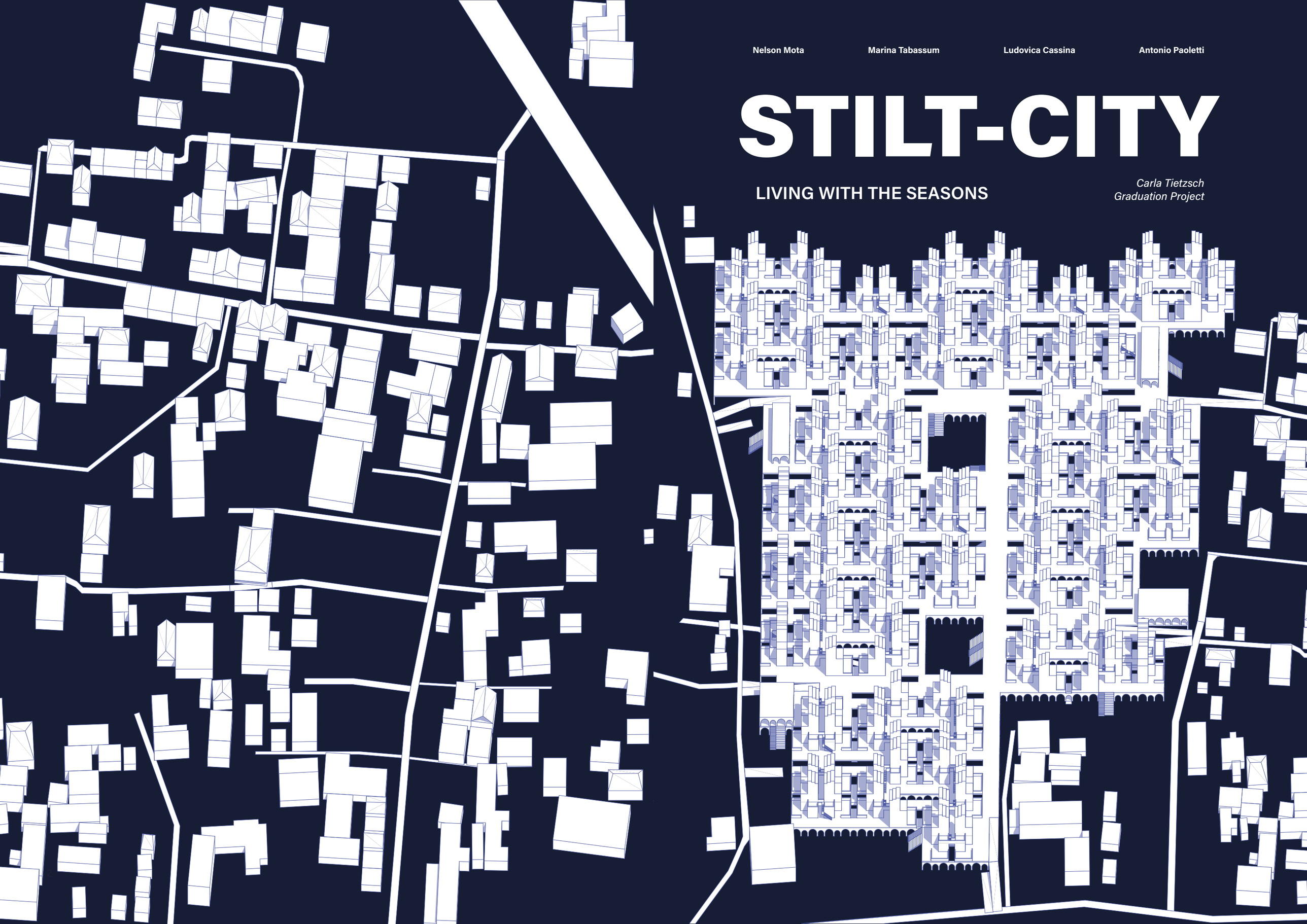
Nelson Mota Marina Tabassum Ludovica Cassina Antonio Paoletti

# STILT-CITY

## LIVING WITH THE SEASONS

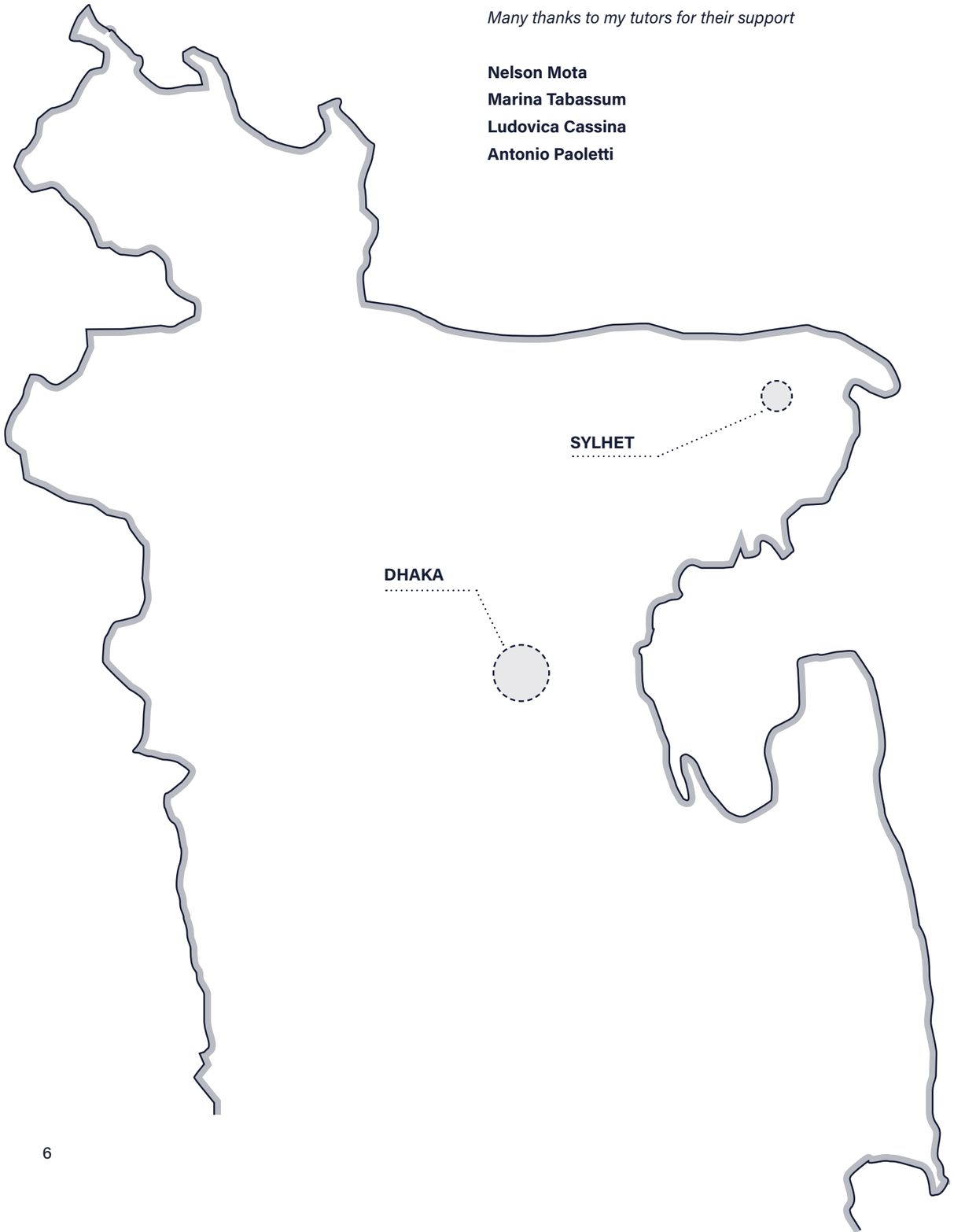
*Carla Tietzsch*
*Graduation Project*



*“In most Third World countries, the annual population growth rate is somewhere between 2 to 3%, but the towns and cities themselves are increasing in more than double this speed.”*

**Charles Correa**

*1989, The New Landscape: Urbanisation in the Third World*




*Many thanks to my tutors for their support*

**Nelson Mota**
**Marina Tabassum**
**Ludovica Cassina**
**Antonio Paoletti**

**Context.** 9
**Site.** 39
**Design Principles.** 61
**Unit.** 69
**Cluster.** 119
**Community.** 161
**Network.** 175
**Process.** 195
**Reflection.** 239
**Bibliography.** 243

# CONTEXT

# Introduction

*Trend of Urbanisation*

Global population growth and the increasing frequency of extreme weather events are intensifying rural-urban migration, creating overcrowded cities with declining living standards. This research aims identify strategies to adapt rural areas to the urbanization processes and setting an example for other regions facing similar challenges.

**Street in Dhaka**
by www.petersbigadventure.com



https://www.washingtonpost.com/world/interactive/2022/millions-stranded-heavy-flooding-sweeps-through-bangladesh-india

Bangladesh, "one of the most climate-vulnerable countries in the world", has endured over 200 extreme weather events in the past two decades, most of which were floods, cyclones and storms (Bairagi 2021). Meanwhile, the country contains an extremely large and continuously growing population, which creates a high density in urban as well as rural areas. According to Tasneem Chowdhury, a Bangladeshi architect, his country was among the least urbanized nations worldwide in 1992 (Chowdhury 1996).

Simultaneously Charles Correa observed a rapid trend of urbanization in developing countries in 1989 (Correa 1989). Consequently, a large rural population that migrates quickly into urban areas resulted in overcrowded cities. According to Correa this rapid urbanization led migrants into overcrowded informal settlements with poor living standards, which allowed them to have access to job opportunities that were mostly located in city centres (Correa 1989).

These observations align with those of Rana and Ilina (2021), who illustrated how rural poverty is shifted into into urban poverty in Bangladesh (Rana 2021). They noted that by 2007, only about half of the households in Dhaka had access to health facilities and the city's water supply infrastructure was inadequate to meet the demand (Rana 2021).

Correa identified economic instability as a primary driver of rural-urban migration (Correa 1989). This global mechanism can be observed in Bangladesh where rural populations face inadequate infrastructures, limited income sources and are disproportionally affected by extreme weather events (Baishakhy 2023). This combination of factors destabilizes rural economies and often leaves migration as the only option for those seeking to improve their quality of life.

# Problem Statement

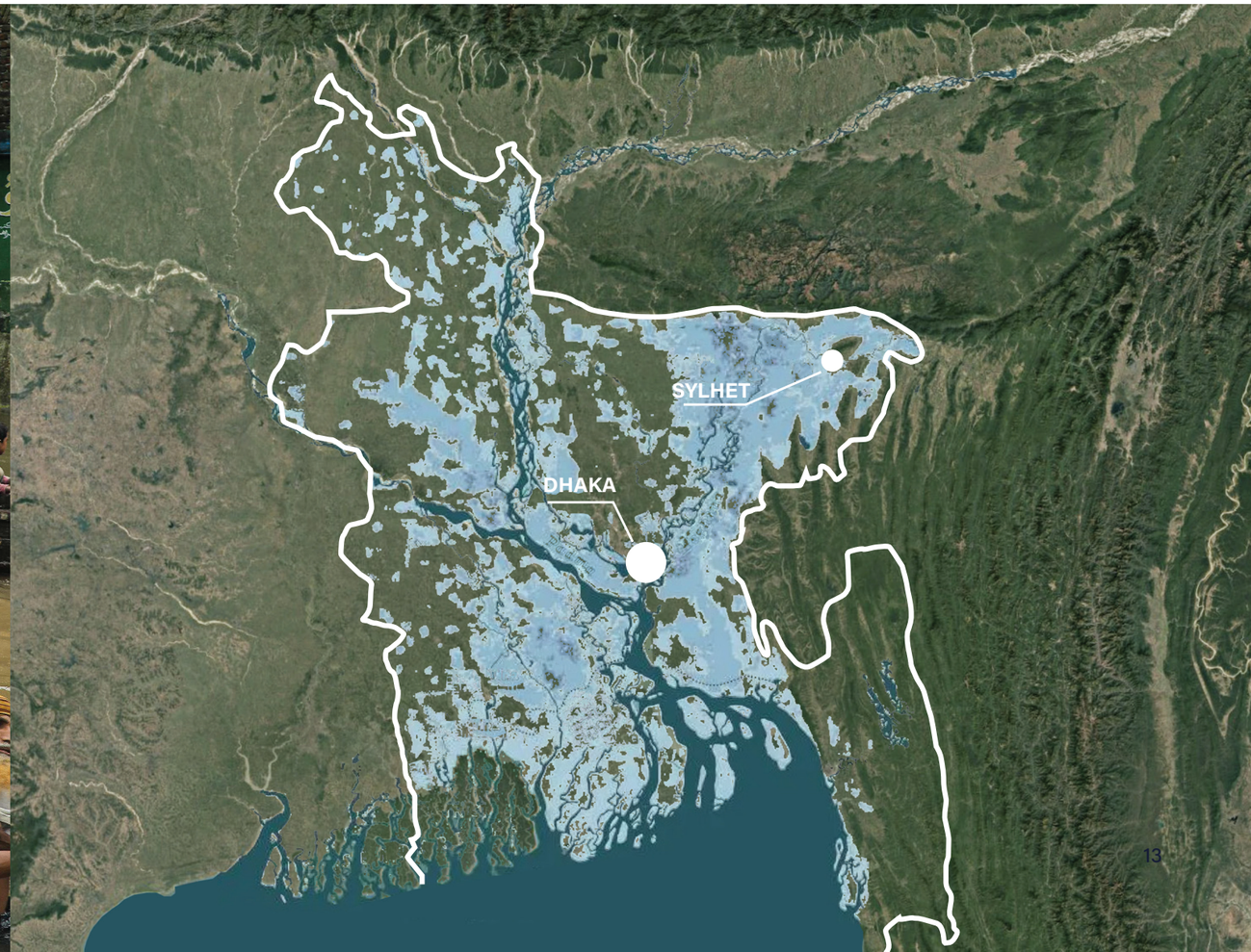
*Increasing Flood Risk*

Economic instability has been identified as a primary driver of rural-urban migration (Correa 1989) in Bangladesh, where annual monsoon seasons and floods strain rural communities (Baishakhy 2023), and climate change intensifies these challenges with more frequent extreme weather events.

Especially the north-east region of the country, the Haor Wetlands, is affected by a high flood risk, and serves as an example of an area where traditional housing designs reach their limits. These common structures include elevated plinths and easily repairable elements made of rather cheap materials (Noble, 2012), yet these designs are not sufficient to withstand the force of severe flash flood events, which often cause immense destruction (Morshed 2016). Due to the reliance on low-cost materials with less durability, economically disadvantaged rural communities often must rebuild their houses after each monsoon season (Noble, 2012). This necessity for yearly reparations continuously decreases the economic stability of already disadvantaged populations (Noble, 2012).



**Heavy Floods in Bangladesh and India in 2022**
by www.washingtonpost.com




**Flood Risk Map Bangladesh**
inspired by www.ecojesuit.com

*Rural-Urban Migration*

However, the weather conditions not only affect the housing situation but also the agriculture. Bangladesh is a “predominantly agriculture-based country“(Baishakhy 2023) that relies immensely on rice farming for its food supply and as a source of income (Baishakhy 2023). While crop losses of around 4% of the annual rice production due to flood events is considered a normal rate (Bairagi 2021), these crop losses naturally affect smallholder farmers stronger and weaken their economic stability once more (Baishakhy 2023). However, climate change is now increasing the frequency of the occurrence of flash flood events, which can cause crop losses of up to 80% at a time (Baishakhy 2023).

Combined with the damage these floods cause on their dwellings, these events result in extreme economic burdens that leads many residents to seek greater economic stability in urban areas, despite the overcrowded and resource-limited conditions of cities like Dhaka. According to Rana and Ilina the “total number of urban slums are increasing after every occasion of natural disasters” (Rana 2021). Therefore, by speeding up the urbanization the reoccurring climate disasters contribute to the overpopulation of cities in Bangladesh which results in formation of slums and a decrease of living standards in many cities. This results in an urgent need for strategies that improve both housing resilience and economic stability in rural communities, creating conditions that allow people to sustain their livelihoods without needing to migrate.

**Main Reasons for Rural-Urban Migration:**

- increasing frequency of extreme weather events

- crop losses

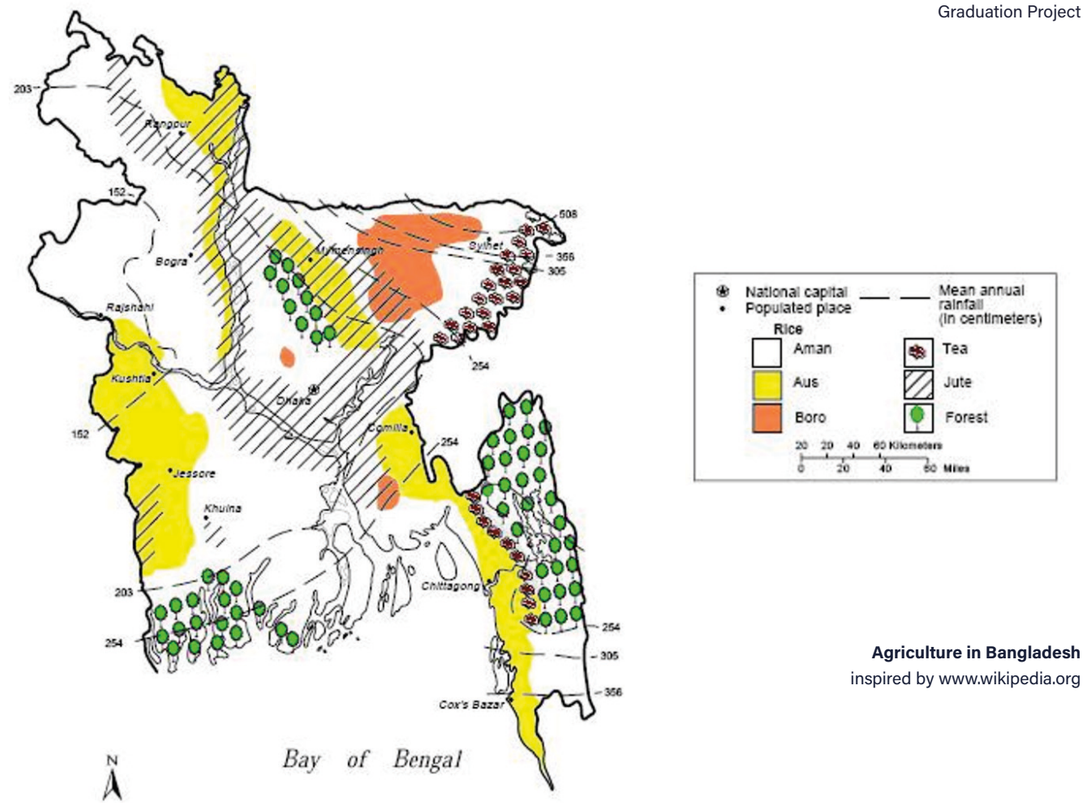
- financial instability

- lack of access to alternative income sources

**Family of Farmers in The Haors**
by author








**Agriculture in Bangladesh**
inspired by www.wikipedia.org



# Climate Change Effects on Housing and Agriculture in Bangladesh

*"Overcoming barriers to adapt rice farming to reoccuring flash floods in haor wetlands of Bangladesh"*

**Author** : Smita D. Baishakhy
Mohammad A. Islam
Md. Kamruzzaman

**Year** : 2023

Climate change increases the frequency and severity of extreme weather events, disproportionately affecting rural regions. Baishakhy, Islam, and Kamruzzaman (2023) illustrate how climate change is increasing the frequency of flash flood events that cause farmers to lose up to 80% of their crops at a time.

**Barriers hindering farmers from adapting to changing climate conditions:**

- Lack of availability of submergence-tolerant rice variety
- Lack of access to knowledge
- Lack of training facilities
- Lack of alternative income sources
- Lack of proper storage facilities for the crops that are resistant to floods
- Inadequate drying places for the harvest





# Socio-Economic Vulnerabilities of Rural Communities

*"Flood-tolerant rice improves climate resilience, profitability, and household consumption in Bangladesh"*

**Author** : Subir Bairagi
Humnath Bhandari
Subrata K. Das
Samarendu Mohanty

**Year** : 2021

Baishakhy, Islam, and Kamruzzaman (2023) identified several vulnerabilities faced by rural farmers in Banglades. These include limited access to flood-resistant crop varieties, inadequate training in climate change-resilient farming practices, and lack of sufficient storage facilities that protect crops during floods. These factors weaken agricultural productivity and increase economic instability, often resulting in migration to urban areas as outlined by Rana and Ilina in Climate change and migration impacts on cities: Lessons from Bangladesh (Rana, 2021). The literature points to a clear need for interventions that stabilize rural economies and enhance resilience to climate change. This research addresses the need for an approach that enhances both housing and farming resilience with the goal of creating economically independent rural communities less vulnerable to migration pressures.

*Density in Urban Areas*

**Resulting Challenges in Urban Areas**

- rapidly growing cities

- overpopulation of urban areas

- formation of informal urban settlements

- decrease of living quality
  + noise- and air- polution
  + extreme density

- insufficient infrastructures

- loss of rural living qualities

**Informal Settlement in Dhaka**
by author



# Urbanization and Rural-Urban Migration

*"The New Landscape: Urbanisation in the Third World*

**Author** : Charles Correa
**Year** : 1989

In The New Landscape (1989) Charles Correa offers fundamental insights into urbanization patterns in developing countries, coherent with the developments in Bangladesh. He identifies economic instability as a significant driver of rural-urban migration. He describes how this process often results in informal settlements, where living standards remain low, and offers alternative urban design strategies to integrate migrating people into the urban fabric. Correa's work suggests that creating job opportunities in rural areas could slow migration by addressing poverty at its origin.

*"Climate change and migration impacts on cities: Lessons from Bangladesh"*

**Authors** : Md Masud P. Rana
Irina N. Ilina
**Year** : 2021

Rana and Ilina expand on this by examining how climate-induced migration transforms rural poverty into urban poverty by leading into informal urban settlements with a lack of access to essential resources and infrastructures. They state a clear causality between extreme weather events and waves of migration. This suggests the need of rural resilience to reduce pressures on urban areas.

**Street in Dhaka**
by author

*Loss of Rural Living Qualities*

**Present Rural Living Qualities**

- community based living
  --> connection between members of extended families

- space for farming & gardening
  --> self-sufficient food supply

- open landscape

- good air quality

- room for expansions







# Relevance

*Subtitle*

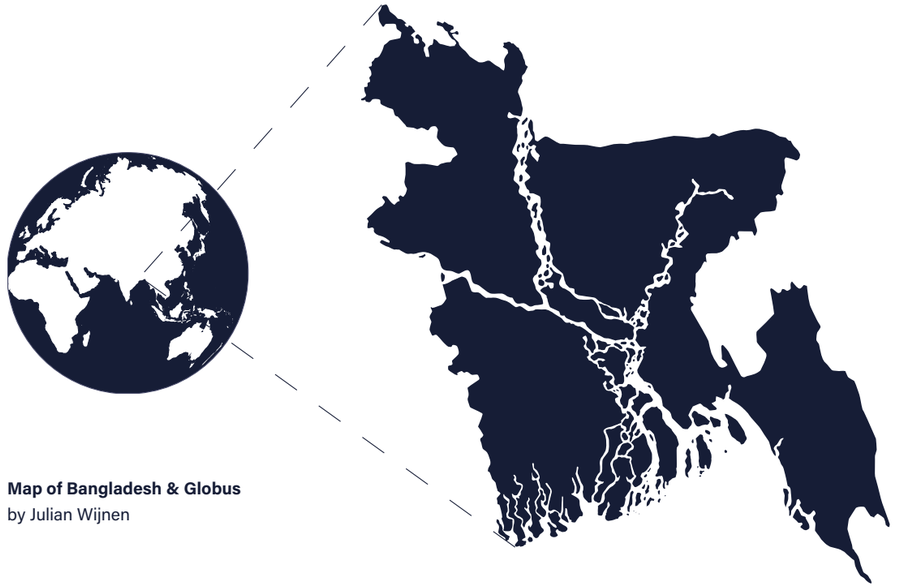
*„Across the globe, the towns and cities of the Third World are growing very rapidly.*

*In most Third World countries, the annual population growth rate is somewhere between 2 to 3%, but the towns and cities themselves are increasing in more than double this speed.*

*This growth is compounded by the great waves of distress migration from rural areas where farmlands cannot sustain the population.“*

- Charles Correa, 1989,
The New Landscape: Urbanisation in the Third World

This research addresses the immediate and long-term impacts of climate change on rural migration in Bangladesh. While Bangladesh faces specific challenges, the research outcomes may be applicable to similar flood-prone regions. By providing rural communities with sustainable alternatives to migration, the study offers potential benefits for urban centres, which are struggling to accommodate growing populations in resource-constrained environments. This approach aligns with global efforts to create sustainable, climate-resilient models for rural areas affected by climate-induced migration.



**Map of Bangladesh & Globus**
by Julian Wijnen

# Initial Research Question

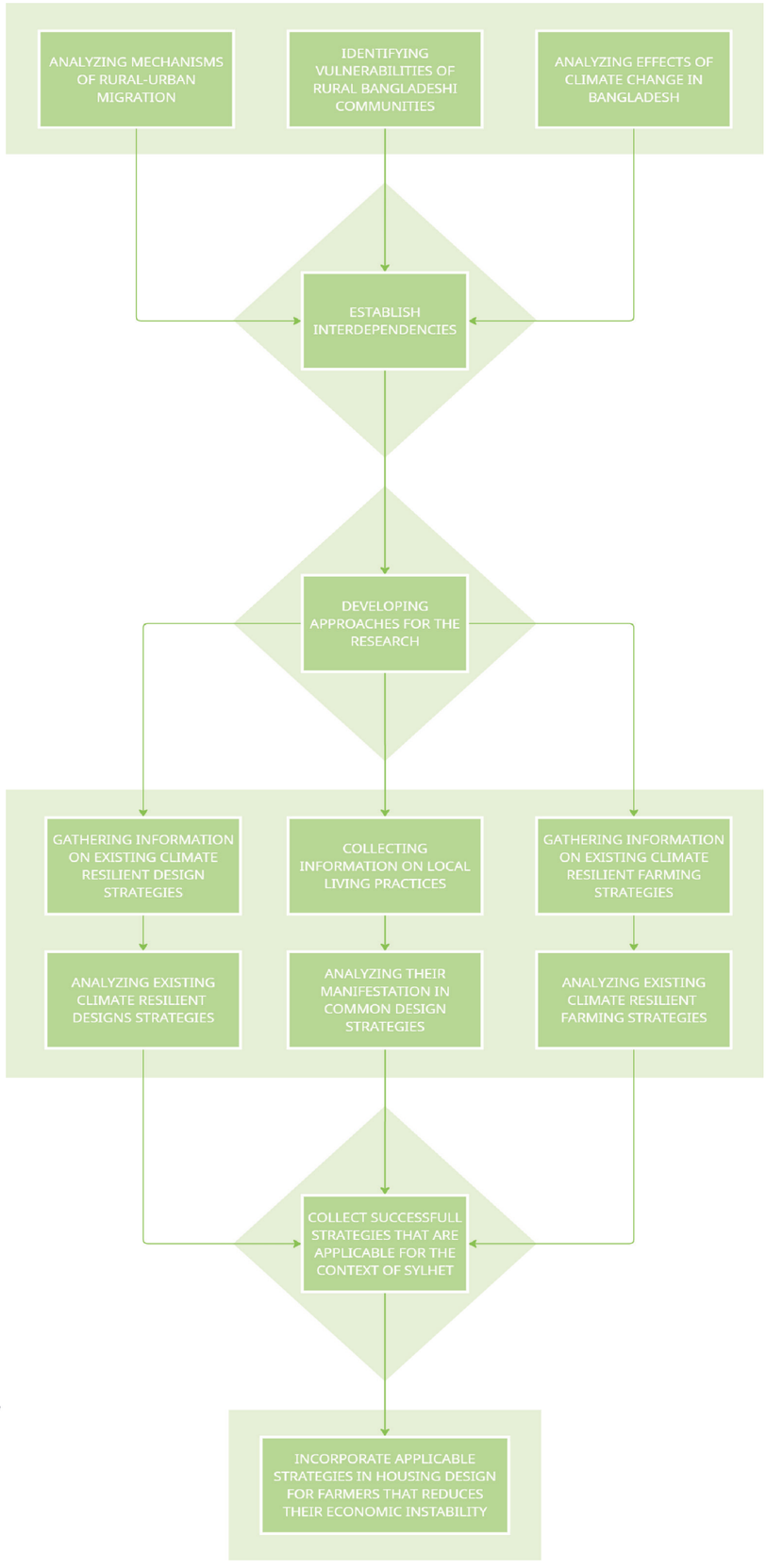
How can housing in rural Sylhet integrate **climate change-resilient** design and farming strategies to enhance the **economic stability** of local farmers and reduce migration pressures while respecting **traditional living practices**?

*1. Which climate-resilient housing and farming strategies are currently in use and which strategies from other regions could be adapted for this area?*

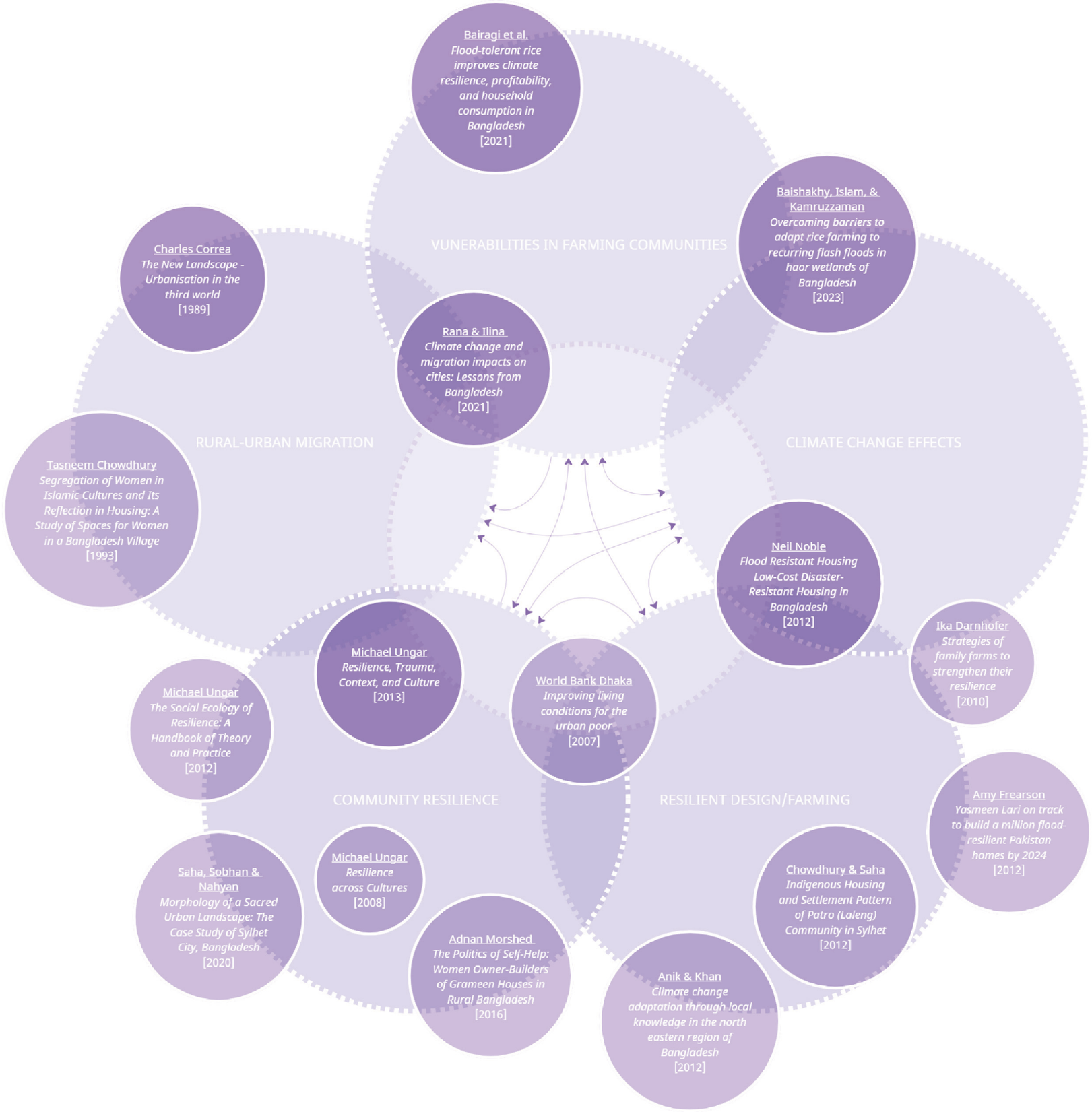
*2. How can these strategies be combined into a sustainable housing design that respects existing living practices and mitigates the risks posed by flash floods?*

*3. Which additional infrastructures can be incorporated to support the economic stability of local farmers?*

The literature relevant to this research highlights the interconnected issues of climate induced rural-urban migration and economic vulnerability in agricultural communities. Additionally, multiple sources provide insights into resilient housing and farming strategies that counter the impact of flooding events.




**Research Scheme**
by author




**Theoretical Framework**
by author

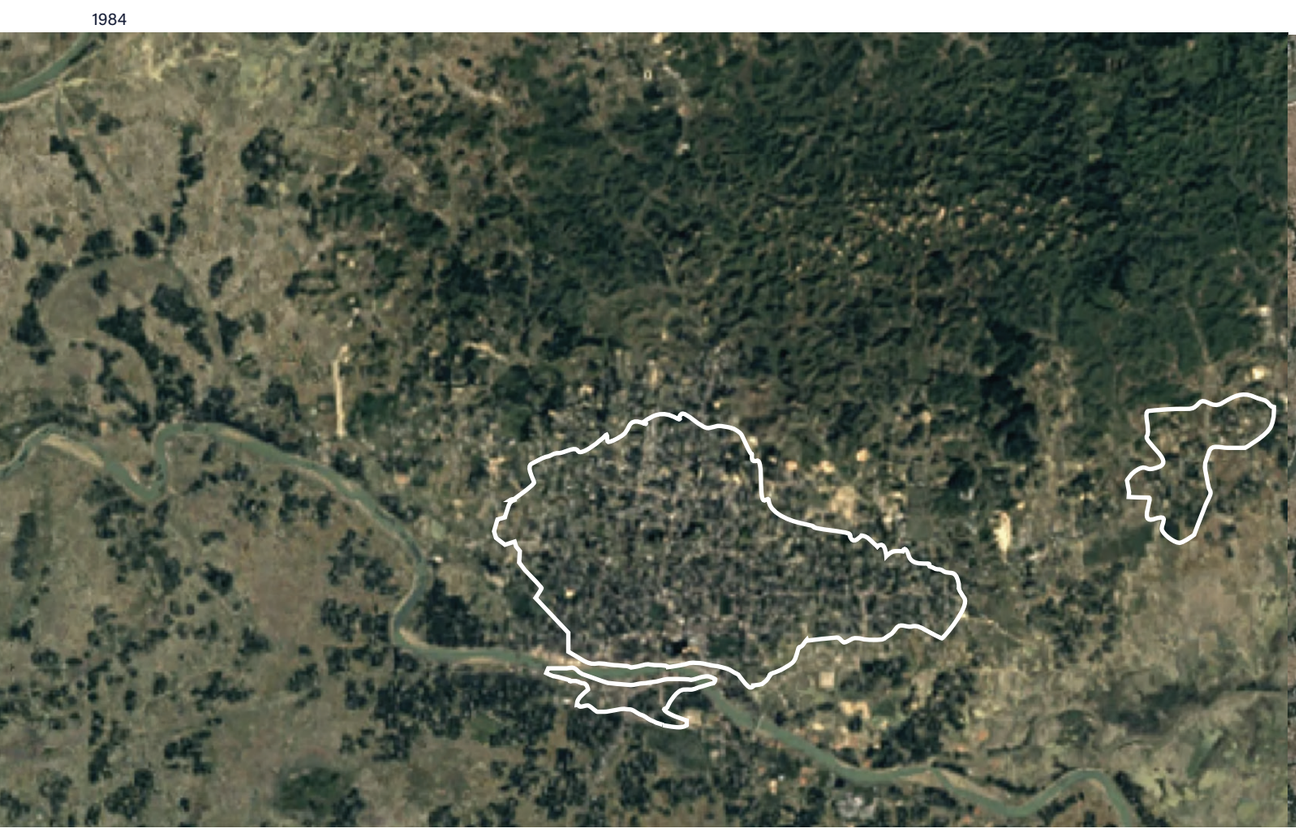
# Specific Problem Statement

*Developments in Sylhet*

Since 1984 the urban fabric of Sylhet City has been continuously expanding, coherent with the trent of urbanisation in Bangladesh. Due to this documented steady development it can be assumed that the city will continue to expand further in the coming decades. This development will affect the currently adjacent rural areas.




**Expansion of Sylhet City Over Time**
by author, on basis of timeplaps on www.googlemaps.com






# Change of Research Question

As part of the research process each year the students and mentors of the Global Housing studio take a collective trip to the country where the project takes place. This trip takes crucial part in the process of gaining knowledge about the living practices and present challenges in a country that is situated in such a different context for students that usually design in the middle-european landscape.

This academic year, due to political riots during summer and autumn of 2024, the research trip, originally scheduled for october 2024, got delayed to december. This development strongly affected the research phase of the studio, as a majority of the research had to take place before we were able to gain any first-hand impressions of the context that we were dealing with. Especially aspects like the scale of pressing flood risks, the density of cities and the reality of present practices of life were hard to grasp from the distance. Therefore, the proposed approach for my thesis that I presented with the research plan did not yet manage to grasp the essence of the present life realities we were presented with when actually visiting Bangladesh. Nevertheless, the research that we did beforehand offered a great base and allowed me to ask more specific questions when visiting the actual site. Especially when working in a context so different it is crucial to take sufficient time to try to grasp present living practices and social interrelations between different societal groups.

Another aspect that drastically influenced the focus of my research was the choice of site which changed location after visiting the periphery of Sylhet city. My initial interest was focused on rural living practices of farmers and their vulnerability to flash flood events in the rural context. I was focused on developing housing strategies that could decrease the damage of these flood events on crops and houses in the rural context and thereby reduce migration pressures to the cities. This initial approach was based on the idea of choosing a location in a more remote context, not spatially connected to the urban context of Sylhet city.

This approach drastically changed during the field trip due to the impression I could gather while visiting Sylhet and the adjacent rural areas. One very prominent aspect of the living reality in Sylhet is its relatively calm character when compared to Dhaka. Sylhet is in a far ealier stage of its urbanisation and densification development, which creates oportunities for the development of strategies to guide the future urbanisation process of the city, which I could not foresee during my research from the Netherlands. Different than in Dhaka, the challenge is not to try to keep people from migrating into an already over-populated city, but rather to find strategies that allow the city to grow while maintaining some of its smaller-scale city qualities and integrating certain rural life qualities.

Therefore, after visiting Shonatola, a village adjacent to a new highway connected to Sylhet city, I shifted my research topic towards developing a project that would incorporate present rural living qualities of the adjacent communities, while reacting to the present urbanisation tendencies and leading the way towards a promising city development.

Nevertheless, eventhough my research topic changed after the field trip, I could repurpose a majority of my obducted research from before for the new research topic, as I could identify farmers as one of the primary target groups of the project.

One aspect of my research that had a strong influence on my later design was the information that I gathered on present flood risks, its affects on the financial stability of many rural populations in Bangladesh and possible strategies to protect dwellings, cattle and crops from rising flood levels. In consequence, my project offers a variety of flood-protected storage oportunities for crops, shelter oportunities for the members of adjactent rural communities and livestock of the residents of the project. Furthermore the project utilises a stilt-structure to project the houses from rising water-levels while guaranteeing that the newly built structure does not increase the flood-risk for existing villages in the area.

The majority of my insights into present living practices I gained through house-visits and informal interviews with residents during our time in Bangladesh. Being able to visit a variety of city apartments and houses in more rural areas helped a lot to understand typical dwelling layouts and the importance of integrated outdoor spaces for instance. Also the density within private spaces of lower income groups was quite impressive and hard to anticipate before taking the trip to Bangladesh. Furthermore, the field trip allowed me to gain valuable insights into typical layouts of rural neighbourhoods, where houses are ofte clustered around communally used courtyards, often catering members of one extended family. These patterns of life were impossible to observe before the trip to Bangladesh as the informality of its character leads to these situations not being properly documented yet.

Additionally, during my field research it became very clear to me that cities in Bangladesh contain many informally created spaces that create a very prominent vibrancy. It became apparent to me that many residents face challenges of low income and low financial stability, which lead to rather low starting capitals for new investments. Therefore, many residential areas showed signs of spatial expansions over time. These observations informed the design strategy for my project which allows room for future expansions and offers a variety of spaces for flexible use depending on the users' needs.

# Adapted Research Question

How can **rural areas** of Sylhet be transformed according to the trend of **rural-urban transition** while maintaining crucial l**iving qualities** of rural populations?

*1. Which climate-resilient housing strategies are currently in use and which strategies from other regions could be adapted for this area?*

*2. How can these strategies be combined into a sustainable housing design that respects existing living practices and mitigates the risks posed by flash floods?*

*3. Which additional infrastructures can be incorporated to support the economic stability of local rural populations?*

*Goal:*

Creating a pilot project which can **guide the future urban development** of Sylhet during the process of its expansion.

