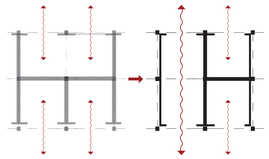
The most common natural material in the area is Bamboo Guadua. There is an abundant supply of reed and stone due to the proximity to the river. Earth can be obtained through excavation

Modulation of bamboo



The structural module aims to reduce the waste of material. The modulation works in a grid of 9.50 by 4.00 since both numbers are multiples of 12, which is the average usable length of bamboo.

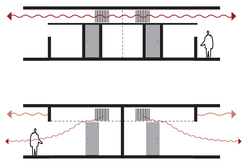
Row layout: Cross ventilation



Conventional | Row (proposed)

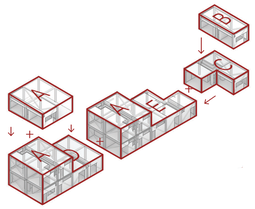
The modules were arranged in a row layout that ensures that all the main living spaces have cross ventilation and natural light. This logic also enhances the efficiency of appliances by being set in a single row, instead of complex networks.

Passive ventilation ceiling



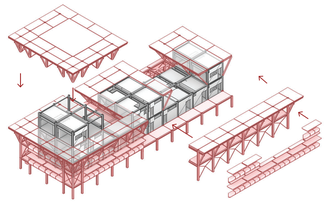
By sorting the "served" and "servant" spaces under the logic of the row, different heights can be provided. This allows to create ventilation ducts which can make cross ventilation to take place.

Concept of assembly



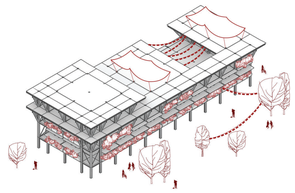
Assemble the "Hardware"

Firstly, the housing typologies would be selected and stacked in accordance to the needs. The resultant is a system that works as the infrastructure for the following layers.



Installation of "Devices"

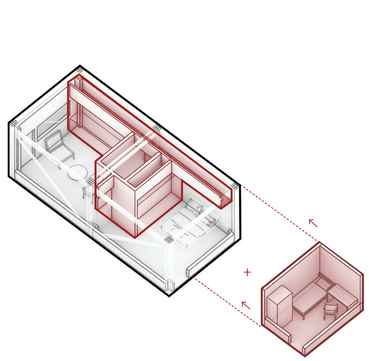
The devices are additional modules that are installed to the "hardware". From roofs to façade devices, these devices enhance the comfort conditions through passive strategies.



People as the "Software"

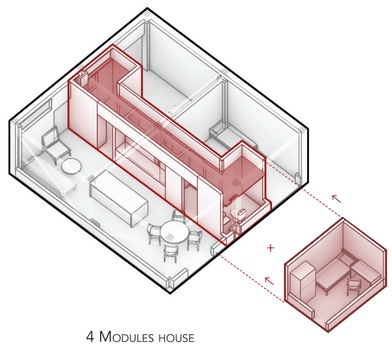
The final layer are the new inhabitants and its footprint to the structure. Through a wide range of options of devices and flexibility, the user can modify the aspect and performance of the building to comply with cultural and aesthetic requirements.

Housing typologies



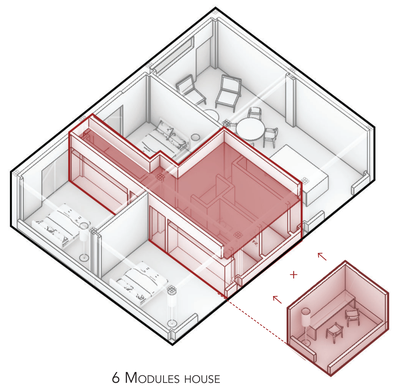
2 Modules house

36m² | 1 | 1



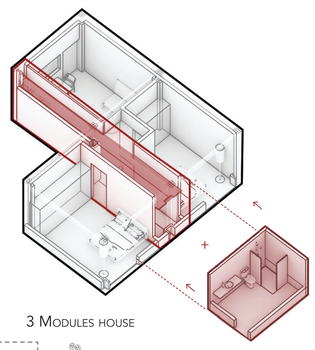
4 Modules house

72m² | 2 | 2



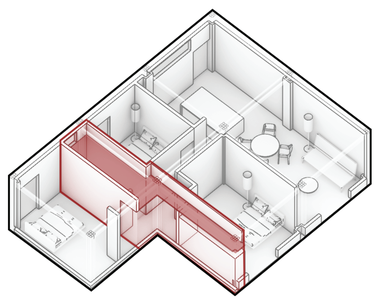
6 Modules house

108m² | 3 | 2



3 Modules house

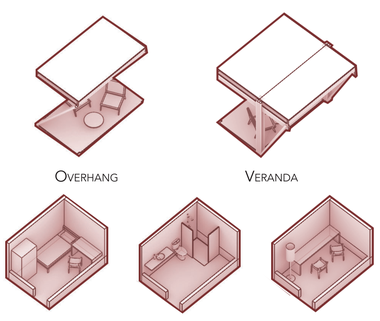
54m² | 2 | 1+1



5 Modules house

90m² | 3 | 1+1

"Devices" and possible extensions



Overhang | Veranda

+1 Bedroom | +1 W.C. | +1 Workspace

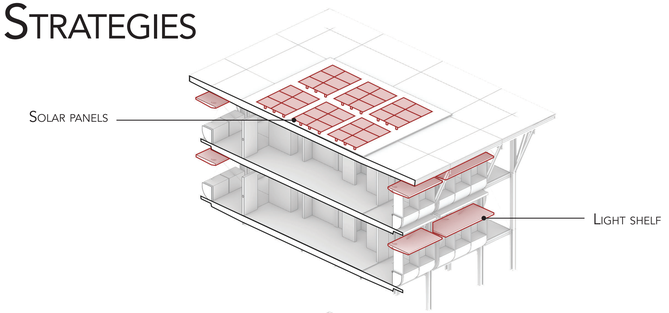
Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

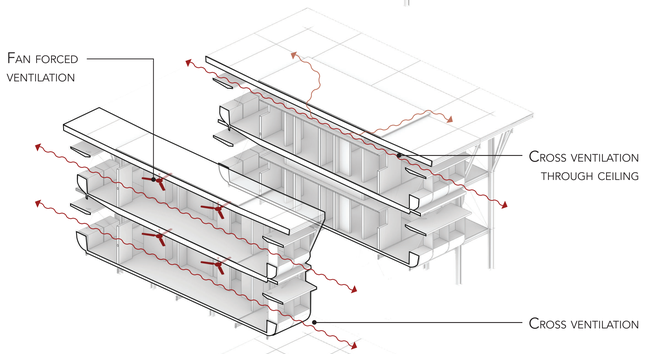
Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

