MOVING FORWARD: FUTURE-PROOFING STILT HOME INTERIORS WHILE INCORPORATING CULTURAL IDENTITY

By

Vety Meng

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Submitted as a final requirement of the Master
of Interior Architecture programme

at

Victoria University of Wellington
February 2017

CONTENTS

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Ms Natasha Perkins from the School of Architecture at Victoria University of Wellington, for her contribution towards my research thesis. She has always been there to guide me in the right direction throughout my research and consistently encourages me to work to my maximum potential. All of her efforts have always been appreciated.

I would like to thank my learning advisor, Dr Xiaodan Gao of Victoria University of Wellington's Student Learning team, for her contribution to the write-up of this thesis. She has helped me to compose a structure that best suits my thesis and what I am trying to achieve. This thesis wouldn't be where it is without her valuable advice.

I would like to thank all those who took part in my field study in Cambodia. Their contributions provided me with the essential data that defines my thesis. Without their input, the research would not have been successful.

I would also like to acknowledge my family for their genuine support and comfort throughout my academic study, especially in this final year. They have always motivated me to strive for success. This accomplishment would not be attainable without them.

Finally, I want to acknowledge that all images in this exegesis belong to the author.

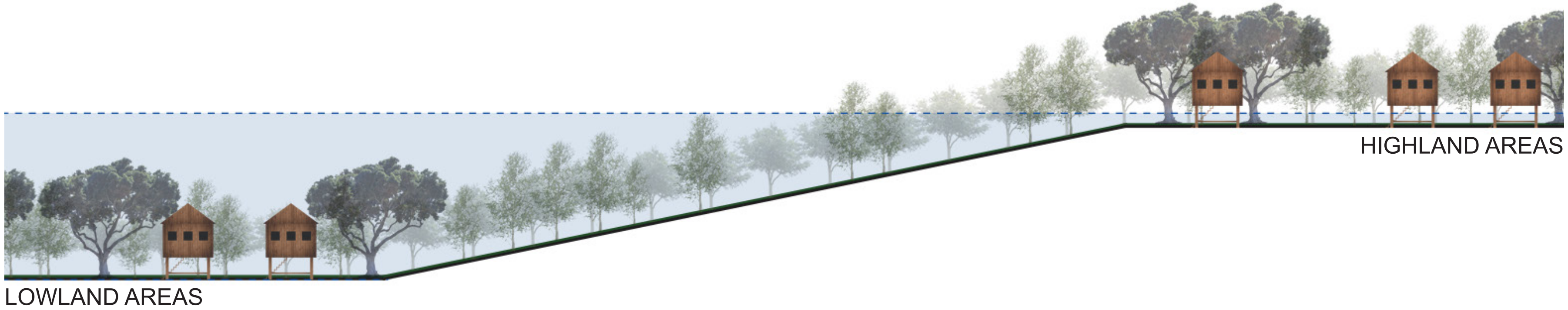


Figure 1. Flooding conditions in highland and lowland areas. In extreme years, flooding can reach up to 16 metres in lowland areas and one metre in high and areas.

ABSTRACT

Kampong Cham is a province in Cambodia that is prone to annual flooding. This affects many families and causes damage and displacement of households every year. This research aims to offer a design solution that enables families to prepare for, endure and mitigate damage during the rainy season while incorporating traditional and cultural features.

A site visit was undertaken to allow for qualitative and quantitative data to be gathered, as was ongoing investigation into Cambodia's traditions and culture in order to understand what is important to the families in this province.

An iterative design process was pursued and a final design concept that seeks solutions and has considered the many issues is presented. The design endeavours to mitigate flood damage and provide a living environment to which families can relate. In addition, it aims to improve the living standards within Cambodia through cost-effective design and materials.

CHAPTER 1: INTRODUCTION

INTRODUCTION I RESEARCH STATEMENT I PURPOSE I BACKGROUND I DISCUSSION

Figure 2. Local woman collecting firewood for cooking purposes.

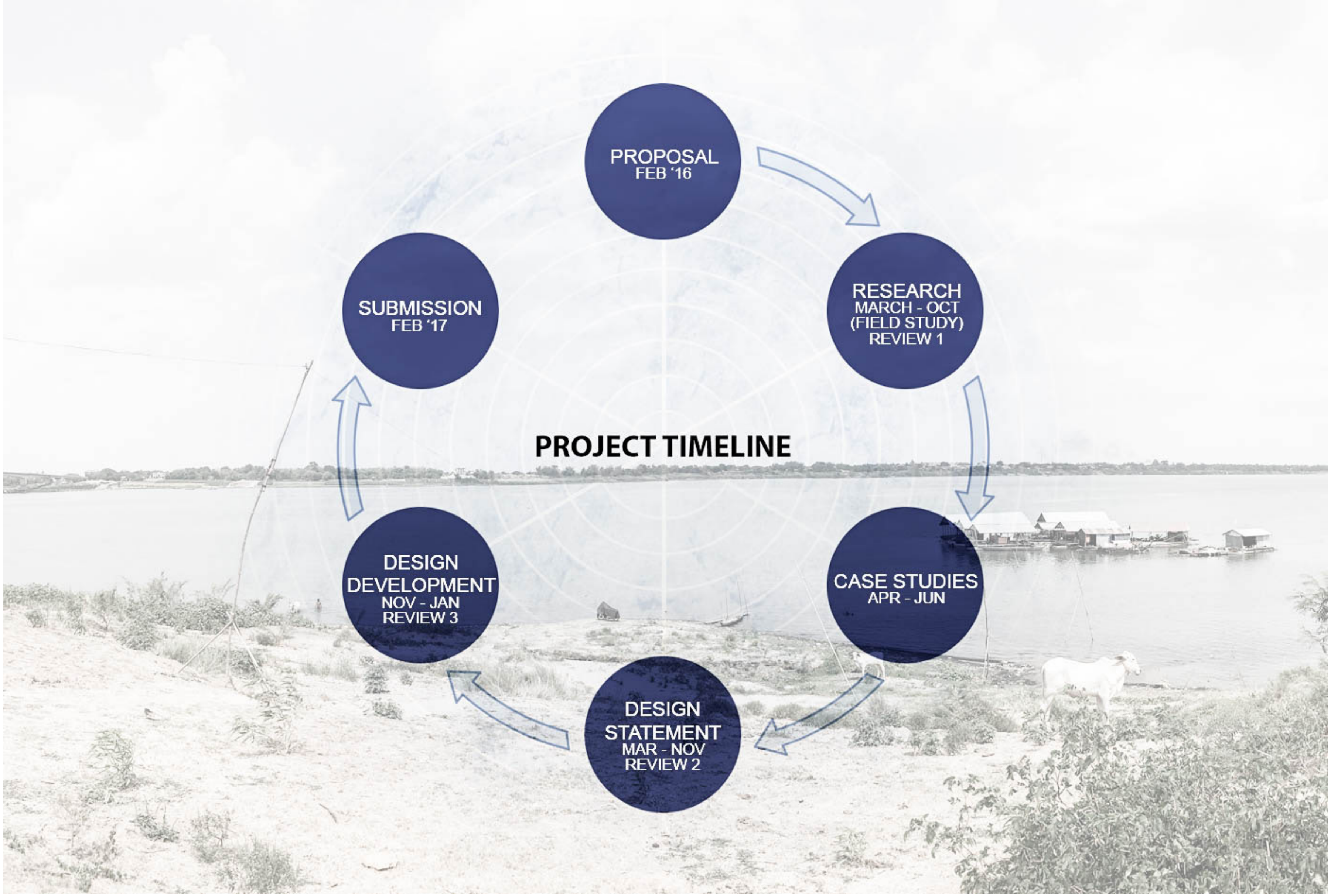


Figure 3. Indicative project timeline.

1.1 INTRODUCTION

Kampong Cham, one of Cambodia's most populated provinces, is affected by annual floods due to the overflowing of the Mekong River, which intersects the region. This has a negative impact on the families in the area, exposing them to hardship and limiting their lifestyles during the rainy season. In 2013 3,546 households were displaced and 51,376 households were affected by the floods (Impact of Flooding in Cambodia).

Flooding not only damages households and environments but also generates a domino effect, leading to diseases and death. This research aims to investigate the impacts of these conditions on families and houses in the Tboung Khmum district of Kampong Cham province, Cambodia, with the intention of finding design solutions to help families become better prepared. It explores different flood-resistant strategies and design features that consider local materials, traditional aspects and cultural values in order to maintain the country's authenticity (Che-Ani et al., 88). It is anticipated that the final solution could be replicated in other flood-prone areas of Cambodia.

Figure 4. Collage of my cousin and I at her house.

1.2 RESEARCH STATEMENT

This research project aims to investigate the impacts of flooding conditions on families and houses in the Tboung Khmum district of Kampong Cham province, Cambodia, with the intention of finding design solutions to help families become better prepared.

1.3 WHY I CHOSE THIS TOPIC

I have been concerned about the flooding conditions in Kampong Cham for two reasons: firstly, since my cousin's home was displaced in 2014, and secondly, after visiting the province in April 2016, I was shocked to see damaged homes scattered along the riverbanks. This sight and the plight of my cousin inspired me to investigate design solutions that will help those affected. I specifically chose a stilt house on the riverbank of the Tboung Khmum district as the site for this research because it is where my cousin's home was swept away and is the zone in which the most annual flood damage occurs.

Additionally, as a Cambodian born and raised, this research project gives me the opportunity to propose a solution as a way to give back and take part in aiding the development of my country.

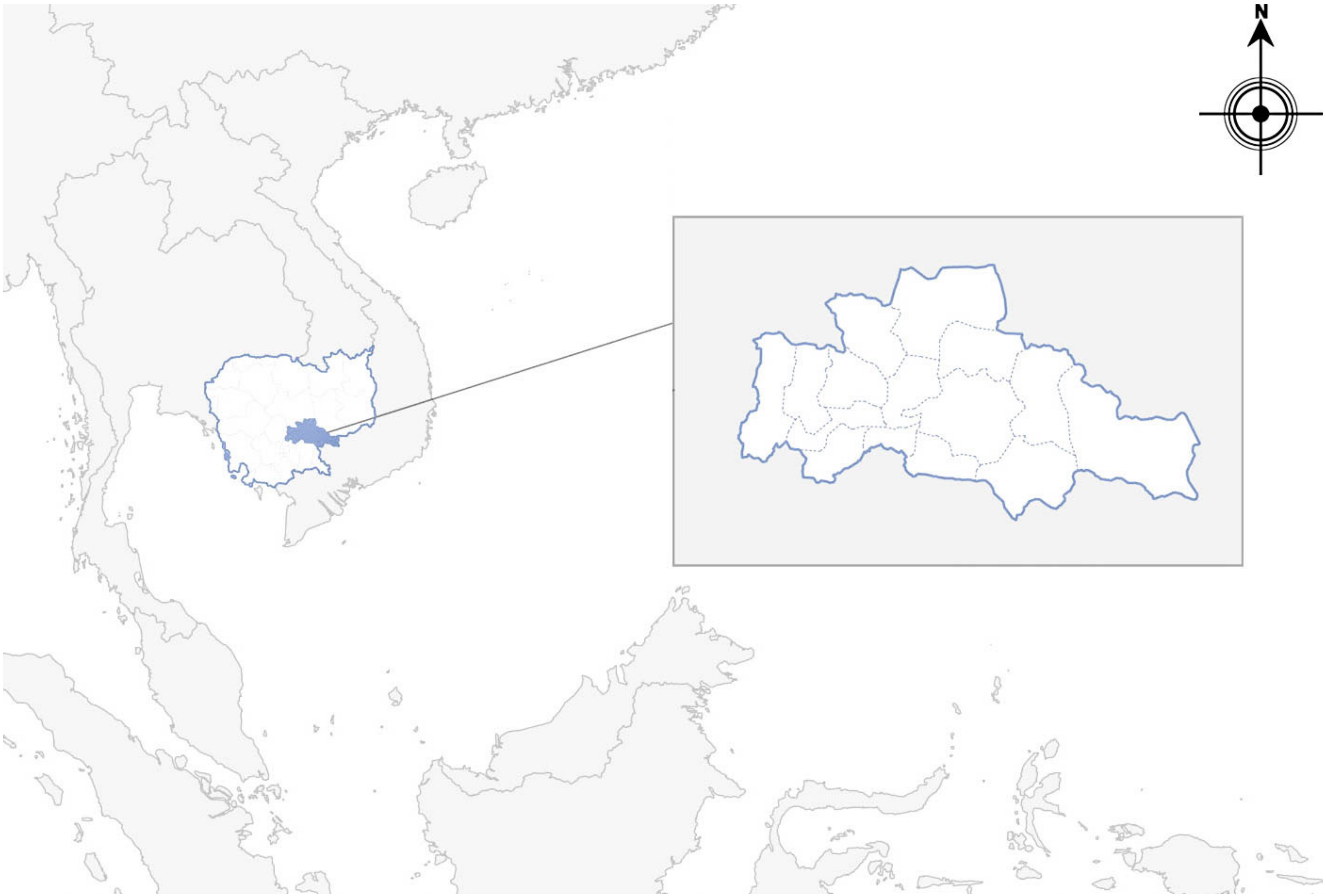


Figure 5. Map of Southeast Asia displaying the location of Cambodia and Kampong Cham.

1.4 BACKGROUND

CAMBODIA

Cambodia is a flood-prone country in Southeast Asia that shares borders with Thailand, Vietnam and Laos. It has 20 provinces and four cities in total, with Phnom Penh being the capital. It is known for its agricultural industries, historical significance and religious culture, which are all highly valued by its citizens.

Cambodia is where 15.9 million people call home. Cambodian people are called 'Khmer' and more than 90% of them are of the Buddhist religion (East & Southeast Asia – Cambodia). Although Cambodia is a growing country, 20% of the population still live in poverty in the rural countryside, with the majority facing recurring floods (Cambodia Country Poverty Analysis 2014).

The rainy season occurs from May to November when annual flooding takes place with varying degrees of disruption and damage. The floods occur in rural areas around the Mekong River where drainage is not able to support a rapid increase in water volume that causes household damage, lifestyle disruption and an increase in life-threatening diseases. Specifically, these are:

- household damage: broken roofs, interior leakage, weakening of columns and other structural elements
- lifestyle disruption: crops are destroyed, animals die, food and water is scarce, cooking and washing is compromised, trade and income is reduced.
- life-threatening diseases: malaria, dengue fever.

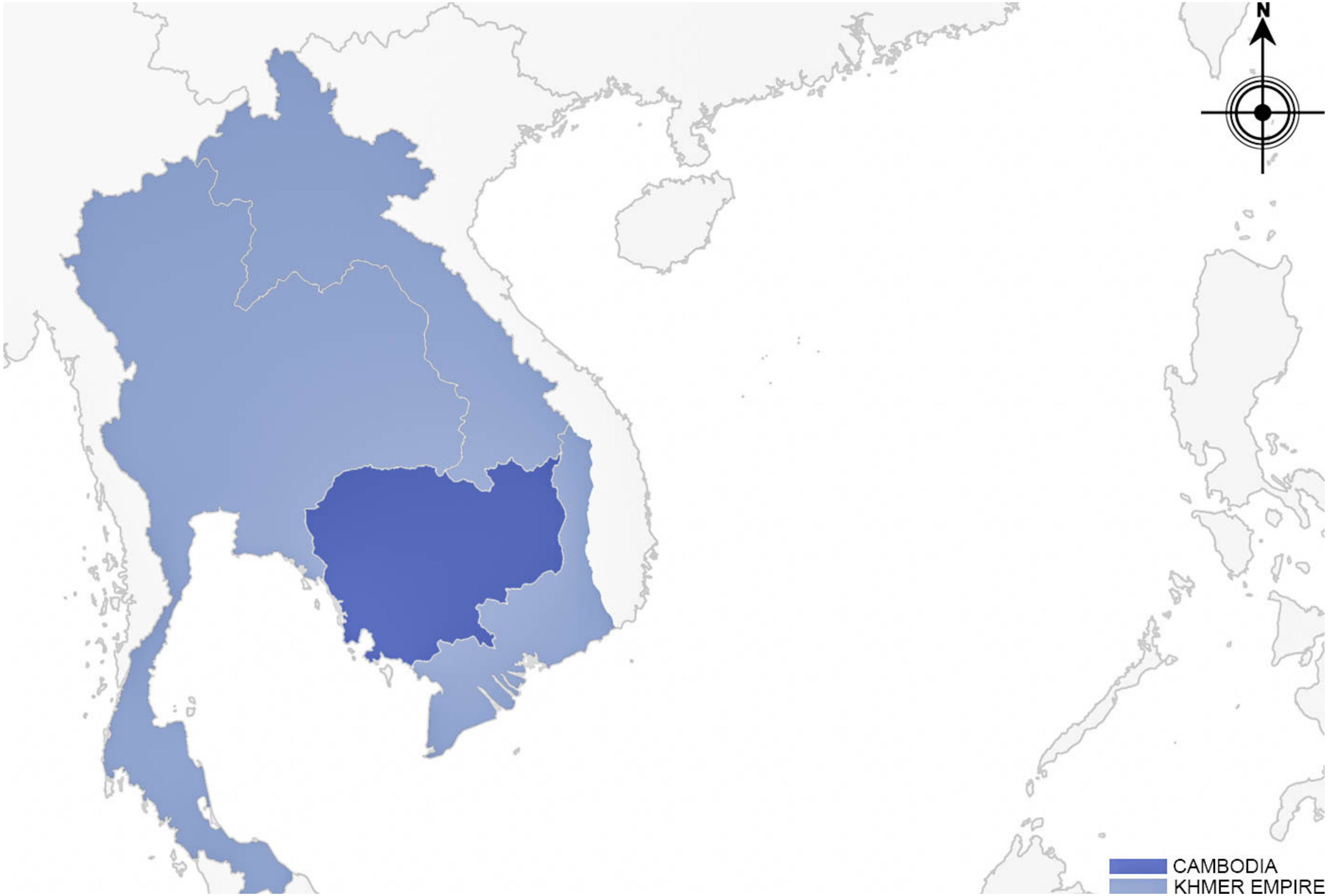


Figure 6. Map of Southeast Asia displaying the expansion of the Khmer Empire between the 10th and 13th centuries.

HISTORY

Cambodia was once an empire called the Khmer Empire that expanded and held power over Southeast Asia between the 10th and 13th centuries. The empire was weakened after it was attacked by Thailand and Vietnam, which resulted in a long period of decline. After numerous wars and civil conflicts that tore the empire apart, Cambodia fought to find peace again after the Khmer Rouge regime in 1979.

The Khmer Rouge regime was a political conflict caused by the Cambodian Communist Party, led by Pol Pot, who rose to the leadership of the communist movement in the 1960s and introduced ruthless and radical reforms once he assumed power. The regime created genocide between 7 April 1975 and 7 January 1979, leaving more than two million innocent people dead through torture, execution, starvation and overwork.

Figure 7. One type of traditional window seen on rural houses.

Figure 8. A second type of traditional window seen on rural houses.

After 7 January 1979 people found peace and freedom; however, many parcels of land were divided unfairly as all government documents had been destroyed, so some people were issued with better locations than others. This explains why some people live in lowland areas that can be subjected up to 16 metres of floodwater yearly (refer to Figure 1); these families stay where they are in order to remain close to their ancestors, as this is what the land represents, while others have migrated to highland areas to avoid the floods.

Fear of the regime has had an extremely negative impact on the Cambodian people, as is evidenced by the architecture: rural housing in Cambodia has adapted a design feature in which metal bars have been added to windows to provide protection for families and their belongings (Lourn, 3).

Figure 9. Kampong Cham district map showing the intersection of the Mekong River.

KAMPONG CHAM

Kampong Cham, a rural province, is the third-largest province in Cambodia located in the southeast region of Cambodia. There are 16 districts, 173 communes and 1,748 villages in Kampong Cham (Geography – Kampong Cham, Cambodia). The province shares borders with Prey Veng, Kandal, Kampong Chhnang, Kampong Thom, and Kratie. It is known for its agricultural industries, such as rubber plantations, silk farms and landmarks like Kisona and Ko Paen Bridge. However, it is intersected by the Mekong River, which causes the annual floods.

The Mekong River flows to the South China Sea. According to the Mekong River Commission, the river is 4,909 kilometres long and covers a land area of 795,000 square kilometres, making it the 10th-largest river in the world (Physiography). The flow velocity of the river reaches its peak between August and September, with an average of approximately 12,000 cumecs, or cubic metres per second. The minimum flow velocity occurs between February and March, with an average of approximately 900 cumecs (Mekong River Commission).

Every rainy season 13 districts of the province are affected by the water discharged from the Mekong River (International Federation of Red Cross). In 2013 research showed that up to 3,546 households were displaced and 51,376 households were affected (Impact of Flooding in Cambodia). Houses along the river's banks face damage every year, causing families to evacuate their homes to live in pagodas and schools that are more structurally stable (Assessment Capacities Project). The floods also affect the agricultural sector because farms and crops are destroyed, leading to a decline in the economy.