# SITE

# Area of Interest

*Rural Area North West of Sylhet City*

To investigate possible effects of the ongoing trend of urbanisation on rural areas close to Sylhet city this project focusses on the rural area north-west of the city. There a newly built highway is expected to catalyse a trransformation process. This will affect the currently present villages. As one of these villages the Shonatola village will be examined further



**Rural Area Adjacent to Sylhet City**
by author, on basis of timeplaps on www.googlemaps.com





# Site Analysis

*Shonatola Village*

22 ha FARMLAND

SCHOOL

MOSQUE

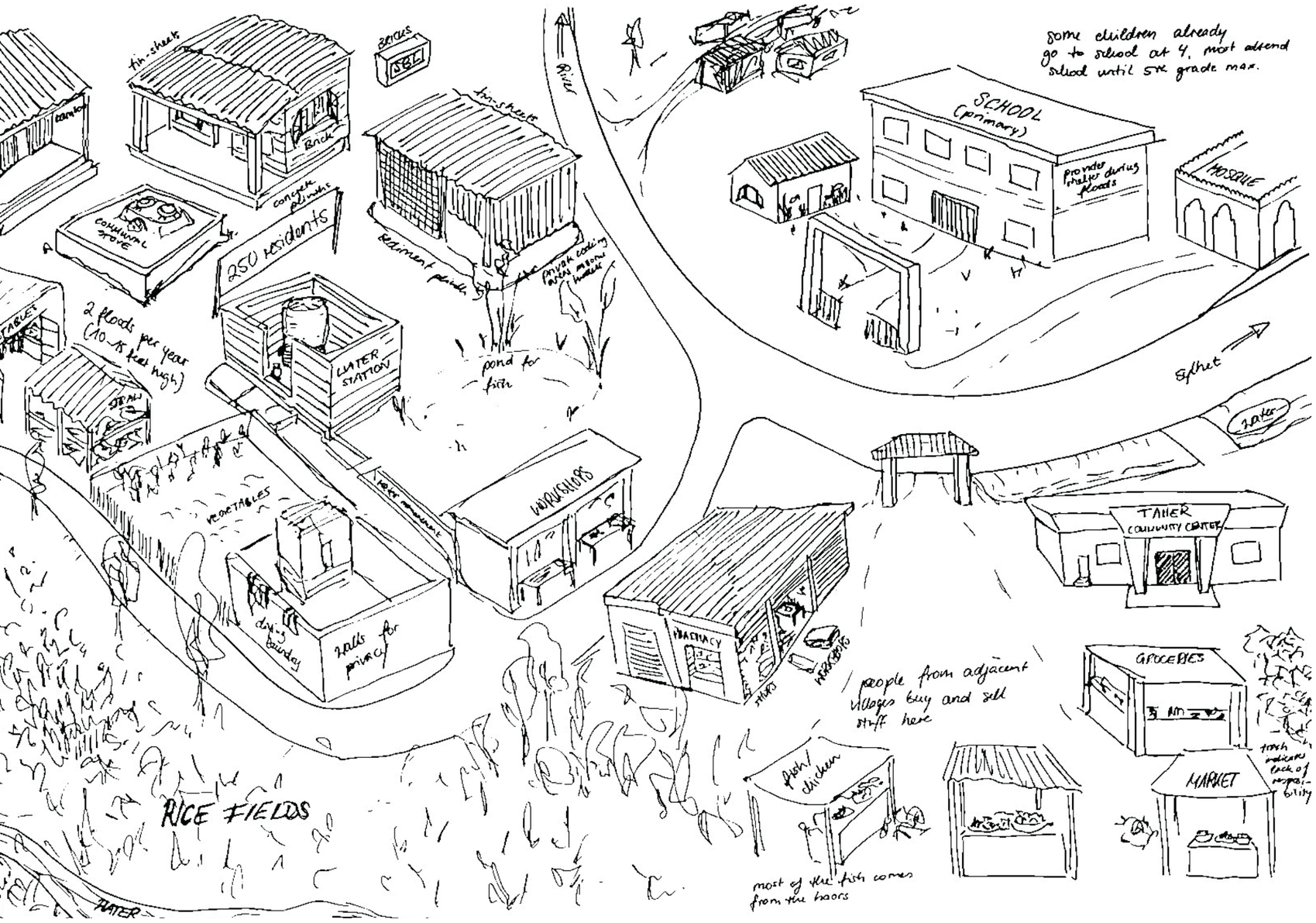
SHONATOLA VILLAGE:
284 DWELLINGS
6-8 RESIDENTS/HOUSE

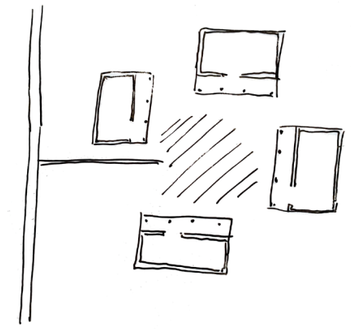
MOSQUE

BAZAR

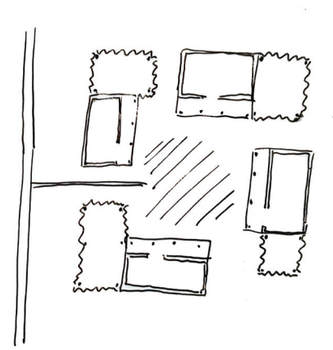
# Research by Field Work

*Shonatola Village*



clusters around courtyards



space for incremental growth



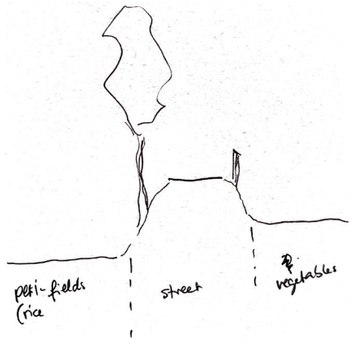
verandas as intermediate spaces



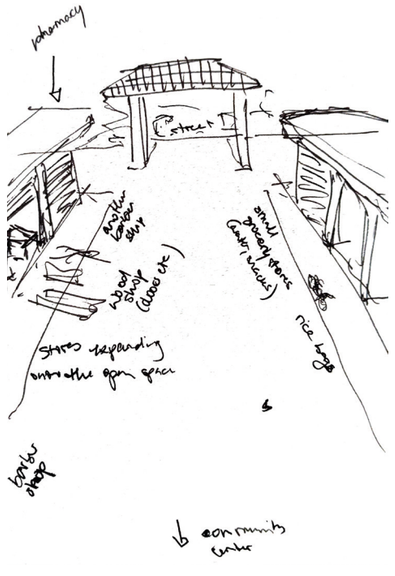


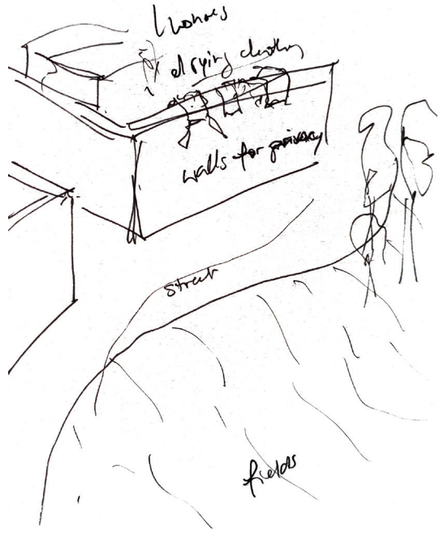


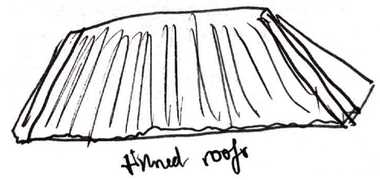


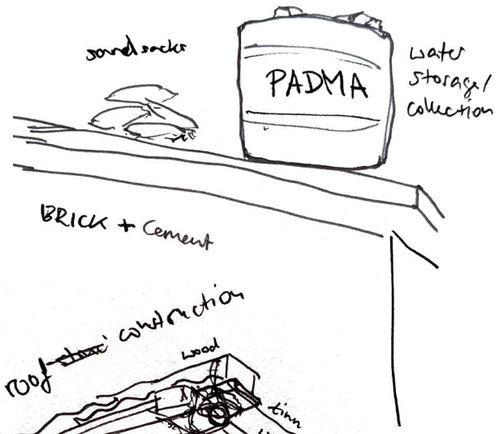



Expanded onto the street



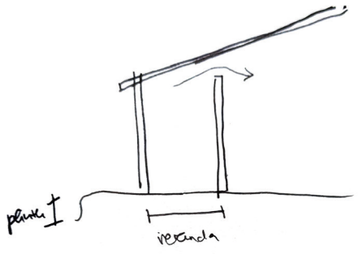










traditional building tactics ensuring sufficient ventilation













Collective; ~~attached to another~~



clusters around courtyards



verandas as intermediate spaces



expansions over time



adjacent farming areas



spaces for vegetables



integrated gardening areas



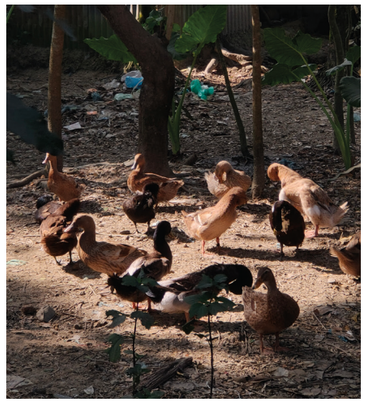
vertical use of space



minimal indoor spaces



one bed for three people



free walking ducks and chickens



incorporated spaces for cattle



integrated spaces for doves



natural ventilation



light structures of bamboo and tin sheets



more durable structures of brick and concrete



cow dung used for fires



integrated spaces for storage of hay



areas to grow bamboo



rainwater collection on roofs



water drainage system



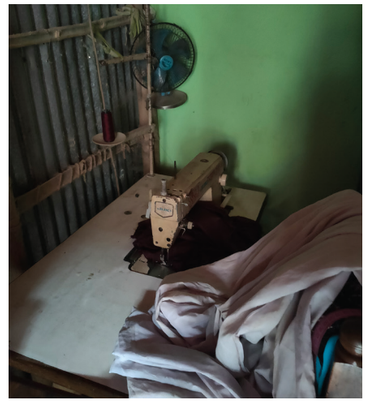
ponds for washing and as gathering spaces



small shops adjacent to access routes



craftmanship as form of income



sewing as source of income



collective water pumps




water tanks for cooking and washing



small water tanks for daily use



adjacent bazar offers space for varying shops



workshop spaces for woodwork and others




pharmacy and other infrastructures present



stoves made of clay



private indoor stoves



collective outdoor cooking areas




rice store generating income

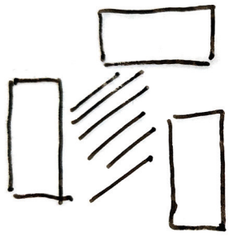


hair dresser generating income




bakery generating income

# Design Strategies in Shonatola



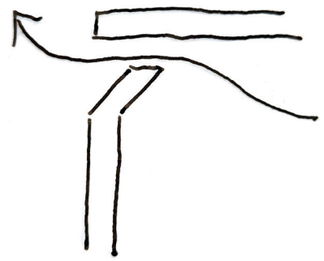
clustering



space for incremental growth



vertical use of space



natural ventilation




# Present Flood Risk

*Shonatola Village*

**- area floods 2-3 times per year**

**- flood-level of up to 1.5 m**

**- houses not usable for 2-3 weeks**

**- only available shelter: small school nearby**

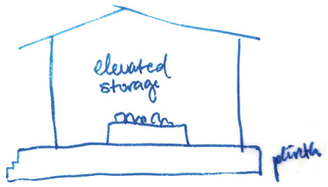
SCHOOL

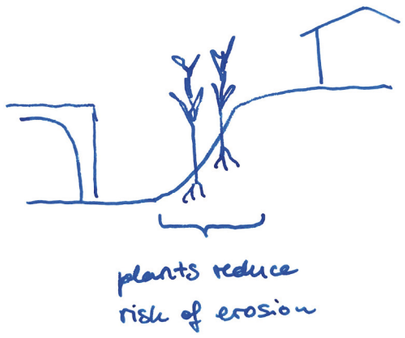
# Flood Resilient Housing Strategies

*“Flood Resistant Housing: Low-Cost Disaster-Resistant Housing in Bangladesh”*

**Author** : Neil Noble
**Year** : 2012

Neil Noble (2012) documents existing design strategies used in traditional Bangladeshi housing to mitigate the effects of regular flooding levels, such as elevated storage spaces a plinths that raise buildings by 30-40 cm. He also describes how erosion resistant plants like bamboo and banana are planted around buildings to prevent soil erosions. However, according to Noble, these strategies are often insufficient to protect against severe flash floods. He suggests that the incorporation of additional measures such as using more durable materials and increasing elevation, could improve housing resilience. Noble also proposes creating bigger areas of elevated land to create connected islands.






plinth

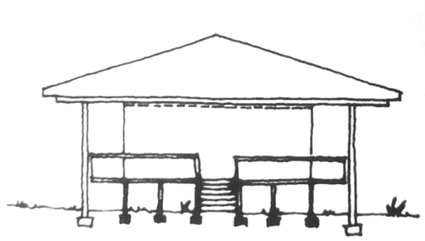


elevated land



building on stilts

While plinths often do not offer enough height to provide sufficient protection from rising flood levels, elevating a whole area quickly increases flood risks for adjacent areas. Therefore, for this project using the third tactic of elevating the built structure on stilts offers the most suitable solution.



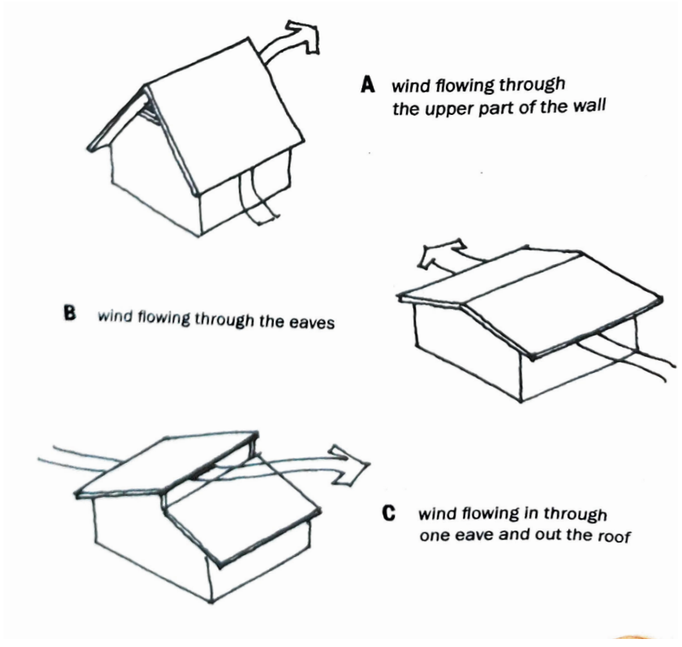
vertical use of space

# Climate Specific Design Strategies

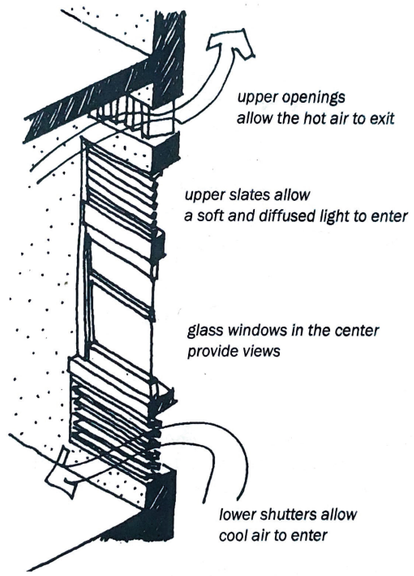
*"The Barefoot Architect"*

**Author** : Johan van Lengen
**Year** : 2008

Lengen hightlights many crucial strategies for housing design in different climates. In humid climates sufficient ventilation is one of the core aspects which guarantee a healthy indoor climate and the prevention of development of mold. Lengen presents multiple strategies to provide sufficient ventilation, such as gaps between walls and roof, differences in room heights to allow air flow and last but not least openings adjacent to windows which allow constant passive ventilation.

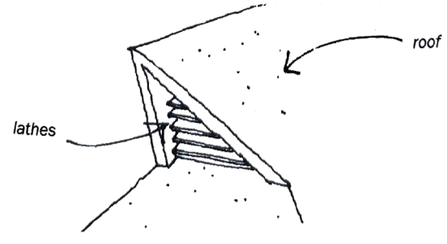



Besides providing a softer and more diffused light, this type of window ventilates the spaces. This window can be made the following way:

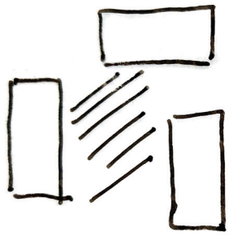



*section of a window in an urban setting where there is less dust as the roads are paved*

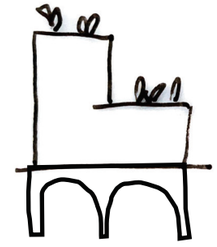
The ventilation opening can be partly closed with wood lathes or louvers, angled to prevent the rain from entering.



# DESIGN PRINCIPLES



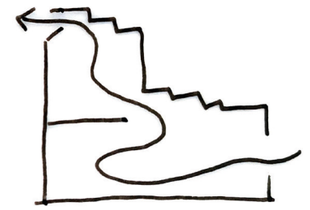
clustering



vertical use of space



space for incremental growth



natural ventilation

# Vertical Use of Space

*Jintai Village Reconstruction*

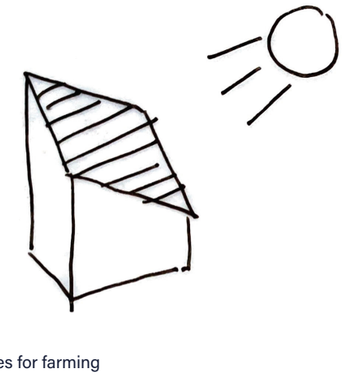




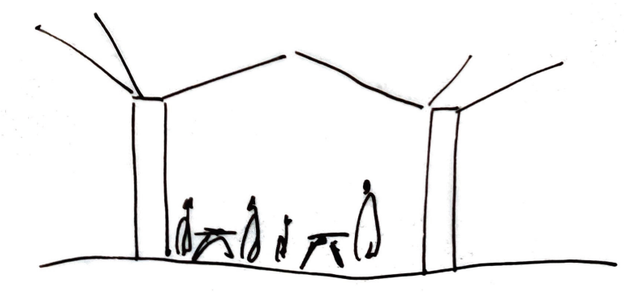


**Jintai Village Reconstruction**
By architectural review

**Name** : Jinai Village Reconstruction
**Location** : Jinai, China
**Architect** : Rural Urban Framework
**Year** : 2014



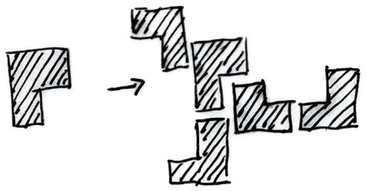
terrasses for farming



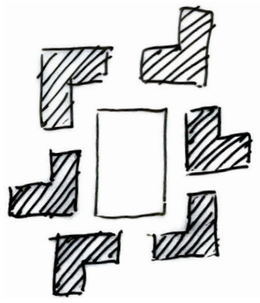
gathering spaces on level below

# Clustering

*CIDCO Housing Project*

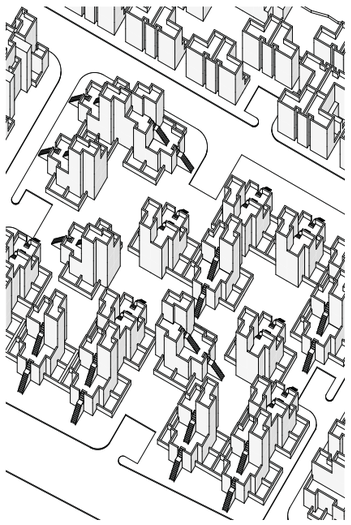


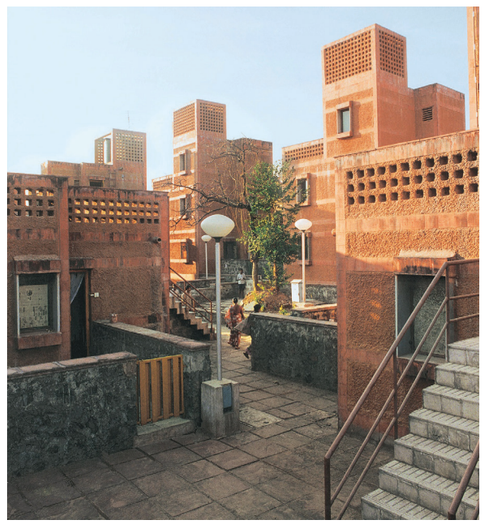
repitition of simple units

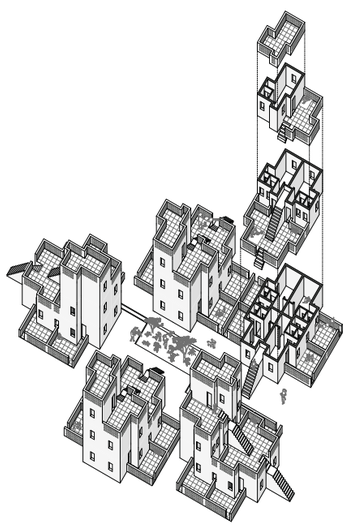


clusters arond courtyards

**Name** : CIDCO Housing Project
**Location** : Navi Mumbai, India
**Architect** : Raj Rewal
**Year** : 1993

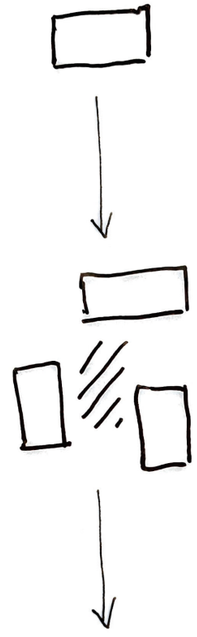






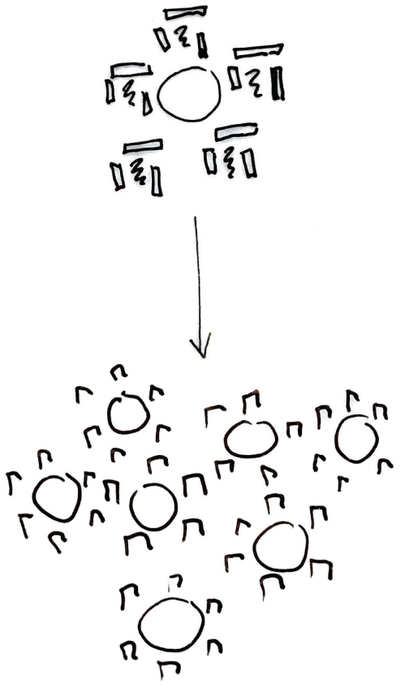






repeatable unit

cluster



community

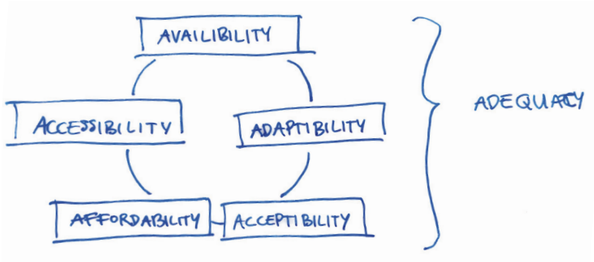
network



# UNIT

# Target Groups & their Needs

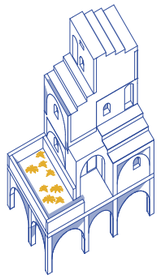
*Importance of Adaptability*



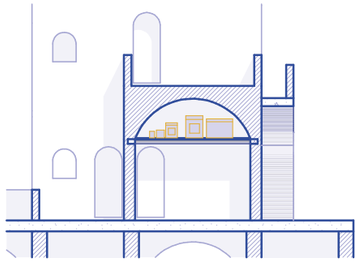



retired couples

+ good accessibility, close to the city
+ more calm than in city center
+ reduced car traffic enhances living qualities
+ space for gardening activities
+ extended family can live nearby



gardening

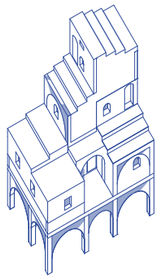


storage space

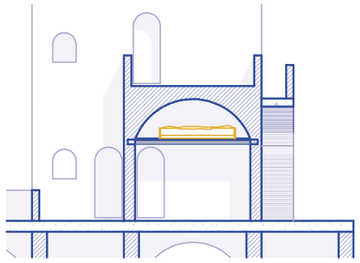


young families

+ access to the city for job opportunities
+ possibilities for icome generation
+ room for expansion when familiy grows
+ room for expansions with increasing income
+ reduced car traffic enhances living qualities



expansion of built space

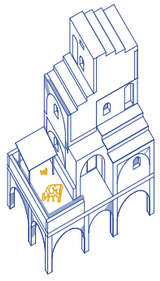


extra sleeping space

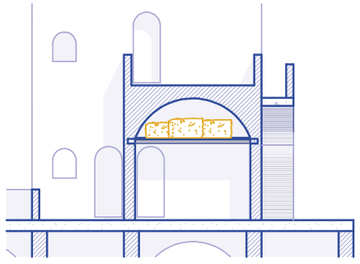


farmers

+ access to the city for job opportunities
+ possibilities for alternative icome sources (e.g. market)
+ integrated strategies for protection of farming practices
+ adaptable spaces for changing income sources
+ flood resistant storage spaces for crops



shelter for cattle & chickens



dry storage for crops

# Rooftop farming in Dhaka

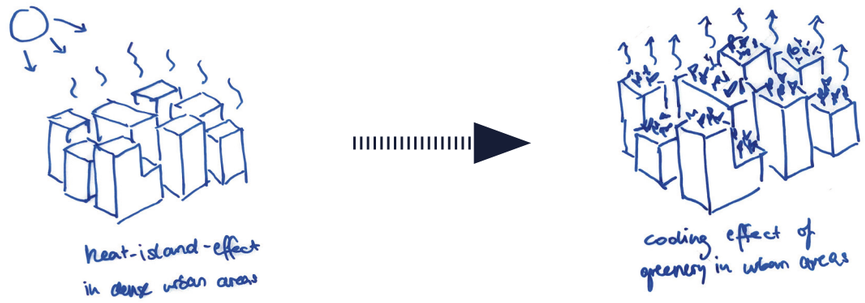
*"Present Practice and Future Prospect of Rooftop Farming in Dhaka city: A Step Towards Urban Sustainability"*

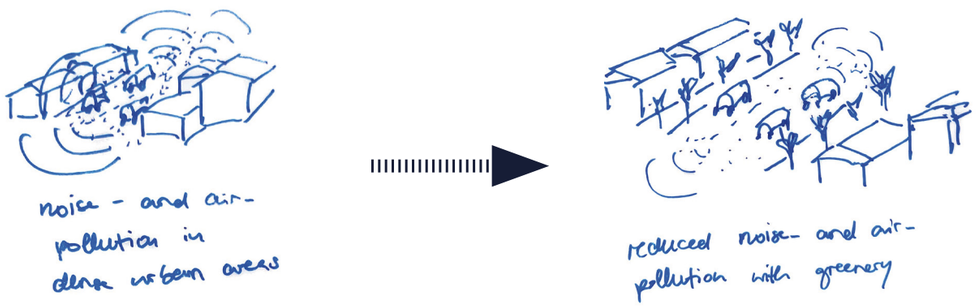
**Author** : Mastura Safayet
Md. Faqrul Arefin
Md. Musleh U. Hasan

**Year** : 2017

This case study investigated the benefits of roof top gardens in Dhaka. According to the presented findings roof gardening can improve financial stability due to the support of constant food supply. This additional food supply is also an important aspect concerning the rapidly growing population and its increasing food demand. Furthermore dense cities with predominantly sealed surfaces create heat islands and therefore difficult living conditions in warm countries such as Bangladesh. Greenery can have a cooling affect on these areas. In addition plants can absorb poluting particles in the air and absorb sound which reduces noise- and air pollution. These effects can lead to destinctively improved living conditions, especially in extremely dense urban areas with high traffic activity and extreme noise pollution and poor air quality.




× financial benefit: $2 – $20
per sqm per month

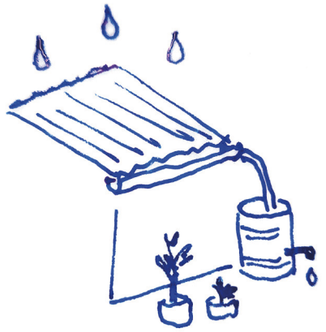
| | | | | |
|---|---|---|---|---|
| STAR FRUIT | TOMATO | CAULIFLOWER | SPINACH | POMEGRANATE |
| ASPARA PLANT | BRINJAL | LEMON PLANTS | MALTA | BANANA |
| CUCUMBER | BROCCOLI | CHILLI | ORANGE | BEAN |
| ONION | CABBAGE | GUAVA | AMLOKI | |

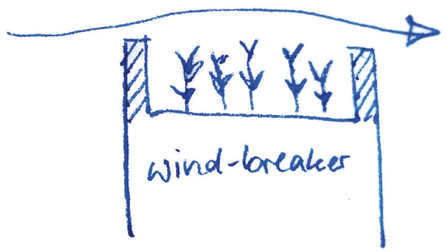
# Farming Strategies Included in the Design

This projects incorporates a variety of flood resistant farming strategies into its design to strengthen the financial stability of local farming communities. To protect crops from rising water levels the design includes areas which are elevated above flood level and can be used for farming purposes, at least to support the food supply for the daily demand of a household. Furthermore the design incorporates flood protected storage areas for crops, as insufficient storage spaces is one of the main issues farmers currently face in rural areas of Bangladesh.

Furthermore the project aims to support a sustainable cycle of ressources as organic waste and fibres can be used in locally present construction methods and materials.

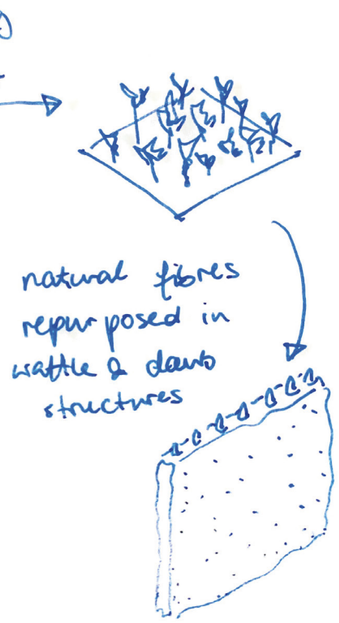
Lastly the project makes use of the present amount of rainwater and offers wind-protected gardening areas.

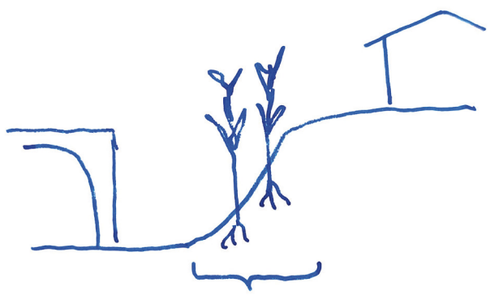


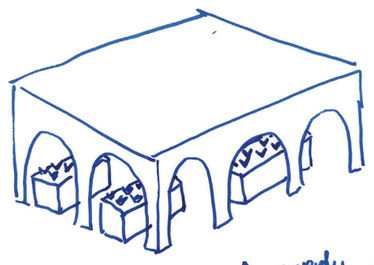





space for cattle



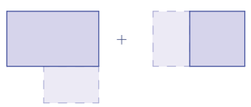




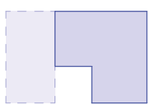


# Variation in Unit Size

*Space for Incremental Growth*



**unit B:** 53,5 m2 + 27 m2 expansion area

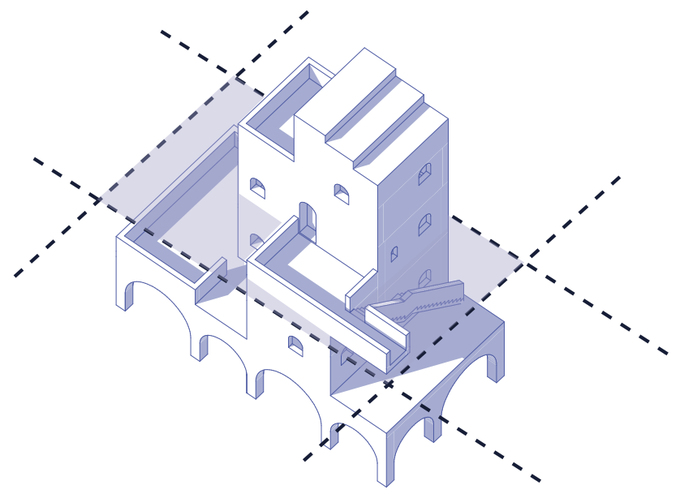


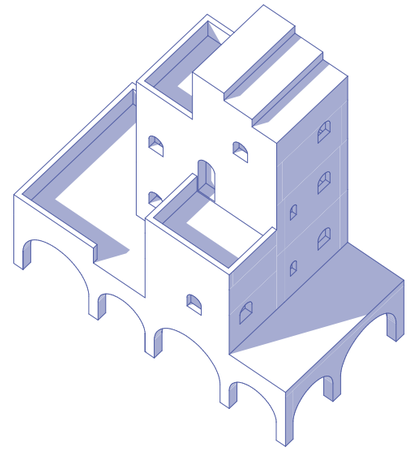
**unit A:** 47 m2 + 30 m2 expansion area

**POSSIBLE TRANSFORMATION INTO SINGLE UNIT**



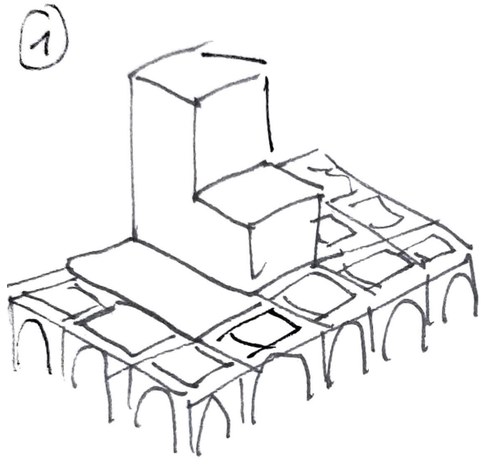
**unit C:** 100,5 m2 + 57 m2 expansion area





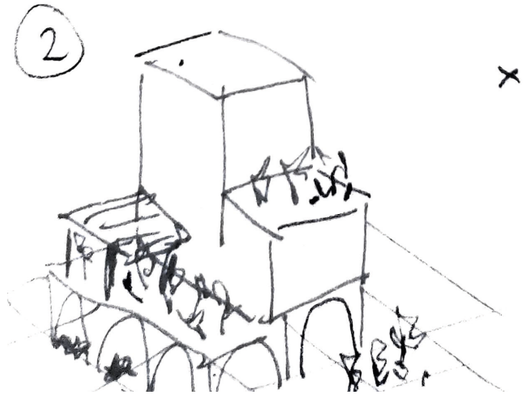
# Incremental Growth

*Development over time*

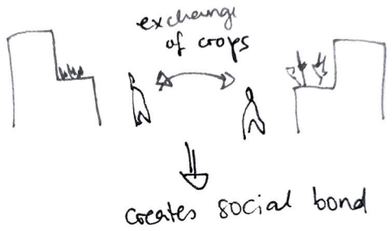


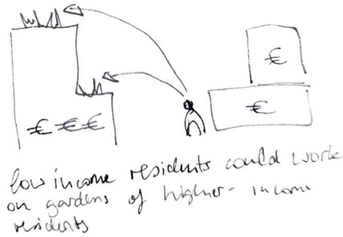
x providing the basics
→ flood-resistance
→ access system
→ necessary amenities (toilet, kitchen)

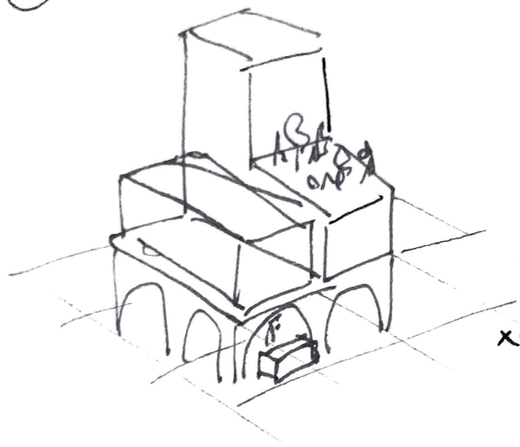
→ spaces for flexible use / incremental growth



x space for agricultural uses to support farming activities
→ shelter for animals during floods
→ storage for crops



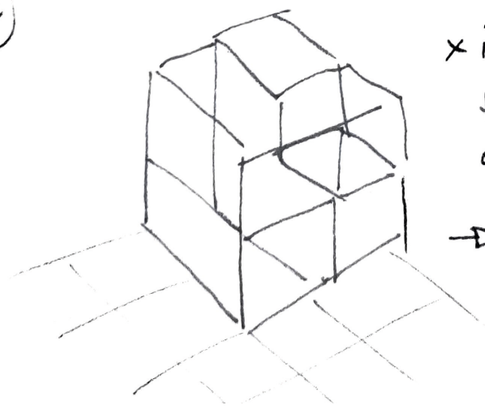



x incremental growth
→ expansion of living space (when family grows etc.)

x still allowing farming activities to support food supply

x supporting other income-sources



x increasing density thanks to incremental growth

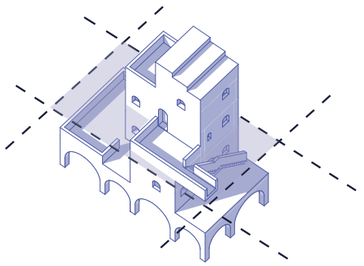
→ development coherent with urbanization of the area

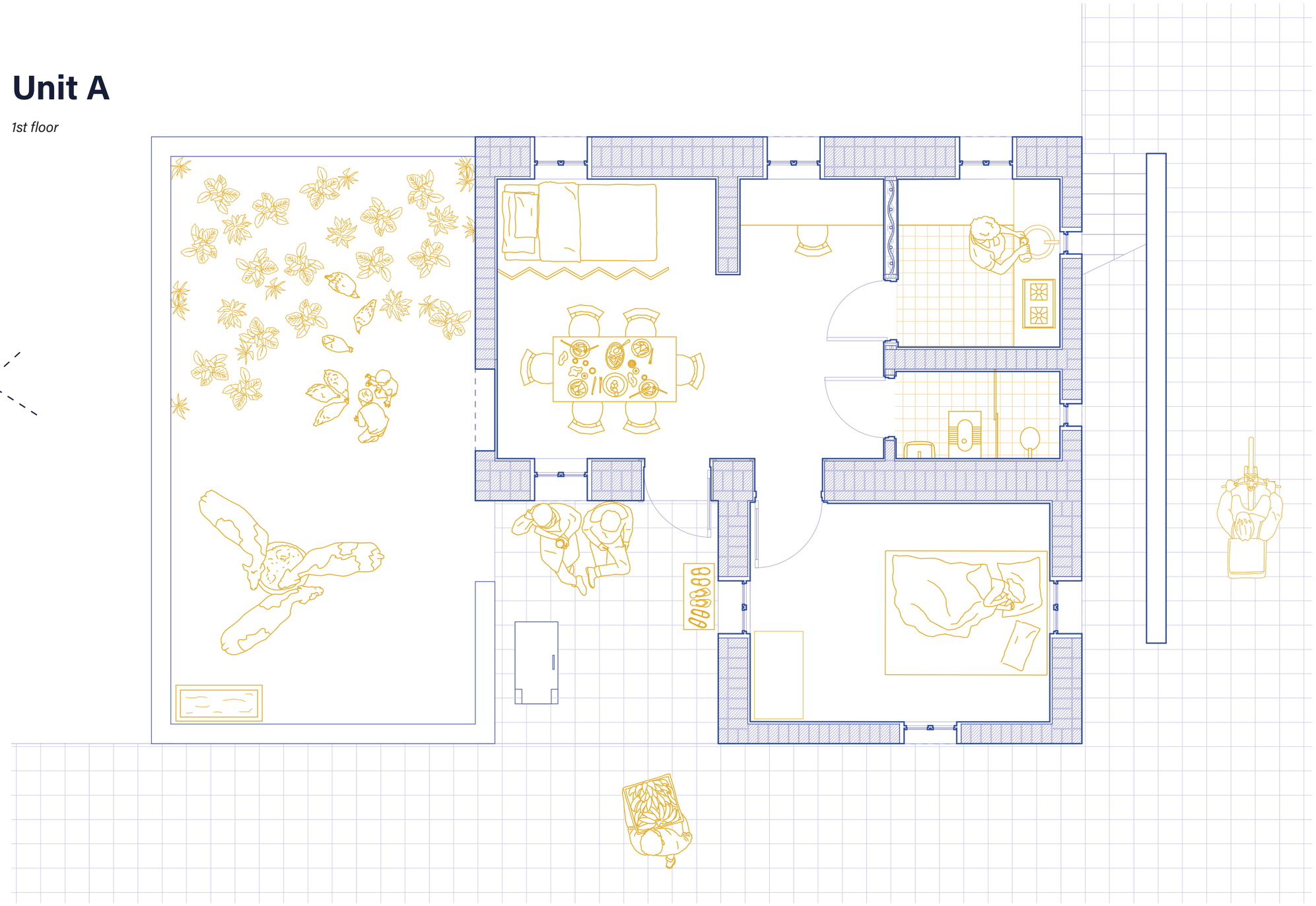
# Unit A

*1st floor*



47 m2 + 30 m2 expansion area

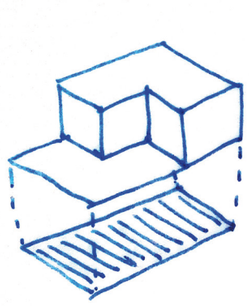




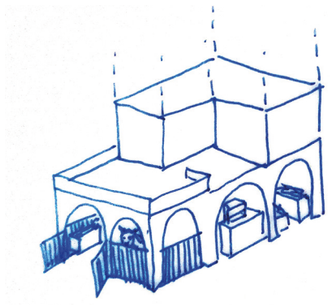
10 cm

# Temporary Plot

*Privately owned plot on groundfloor*

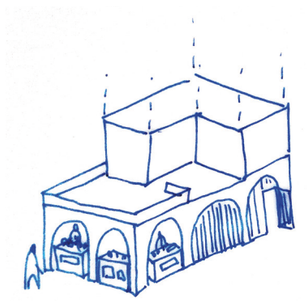


PRIVATE PLOT BELOW EACH UNIT



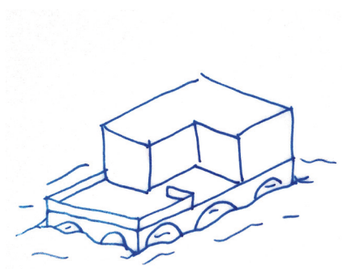
SCENARIO 1:

SHELTER FOR CATTLE + WORKSHOP SPACE



SCENARIO 2:

SHOP + STORAGE SPACE



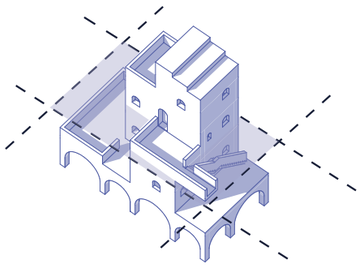
SCENARIO 2:

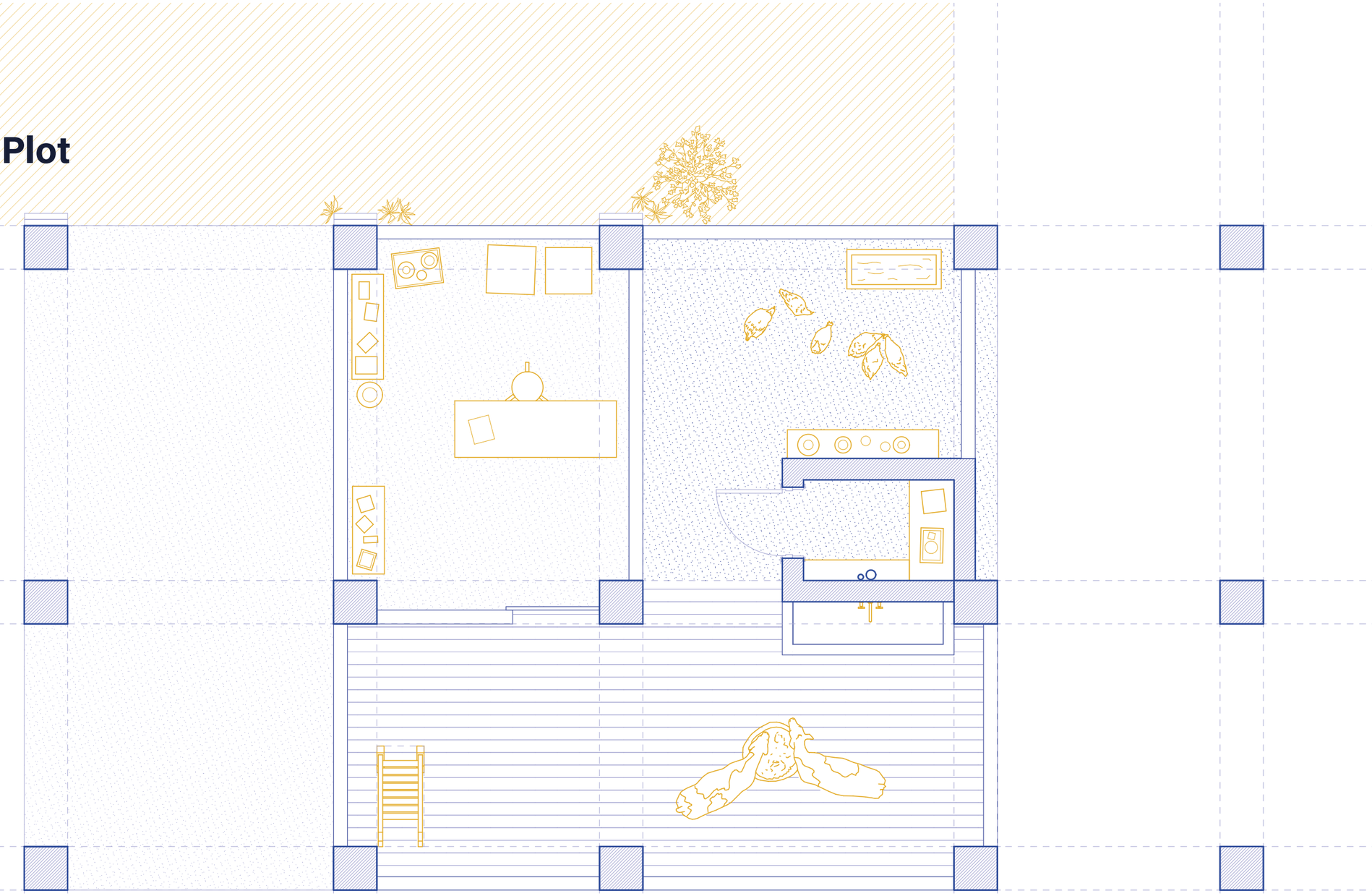
FLOOD SEASON

# Temporary Plot

*usable during dry season*

77 m2 flexible space

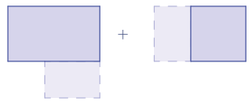




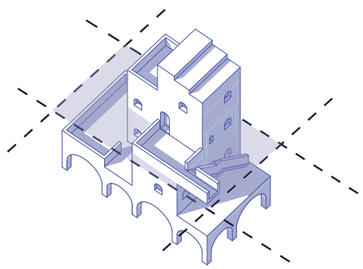
10 cm

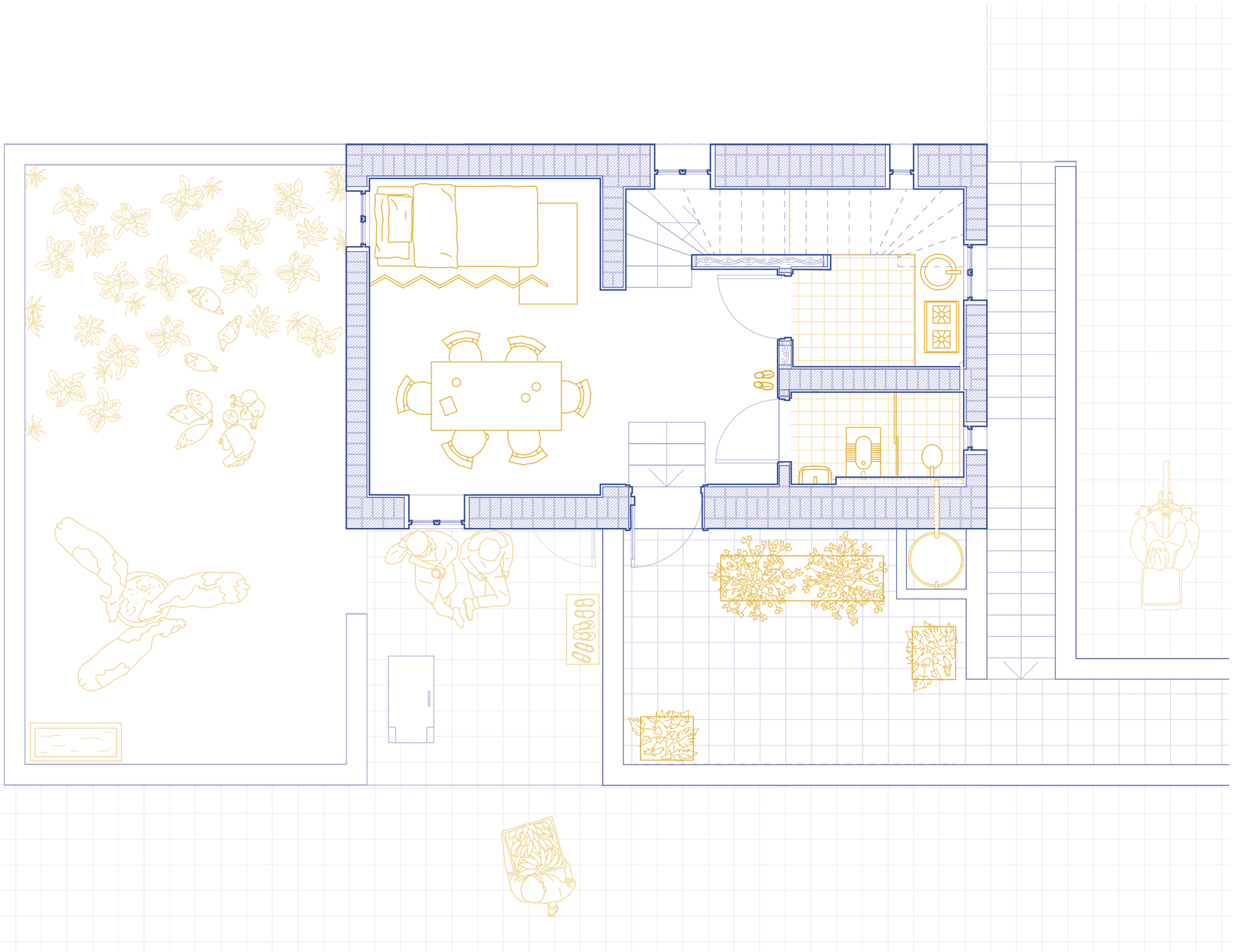
# Unit B

*2nd & 3rd floor*

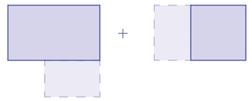


53,5 m2 + 27 m2 expansion area

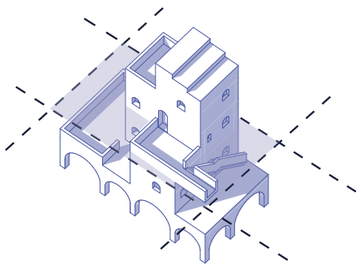


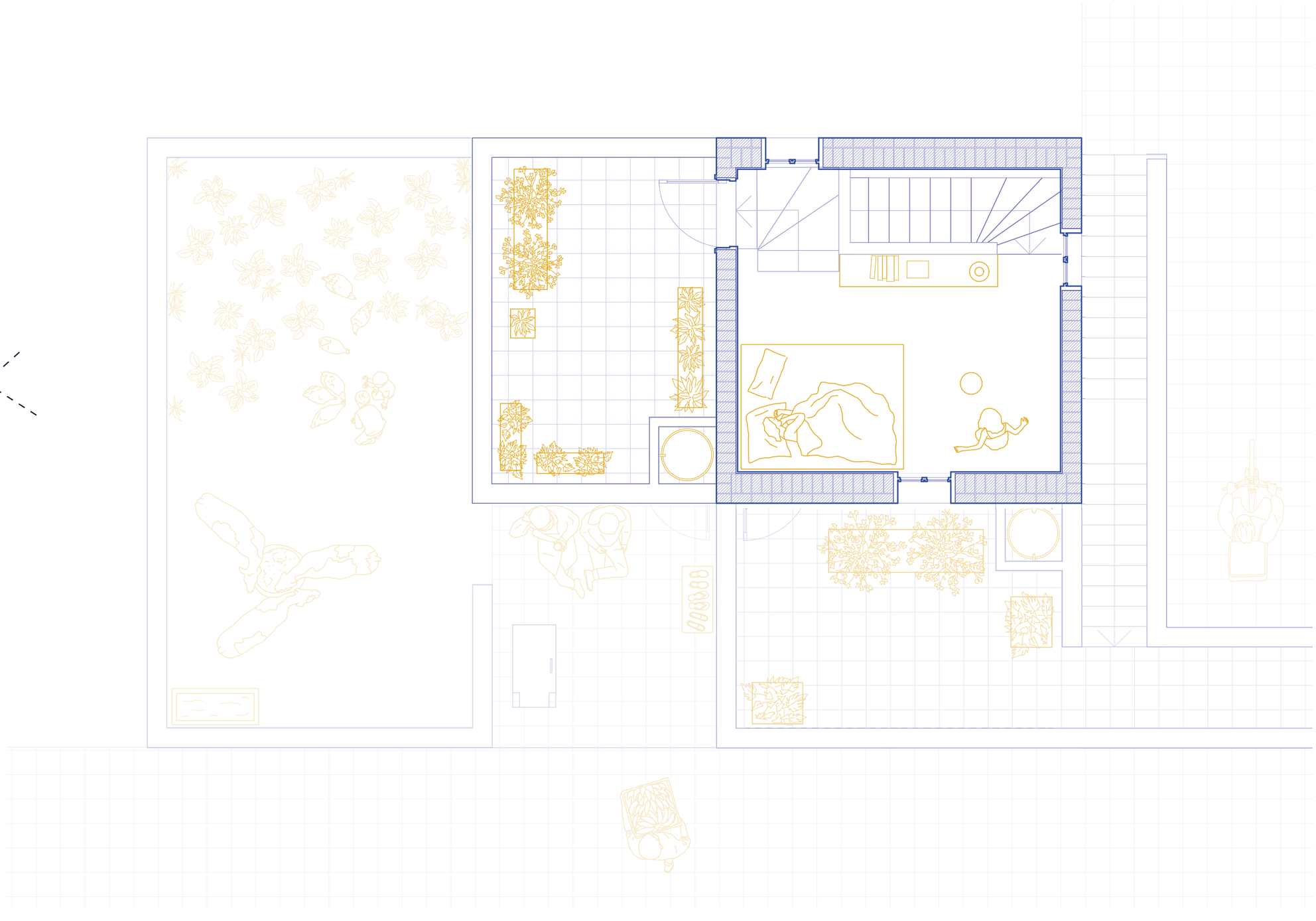


10 cm

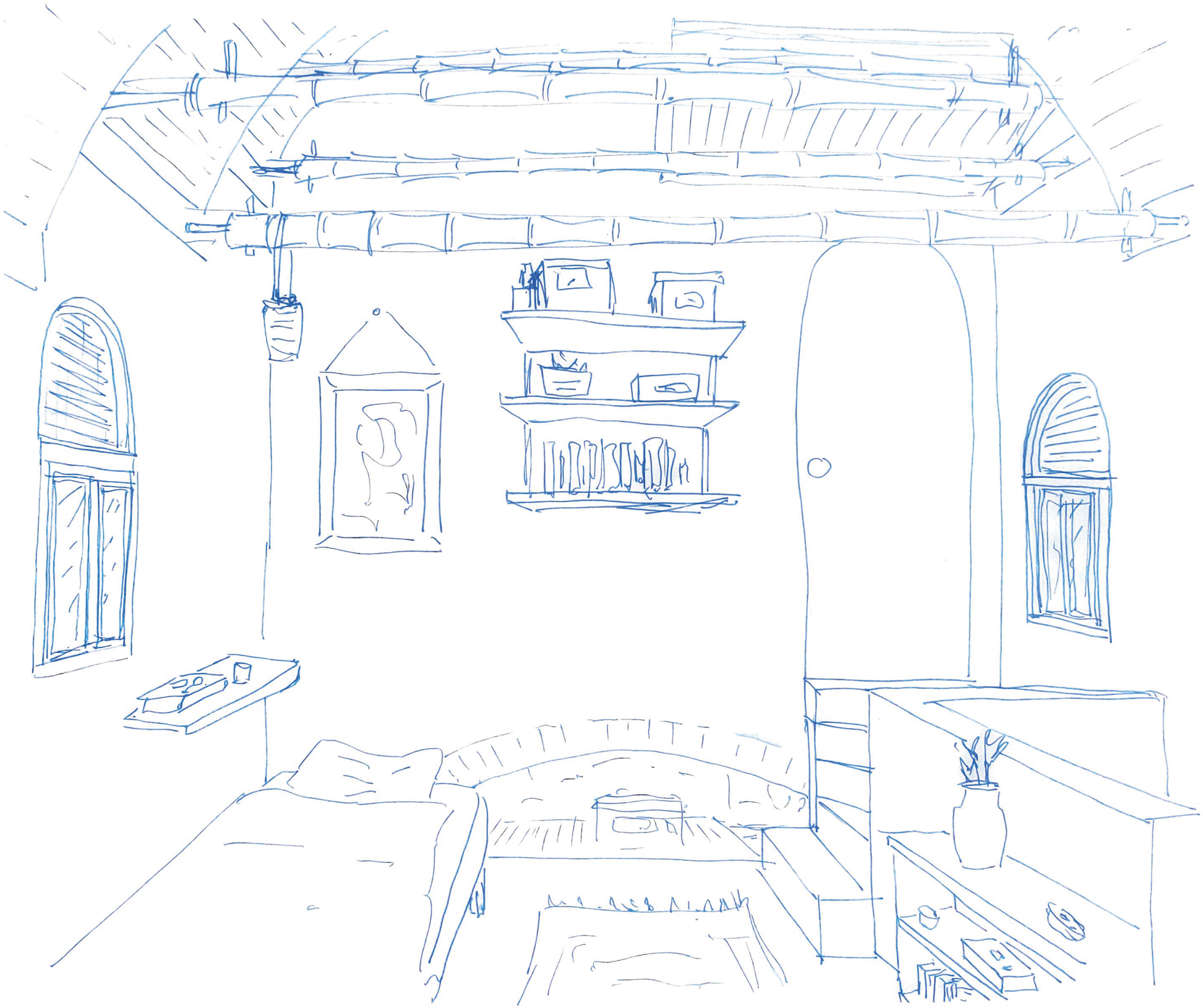


53,5 m2 + 27 m2 expansion area



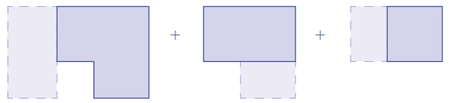


10 cm

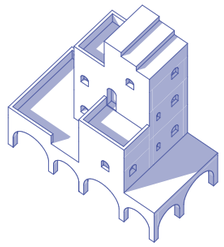


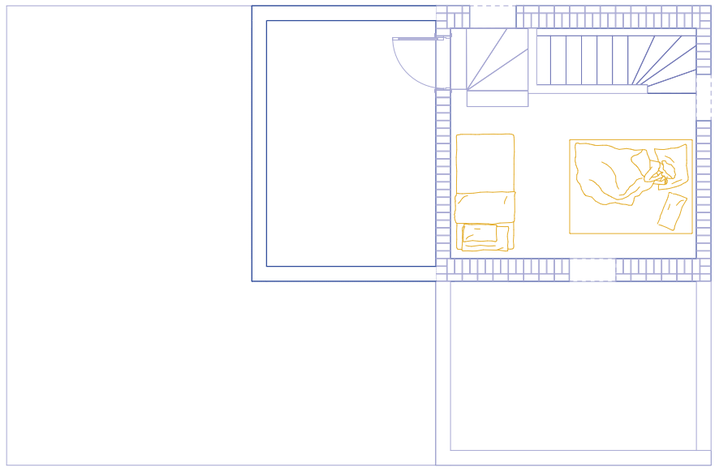
# Unit C

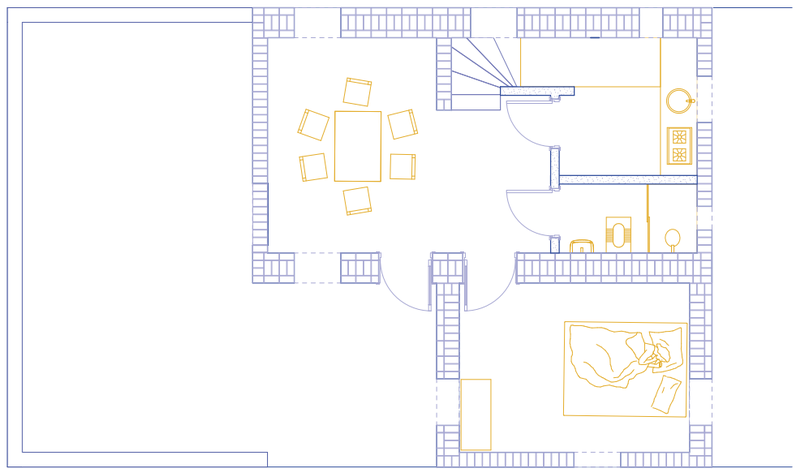
*1st, 2nd & 3rd floor*

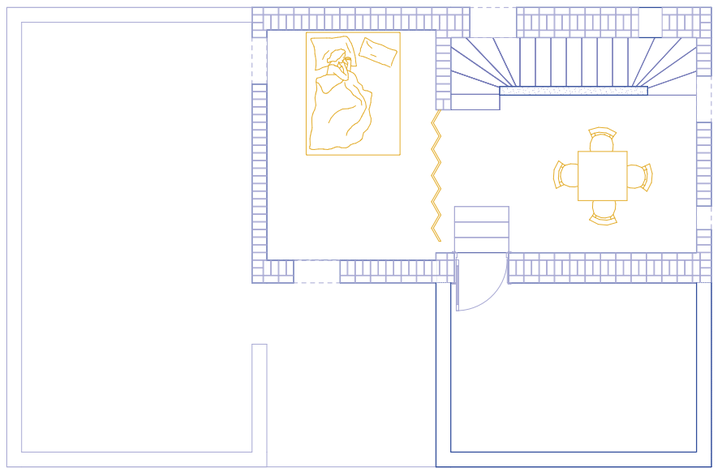


100,5 m2 + 57 m2 expansion area









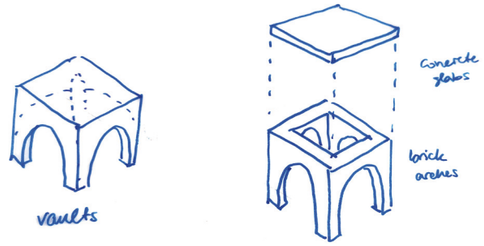
1 m





# Material Choices

*Resilience, Life Span, Availability and CO2-Emissions*



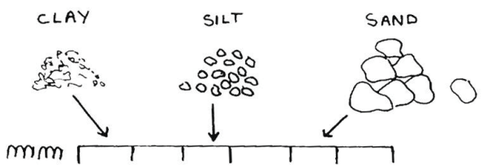

| MATERIAL | CHARACTERISTICS | |
|---|---|---|
| fired brick / concrete | + water resistance<br>+ long lifespan | FLOOD-RESISTANT STILT STRUCTURE |
| CSEB | + long lifespan<br>+ less CO2 emissions than baked brick<br>+ excravated soil can be repurposed<br>+ chance to establish less poluting building material while using present construction skills | PERMANENT STRUCTURES ABOVE FLOOD LEVEL |
| bamboo | + locally available ressource<br>+ adaptability | ADAPTABLE STRUCTURES |
| wattle & daub | + typical local building technique<br>+ adaptability | |
| earth plaster | + creates pleasent indoor climate | TOP LAYER FOR INDOOR SURFACES |



# Soil-Based Building Materials

*Material Research*

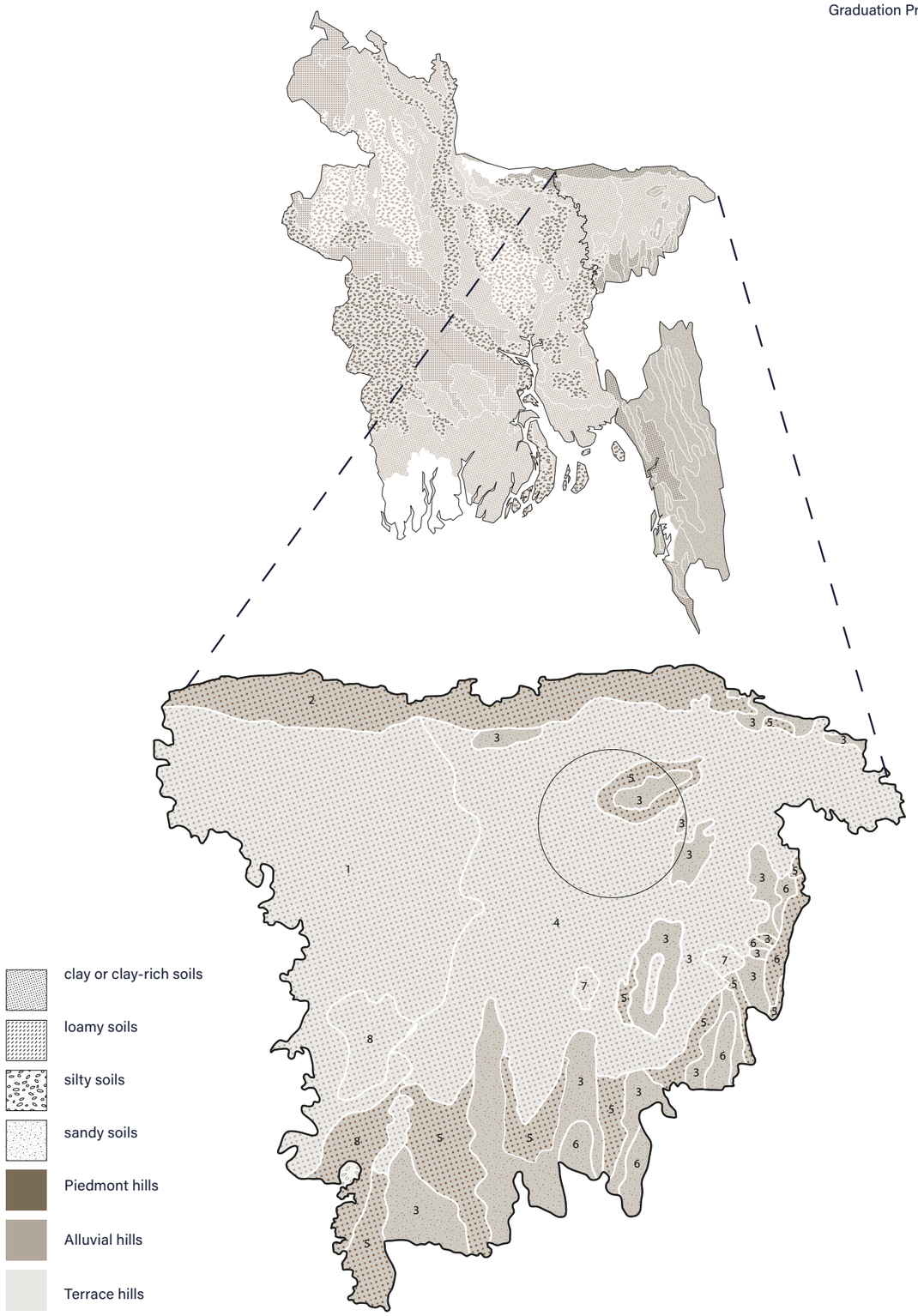
Clay is composed of very fine mineral particles that are tightly packed together in a plate-like structure. It has a high water-holding capacity, making it dense, heavy, and sticky when wet but hard and compact when dry. Sand is composed of large, coarse particles that are mostly made of silica (quartz). It has a loose texture, which allows for excellent drainage but low water-holding capacity.



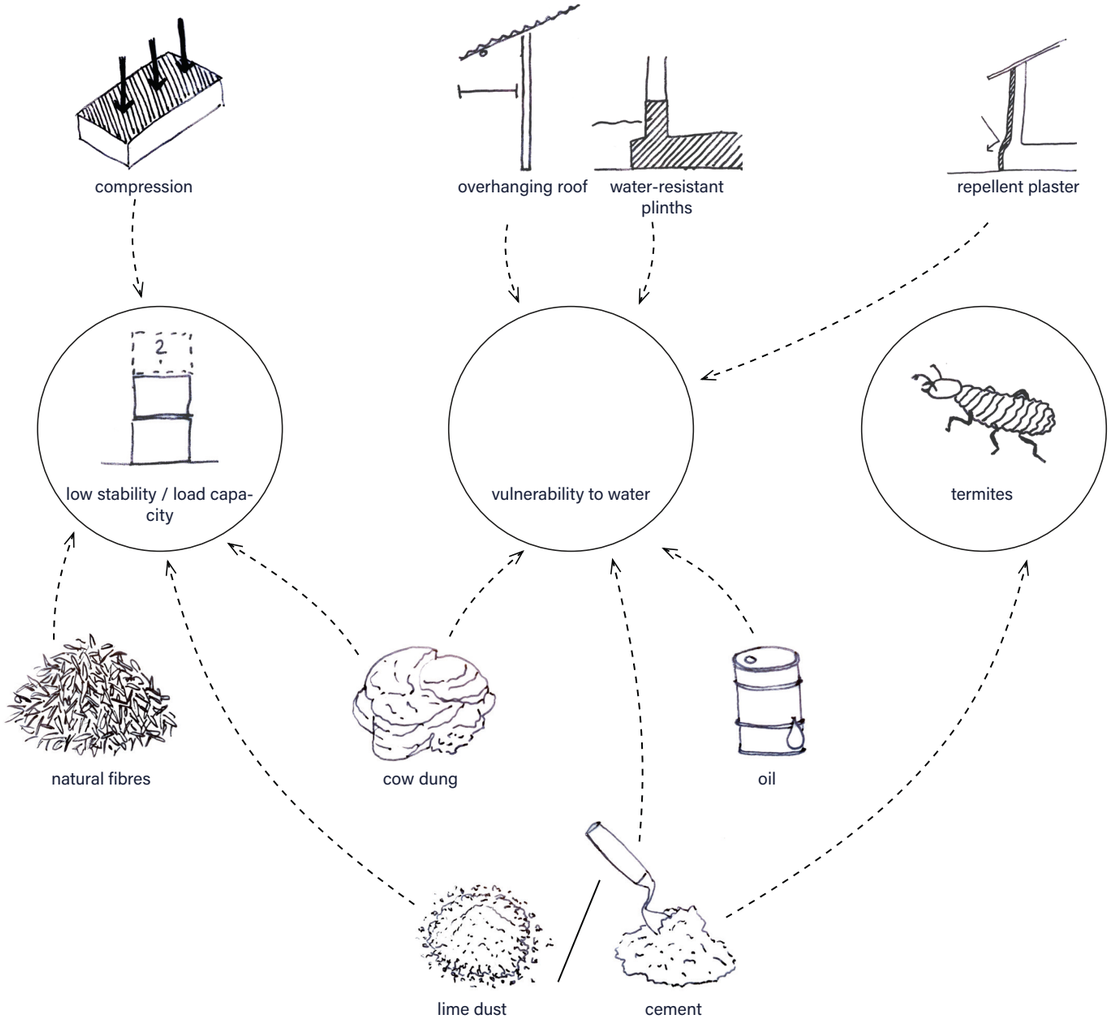



clay silt sand

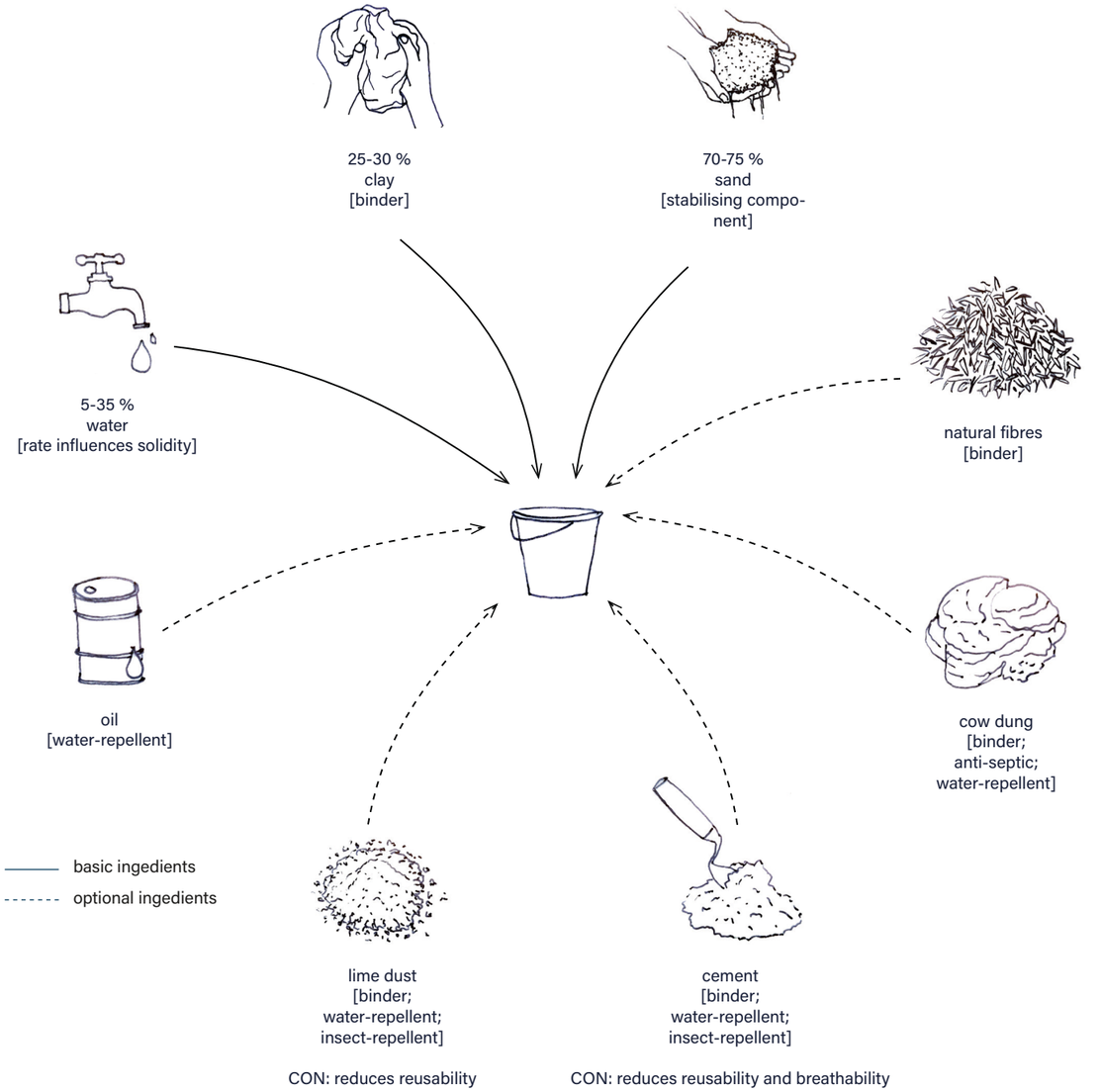
A single soil sample may fall somewhere on the spectrum between clay, sand, silt, and loam. For instance, a sample taken from alluvial soils could very well be a sandy clay loam. For the purposes of this mapping exercise, the dominant soil texture is used to categorize each soil sample. The color and composition of a soil sample are determined by its origin and the geological processes it has undergone—specifically, whether it comes from alluvial, piedmont, or terrace soils. These factors not only influence the soil's color but also affect its accessibility and suitability for construction in different regions.



To increase the stability of the material, different techniques of compression can be used (e.g. pressed earth blocks or rammed earth). Additionally, binders like lime, cow dung or natural fibres can increase the loadbearing capaticy. The prominent vulnerabilty to water can be reduced by incorporating water resistant plinths and plasters or overhanging roofs, as well as adding water-repellent supplements. To protect buildings from termites, lime or cement and tumeric leaves can be added to the material.




All earth based construction methods work with the same basic 'recipe'. While sand is the stabilising component, clay works as a binder thanks to its flat microscopic structure. Most techniques use a ration of clay to sand of 1:2 (Lengen, 2007). Depending on the aspired consitancy the mix also contains between 5 and 35% of water (Carrobé & Rincón & Martorell, 2021). To change the characteristics of the mixture, different binders can be added as well as water- or insect-repellent components.



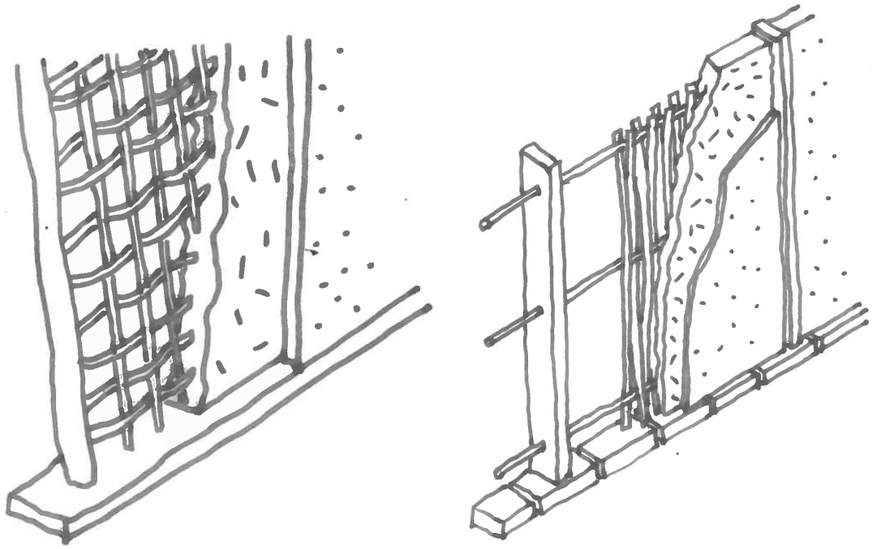
# Wattle and Daub

The wattle & daub technique is one of the most prominent and oldest building techniques in Bangladesh. Thanks to its long local tradition, the necessary knowledge is already present, which makes it an ideal technique for affordable housing solutions. (The Arch Insider, 2020).

**PROs and CONs**

+ locally present building method (knowledge is already present)
+ quick construction
+ cheap technique (cheap materials and tools)
+ utilises strengths of different materials (bamboo = structure; mud = insulation)

- only suitable for buildings with 1-2 stories



# CSEB

*Compressed Stabilised Earth Block*

Compressed earth block (CEB) construction is an efficient and sustainable building technique that enhances traditional earthen materials through controlled compaction. CSEB are compressed earth blocks that are stabilized with lime or cement.

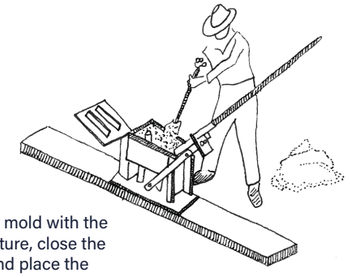
**PROs and CONs**

+ great loadbearing capacity
+ low labour-intensity
+ flexible dimensions of produced blocks
+ air drying process requires little space
+ pressing machine can serve for a long time

- high starting cost due to necessary investment into pressing machine (average cost of a manual compression machine: 70.000 BDT)



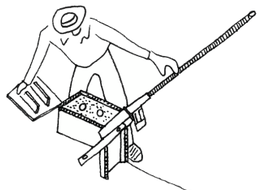
**Earth Block Pressing Process**
Lida Ganotaki



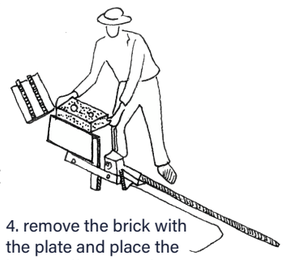
1. fill the mold with the wet mixture, close the cover and place the lever in a vertical position



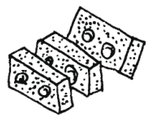
2. remove the hook to free the level and lower the lever to press the mixture



3. place the lever back in the original position and open the cover

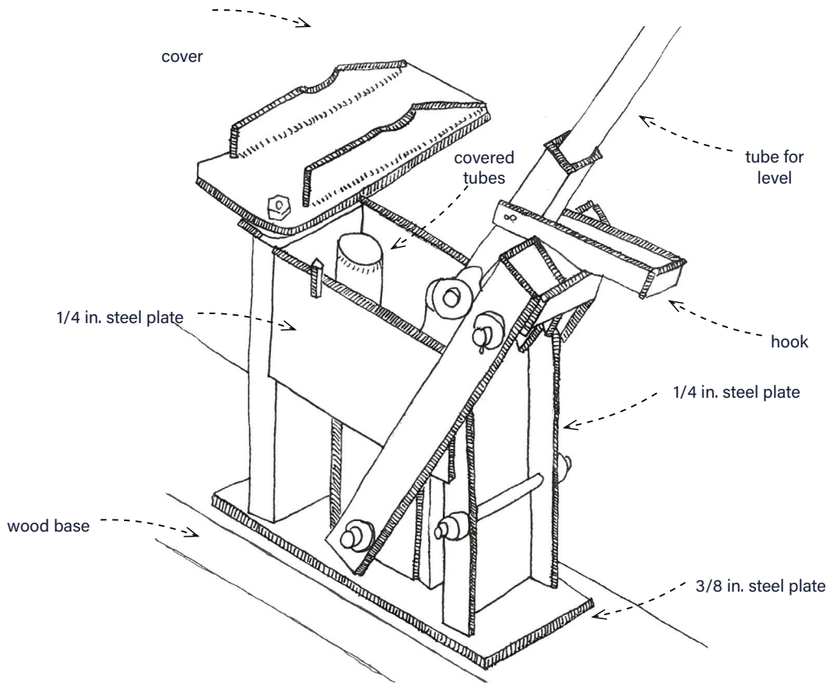


4. remove the brick with the plate and place the lever on the ground



5. place the brick on its side on flat ground and remove the plate

**Earth Block Press**
Lida Ganotaki



- Earth is a local material and the soil should preferably be extracted from the site itself or not transported from too far away

- Labour costs for CSEB production amount to 40 to 45% of the total cost. This promotes endogenous development.

- It is a cost and energy effective material.

- The embodied energy of CSEB is 10.7 times less than country fired brick.

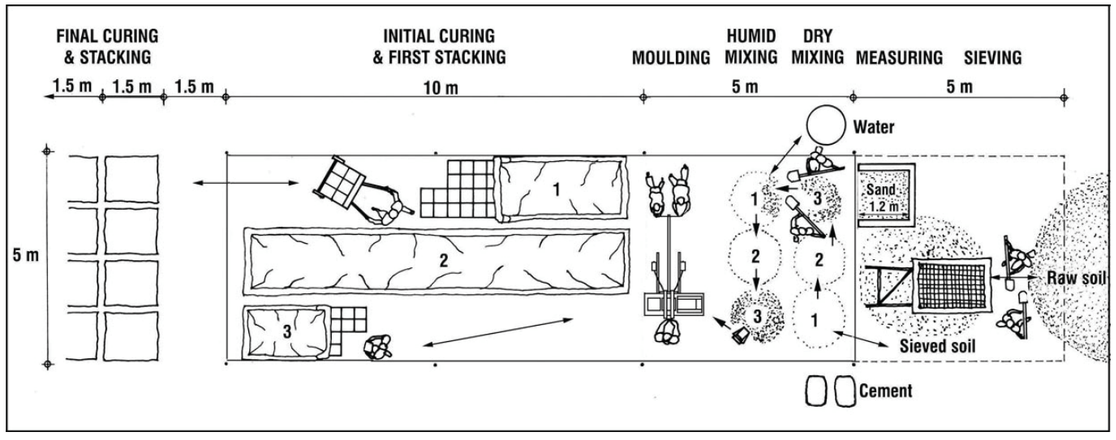
- Carbon emissions of CSEB are 11.8 times less than country fired brick.

| INITIAL EMBODIED ENERGY PER $M^3$ | CARBON EMISSIONS (Kg Of CO2) PER $M^3$ |
|---|---|
| CSEB = 572.6 MJ / $m^3$<br>Country Fired Brick (CFB) = 6,122.5 MJ / $m^3$ | CSEB = 54.5 Kg / $m^3$<br>Country Fired Brick (CFB) = 642.9 Kg / $m^3$ |

**Note:** Data for Auroville and Pondicherry, India, 2011

miro

**Benefits of CSEB**
by www.earth-auroville.com



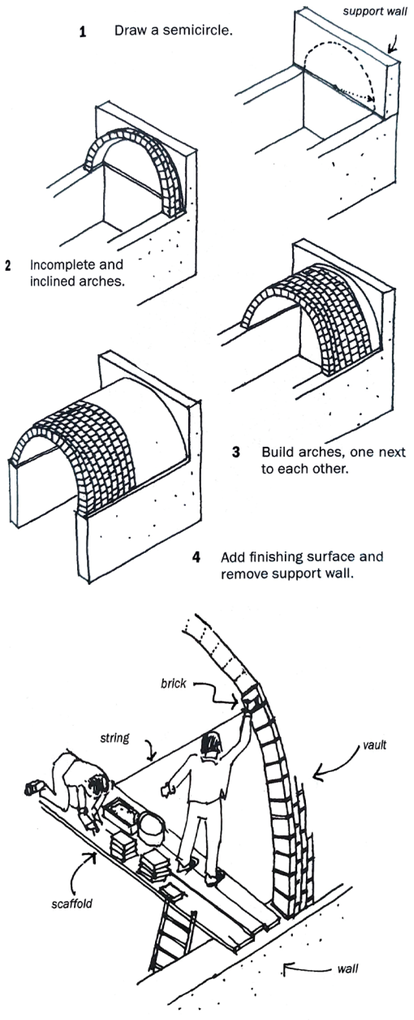

| PROPERTIES | SYMBOL | UNIT | CLASS A | CLASS B | CLASS C |
|---|---|---|---|---|---|
| Dry compressive crushing strength (@ 28 days, +10% after 1 year) | σ Cd | MPa | 5 - 7 | 4 - 5 | 3 - 4 |
| Wet compressive crushing strength (@ 28 days, after 24 hours immersion) | σ Cw | MPa | 3 - 4 | 2 - 3 | 1.5 - 2 |
| Tensile crushing strength, dry (on a core @ 28 days) | τ | MPa | 0.5 - 1 | 0.5 - 1 | 0.5 - 1 |
| Bending crushing strength, dry (@ 28 days) | σ Bd | MPa | 0.5 - 1 | 0.4 - 0.8 | 0.3 - 0.6 |
| Shear crushing strength, dry (@ 28 days) | τ | MPa | 0.4 - 0.6 | 0.3 - 0.5 | 0.2 - 0.3 |
| Total water absorption | - | % weight | 8 - 10 | 10 - 12 | 12 - 15 |
| Apparent bulk density | γ | Kg/$m^3$ | 1900 - 2000 | 1800 - 1900 | 1700 - 1800 |
| Poisson's ratio | μ | - | 0.15 - 0.35 | | |
| Young's Modulus | E | MPa | 700 - 1000 | | |
| Coefficient of thermal expansion | - | mm/m°C | 0.010-0.015 | | |
| Swell after saturation (24 hours immersion) | - | mm/m | 0.5 - 1 | | |
| Shrinkage (due to natural air drying) | - | mm/m | 0.2 - 1 | | |
| Permeability | - | mm/sec | $1.10^{-5}$ | | |
| Specific heat | C | KJ/Kg | 0.65 - 0.85 | | |
| Coefficient of conductivity | λ | W/m° | 0.81 – 0.93 | | |
| Damping coefficient | m | % | 5 - 10 | | |
| Lag time (for 40 cm thick wall) | d | h | 10 - 12 | | |
| Coefficient of acoustic attenuation (for 40 cm thick wall at 500 Hz) | - | dB | 50 | | |
| Fire resistance * | - | - | Good | | |
| Flammability * | - | - | Poor | | |
| Embodied energy (for 5% cement stabilised and produced by hand press) | - | MJ/$m^3$ | 572.58 ** | | |
| Carbon emission (CO2/m3 raw material) | - | $CO_2/m^3$ | 49.37 ** | | |

miro

# Building with Brick

*"The Barefoot Architect"*

**Author** : Johan van Lengen
**Year** : 2008

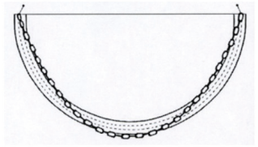



With the use of the string, the bricks are always at the same distance from the center, therefore making a perfect arch.