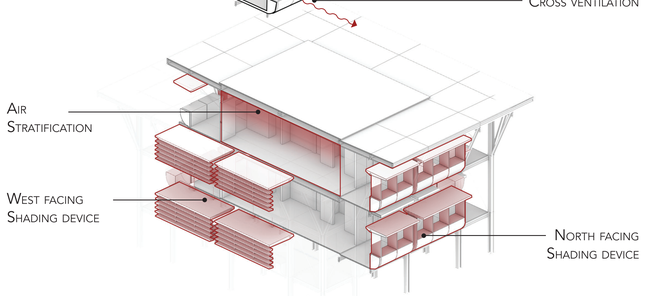
Supervisor:
Alessio Battistella

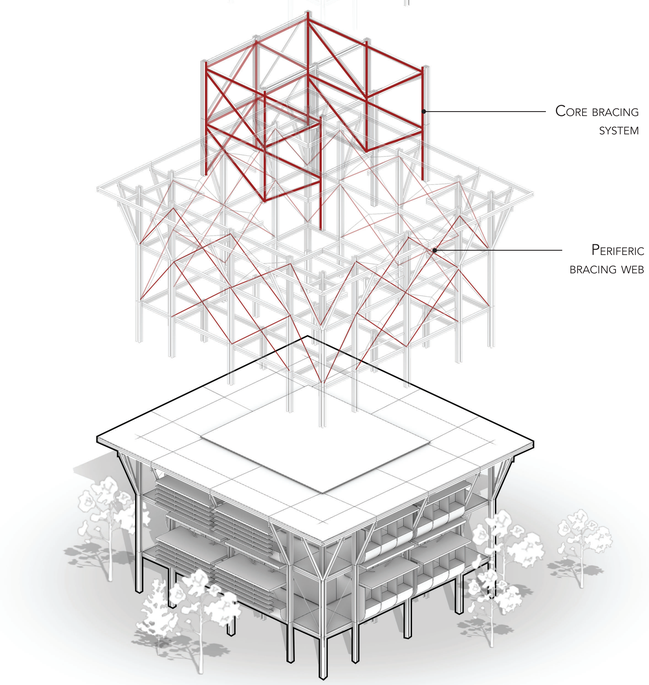
October 2023

Strategies

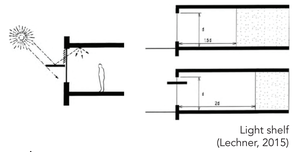








Lighting and active solar



Light shelf (Lechner, 2015)

Light shelf

According to Lechner, a light shelf can increase the light penetration up to two times the height of the opening.

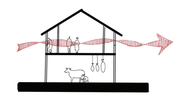
Daylighting

Strategies like the light shelf and skylights on the upper floors can reduce energy demand of the users.

Photovoltaic panels

By the use of solar panels, the system can make use of sun radiation that is abundant in this latitude

Cooling



Cross ventilation

Wind speed increases the user's comfort zone by evaporative cooling. The main spaces face both sides to allow windflow

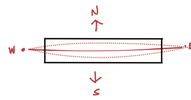
Radiative cooling

The high thermal mass of the indoor partitions made of earth allow to take heat from users by radiation.

Fan forced ventilation

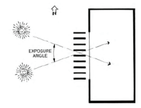
Since natural ventilation may not be enough some days, ceiling fans induce windflow with low energy consume.

Heat avoidance



Orientation

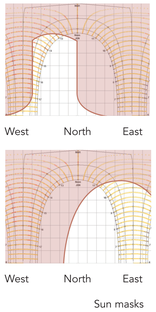
The houses would be set in order to avoid overheating from the sun, therefore facing either north or south.



(Lechner, 2015)

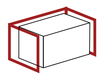
Mixed Shading

Mixing vertical and horizontal shading systems can offer the best protection while keeping the visual asset of the opening.



Sun masks

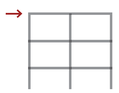
Structure and resilience



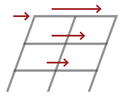
"U" Shape System

Bracing

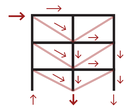
Firstly, the housing typologies would be selected and stacked in accordance to the needs. The resultant is a system that works as the infrastructure for the following layers.



Conventional 90° frame

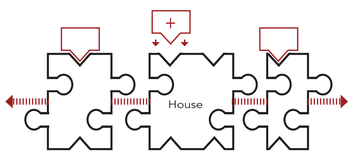


Seismic Deformation



Bracing system

Assembly and disassembly

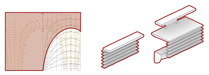


The system aims to offer the possibility to extend the units without affecting its functionality and performance.

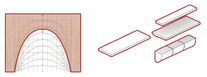
House modules connect to each other in one direction, so extension modules attach perpendicularly.