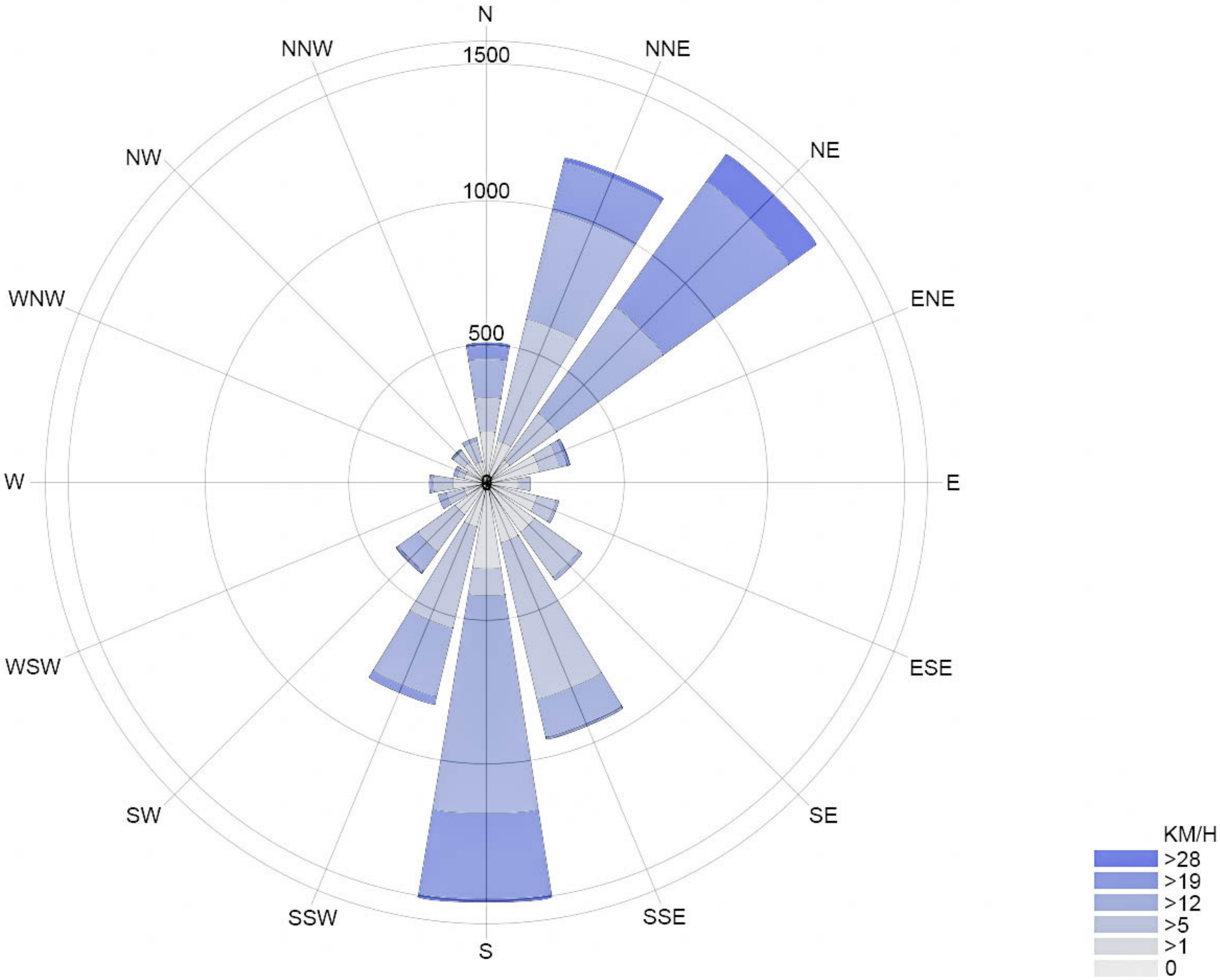


Figure 10. Wind rose diagram displaying wind speed and direction for Kampomg Cham.

There are several factors contributing to the climate in Cambodia and these include heat, humidity, and wind. Cambodia is located in the tropical zone, approximately 10 degrees north of the Equator. This makes the country hot all year round because the sun is directly above every day. The average maximum temperature in the province is around 31°C and can reach up to 37°C. On the other hand, the average minimum temperature is around 22°C, but can decrease to 16°C on cold nights (Climate Kampong Cham).

The average daily humidity for the province is approximately 77%, October being the most humid month and February being the least humid (Humidity).

The average daily wind speed for the province is approximately 2.5m/s (9km/h). For many hours every year stronger winds travel from the north and south (Climate Kampong Cham). Wind from the east and west is reduced because of land barriers.

After many years of recurring floods, a solution is needed. Too many families and households are affected annually. It is envisioned that a design solution will be developed to address the issues of living in stilt housing during the rainy season, while still maintaining the traditional qualities of Cambodian home interiors.

CHAPTER 2: CONTEXT
SITE I TRADITION

Figure 11. A main road in Tboung Khmum district.

Figure 12. Map of the region visited in Tboung Khmum district. In order to preserve anonymity , the families are not named.

A good understanding of traditional qualities and beliefs is important to this research project as it allows for an opportunity to understand the Cambodian lifestyle. By identifying Cambodians' wants and needs, various triggers can lead to potential design solutions. Therefore this section expands on the contextual, societal, and commercial elements presented in the previous section by reviewing the siting, typology, materials and layout of traditional homes and the relevance and pragmatics of everyday life.

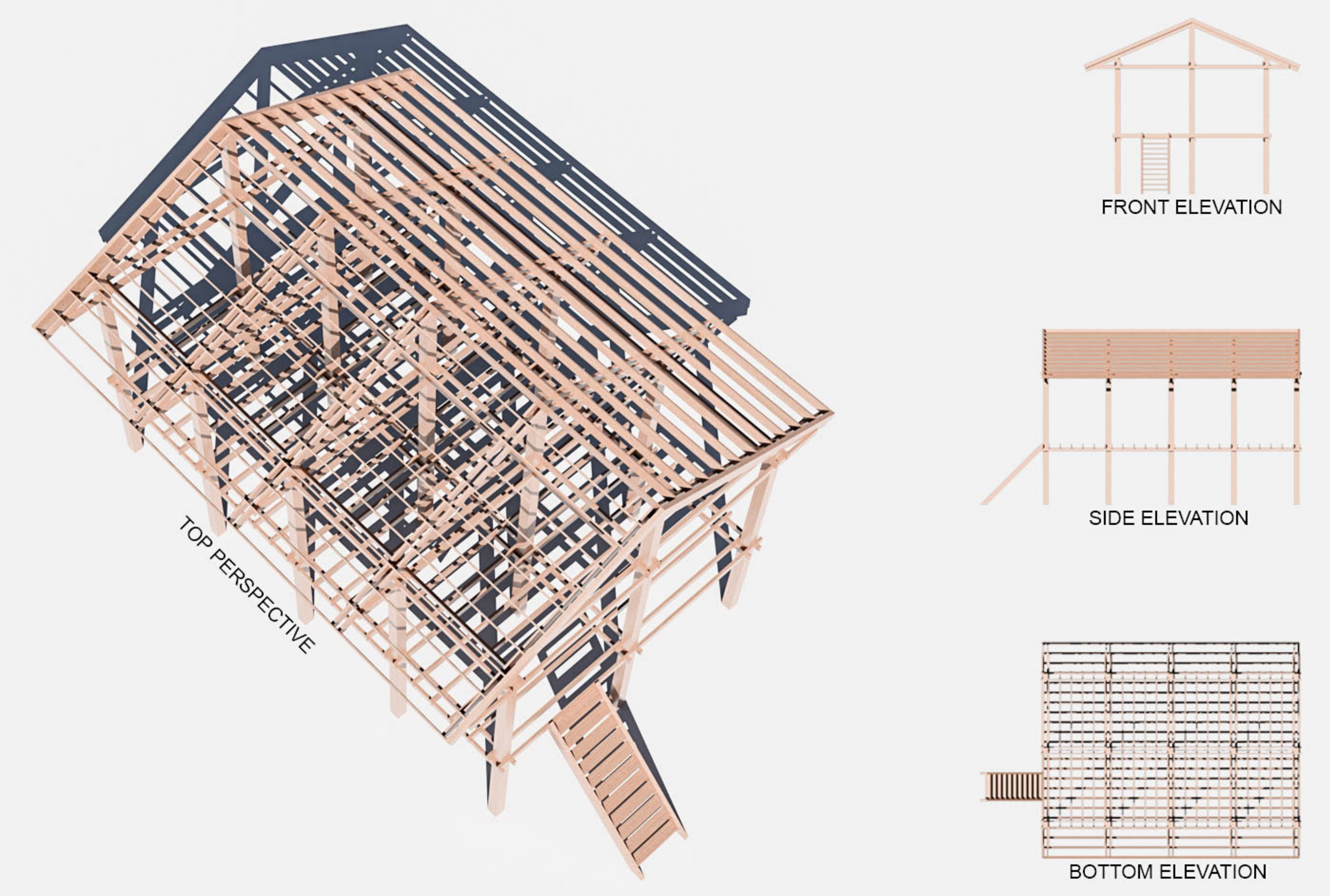


Figure 13. Existing structure of chosen site.

2.1 SITE

STRUCTURE

The house is made up of columns, joists and rafters. Together, the three components form a structural frame that stabilises the entire house. The frame dimensions range, with 2m column layout, from 4m x 6m to 6m x 10m and may go up to 3m high (Australian Lutheran World Service). This is to protect families from annual floods; however, the annual wetting of the columns weakens the structure on an ever-increasing basis.

Stilt houses are generally built by specialised builders. In some cases people choose to build them themselves because there are no established building codes in Cambodian provinces. People build their homes based on budget and personal preferences, resulting in reduced costs.

Figure 14. Interior perspective render of chosen site.

Figure 15. Interior perspective render 2 of chosen site.

Figure 16. Exterior render of chosen site during the dry season.

Figure 17. Exterior render of chosen site during the wet season.

STILT HOUSE

Cambodia's traditional stilt house is a two-storey structure that presents many of the traditional ways of living and local materials. It has a wooden frame that supports the geometrical design features, such as rows of vertical stilts, a rectangular body and a triangular gabled roof (Australian Lutheran World Service). This type of house can be seen in rural areas, especially along riverbanks. It is built for a family of four to five; however, owing to an increase in technology and a growing economy, these houses are slowly disappearing and are being replaced by contemporary homes.

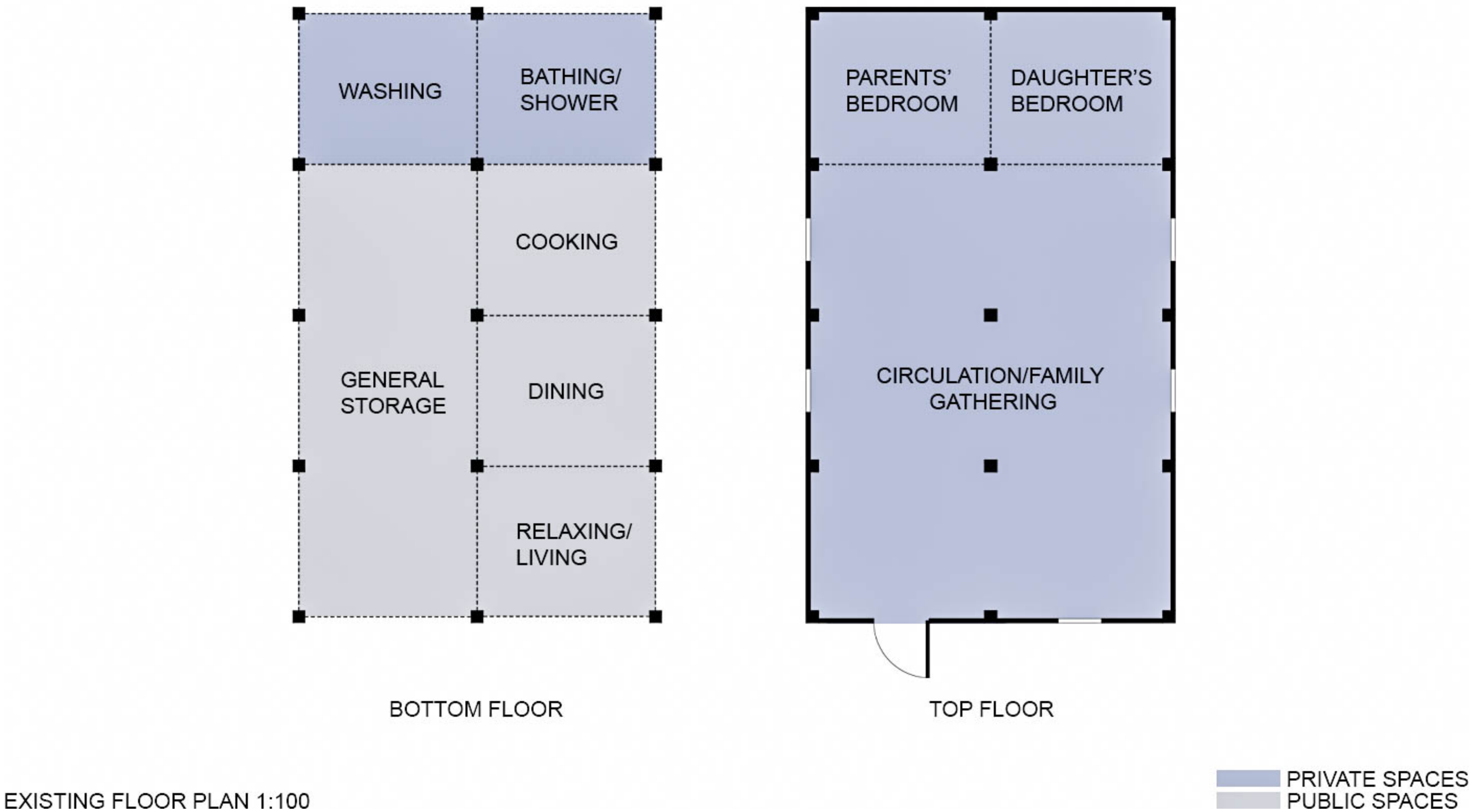


Figure 18. Existing floor plans of chosen site.

PLAN

Stilt houses generally have an open plan on both floors that is divided into square grids (column layout). The ground floor is used as a public space where the cooking, dining and living areas are located. The top floor is a private area used for resting and sleeping. Traditionally, the top floor is divided into three rooms. The first room is for receiving visitors, the second room is for the parents, and the third room is for the unmarried daughter. The son generally sleeps anywhere he can find space (Australian Lutheran World Service).

Figure 19. Cooking area.

Figure 20. Living area.

Figure 21. Bathing area.

Figure 22. Sleeping area.

AREAS AND COMPONENTS OF THE HOUSE

This section provides an overview of the different areas of a traditional dwelling during most of the year outside the wet season.

KITCHEN

The kitchen is located towards the back of the house on the ground floor. It is downstairs because the bottom floor is not enclosed by walls, which allows for good ventilation. The main tool for cooking is a portable clay stove that uses charcoal as fuel.

LIVING

The living space can be found towards the front of the house on the ground floor. This is because in hot weather the top floor acts as a sun shade for this area, allowing cool air to pass through and creating a positive and comfortable space to live in.

BATHING

The bathing area is located on the ground floor. It is an area with a large concrete vessel that collects and stores water. Water from this vessel is used for all types of washing. The toilet is located a short distance away from the house; it is a small facility in the traditional 'long-drop' style.

SLEEPING

The sleeping areas and bedrooms are separated by hanging textiles or insect nets to allow for privacy and in each room people sleep on woven mats made of grass.

FURNITURE

It should be noted that traditional houses rarely contain furniture. However, one essential piece of furniture that can be found in all houses is a low wooden bed (refer to Figures 23 and 24). This platform has multiple functions as it is used for sleeping, sitting and daily chores – while the woven mats are used only for sleeping. It leads to a simple way of living that many Cambodians prefer and can afford (Australian Lutheran World Service).

Figure 23. A wooden bed, a traditional item of furniture seen in most Cambodian houses.

Figure 24. The wooden bed is for multi-purpose use.

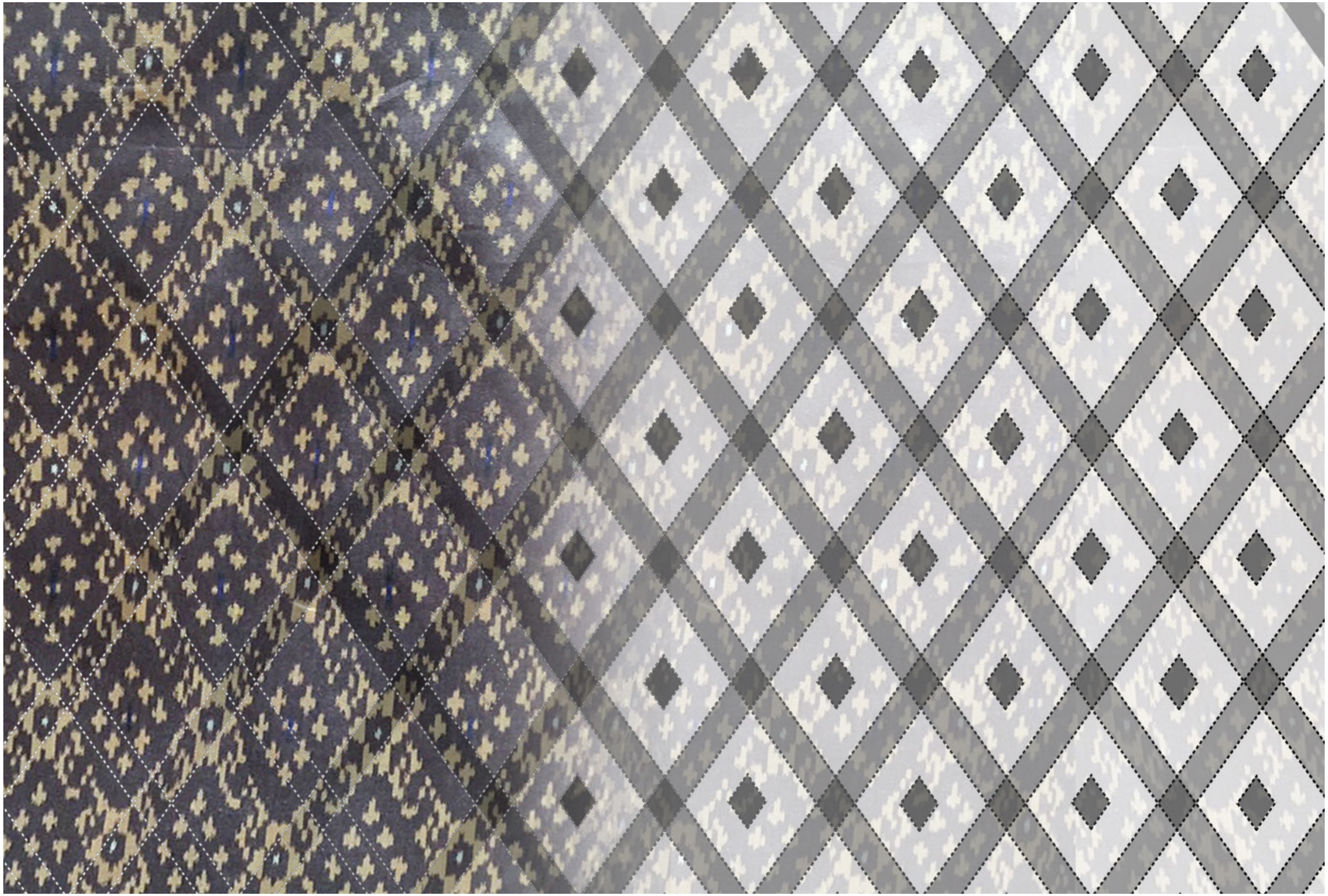


Figure 25. Hol pattern.

2.2 TRADITION

In this section the traditional textile pattern, forms, architectural features and materials that have relevance to domestic dwellings are presented and discussed.

PATTERN

The Cambodian ‘hol’ traditional textile is a patterned silk that represents the cultural heritage. Hol can be seen in a five different colours: red, black, yellow, green and blue. The motifs woven into hol textiles are recurring patterns that reflect the artistic culture of the country since the Khmer Empire period. This fabric is worn by men and women for traditional ceremonies and weddings; for women as skirts and for men as long-sleeved shirts (Sor et al., 10).

ARCHITECTURAL FEATURES AND MATERIALS

WATER STORAGE

The traditional Cambodian water storage system involves a concrete tank that collects and stores water for multiple purposes, including bathing and daily chores. It is located towards the side or back of the house on the ground floor. In the rainy season it collects rain water with a filter that keeps out silt; however, in the dry season family members must go to the nearest well to collect water to replenish the tank.

WINDOWS

Cambodian windows are made up of three different layers of glass, steel and mesh, although single glass layers are becoming more commonplace in modern-day houses. Each layer serves a functional purpose in the house.

- Glass: controls heat, noise and dust.
- Steel: protects the family from danger.
- Mesh: keeps insects away.

Figure 26. Cambodian artisan creating art.

