Food in Floods

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Cover: The wetland ecosystem of the Sylhet division, Bangladesh.

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Improving food security during monsoon season by optimizing housing conditions and space.

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Abstract

Floods are part of Sylhetis' daily lives and profoundly influence their lifestyle and overall well-being. Within this context, it is noted in this study that one of the main problems people encounter in the Haors is that: Despite local adaptation strategies to cope with flash floods, the scarcity of space remains a limitation to cultivating crops essential for a balanced diet. This situation prompts the following question: How can we improve food security and dietary diversity while ensuring adequate housing conditions for the local population? To address this inquiry, extensive examination of case studies, scholarly research papers, and field observations has been conducted. Subsequently, an architectural design for a new settlement in the Haor region has been proposed. Prior to this, the agricultural practices and adaptive strategies employed to manage flood conditions are thoroughly analyzed.

In the subsequent section of this paper, careful considerations are made regarding the selection of suitable vegetables and fruits, as well as the size of food storage facilities to be integrated into the settlement design.

In conclusion, it is evident that given the constraints of population density and limited spatial resources within the new settlement, agricultural spaces can produce enough rice for seven days of flash floods, enough vegetables for 12 days in the year, and enough fruits for 20 weeks.

Keywords: Sylhet division, Haor, floods, agriculture, adequate housing.

Contents

Introduction

During my journey to Sylhet, I was struck by the flat landscape of Bangladesh and the quiet, verdant landscape, which sharply contrasted with my experiences in Dhaka. Stretching to the horizon, vast rice fields dominated the scenery, where villagers engaged in fishing and harvesting their crops. I therefore had to think that Bangladesh is a country of contrasts. Where the cities could make us feel overwhelmed whereas the calmness of the countryside would not let us believe that it is one the densest countries in the world, a quality that contributes to its unique beauty.

Bangladesh is characterized by its low-lying geography, with approximately 21% of its eastern region considered hilly (Brammer, 2016). However, most of its territory remains up to 10 meters below sea level. The Sylhet division features a varied topography ranging from 30 to 240 meters above sea level, with mountains rising in the eastern part of the division. Meanwhile, the central region of the division comprises low-lying floodplains, referred to as Haors.

The country's predominantly flat topography makes it susceptible to flash floods, particularly during the monsoon season from June to October (Shahid, 2010). Moreover, two-thirds of Bangladesh is comprised of wetlands, characterized by rivers and recognizable marshland features such as Haors (Mukul, 2007). In addition to its rich biodiversity, Haors iare an important source of food for the inhabitants of Sylhet. Besides these seasonal floods, flash floods occur a few times a year for an average of seven days and might negatively impact agricultural production.

To comprehend the potential impact of flash floods on the local population, several critical challenges must be considered:

1) Climate change:
Climate change is one of the most significant challenges of the 21st century. Despite contributing only to 0.56% of global emissions (Rojas, 2021), Bangladesh ranks among the most vulnerable countries in the world, due to its low-lying geography and human activities that heighten the risk of floods and sea-level rise: key manifestations of climate change. The country already experiences annual flooding affecting 25% of its landmass, a situation expected to escalate in the coming years (Letsch, 2023). The Sylhet division, particularly the Sunamganj district, faces severe repercussions from flash floods (UNICEF, 2022).

2) Impacts of flash floods on agriculture:
Flash floods have devastating consequences for Sylhet's population. During the 2022 flash floods, two million people in the Sylhet division were affected, including 800,000 children (UNICEF, 2022). Countless homes were lost, and thousands of hectares of agricultural land were damaged (UNICEF, 2022), threatening food security (Saiful Islam et al., 2021) and contributing to malnutrition, starvation, and migration (Islam Chowdhury et al., 2022). Additionally, research by Gabrysch et al. (2018) highlights how monsoons exacerbate dietary deficiencies among farmers, leading to malnutrition.

3) Children malnutrition in the Haor region:
Despite being one of Bangladesh's wealthier divisions with a lower poverty rate compared to other regions (Sanin et al., 2022), the Sylhet division exhibits a disproportionately higher prevalence of undernutrition (Sanin et al., 2022). A study conducted among 300 children aged 7 to 12 in the Haor regions revealed alarming rates of undernutrition, with 45.67% having a BMI below the normal

threshold of 18.5 (Chandra Nath et al., 2019). According to WHO standards, 48% of children in these areas are malnourished (Chandra Nath et al., 2019). Seasonal fluctuations in diet, particularly during monsoons when access to vegetables is challenging, exacerbate nutritional deficiencies critical for growth and balanced diets, ultimately impacting long-term health and development (Ahmed & Islam, 2022).

4) The lack of space:

Settlement patterns in the Haor region are shaped by environmental constraints, resulting in limited space due to high population density and seasonal wetland inundation. Shahjalal University of Science and Technology (SUST) students' research in the Haor area revealed densely packed living conditions, with predominantly rice cultivation and limited vegetable plots (Deguara et al., 2021). Observations during fieldwork by Prof. Subrata Das underscored these findings, highlighting cramped living conditions and innovative strategies such as vertical and elevated food gardens to optimize limited space and mitigate agricultural risks posed by natural disasters.

All challenges considered; it is evident that children constitute 40% of those affected by monsoons in the Haor region of Sylhet. With the agricultural crops being destroyed by flash streams, and the limited amount of space found on the embankment, they suffer from malnutrition and their dietary diversity is scarce between June and October. **Despite local adaptation strategies to cope with flash floods, the scarcity of space remains a limitation to cultivating crops essential for a balanced diet.**

This main problem emphasizes the central question: ***How can we enhance food security and dietary diversity while ensuring adequate housing for the local population?*** To address this question effectively, it is imperative to explore: *What are the existing crops present in the wetlands? How to provide adequate housing conditions for the population considering the limited amount of space? What building typology is appropriate to make space for agricultural crops? What building typology is suitable for cultivating crops on rooftops and building facades? How can outdoor spaces be designed to actively engage children in the concept of food gardening?*

In the initial chapter, an analysis of the Bangladeshi agricultural system is undertaken. Subsequently, a comprehensive site investigation is conducted in the subsequent chapter. The final chapter is dedicated to the design phase of a new settlement situated on the western side of Tahirpur village within the Sunamganj district.

Methodology

To develop the research and explore potential answers to the research question, three primary methodologies are employed: literature review, data analysis, and case study analysis.

1) Literature:
In addition to field observations, extensive readings are conducted to deepen understanding of the selected topic. Essays, articles, books, and research papers contribute valuable insights into concepts such as urban agriculture and homestead gardens, which are particularly pertinent in environments characterized by spatial constraints. Additionally, literature addressing food gardens and other agricultural traditions specific to the Sylhet region is consulted to ensure the design of the settlement aligns with local needs. Furthermore, existing technologies and strategies for adapting to congested urban settings are analyzed.

2) Data analysis:
- *Quantitative data*

To assess spatial characteristics and potentialities of the Haors, spatial mapping and data collection methods are employed. Tools such as Google Earth facilitate the visualization and analysis of available space.
- *Qualitative data*

Field observations during the research trip involve the documentation of photographs, written notes, and interviews. Conversations with locals such as Sylheti student Farha Moon and an anonymous child residing within the Sunamganj wetland ecosystem provide qualitative insights. Additionally, insights gained from a lecture given by Prof. Subrata Das further inform the research.

3) Case studies:
Moreover, housing projects and settlements situated in densely populated areas are analyzed through case studies. This analysis aims to gain insights into effective design strategies for accommodating large populations within confined spaces, like the linear roads characteristic of the Haor region.

Literature review

This section critically examines prior research on efficient dwelling and spatial design strategies aimed at enhancing food security, as well as what this actual work adds to the topic.

The concept of urban agriculture offers valuable insights into optimizing limited space for agricultural purposes. In a world expecting to host 9.8 billion inhabitants in 2050 (United nations, 2023), the lack of space is a global challenge. Especially in cities, where spaces are limited and regulated. It is essential to review how land can be used in an efficient manner to satisfy the nutritional needs of billions of people. Some architectural and urban concepts have already arisen. In her article written for *Archdaily*, Ghisleni argues that multistorey farms could be the solution and mentioned a few projects such as the *Nature Urbaine*, being implemented in Paris and known to be Europe's largest rooftop urban farm (Ghisleni, 2023). Another example is a modular structure designed by Framlab in New York City to grow vegetables (Ghisleni, 2023). These innovative projects demonstrate the feasibility of urban farming on buildings to conserve land resources.

In their paper, *Social perception of urban agriculture in Latin America. A case study in Mexican social housing, the authors* (Nadal et al., 2017) found that residents of Merida, Mexico, are less receptive to urban agriculture due to inadequate space and governance support. Stating that the government should dedicate more space to urban farming. The writers argue that this lack of development is shown by the limited consumption of vegetables and fruits in the area. Concerning the typology of the social housing, it seems to be modified by their residents themselves to adapt to their needs (Nadal et al., 2017).

Nonetheless, these buildings have the potential to grow vertical gardens on them (Nadal et al., 2017). This paper is relevant as it shows the initiative to grow agricultural crops on housing buildings to improve their diet and limit environmental impacts.

While the current project focuses on a rural area susceptible to seasonal floods, insights from urban agriculture projects are instrumental in understanding innovations, diverse land use practices, and spatial efficiencies applicable to densely populated regions.

Rahman et al. (2013) highlight the potential of rooftop gardening in the paper *Present status of rooftop gardening in Sylhet City Corporation of Bangladesh: an assessment based on ecological and economic perspectives.* According to the writers, rooftops can improve food security and nutritional habits while encouraging community involvement in garden design to promote plant cultivation. This research underscores the positive correlation between rooftop gardens and nutritional outcomes. This literature shows the nutritional benefits of growing crops on housing structures in an urban context. However, no studies were found about the wetlands of Sylhet.

Finally, in their paper *Displacement and deplorable living conditions of slum dwellers: with special reference to Sylhet City,* Uddin Khan et al. (2015) explore the inadequate living conditions of displaced people in informal settlements. Places characterized by high population density, limited access to sanitation and education, and elevated risks of diseases and malnutrition due to low income. (Uddin Khan et al., 2015).

This study underscores the urgent need to rethink spatial arrangements in congested areas to ensure adequate living standards.

All things considered, those papers were related to the topic of improving food security by optimizing housing conditions and spatial qualities. However, limited research specifically addresses the Haor region of Sylhet. Therefore, this graduation project aims to bridge this knowledge gap by investigating space efficiency and its implications for food security in the Haor region.

Chapter I: Agriculture

In this chapter, main agricultural crops on a national scale and existing income generating activities related to food production are identified. Additionally, the viability of granaries as a strategic measure for enhancing food security during flash floods is explored.

A) Agriculture in Bangladesh

Agriculture takes an important place in Bangladesh's economy and its people's lifestyles. More than 70% of the territory is used to grow crops and 50% of the Bangladeshi population works in the sector of agriculture (FAO, 2023). The agriculture map (Fig. 1) depicts the main crops of the country: rice, tea, potato, and wheat. Rice grows in the whole country, whereas potato and wheat crops are present in every division except in the Barishal division in the south. Furthermore, it can be noticed that the main crops can grow around the main rivers. The climate conditions of Bangladesh make it optimal to grow rice, which might be the reason why it is present everywhere in the country.

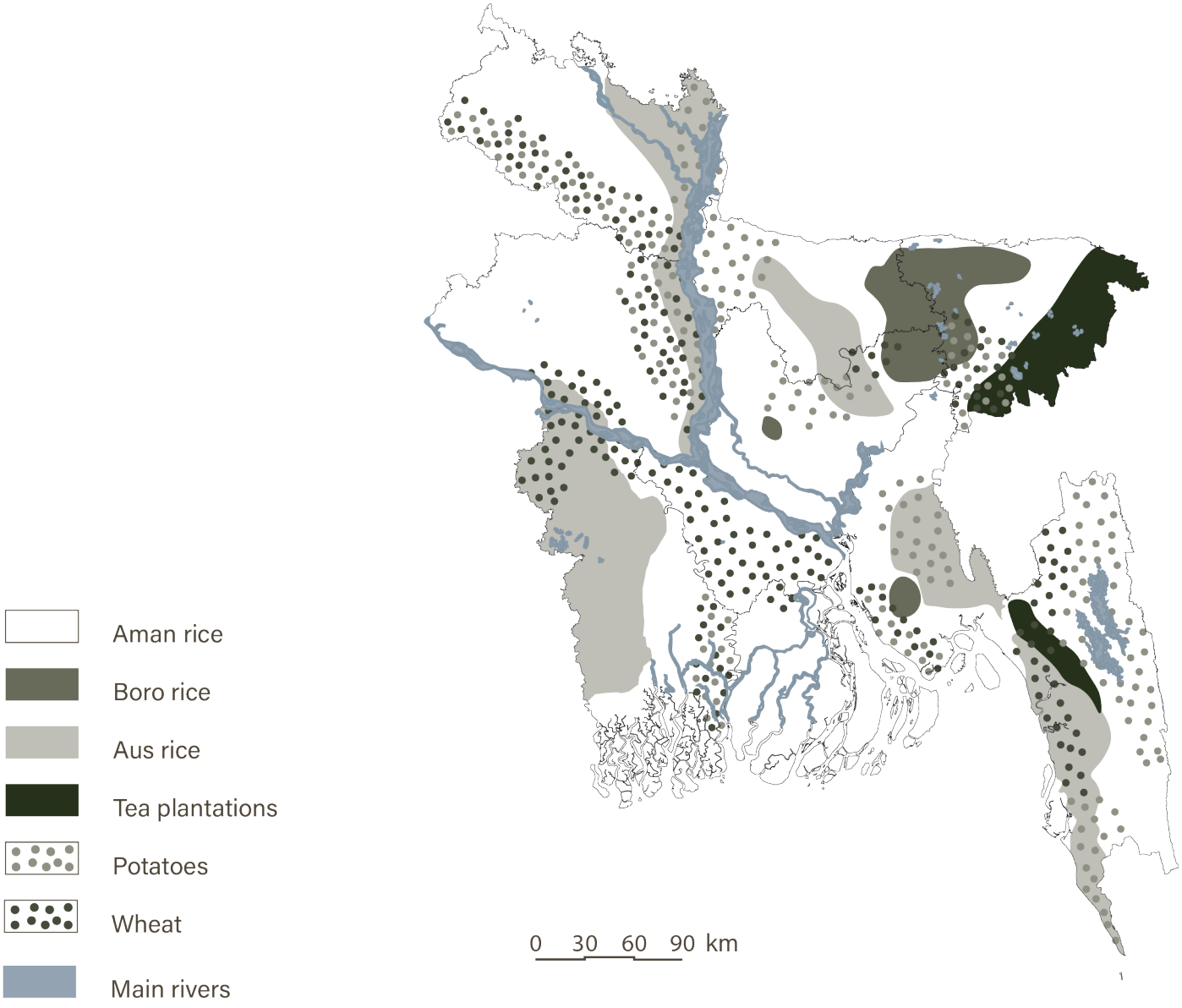


Figure 1: Main agricultural crops on a national scale

B) Existing income-generating activities

When looking into income-generating activities related to food production in the Sylhet division, three main activities are identified: Poultry farming, aquaculture and home gardening.

1) Poultry farming:

Livestock are very important for the inhabitants of Sylhet. Besides creating employment opportunities, it improves food security, livelihood and nutrition (Saleque, 2020). In a research paper written in 2020 called *Poultry industry in Bangladesh: Challenges and solutions introduction*, it is stated that on a national scale, poultry industry has created employment possibilities for more than 6 million of people. Particularly for youth and women. In 2019, the country produced 46.6 million eggs and 3.1 million kg of poultry meat per day.

Concerning the space livestock occupies, rules of thumb state that cattle need 3.7m2 (Reuter 2023), sheep 2.8m2 (Burton, 2023), and 0.37m2 per chicken or ducks at least (Unknown, 2024) of indoor space. Finally, it is seen in the *Journal of water and climate change* (Raihan and Milon, 2021) that in the Tahirpur Upazila located in the Sunamganj district, people own on average 2 livestock per household regardless the animal type.