Assembly

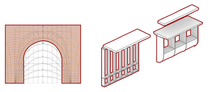
Facade devices



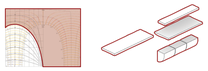
West Facades
Horizontal: 60°



South Facades
Horizontal: 25°



North Facades
Horizontal: 25° Vertical 30°



East Facades
Horizontal: 25°

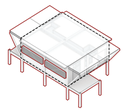
Veranda
2.50x4.00

Portico
2.50x4.00

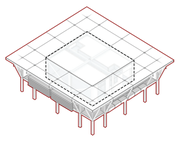
Platmform
2.50x4.00

Assembly examples

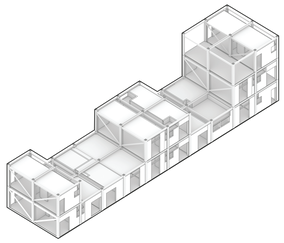
Single house for 1 family



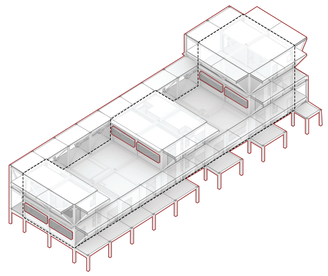
Single house + Shading devices



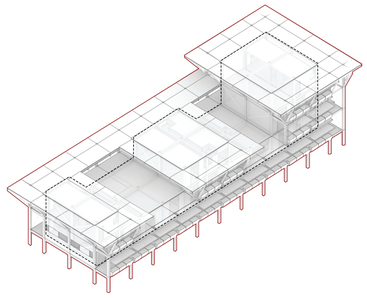
Single house + Veranda



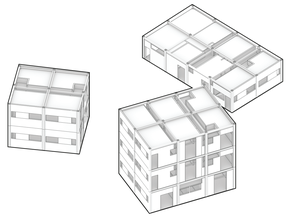
Colective housing building



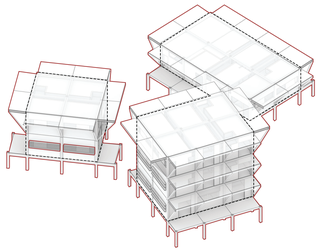
Colective housing + Shading devices



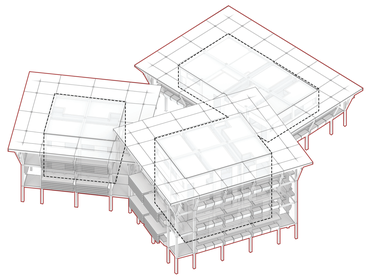
Colective housing + Veranda



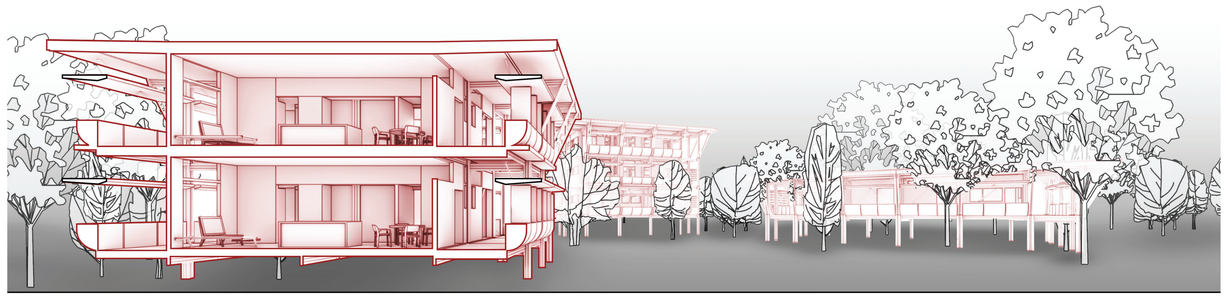
"Off the grid"Community



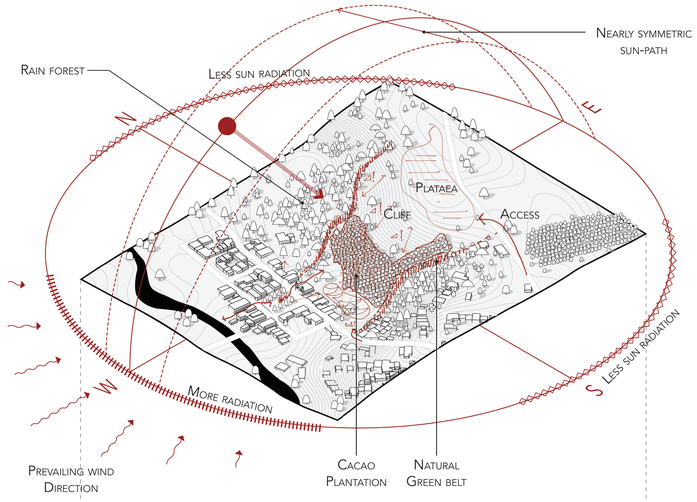
"Off the grid"Community + Shading devices

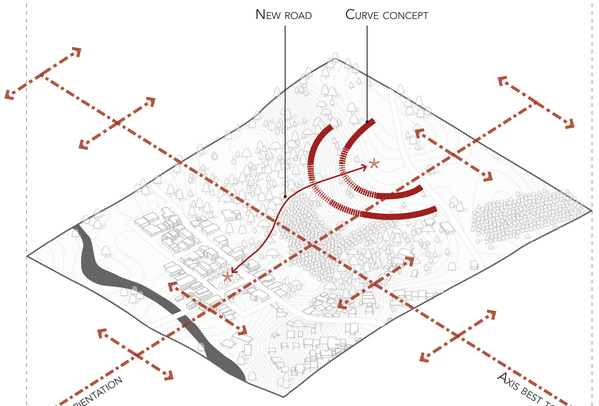


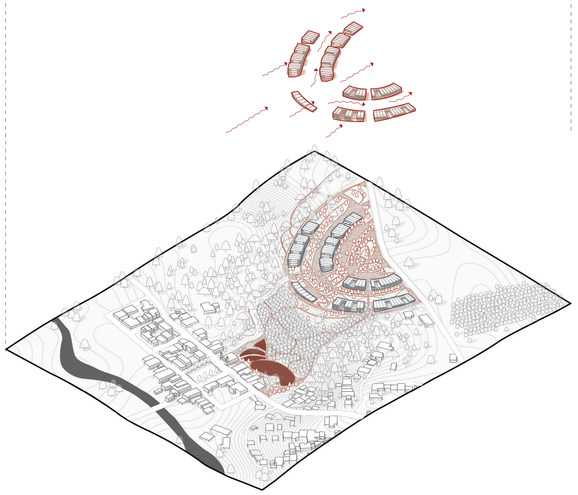
"Off the grid"Community + Veranda



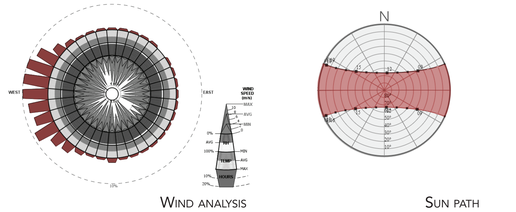
Site analysis and master plan

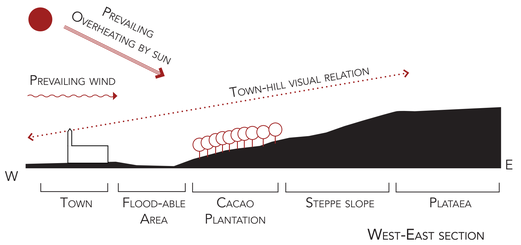




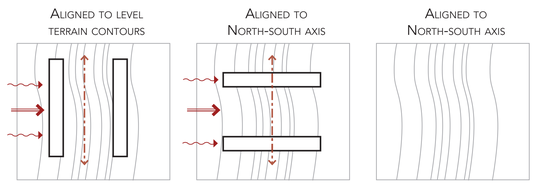


Site analysis

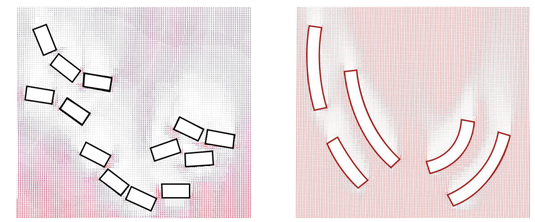




Strategy



Wind tunnel analysis



Conventional scattered: wind shadow

Curve scheme: Aerodynamic

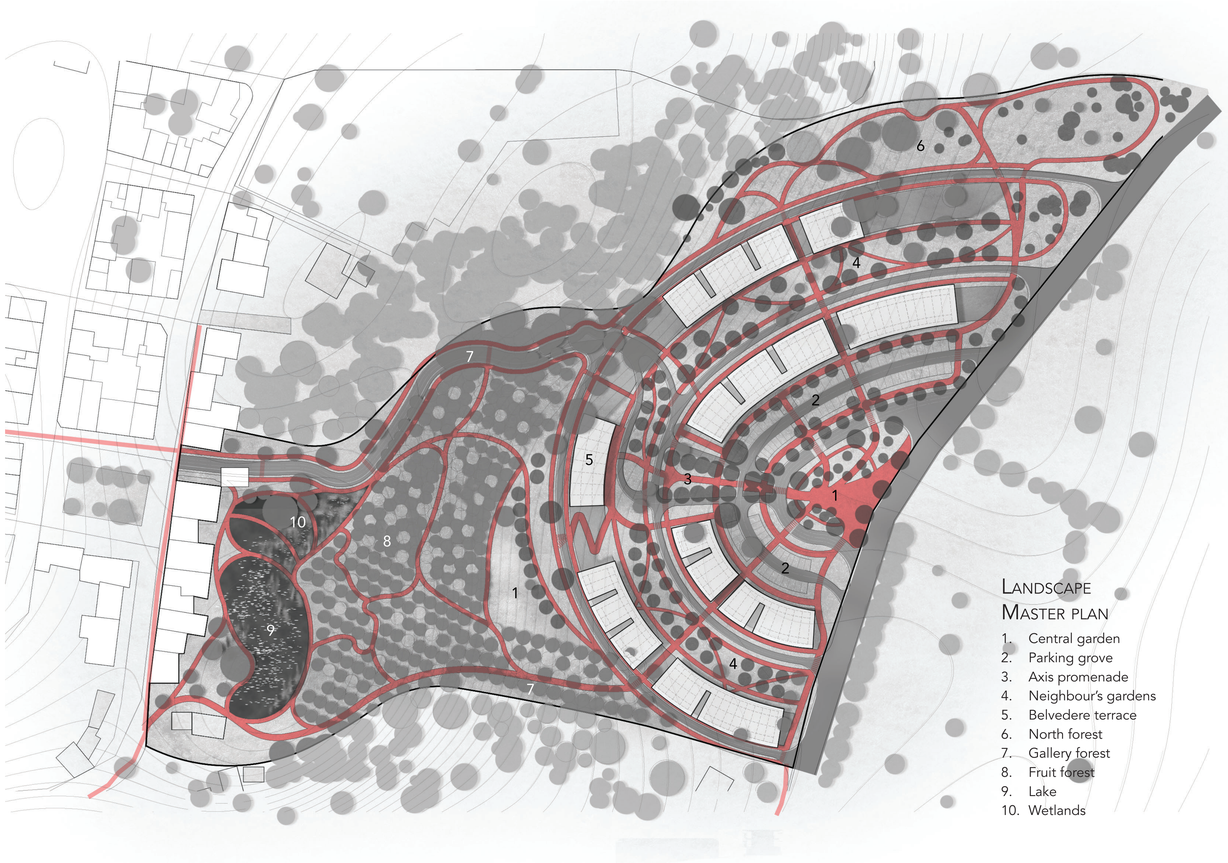
Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