CARVINGS

Carvings and engravings are common in Cambodian architecture. The carvings may include gods, nagas, bas relief, apsaras and abstract motifs and represent Cambodian mythology. They can be found in Angkor Wat, the world-famous collection of stone temples from the Khmer Empire period, and in pagodas throughout the country (Ray). Carvings depicting God are more common in modern-day architecture as these are worshipped by people in annual traditional Cambodian ceremonies.

FENG SHUI

Feng Shui is a Chinese philosophical system that was adopted into Cambodian traditions. The system is a form of art that allows people to live in harmony with their surrounding environments. It is believed to bring out positive energies, opportunities, happiness, abundance and contentment (Smith, 59). In relation to architecture, Cambodian people design and decorate according to the Feng Shui system. Common Feng Shui seen in Cambodian homes are in the entrance, space layout, spirit house, furniture arrangement and colour selections, as presented by Yim, Sforza and Smith.

- Access: the entrance of the house should be facing either north or south (Yim).
- Space: sleeping spaces should not be level with the floor and kitchen spaces should be at the back the house (Yim).
- Spirit house: the spirit house should be located on the wall directly opposite the entrance (Yim).
- Furniture: bed heads should be on the wall furthest from the entrance of bedrooms and should not share walls with toilets (Sforza). They should align in one direction, allowing space on either side.
- Colours: red for luck, yellow for power, pink for happiness and green for positivity (Smith, 61).

BAMBOO

Bamboo is a traditional building material and one of the most common natural resources in Cambodia. Because of Cambodia's tropical climate, bamboo grows rapidly in 18 provinces, including Kampong Cham (Meng). There are 10 species from four different groups of bamboo. The four groups are: *Bambusa*, *Arundinaria*, *Dendrocalamus* and *Oxytenanthera*. However, according to Monyrak Meng, the Deputy Director of International Conventions and Biodiversity in the General Department of the Ministry of Environment, Cambodia, only five of the 10 species are used for construction (Meng):

- *Bambusa bambos*: Rusey Khley
- *Bambusa burmanica*: Rusey Srok Chin
- *Bambusa flexuosa*: Rusey Srok
- *Bambusa vulgaris*: Rusey Koa
- *Oxytenanthera densa*: Rusey Ping Pong

Figure 27. Sandstone/stone.

Figure 28. Silk.

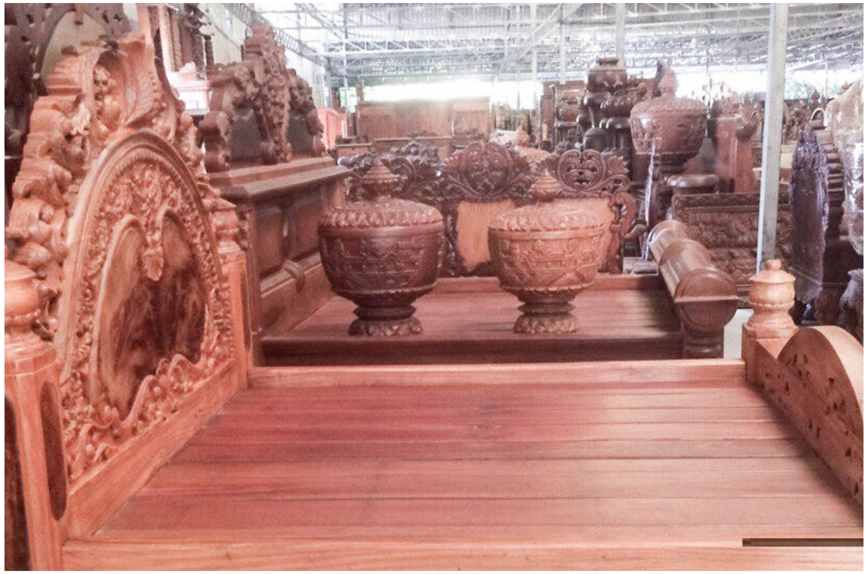


Figure 29. Wood.

SANDSTONE/STONE

Sandstone is a very traditional material in Cambodia due to the soil being rich in sandstone. More than 300 stone temples were built between the 9th and 13th centuries. After the 13th century sandstone use slowly decreased – even more in recent times when many artisans were killed during the Khmer Rouge regime. The use of sandstone and stone has only begun to rise in the last decade or so (The Tradition of Stone Carving in Cambodia).

SILK

Silk is a traditional textile handmade by artisans in silk farms around Cambodia. It is made from *Bombyx mori*, a species of moth, and can be made into bed sets, clothing and decorations. As mentioned earlier, silk is worn by both men and women in traditional ceremonies and the recurring pattern represents the Cambodian culture.

WOOD

Wood is a natural resource and a traditional building material in Cambodia. It is the main material used in the construction of traditional Cambodian houses and furniture (Wood Carvings). There has been a decrease in the amount of wood used in the construction of modern houses due to a high demand for concrete; however, wood is still used for furniture and interior decoration. In addition, Cambodia is well known for wood carving. Carvings can be seen in religious sculptures and adorned furniture.

CHAPTER 3: LITERATURE REVIEW

CASE1 I CASE 2 I CASE 3

Figure 30. Floating homes on Mekong river.

This literature review chapter analyses three projects that have been designed to adapt to flooding conditions in flood-prone countries like Vietnam and Bangladesh. Presented and discussed are the ‘Blooming Bamboo’ house, the ‘Lift’ house and flood-resistant villages in flood-prone areas of the country. This investigation determines what has been done by the designers and also highlights the successful and unsuccessful aspects of each project. The observations identify gaps in the previous designs, thereby giving this research project insight and opportunity for development.

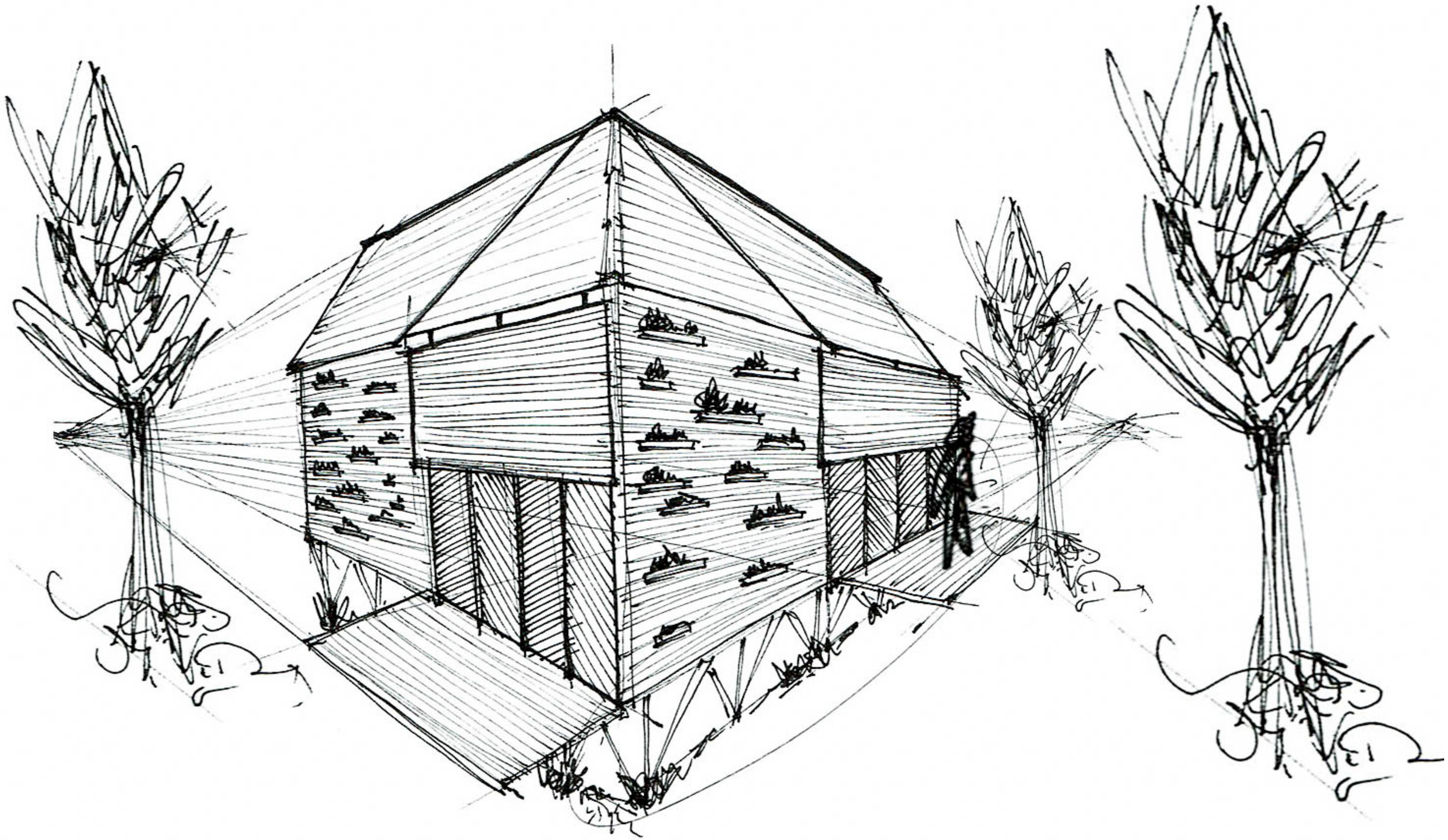


Figure 31. Sketch of Blooming Bamboo house.

3.1 CASE 1

BLOOMING BAMBOO HOUSE

The Blooming Bamboo house is a project by H&P Architects in Hanoi, Vietnam, built to withstand floods of up to three metres high. H&P Architects designed this house to help people who struggle with annual flooding in flood-prone areas, with the house based on the idea of amphibious architecture applied in a cost-efficient manner (Davis).

The amphibious system used on the Blooming Bamboo house has meant lifestyle changes for Vietnamese people living in flood-prone areas. According to designers Kunlé Adeyemi and Richard Coutts, the system allows floodwater to become a feature in the design of the house; flooding comes and goes because climate change is unpredictable and going against water pressure would only do more harm than good.

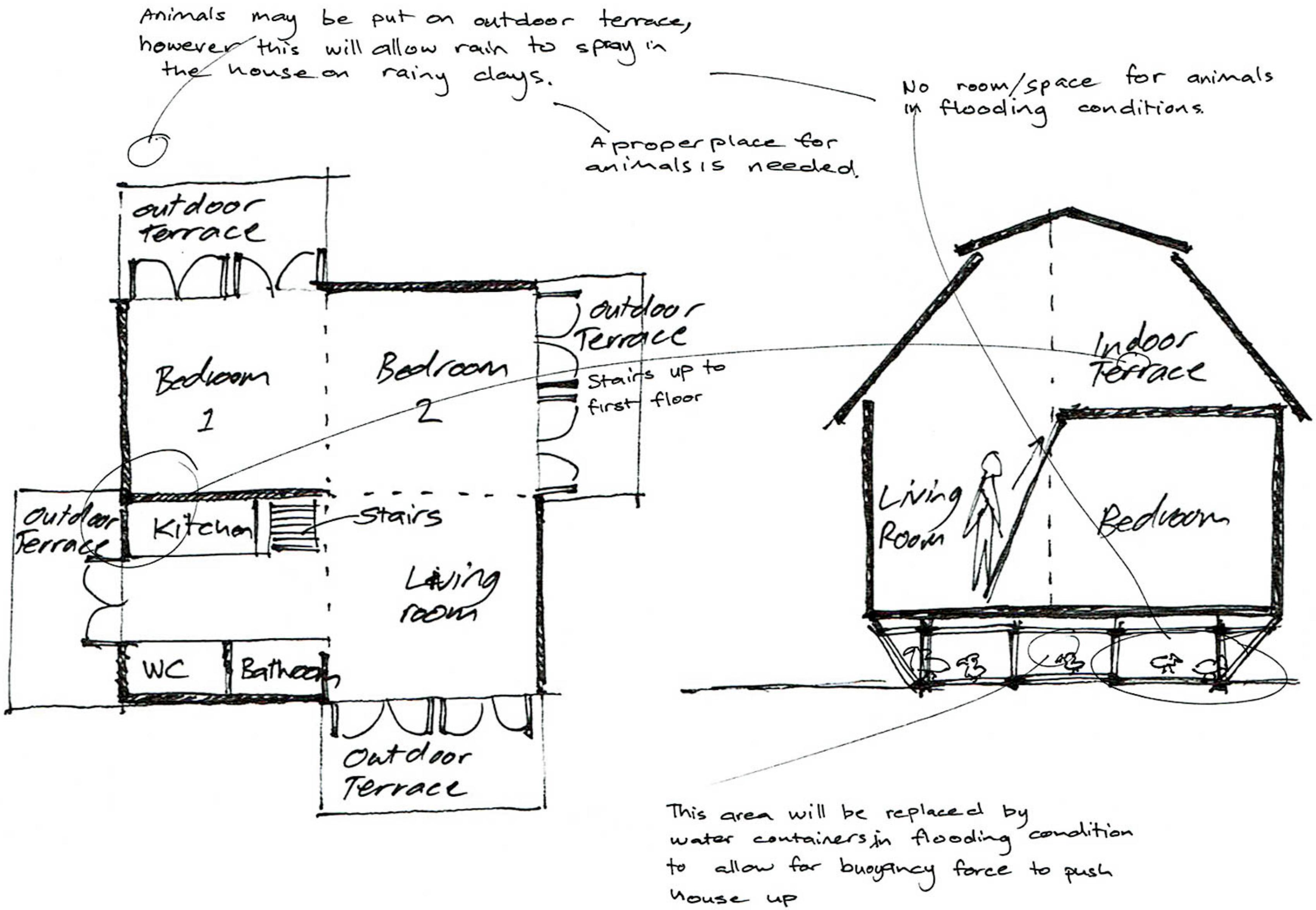


Figure 32. Analysing the Blooming Bamboo house.

Nigerian architect Kunlé Adeyemi encourages designers to see floods as good opportunities for potentially adaptable designs, rather than disasters, and says, “Given the impact of climate change, we can begin to think a lot more about the opportunity for living with water, as opposed to fighting it and doing land reclamation" (Mairs).

Richard Coutts, architect and creator of the LifE (Long-term Initiatives for Flood-risk Environments) Project, agrees with Adeyemi, believing that designers should adapt floodwater as a design feature. Coutts says, "Rather than building flood defences, the LifE Project considers a different approach, to acknowledge man cannot beat nature and to actually make space for water" (Winston).

However, in flooding situations, this design fails to consider an aspect of key importance to the inhabitants of the house: the space for breeding animals and growing plants beneath the house is replaced with recycled oil tanks, raising concerns around shelter for animals and food production during a flood.

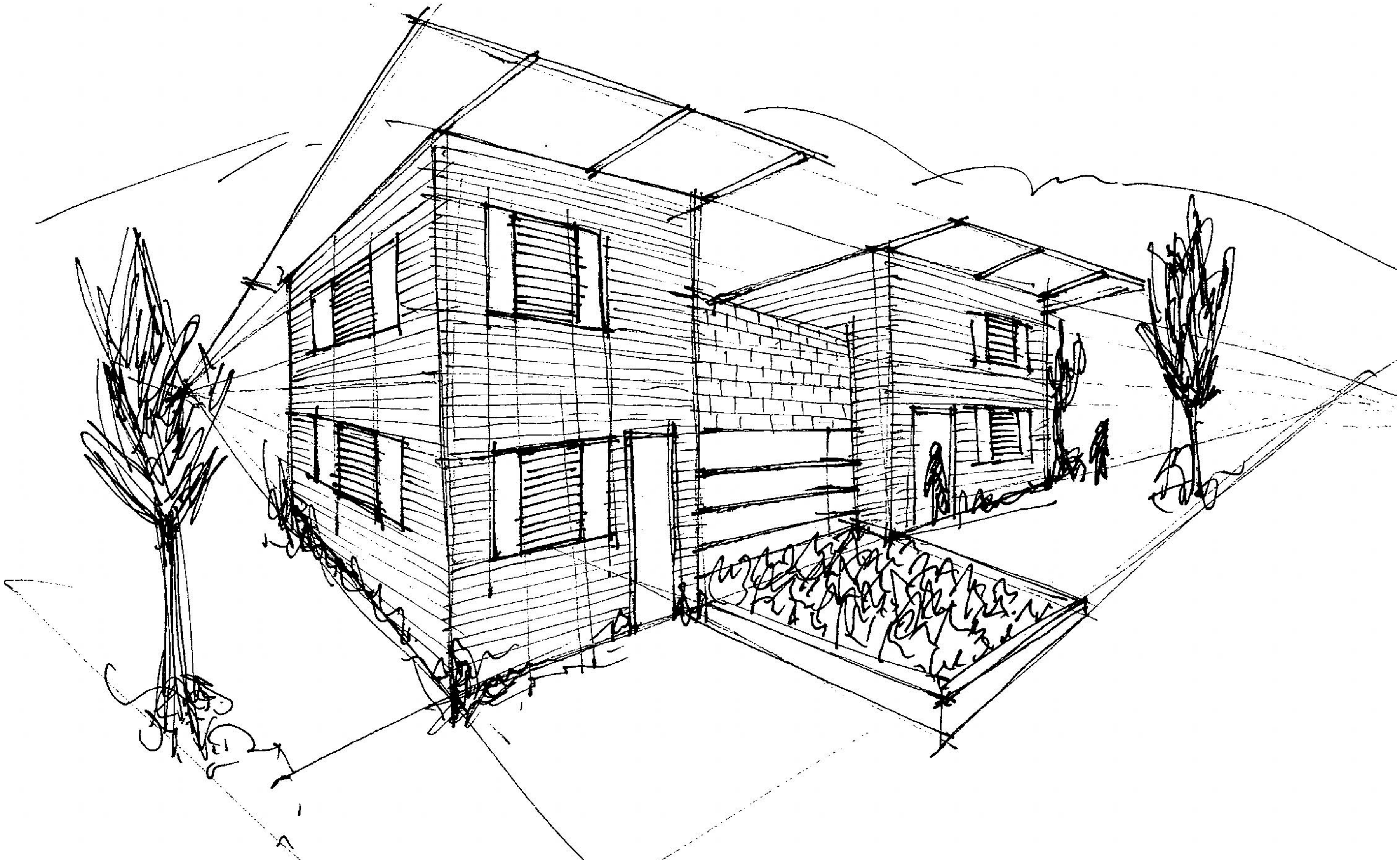


Figure 33. Sketch of Lift house.

3.2 CASE 2

LIFT HOUSE

The Lift house is a flood-resistant project by Prithula Prosun to help people in Dhaka, Bangladesh, who are affected by heavy flooding every year. The project involves a sustainable bamboo shelter built around a brick core. During heavy flooding the bamboo structure rises and settles back onto the ground only when waters recede. Prosun has kept the cost of this amphibious system under $10,000 by focusing on indigenous materials and local skills (Prosun).

Because bamboo is so light, it is a perfect material for amphibious systems because it requires less buoyancy force to keep it up. The material's selection is important for structural stability in construction.

Materiality is what defines the form and structure of architecture. Hungarian architectural professor Peter Gaborjani says, "The means of expression of architecture is the material". He adds, "Until the material has taken its definitive place, the architect may have an influence on its forms of being built in" (Gaborjani, 1).

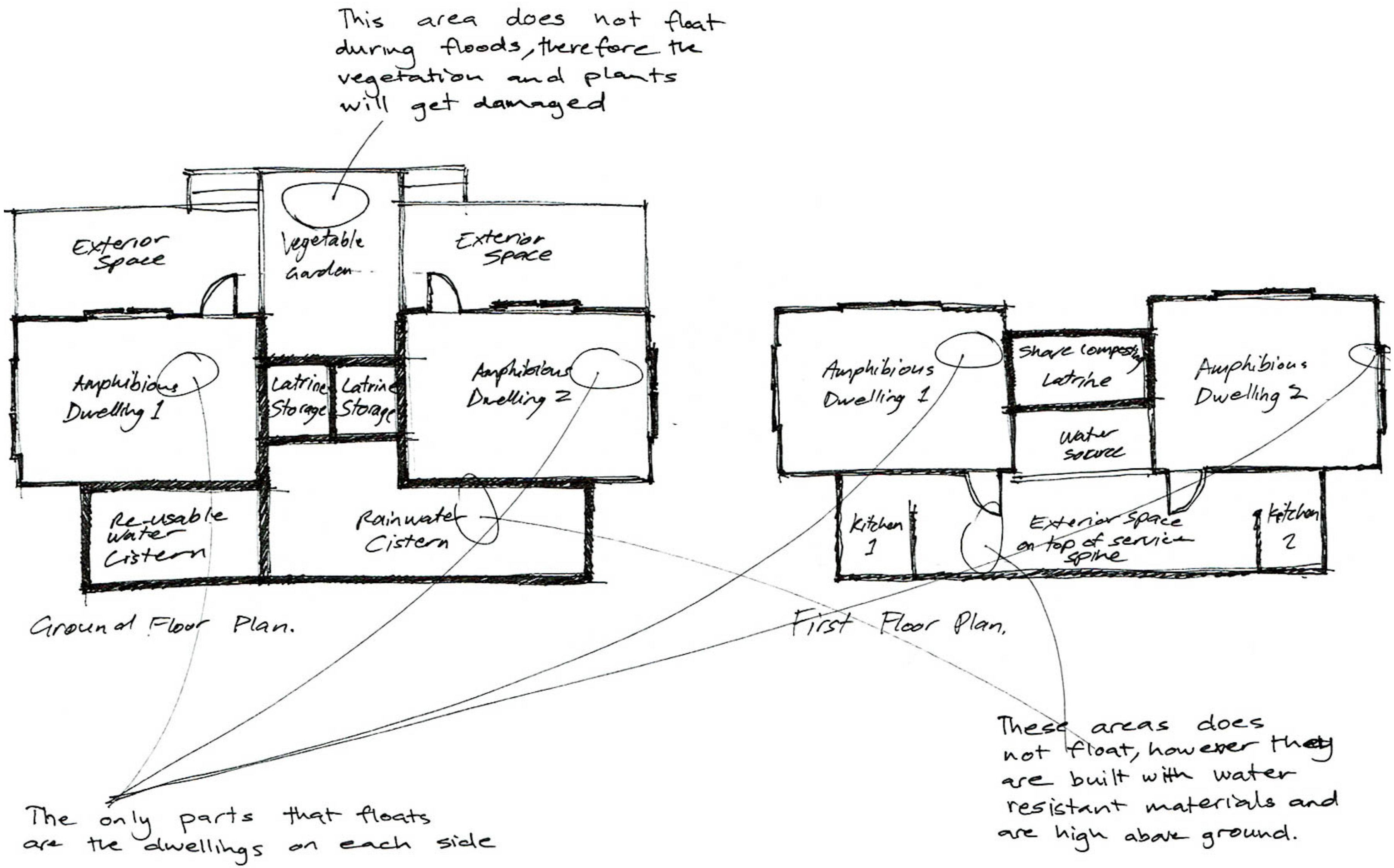


Figure 34. Analysing the Lift house.