2) Aquaculture:

In 2022, the fisheries production reached 4,759,000 metric tons (Hridoy et al., 2024) on a national scale, and that same year, the fisheries sector recorded a GDP growth rate of 2.08%. The Sylhet division produced 315,850 metric tons of fish, of which 55,850 metric tons are available for exploitation (Hridoy et al., 2024). And according to the same source, fish constitutes approximately 60% of the daily animal protein consumption in Bangladesh.

There are three types of fish culture practices:

- Pond fish farming where mostly carps, tilapias and catfishes are fished. Monoculture and polyculture (farming multiple fish species) are practices related to pond farming. In the rural areas of Bangladesh, 0.1Ha is the average size of a homestead pond (Chandan and Roy, 2023).
- Baor also called oxbow lakes are also used for fish culture. They look like big lakes but are connected to rivers through channels during monsoons (June to October). Carps, tilapias and olive barbs are identified in these waterbodies. The fish production reached 2060 kg per hectare in 2022 (Chandan and Roy, 2023).
- Haor are seasonal waterbodies used for aquaculture during monsoons (June to October) and rice culture when it dries up (November to May). Those are low lying lands especially present in the Sylhet division. In 2022, the country produced 1555 kg per hectare of fish in those types of wetlands (Chandan and Roy, 2023). In Tanguar Haor, 188 species of fish are available. Many types can be found as seen on Figure 2. The wetland is in the majority composed of 25% of Catfish (Fig. 2). The prawns and eels are the rarest and represent only 6% of the entire fish population. Moreover, only 15% of the fish are considered abundant and the majority of 42% is moderately available (Fig. 3). It is seen that there is a decrease in fish diversity, and the average fish catch per fisherman per day is reduced (Islam et al., 2015). This might be explained by over-fishing and climate change.

3) Home gardening:

In the paper called *Homestead gardening and nutrition security in Bangladesh* (Prodhan, 2017) the writer defines homestead as a dwelling with its land and structures, occupied by the owner. diet diversity (Prodhan, 2017).

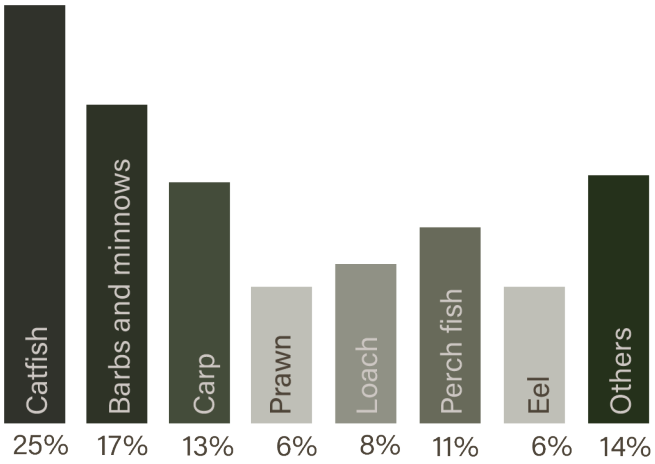


Figure 2: Types of fishes available in the Haors (Sylhet division)

Figure 3: Availability of the fishes displayed in figure 2

It is described as a self-sufficient system encompassing livestock, home gardening, and sometimes fish culture (Prodhan, 2017). This system produces food for household consumption or sale. Home gardening involves the use of land where vegetables and fruits are cultivated and maintained by families. Furthermore, the author argues that home gardening promotes self-sufficiency and improves food security and nutrition by enhancing dietary diversity (Prodhan, 2017). Additionally, selling harvested vegetables and fruits contributes to the household's economic growth, providing nearly 50% of the cash flow for rural poor families (Prodhan, 2017).

C) Granaries as a mean to improve food security during flash-floods

From a climatic perspective, Bangladesh experiences four distinct seasons: a dry winter season from December to February, a warm pre-monsoon summer season from February to June, a wet monsoon season from June to October, and a post-monsoon autumn season from October to December (Shahid, 2010). Around 71% of the annual rainfall happens during the monsoon period (Khatun et al.,2016). Due to its low-topography and heavy rainfall during monsoon seasons, the country is often subjected to inundations.
Nonetheless, not all inundations have negative impacts, as mild flooding is essential for the healthy growth of agricultural crops and aquaculture. It serves as a natural irrigation system and fertilizes the land (Wikipedia, 2023). However, inundations become detrimental to people and their crops when their frequency and intensity increase. As previously mentioned in the introduction, flash flood threatened food security during this period. In the Sylhet division, the 2022 flood season started in May, with flash floods occurring in June and July (Doctors worldwide, 2022).

During the field trip, an interview was conducted with Farha Moon, a student volunteer. Moon, who was born and raised in Sylhet, studies architecture at Shahjalal University of Science and Technology (Abbreviated SUST). According to her, the residents of the Haors in Sylhet are predominantly farmers and fishermen. Due to the difficulty of reaching the city and the central point of the village during flash floods and monsoon, they store their food during these periods. She also mentioned that villagers primarily store fruits, puffed rice (Muri), and flattened rice (Chira). Finally, it was reported that Haor inhabitants mostly consume potatoes, tomatoes, gourds, and eggplants.

The practice of storing dried food dates back to 9500 BC. Known as granaries, these structures were originally constructed from clay and other raw materials. Additionally, they are typically built above ground level to prevent damage from floods and vermin (Wikipedia, 2024).

In Bangladesh, rice, wheat and maize are mostly stored. The level of avoidable post-harvest losses of stored cereal grains in Bangladesh remains high, ranging from 10% to 25%. This issue is due to vermin attacks and could be avoided by adequately cleaning, drying and storing the crops (Banglapedia, 2021). In rural regions 80% of the harvested products are stored for long term purposes.

In rural areas, various types of granary structures are observed, including the Danghola and the Dole. As shown in Figure 4, the Dole is proportionally smaller than the Danghola and has a storage capacity of 750 kg in 0.28274m2. Furthermore, it is constructed from raw materials such as mud and bamboo. In contrast, the Danghola is built with a sturdier structure and has a storage capacity of 40,000kg in 24.5m2. However, it is a costly structure in terms of construction and maintenance (Banglapedia, 2021). According to experimental studies, the Dole is the most efficient among them.

To define the size of the food storage designed in the settlement (Chapter III), calculations were based on rules of thumb set by the Food and Agriculture Organization (Abbreviated FAO):

The minimum amount of grain to be stored to ensure food security during flash floods:

(200kg/52 weeks) x number of people x weeks of shortage
* 200kg is the ideal consumption of grain in kg per year per person.
* Weeks of shortage are the period of flash floods. In the Sunamganj district it lasts a couple of weeks and come back a few times a year. So, six weeks in total.
* Number of people is the number of inhabitants in the settlement.

The minimum amount of grain to be stored to ensure food security during flash floods:

(55kg/52 weeks) x number of people x weeks of shortage

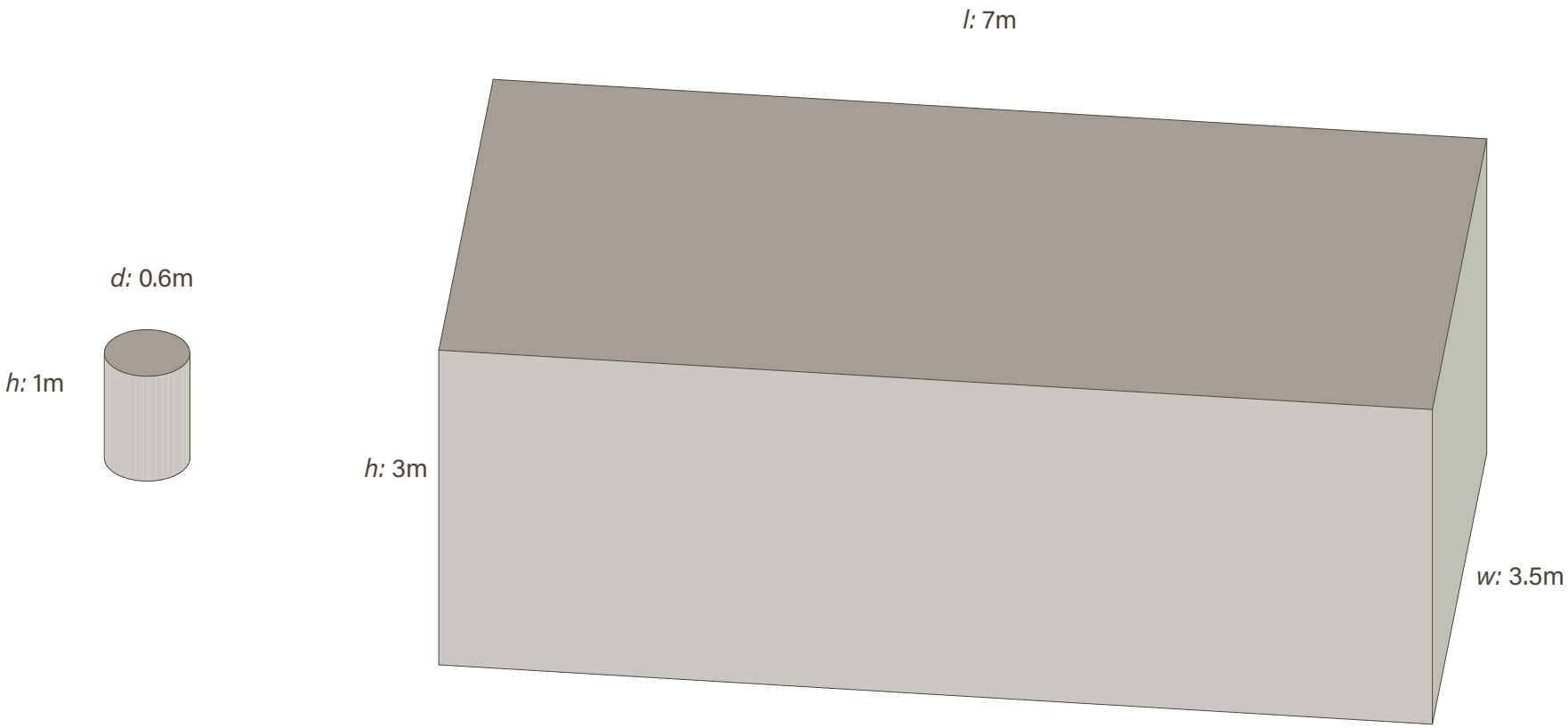


Figure 4: The Dole and Danghola

* 55kg is the ideal consumption of fruits in kg per year per person.
* Weeks of shortage are the period of flash floods. In the Sunamganj district it lasts a couple of weeks and come back a few times a year. So, six weeks in total.
* Number of people is the number of inhabitants in the settlement.

For a population of 696 people, which is the number of inhabitants in the designed settlement, a minimum of 16,061 kg of rice and 4,417 kg of fruits need to be stored to ensure food security for at least six weeks. Hence, the designed food storages need to be between at least 24m2 to 126m2 in total.

Chapter II: The wetlands of Sylhet

In this chapter, the socio-economic background of the Sylheti people is analyzed. Furthermore, the typology and urban setting of villages in the Haor region are examined. Additionally, main agricultural crops growing in Sylhet are identified to inform choices for the future settlement. Finally, the project site is analyzed to determine its spatial and agricultural potential.

A) The inhabitants of Sylhet division

With 174,615,073 people living in the country, Bangladesh is known to be one of the most densely populated country in the world, with 1,329 people per km2 (Worldometer, 2023). Comparing to the average, the population density in the division of Sylhet is significantly lower, with 873 people per km2 (Bangladesh Bureau of Statistics, 2022).

The Bangladeshi population is predominantly young, with a significant portion under the age of 30 (Fig. 5). A youthful population offers the advantage of a large number of individuals entering the labor market, thereby contributing to economic growth. However, this demographic trend also presents challenges, including potential strain on resources, healthcare, and employment opportunities (Population Pyramid, 2022).

The agricultural sector is one of the most prominent industries in the country, employing a significant portion of the population. However, recent decades have seen a rise in the popularity of the services sector (Statista, 2021). In rural areas such as the Haors, agriculture remains the primary source of income, with both men and women actively involved (Bangladesh Bureau of Statistics, 2022).

In the Sylhet division, the average household comprises 4.03 individuals (Bangladesh Bureau of Statistics, 2022). However, during the excursion, it was noted that families with nine to ten members are not uncommon. In their paper *Study on Livelihood of Haor Community in Bangladesh* (Khatun and Rahman, 2021), the authors assess the socio-economic conditions and livelihoods in the wetlands. Although the study focuses on districts in other divisions of Bangladesh, it provides valuable insights into the livelihoods in the Haors. In their paper, Khatun and Rahman (2021) state that 80% of the population's primary occupation is related to agriculture and food production. Furthermore, the study reports that within the wetland ecosystem villages which were analyzed, 52% of households consist of five to seven individuals, 22% have maximum four individuals, and 27% are large families with at least eight members.

Concerning the average income on a national level, a typical household earns around 32,422 Bangladeshi Taka per month, which is around 277.92 Euros, whereas per capita, it is 7,614 BDT per month, so 65.27 Euros As seen in Fig. 6 (Bangladesh Bureau of Statistics, 2023).

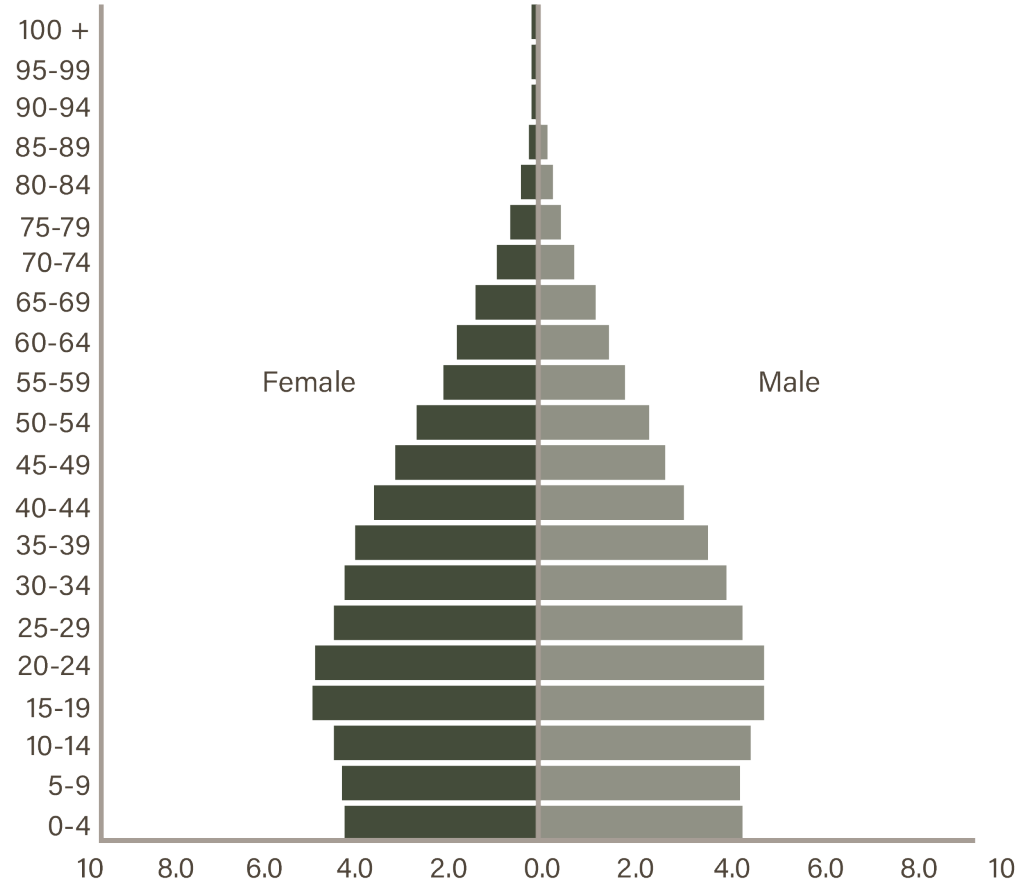


Figure 5: Age pyramid on a national level

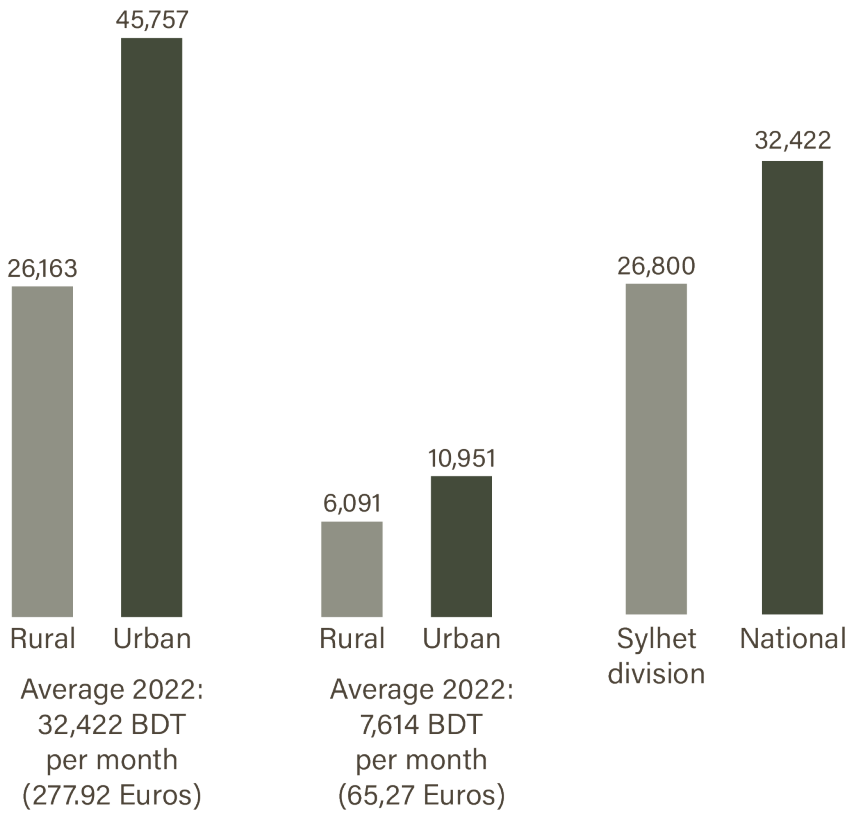


Figure 6: Comparison of income

B) Case study:

In terms of inhabitants' residential arrangements, insights provided during a lecture by Professor Subrata Das reveal that their settlements are typically elevated by at least 1.5 meters above ground level, thereby mitigating the risk of flooding, given that the roads and embankment are already elevated (Fig. 7). These man-made lands feature a linear layout, with houses oriented at a 45-degree angle relative to the main road (Das, 2023). Courtyards exhibit a linear configuration, while passages are narrow due to spatial limitations, resulting in few delineations between households. Fieldwork observations indicate an average household size of nine individuals, with modular houses designed to accommodate family expansion (Das, 2023). Courtyards primarily serve as spaces utilized by women and children, as men are primarily engaged in agricultural and fishing activities outside the settlements (Das, 2023). Finally, it is observed that re-used CI sheets, bamboo, mud, and thatched are abundant.

Despite the inhabitants of the Haors having planned adaptation strategies to cope with floods, their lives remain precarious due to the presence of water in the landscape. Moreover, the constrained availability of land for expansion induces inhabitants to adapt and use the existing spaces effectively.

Consequently, houses typology exhibits a linear form, which could withstand the wind and accommodate to the lack of space (Fig. 8). Additionally, during the excursion, it was estimated that there are 77 dwellings per hectare, with an average of 460 people per hectare, resulting in approximately six people per dwelling. Furthermore the average size of a room is around 3 x 3 meters.

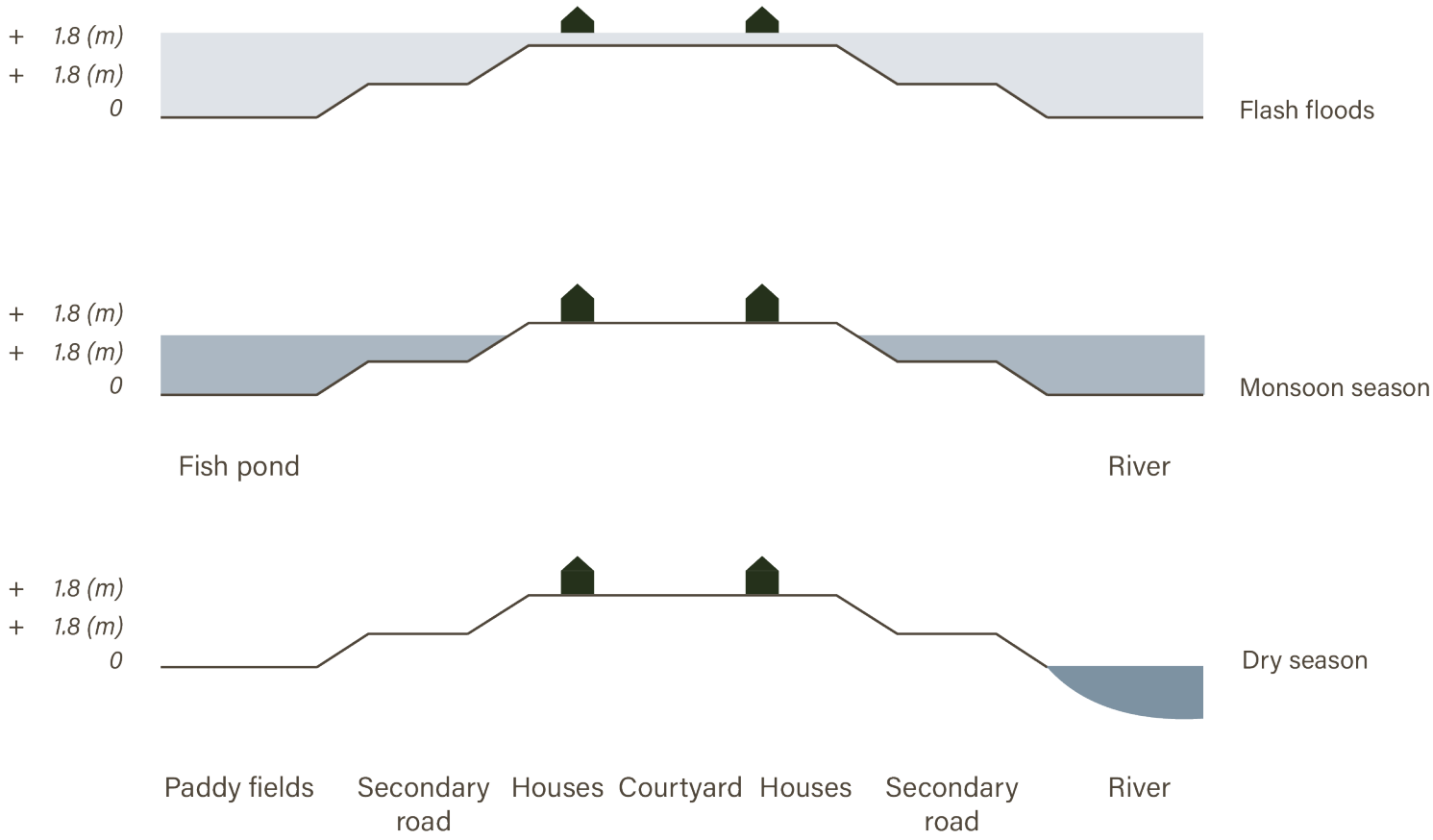
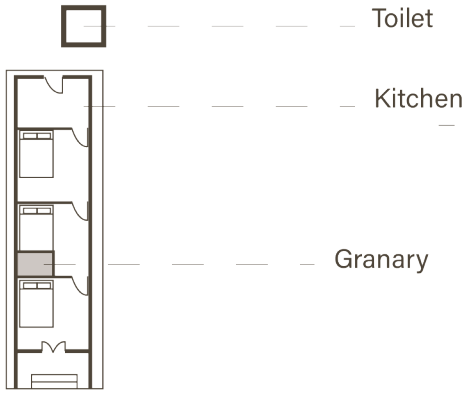
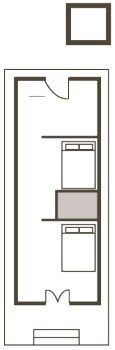


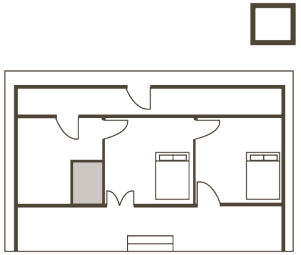
Figure 7: Elevation of standard embankments in the Sunamganj district (Sylhet division)



Typology A



Typology B



Typology C

Figure 8: Main existing house typologies in the Haor villages

C) Main agricultural crops of Sylhet division

In this section, some of the main agricultural crops present in the Sylhet division are identified (Fig.9).

Agriculture is rhythmed by two seasons: Kharif and Rabi seasons. Kharif crops are grown between April and November while Rabi crops are grown between December to March (Banglapedia, 2021).

During the pre-monsoon, mid-monsoon, and post-monsoon seasons, spanning from March to November as discussed in the previous chapter, vegetables and fruits primarily grow on the embankment where the village is located, as the rest of the landscape is submerged by water. Consequently, mainly Kharif crops are cultivated during this period.

Besides making the inhabitants of the new village (Chapter III) food secured during flash floods, space for home gardens is also designed. As seen in the previous chapter, home gardening has nutritional benefits for the inhabitants and is mostly made to plant vegetables and fruits. According to the FAO, each person should consume 90 kg of vegetables per year.

The selection of crops is based on the dietary habits of the Haor inhabitants, the nutritional value of the crops, their yield (as reported by the Bangladesh Bureau of Statistics 2022), and their capacity to grow during the monsoon season (primarily Kharif crops) when space is limited to the embankment. Consequently, the chosen vegetables are gourds, beans, tomatoes, cucumbers, eggplants, and herbs of their choice, while the selected fruits are bananas, papayas, jackfruits, and coconuts.

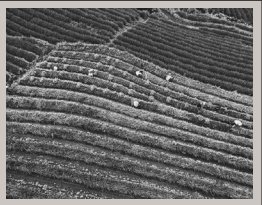
Figure 9: Matrix of the main agricultural crops of Sylhet

Main crops

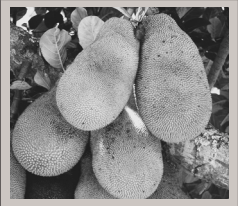
Name	Aman rice *Oryza sativa*	Aus rice *Oryza sativa*	Boro rice *Oryza sativa*	Wheat *Triticum aestivum*	Tea	Mustard oil *Brassicaceae*
Appearance						
Planted time	Mid-July	March/April	November/December	November to March	April/May	December/January
Nutritional value	Manganese, Iron, Vitamin B	Manganese, Iron, Vitamin B	Manganese, Iron, Vitamin B	Carbs, Fiber, Protein	Caffeine, Antioxidant	Monounsaturated fats, Vitamin E
Harvest time	November/December	July/August	April/May	100 to 120 days after planting	December to March	February/March
Kharif (April to November) OR Rabi (December to March)	Kharif	Kharif	Rabi	Rabi	Kharif	Rabi
Spatial use						

Vegetables

Name	Potato *Solanum tuberosum*	Sweet potato *Ipomoea batatas*	Gourd *Cucurbitaceae*	Lentil *Lens culinaris*	Bean *Phaseolus vulgaris*	Tomato *Solanum lycopersicum*	Eggplant *Solanum melongena*
Appearance							
Planted time	October	October	Year long	October/November	October to January	August to December	August to December
Nutritional value	Carbs, Potassium, Vitamin C and B6 Folate	Carbs, Fibers, Potassium Vitamin A, C, B6, B5 and E	Vitamin A and C, Antioxydant	Vitamin B, Iron, Magnesium, Potassium, Zinc	Copper, Phosphorus, Manganese, Magnesium	Vitamin C, Potassium, Folate, Vitamin K	Manganese, Potassium, Vitamin K
Harvest time	February/March	February/March	55 to 60 days after planting	February/March	60 to 100 days after planting	120 to 150 days after planting	120 to 140 days after planting
Kharif (April to November) OR Rabi (December to March)	Rabi	Rabi	Kharif (sweet, bitter, snake, ridged) Rabi (bottle)	Rabi	Kharif (soy, mung, yardlong) Rabi (country)	Kharif Rabi	Kharif
Spatial use							

Amaranth *Amaranthus*	Cabbage *Brassica oleracea*	Cauliflower *Brassica oleracea*	Cucumber *Cucumis sativus*	Radish *Raphanus raphanistrum subsp. sativus*	Spinach *Spinacia oleracea*	Onion *Allium cepa*	Garlic *Allium sativum*
							
April to November	November to March	November to June	September to December	November to March	February to June	January	November/December
Protein, Carbs, Manganese	Vitamin C and K, Potassium, Folate	Fibers, Vitamin C and B6, Magnesium	Potassium, Vitamin C and K	Vitamin C, Fibers, Antioxidants	Fibers, Vitamin K and C, Potassium	Vitamin B, Folate, Vitamin B6, Potassium	Manganese, Vitamin B6 and C, Selenium, Fibers
100 to 120 days after planting	100 to 160 days after planting	130 to 170 days after planting	60 to 80 days after planting	140 to 150 days after planting	40 to 60 days after planting	140 to 150 days after planting	140 to 150 days after planting
Kharif	Rabi	Rabi	Kharif	Rabi	Kharif	Rabi	Rabi
							

Fruits

Name	Jackfruit *Artocarpus hetero-phyllus*	Pineapple *Ananas comosus*	Banana *Musa*	Papaya *Carica papaya*	Mango *Mangifera indica*	Guava *Psidium guajava*	Coconut *Arecaceae*	Litchi *Litchi chinensis*
Appearance								
Planted time	April/May	April to November	May/June, Or September/October	September/October, Or December/January	Mid-May to Mid-July	April to November	May	June/July
Nutritional value	Protein, Carbs, Fibers, Manganese, Magnesium, Vitamin C	Vitamin C and A, Manganese, Fiber	Fibers, Potassium, Vitamin B6 and C, Antioxydant	Fibers, Vitamin C and A, Antioxydant	Vitamin C, Fiber, Antioxydants	Antioxydant, Vitamin C, Potassium, Fibers	Fibers, Potassium, Manganese	Carbs, Vitamin C, Copper, Potassium
Harvest time	June to August	June to August	September to April	10 months after planting	4 months after planting	4 to 5 months after planting	11/12 months after planting	May/June
Kharif (April to November) OR Rabi (December to March)	Kharif	Kharif	Kharif	Kharif	Kharif	Kharif	Kharif	Kharif
Spatial use								

Others

Name	Sugarcane *Saccharum officinarum*	Betel leaves *Piperaceae*	Coriander *Coriandrum sativum*	Turmeric *Curcuma longa*	Chili *Capsicum annuum*
Appearance					
Planted time	October to March	May to August	October/November	April to November	August to December
Nutritional value	Phosphorus, Potassium, Calcium, Vitamin B	Calcium, Carotene, Thiamine, Riboflavin, Niacin, Vitamin C	Antioxydant, Vitamin A, C, K Iron and Calcium	Manganese, Iron, Potassium, Vitamin C	Vitamin D, Calcium, Iron, Potassium
Harvest time	October to March	June (Ashad), February/March (Phalgun), October/November (Kartik)	90 to 105 days after planting	8 to 10 months after planting	90 to 130 days
Kharif (April to November) OR Rabi (December to March)	Kharif Rabi	Kharif Rabi	Rabi	Kharif	Kharif Rabi
Spatial use					

D) Adaptative strategies against flash floods

In their paper *Climate change adaptation through local knowledge in the northeastern region of Bangladesh* (Anik and Khan, 2012), the authors delineate several strategies employed by inhabitants of the wetlands to adapt to rising water levels and its impacts.

These adaptations encompass modifications in agricultural practices and innovations in cultural traditions, including alterations in planting and harvesting schedules, adjustment to the landscape through fishing or rice cultivation, use of hyacinth as a barrier against moisture stress, and the implementation of floating gardens (Anik and Khan, 2012).