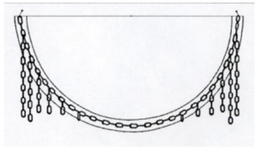
*"Bögen, Gewölbe, Kuppeln - Teil 2"*

**Author** : Georg Böttcher
**Year** : 2016

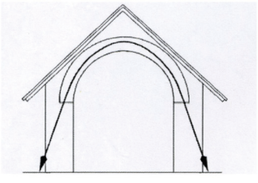


unbelasteter Kraftverlauf (nur Eigenlast)

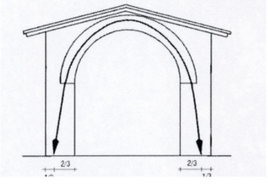
Zusätzliche Auflasten stellte er durch kleine Kettenstücke, die an den jeweiligen Krafteintragspunkten an die Kette gehängt wurden, dar.
So ergab sich die annähernde Form der Stützlinie unter Auflast und Eigengewicht des Bogens:



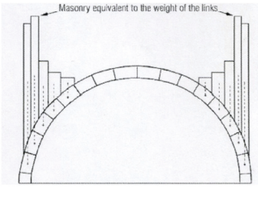
Die Stützlinie verläuft als Kreisbogen

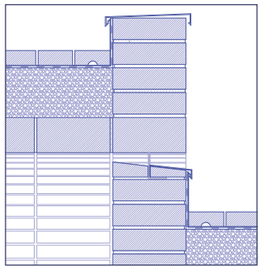


*Konstruktion ist einsturzgefährdet*

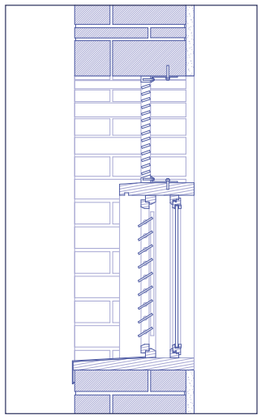



*Sicherung durch Auflast*

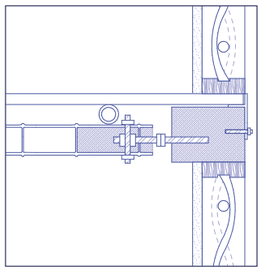




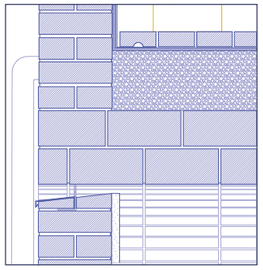
1



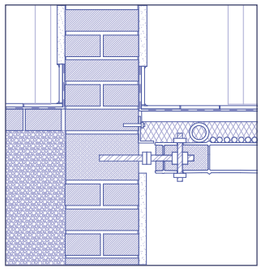
2



3



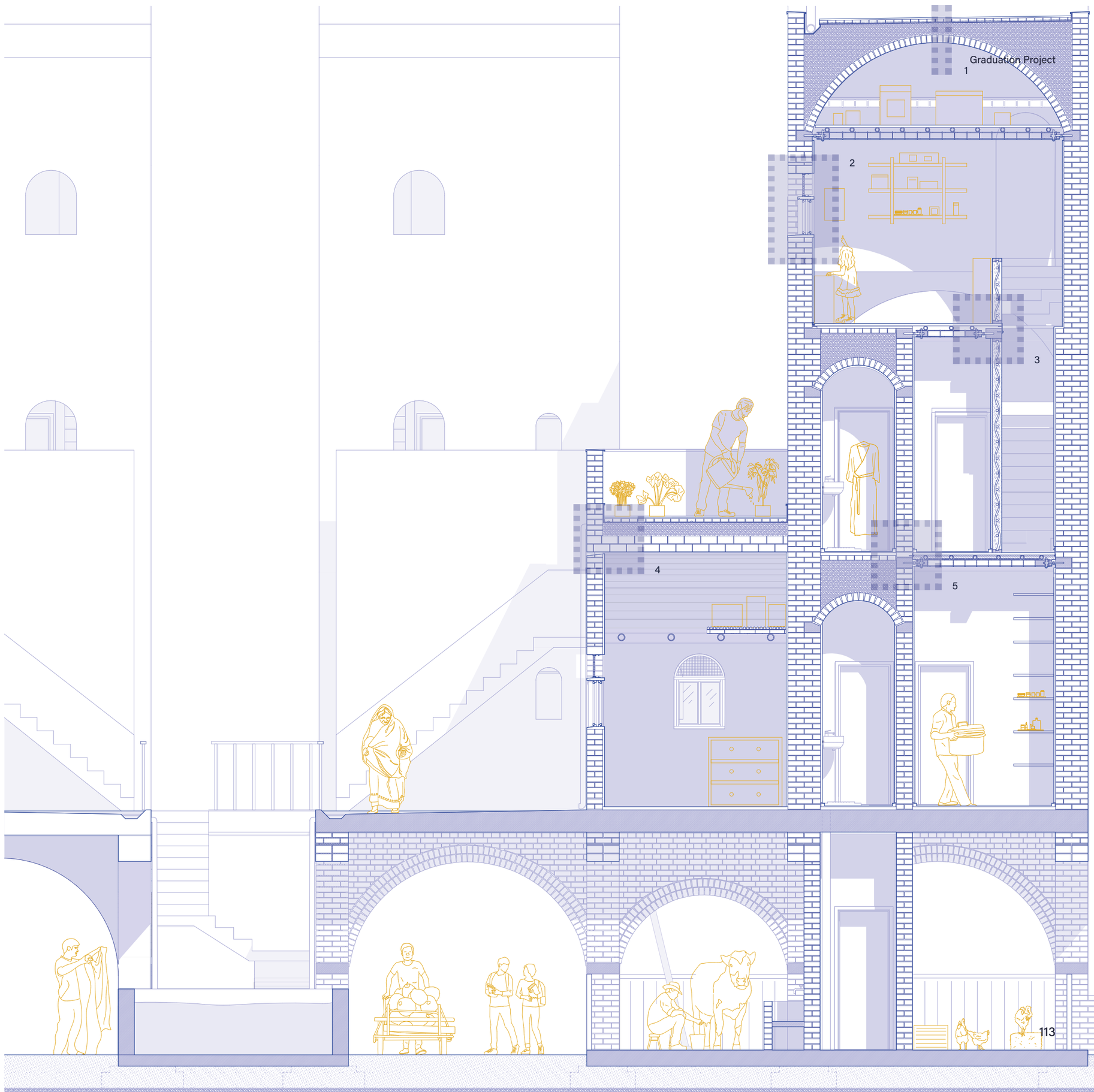
4

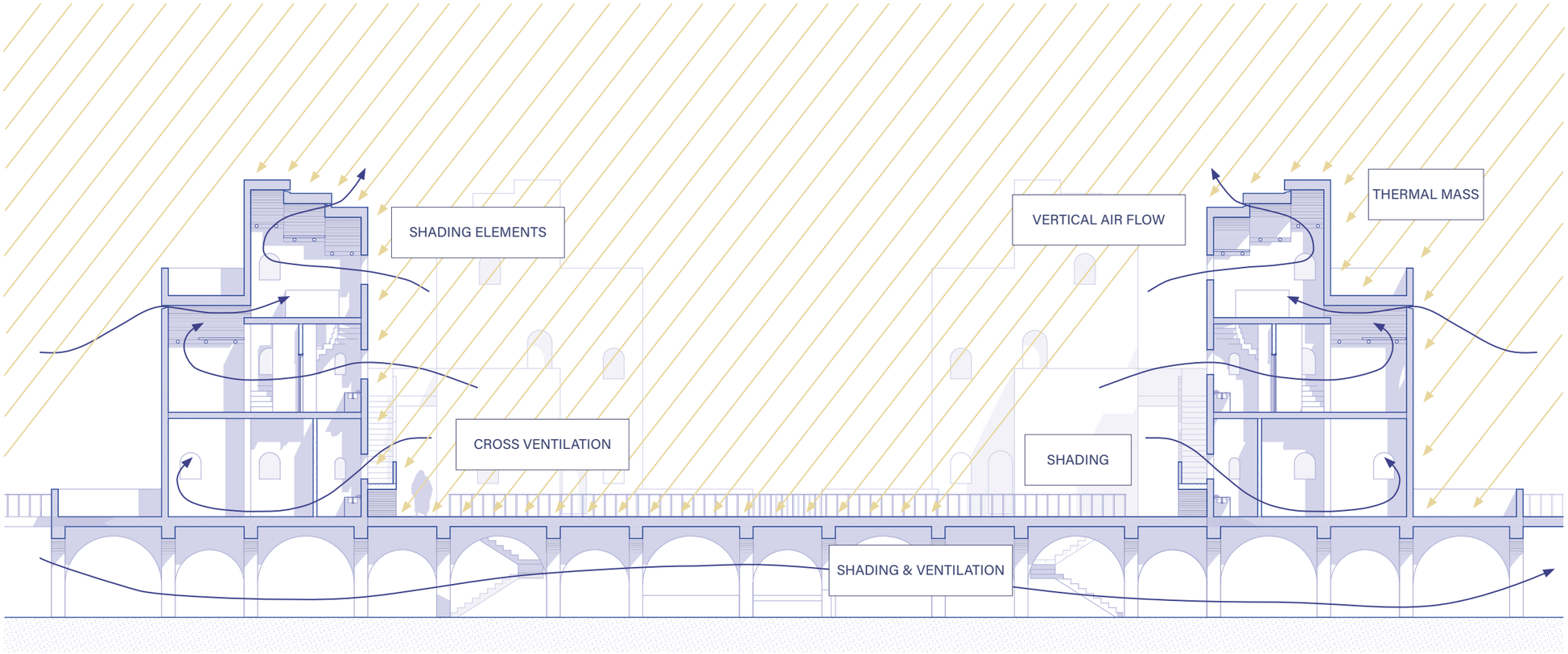


5









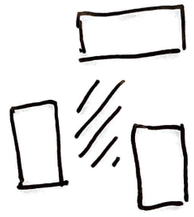

dry season




flood season

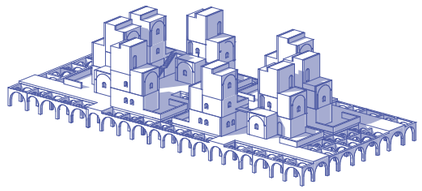


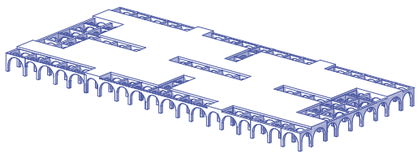


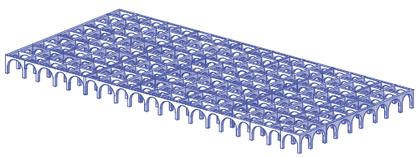


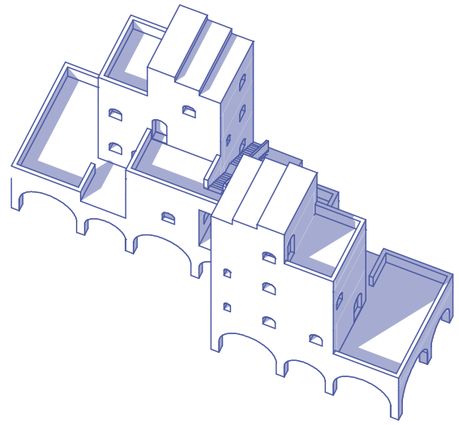
# CLUSTER

# Construction & Configuration

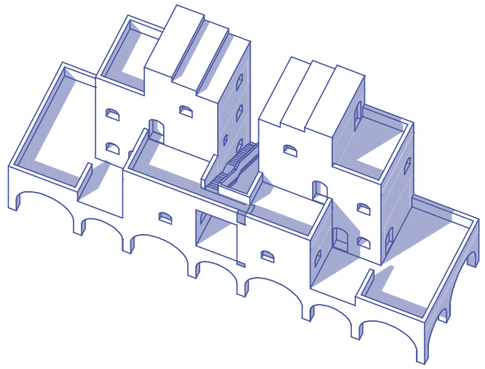




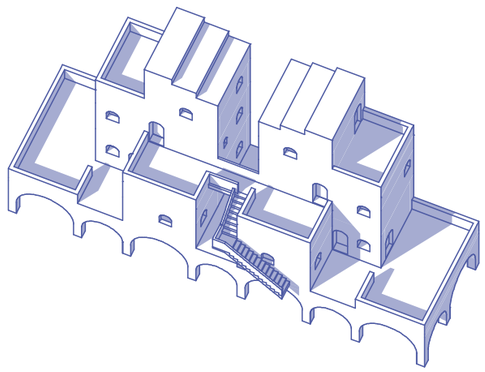




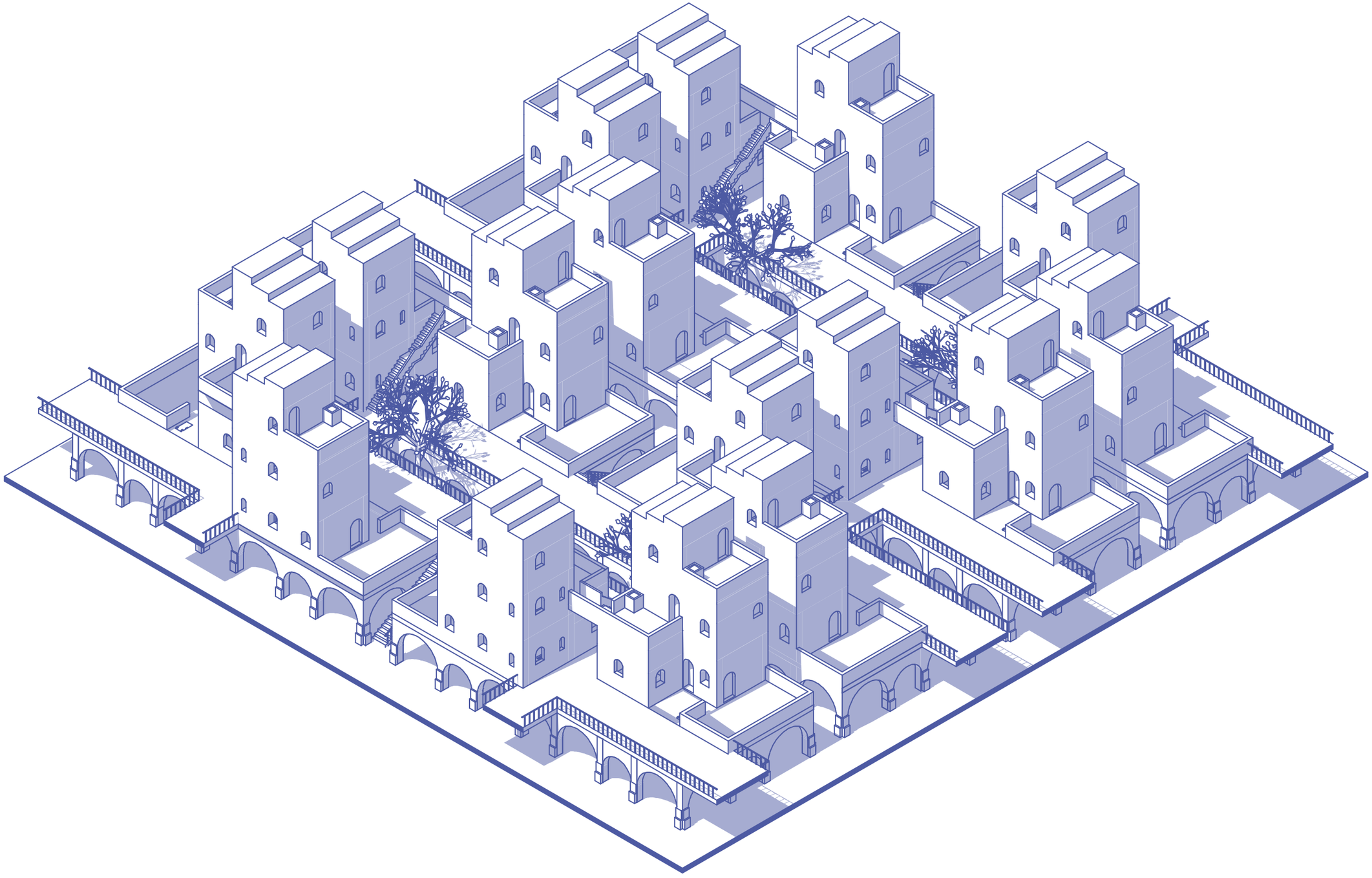
CLUSTERING STRATERY 1



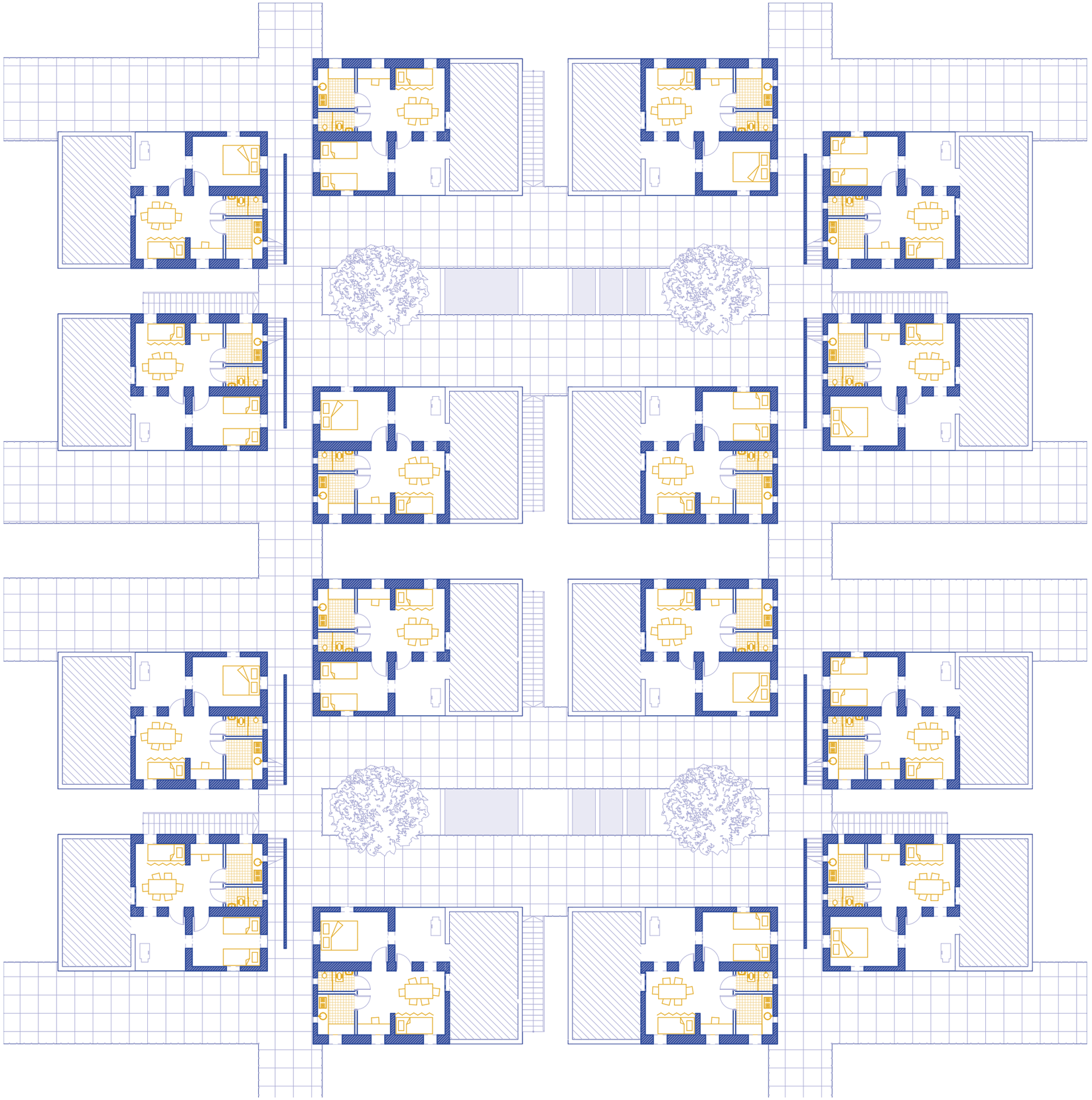
CLUSTERING STRATERY 2



CLUSTERING STRATERY 3

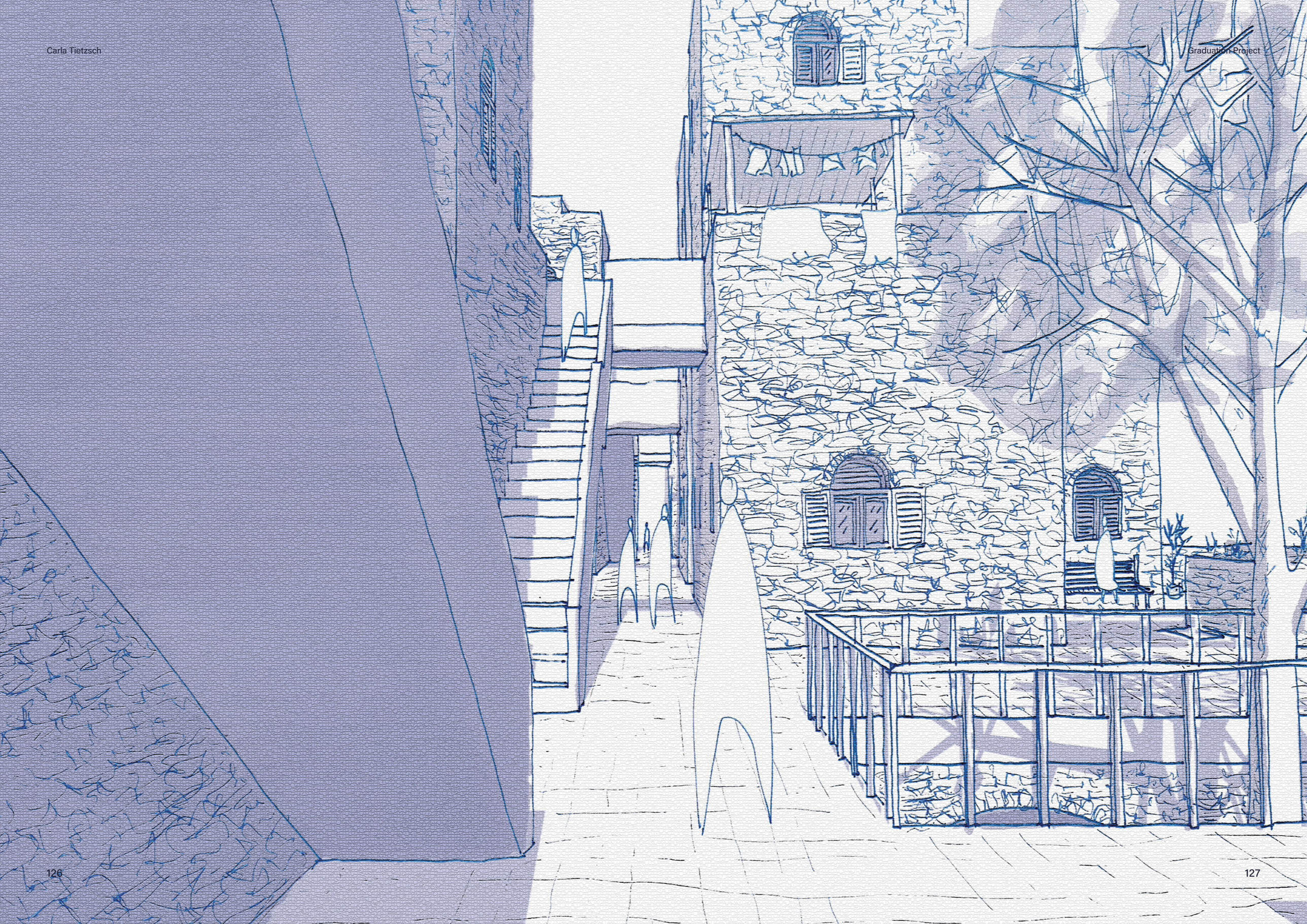


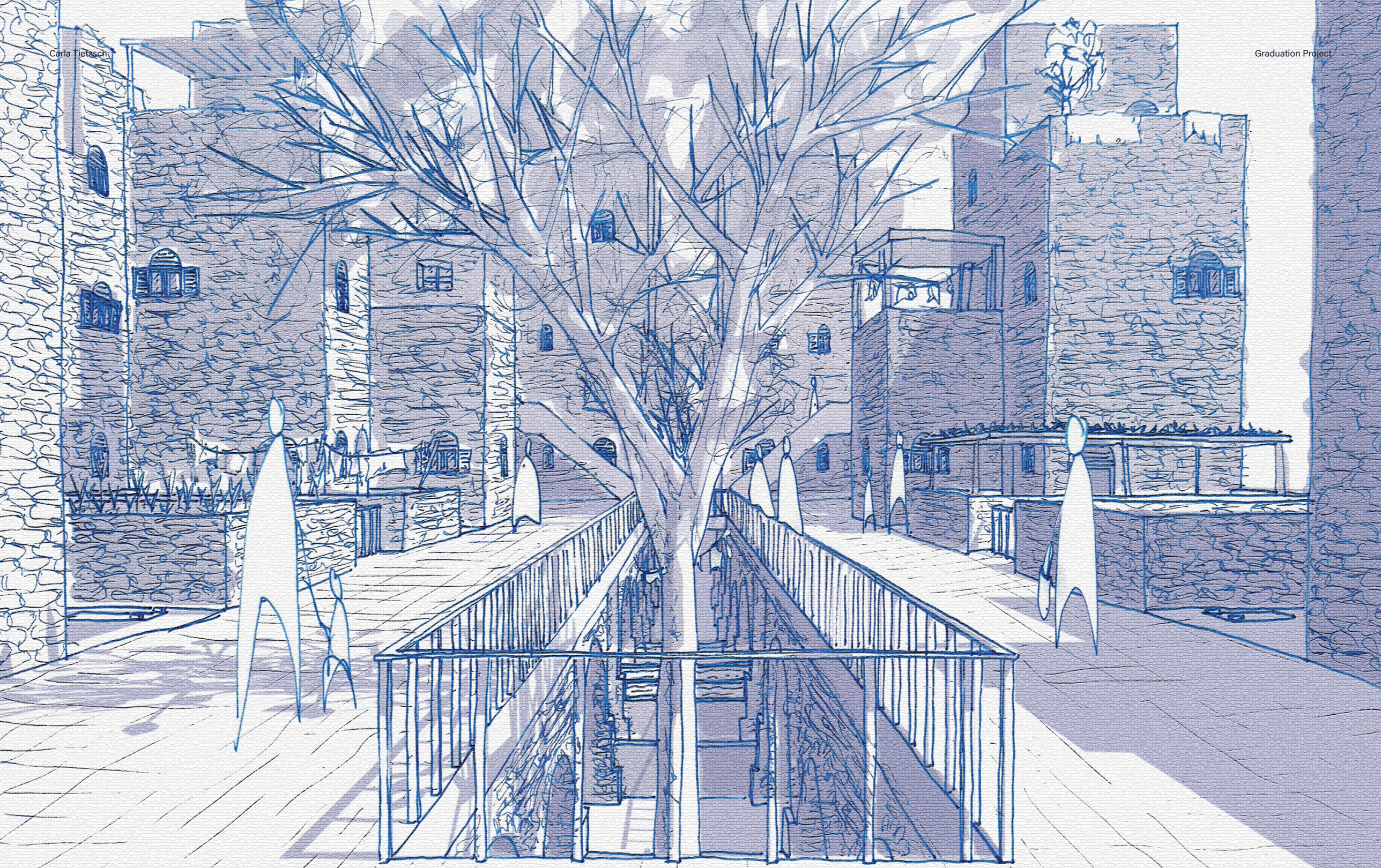
1 m

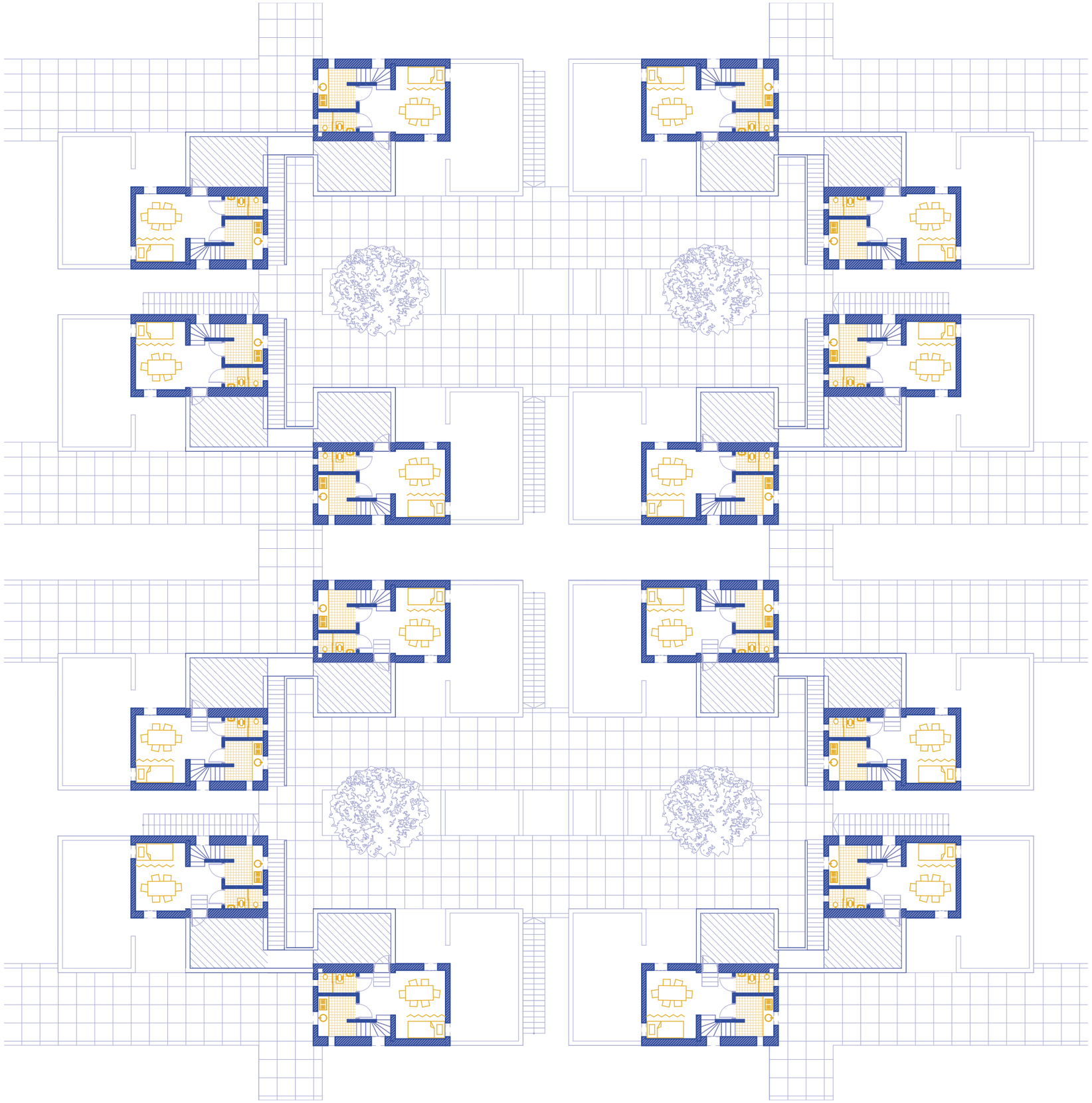


1st floor

1 m

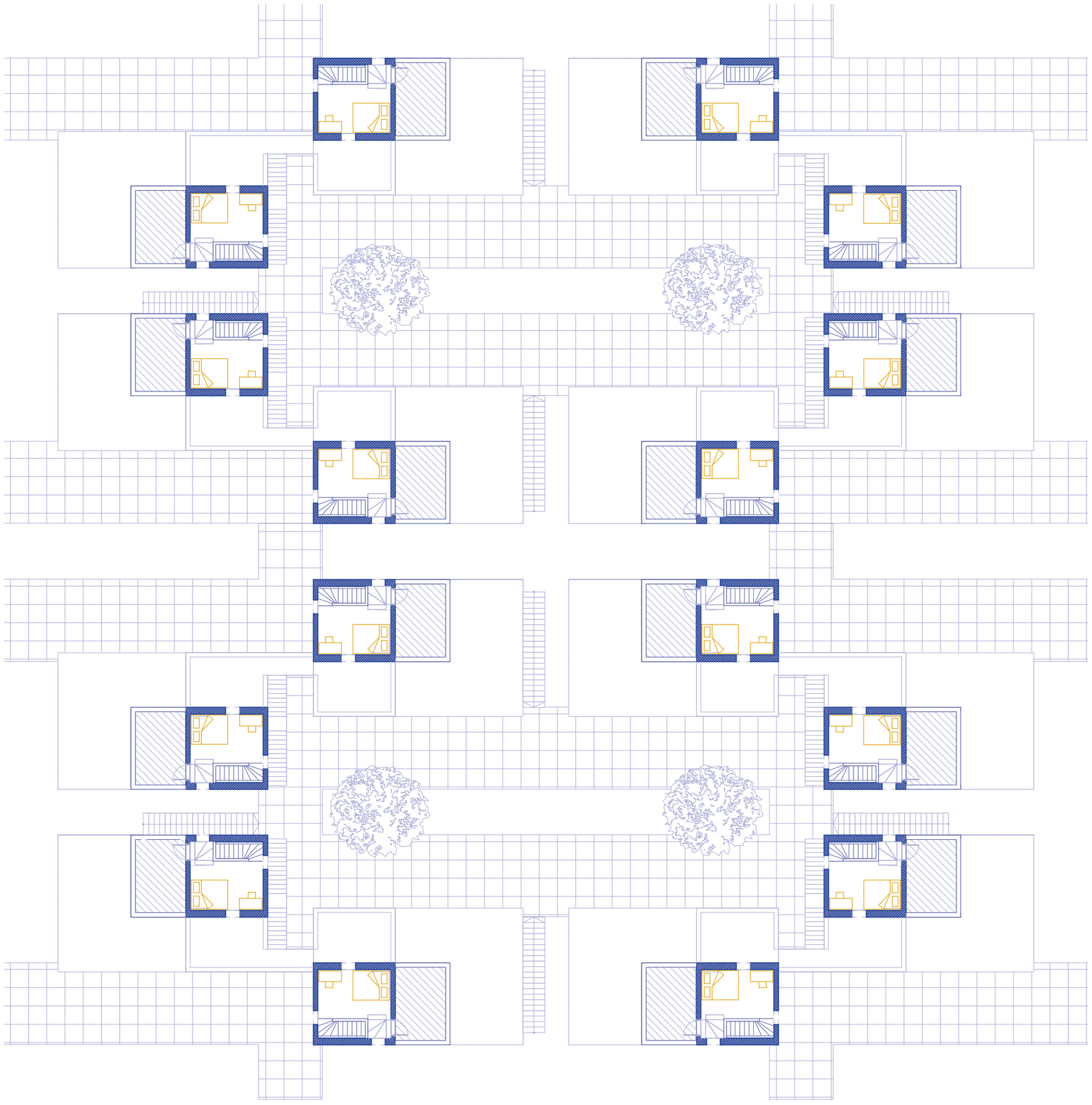






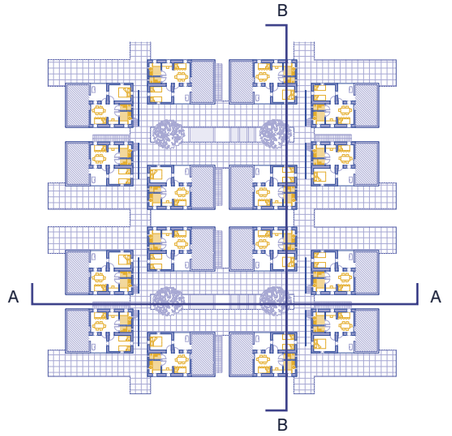
2nd floor

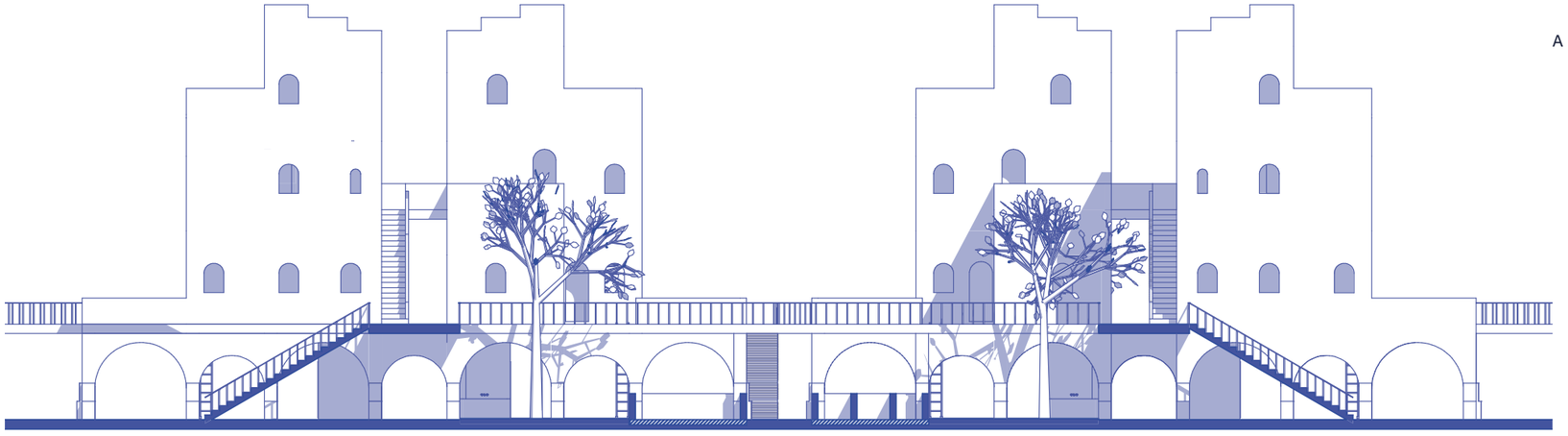
1 m



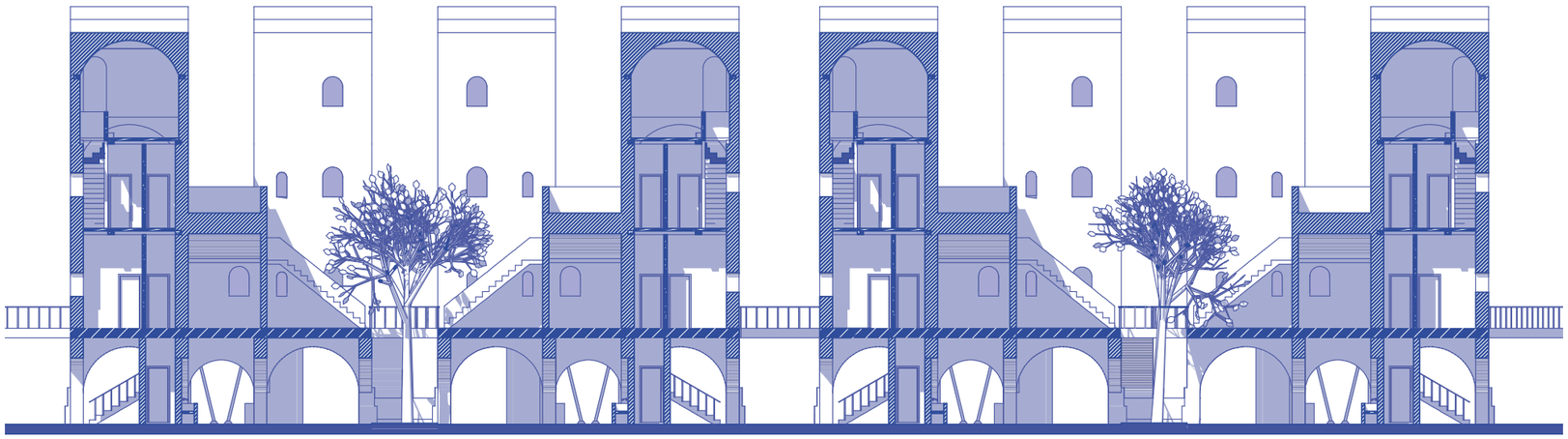
3rd floor

1 m



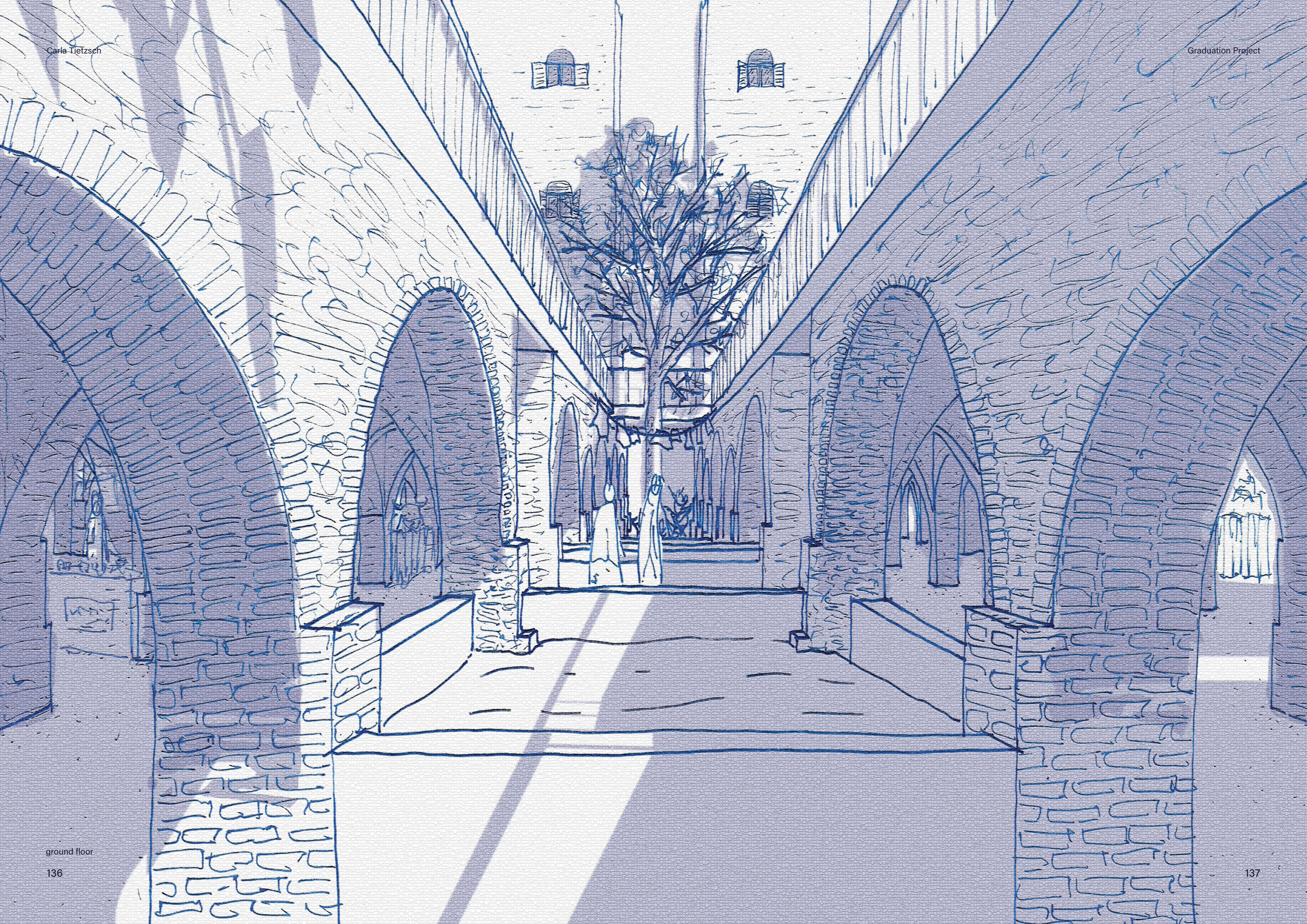



section A-A



section B-B

1 m

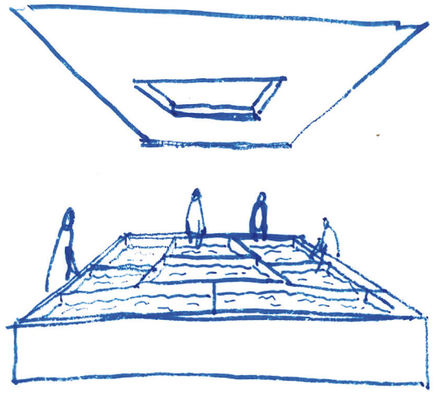


ground floor

# Communal Laundry Center

*Lavadouro público da Afurada*

The Public Washhouse of Afurada (Portugal) is a small-scale community center that was built after the planning of Afurada between 2001 and 2005. The building, in the shape of an impluvium, collects rainwater that falls into a central tank. At the same time, this large void in the roof allows the interior space to receive sunlight throughout the day, with different incidences depending on the time of day, as if the building were a large sundial. Around this central and bright tank there are eight smaller tanks for washing clothes. Deep walls with shelves enclose this sheltered space, where the sound of moving water, the smell of soap, and conversations mingle. In contrast, outside, the lightness of the clotheslines with the washed laundry in the wind defies gravity.