October 2023

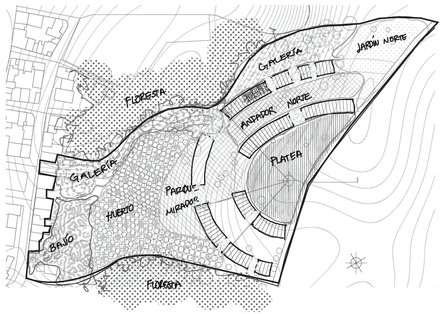
Landscape design



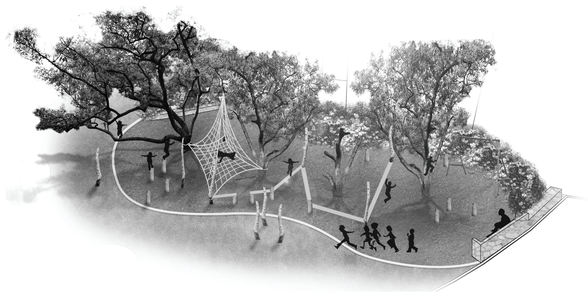
Landscape Master plan

1. Central garden
2. Parking grove
3. Axis promenade
4. Neighbour's gardens
5. Belvedere terrace
6. North forest
7. Gallery forest
8. Fruit forest
9. Lake
10. Wetlands

Analysis of pre-existant elements



Playground in cacao plantation

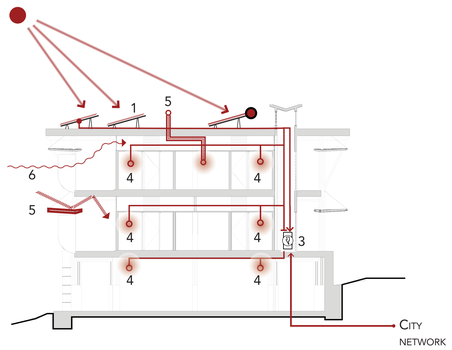


Analysis of flows

Excercise furniture along paths

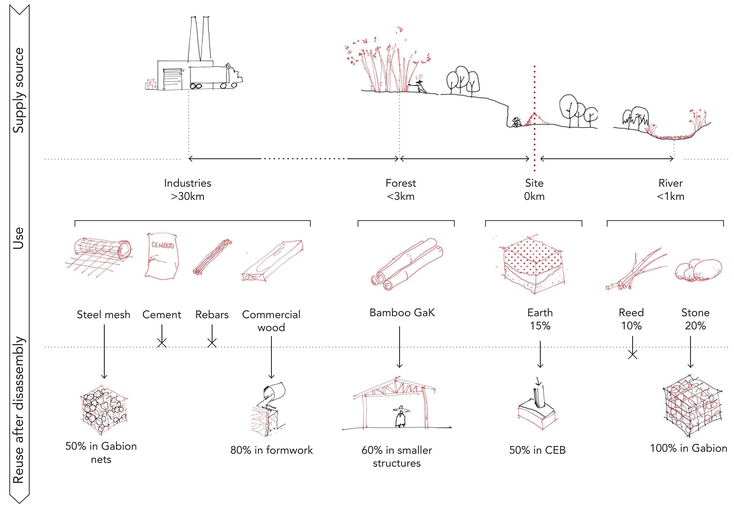
Circularity features

Sustainable cycle of ENERGY

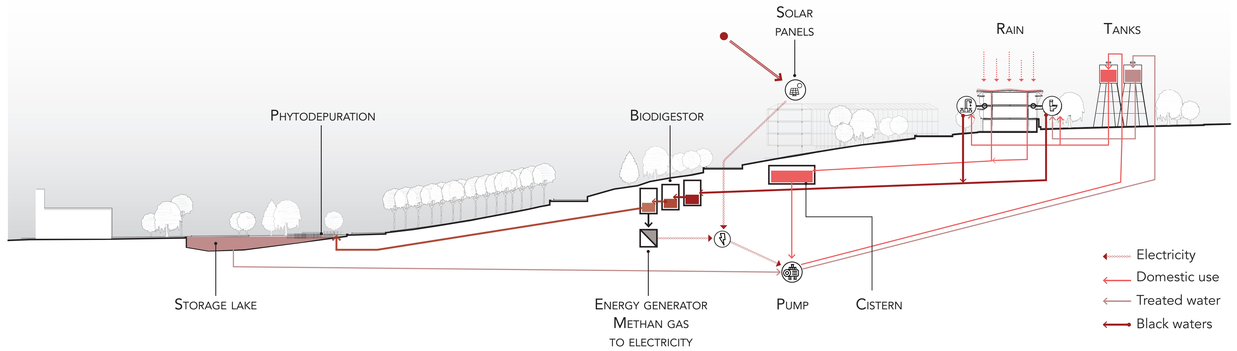


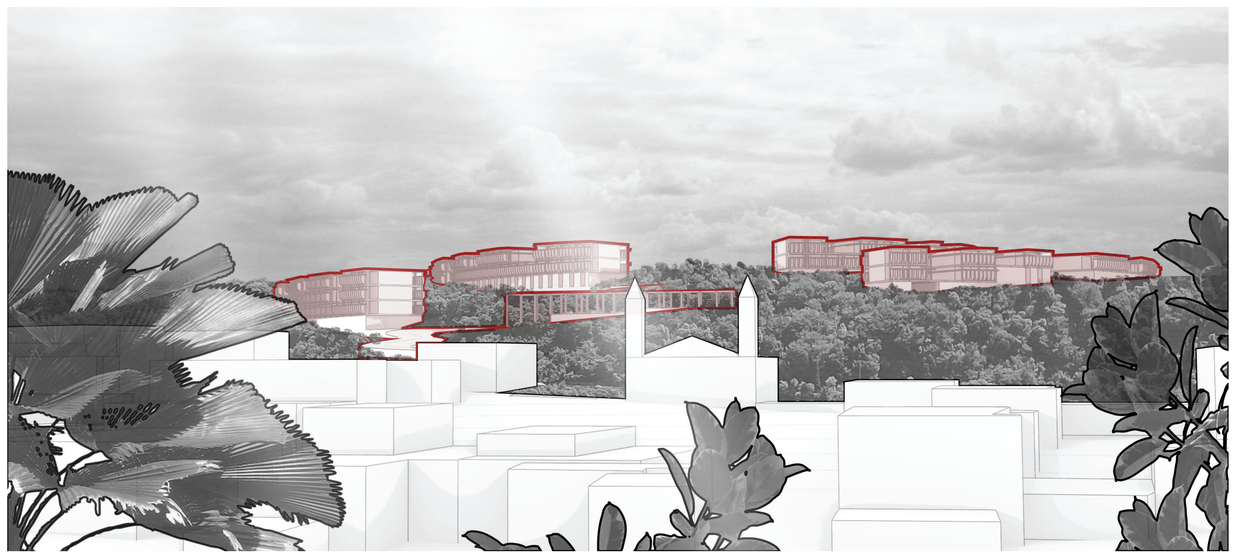
1 Solar panels
2 Solar heater
3 Battery
4 Efficient lighting design
5 Daylighting = -lighting demand
6 Ventilation = -cooling demand