According to Dirk Hebel, a professor at the Swiss Federal Institute of Technology in Zurich, bamboo could revolutionise the building industry, replacing steel as a reinforcing material. He says, “Bamboo is a rapid-growing, affordable and available natural resource in many developing countries. It is potentially superior to timber and to construction steel in terms of its weight to strength ratio” (Hebel et al., 110). In his research, Hebel mixed organic resin with natural bamboo fibre, which resulted in a better tensile capacity than steel. He adds, “Our material is only a quarter of the weight of steel. In terms of strength to weight, it performs better than steel” (quoted in Fairs).

Vietnamese architect Vo Trong Nghia also believes that bamboo is the future of building materials, saying, “Bamboo will replace other materials and become the green steel of the 21st century” (quoted in Russel et al., 23). He adds, “I hope many architects realise the potential of the material and build with bamboo more and more” (quoted in Fairs, ‘Bamboo will Replace Other Materials in Architecture’).

However, one issue with the design is that the garden area is not supported by an amphibious system. With no amphibious system in place, the vegetation will be washed out by the flood, raising concerns that in high-flood conditions the vegetation will be damaged, leading to a decrease in income and food.

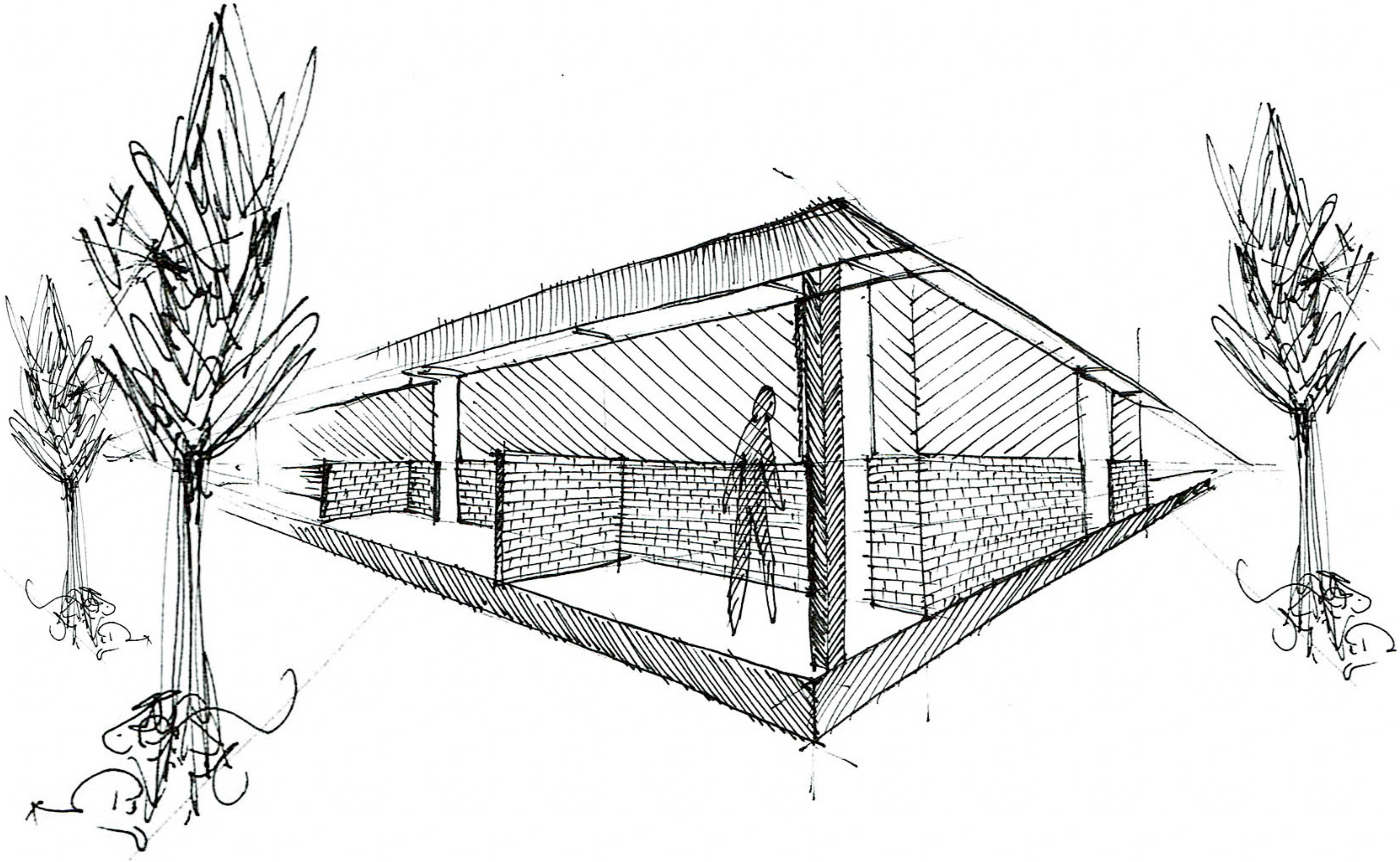


Figure 35. Sketch of flood-resistant village housing.

3.3 CASE 3

FLOOD-RESISTANT VILLAGE HOUSING

Due to recurring damage every year caused by flooding, ‘Practical Action’ a non-governmental organisation (NGO) has worked with communities to develop affordable flood-resistant housing. This housing allows people to stay safe in flooding situations and the organisation has supplied materials and design techniques to help overcome the damage. Its aim is to prevent families having to rebuild their houses after every monsoon season, while keeping the cost of production to a minimum (Noble et al., 1).

Design features include:

- brick walls: increased resilience
- concrete footings: strengthened structure
- corrugated iron roofs: reduced maintenance cost.

The pallet of materials for flood-resistant housing involves a variety of water-resistant and solar heat reduction qualities.

Bricks provide many benefits in construction. Architect Caren Yglesias says, “Builders use bricks because they are inexpensive, strong, durable, fireproof and water resistant” (Yglesias, 49). These qualities make brick an ideal material to use, not just in flooding conditions but in any disaster conditions.

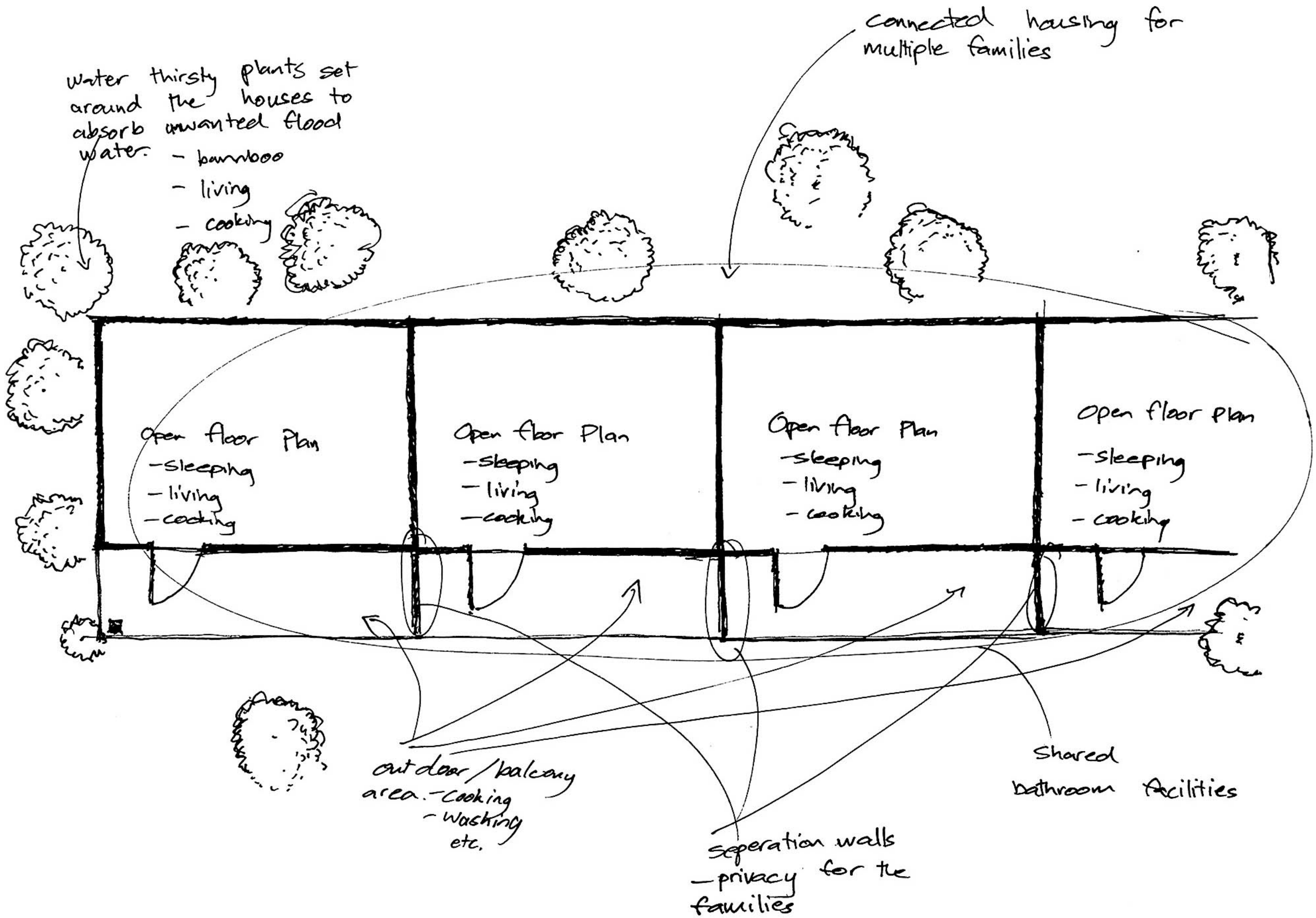


Figure 36. Analysis of flood-resistant village housing.

Concrete is a porous material, but the pores are so small that it takes a long time for water to seep through. Engineer Claude Goguen says, "It would take water approximately 4,800 years to travel through a six-inch concrete wall if the concrete is of good quality" (Goguen). Goguen also discusses other ways of making concrete more watertight. These include aggregates, SCM (supplementary concrete materials), admixtures, consolidations, sealers, penetrants and coatings.

Corrugated iron sheeting is a low-cost and lightweight roofing system that is durable. Light-reflective colours absorb less heat, reducing solar heating. Author Richard Hyde says, "A reflective surface reduces solar heating. A dark surface can increase the internal temperature to 30°C above the external temperature" (Hyde, 141). In hot climates like Bangladesh, light-reflective coloured iron sheets are beneficial because they keep water and heat out.

A combination of these low-cost materials allows many families to afford a better living environment. However, the footings do not have gaps for flood water to pass through, leading to an increase in lateral force against them. Additionally, the footings are very low to the ground, raising concerns in high-flood conditions.

From the cases studied, I have learnt that the amphibious system is a very important design feature for flood-resistant architecture. The choice of material is also important because some perform better than others in water. However, learning from the unsuccessful aspects will enable this research project to develop further. The main concerns are animal shelter and potential damage in high-flood conditions. This research project will investigate alternatives to overcome these issues.

CHAPTER 4: METHODOLOGY

FIELD STUDY AND SITE VISIT I MATERIAL STUDY

Figure 37. Flying to Cambodia for the field trip.

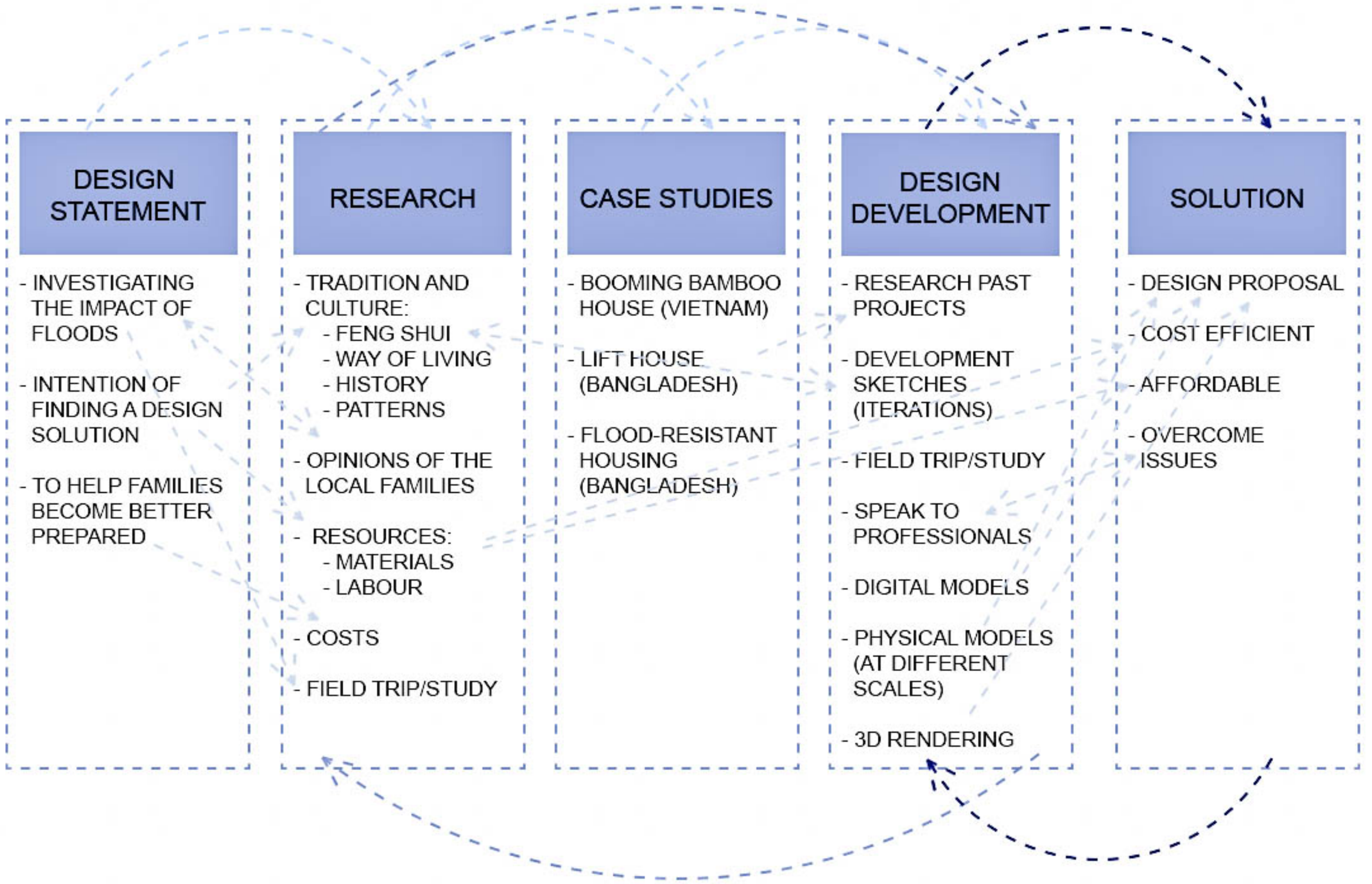


Figure 38. The methodology stages showing some of the methods used.

This chapter presents the methodology for this research and outlines the methods and approaches undertaken throughout the project to reach the design intervention. As can be seen in Figure 38, a field study, traditional/cutural study and a material study were undertaken at the beginning of the project. This allowed for qualitative and quantitative data to be gathered in order to understand the problem and have a baseline of knowledge to approach the design phase.

The design phase consisted of concept and idea generation, concept development, and documentation of the final concept. An iterative process was undertaken using various methods that included sketching, quick and simple model-making, physical and computer scale models, mock-up rigs and prototyping.

Figure 39. Road trip from Phnom Penh city to Kampong Cham province.

4.1 FIELD STUDY AND SITE VISIT

A field study of Tboung Khmum district was organised for April 2016. Prior to the visit, ethics approval was obtained and a questionnaire was prepared. Upon arrival, eight families (refer to Figure 40), selected for their interest in the project, were interviewed about their lifestyles and dwellings. Primary qualitative data was gathered and a summary is presented further in the research (refer to Appendices 1 and 2 for the ethics approval and questionnaire). While in the region (refer to Figure 12), quantitative data was gathered and research into locally available materials was undertaken to obtain an idea of what is available and an estimation of how much a project may cost to construct or repair.

Figure 40. Some of the families that were visited, pictured with the author. (Consent to publish these images was obtained.)

SUMMARY

The comments below are summarised from interviews with the participant families.

POSITIVES

- Safety and security is very good in the area in which they live.
- Very minimal damage compared with other houses in the area.
- Private boat for transportation during the wet season.
- Strong relationship with neighbours.
- Live in and belong to a friendly community.
- Stilts extend high above ground level and are made of concrete that can withstand floodwater.
- Live on higher ground so are less affected by annual flooding.

NEGATIVES

- Incomes decline due to the number of crops destroyed in the wet season.
- Not able to use all areas of their homes as the ground becomes flooded in the wet season.
- Roof leakage.
- Houses shake in strong flows of floodwater or wind conditions.
- Difficulties supporting family.
- Have to evacuate to live in pagodas in high flood coditions.

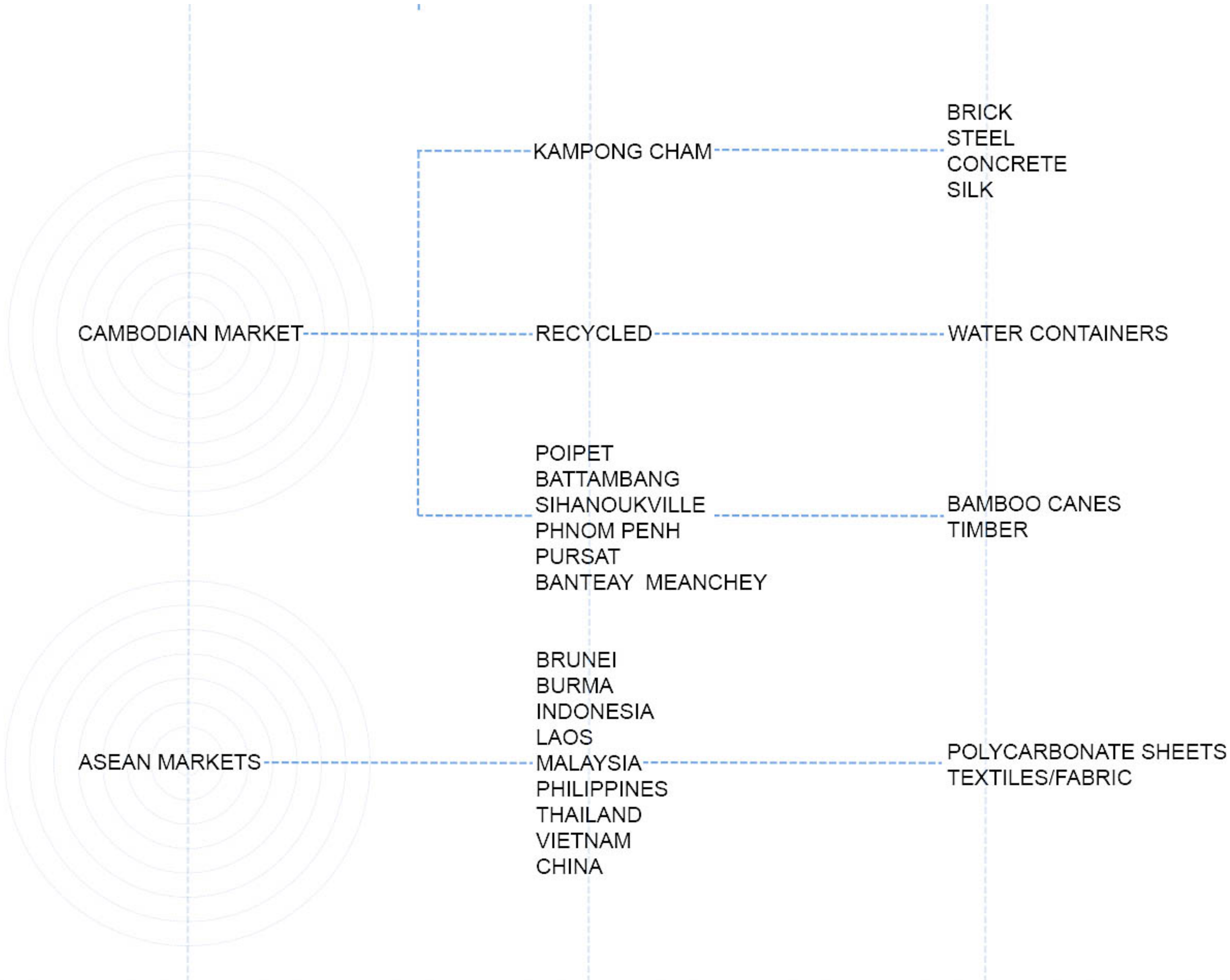


Figure 41. Material palette.