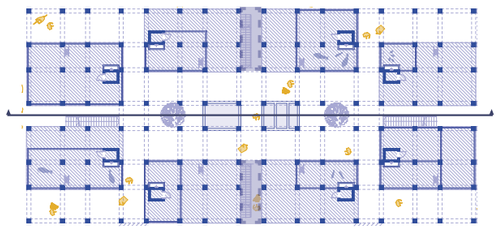


**Name** : Lavadouro público da Afurada
**Location** : Afurada
**Architect** : Afurada
**Year** : 2005

**Communal Laundry Station**
2025.openhouseporto.com

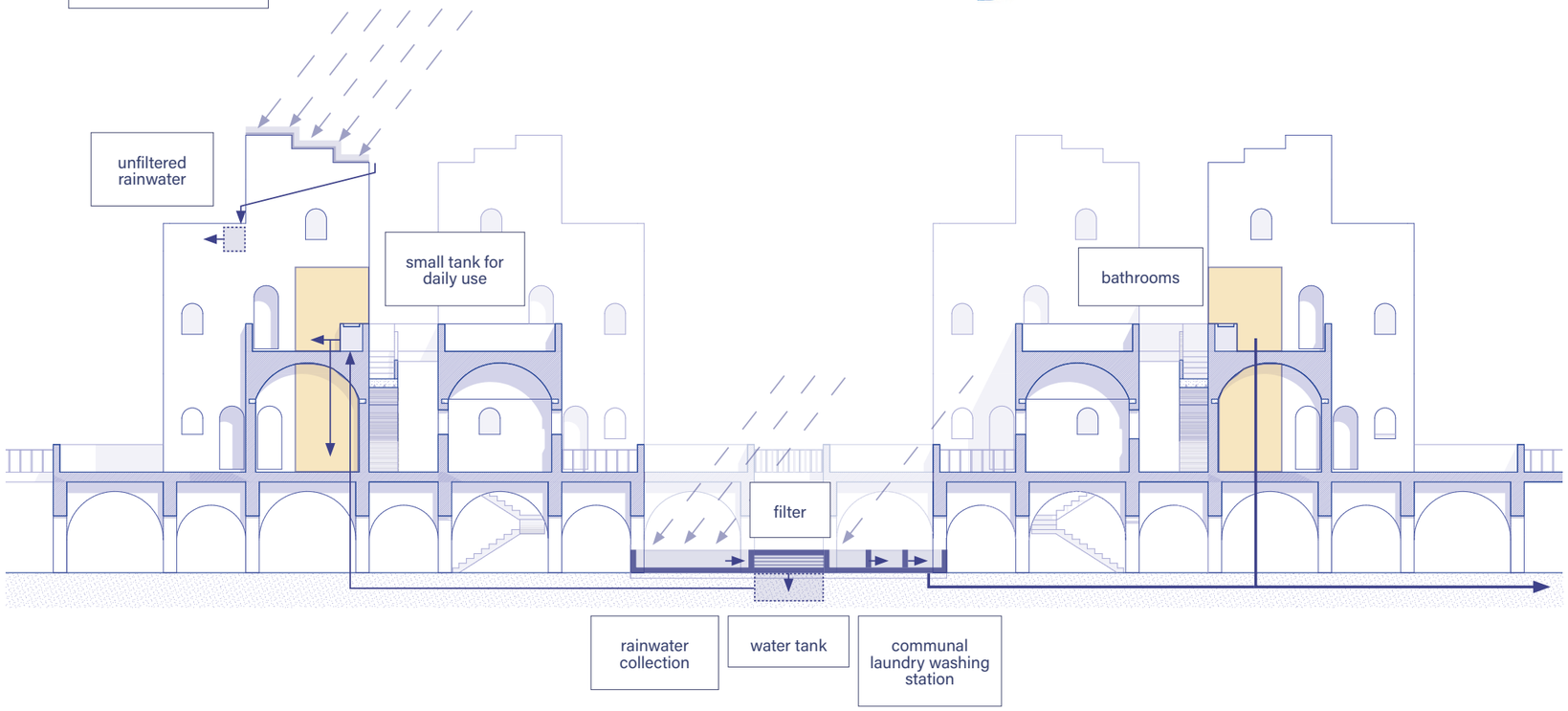


# Rainwater collection



2 WATER TANKS (18 m3)






1 m

# Water Demand

*Daily Use and Storage Capacity*

WATER USAGE PER DAY PER PERSON (WITHOUT DRINKING WATER AND LAUNDRY): 50 L

PEOPLE PER HOUSE: 6-10

WATER DEMAND PER HOUSE PER DAY: 400 L

3 HOUSES PER WATER TANK --> 1200 L PER DAY

WATER TANK CAPACITY: 18 M3 = 18.000 L

WATER STORAGE CAN ENSURE 2 WEEKS WATER SUPPLY

FOR DRINKING WATER AND EXTREMELY LONG DRY PERIODS THE COMMUNITY IS CONNECTED TO THE CITY'S WATER SUPPLY

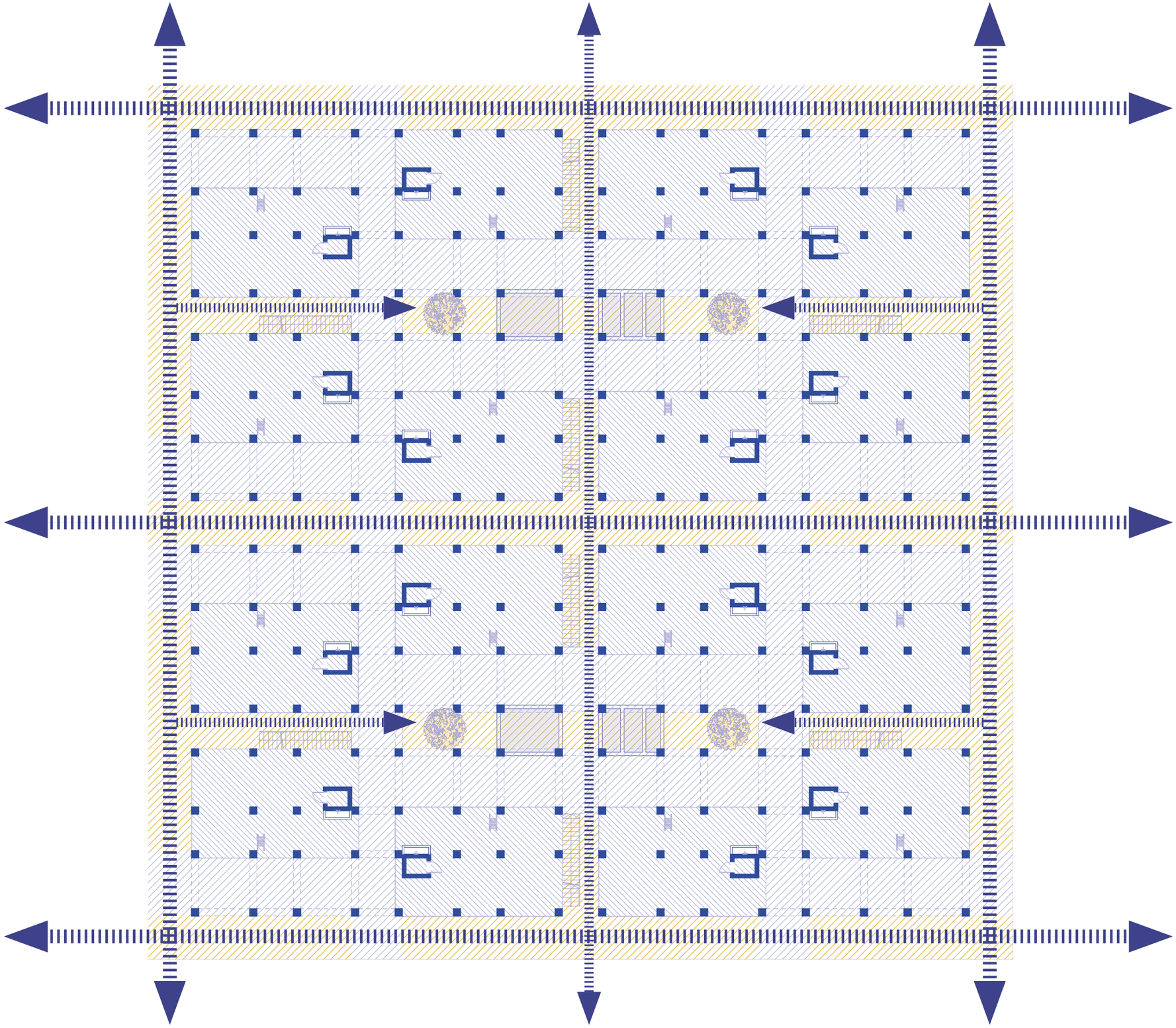
*"Water consumption patterns in rural Bangladesh: are we underestimating total arsenic load?"*

**Author** : Abul Hasnat Milton, Habibur Rahman, Wayne Smith, Rupendra Shrestha Keith Dear

**Year** : 2006

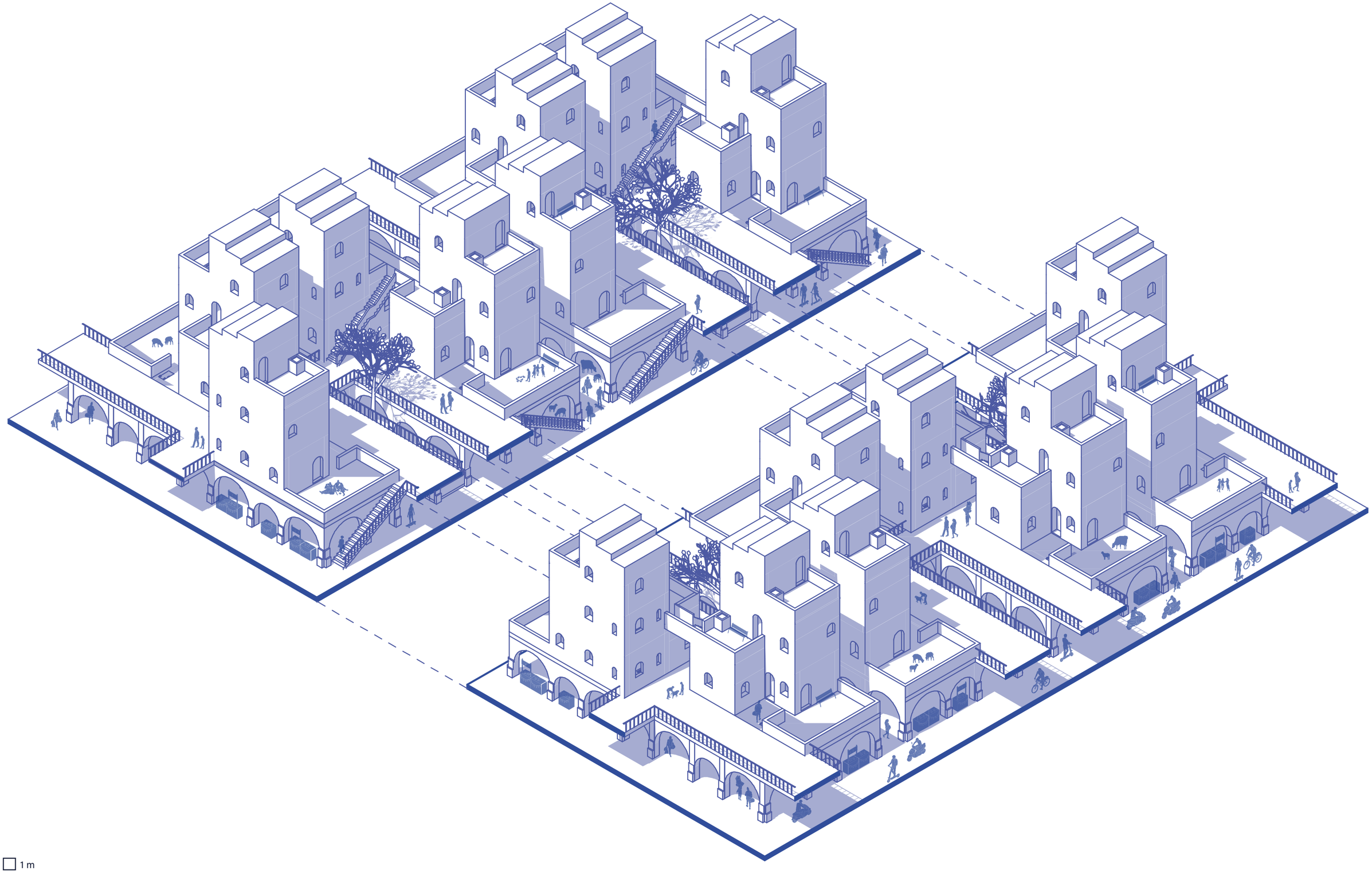
**Table 3** | Amount of water used for different household purposes

| | Per person daily consumption | |
|---|---|---|
| **Purpose** | **Mean (sd)** | **95% CI** |
| Drinking (l/d) | 3.53 (0.98) | 3.45–3.61 |
| Drinking (ml/kg/d) | 73.04 (22.96) | 71.24–74.84 |
| Cooking (l/d) | 6.71 (2.41) | 6.52–6.89 |
| Cooking (ml/kg/d) | 139.14 (56.39) | 134.72–143.55 |
| Bathing (l/d) | 27.26 (13.28) | 26.22–28.30 |
| Domestic washing (l/d) | 12.18 (10.19) | 11.81–13.69 |
| Toileting and cattle feeding (l/d) | 12.75 (12.09) | 11.81–13.69 |
| For all purposes (l/d) | 62.47 (27.25) | 60.33–64.61 |

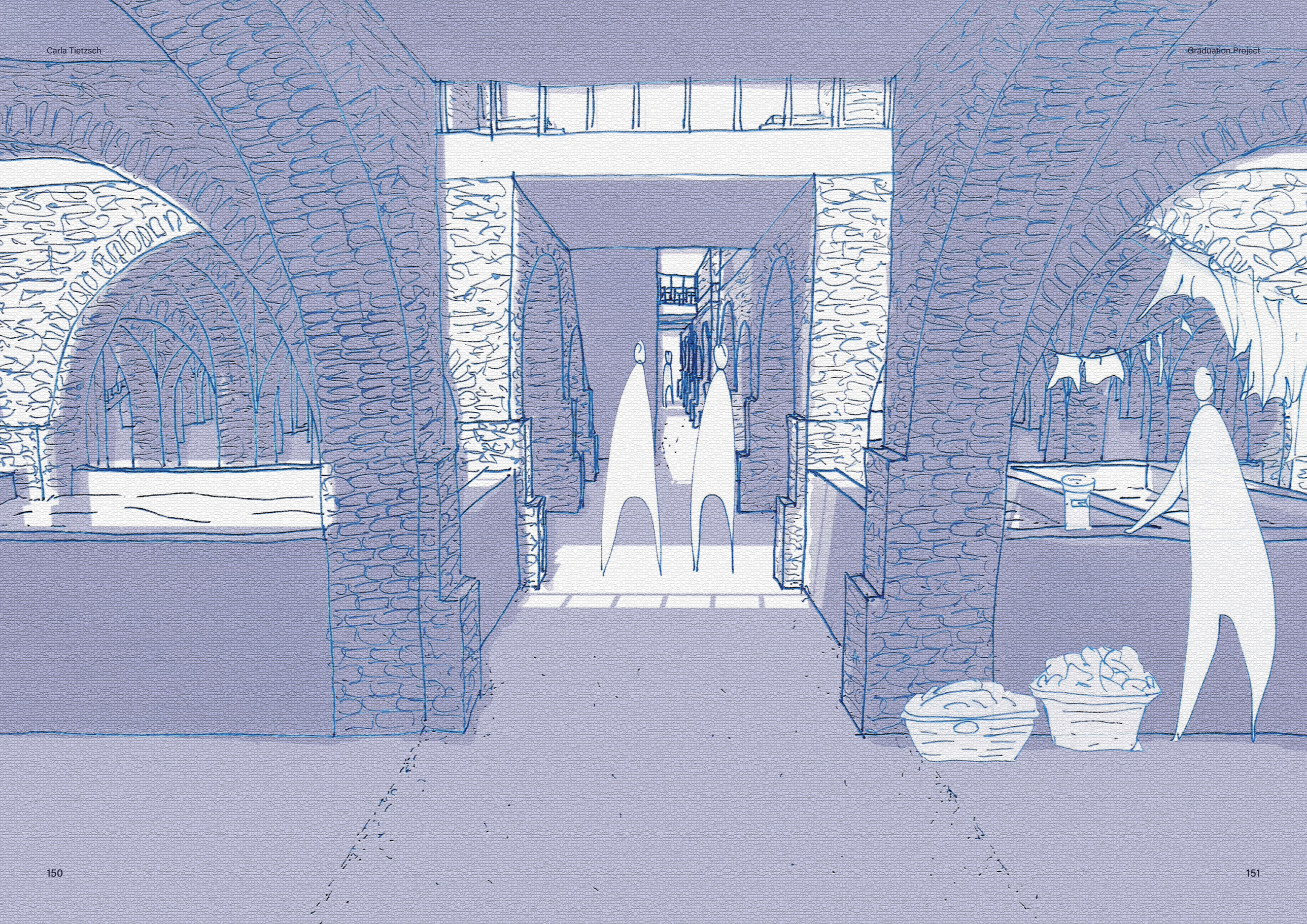


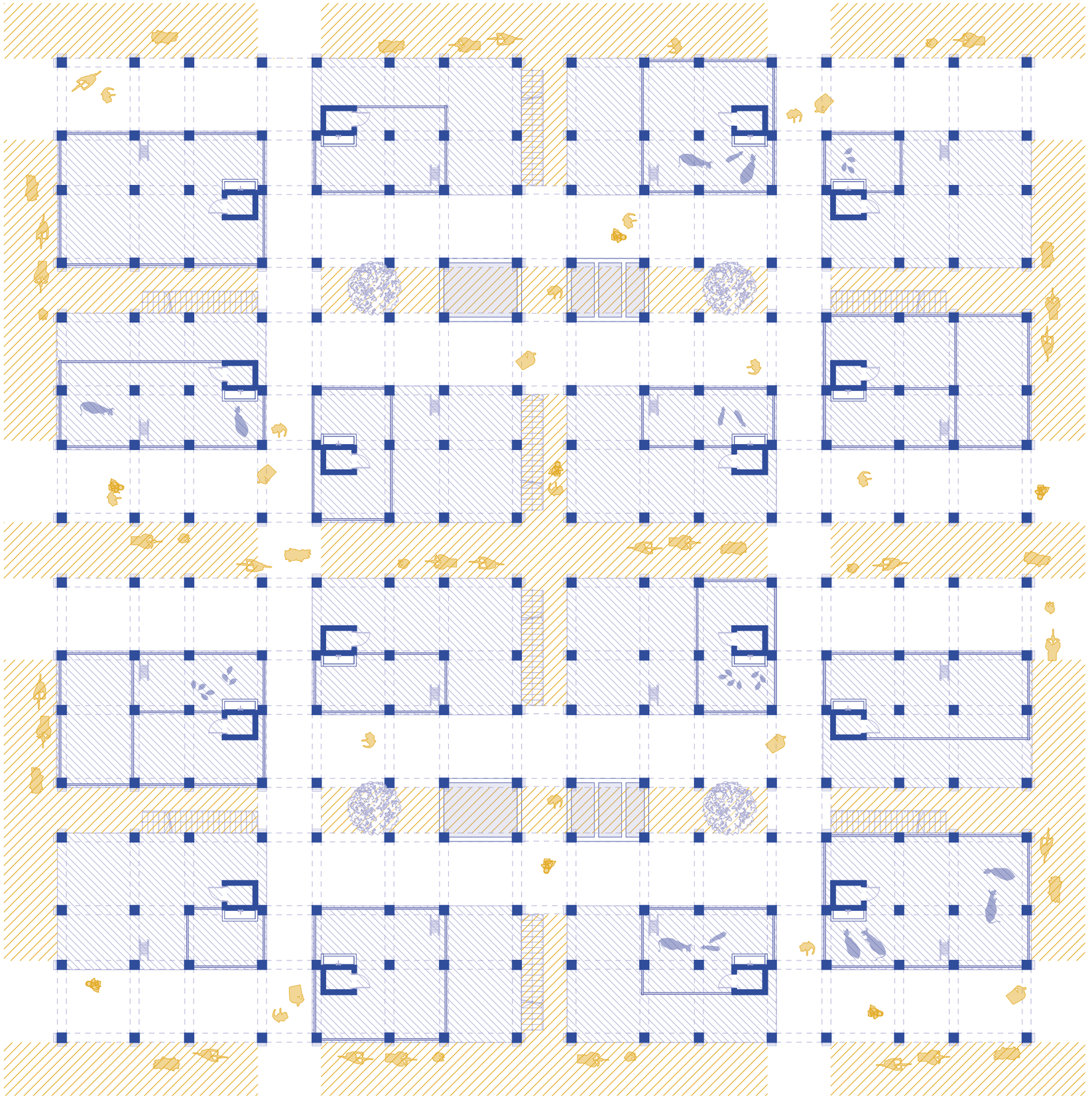
1 m





1 m

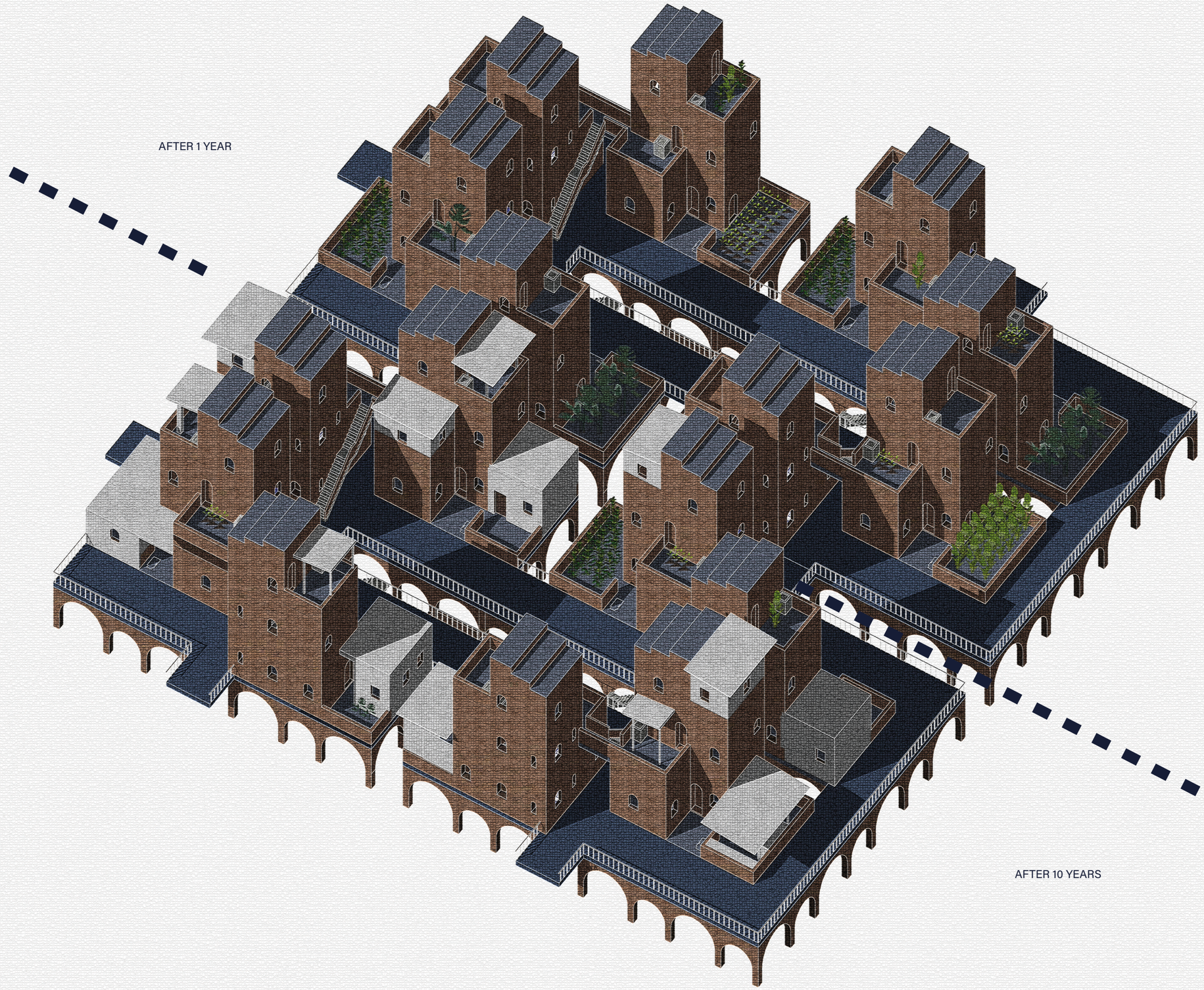




1 m



AFTER 1 YEAR



AFTER 10 YEARS



# COMMUNITY

Carla Tietzsch

# Community Resilience and the Role of Social Environments

*Resilience, Trauma, Context, and Culture*

**Author** : Michael Ungar
**Year** : 2013

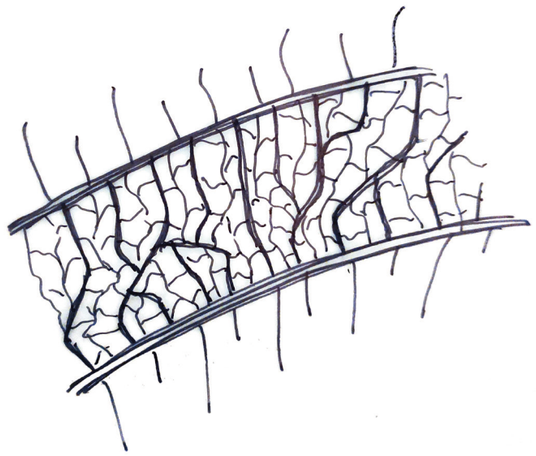
Michael Ungar's research (2013) on resilience emphasizes that social environments play a crucial role in protecting individuals and communities against extreme events. Although his work is not directly connected to housing design, it highlights the importance of community cohesion and local cultural integration. In the context of this research these findings support the need to respect and incorporate traditional living practices in the development of resilient housing for rural Bangladesh.

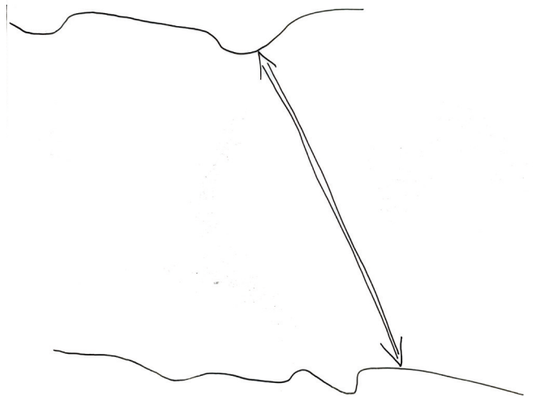


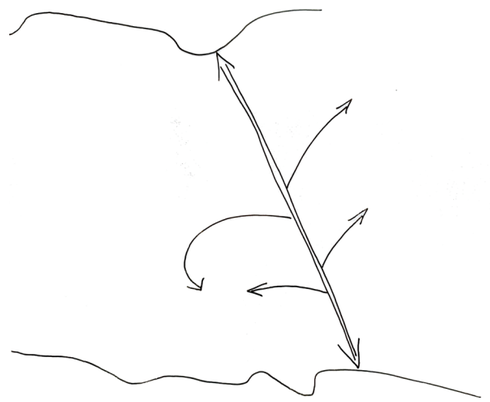
# Urban Strategy

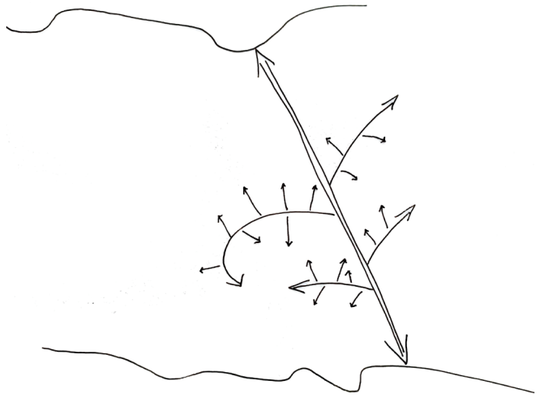
*Connecting Rural Fabrics*









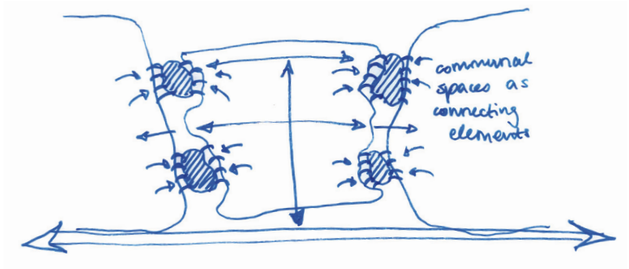








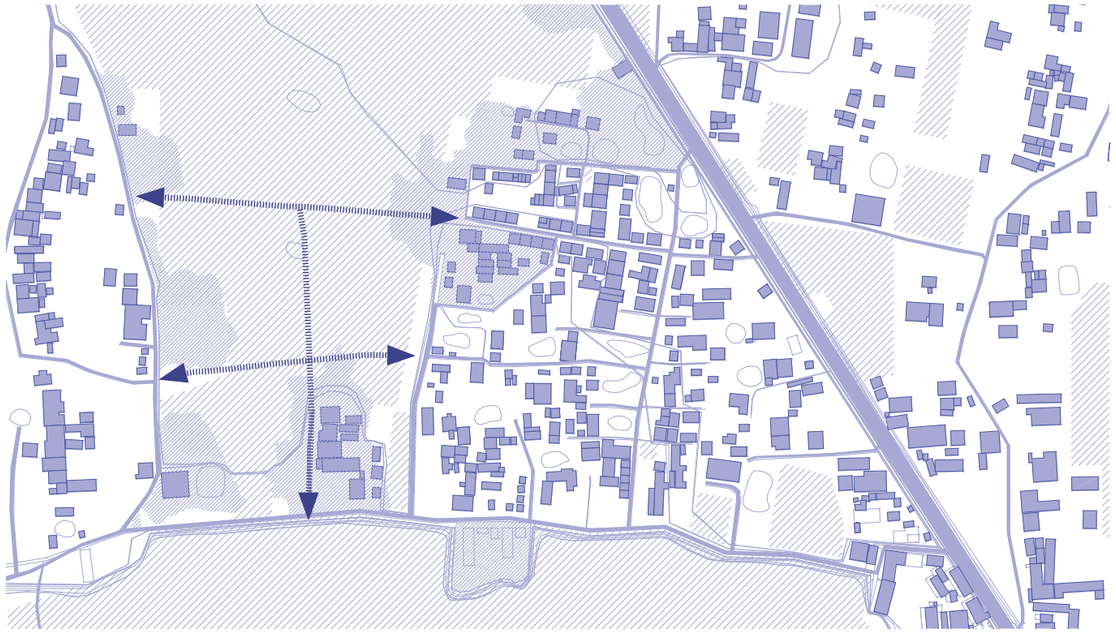
# Connecting Rural Fabric









CHILD CARE

SCHOOL

WOMEN'S CENTER

SCHOOL

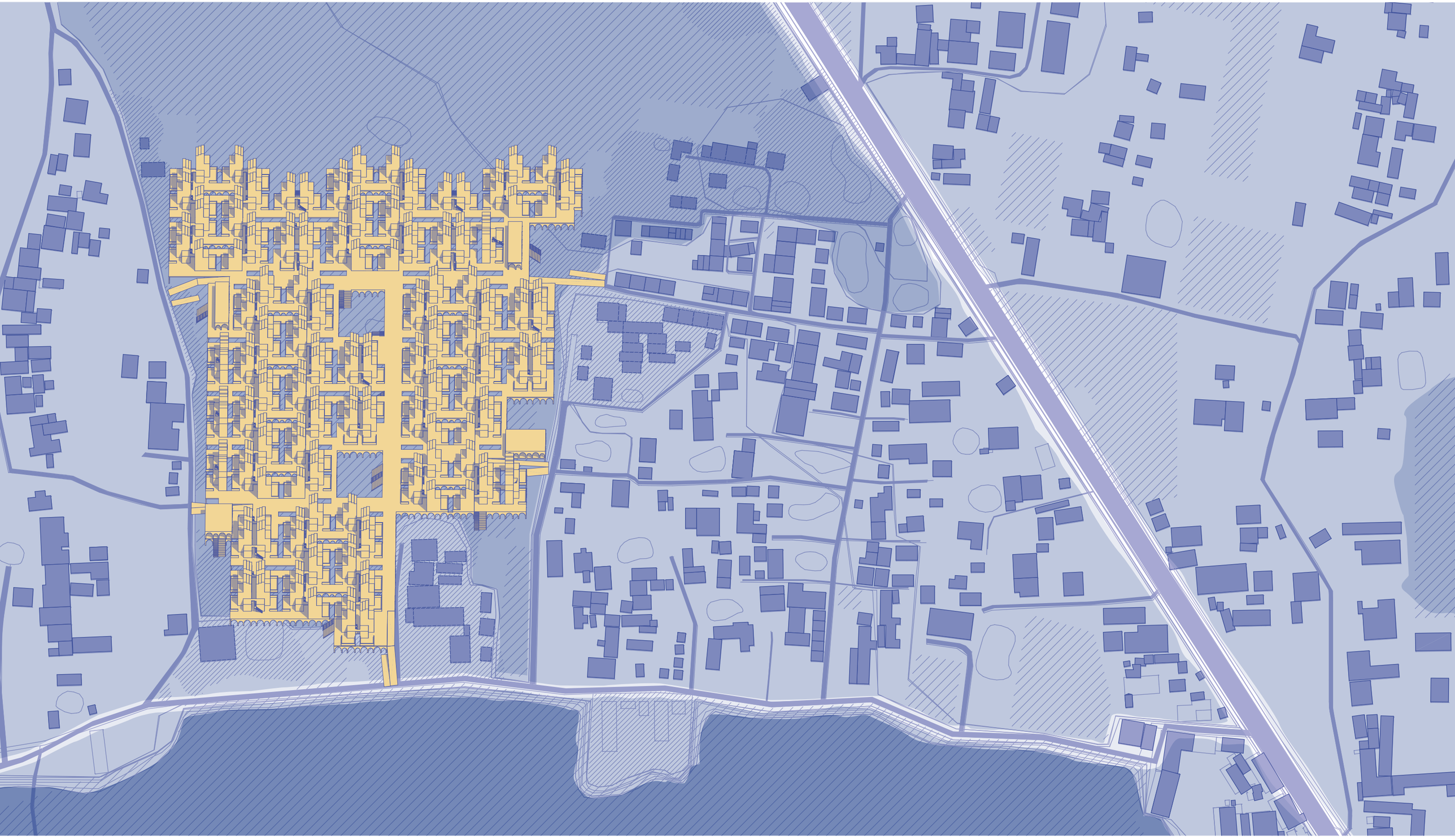
MOSQUE

COMMUNITY/
WORKSHOP
CENTER

MOSQUE

BAZAR

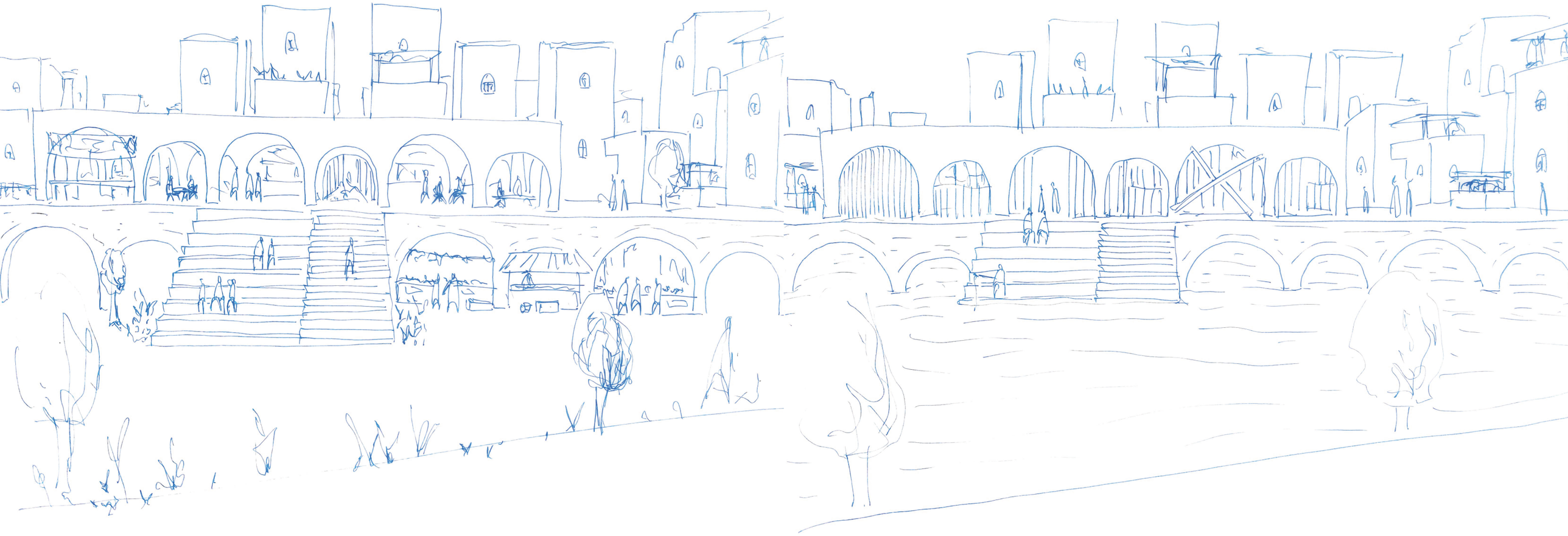
10 m

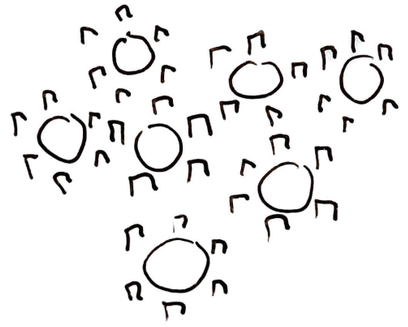


# Communal Ammenities

*During dry and flood season*

The communal ammenities, which are positioned as connecting elements between the implemented structure and the existing adjacent villages, provide shelter for vulnerable communities during flood season.





# NETWORK

# Access

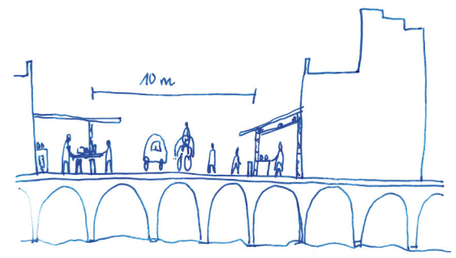
*Entrance and main street*

An open ground floor creates a welcoming gesture which is reinforced by large staircases that offer seating spaces. Meanwhile on top of the platform large streets create opportunities for residents to make use of their flexible plots for workshop spaces and market stands and thereby create alternative sources of income.

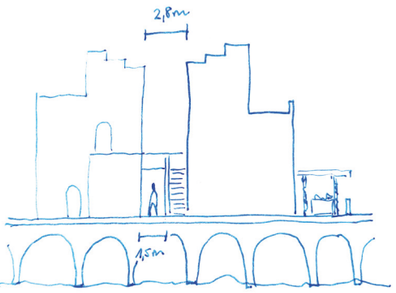




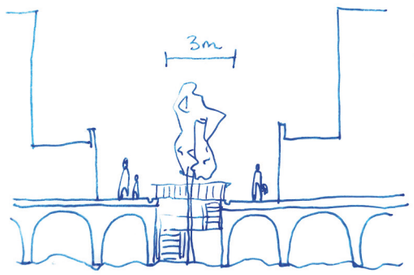



wide streets, suitable for car traffic




narrow streets for pedestrians



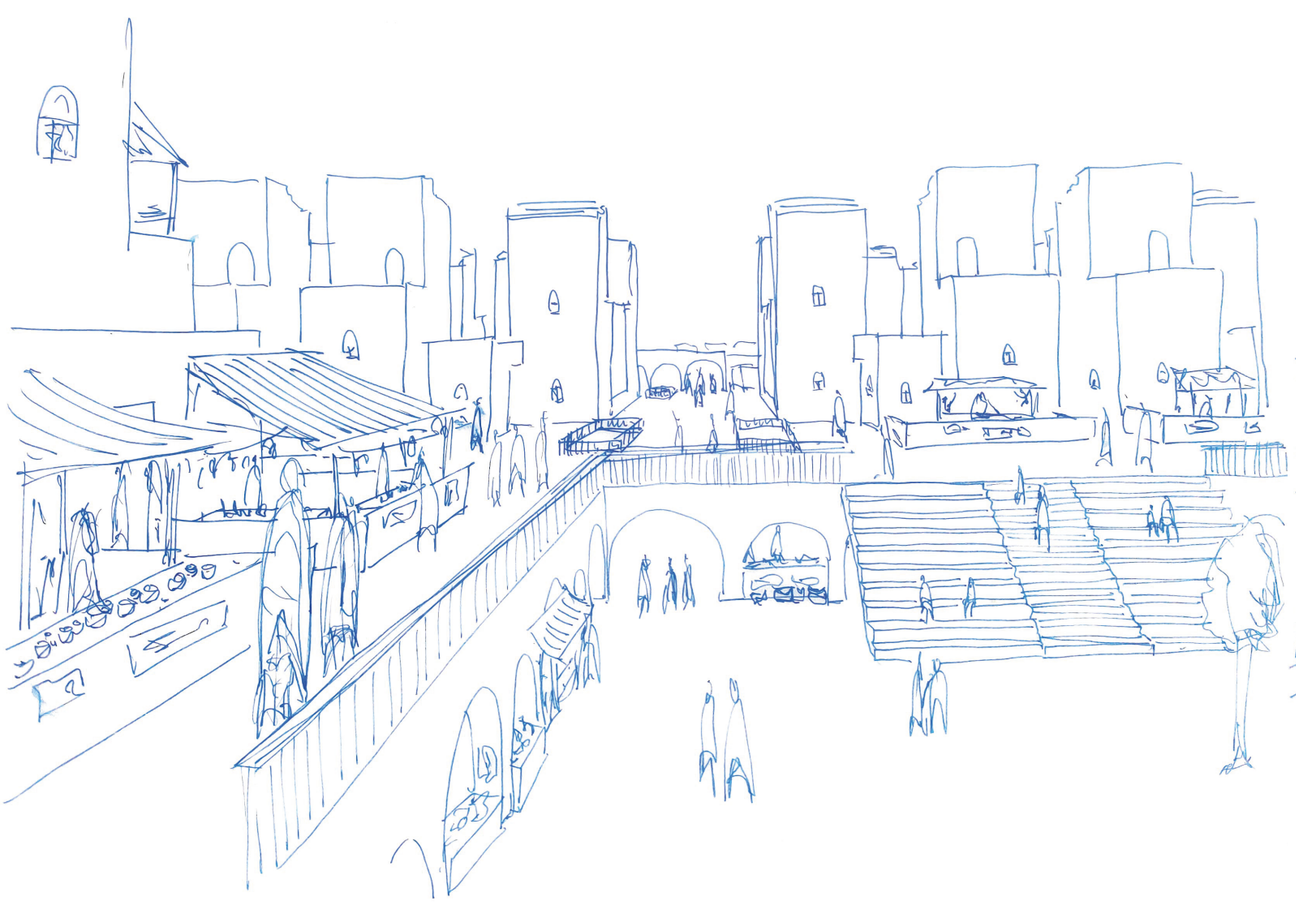

semi-public courtyard of cluster

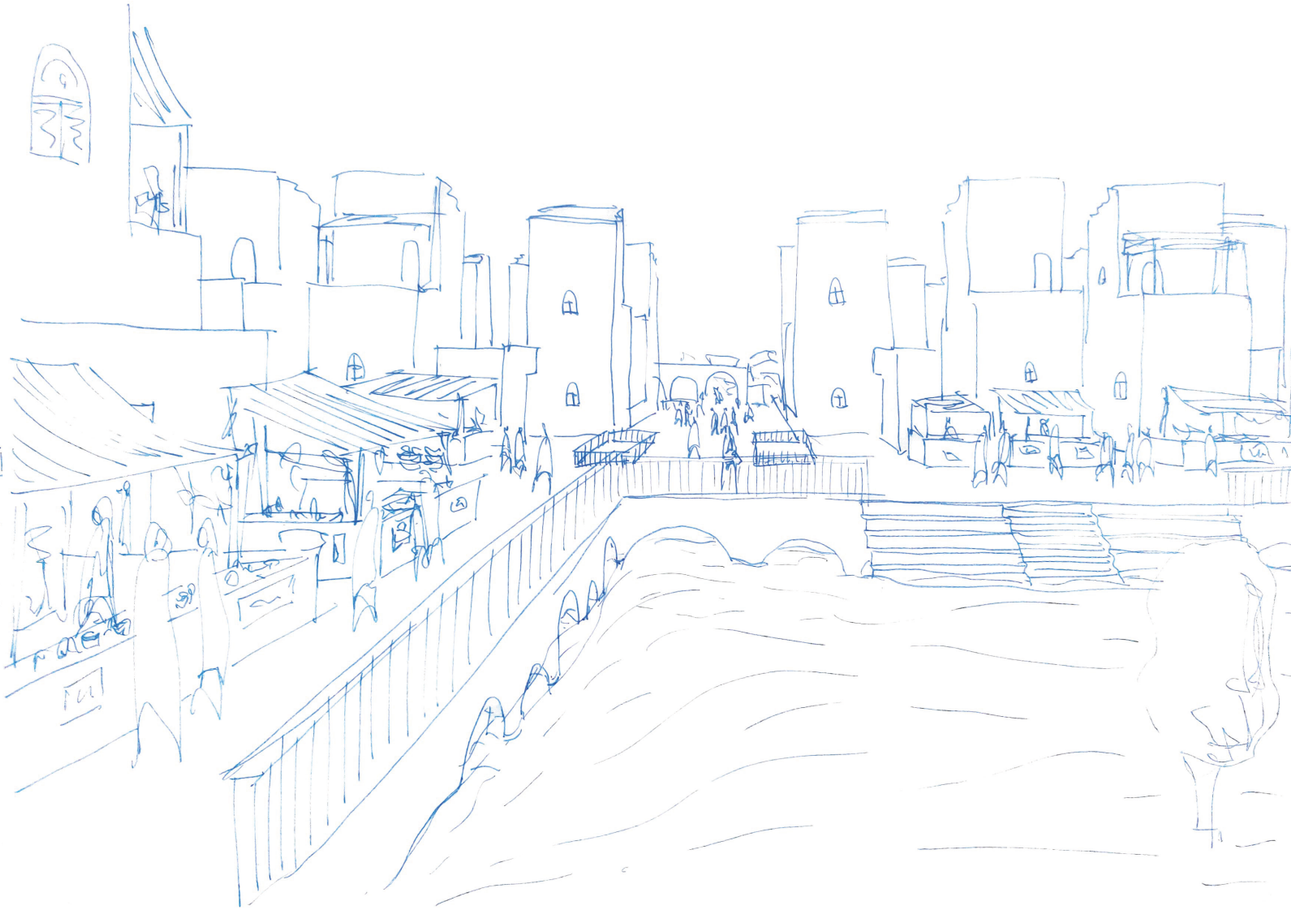
10 m

# Central Courtyard

*Dry and flood season*

Central plazas offer space for interaction and exchange that support the strength of the larger community. During dry season the ground floor offers shaded spaces for market stands and other ammenities while these activities are relocated on top of the platform during flood season.