Sustainable cycle of RESOURCES



Sustainable cycle of WATER





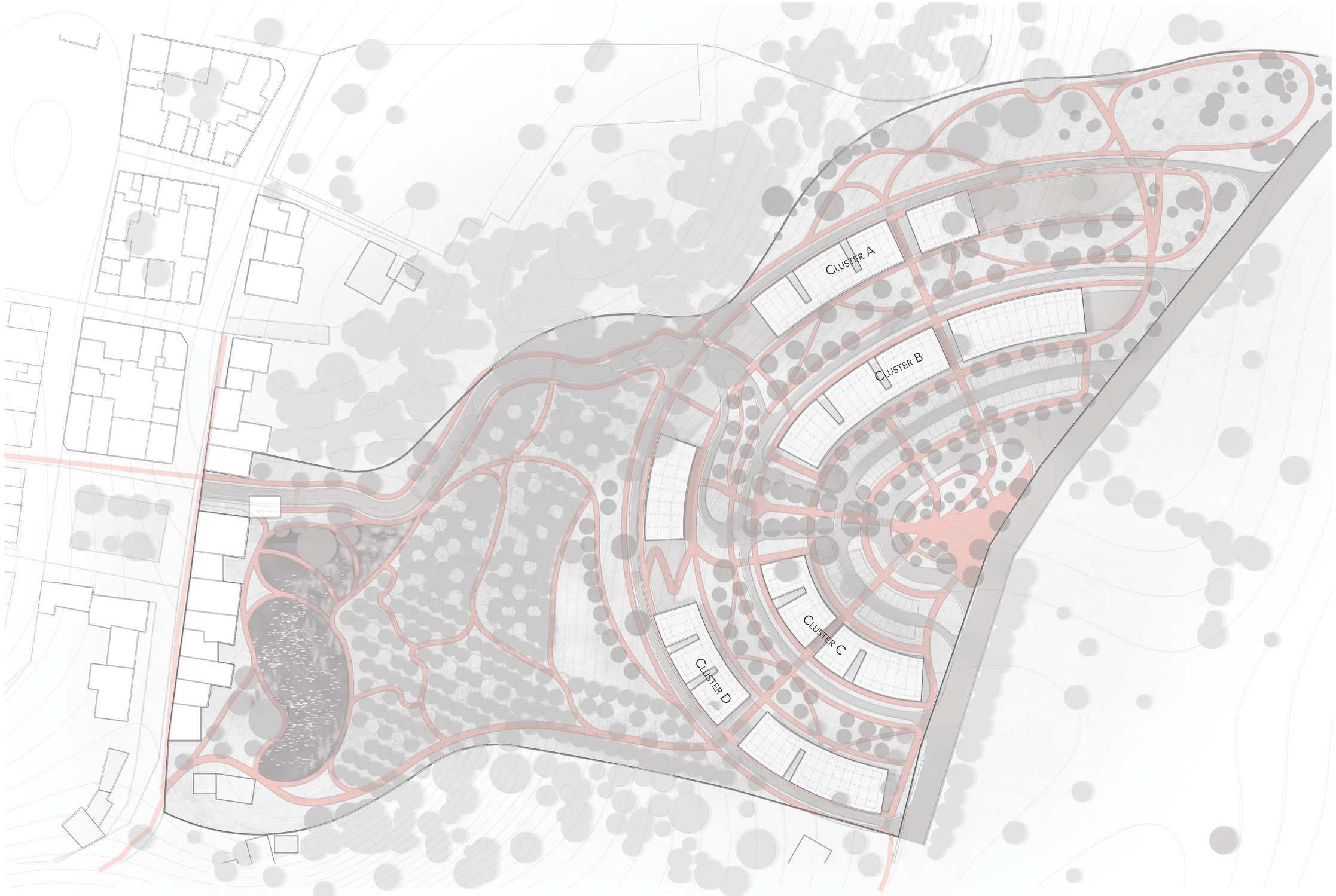
View from the town

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

October 2023



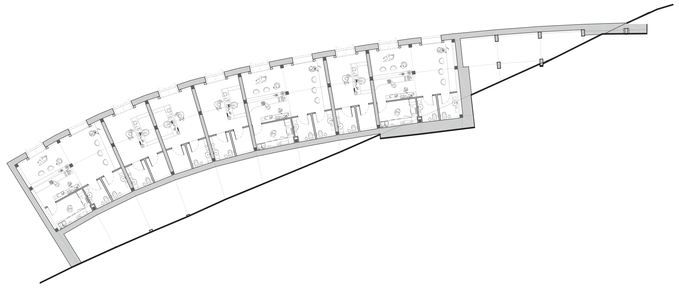
01 Master plan
Esc: 1:500

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

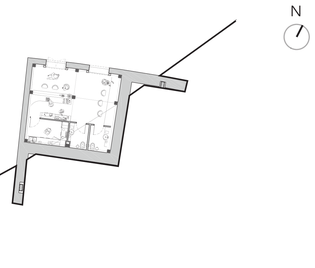
Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