4.2 AVAILABLE MATERIALS

While in the region, a local material study was undertaken to obtain an idea of what is available and an estimation of how much the project may cost. Quantitative data was gathered.

The design concept will aim to involve locally sourced materials such as bamboo, timber, steel, silk, brick and recycled plastic water containers. Any internationally sourced materials, such as polycarbonate sheets, are imported from surrounding countries in the ASEAN community. As Cambodia is part of the ASEAN community, the AFTA (ASEAN Free Trade Area) applies and eliminate tariffs.

CHAPTER 5: DESIGN PHASE

DESIGN DEVELOPMENT I DESIGN BREAKDOWN I SYSTEMS I LIGHTING I VENTILATION

Figure 42. Local man preparing for the wet season.

The design phase presented in this section is divided into concept and idea generation, concept/ design development, and final concept documentation. It reviews the various design investigation methods used, such as hands-on sketching and modelling through to computer modelling and rendering of the final site. This version has been simplified to provide better understanding, with more advanced sketch and design information being presented in the appendices.

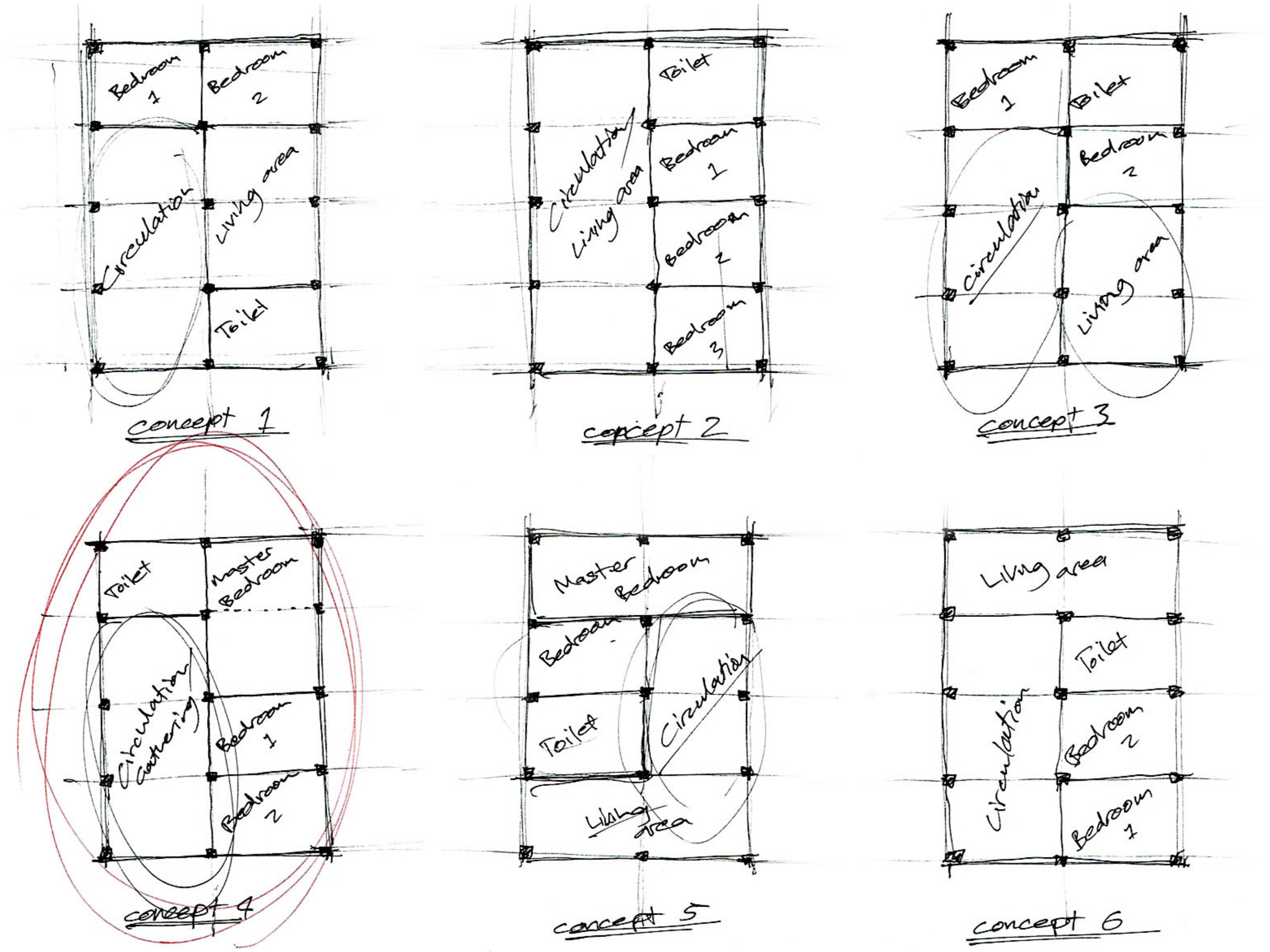


Figure 43. Concept plans.

5.1 CONCEPT IDEAS

Iterative sketches of the plan involving the placement of individual areas were made. This trial-and-error process (refer to Appendix 3 for early concept sketches) allowed me to experiment with different variations in order to find the most suitable outcome. The process combines the importance of Feng Shui and traditional and cultural beliefs to maintain the authenticity of the Cambodian culture. It also considers costs and materials in order to achieve a design concept that is affordable for families in the region and stays within the scope of this research.

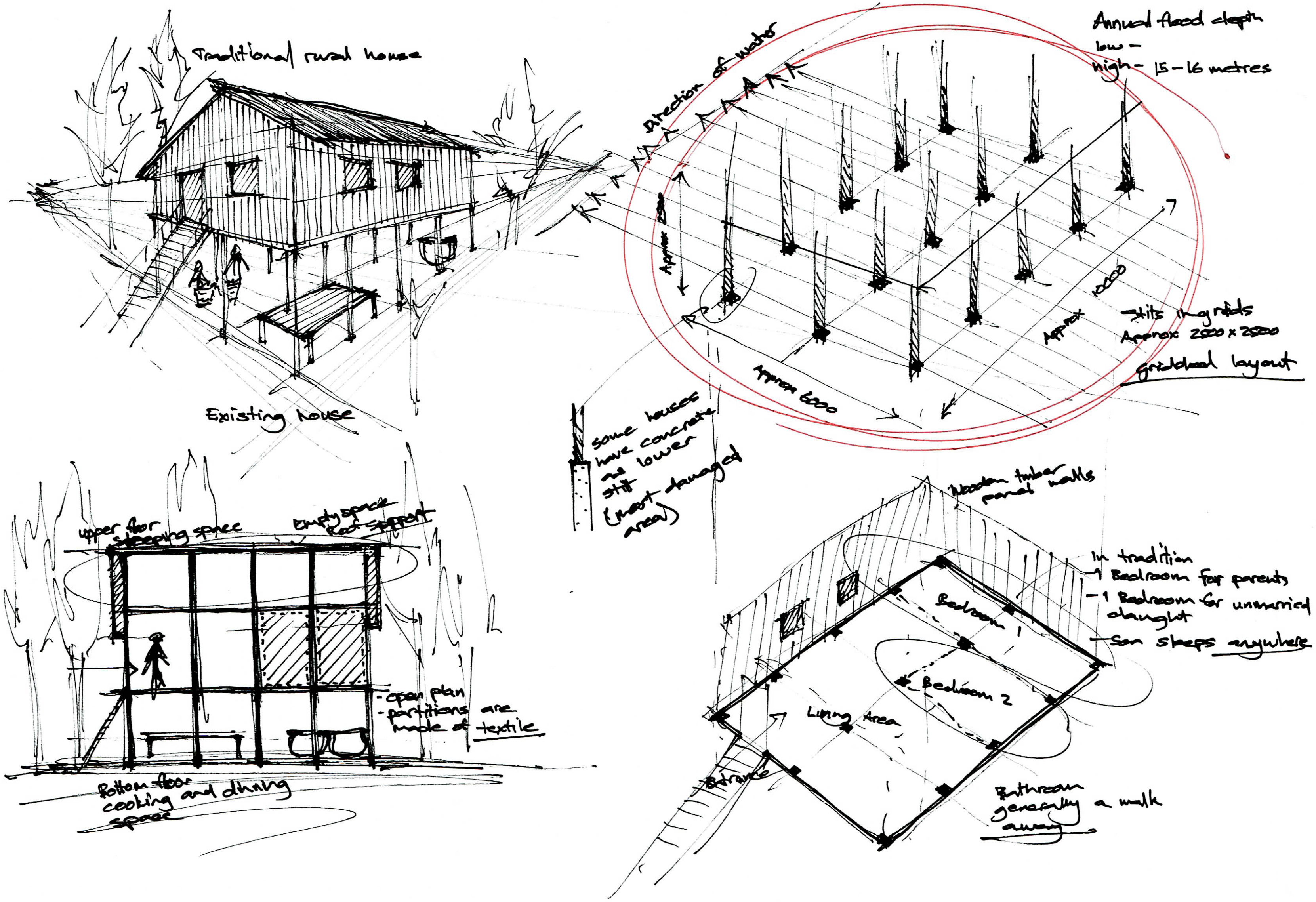


Figure 44. Design development sketch 1.

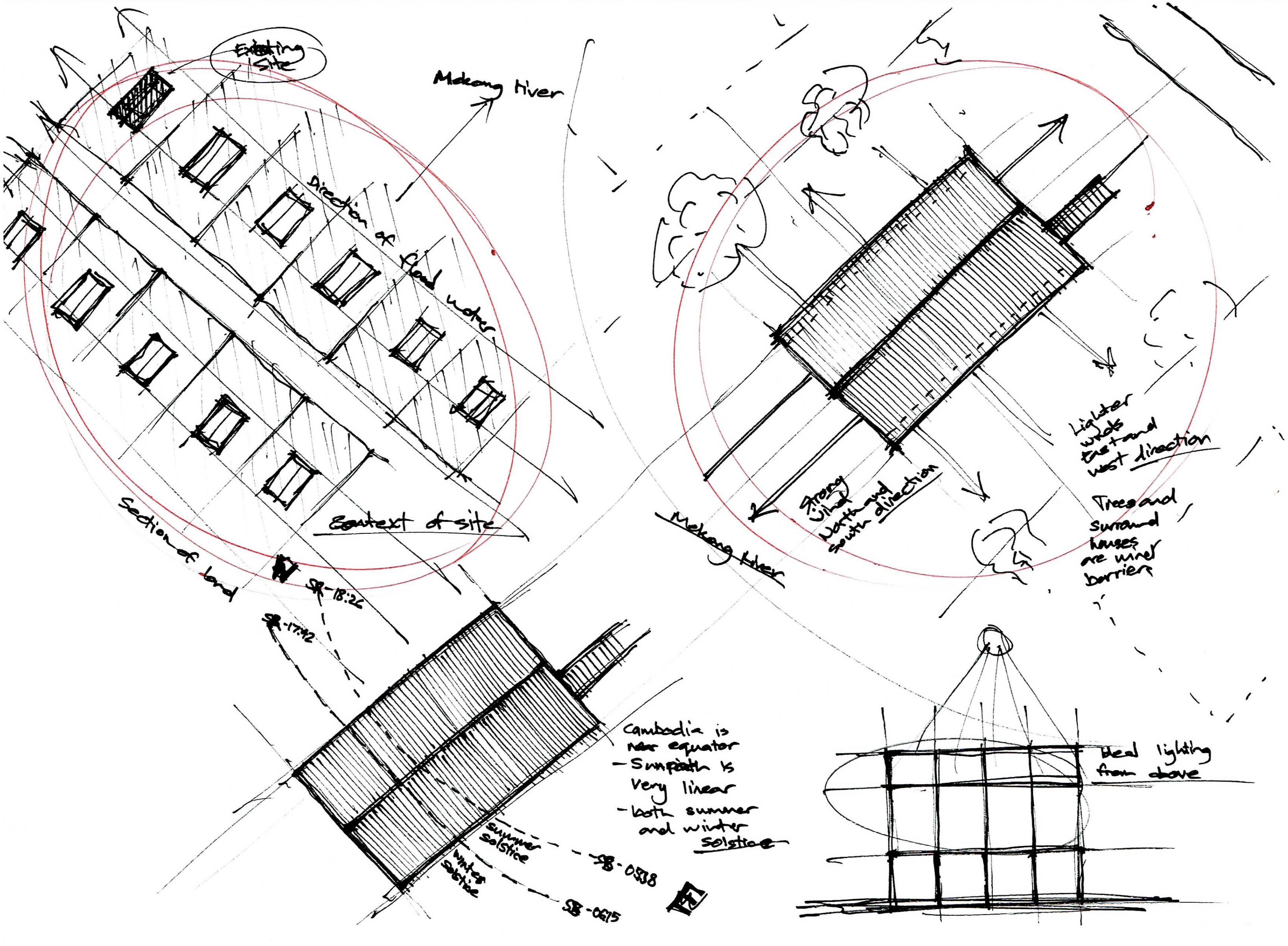


Figure 45. Design development sketch 2.

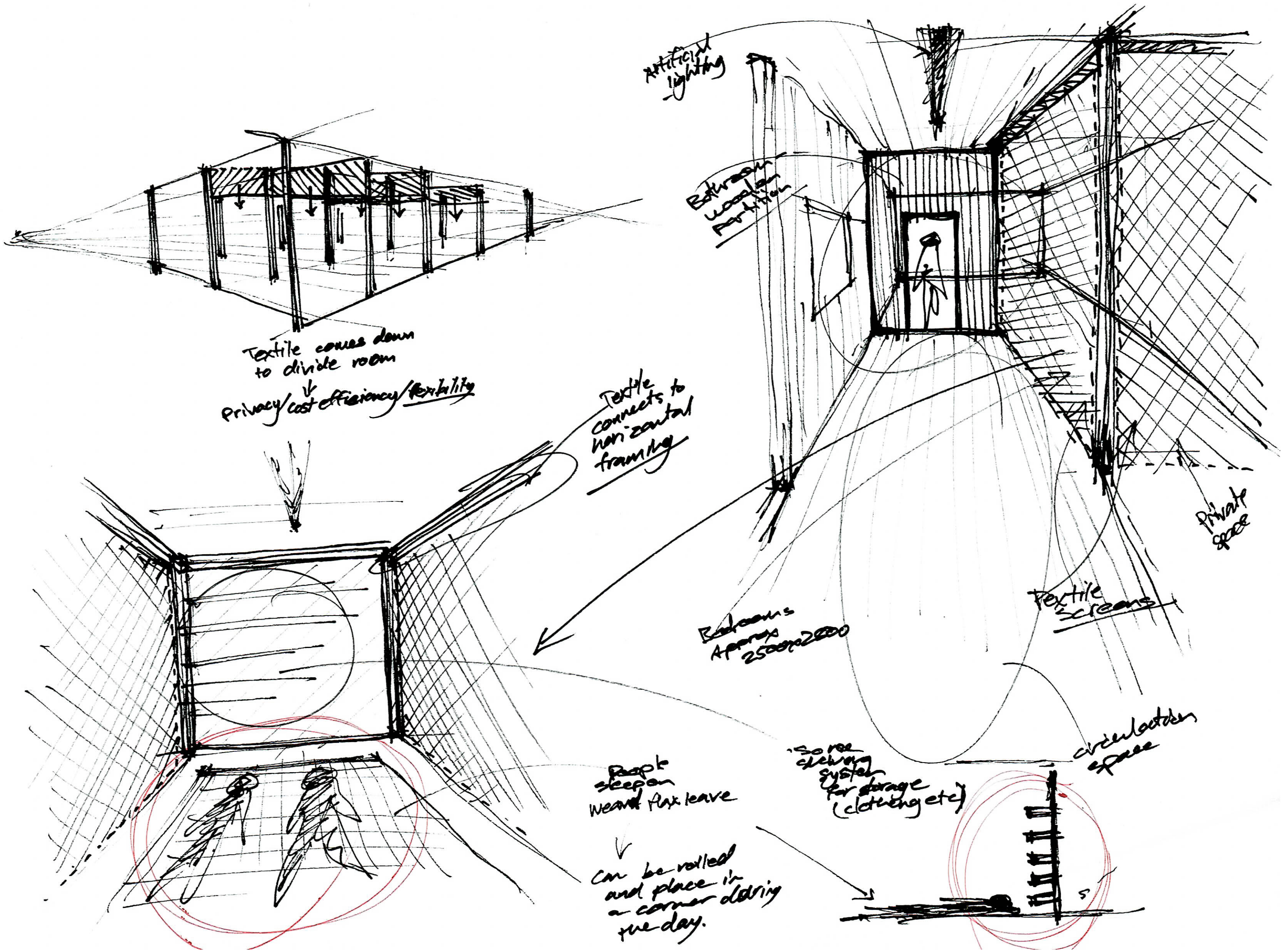


Figure 46. Design development sketch 3.

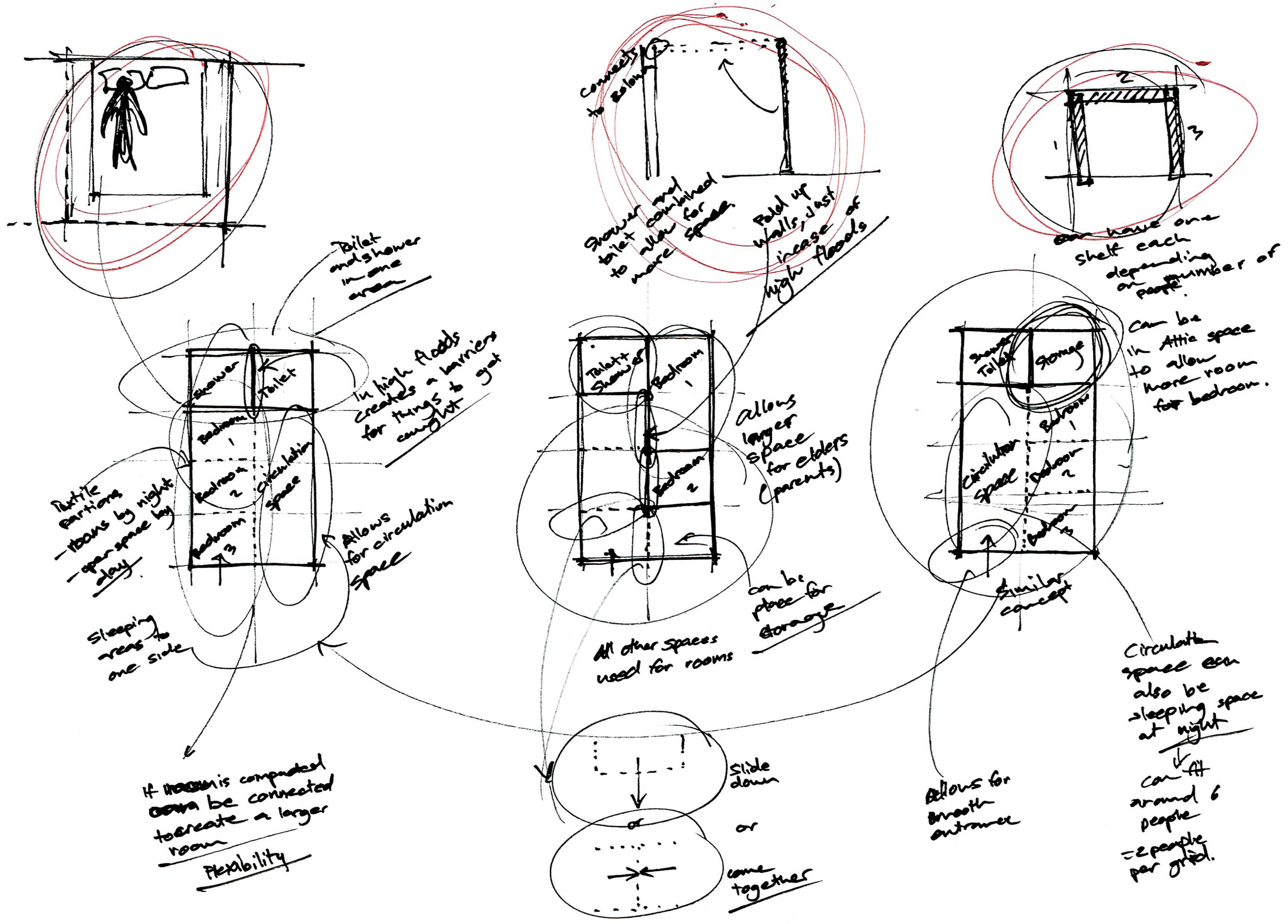


Figure 47. Design development sketch 4.