# Ground Floor

*Lighting and spatial organisation*

A large number of openings in the platform guarantee sufficient lighting on ground floor level which allows residents to use their private plots for a variety of uses, for instance woodwork in a workshop space or as shelter for cattle.

opening in platform

private plot, usable during dry season

10 m

# Bazar - Spatial Quality

*References from around the world*

Densely populated urban areas are prone to accomodating bazars that offer a very special spatial quality. For foreigners the pesent density and intensity of colours, smells and noises can be overstimulating, but at the same time these spaces offer unique opportunities for social and financial exchange between members of different societal communities.



**Souks in Marrakech, Marrocco**
by www.istockphoto.com

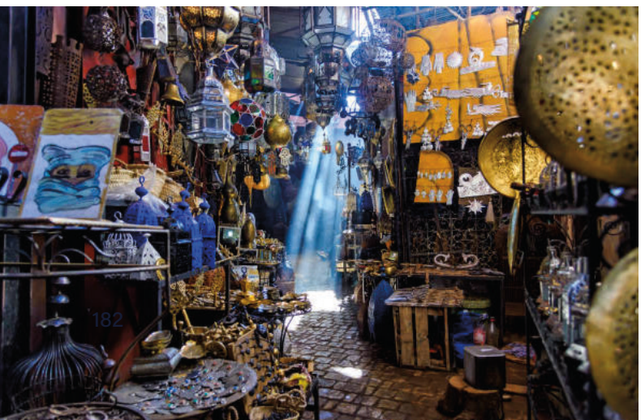




**Marketplaces and Bazaars in India**
by www.archdaily.com















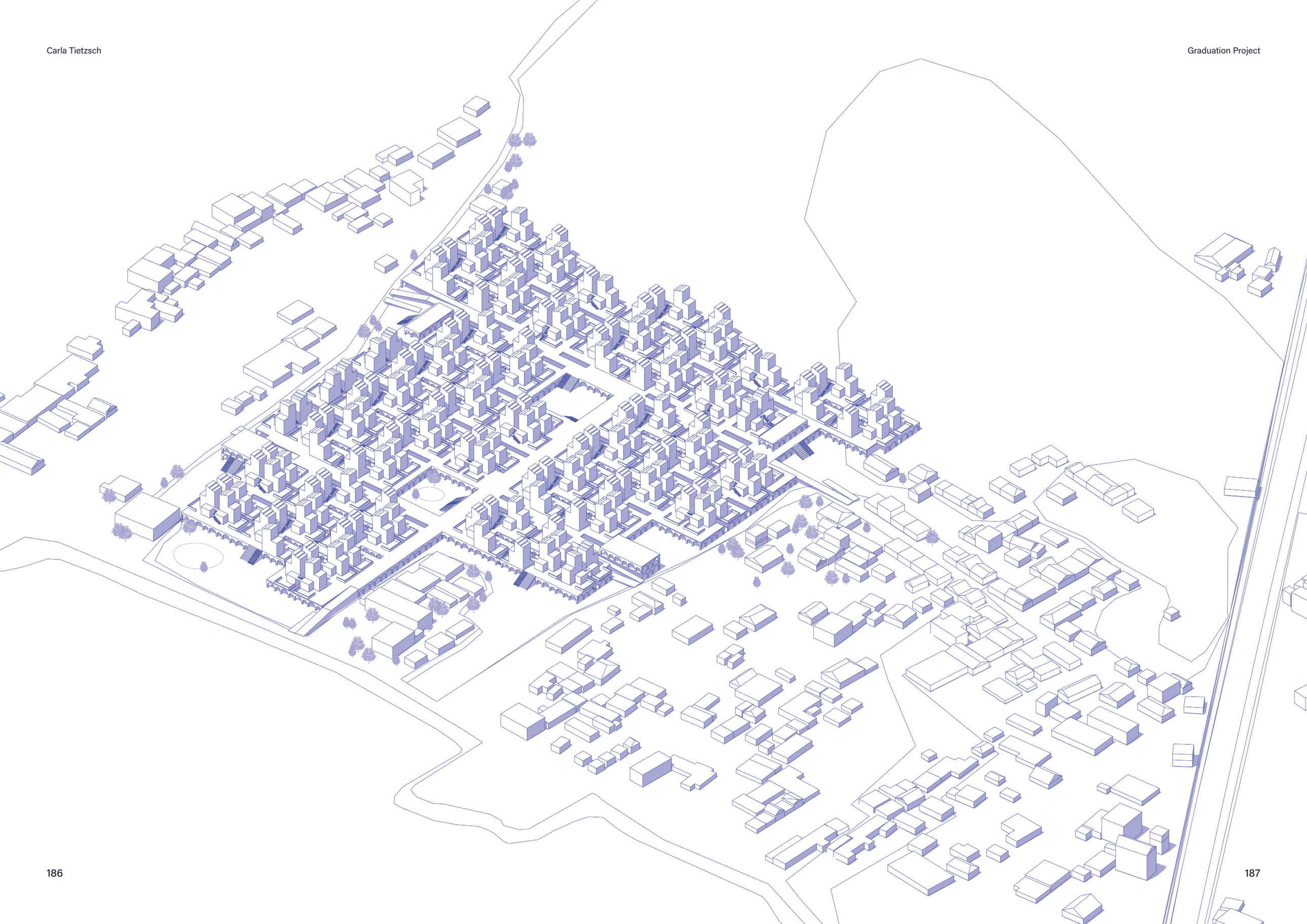


private plot with commercial potential

narrow street through courtyards for slow, pedestrian traffic

wider path, accessible with CNGs and motor bikes

wide streets for public access



# Increased Density

platform size: 32.700 m2

start building mass:
16.900 m2 --> building/platform - ration = 0,52

scenario 1 (maximal expansion during flood season):
27.200 m2 --> ratio = 0,83

scenario 2 (maximal expansion during dry season):
40.900 m2 --> ratio = 1,25



FSI (start): 0,39

FSI (scenario 1): 0,63

FSI (scenario 2): 0,95



buildings: 168

units: up to 336

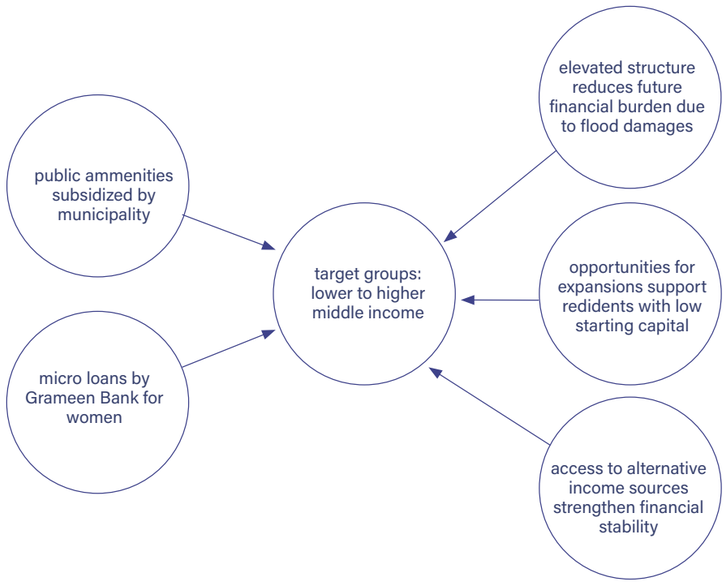
plot: 43.000 m2

GSI: ~0,31

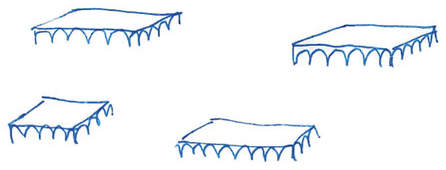


# Managerial Strategy

*Ownership and financing strategy*

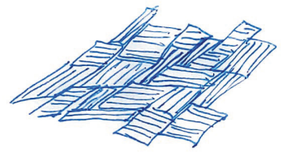



publicly owned communal ammenities (school, kindergarden etc.), financed by municipality

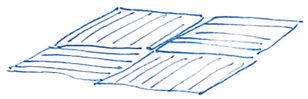


public access system

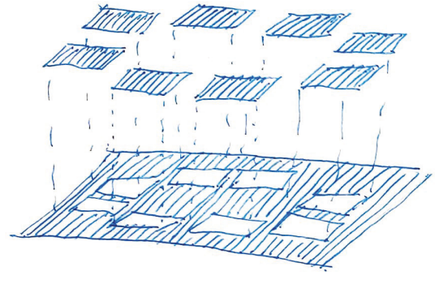




currently: patchwork of privately owned land



transformation into several communaty land trusts

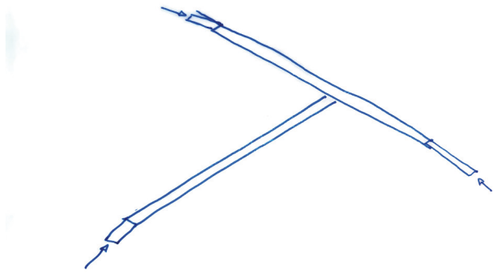


privately owned units

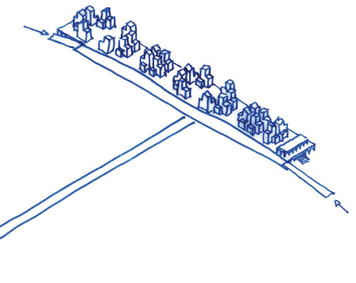
one community land trust per cluster

# Phasing Strategy

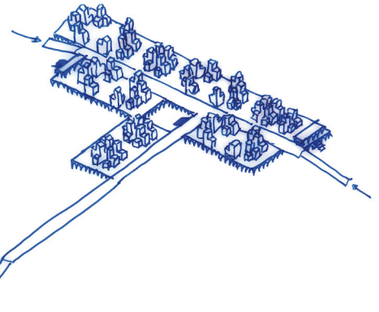
*Construction in steps*



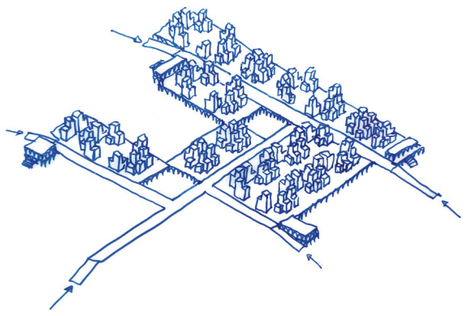
1.



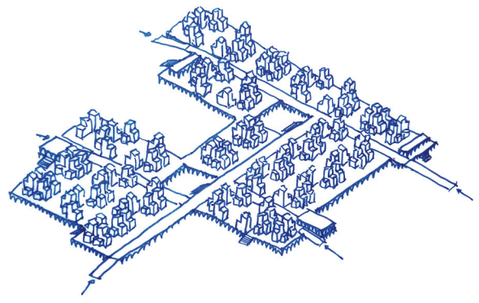
2.



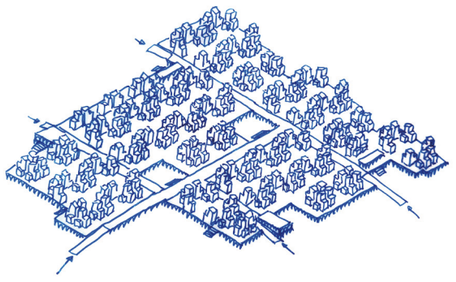
3.



4.



5.



6.

# PROCESS

# CIDCO Housing  Project

*Case Study I*

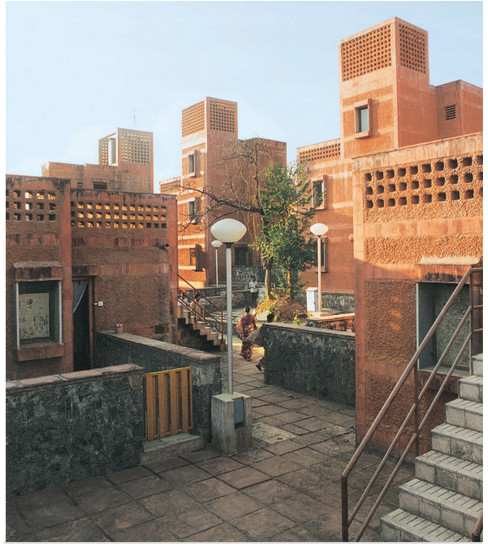
The CIDCO Housing Project was developed by the famous architect Raj Rewal, who put a lot of effort into the design of replicable housing units that offer a large variety of configurations.  With this project he created a playful village-like neighbourhood that incorporates the human scale very well.

**Name** : CIDCO Housing Project
**Location** : Navi Mumbai, India
**Architect** : Raj Rewal
**Year** : 1993

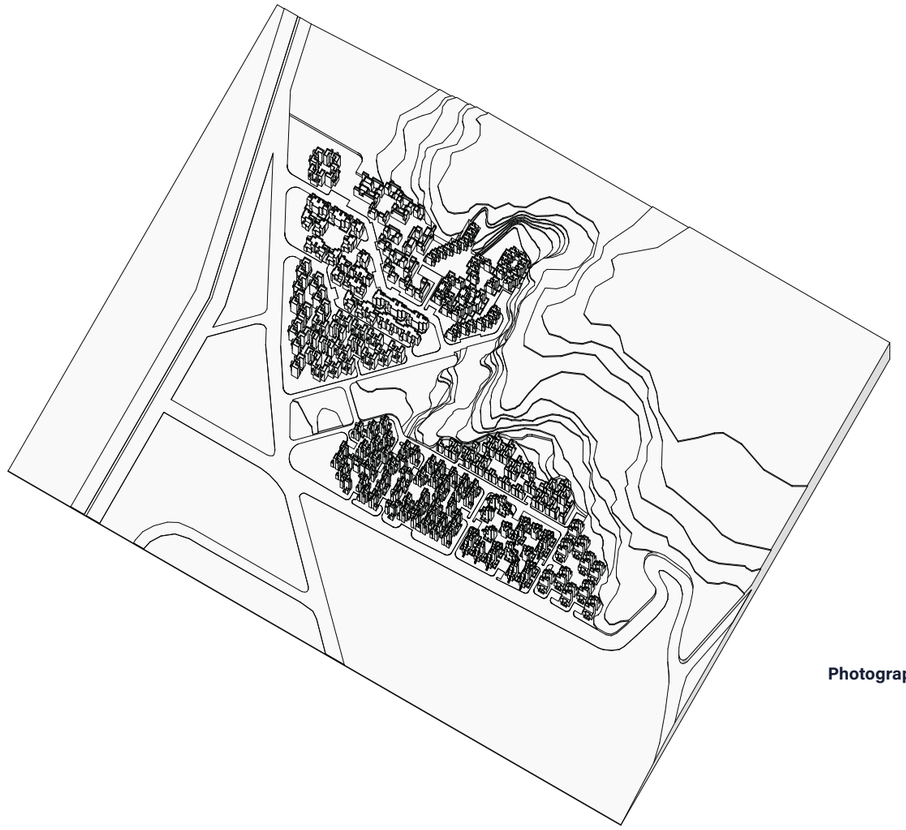
**Photographed**
By rajrewal.in



With this project Raj Rewal answered to the pressing issue of lack of affordable housing solutions in high-density areas. The project offered extremely low-cost accomodations for the lowest income group. He developed the project as an alternative form of mass housing design that offers a higher living quality through the implementation of simple variations. With this strategy he broke with the stereo types associated with mass housing projects and offered a new perspective for the housing market in a time of crisis.



| | |
|---|---|
| **plot:** | 3.44 ha |
| **number of dwellings:** | 714 |
| **density:** | 207 dwellings/ha |
| **FSI:** | 0.49 |
| **unit sizes:** | 20-100 sqm |
| **GSI:** | 0.30 |



**Photographed**

With his playful approach Rewal created a complex topography that situated the project ideally into the site, located next to a mountain. The Project had a great potential to offer a variety of sufficient living gspaces with acces to a large amout of outside spaces. Unfortunately the maintenance was neglected in the following decades which resulted in the decay of most buildings. Today only a small part of the project is still intact and a majority was demolished to make space for newer dwellings or sell the empty plots.



0 10 m

# CIDCO Housing

Navi Mumbai, Raj Rewal, 1993

With the CIDCO Housing Project Raj Rewal answered to the pressing issue of lack of affordable housing solutions in high-density areas. The project offered extremely low-cost accomodations for the lowest income group. He developed the project as an alternative form of mass housing design that offers a higher living quality through the implementation of simple variations. With this strategy he broke with the stereotypes associated with mass housing projects and offered a new perspective for the housing market in a time of crisis.

With his playful approach Rewal created a complex topography that situated the project ideally into the site, located next to a mountain.

The Project had a great potential to offer a variety of sufficient living gspaces with acces to a large amout of outside spaces. Unfortunately the maintenance was neglected in the following decades which resulted in the decay of most buildings. Today only a small part of the project is still intact and a majority was demolished to make space for newer dwellings or sell the empty plots.

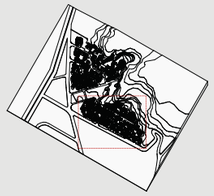
**Design Research: Global Housing**
Global Housing Graduation Studio
Architecture of Transition in the Bangladesh Delta:
Autumn Semester 2024/25 [AR3AD105]

**Tutors:**
Prof. Marina Tabassum
Prof. Dick van Gameren
Ir. Rohan Varma
Ir. Frederique van Andel
Ir. Antonio Paoletti

**Student:**
Carla Tietzsch

GLOBAL HOUSING TUDelft Architecture and the Built Environment

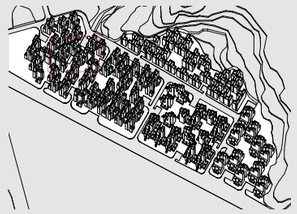
## Neighbourhood



**Plot**
Area: 3,44 Ha
Dwelling Units: 714



**Program**
Housing: 17.000 m2



**FSI/FAR**
0,49

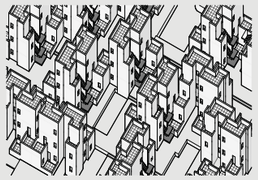


**GSI**
0.3

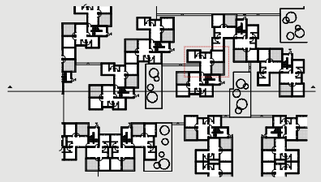


**Density**
207 dw/ha

## Block



**Type 01 - Volume & Connectivity**
Ground floor + 2



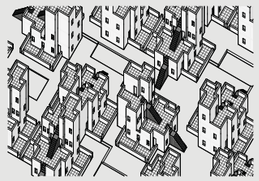
**Type 01 - Ground Floor Plan**
Access Points



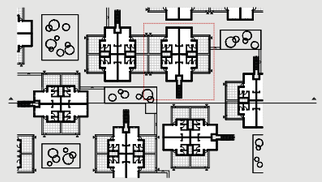
**Type 01 - Section**
Ground Floor + 2



**Type 02 - Section**
Ground Floor + 2

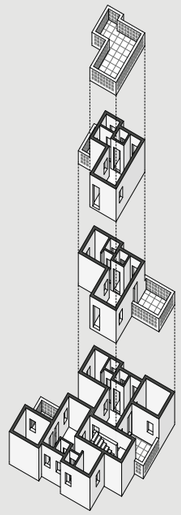


**Type 02 - Volume & Connectivity**
Ground Floor + 2

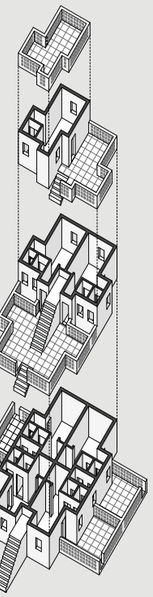


**Type 02 - Ground Floor Plan**
Access Point

## Unit



**Dwelling Type 01**
Area: 105 m2 (ground floor + 2)



**Dwelling Type 02**
Area: 155 m2 (ground floor + 2)

# CIDCO Housing

Navi Mumbai, Raj Rewal, 1993

**Plot Area:** 3.44 ha
**Number of Dwellings:** 714
**Density:** 207 dw/ha
**FSI:** 0.49
**Unit Sizes:** 20 sqm - 100 sqm
**GSI:** 0.30
**Client:** CIDCO
**Scheme:** Public Housing
**Design:** Raj Rewal
**Tenure:** Home Ownership

CIDCO Housing was developed by the famous architect Raj Rewal, who put a lot of effort into the design of replicable housing units that offer a large variety of configurations. With this project he created a playful village-like neighbourhood that incorporates the human scale very well.

Thanks to the repetition of the same units the project could offer affordable housing solutions for different family sizes. Meanwhile he incorporated different types and thereby gave each of the seven neighbourhoods a unique character. Depending on the type the access is either located in a core or on the outside of the unit. This differentiation allows the project to develop more private and more public configurations.

The density of the project is relatively low due to a maximum of three stories. This factor supports the village-like character of the neighbourhoods and creates a potential for a high living quality. The staggering of terrasses reduces the volume with each level which creates an even lighter appearance.

The project is pedestrian friendly and limits the car traffic to the outside of the neighbourhoods. A large number of courtyards supports the perforated character of the project.

**Design Research: Global Housing**
Global Housing Graduation Studio
Architecture of Transition in the Bangladesh Delta:
Autumn Semester 2024/25 [AR3AD105]

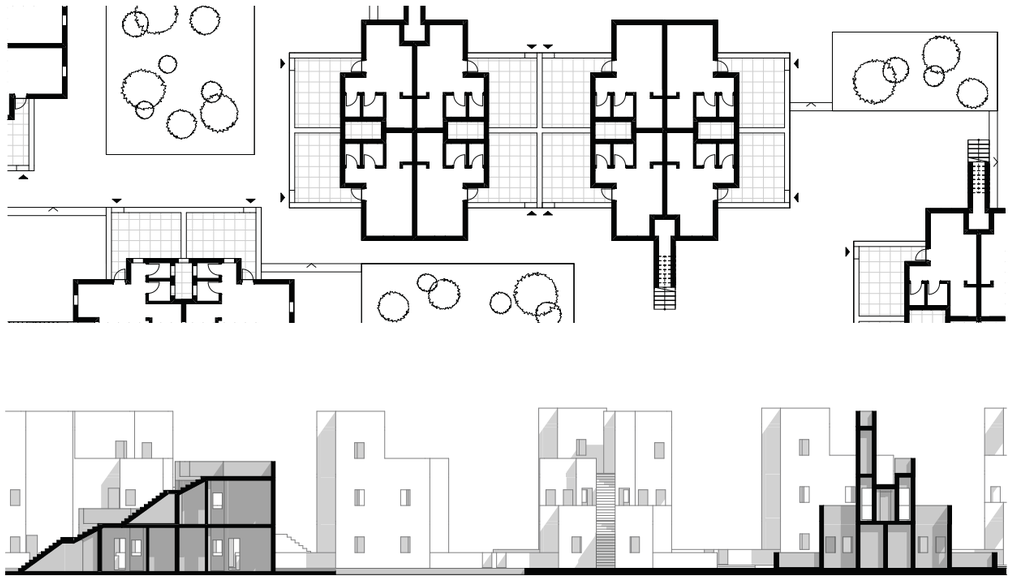
**Tutors:**
Prof. Marina Tabassum
Prof. Dick van Gameren
Ir. Rohan Varma
Ir. Frederique van Andel
Ir. Antonio Paoletti

**Student:**
Carla Tietzsch

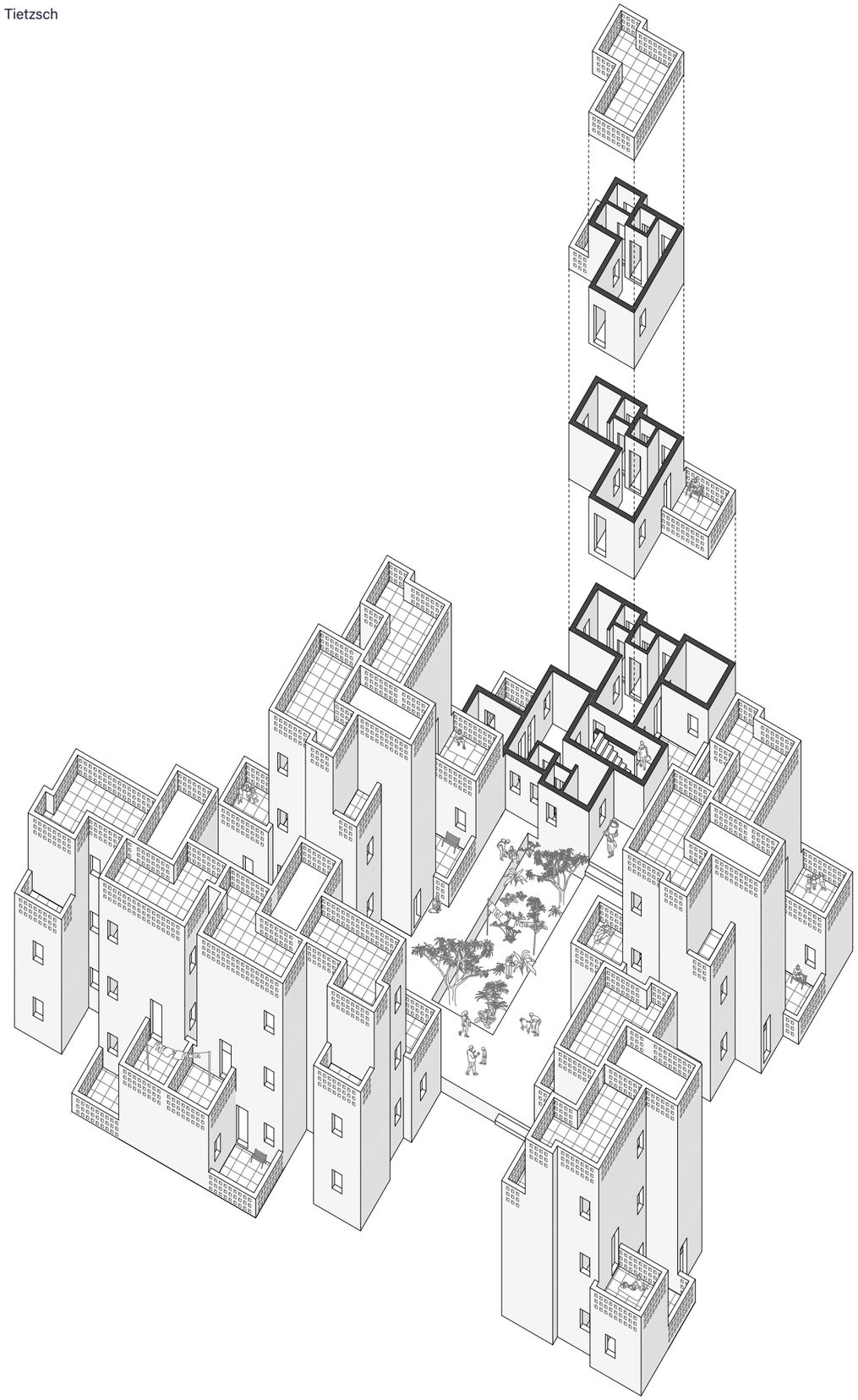
GLOBAL HOUSING | TUDelft | Architecture and the Built Environment

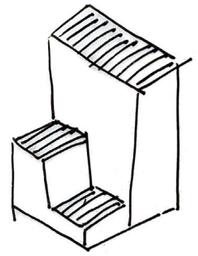


section west 1:400

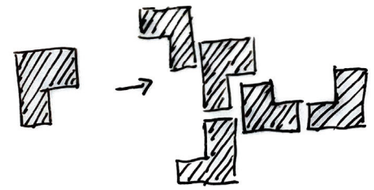


section east 1:400

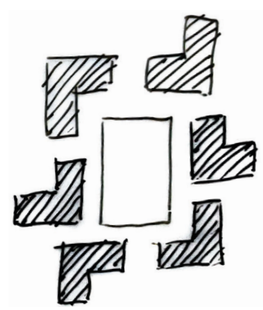




terrasses offer communal spaces



repitition of simple units



clusters arond courtyards

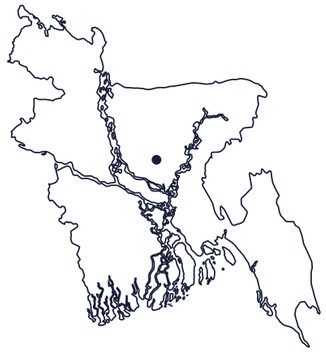
# Hostels, National Assembly

*Case Study II*

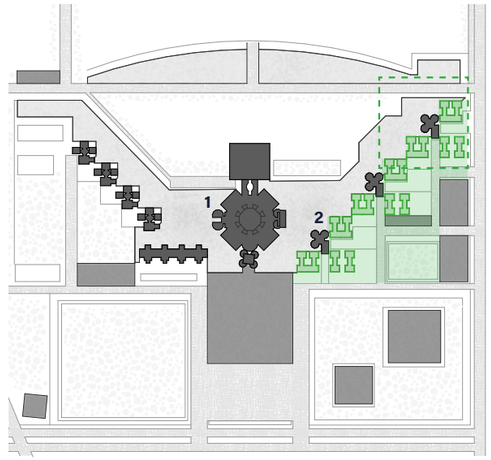
The Sher-E-Bangla-Nagar Master Plan was originally intended as the Second Capital of Pakistan (Lobell). After the independence of Bangladesh in 1971 the master plan received a new purpose by housing the National Assembly of Bangladesh.

**Name** : Hostels for the Members of the National Assembly
**Location** : Dhaka, Bangladesh
**Architect** : Louis I. Kahn
**Year** : 1983

**Photographed**
By architectural review








1 assembly building

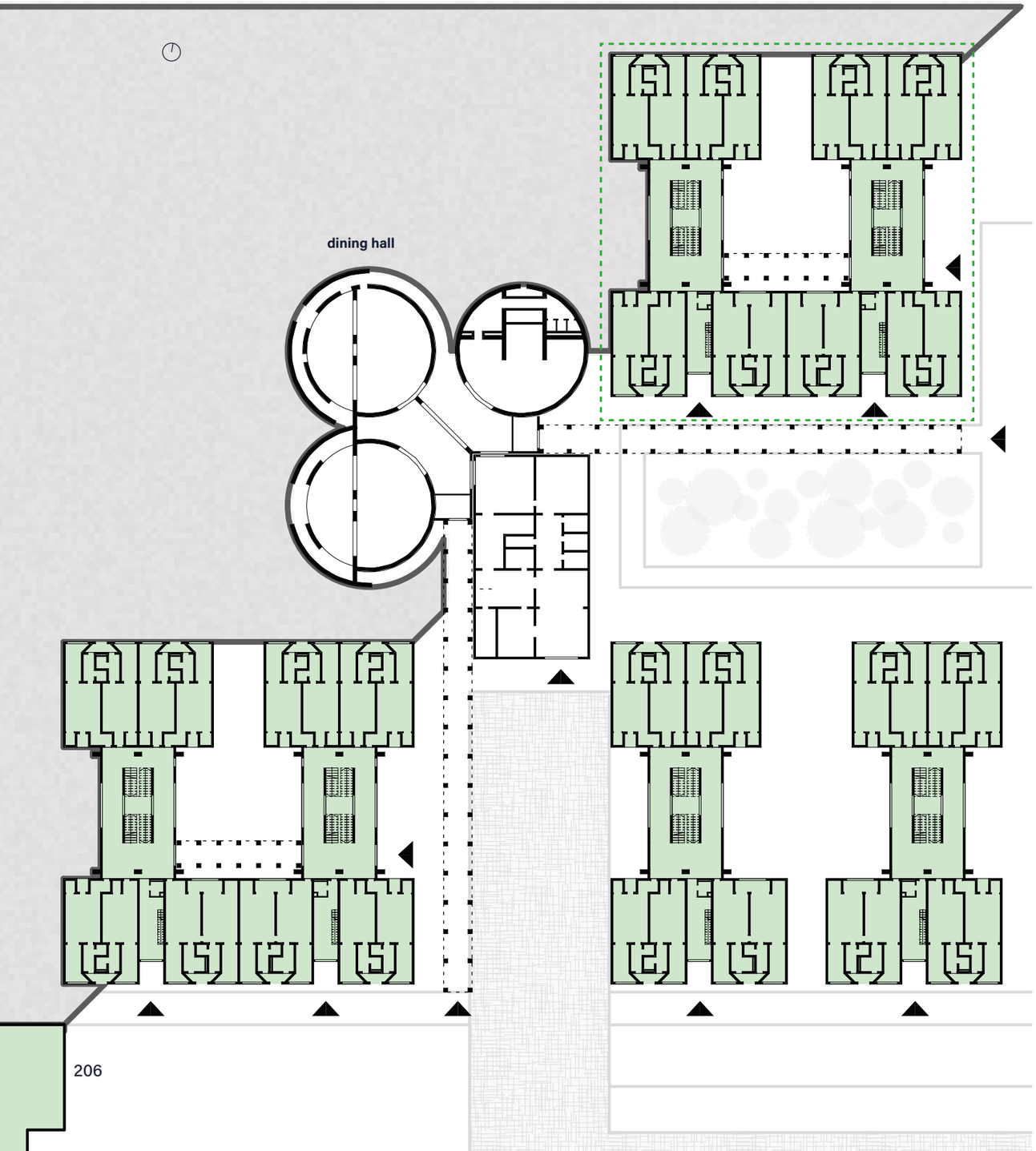
2 dining halls

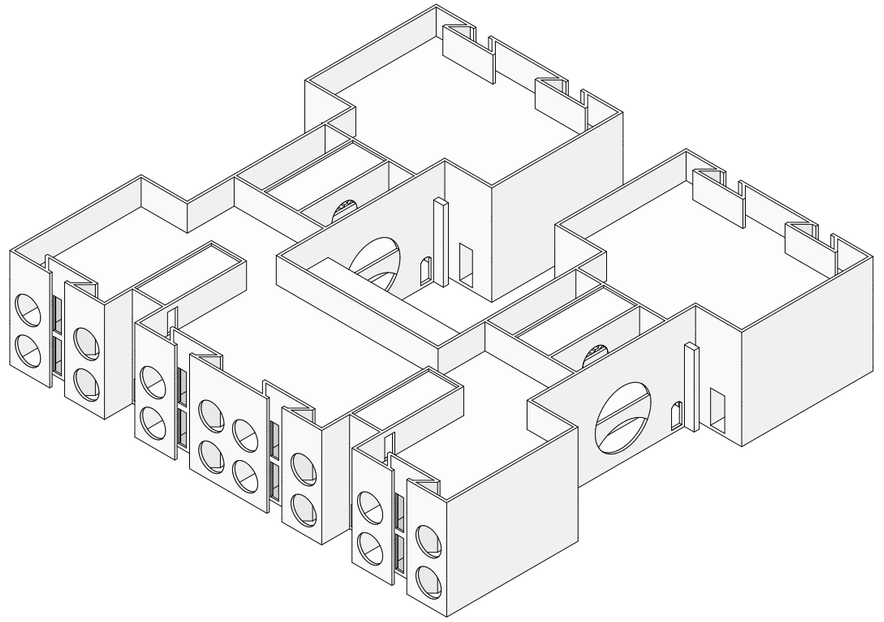
plot

hostels for members of the assembly

The Master Plan is dominated by a great sense of symmetry. While the National Assembly is placed in the center, other institutions like the presidential square and the citadel are located adjacently. In the east of the lake a formation of hostels for members of the assembly is clustered around three large dining halls.

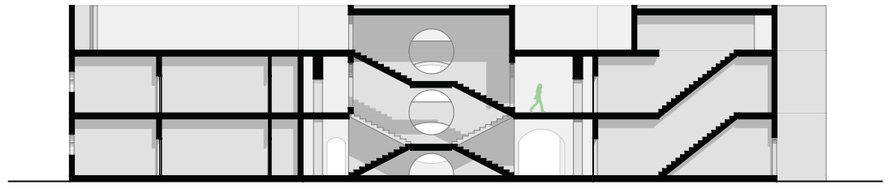
| | |
|---|---|
| **plot:** | 6 ha |
| **number of dwellings:** | 252 |
| **density:** | 42 dwellings/ha |
| **FSI:** | 0.39 |
| **unit sizes:** | 58-116 sqm |
| **GSI:** | 0.20 |



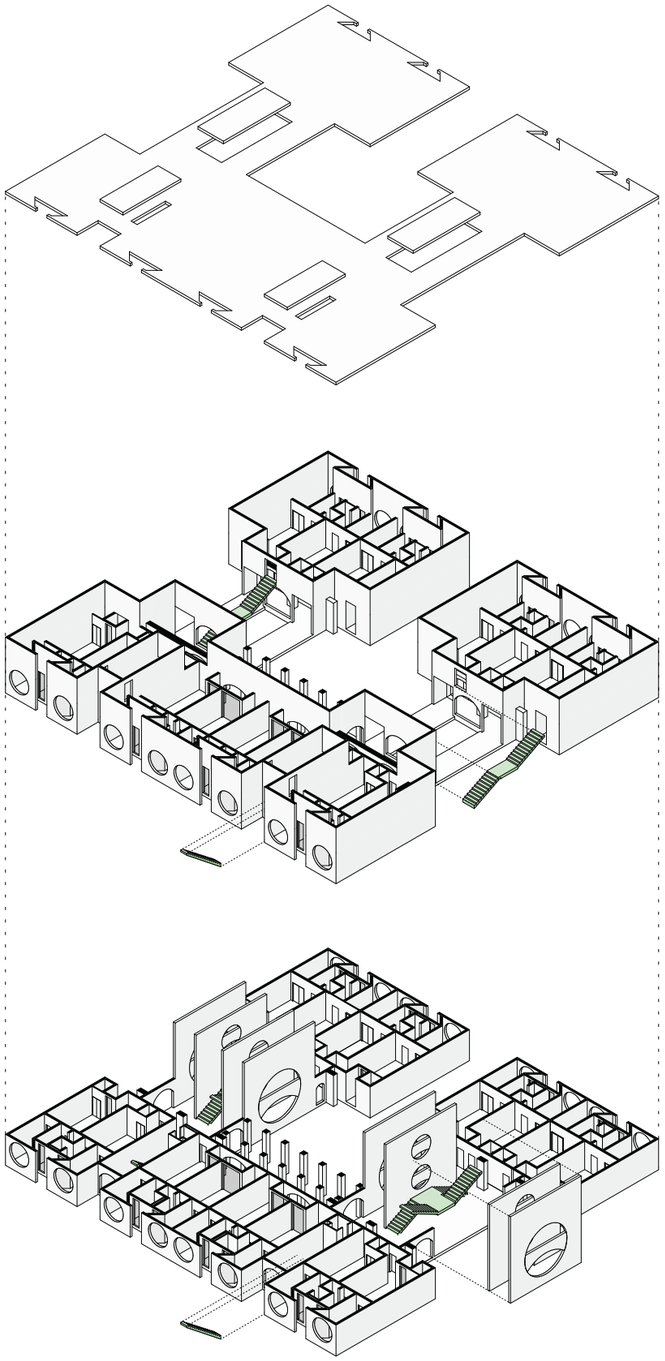



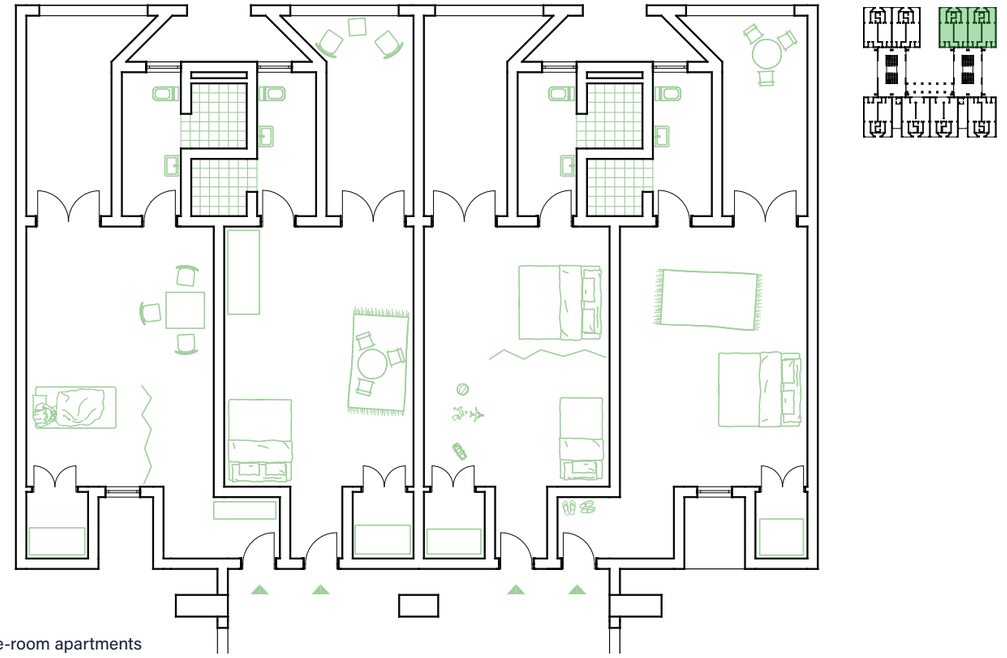


elevation A-A' from west

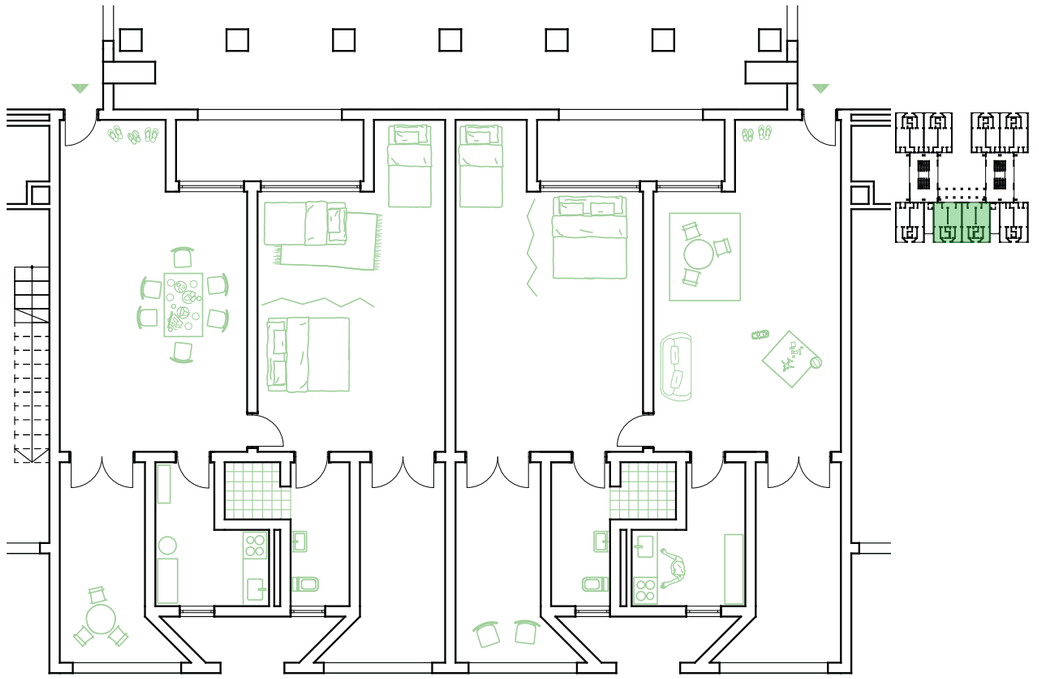


section B-B'





one-room apartments



two-room apartments

**Photographed**
By Arne Maasik 2017







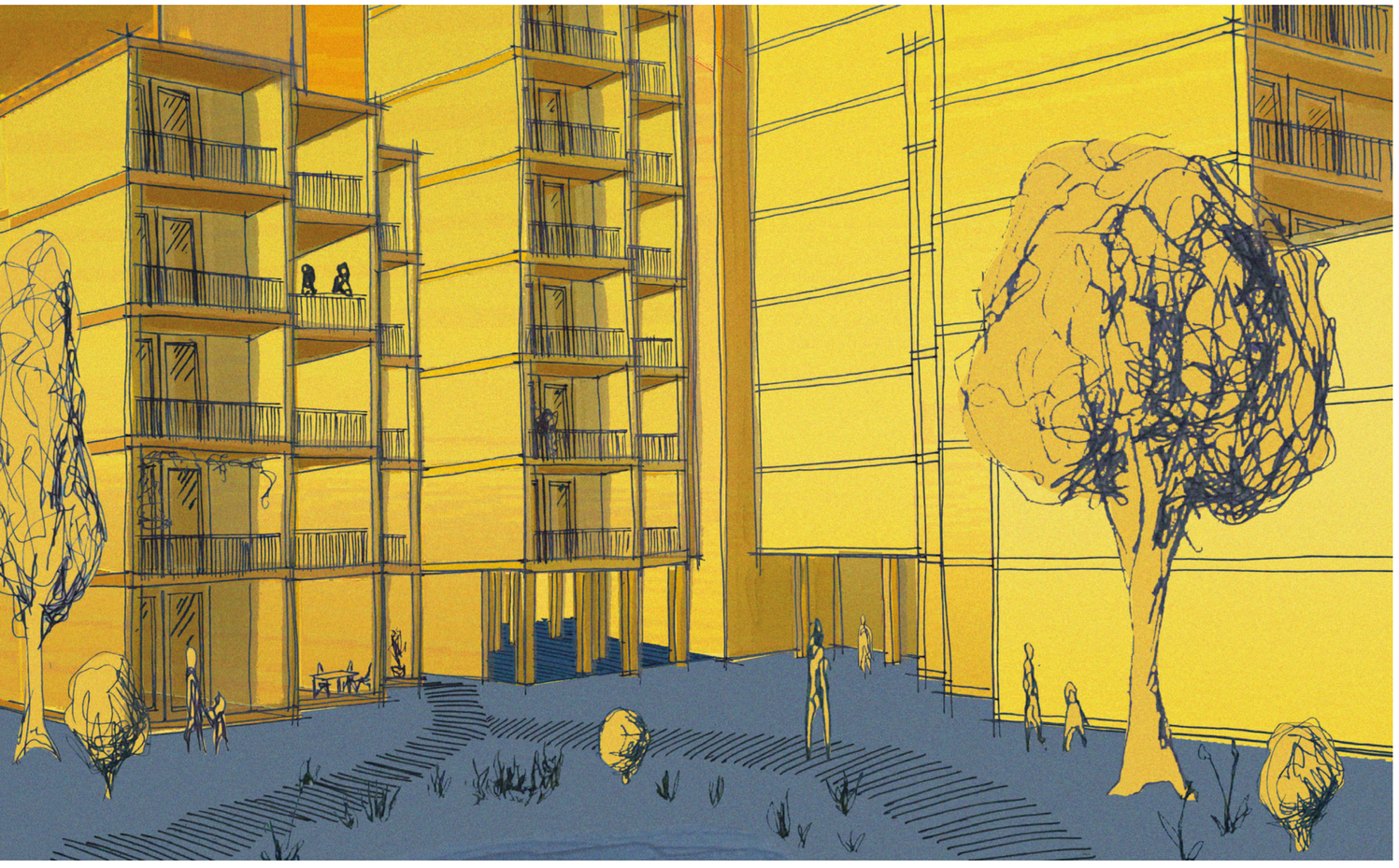




# Pilot Project

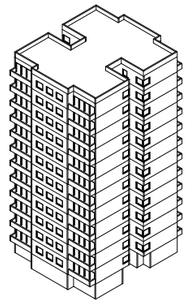
*Design Exercise*

This pilot project was developed as an exercise that supported a playful incorporation of different reference projects over the duration of two weeks. While making use of the case studies from phase I & II this exercise encouraged experimenting with different densities and high- or low-rise designs.