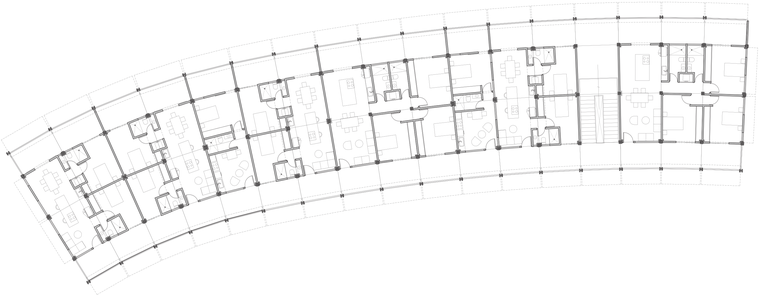
October 2023

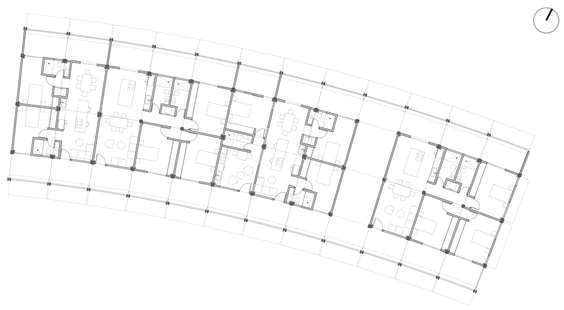


01 Cluster B lvl + 3.50
Esc: 1:200

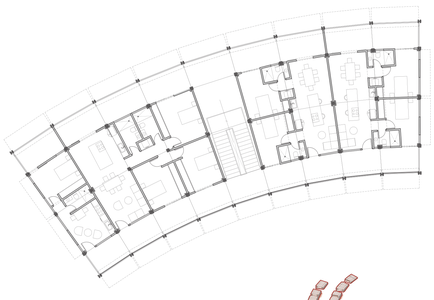


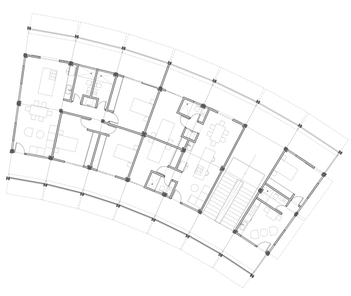
02 Cluster B lvl + 7.00
Esc: 1:200



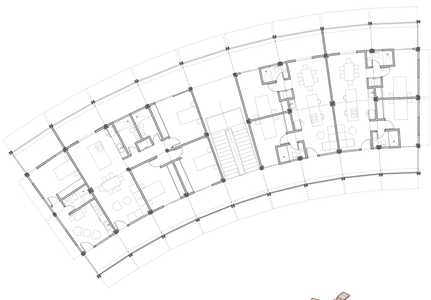


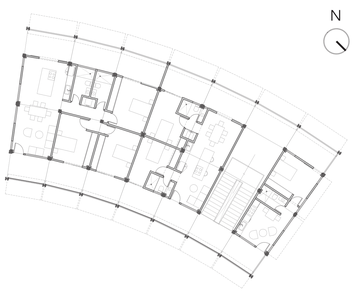
03 Cluster B lvl + 10.50
Esc: 1:200



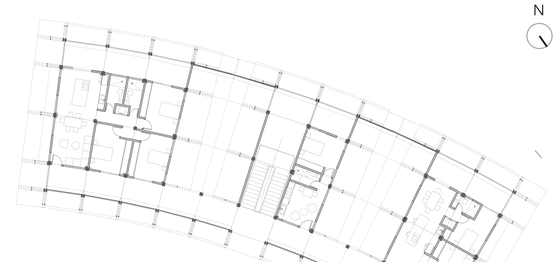


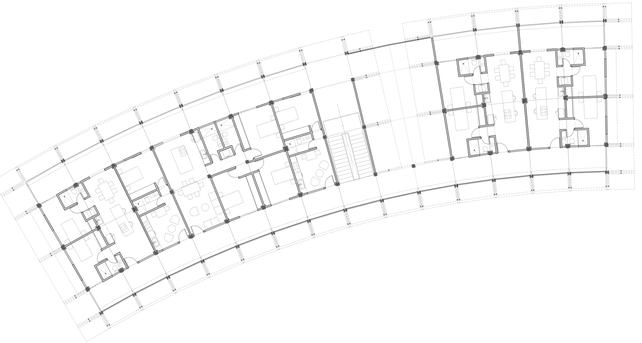
04 Cluster C lvl + 14.00
Esc: 1:200



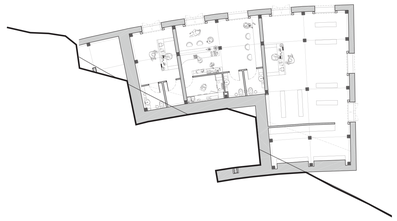


05 Cluster C lvl + 17.50
Esc: 1:200

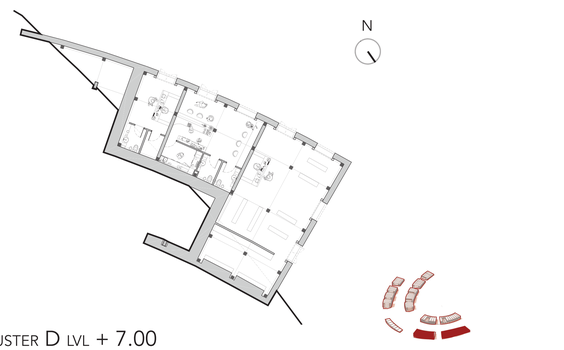




08 Cluster D lvl + 14.00
Esc: 1:200



07 Cluster D lvl + 10.50
Esc: 1:200



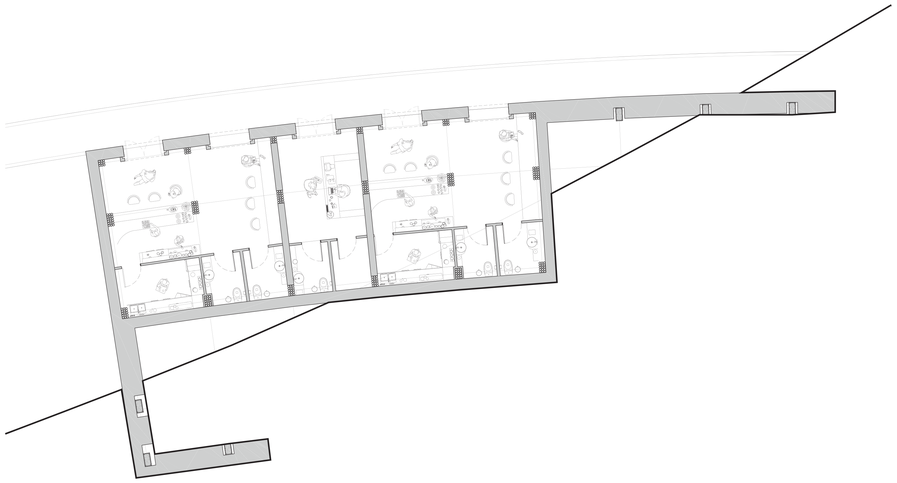
06 Cluster D lvl + 7.00
Esc: 1:200

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

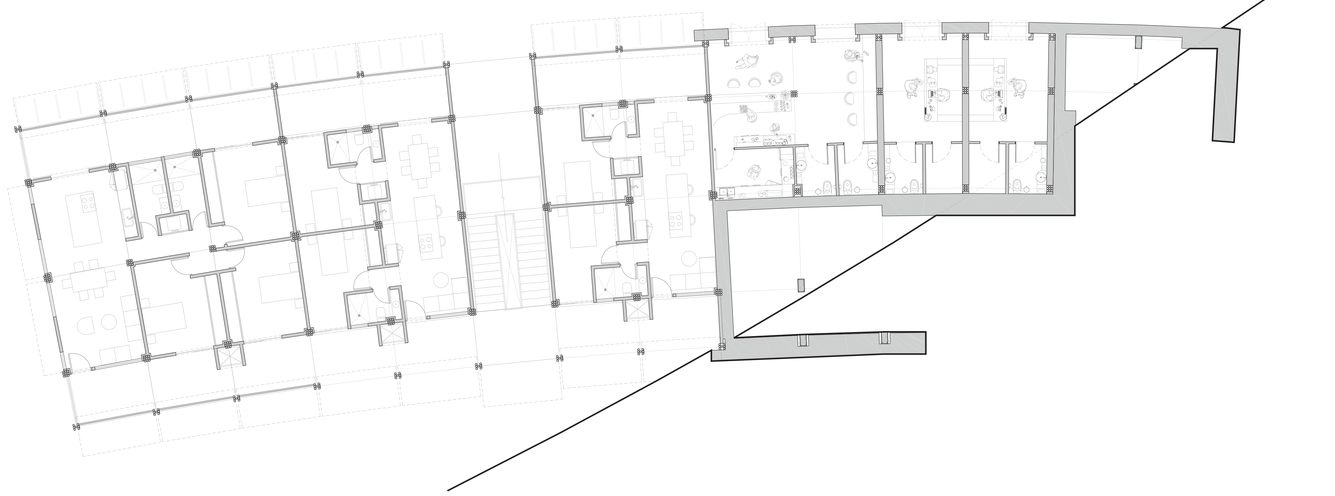
Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