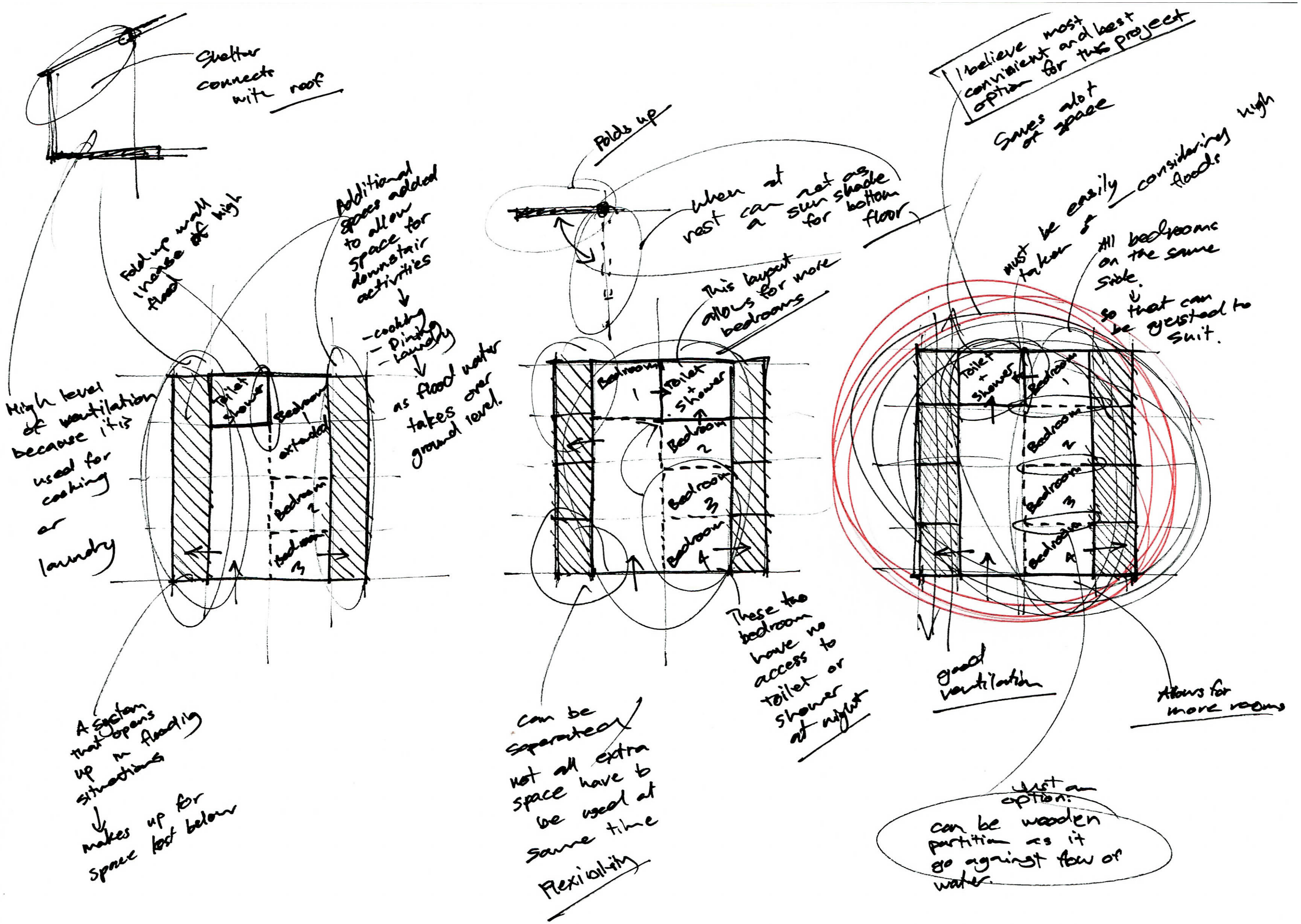


Figure 48. Design development sketch 5.

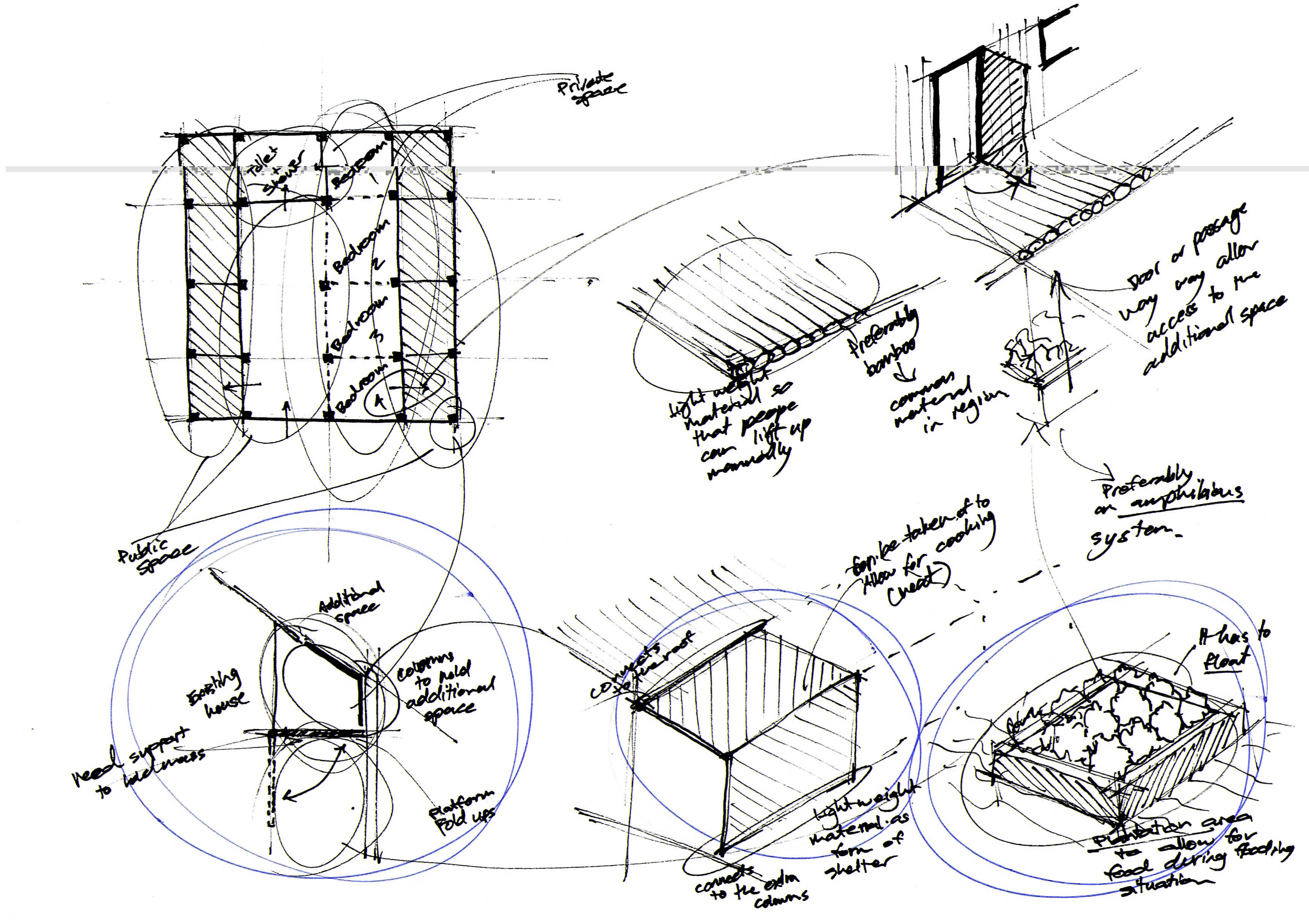


Figure 49. Design development sketch 6.

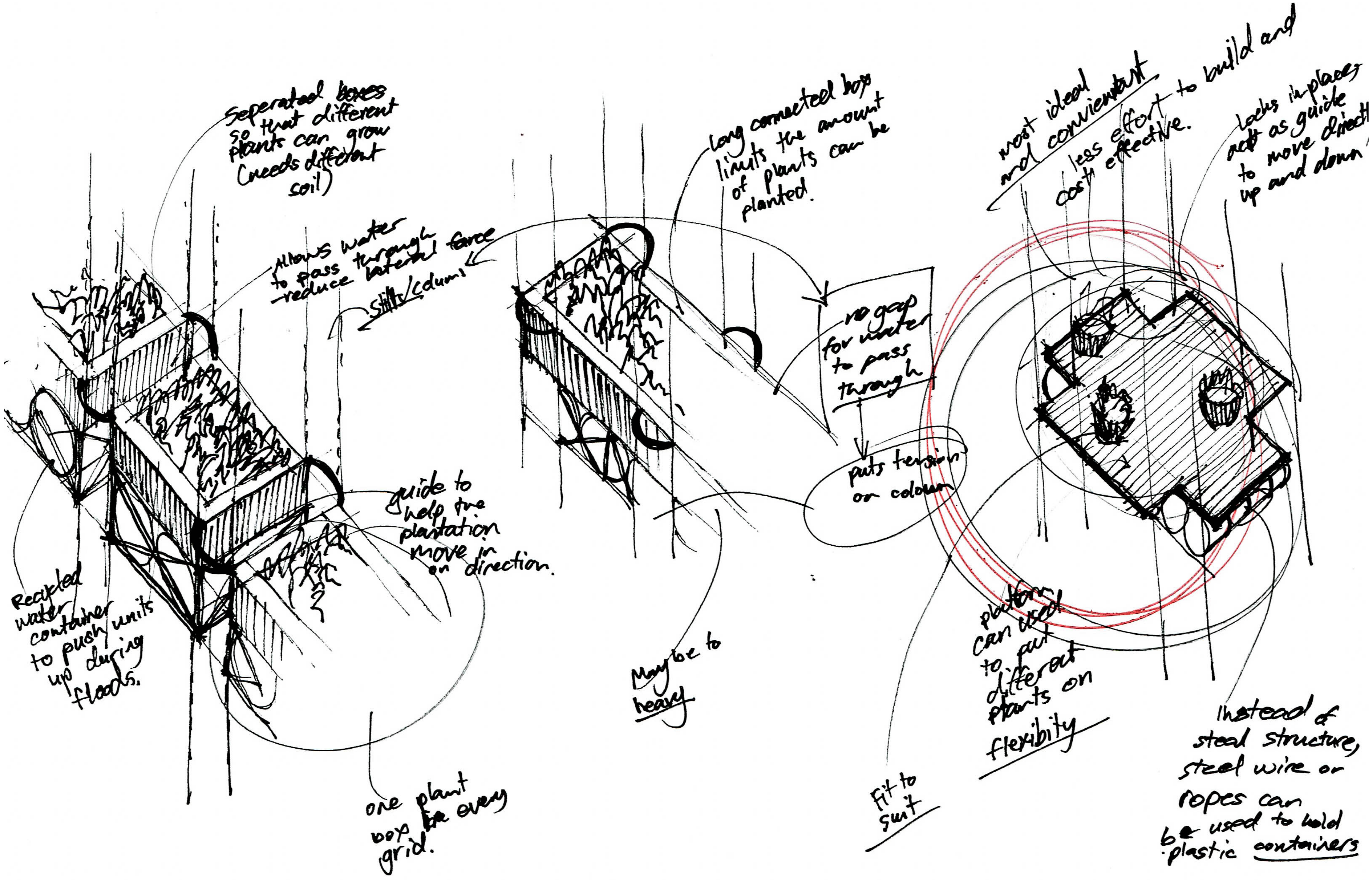


Figure 50. Design development sketch 7.

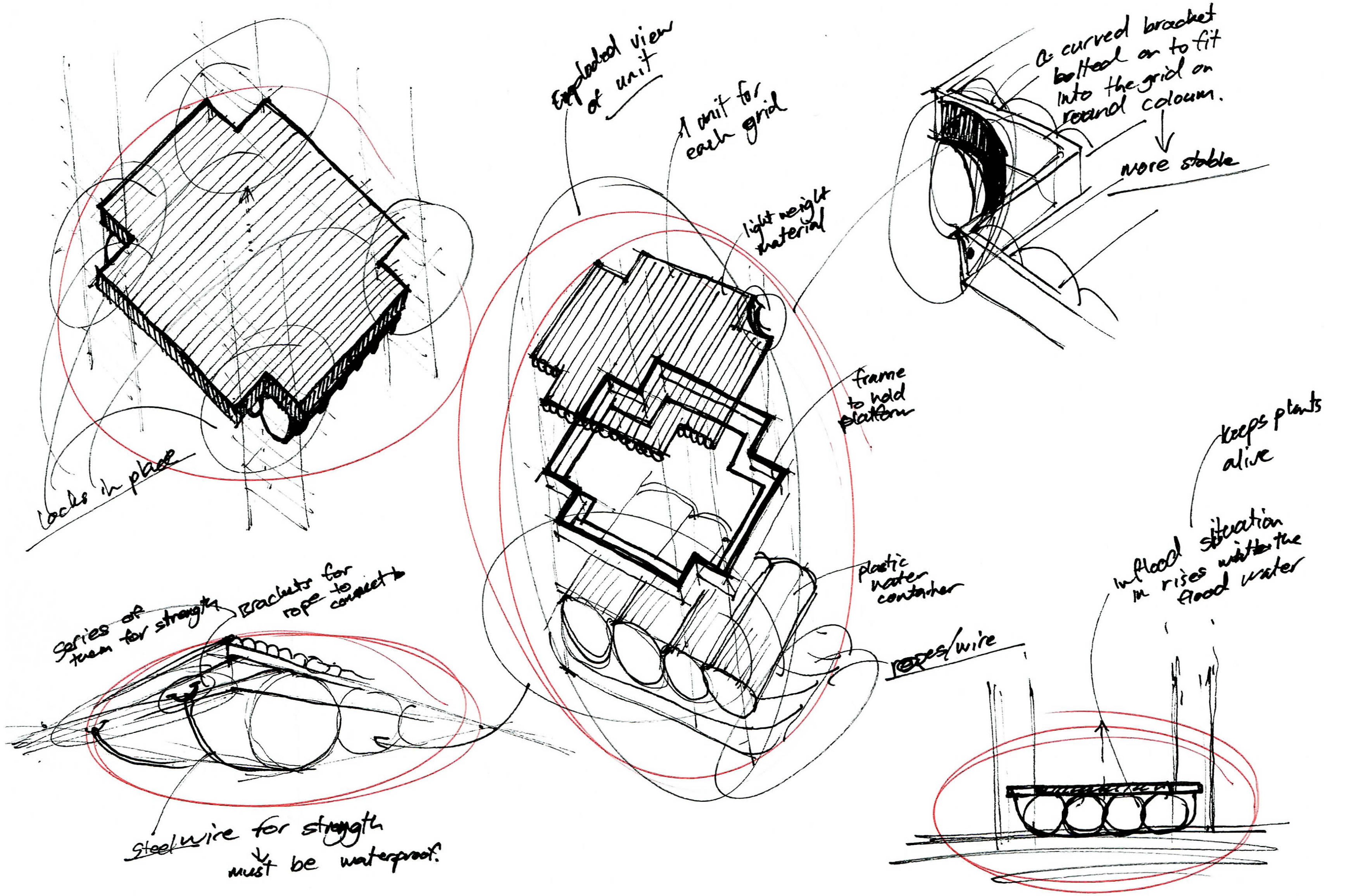


Figure 51. Design development sketch 8.

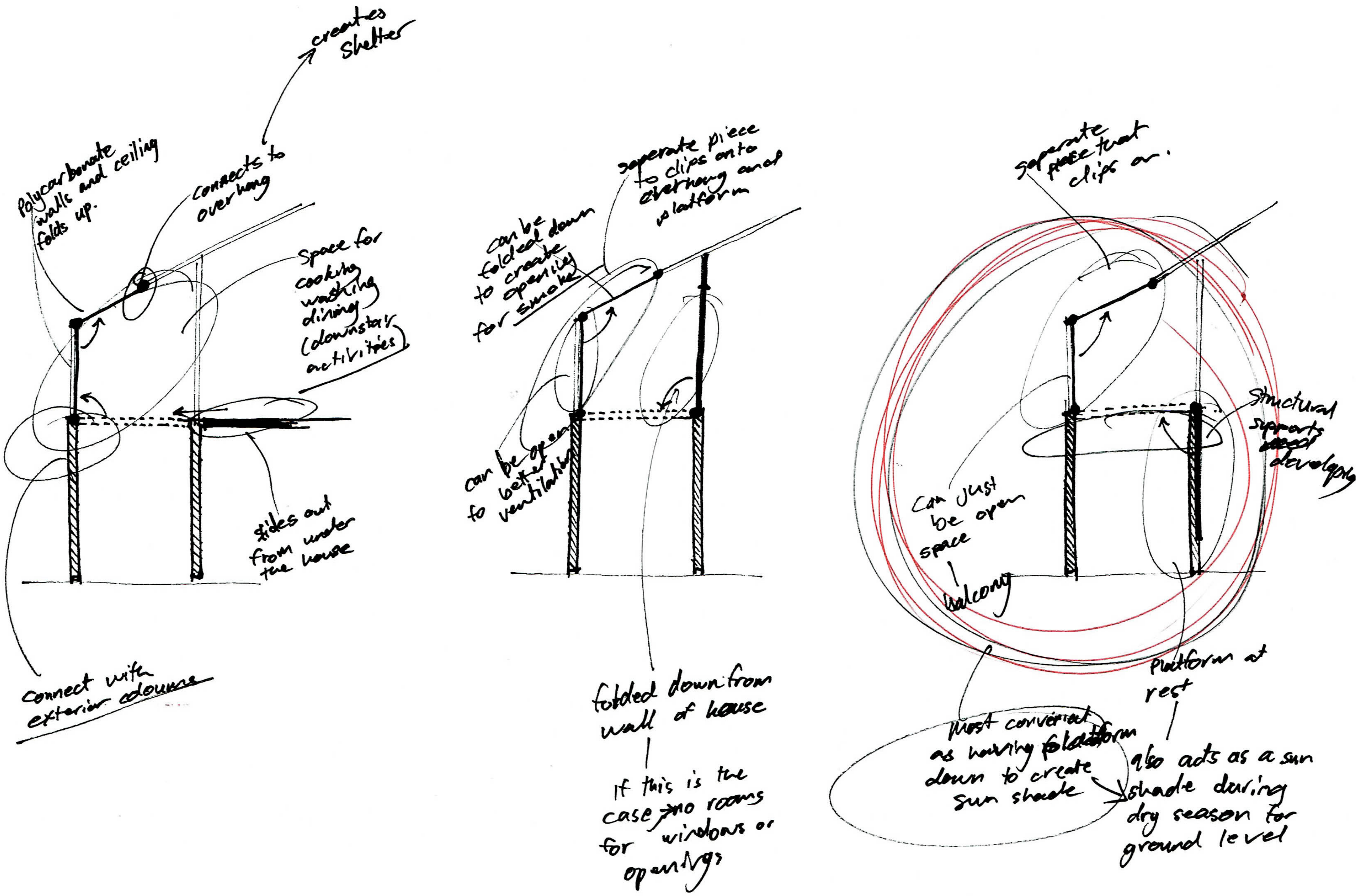


Figure 52. Design development sketch 9.