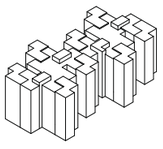
**Thamesmead**

Robert Rigg / Greater London Council (GLC)
London
1960-1970
FSI 0.95



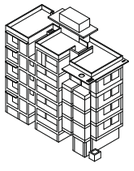
**Student Hostels at Sylhet Polytechnic Institute**

Muzharul Islam & Stanley Tigerman
Sylhet
1966-78
FSI 3,8

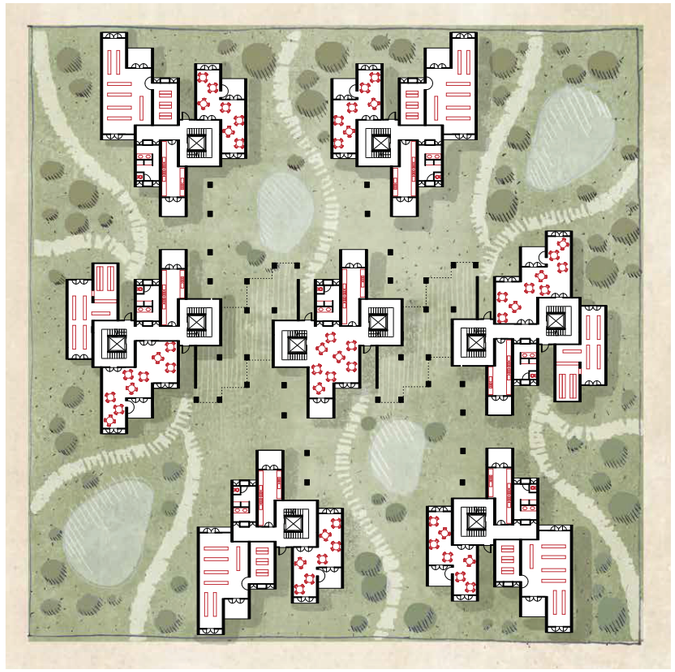


**Kazedewan Apartment Building**

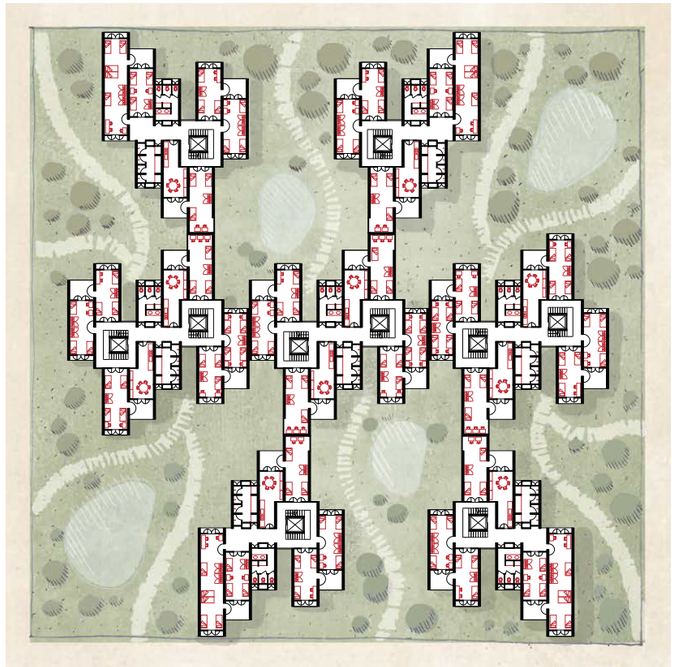
Rafik Azam
Dhaka
2001
FSI 3.7



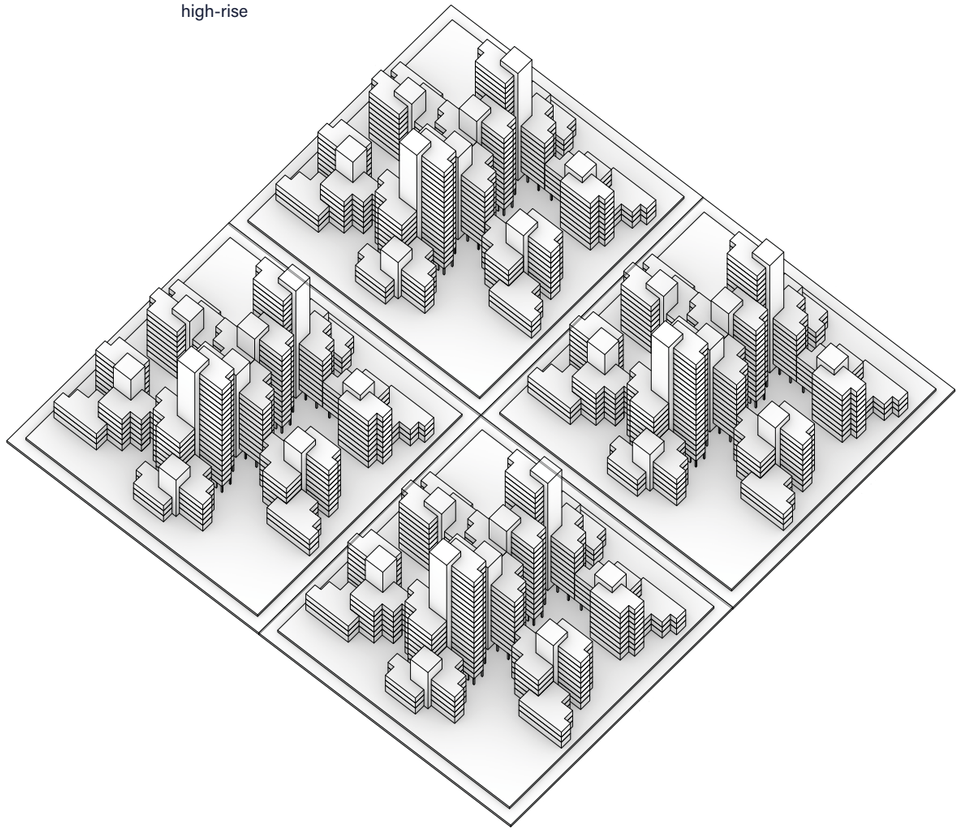
**plot:** 1 ha
**FSI:** 2.5
**height:** high-rise