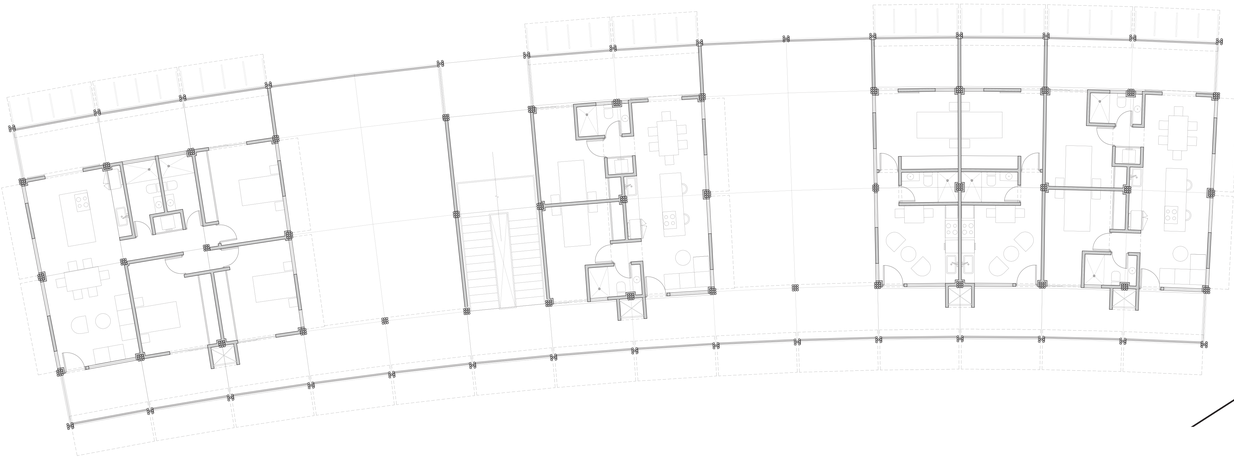
October 2023

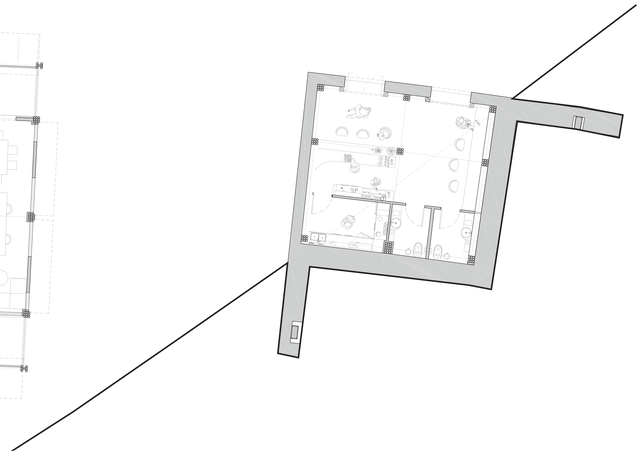


01 Cluster A lvl + 0.00
Esc: 1:100



02 Cluster A lvl + 3.50
Esc: 1:100





03 Cluster A lvl + 7.00
Esc: 1:100

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

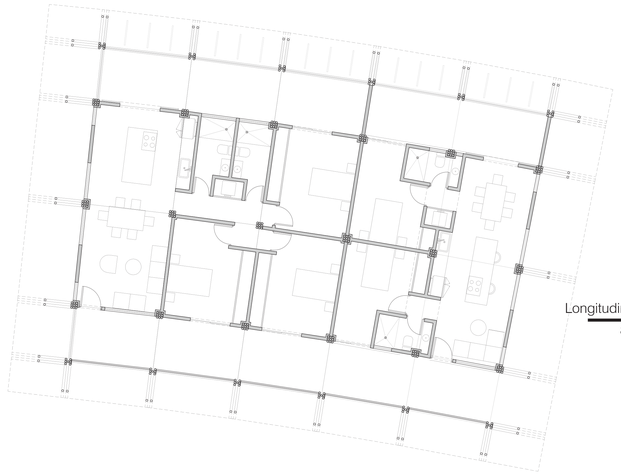
Supervisor:
Alessio Battistella

October 2023

Section 1
8-02

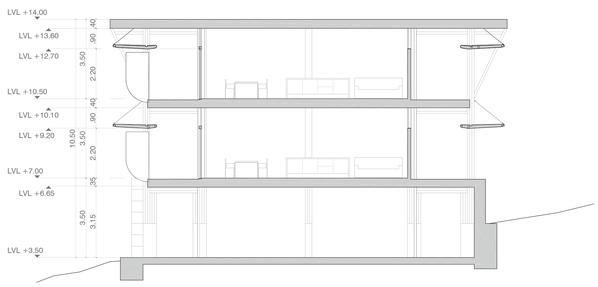
Section 2
8-03

Longitudinal section
8-04

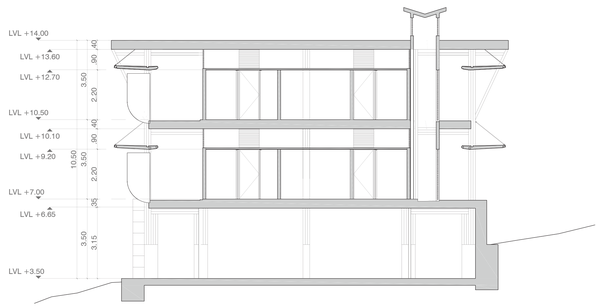


Longitudinal section
8-04

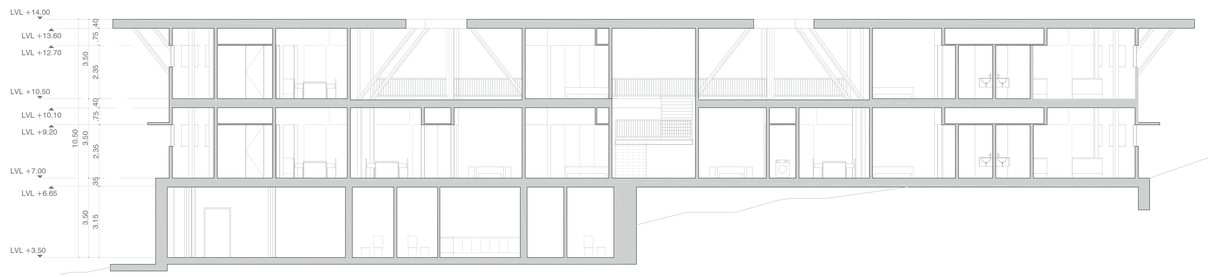
01 Cluster A lvl + 10.50
Esc: 1:100



02 Section 1
Esc: 1:100



03 Section 2
Esc: 1:100



04 Longitudinal section
Esc: 1:100

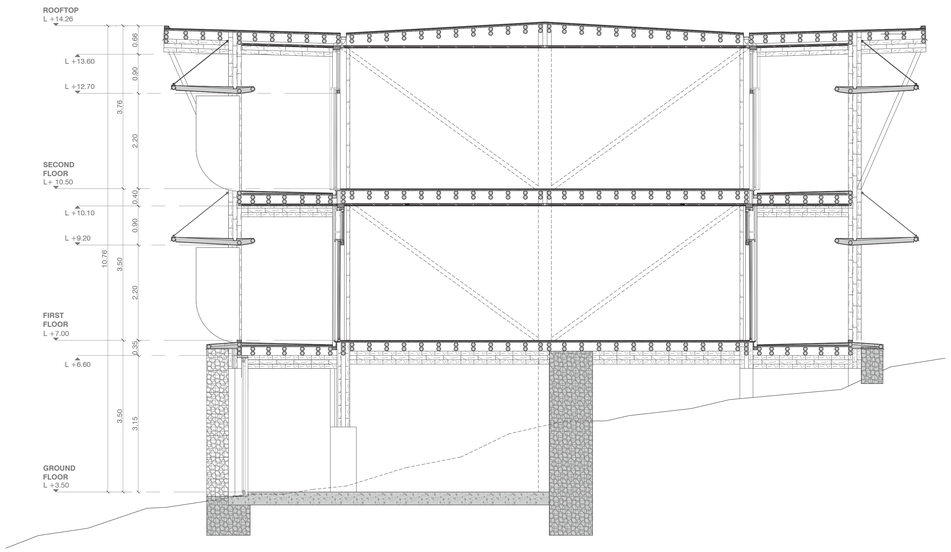
Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

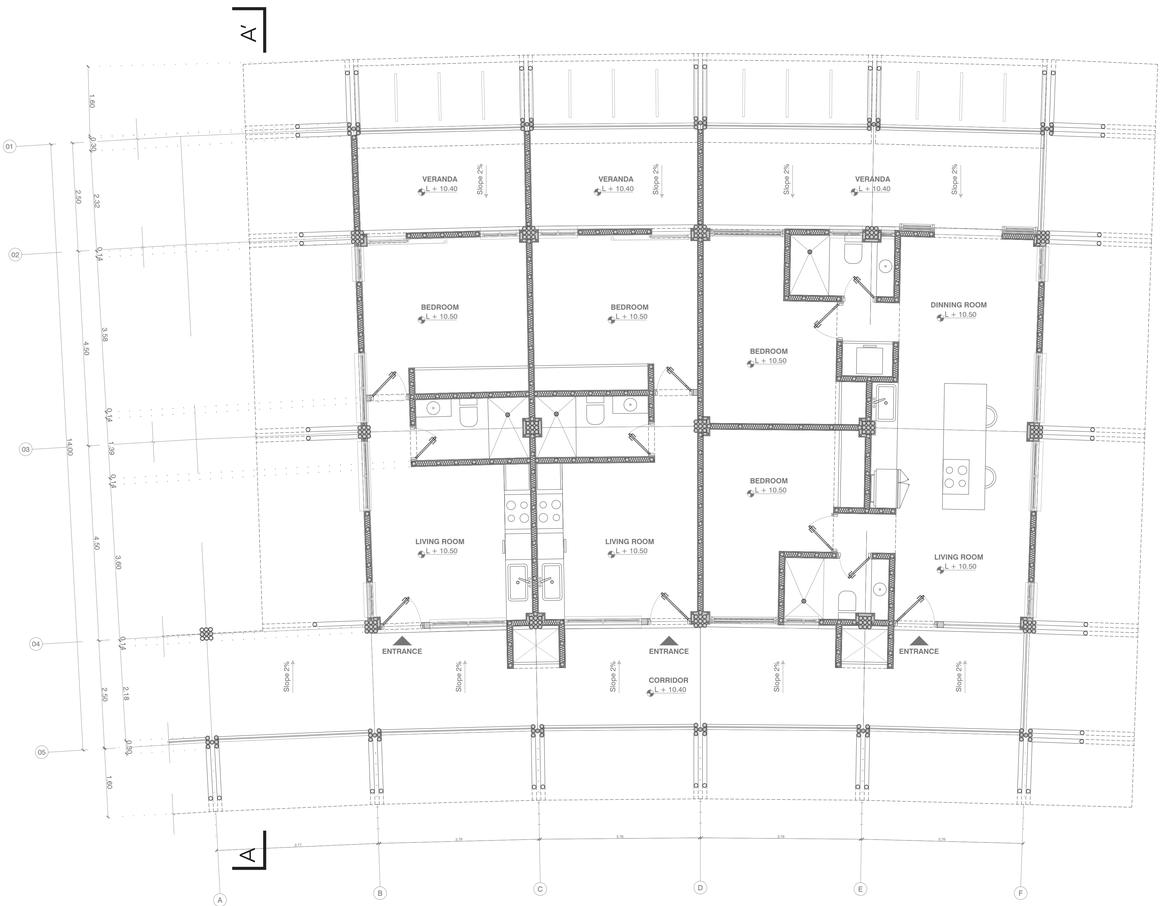