However, certain strategies also involve adapting the land to the evolving landscape. Koroch plants (Pongamia pinnata) are cultivated along the embankments to mitigate erosion during the monsoon season and to provide a source of wood for the inhabitants. This strategy turns out to be effective and low-cost. Furthermore, other adaptation measures include the construction of wave protection walls, the excavation of canals to facilitate irrigation, and the establishment and maintenance of embankments (Anik and Khan, 2012).

Finally, Anik and Khan conclude that farmers and fishermen are one of the most vulnerable folks in the Sylhet division (Anik and Khan, 2012).

Figure 10: Google earth

E) Project location

Figure 11: Google earth

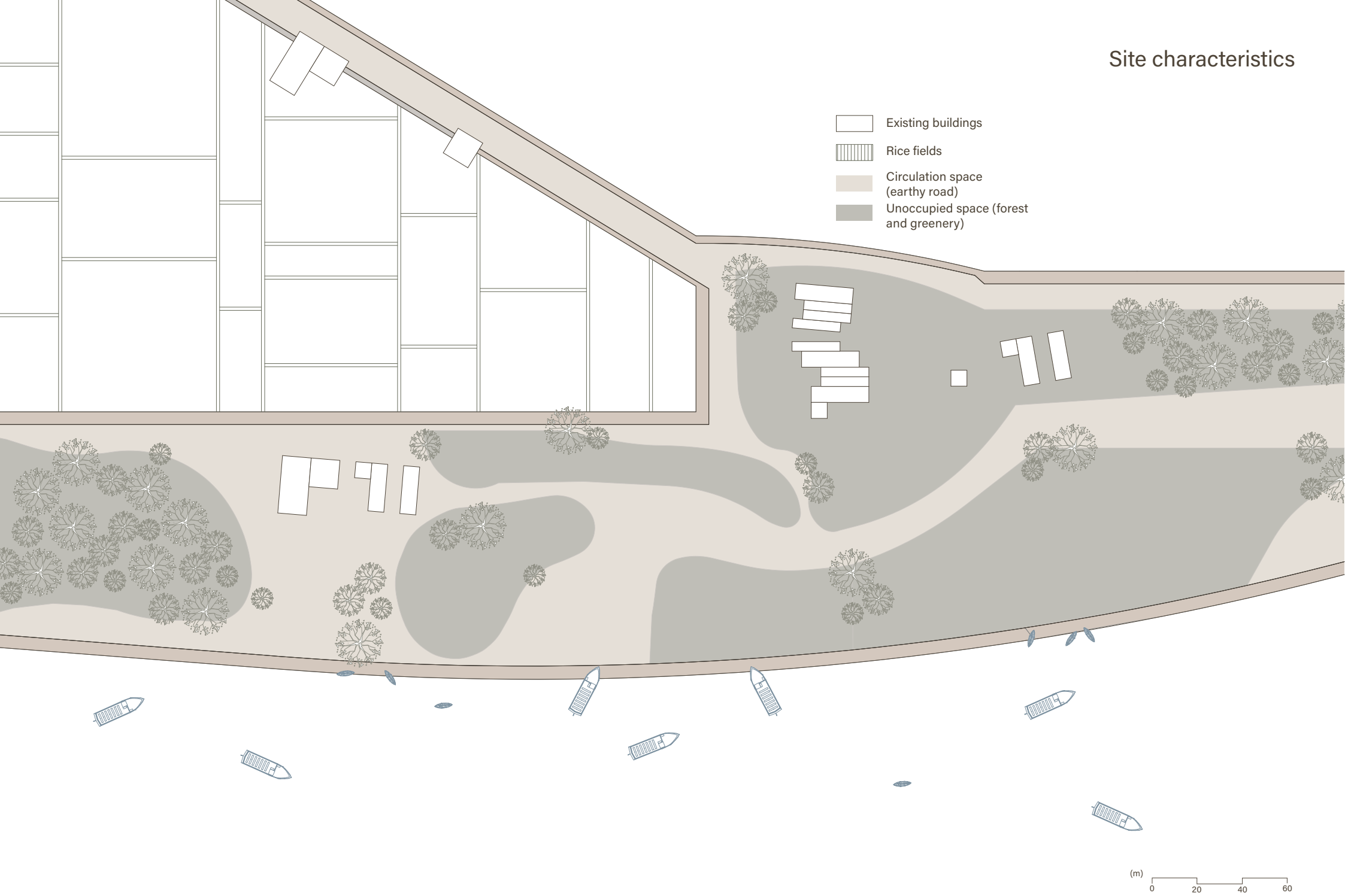
Project site in 2014

Project site in 2019

Project site in 2023

Project site: 1.1 Ha
Rice fields (dry season, November to May): 0.85Ha
Fishing pond (monsoon season, June to October): 0.85Ha

Site characteristics



Chapter III: A settlement for the farmers and fishermen of the Haor

A) Program of requirements

1) Housing:

- 696 people: 5, 7, and 10 people per household (30m^2,45m^2,60m^2)

6 m^2 per person (UN housing standards)

- 96 Dwellings for 1.1 Ha:

24 houses for 5 ppl 25%

48 houses for 7 ppl 50%

24 houses for 10 ppl 25%

- Low rise building (G+1)

- FSI: 0.45 GSI: 0.22

2) Adaptation to climate change disasters:

- Shelter on upper floors in the event of flash floods

- Elevated Living facilities and storage

3) Income generating activities:

- Livestock (indoor space: 3.7m^2 per cattle, 0.37m^2 per chicken or ducks)

- Aquaculture (Fish farming: 0.85Ha)

4) Homestead gardens:

- Communal food gardens

- Composition of food gardens: Gourd, beans, tomatoes, cucumber, eggplants and diverse herbs.

5) Food security and homestead gardens:

- Rice fields (0.85Ha)

- Fruits trees: Banana, papaya, jackfruit and coconut

- Food storage for six weeks of flash floods (24m^2 to 126m^2)

- Outdoor communal activities: Crop sorting area etc.

6) Public facilities:

- Mosque (200m^2)

- Community centre including a little shop for basic needs, and rooms to sort agricultural production sent to the bazar (400m^2)

- Meeting point (135m^2)

- Multiple purposes space (135m^2)

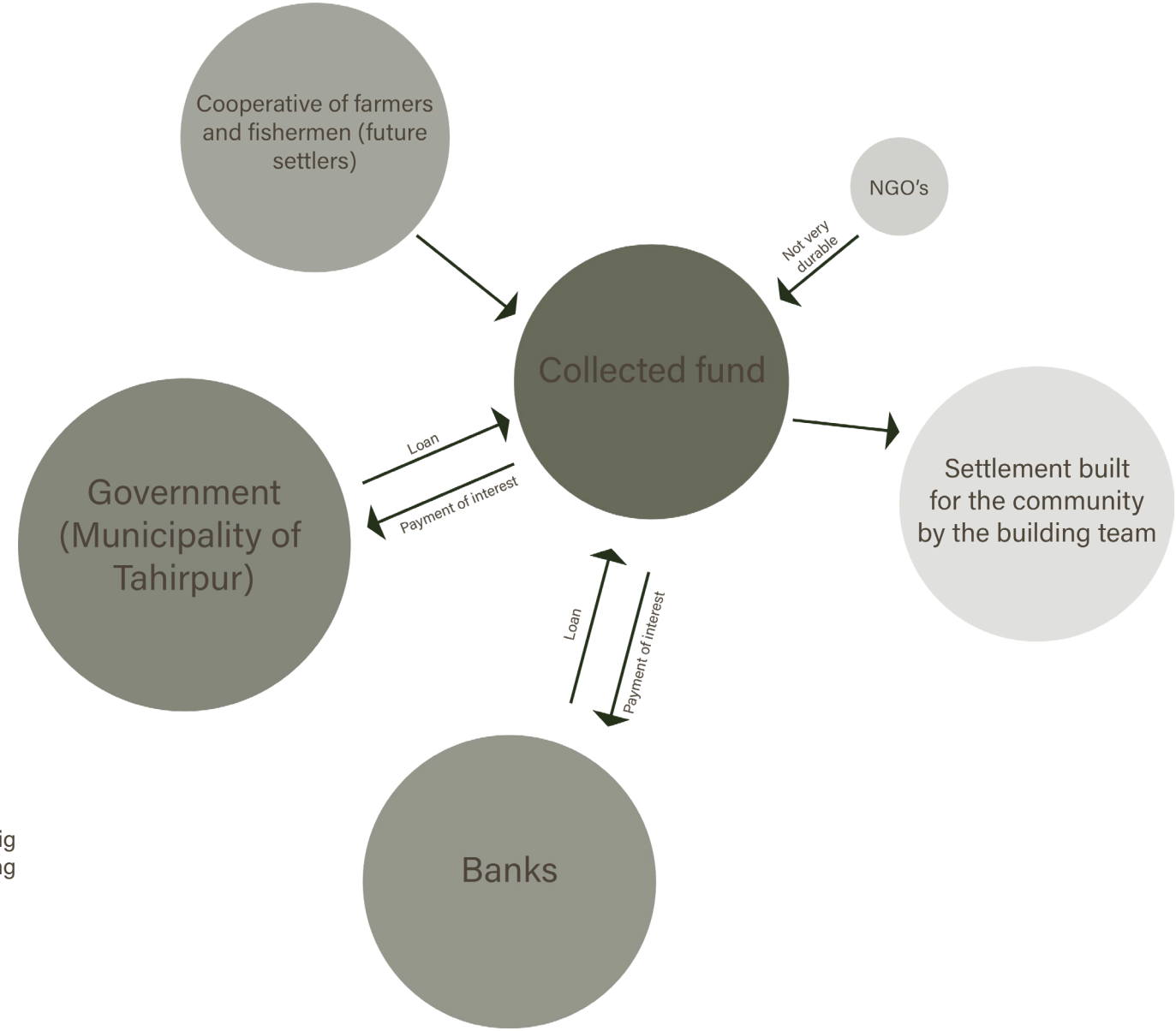
7) Public facilities available around the settlement:

- Tahirpur bazar (3.5km)
- Primary and High school (1.22km)
- Health care centre (3.5km)

B) Managerial strategy

Figure 12: Stakeholders analysis

Figure 13: Financial model



STEP I: Collect fund

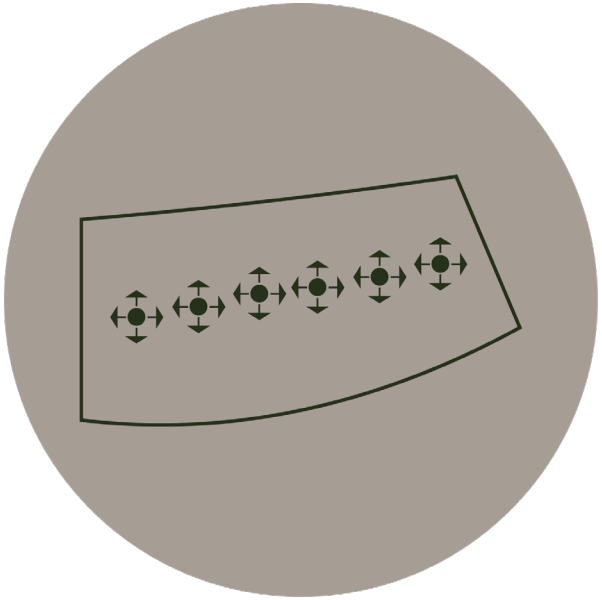
STEP II: Buying the empty plot from the government (big investment compensated by the future income generating activities.)

STEP III: Build foundation with the personal investment

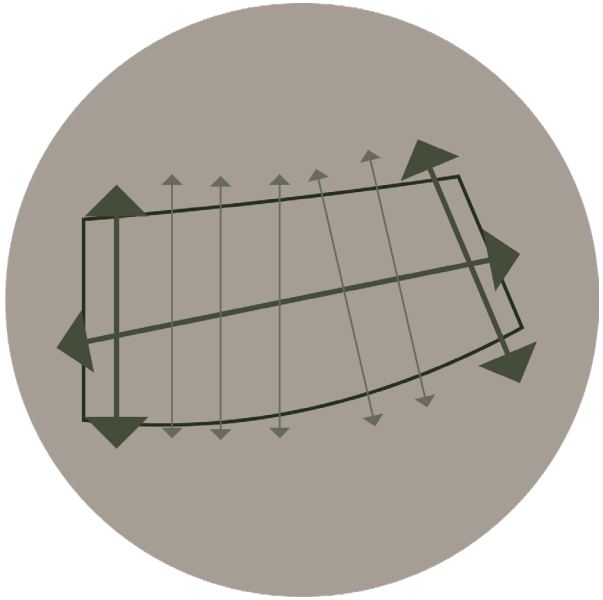
STEP IV: Build the houses with the money from the loan

STEP V: Settlers come in when the buildings are ready

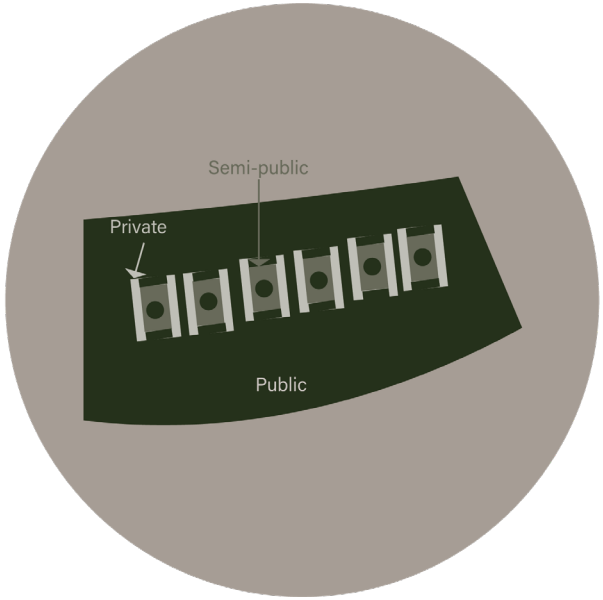
STEP VI: Pay back the loan with small interest