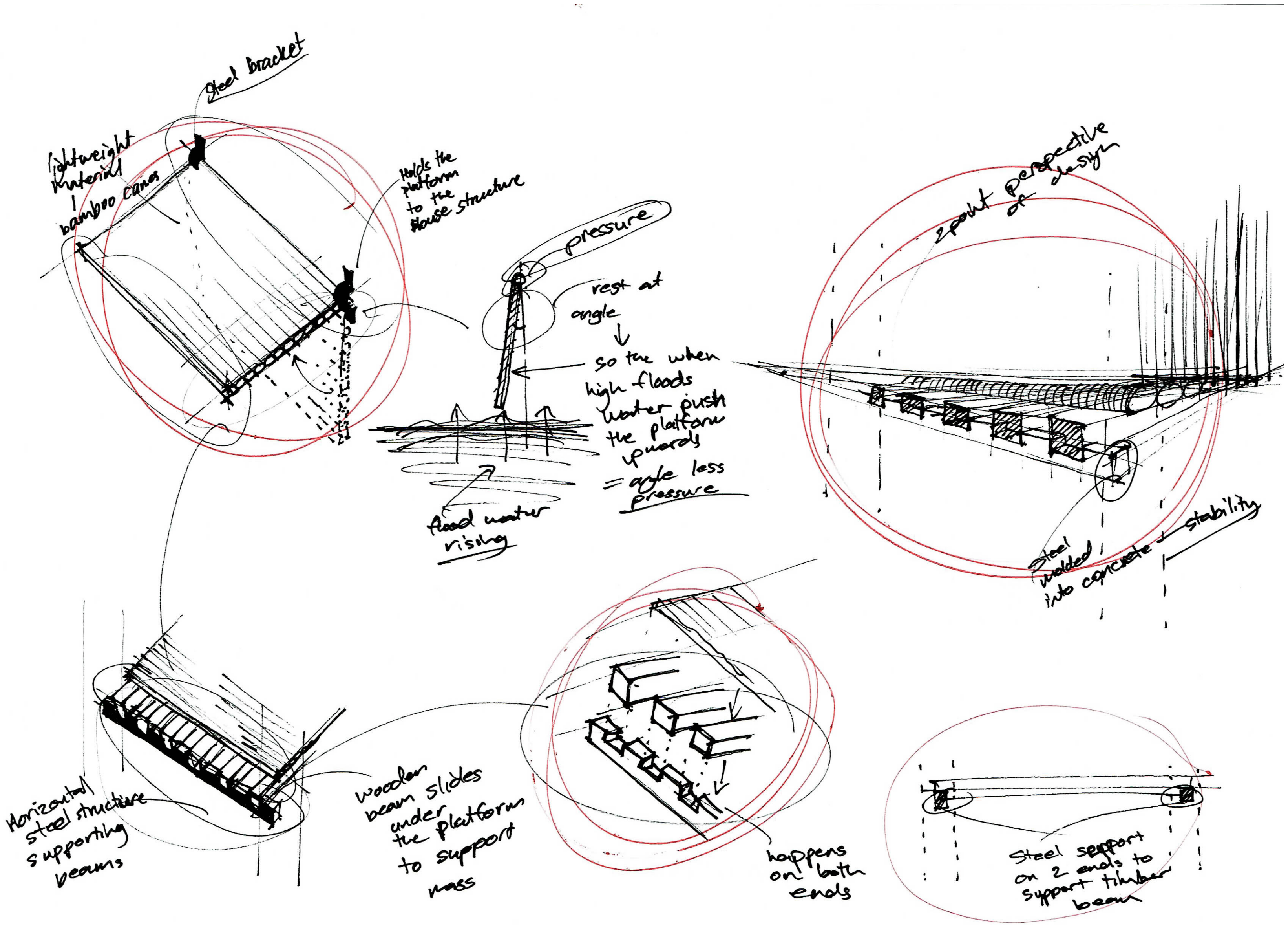


Figure 53. Design development sketch 10.

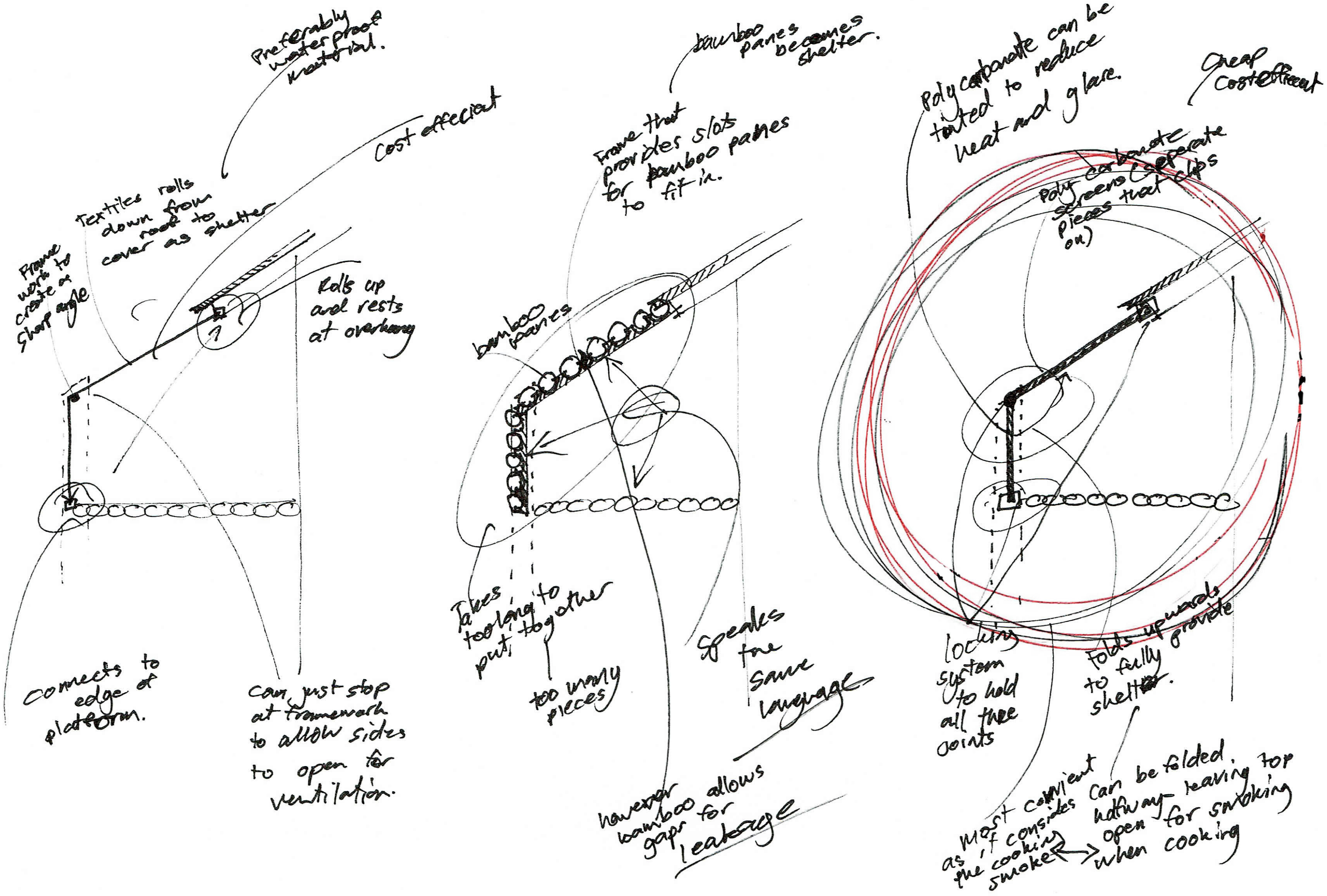


Figure 54. Design development sketch 11.

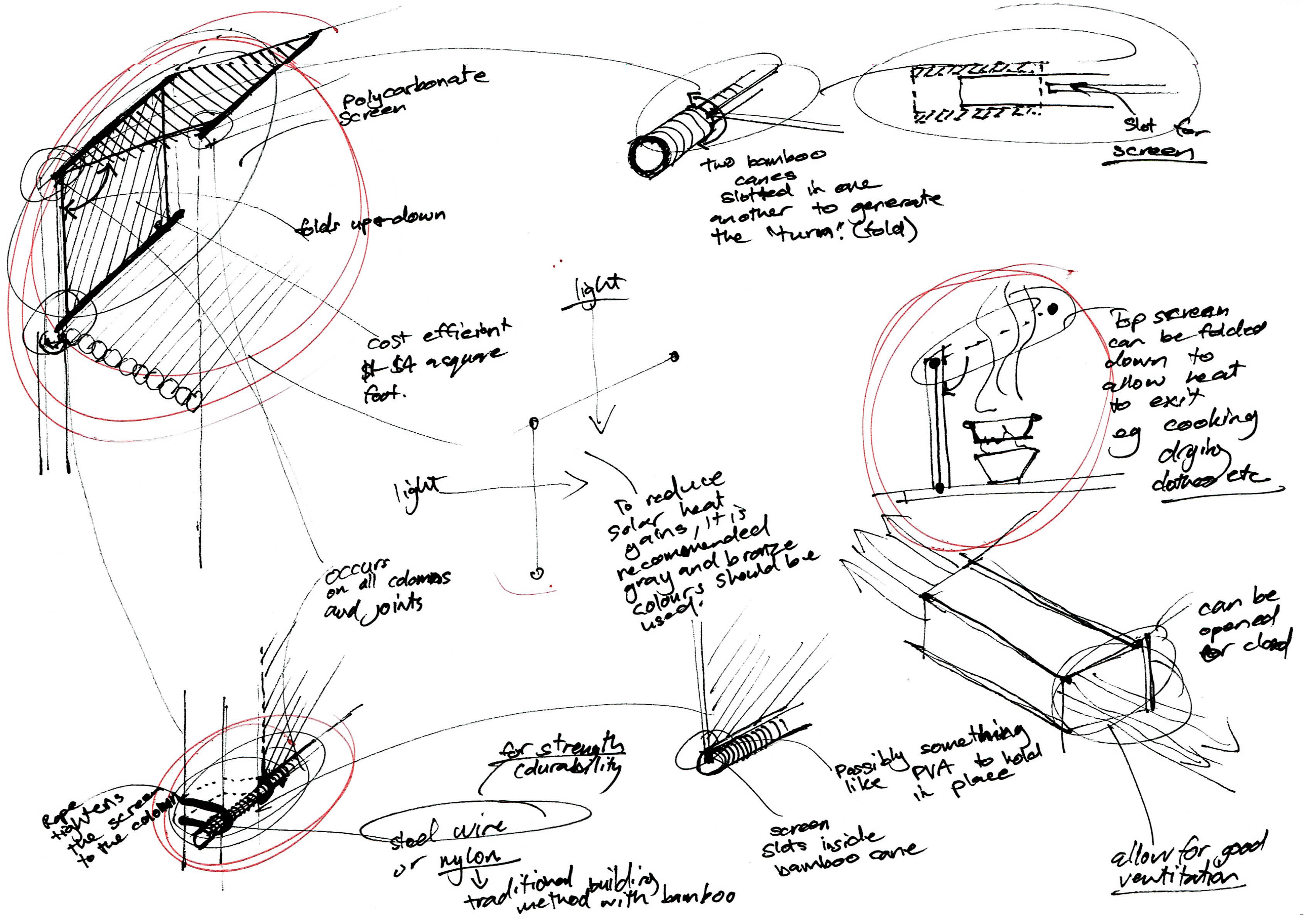
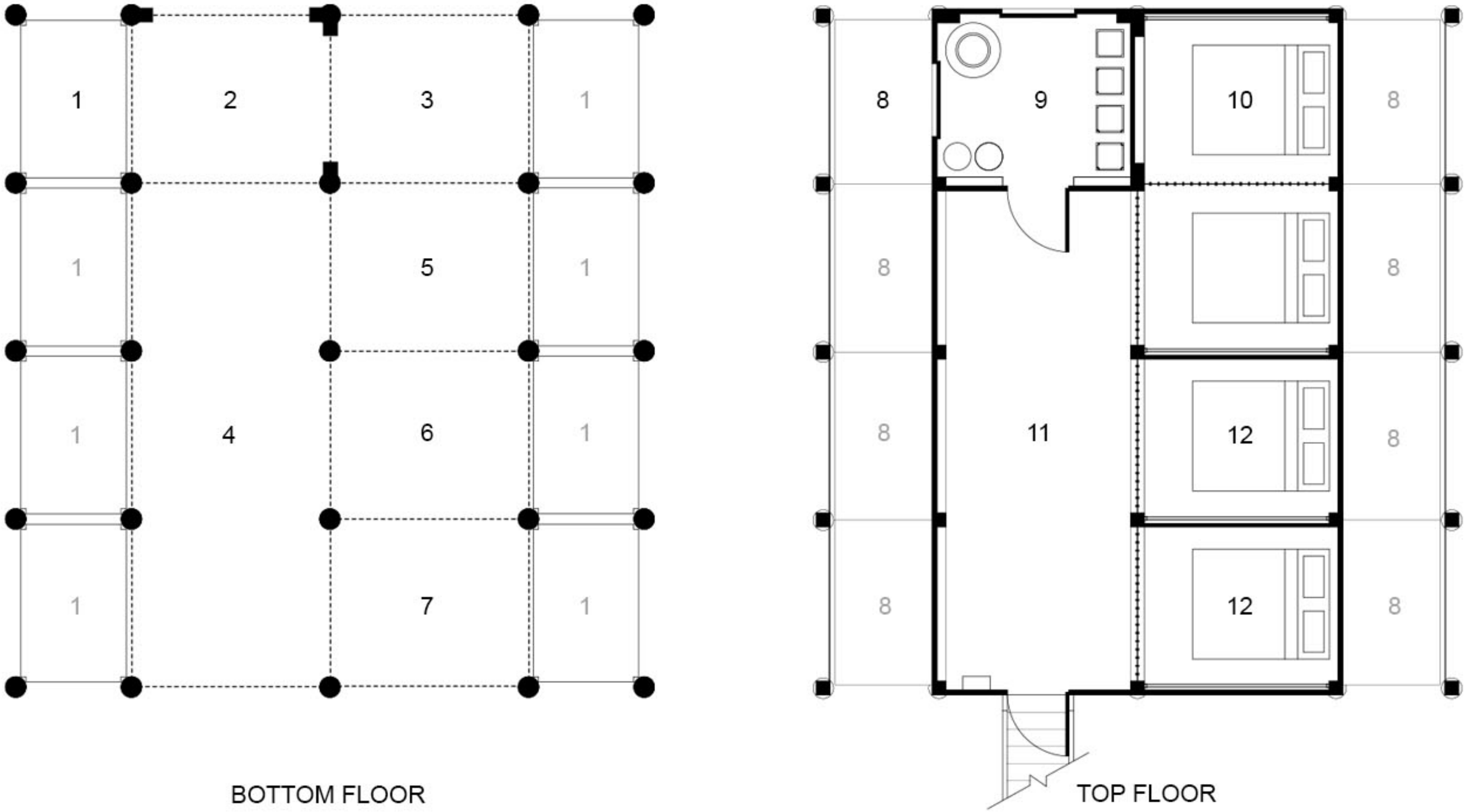


Figure 55. Design development sketch 12.



BOTTOM FLOOR

TOP FLOOR

1 AMPHIBIOUS PLATFORMS
2 WASHING
3 BATHING/SHOWER
4 GENERAL STORAGE
5 COOKING AREA
6 DINING AREA
7 LIVING AREA
8 ADDITIONAL FLOORS
9 TOILET/STORAGE
10 MASTER BEDROOM
11 CIRCULATION/GATHERING
12 BEDROOMS

CONCEPT PLAN 1:100

Figure 56. Final concept plan.

5.2 CONCEPT DEVELOPMENT

The final plan of the top floor involves a storage space, a family gathering space, additional cooking/laundry (during wet season), two bedrooms and one master bedroom that could be divided into two to allow for more sleeping space. As shown in Figure 56, the sleeping area is raised above all other spaces because Cambodians believe that the sleeping area is a sacred space. This design feature is seen in religious architecture in Cambodia, such as the Angkor Wat temple. The bottom floor remains an open floor area.

Figure 57. 1:1 scale window model 1.

Figure 58. 1:1 scale window model 2.

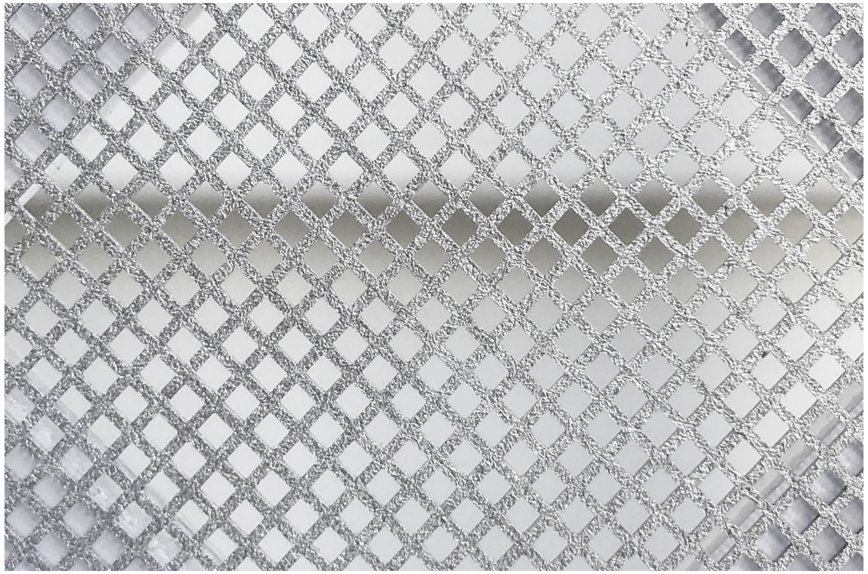


Figure 59. 1:1 scale window model 3.

From the initial research it was ascertained that flooding conditions increase the rate of diseases such as malaria and dengue fever. More than 12,000 people were diagnosed with dengue fever during the 2011 floods (Khoun and MacIsaac). I took this information and designed a screen that could be fitted to openings to prevent insects from entering interior environments.

A 1:1 scale section model of the window (see Figure 57, 58, 59) was made. It involved three layers in accordance with Cambodian tradition: glass, mesh and steel. However, polycarbonate was used as an alternative material for glass as glass is too expensive and heavy (refer to Appendix 3 for development models).

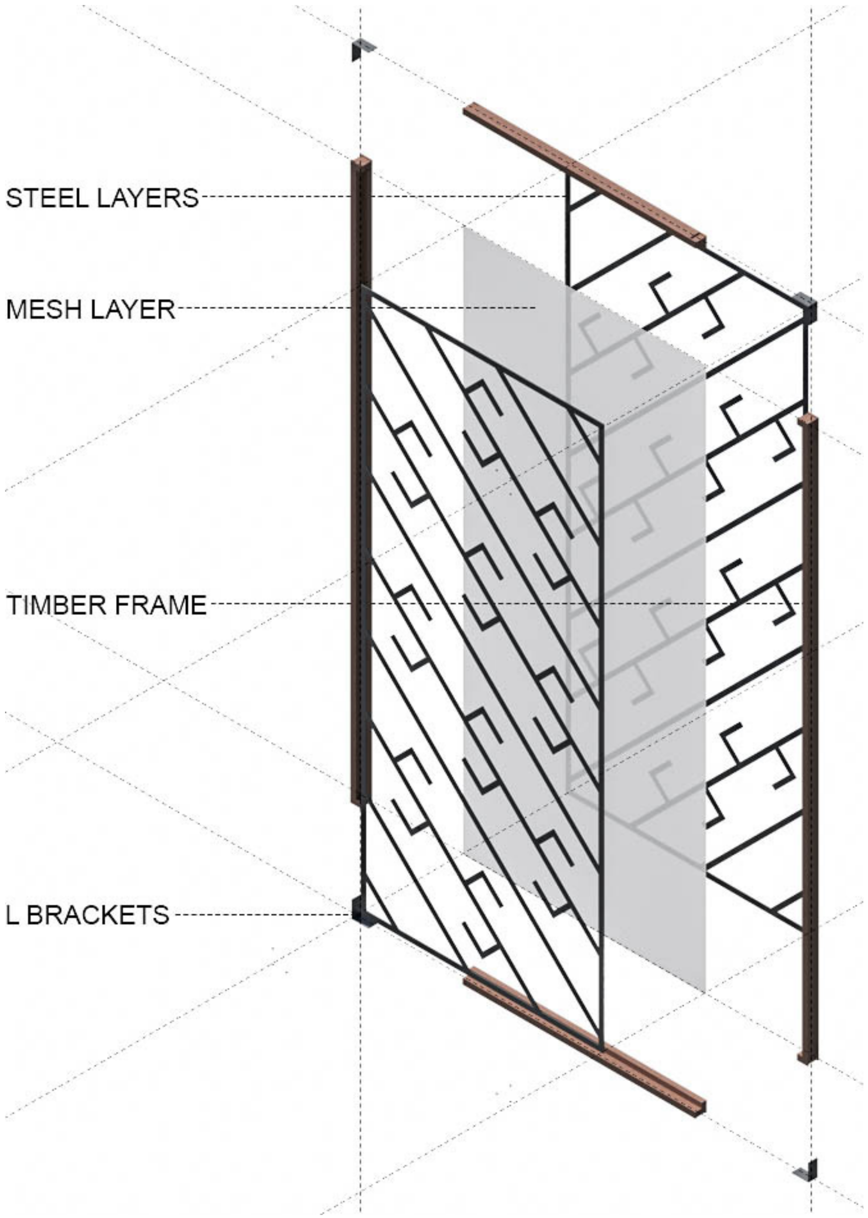


Figure 60. Exploded view of developed window.