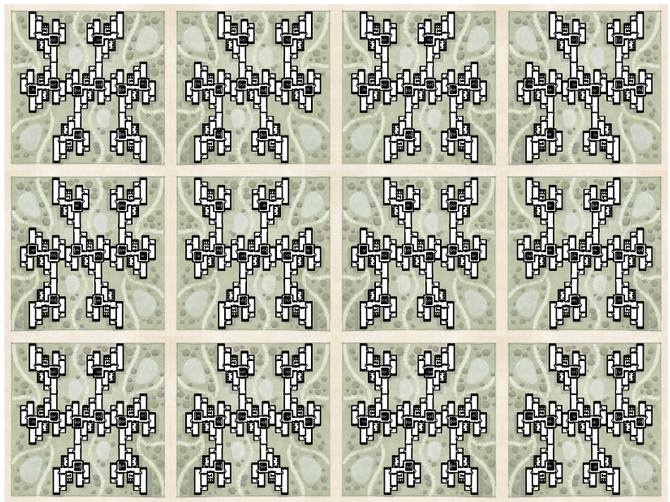


ground floor

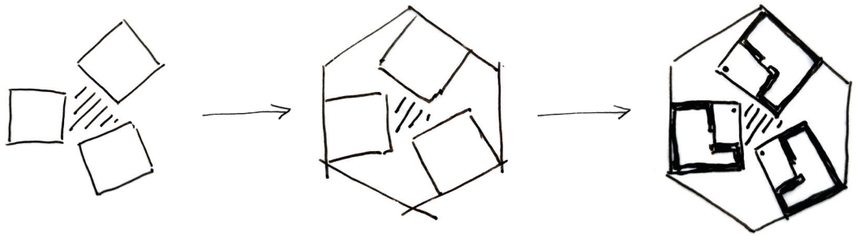


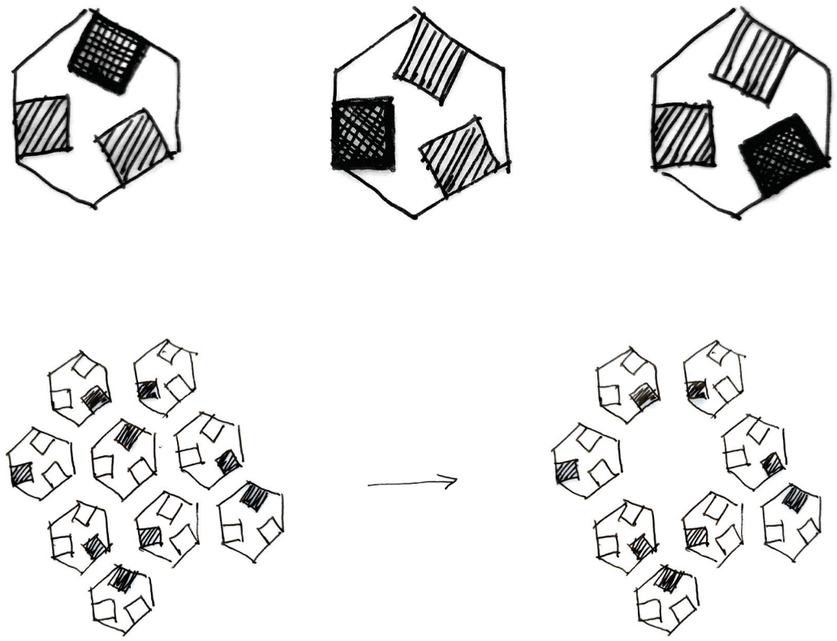
typical floor



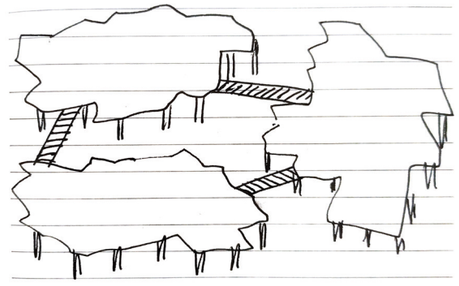


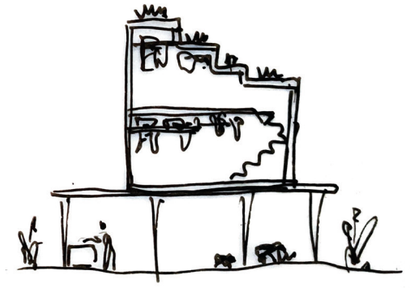
# P2 Presentation

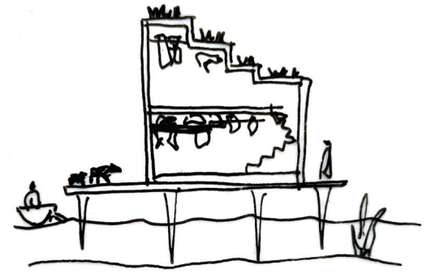


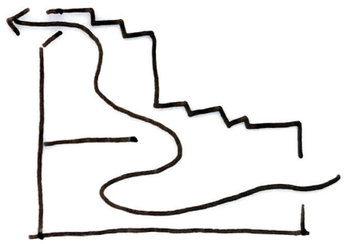


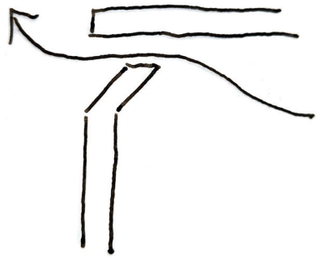


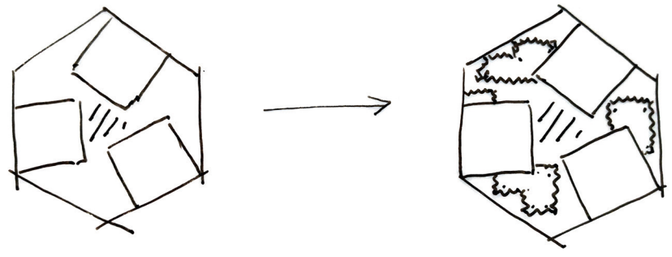


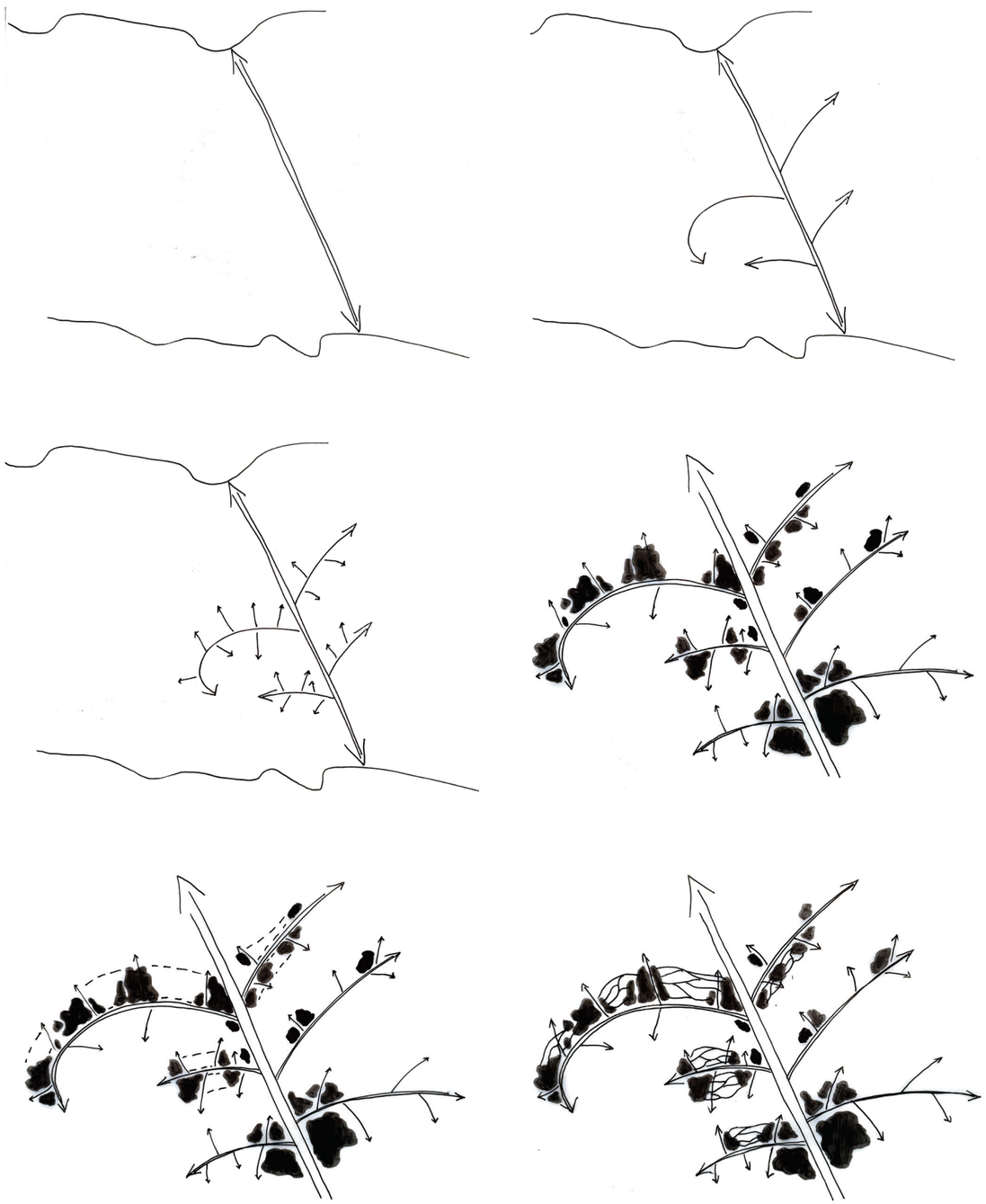


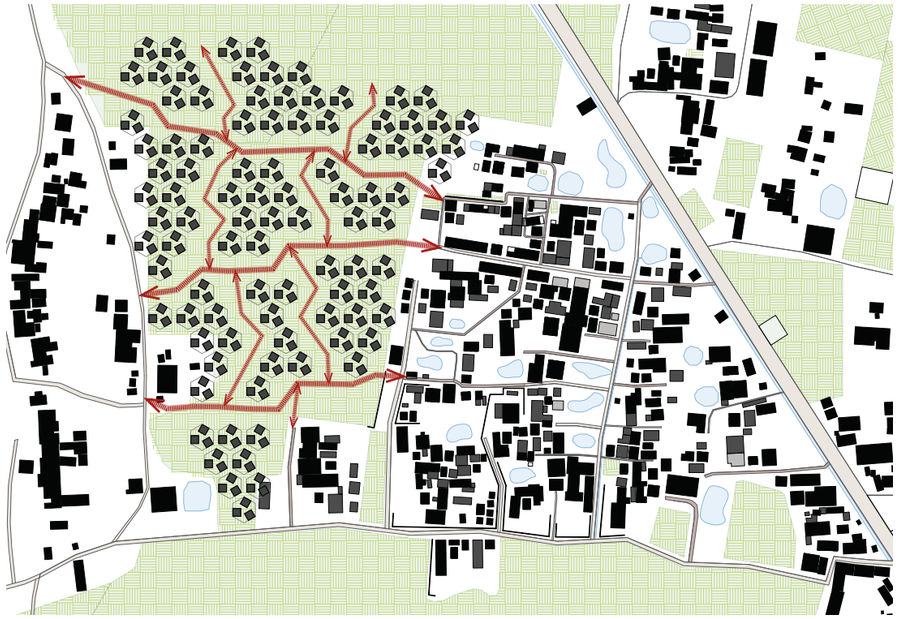


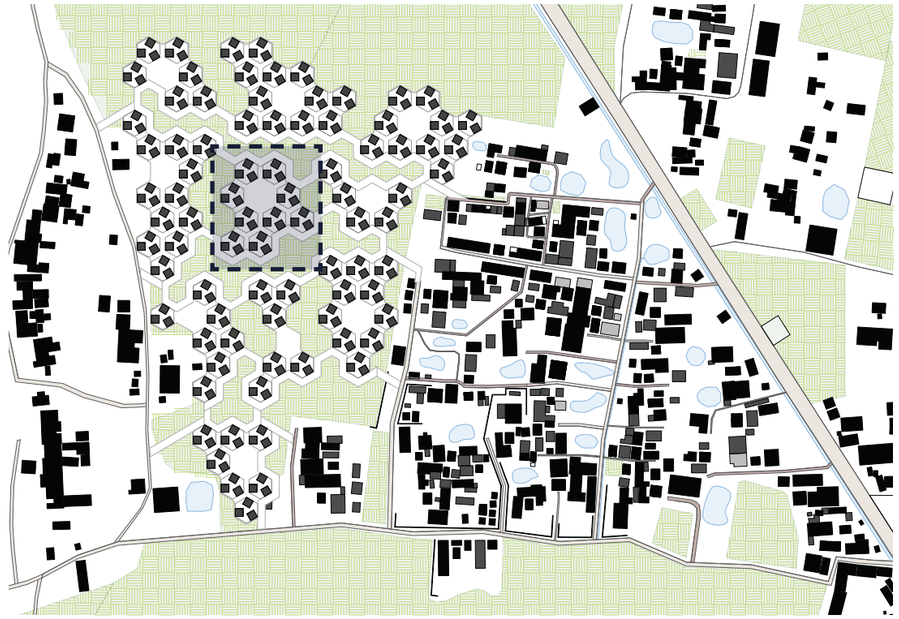


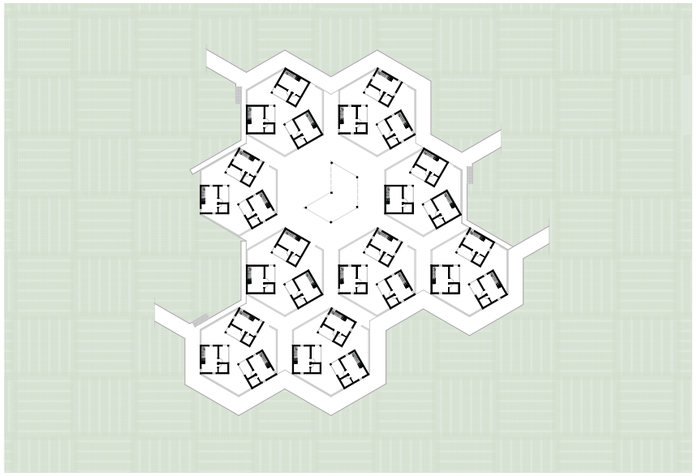


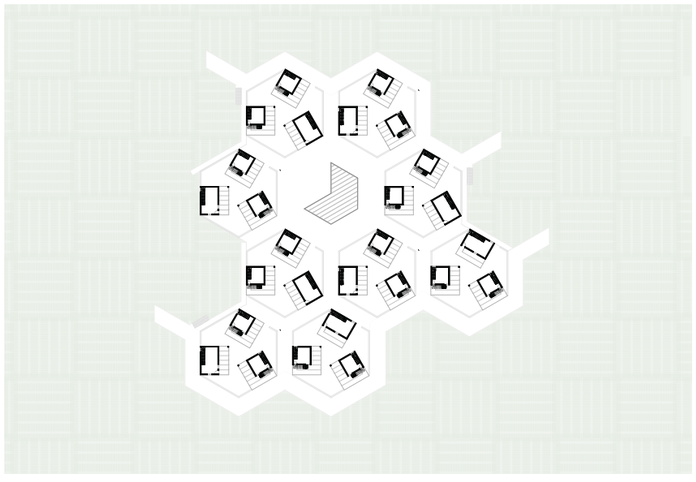


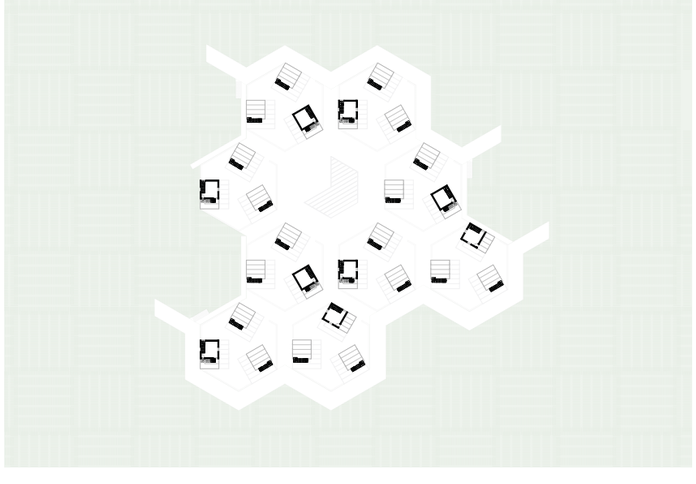


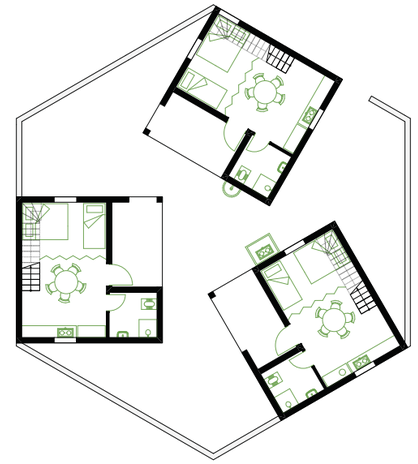


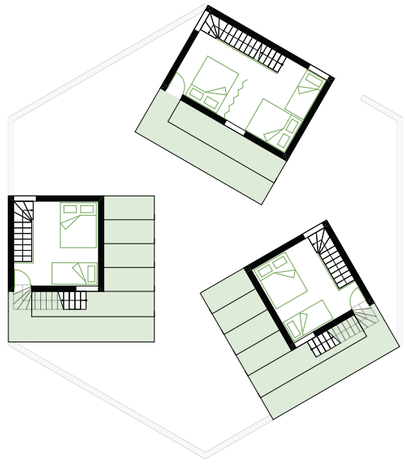


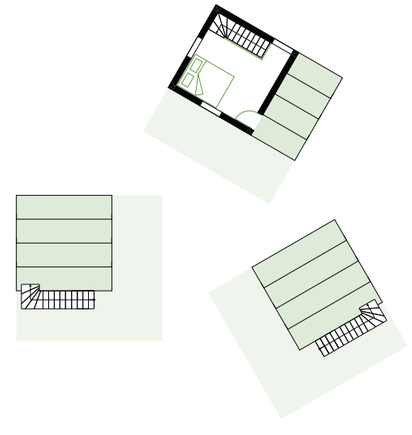


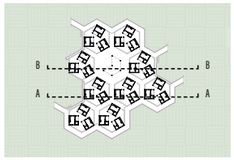


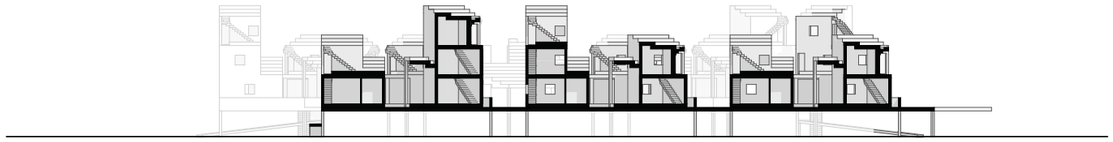




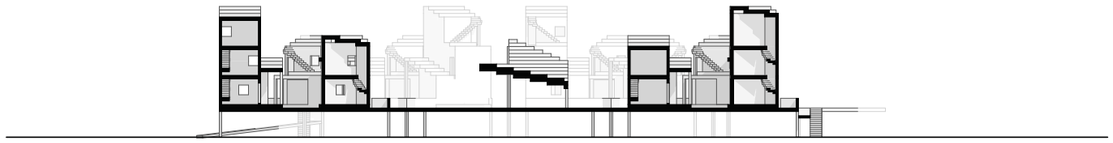




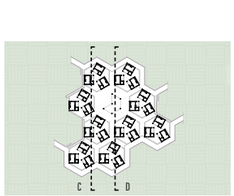


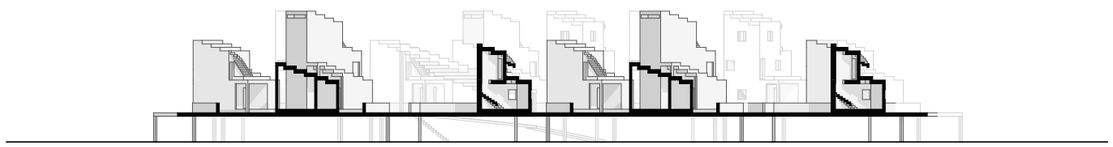



SECTION A-A

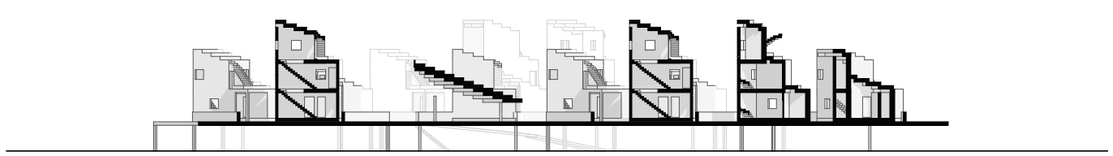


SECTION B-B

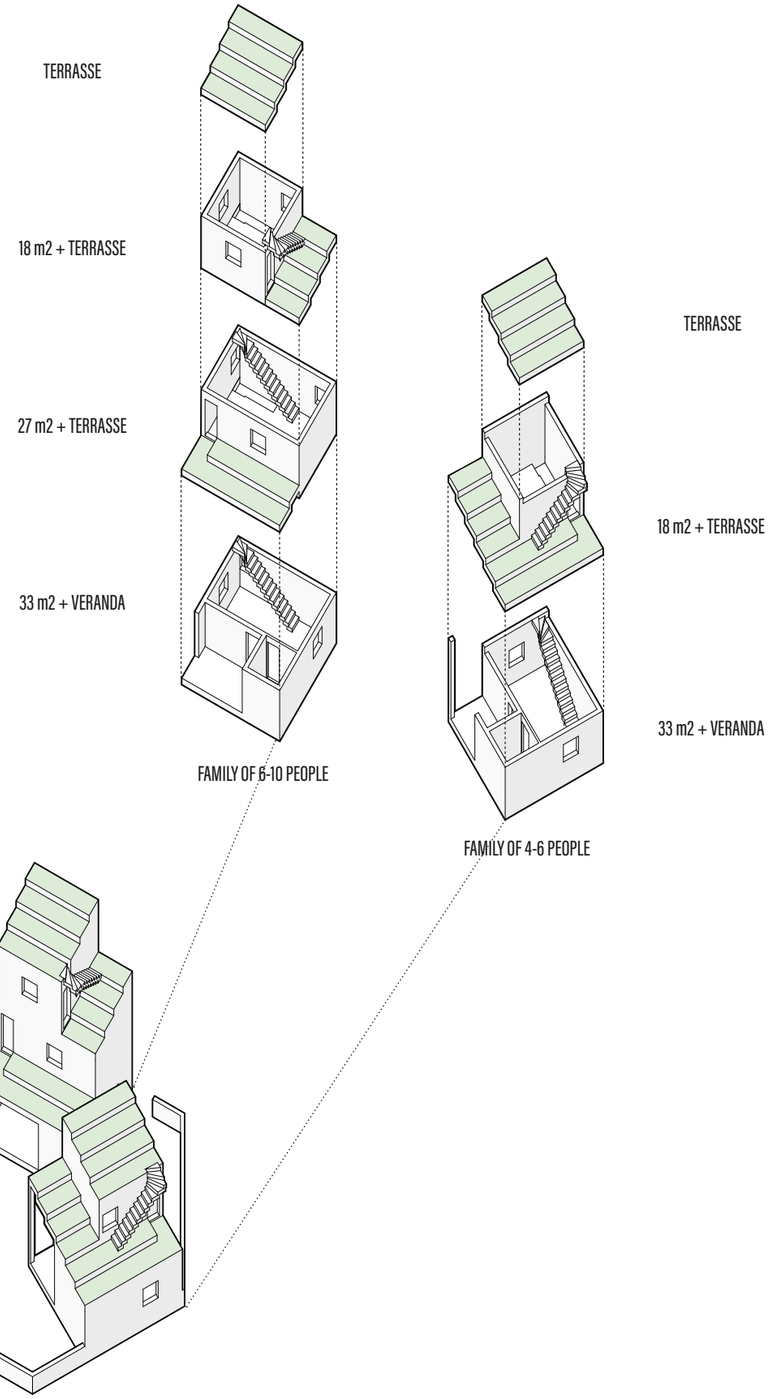


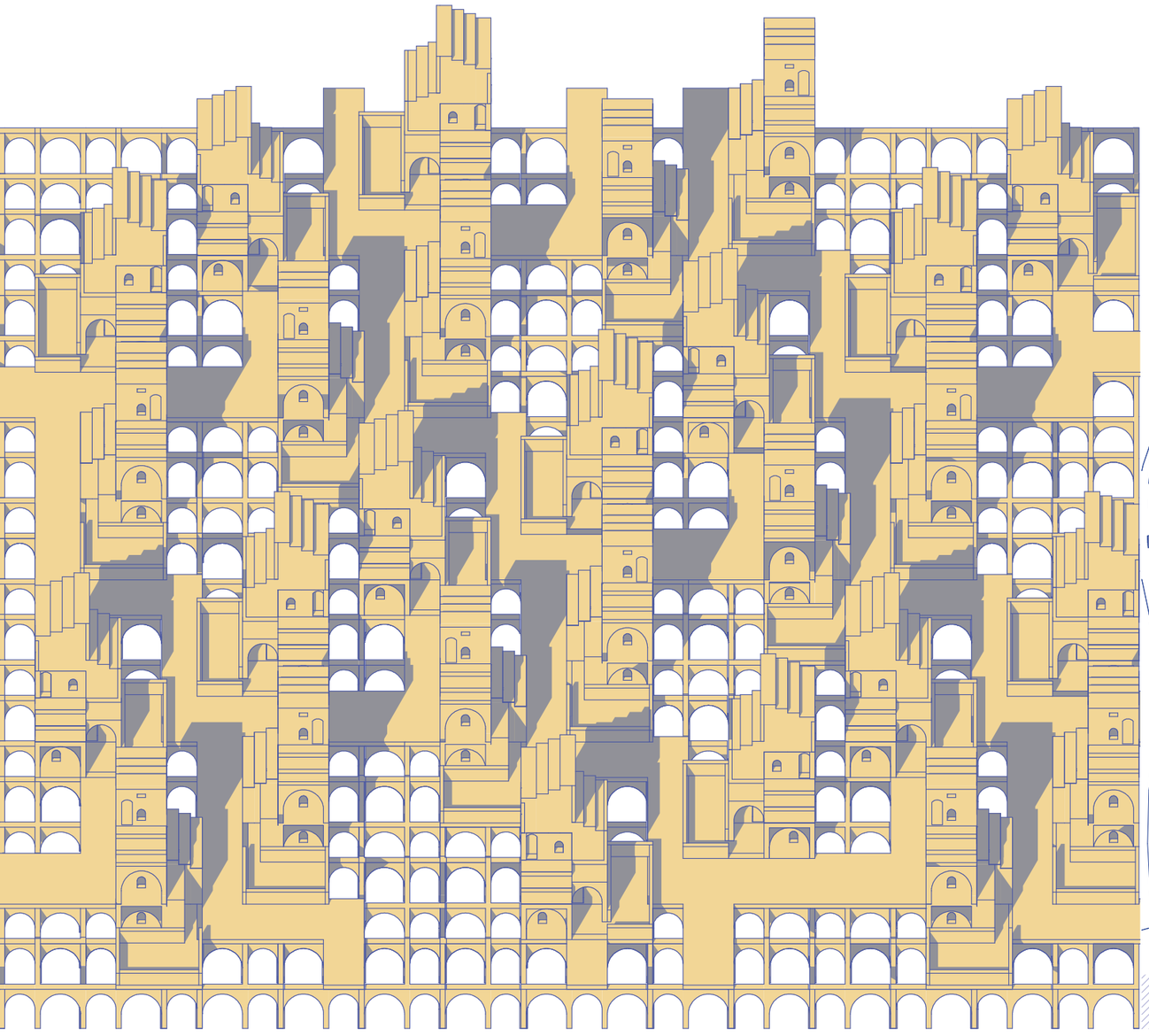
SECTION C-C

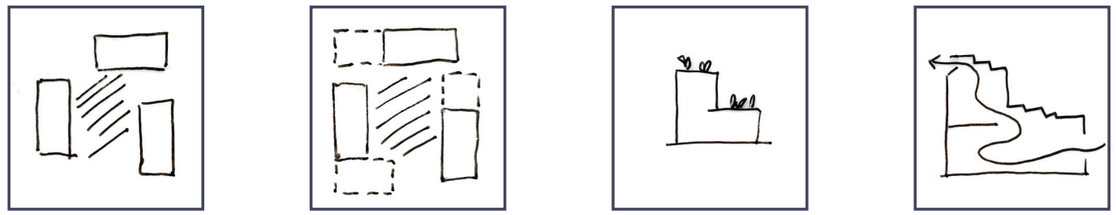


SECTION D-D

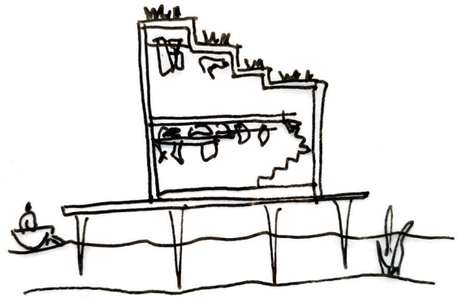


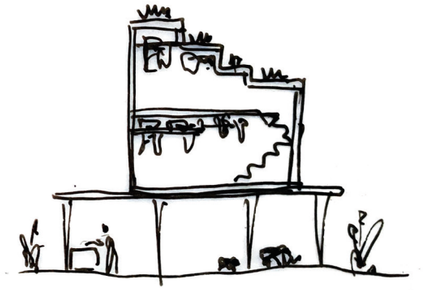
# P3 Presentation

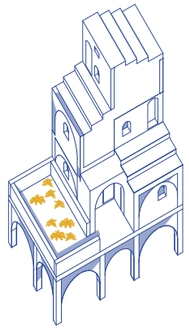




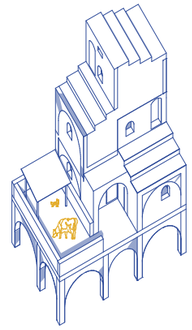




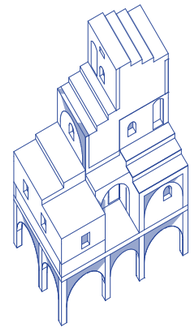




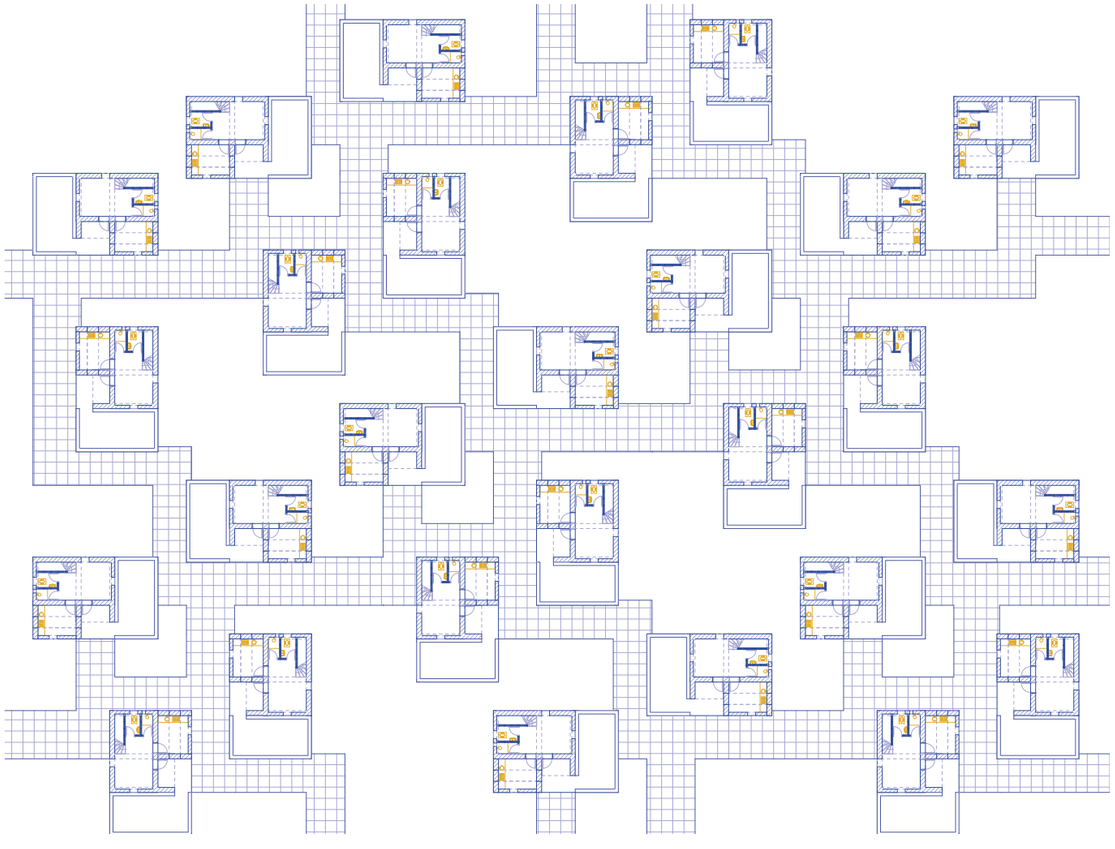
farming area

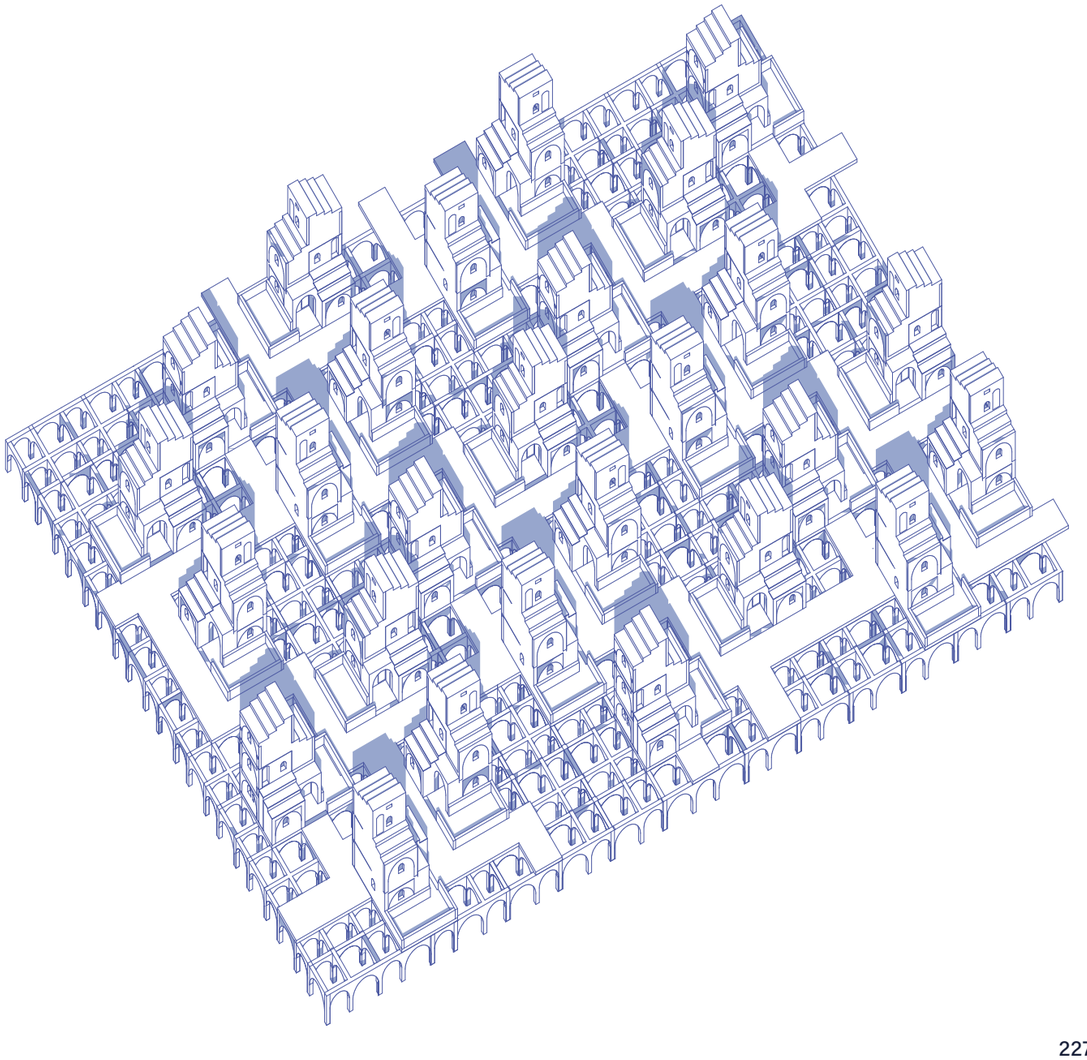


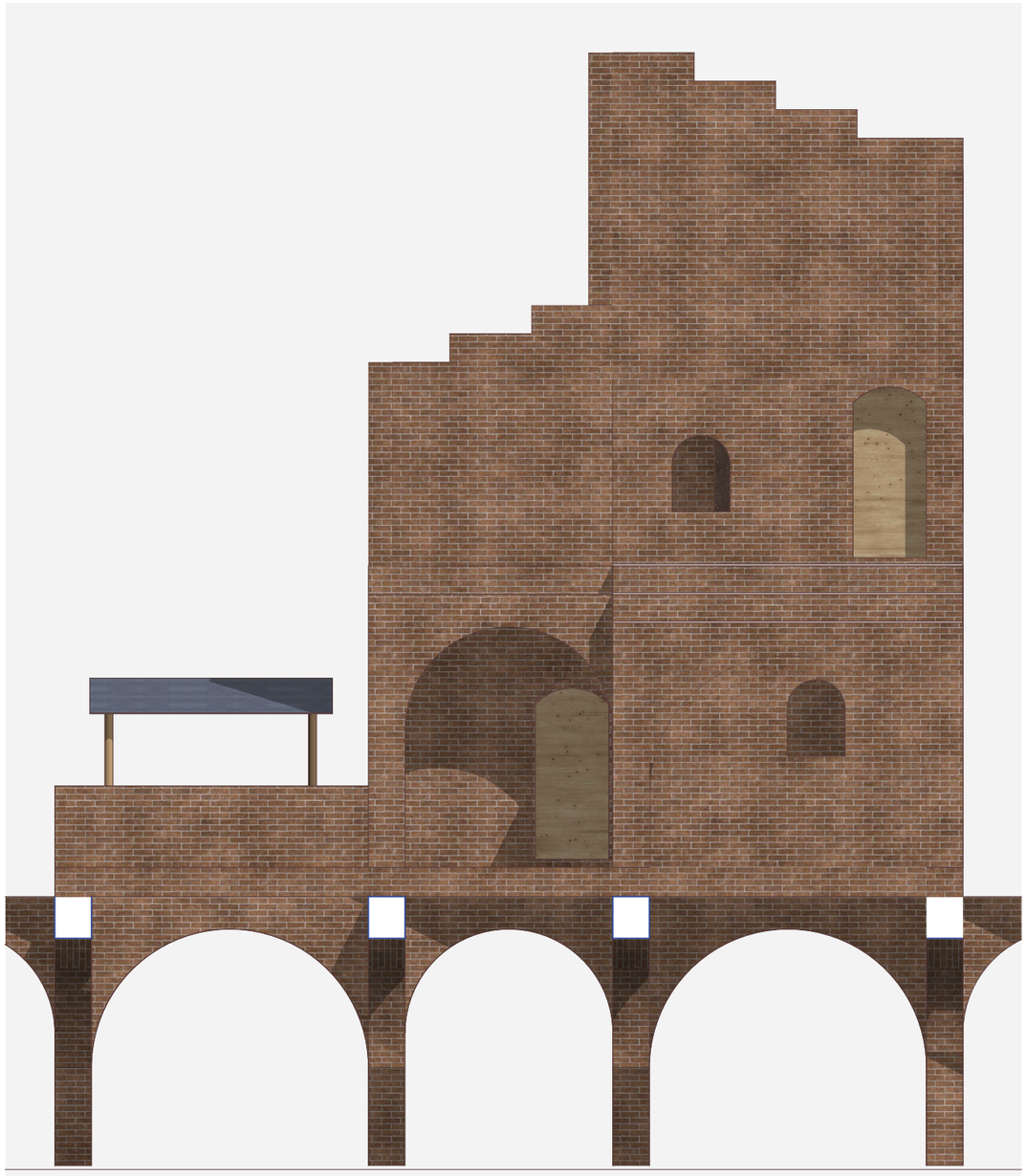
cattle shed

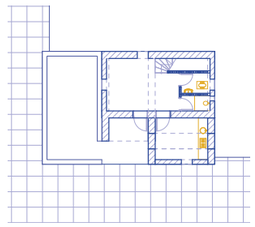


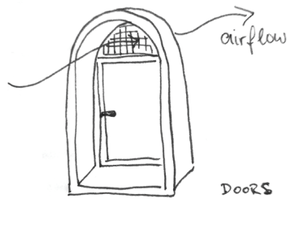
house expansion

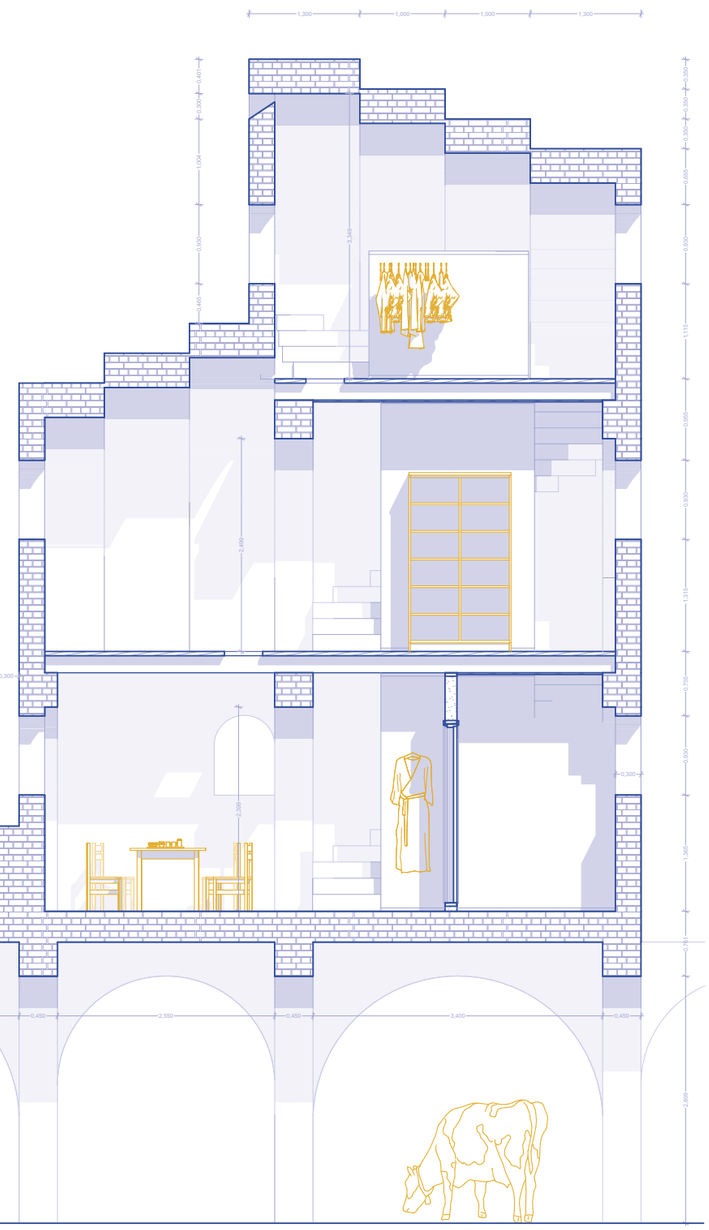


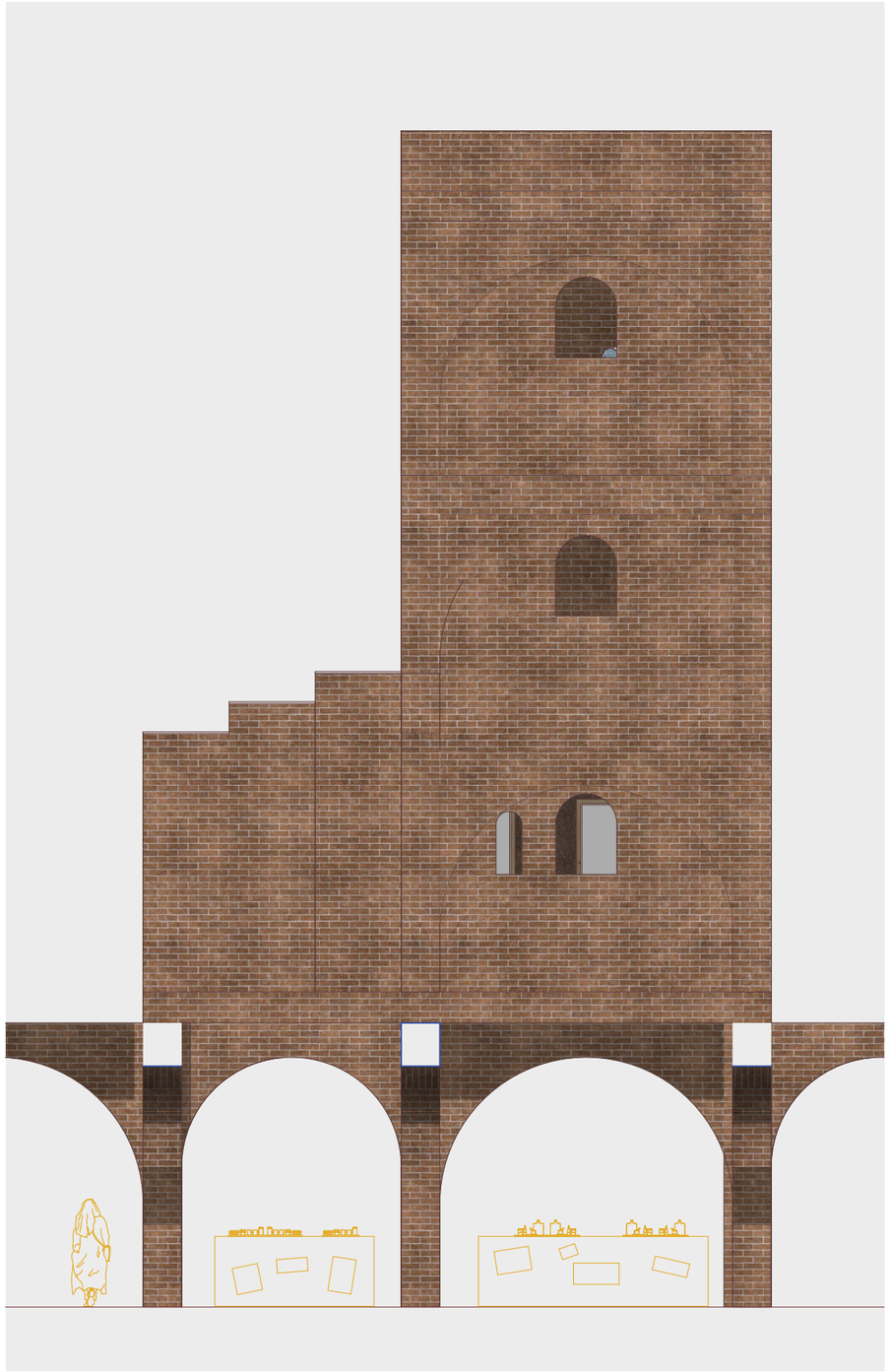


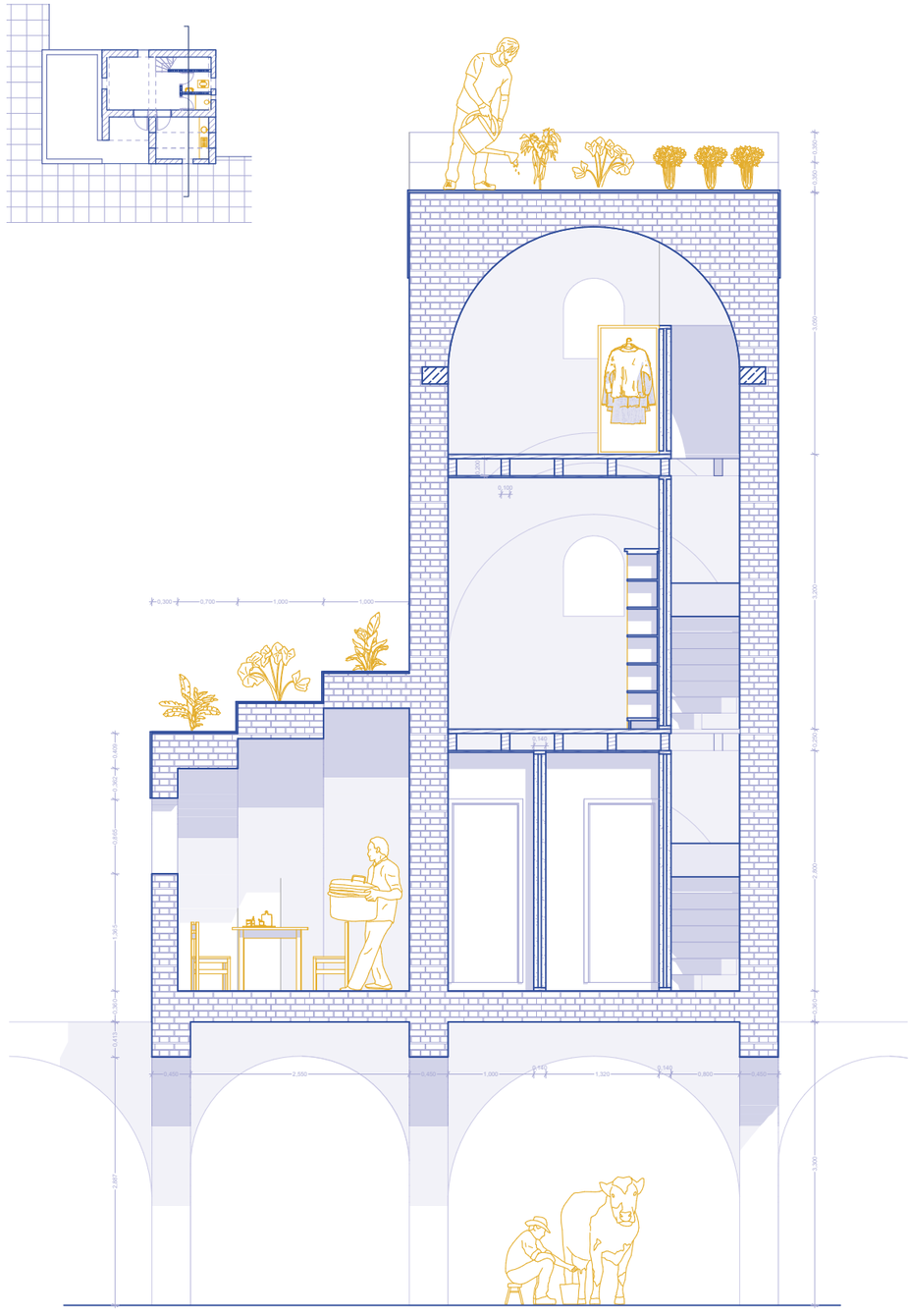


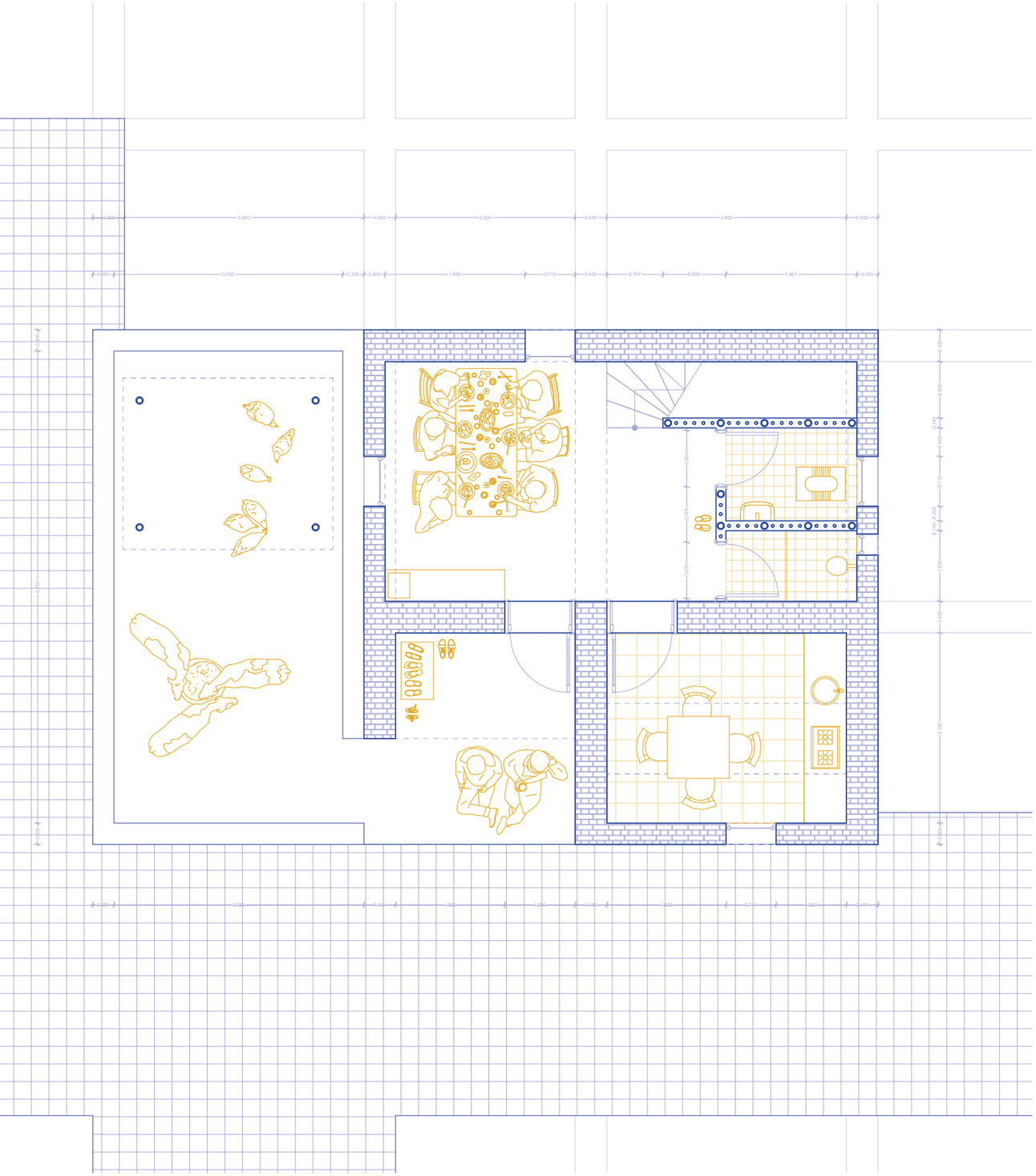


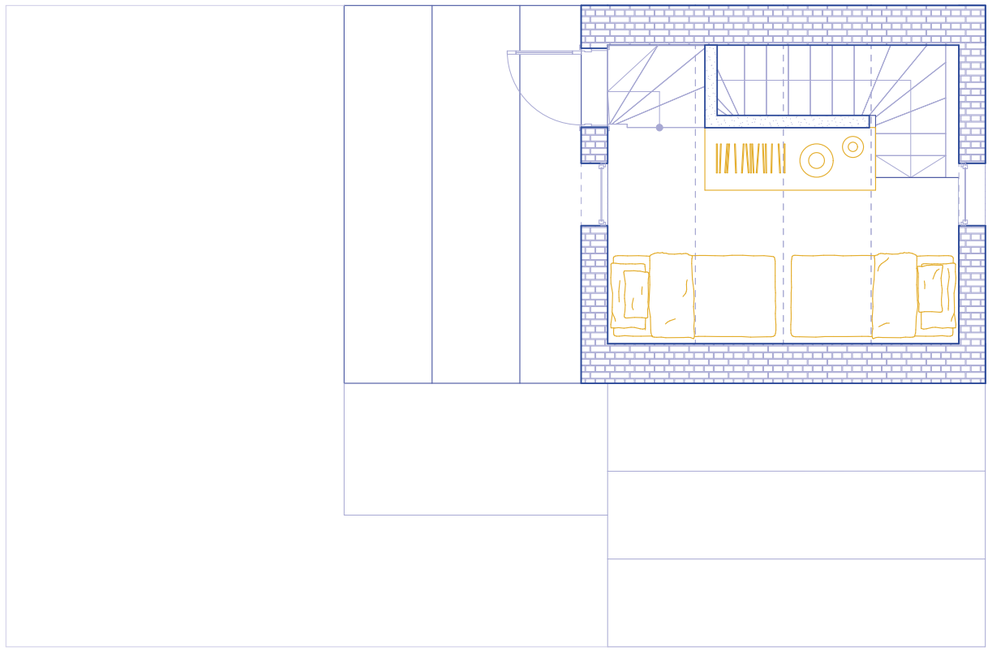

airflow
DOORS

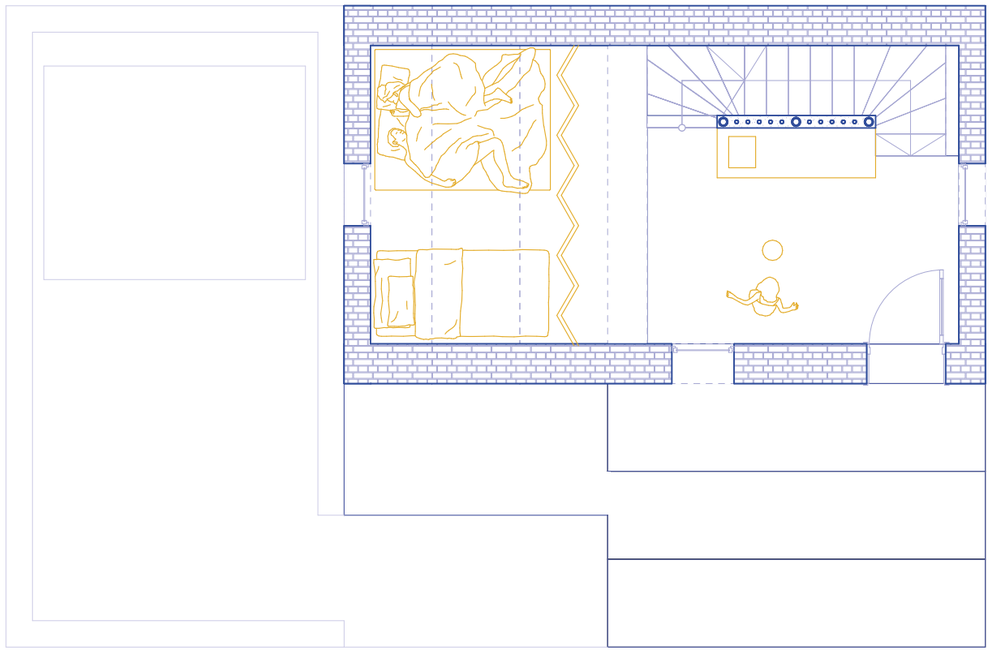


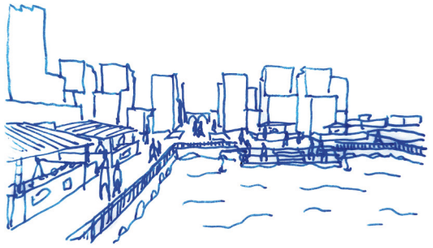


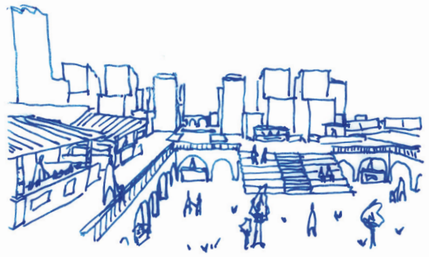








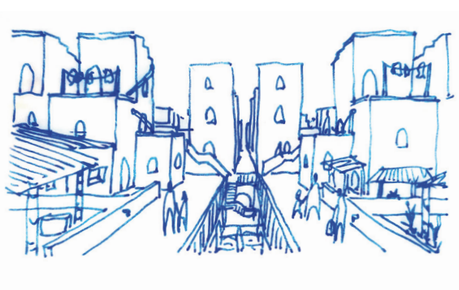












# REFLECTION

In general the character of my project changed a lot since the P2 presentation, which was probably influenced by the shortened time we had for the development of the first version of our project after the delayed trip to Bangladesh. Nevertheless, while the visual language changed quite a lot the central concept of integrating rural living qualities into a project that reacts to the ongoing urbanisation process stayed the same during the design process. In addition, the relevance of integrating communal spaces and creating social and spatial clusters remained a core aspect throughout the development of my project. The changes that I made since P2 were mainly rooted in concerns about the affordability of the project and the feasibility of chosen construction methods, which were voiced by various tutors. One of the main challenges for me during the design process was choosing the right materials for this project, as I aspired to work with the materials and integrate its characteristics into the spatial configuration. Choosing the right materials was difficult, because I had to make some compromises between aspects of affordability, local availability, water resistance, produced CO2 emissions and affects on room climates. In the end I believe I managed to choose suitable materials for the different parts of the project to increase flood resistance and flexibility while utilising locally available resources and reducing impacts on climate change.

While designing in such a different context offered many opportunities to aquire new skills and gain knowledge about different living habits but also similarities in spatial organisation, the distance to the location of the site also posed issues during the design process which were new to me. One difficulty was that repeated visits at a later stage of the design process were not possible. This would have helped a lot, for instance to observe typical construction details in further detail or to gather data about specific aspects of the site.

Fortunately having Marina Tabassum as one of our tutors helped a lot in that regard, as she could support my design process with specific feedback on discrepancies between design hypothesis and present life realities in Bangladesh. To only showcase one example, I proposed open kitchens at the beginning which turned out to not be feasible for the Bangladeshi context, as the smells of typically strong spices would quickly fill up the whole house during cooking. It was also immensely helpful to benefit from Tabassum's insights into the social connotation of certain building materials and the differences in housing preferences of different income groups, to only name a few examples.

One of the reasons why I chose the Global Housing graduation studio was my interest in increasing issues of climate change and their impacts on practices of life and the design of housing. I still believe that many findings of this studio can be applied to other contexts and I surely learned a lot about affordable material choices, vernacular building techniques, energy efficient strategies and flood resistand building techniques. As these aspects of housing design gain increasing relevance with rising global temperatures and pressing issues of dispacement due to rising water levels, the aquired knowledge of this studio will hopefully play its part in tackling these issues. With my project specifically I investigated strategies to protect goods, animals and people from rising flood levels and offer oportunities of alternative income sources to increase financial stability. Furthermore I investigated building strategies that use locally available resources and cater to the lifespan of different materials and design methods that allow incremental growth and flexible occupation of space over time. I believe that these strategies can increase the resilience of cities against pressing issues of climate change and growing populations and that my findings can be applicable to housing projects in other contexts that deal with similar issues.

# Bibliography

Achtziger, Joachim, Günter Pfeifer, Rolf Ramcke, and Konrad Zilch. Mauerwerk Atlas. DETAIL, 2013. https://doi.org/10.11129/detail.9783955531652.

'Agriculture in Bangladesh.' In Wikipedia, 28 February 2025. https://en.wikipedia.org/w/index.php?title=Agriculture_in_Bangladesh&oldid=1278112149#Food_crops.

Alam, M., and Y. Furukawa. 'Sustainability of Sal (Shorea Robusta) Forest in Bangladesh: Past, Present and Future Actions.' ResearchGate. Accessed 29 June 2025. https://doi.org/10.1505/ifor.10.1.29.

Anik, Sawon Istiak, and Mohammed Abu Sayed Arfin Khan. 'Climate Change Adaptation through Local Knowledge in the North Eastern Region of Bangladesh.' Mitigation and Adaptation Strategies for Global Change 17, no. 8 (1 December 2012): 87996. https://doi.org/10.1007/s11027-011-9350-6.

Architecture, Hidden. 'Atira and PRL Low-Cost Housing.' Hidden Architecture (blog), 9 March 2018. http://hiddenarchitecture.net/atira-and-prl-low-cost-housing/. 'De Kasbah.' Hidden Architecture (blog), 14 November 2023.

https://hiddenarchitecture.net/de-kasbah/. 'Sangath Office.' Hidden Architecture (blog), 3 December 2020. https://hiddenarchitecture.net/sangath-office/.

Ashraf, Kazi Khaleed. 'Revisit: Louis Kahn's Sher-e-Bangla Nagar, Dhaka, Bangladesh.'

The Architectural Review (blog), 26 November 2019. https://www-architecturalreview-com.tudelft.idm.oclc.org/buildings/revisit-louis-kahns-sher-e-banglanagar-dhaka-bangladesh.

Asian Desaster Preparedness Center. 'Design and Construction of Housing for Flood Prone Rural Areas Of', 2005. https://docslib.org/doc/2592650/design-andconstruction-of-housing-for-flood-prone-rural-areas-of.

'Asian Games Village-New Delhi – 1980-1982 – Raj Rewal Associates.' Accessed 29 June 2025. https://rajrewal.in/portfolio/asian-games-village-1980-1982/.

Auroville Earth Institute. 'Al Medy Mosque, 2004.' Accessed 29 June 2025. https://dev.earth-auroville.com/al-medy-mosque-2004/.

Auroville Earth Institute. 'Catenary Vault.' Accessed 29 June 2025. https://dev.earthauroville.com/catenary-vault/.



Auroville Earth Institute. 'Compressed Stabilised Earth Block.' Accessed 29 June 2025. https://dev.earth-auroville.com/compressed-stabilised-earth-block/.

Auroville Earth Institute. 'Segmental Groined Dome.' Accessed 29 June 2025. https://dev.earth-auroville.com/segmental-groined-dome/.

Auroville Earth Institute. 'Semicircular Vault.' Accessed 29 June 2025. https://dev.earthauroville.com/semicircular-vault/.

Auroville Earth Institute. 'Stability Calculations.' Accessed 29 June 2025. https://dev.earth-auroville.com/stability-calculations/.

Auroville Earth Institute. 'Stability Notions.' Accessed 29 June 2025. https://dev.earthauroville.com/stability-notions/.

Auroville Earth Institute. 'Vikas Community, 1991-1998.' Accessed 29 June 2025. https://dev.earth-auroville.com/vikas-community-1991-1998/.

Bairagi, Subir, Humnath Bhandari, Subrata Kumar Das, and Samarendu Mohanty. 'Flood Tolerant Rice Improves Climate Resilience, Profitability, and Household Consumption in Bangladesh.' Food Policy 105 (1 December 2021): 102183. https://doi.org/10.1016/j.foodpol.2021.102183.

Baishakhy, Smita Dash, Mohammad Ashraful Islam, and Md Kamruzzaman. 'Overcoming Barriers to Adapt Rice Farming to Recurring Flash Floods in Haor Wetlands of Bangladesh.' Heliyon 9, no. 3 (1 March 2023). https://doi.org/10.1016/j.heliyon.2023.e14011.

Bangladesh National Building Code, § BNBC (2020). https://compliancebangladesh.com/bnbc-2020-pdf-download/.

Bello, Lou Del. 'Could Bangladesh's "Eco-Bricks" Do More Harm than Good?' Dialogue Earth (blog), 27 August 2021. https://dialogue.earth/en/pollution/couldbangladeshs-eco-bricks-do-more-harm-than-good/.

Biswas, Biplob Kumar, and Bablu Hira Mandal. 'Construction and Evaluation of Rainwater Harvesting System for Domestic Use in a Remote and Rural Area of Khulna, Bangladesh.' International Scholarly Research Notices 2014, no. 1 (2014): 751952. https://doi.org/10.1155/2014/751952.

Chowdhury, Shubhajit, and Kawshik Saha. 'Indigenous Housing and Settlement Pattern of Patro (Laleng) Community in Sylhet' 2 (1 December 2012): 202–6. https://doi.org/10.5281/

zenodo.4420273.

Chowdhury, Tasneem. ‘Segregation of Women in Islamic Cultures and Its Reflection in Housing: A Study of Spaces for Women in a  Bangladesh Village’. In Shelter, Women and Development: First and Third World Perspectives, by Hemalata Dandekar, 338–46, 2nd ed. United Stated of America: George Wahr Publishing Company, 1996. https://www.academia.edu/77220413/Shelter_women_and_development_First_ and_third_world_perspectives.

‘CIDCO Housing – Navi Mumbai -1988-1993 – Raj Rewal Associates’. Accessed 29 June 2025. https://rajrewal.in/wp/portfolio/cidco-housing-navi-mumbai/.

‘Circular Water Stories – Landscape Architecture Research and Education – TU Delft Faculty of Architecture and the Built Environment’, 7 February 2024. https://circularwaterstories.org/.

‘Compressed Earth Block – EARTH ARCHITECTURE’. Accessed 29 June 2025. https://eartharchitecture.org/?cat=79.

Conti, Massimo De. ‘Hassan Fathy: l’utopia continua’. Living, 8 November 2018. https://living.corriere.it/architettura/hassan-fathy-lutopia-continua/.

Correa, Charles. The New Landscape - Urbanisation in the Third World. Concept Media Ltd. with Butterworth Architecture, 1989.

Darnhofer, Ika. ‘Strategies of Family Farms to Strengthen Their Resilience’. Environmental Policy and Governance 20, no. 4 (2010): 212–22. https://doi.org/10.1002/eet.547.

Deshpande, Amruta. ‘Mahatma Gandhi Labor Institute - by B. V. Doshi’. archEstudy (blog), 26 June 2021. https://archestudy.com/mahatma-gandhi-labor-institute/.

Divisare. ‘Rural Urban Framework · Jintai Village Recostruction’. Accessed 29 June 2025. https://divisare.com/projects/301565-rural-urban-framework-jintai-villagerecostruction.

‘Flood Resilient Construction and Adaptation of Buildings | Request PDF’. ResearchGate, 27 April 2025. https://www.researchgate.net/publication/325810201_Flood_Resilient_Construction_and_Adaptation_of_Buildings.

Frearson, Amy. ‘Yasmeen Lari on Track to Build a Million Flood-Resilient Pakistan Homes by 2024’. Dezeen, 2023. https://www.dezeen.com/2023/11/16/yasmeen-lari-onemillion-flood-resilient-pakistan-homes-designing-for-disaster/.

García, Marta López. ‘Angoori Bagh Housing’. Hidden Architecture (blog), 9 May 2020. https://hiddenarchitecture.net/angoori-bagh-housing/.

Guide, Agri. ‘Flood-Resilient Farming Practices’. The Farming Insider (blog), 29 January 2024. https://thefarminginsider.com/flood-resilient-farming-practices/.

‘How to Do Waterproof Mud Plaster?’ Accessed 29 June 2025. http://way2construct.blogspot.com/2013/10/how-to-do-waterproof-mudplaster.html.

https://plasteringnational.com.au/. ‘What You Need To Know About Lime Plastering’, 13 March 2024. https://plasteringnational.com.au/what-you-need-to-know-aboutlime-plastering/.

http://www.103.be, Firma 103-. ‘RE-ST – Design Museum Gent’. Accessed 29 June 2025. https://www.re-st.be/nl/project/design-museum-gent.

Ioannou-Naoum, Alexandros Vassileios Emilios. Architecture Follows Climate: Traditionelle Architektur in den fünf Klimazonen. Birkhäuser, 2024. https://doi.org/10.1515/9783035627824.

‘Jintai Village – Rural Urban Framework’. Accessed 29 June 2025. https://rufwork.hku.hk/jintai-village/.

‘Jintai Village Reconstruction / Rural Urban Framework | ArchDaily’. Accessed 29 June 2025. https://www.archdaily.com/882714/JINTAI-VILLAGE-RECONSTRUCTIONRURAL-URBAN-FRAMEWORK.

Lan, Guanqi, Tianya Wang, Yihong Wang, and Kun Zhang. ‘Seismic Performance of Interlocking Compressed-Earth Block Composite Walls’. Composite Structures 308 (15 March 2023): 116704. https://doi.org/10.1016/j.compstruct.2023.116704.

‘Lavadouro Público Da Afurada | Lavaderos Públicos’. Accessed 29 June 2025. https://www.lavaderospublicos.net/2020/11/lavadouro-publico-daafurada.html.

‘Library of Muyinga | Bc-As’, 10 July 2025. https://bc-as.org/projects/the-library-muyinga.

‘Louis Kahn in Dhaka, from the Domus Archive’. Accessed 29 June 2025. https://www.domusweb.it/en/from-the-archive/2012/09/08/louis-kahn-indacca.html.

‘Mauerwerksbögen, Grundlagen’. Accessed 29 June 2025. https://zimmerertreff.com/storage/BSWALSzt/wrl-m/bogen/bogen.htm.

Md Rana, Masud Parves, and Irina N. Ilina. 'Climate Change and Migration Impacts on Cities: Lessons from Bangladesh.' Environmental Challenges, no. 5 (2021).

Miloudi, Yassine, and Claude-Alain Roulet. 'Contribution of Compressed Stabilized Earth Bricks (CSEB) to the Control of Indoor Air Quality in Buildings: Case Study ofAlgeria.' ResearchGate. Accessed 29 June 2025. https://doi.org/10.37789/rjce.2021.12.1.6.

Minke, Gernot. Building with Bamboo: Design and Technology of a Sustainable Architecture. Third and Revised Edition. Birkhäuser, 2022. https://doi.org/10.1515/9783035625738.

Morshed, Adnan. 'The Politics of Self-Help: Women Owner-Builders of Grameen Houses in Rural Bangladesh.' Traditional Dwellings and Settlements Review, 1 January 2016. https://www.academia.edu/43535222/The_Politics_of_Self_Help_Women_Owne r_Builders_of_Grameen_Houses_in_Rural_Bangladesh.

Mukherjee, Abhijit. Groundwater of South Asia - University of Edinburgh, 2018. https://discovered.ed.ac.uk/discovery/fulldisplay/alma9924107974602466/44UOE_INST:44UOE_VU2.

Noble, Neil. 'Flood Resistant Housing Low-Cost Disaster-Resistant Housing in Bangladesh.' Text, 2012. https://www.humanitarianlibrary.org/resource/floodresistant-housing-low-cost-disaster-resistant-housing-bangladesh-0.

None, None. 'Bamboo Connected', 2020. https://repository.tudelft.nl/record/uuid:4b9f8822-8f60-4f17-85d2c8726fb6eacb.

'Open House Porto.' Accessed 29 June 2025. https://2024.openhouseporto.com. Peter's Big Adventure. 'Travel Guide To Dhaka, Bangladesh', 6 October 2015.

https://www.petersbigadventure.com/city-guides/dhaka/guide.

'Primary School Tanouan Ibi.' Accessed 29 June 2025. https://www.levs.nl/projecten/basisschool-tanouan-ibi.

'Quinta Monroy / ELEMENTAL | ArchDaily.' Accessed 29 June 2025. https://www.archdaily.com/10775/quinta-monroy-elemental.

'Realization Community.' Accessed 29 June 2025. https://www.cseindia.org/realizationcommunity-3615.





'Realization Community, 2007-2012 - Auroville Earth Institute.' Accessed 29 June 2025. https://dev.earth-auroville.com/realization-community-2007-2012/.

Reddy, B. V. Venkatarama. 'Stabilised Compressed Earth Block Production.' In Compressed Earth Block & Rammed Earth Structures, 97–130. Springer, Singapore, 2022. https://doi.org/10.1007/978-981-16-7877-6_4.

'Rwanda Cricket Stadium / Light Earth Designs | ArchDaily.' Accessed 29 June 2025. https://www.archdaily.com/886036/rwanda-cricket-stadium-light-earth-designs.

Safayet, Mastura, Md. Faqrul Arefin, and Md. Musleh Uddin Hasan. 'Present Practice and Future Prospect of Rooftop Farming in Dhaka City: A Step towards Urban Sustainability.' Journal of Urban Management 6, no. 2 (1 December 2017): 56–65. https://doi.org/10.1016/j.jum.2017.12.001.

Saha, Kawshik, Rezwan Sobhan, and Mohammad Nahyan. 'Morphology of a Sacred Urban Landscape: The Case Study of Sylhet City, Bangladesh.' Journal of Architectural Research and Education 2 (18 December 2020): 111–20. https://doi.org/10.17509/jare.v2i2.26308.

Sedighi, E., M. Yaghoubi, S. M. Mousavi, and Sh. Siahpour. 'Thermal Study of Domed Roofs in a Traditional Bazaar (the Case of Old Ganj-Alikhan Bazaar in Kerman, Iran).' Energy for Sustainable Development 39 (1 August 2017): 67–81. https://doi.org/10.1016/j.esd.2017.04.002.

'Sheikh Sarai Housing – New Delhi – 1970-1982 – Raj Rewal Associates.' Accessed 29 June 2025. https://rajrewal.in/portfolio/sheikh-sarai-housing-new-delhi/.

SlideShare. 'Raj Rewal Asian games village case study.' Accessed 29 June 2025. https://www.slideshare.net/slideshow/asian-games-village-raj-rewal-casestudy/249854550.

Sokolova, Elena. 'Lime Plaster: Types of Plaster, Methods of Application.' KaskadM (blog), 17 August 2024. https://kaskad-m.com/lime-plaster/.

Sujith.g.s. 'ARCHITECTURE STUDENT'S CORNER: REALIZATION HOUSING, AUROVILLE.' ARCHITECTURE STUDENT'S CORNER (blog), 11 January 2012. https://arkistudentscorner.blogspot.com/2012/01/realization-housingauroville.html.

'Sylhet Division Topographic Map, Elevation, Terrain.' Accessed 29 June 2025. https://engb.topographic-map.com/map-65kftf/SylhetDivision/?center=24.9309%2C91.80839&zoom=17.

Tabassum, Nazifa, and Fatema Rezwana. 'Bangladesh Agriculture A Review of Modern Practice and Proposal of a Sustainable Method.' Accessed 29 June 2025. https://de.scribd.

com/document/780747585/Bangladesh-Agriculture-A-Reviewof-Modern-Practice.

'The Barefoot Architect : A Handbook for Green Building : Lengen, Johan van :

theconstructor.org. 'Bamboo Reinforced Concrete – Properties, Mix Proportion, Design and Construction', 12 December 2016. https://theconstructor.org/structuralengg/bamboo-reinforced-concrete-mix-design-construction/15054/.

Ungar, Michael. 'Resilience across Cultures'. British Journal of Social Work 38 (1 February 2008). https://doi.org/10.1093/bjsw/bcl343.

Ungar, Michael. 'Resilience, Trauma, Context, and Culture'. Trauma, Violence, & Abuse 14, no. 3 (1 July 2013): 255–66. https://doi.org/10.1177/1524838013487805.

Ungar, Michael. The Social Ecology of Resilience: A Handbook of Theory and Practice. New York, NY: Springer, 2012. https://doi.org/10.1007/978-1-4614-0586-3.

Vymazal, Jan. 'Constructed Wetlands for Treatment of Industrial Wastewaters: A Review'. Ecological Engineering 73 (1 December 2014): 724–51. https://doi.org/10.1016/j.ecoleng.2014.09.034.

World Bank. 'Dhaka: Improving Living Conditions for the Urban Poor'. Bangladesh Development Series, no. 17 (2007). https://scholar.google.comworldpopulationreview.com. 'Bangladesh Population 2025'. Accessed 29 June 2025. https://worldpopulationreview.com/countries/bangladesh.