Polycentric

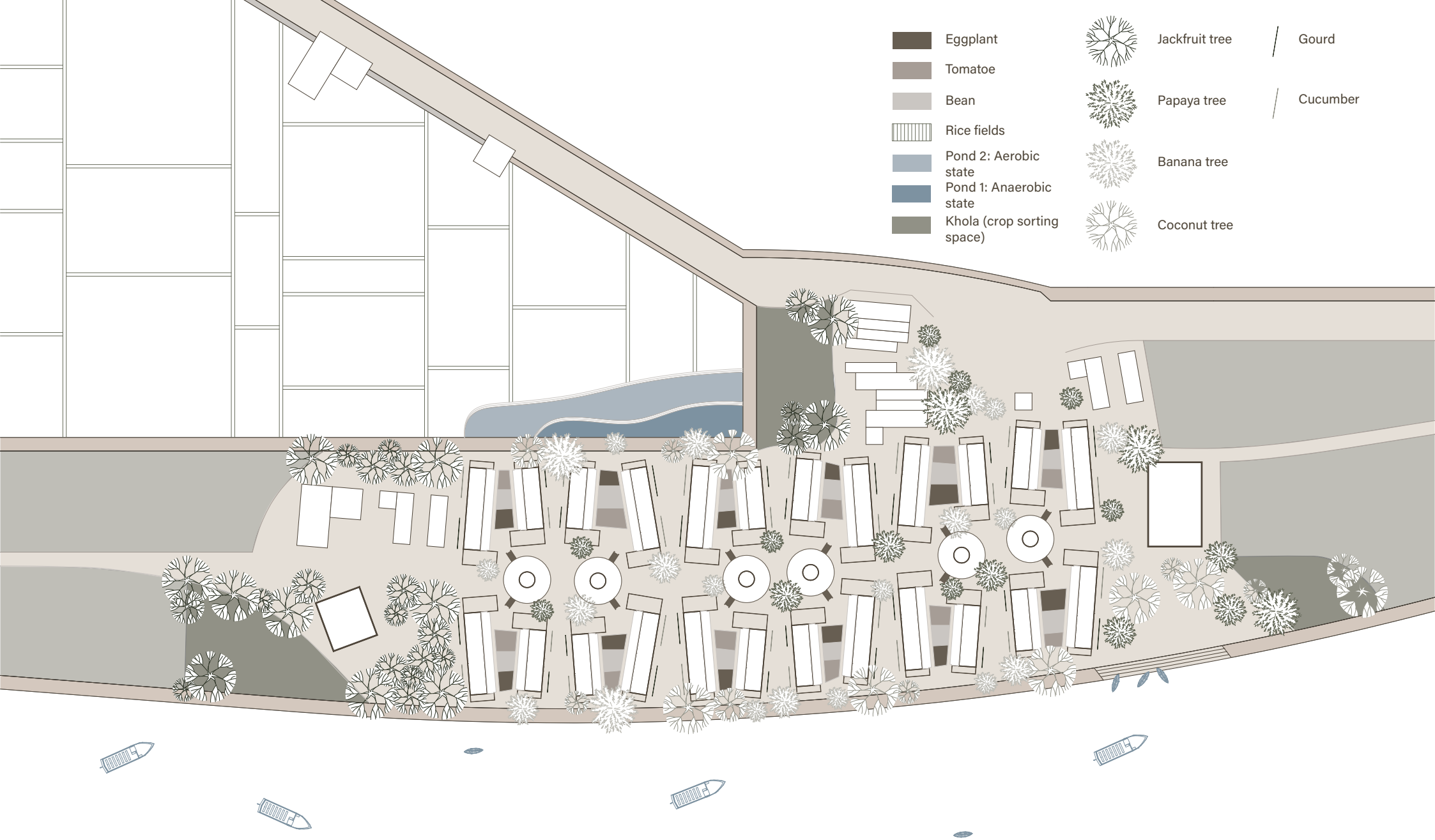


Accessibility



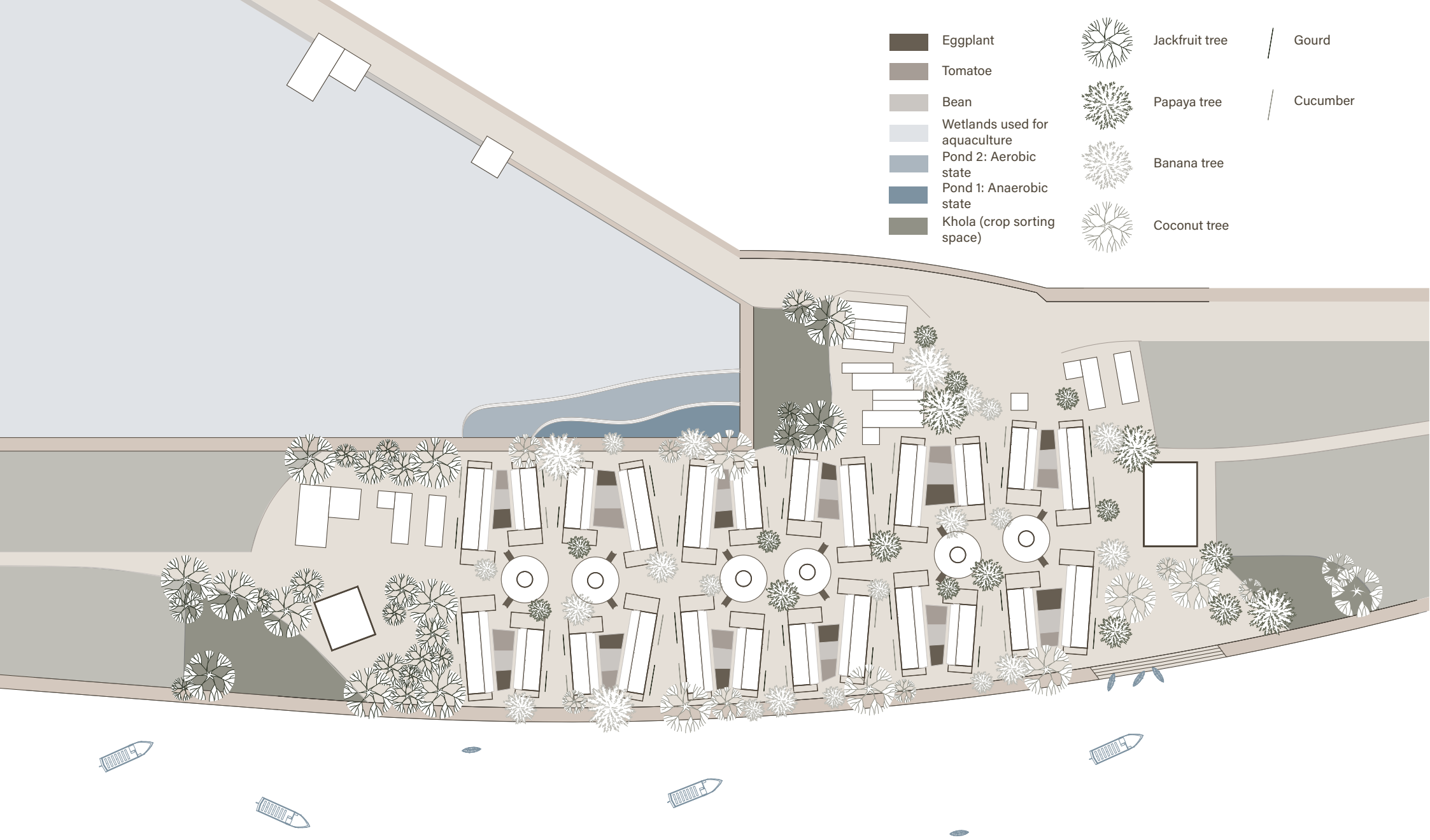
Zoning

C) Urban scale



Master plan during dry season (November to May)

(m) 0 20 40 60



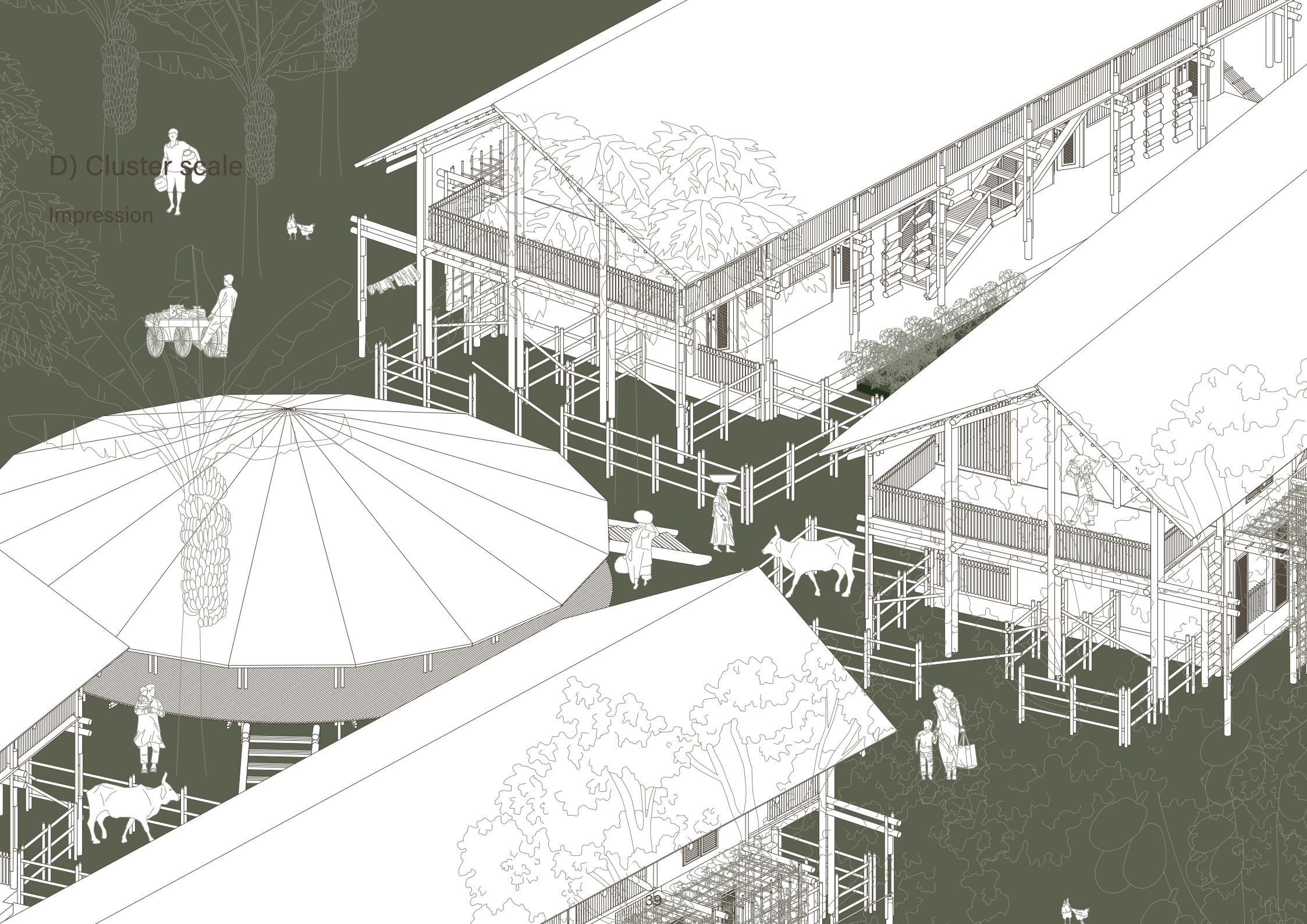
Master plan during dry season (November to May)