Supervisor:
Alessio Battistella

October 2023

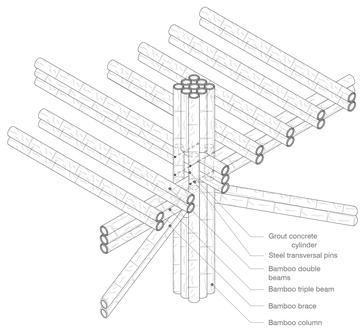
01 Cluster A Elevation
Esc: 1:50

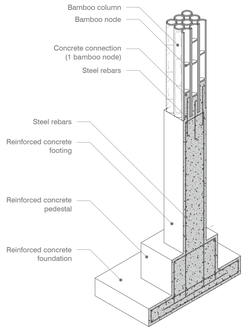


02 Cluster A Section
Esc: 1:50

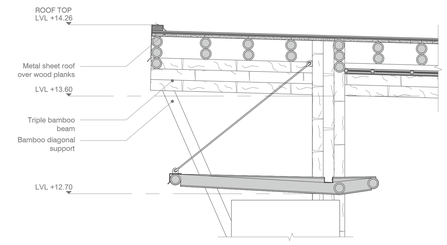


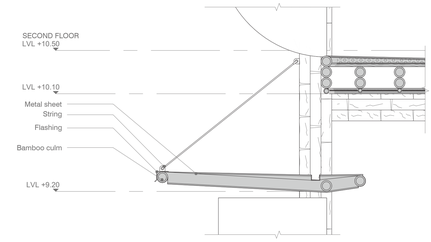
03 Constructive plan
Esc: 1:50

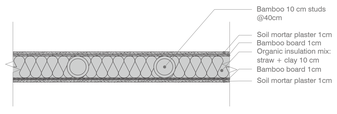




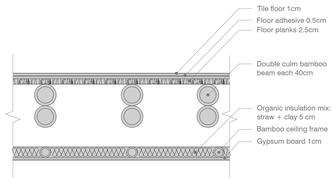
04 Detail of joints
Esc: 1:20



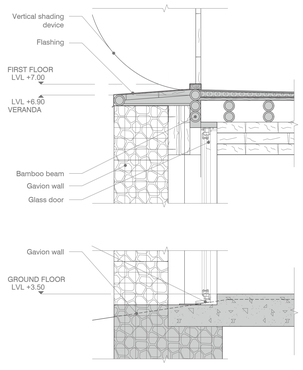




05 Bahareque stratigraphy
Esc: 1:10



06 Floor stratigraphy
Esc: 1:10



07 Facade section
Esc: 1:20

Sustainable Prototype for a Critical Climate Future in the Tropics
Master Thesis
Msc Architecture and Urban design
Politecnico di Milano

Author:
Rodrigo Antonio Velasco Barreda
Co-author:
Carlos David Arcos Jácome

Supervisor:
Alessio Battistella

October 2023