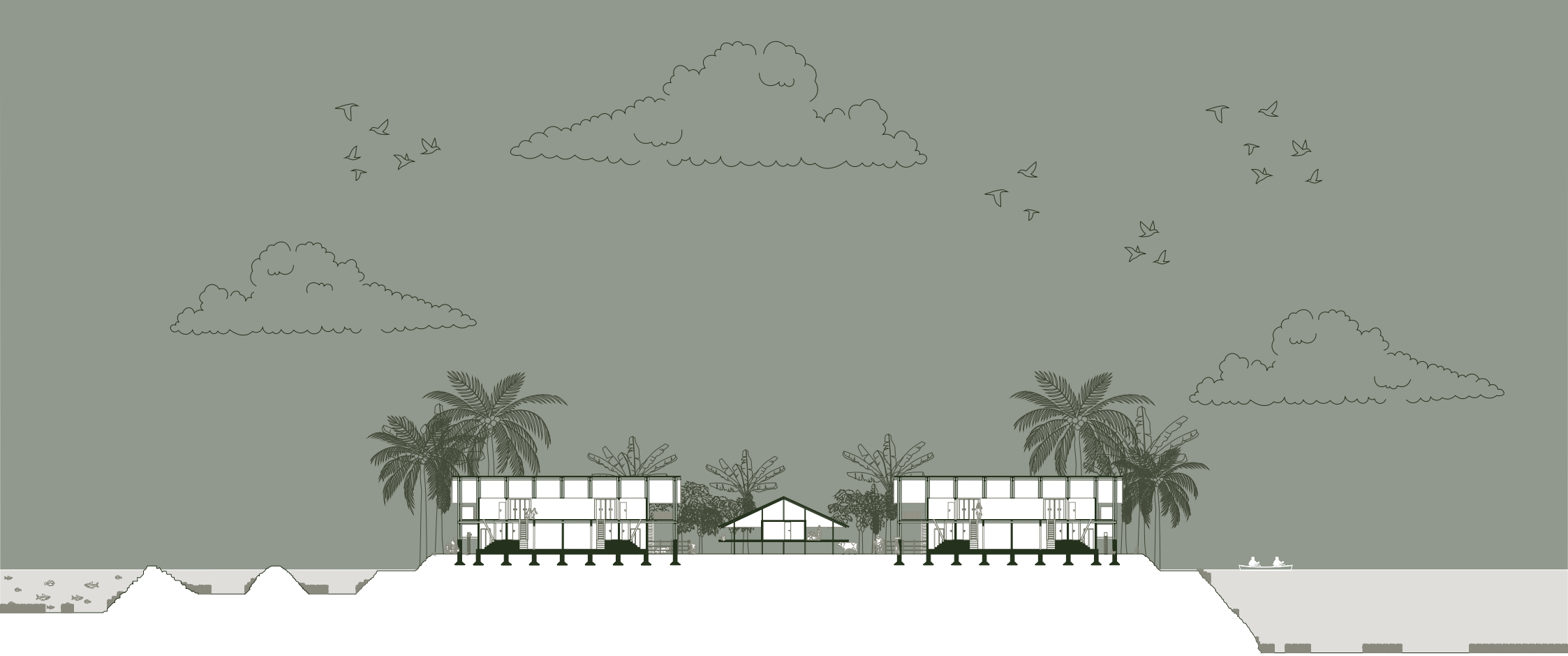
Urban section

(m)
0 3 6 9

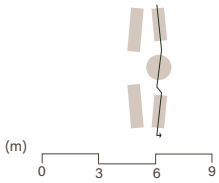
D) Cluster Scale

Impression

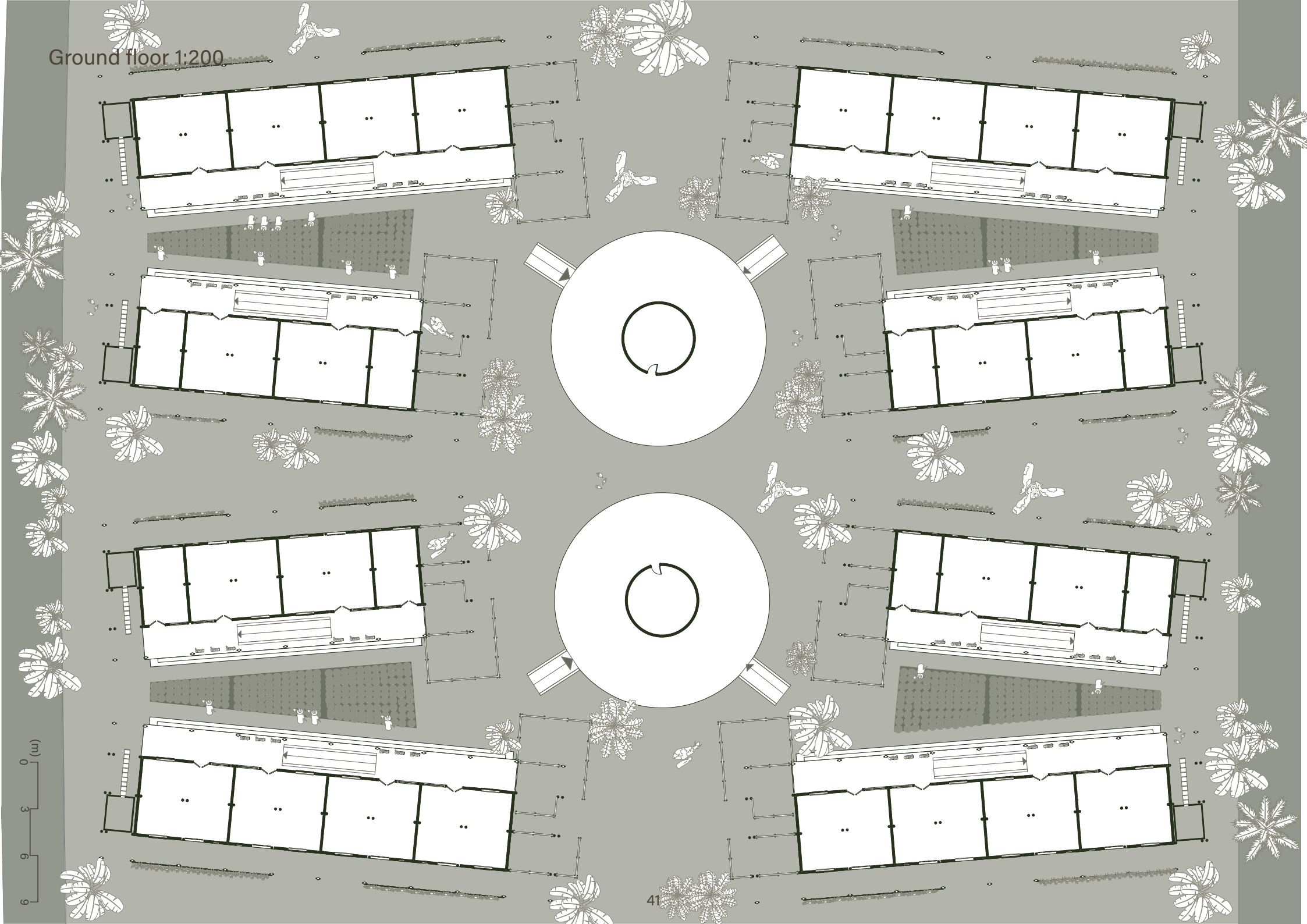


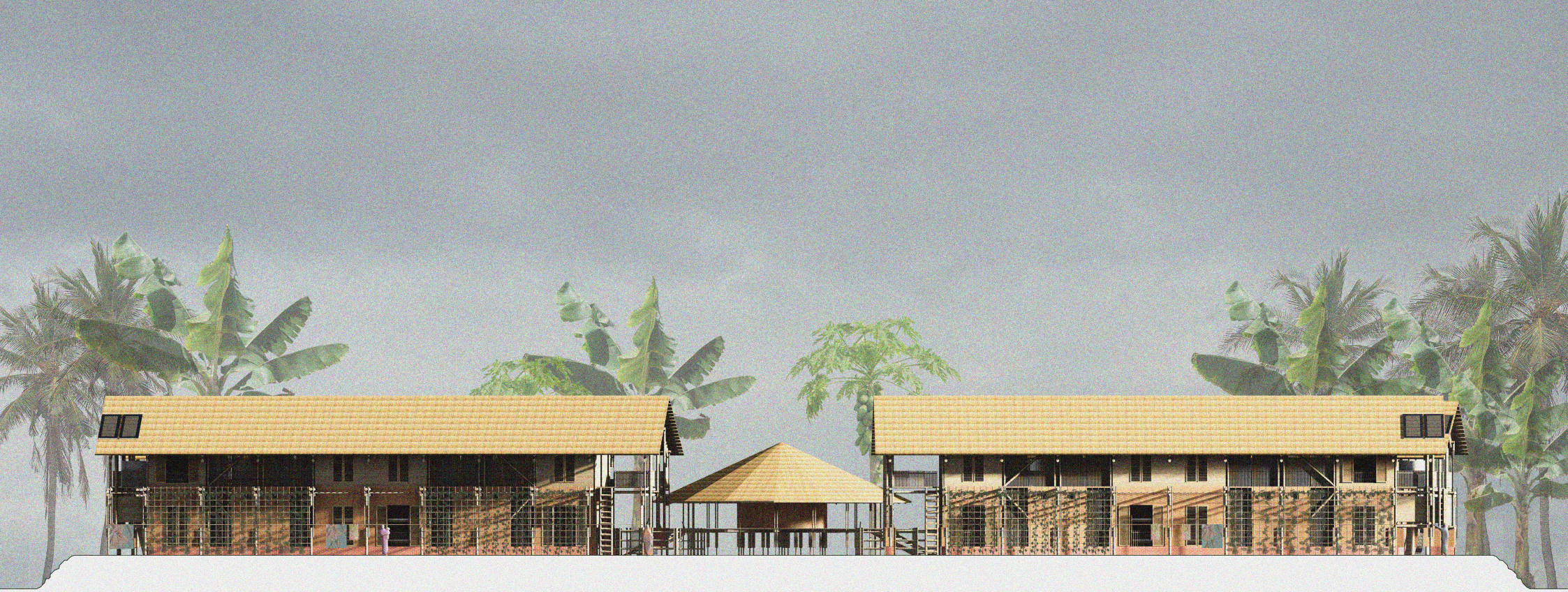


Longitudinal section 1:200



Ground floor 1:200





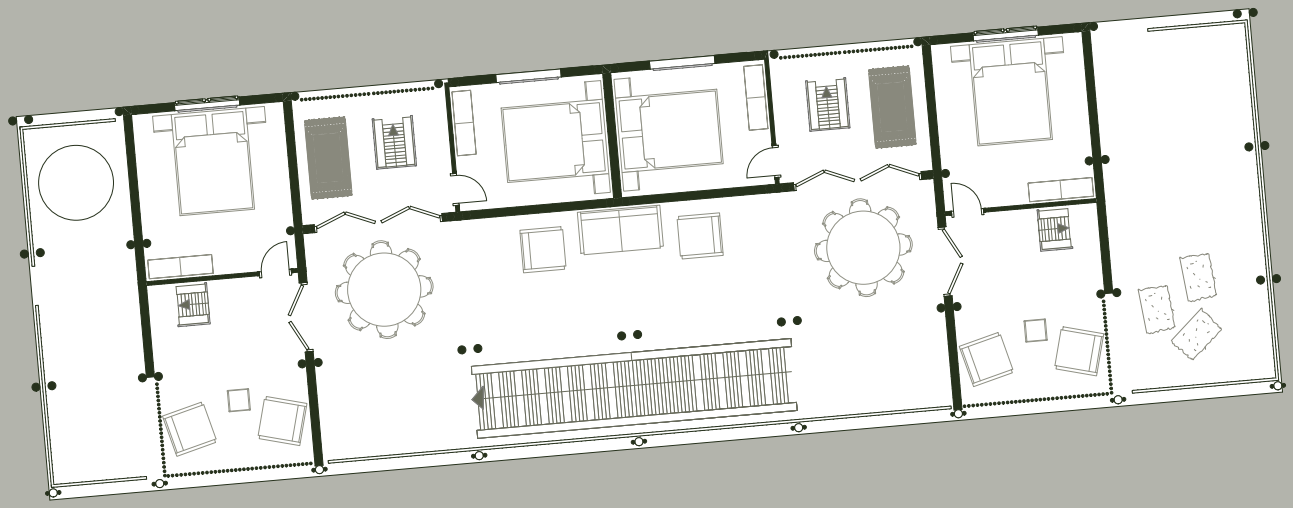
Back facade 1:100

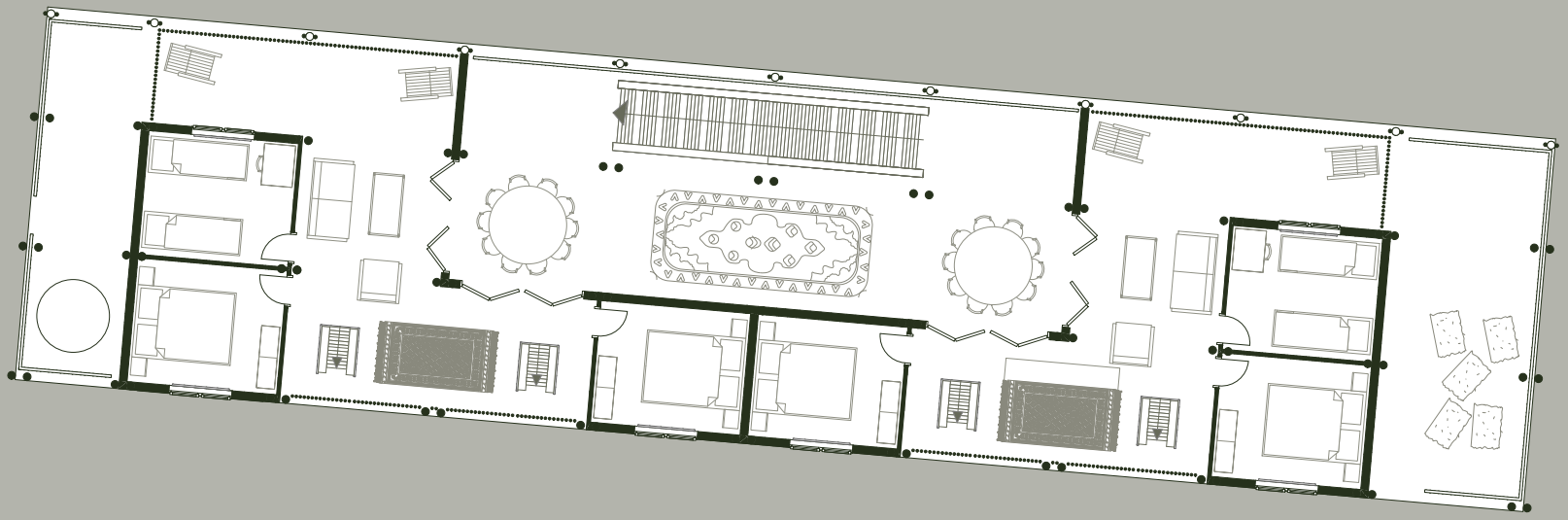
(m)
0 3 6 9

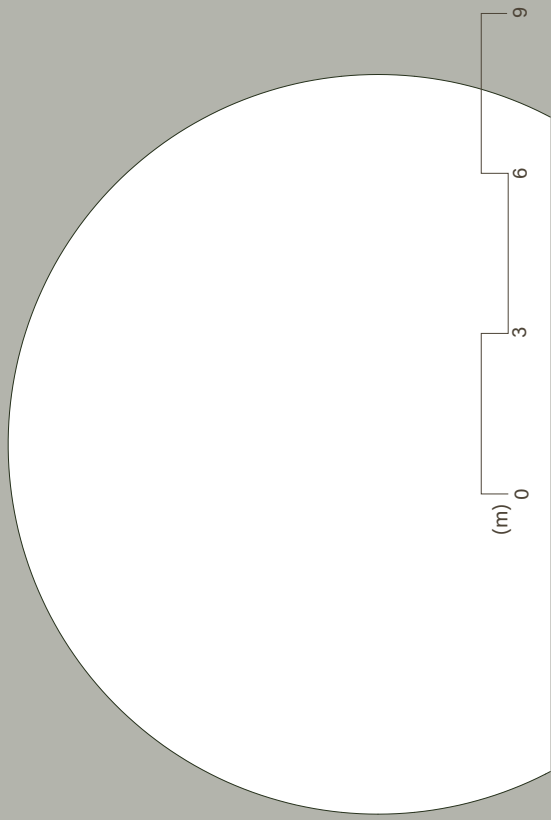
Ground floor 1:100

E) Dwelling scale

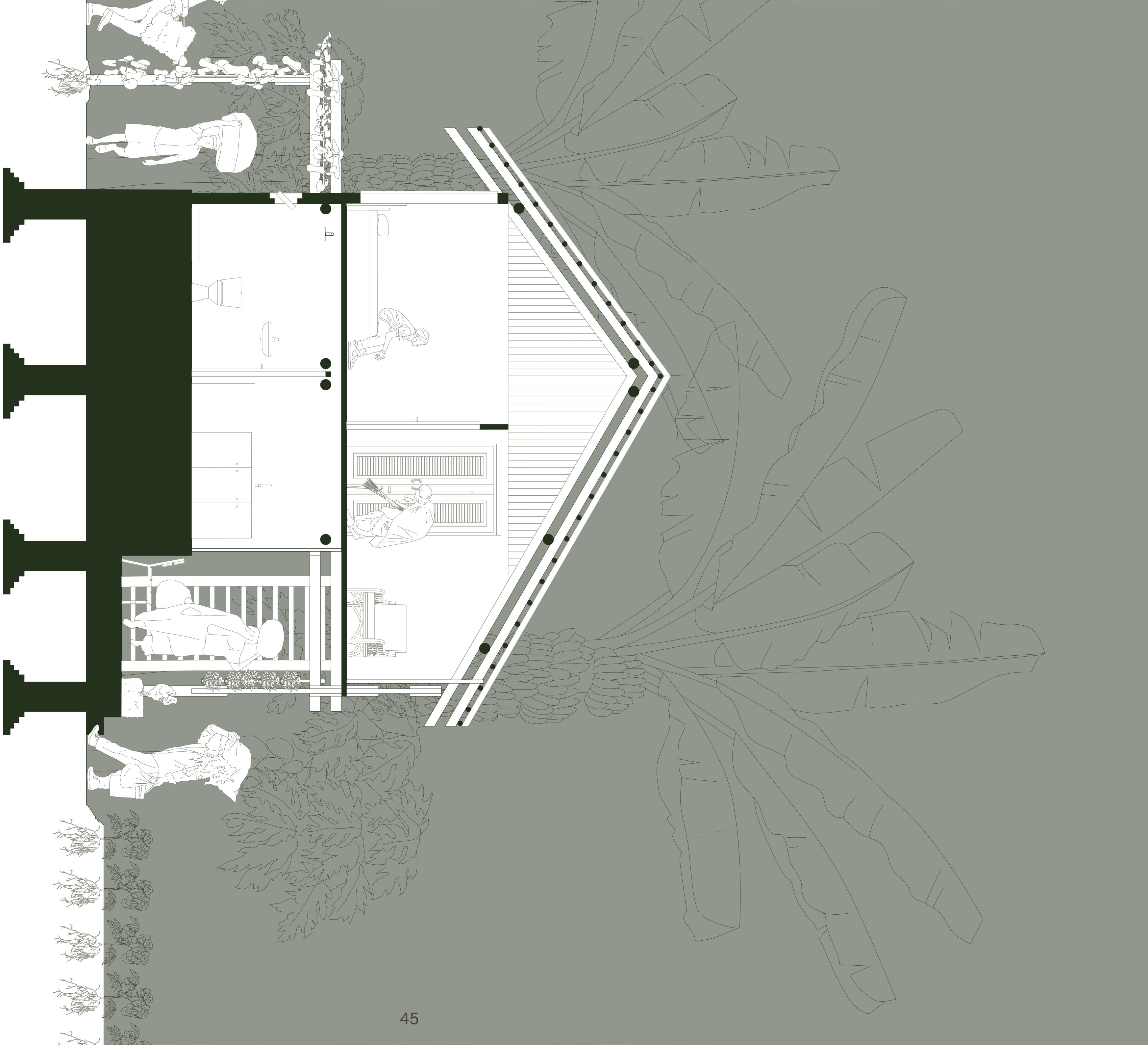
First floor 1:100

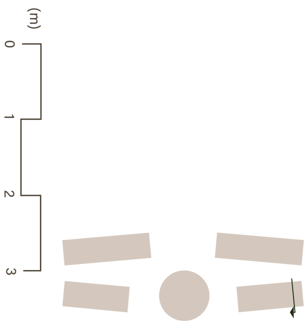




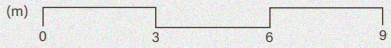


Transversal section 1:50



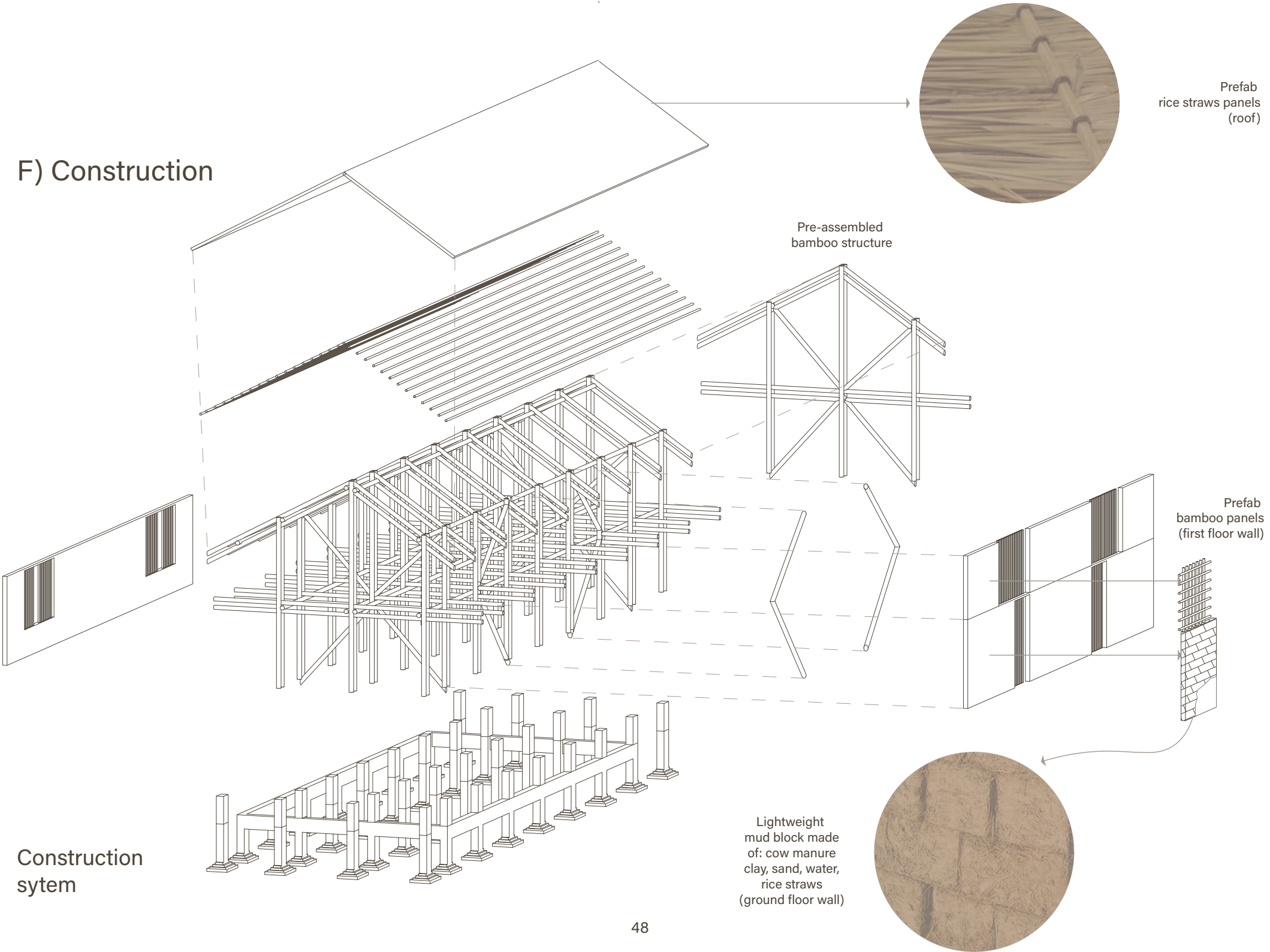


Front facade 1:100



Impression

F) Construction



Construction
sytem

Food for the people

Net income and ability to buy more food at the market

Part of the fishes and poultry farming products sent to the market

Eggs, dairy, rice, vegetables, fruits, and fish produced for a balanced diet and food security

Livestock manure as nutrient for fishes and fertilizer

Rice straws and livestock manure as building material

Harvested energy

Harvested water (rainy season)

Filtered water (biosand filter)

Purified water for aquaculture and crops irrigation

River as a natural buffer (dry season)

Pond system to purify water

Pond 1: Anaerobic state

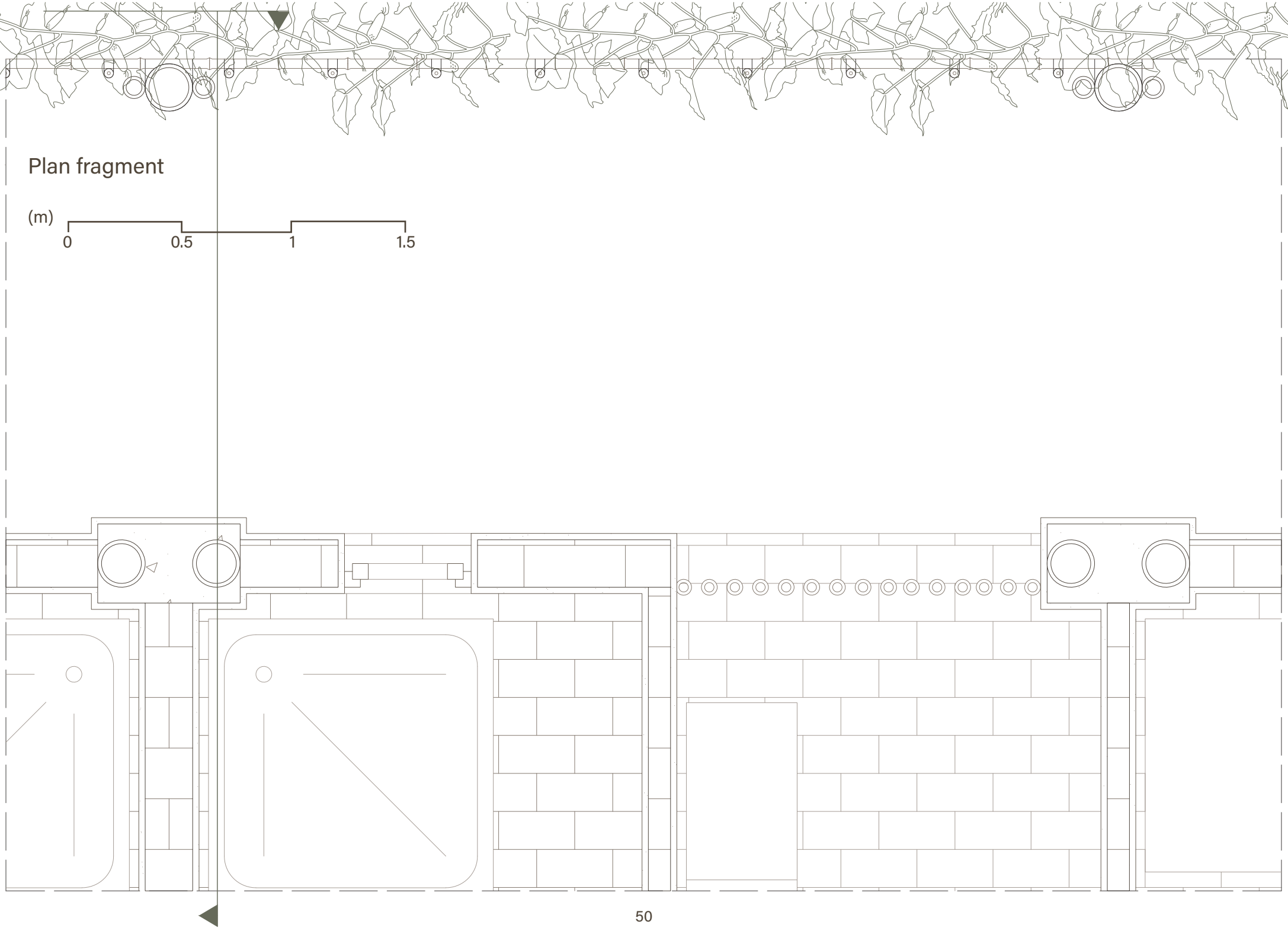
Pond 2: Aerobic state

Ressource management

Plan fragment

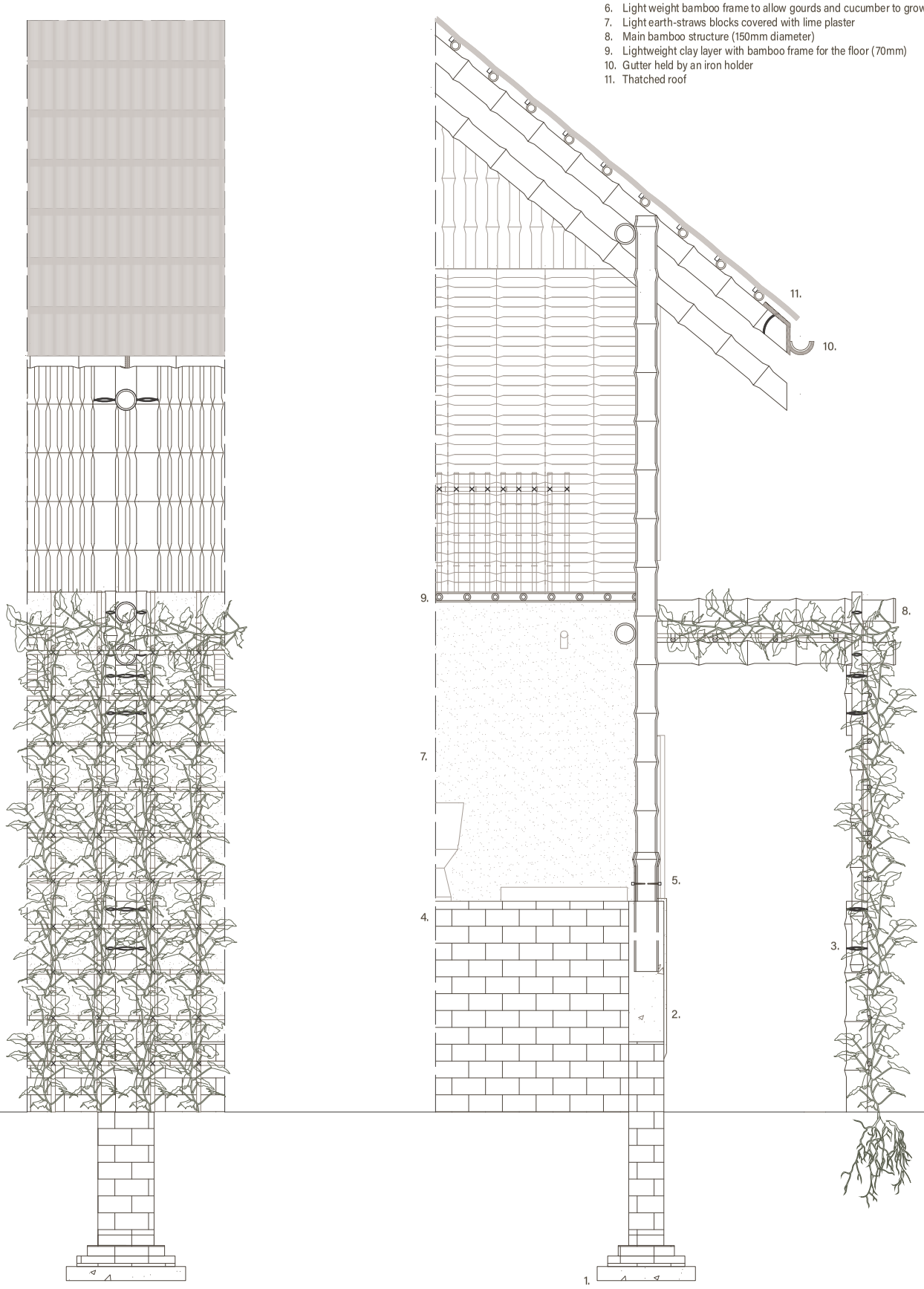
(m)

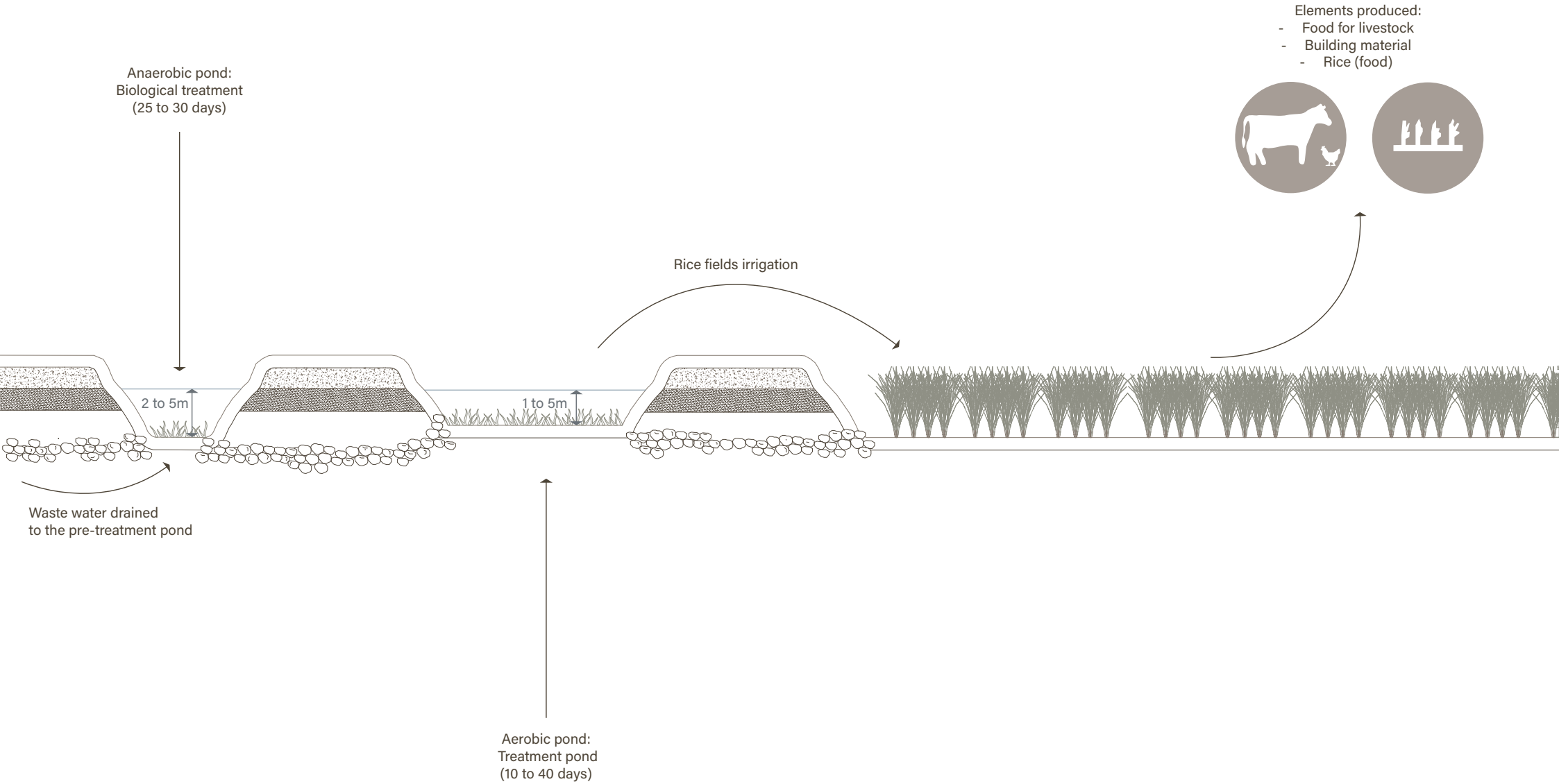
0 0.5 1 1.5



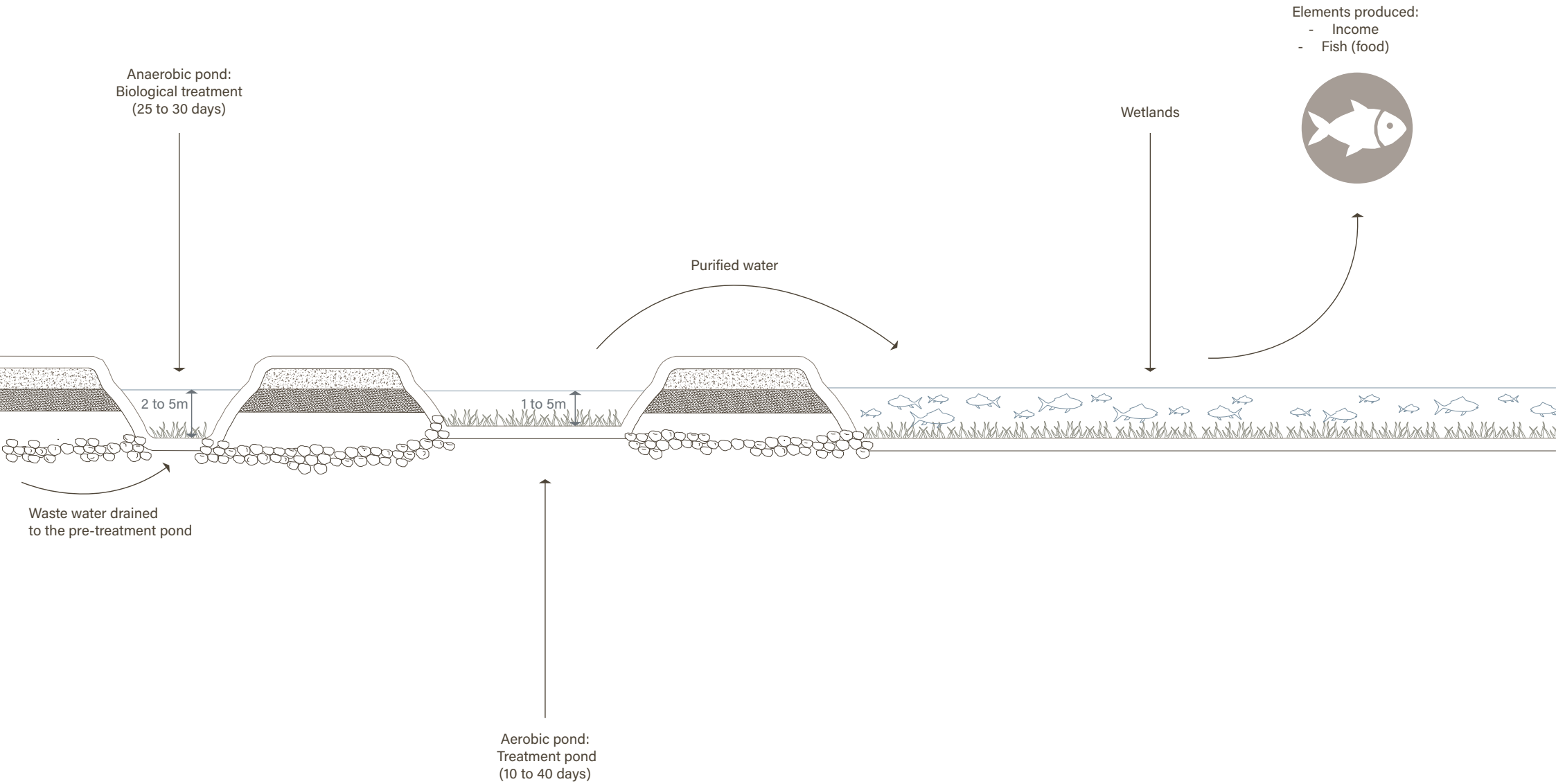
Facade and section fragment

1. Stepped brick wall foundation laying on lime-mortar bed
2. Cement and mortar column to allow bamboo to connect
3. Zinc coated wire for wire connection
4. Brick ground floor
5. Steel tube embedded in cement and mortar column
6. Light weight bamboo frame to allow gourds and cucumber to grow
7. Light earth-straws blocks covered with lime plaster
8. Main bamboo structure (150mm diameter)
9. Lightweight clay layer with bamboo frame for the floor (70mm)
10. Gutter held by an iron holder
11. Thatched roof




Elements produced:
- Food for livestock
- Building material
- Rice (food)
Anaerobic pond:
Biological treatment
(25 to 30 days)
Rice fields irrigation
2 to 5m
1 to 5m
Waste water drained
to the pre-treatment pond
Aerobic pond:
Treatment pond
(10 to 40 days)

Pond system


Elements produced:
- Income
- Fish (food)
Anaerobic pond:
Biological treatment
(25 to 30 days)
Wetlands
Purified water
2 to 5m
1 to 5m
Waste water drained
to the pre-treatment pond
Aerobic pond:
Treatment pond
(10 to 40 days)

Conclusion

Under optimal conditions, taking into account the crop yield data from 2022 (Bangladesh Bureau of Statistics, 2022) and the available space in and around the village, the new settlement would enable its residents to produce: 2,563 kg of rice, 176 kg of fish, 266 kg of eggplants, 496 kg of tomatoes, 366 kg of beans, 10 kg of coriander, 510 kg of gourds, 432 kg of cucumbers, 8,306 kg of jackfruits, 3,253 kg of coconuts, 3,177 kg of bananas, and 11 kg of papayas. This totals 2,080 kg of vegetables and 14,747 kg of fruits.

Considering the target of storing 16,061 kg of grains (rice) and 4,417 kg for 696 people to ensure food security during six weeks of flash floods, the target is achieved in terms of fruit production. However, the rice fields on the north side of the settlement would produce enough rice for only one week. The remaining rice could be purchased from the market through income-generating activities.

In addition to being able to store fruits for six weeks of flash floods, the villagers would have a fruit supply for an additional 14 weeks. Finally, the production of 2,080 kg of vegetables would meet the dietary requirements set by the FAO for 12 days.

Reflection

Relationship between the graduation project topic, architecture and the built environment

During my master's program, I learned to design for a world facing numerous challenges, including climate change caused by factors such as gas emissions, rising pollution, and deforestation. And other challenges include the loss of biodiversity and the rise of the global population. I was also taught to reflect on my choices and provide arguments to support them. The Global Housing graduation studio allowed me to continue my learning trajectory in the context of the Global South. In the studio, we focus on designing mass housing for a growing population in the Global South. This year we concentrate on the Sylhet division, a region of Bangladesh that is prone to climate-induced disasters. The studio evaluates the state and consequences of migration caused by those disasters. In my graduation project, I researched how to provide adequate housing for people living in the wetlands, an area prone to seasonal floods, and flash floods occurring a few times a year. Since most of this population works in the agricultural sector, I designed a settlement that will allow them to continue their main occupation, without being forced to be displaced in case of a flash flood.

Relationship between research and design

The preliminary research that initiated my design process began following the site investigation in October 2023. After our study trip to Bangladesh, I became convinced that I wanted to integrate the topics of agriculture and adequate housing conditions for farmers and fishermen in the Haor region of Sylhet. Considering that agriculture is the largest employment sector in rural Bangladesh and that the country is one of the most densely populated in the world, I aimed to design for the food producers and their families. In addition to improving food security during floods, my objective is to enhance their standard of living while respecting their daily routines and culture.

To begin with, I started to research the main crops on a national scale, the concept of homestead gardening, poultry farming, and adaptative strategies the inhabitants of Sylhet use to produce food during seasonal floods. The results helped me to understand what spatial elements are required in my future settlement and how I could combine them with my dwellings. During P1, I presented a section (Fig.14) that can now be considered a preliminary sketch of my design. To maximize agricultural land, I decided to build vertically, limiting the houses to a maximum of three stories. Additionally, elevated gardens are a strategy that locals employ to adapt to the limited space caused by seasonal floods. I integrated this strategy into the building design to save space and implemented crops into the structure. Hence, the section illustrates how I incorporated crops into the façades and roofs. Finally, I also showed different modules of houses and how a house could expand with time, depending on the family needs. However, this was not applied anymore later in my design. For the preparation of P2 and the continuation of the design process, it was necessary to be more precise regarding the types of crops grown in my settlement, the methods employed to optimize food security, and the typology and orientation of the dwellings.

Thus, I created a matrix of all existing crops in the Sylhet division, illustrating their spatial requirements and growth periods. For the typology, I conducted a site analysis to determine the general shape of the structures, selecting construction materials based on my observations. To improve food security, I investigated the methods used to ensure food availability during seasonal floods and flash floods. It was found that grains and dried fruits are stored in granaries.

Therefore, I incorporated food storage facilities into the housing clusters of my settlement. However, for my P2 retake, I had feedback that more research should be done on the size of my food storage and crop yields to support the choice of crops. Regarding the housing clusters I focused on roof gardens and related my project to urban agriculture. However, this approach proved to be unsuitable for the context, given the climate, the financial means of the population, and my concept of maximizing space for agricultural lands. As a result, I reduced the number of floors, focused less on roof gardening, and combined four dwellings into a single building. The time I had to prepare for my retake allowed me to better understand the dimensions of the dwellings and food storage, as well as to refine my choices regarding the types of crops to be cultivated.

Hence, the research I made from October 2023 to my retake in February permitted me to have a good base for my design and to understand what a settlement centered on food production and food security needs in terms of space.

After the retake of my P2, I received feedback indicating that my project remained schematic and needed to be made more feasible, realistic, and more detailed. Thus, for the second phase of the design process, I conducted additional research related to building costs and construction processes. Furthermore, I undertook research on the technical design aspects of the houses, focusing on building and energy systems, and nutrient management.

Therefore, I can say that throughout the academic year, research influenced my design choices and the other way around. I first began with research and as I went through the design process, I needed more research to support my choices and get a better understanding of how to design for food producers in the Haor of Sylhet.

Design process and methodology

Research and design complemented each other throughout the year, which influenced my design process and methodology. As mentioned earlier, the research I conducted during the first semester provided me with a good base for my preliminary design presented during the retake of P2. Although the approach of integrating research into each phase of the design process proved to be quite effective, the process was not without difficulties. The most challenging phase of my graduation year was P2 as I had the feeling I was going in the wrong direction and concentrated too much on a concept that was not appropriate for my design and its context. However, the two additional weeks I had put me back on track. After my retake I also found myself to be in difficulty as my design process stagnated for five weeks. As a matter of fact, I wanted my housing typology to be more centered on my food storage.

Figure 14: P1 poster

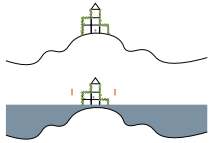
Food in floods

Floods are part of Sylheti's daily lives and impact their lifestyle and wellbeing in many ways. It is seen that 40% of the people affected by monsoons in the Haor region of Sylhet are children. With the agricultural crops being destroyed by seasonal streams, they suffer from malnutrition and their dietary diversity is scarce between June and October.
Although technics have been found by the locals to adapt to flash floods, ***the limited amount of space is not optimal to grow crops necessary for a balanced diet.***
Therefore, **How to improve the use of available space in the wetlands to guarantee food security throughout the year?**
What are the existing crops of the wetlands and what can be introduced?
How to provide adequate housing conditions for a large population considering the limited amount of space? What building typology is appropriate to grow crops on the roof and facades while being spatially efficient?
How to design spaces for children to allow them to be involved in the food garden concept?

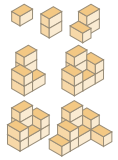
Design principles

1
Space efficiency

2
Self sustained settlement



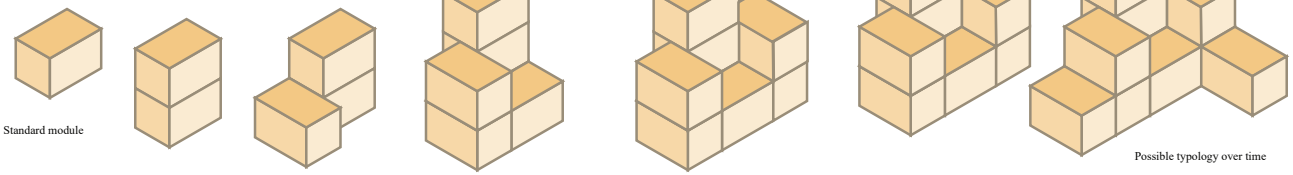
3
Climate change adaptation

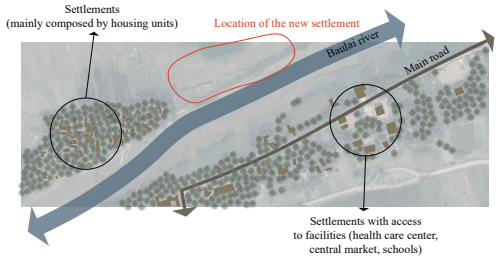


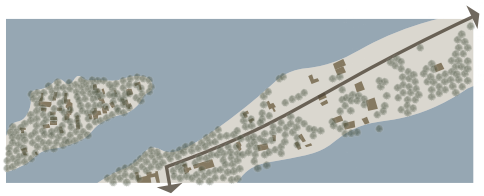
4
Housing resilience

5
Use of local materials

Possible typologies







Master plan diagram

Christelle Rarivo 5655528
Q1 2023-2024

However, the orientation of the dwelling and its typology did not match with the existing buildings around the project site. Consequently, I decided to go back to the preliminary design I had for the retake of P2 and developed it further, by changing the orientation of my structures and making it less schematic. Between this period of stagnation and P3, I focused more on a housing cluster including food storage, four buildings, and space for livestock. As I ran out of time, the implementation of the agricultural elements on an urban and dwelling scale was still incomplete for P3. Additionally, I found my facades to be too close and rather simple. Thus, the feedback I received during P3 was predictable, as I was already aware of the aspects I still had to improve and cover.

Regarding the feedback I received from my mentors throughout the year, it helped me to concentrate on a specific aspect of my design and gave me direction for my research. During the first semester, I was rather impulsive in making changes to my design following feedback sessions. I would drastically change my design, resulting in a new version of it almost every week. Due to personal circumstances, I have an academic counsellor who has helped me with my academic progress since I started my master program. After a meeting with her, she suggested devoting an afternoon or a day of reflection regarding the feedback I get. This method turned out to be more effective, as I allowed myself to think of the improvements I needed to make without impulsively changing things. During this period of reflection, I considered what aspects of my design needed changes or improvements and what elements could be kept but required stronger arguments to support my choices. I think that during the first semester, I lacked a bit of self-confidence.

Which might be the reason I took an impulsive approach after a feedback session. However, the advice my counsellor gave me was a gentle reminder that I am still the architectural designer of my own graduation project.

Furthermore, when I look back at my research plan, the problem statement and the theme remain the same. However, a couple of elements changed. Initially, my objective was to guarantee food security. However, given the actual circumstances, I concluded that as a designer, the best I could do was to improve food security by designing a typology that accommodates agricultural crops and fosters a community centered around a common food storage. Nevertheless, I could not fully ensure food security. Furthermore, I wanted the crops to grow on the dwelling structure as that would bring food producers closer to their crops, but it is also a way to use the space efficiently. I managed to implement the concept on my façades, by designing elevated gardens on them. On it, I have decided to grow gourds and cucumber, as they grow vertically. Nonetheless, on the roof was not possible as it would carry too much load on my bamboo structure. Having a roof garden would require a specific roof construction and maintenance that might be costly. However, I am designing low-income housings. Additionally, having a flat roof garden was questionable as the region where I design is subjected to heavy rain. Although it might have been possible, I would have to think of a more advanced drainage system, and a construction that might have been too pricey considering my financial model. And I also had to think of how such a system might evolve with time in a low-income setting. Thus, during the design process, I also learned to make tradeoffs and accepted that a concept does not necessarily work in every context.

Finally, I would like to point that in my research plan, I introduce children malnutrition as being one of the challenges the inhabitants of Sylhet face and I also stated as a sub-question *"How can outdoor spaces be designed to actively engage children in the concept of food gardening?"*. I believe that children malnutrition was, and continues to be, a significant inspiration for me, as it is the theme that guided me in selecting my graduation topic. Nevertheless, I made the choice to design my settlement for families of farmers and fishermen instead of only focusing on their children. I did not disregard this group, but I wanted to design for the entire community, and I believe that having agricultural lands and crops surrounding their houses is a way to make children aware of their environment and nutrition.

Societal importance

In a larger perspective, the research I conducted and the design I am developing are bringing more knowledge about designing in areas prone to climate-related destruction. According to the Climate Risk Index 2021, Bangladesh contributes to 0.56% of the global gas emissions. And yet, it is ranked the seventh most vulnerable country to suffer from the consequences of climate change. This fact shows how relevant it is to design for vulnerable groups of people.

Nonetheless, it is of a great importance to study the place where we design, to observe and respect its traditions and culture, to learn from the local population and to consider their needs. As an architectural designer, it is my duty to provide suitable living conditions and propose innovative strategies to people. However, I also should learn from the people I am designing for and respect their lifestyles.

Additionally, it is my responsibility to study the landscape and context before beginning the design process. Disregarding cultures and traditions can be ethically problematic and may be interpreted as a form of arrogance, and in some cases, neo-colonialism. This relates to my Architectural History Thesis (AR2A011) in which I examined the influence of French colonization on the city of Antananarivo. In my thesis, I argued that the current problems faced by the city are caused by a neglect for its socio-cultural and geographical contexts. Like other Sub-Saharan cities, the urban concept applied to Madagascar's capital were based on colonial ideologies. In the conclusion of my paper, I recommended urbanists and architects to involve the local population more actively in the design process by considering their needs.

Hence, my graduation project is a design proposal for a population suffering from the consequences of climate change. As I designed for the Bangladeshi context, the building materials and the orientation of the buildings are characteristic of the region. However, the agricultural concept, the building methods, and systems could be replicable in places prone to climate disasters and where food security is threatened.

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