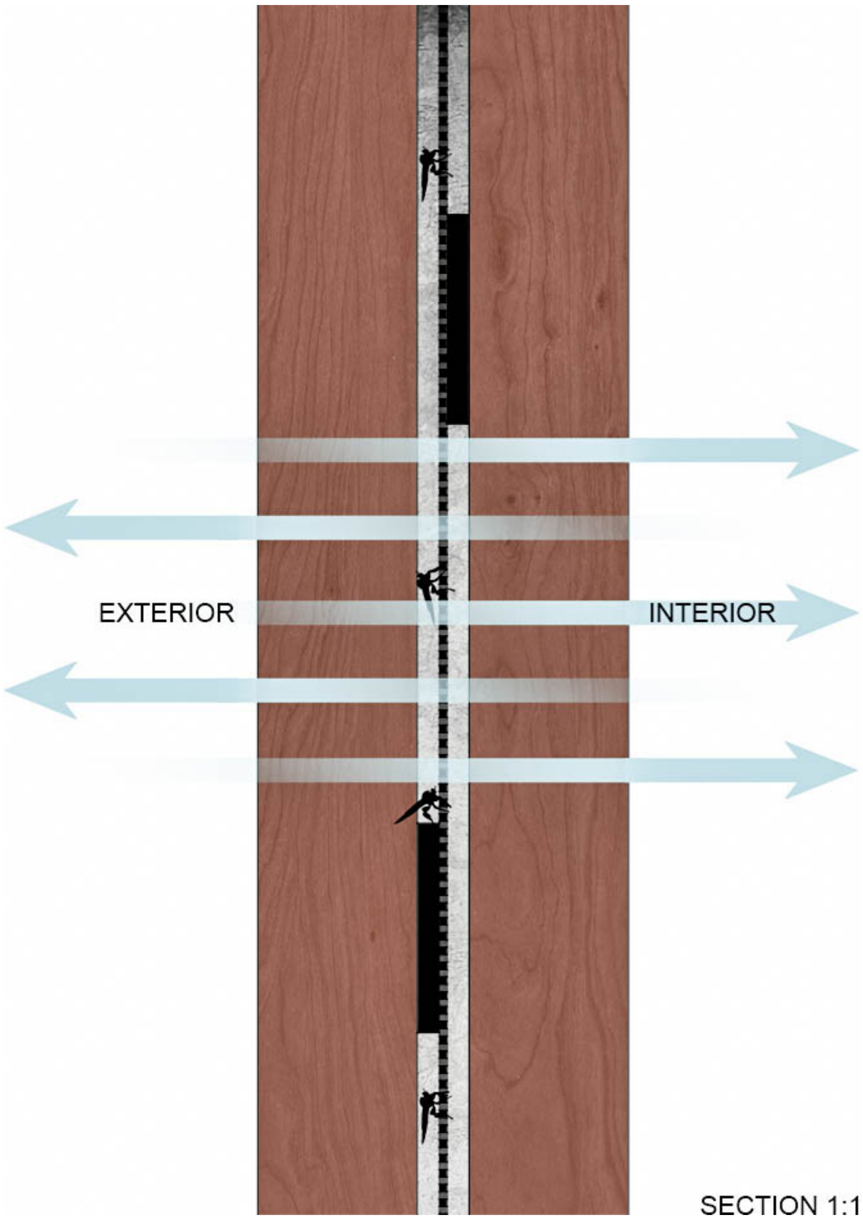


Figure 61. Section of developed window.

Even with this substituted material, the overall weight of each unit was too heavy for one person to carry up to the top floor in the construction phase. The units were calculated to be 54kg each, meaning that the 14 units the final design required would have totalled approximately 750kg. Adjustments were made to overcome this issue.

After more iterations, I reduced the window to only two layers by removing the polycarbonate layer (refer to Appendix 3 for development models). A polycarbonate layer is not necessary and only increases the weight of each unit. It is also a barrier for ventilation, which is not ideal for a hot country. The thickness of the steel layer was also reduced from 16mm to 4mm (refer to Figures 60 and 61). This reduced the weight of each unit even further to approximately 20kg.

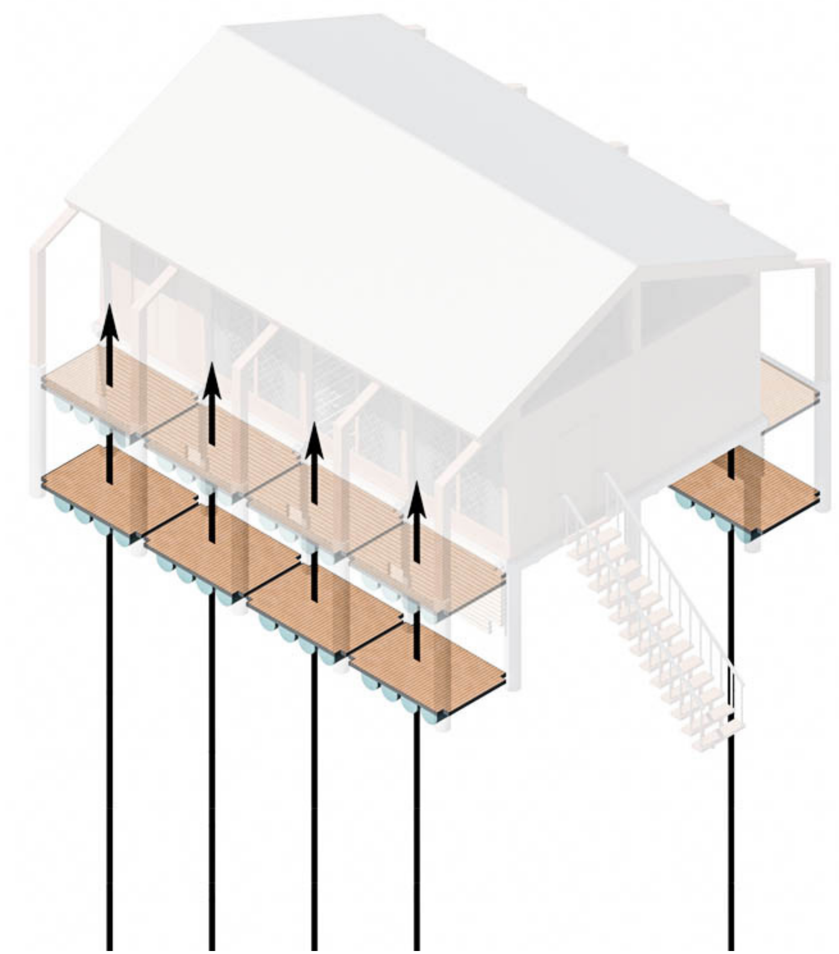


Figure 62. Movement of the amphibious platforms.

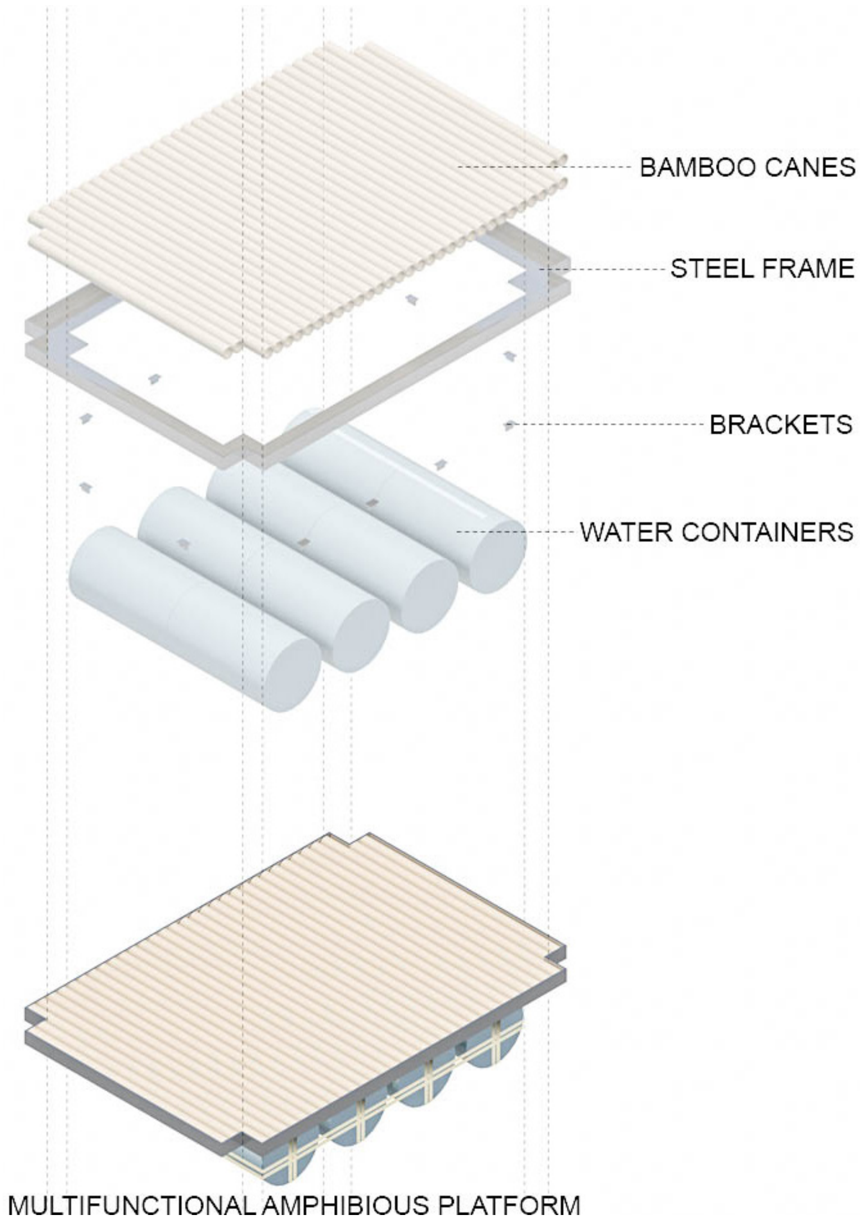


Figure 63. Exploded view of an amphibious platform.

Considering the qualitative and quantitative data gathered from the field trip, it is clear that damaged stilts and reduced incomes during wet season due to damaged vegetation and deaths of animals are the main problems. Referring to the case studies on pages 44 to 54, I took the amphibious system used by Prosun and H&P Architects, developed it further and tailored it to suit the scope of my research (refer to Figures 50 and 51). This meant creating an amphibious platform that could be used to support animals and vegetation during the wet season and could also be used for storage in the dry season (refer to Figure 63).

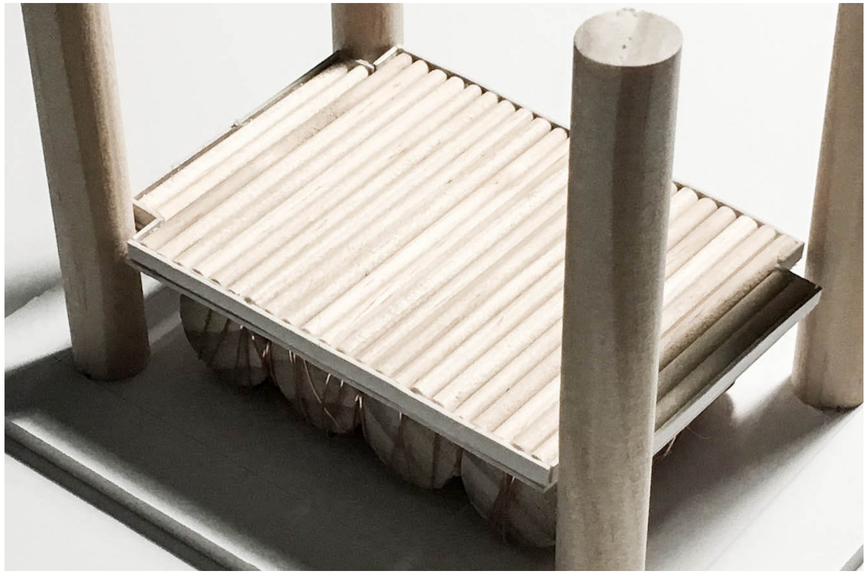


Figure 64. Platform model 1.

Figure 65. Platform model 2.

Figure 66. Platform model 3.

Figure 67. Platform model 4.

Further developing the platform, I made a 1:50 physical model (refer to Figures 64, 65, 66 and 67) to get a 3D perspective and an idea of how it could be built. Not only did the model provide me with new information but it also showed me another possible way the platform could be used. As the platform is designed as a separate component that engages between stilts, it could also be disengaged and used as a raft. This would be beneficial for the families in the region because it would make transportation less complicated.

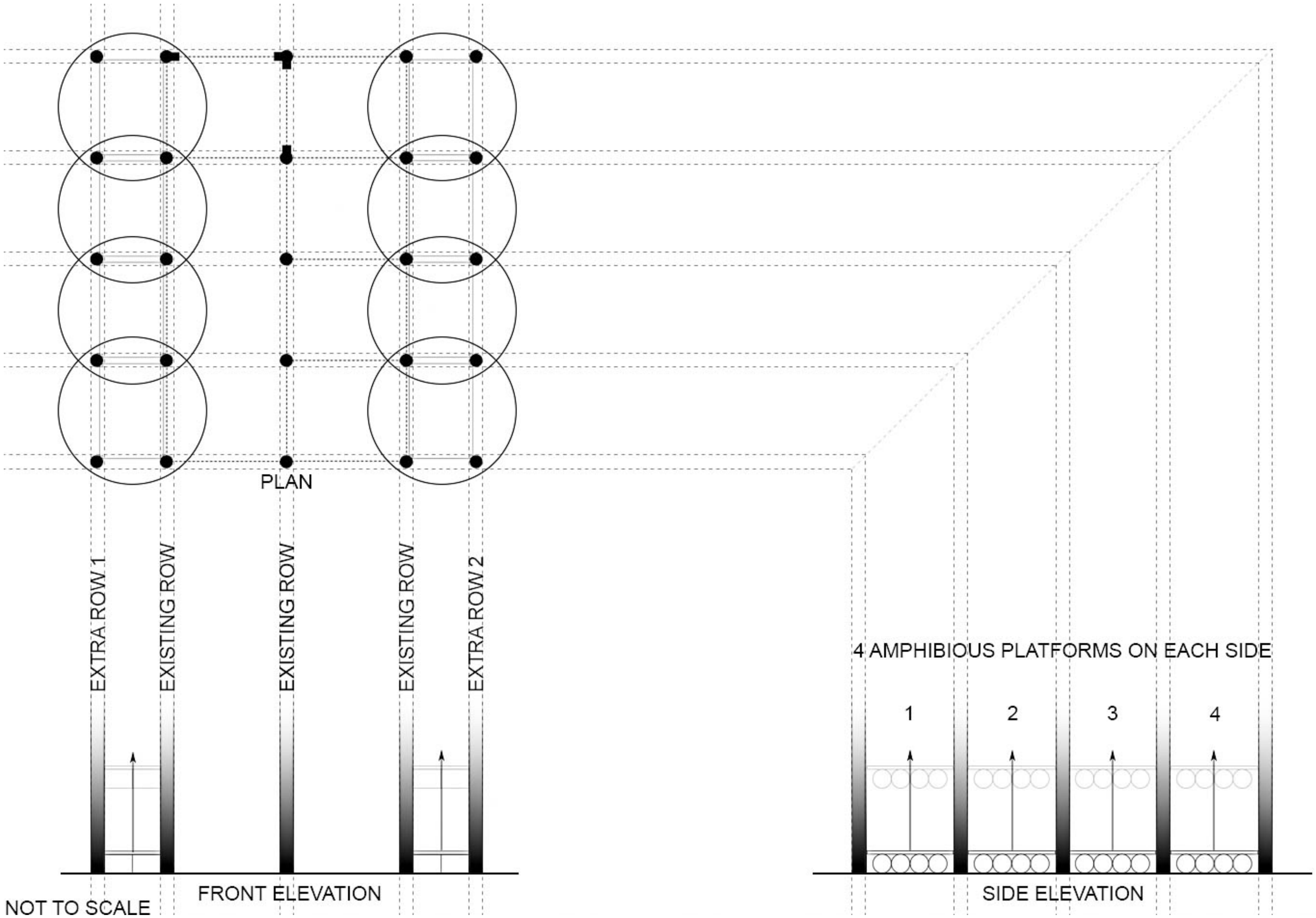


Figure 68. Two rows of stilts added to the existing structure.

Two extra rows of stilts will be added to the existing structure (refer to Figure 68). This will allow space for the amphibious system for animals and vegetation without interfering with the existing ground floor (refer to Figure 49). It also provides structural support for the additional space on the top floor. The added space will be used as a replacement for the lost space on the bottom floor during a flood.

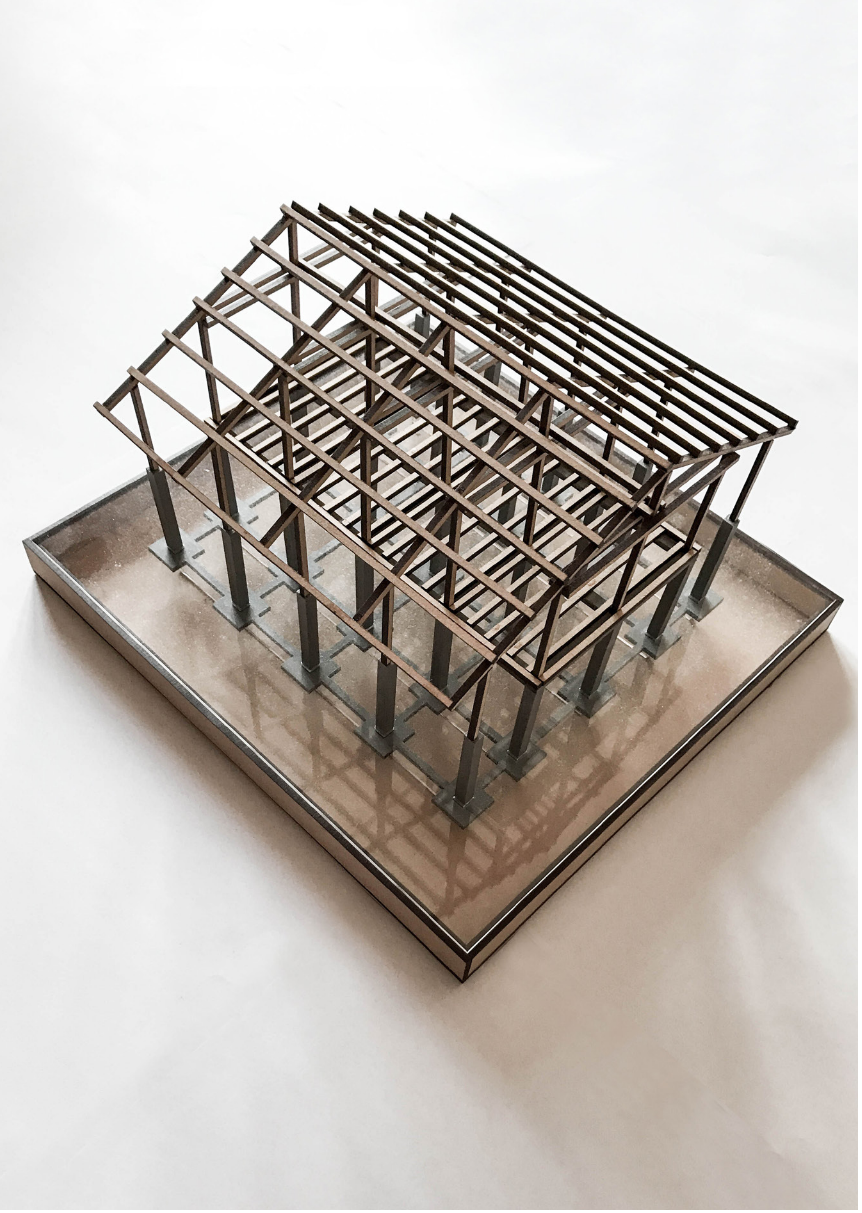


Figure 69. 1:100 sacle model of the developing structure 1.

Figure 70. 1:100 sacle model of the developing structure 2.

Figure 71. 1:100 sacle model of the developing structure 3.

A 1:100 scale model of the overall structure was made, allowing me to see how the design looked in 3D. It was presented to Victoria University structural expert Andrew Charleson for feedback. Charleson advised that the design would be a cost-efficient way to strengthen stilt houses because the use of concrete would prevent damage to the stilts during flooding (Charleson). However, the rectangular form is not considered ideal as it would generate lateral force against the structure. Charleson recommended that the concrete is cast in a cylindrical form, allowing the water to flow through without unnecessary pressure (Charleson). This material will be least affected during a flood (Elpel, 24).

By using mainly local materials that are easily sourced, costs will be kept down. During the field trip, I did some research on the price of materials in the region. The current prices are:
Bamboo canes: US$1 per unit
Concrete coloums: US$150 per unit
Timber: US$600 per m^3
Steel: US$40 per m^2 (6mm)
Brick: US$0.05 per unit
Silk: US$50 per unit
Polycarbonate sheets: US$5 per m^2
Labour: US$1200

According to my calculations (refer to Appendix 4) the total cost to build the design concept is approximately US$7,705, excluding labour, or US$8,905, including labour. Depending on their preferences, families may build their own houses; however, in more complex projects such as this, additional labour may be required.

The cost of constructing this proposed concept is higher than it is to repair regular housing. However, considering yearly repair costs, it is considered more beneficial to invest in something that will be more stable long term than to repair damages annually.

Figure 72. Final concept design – dry season.

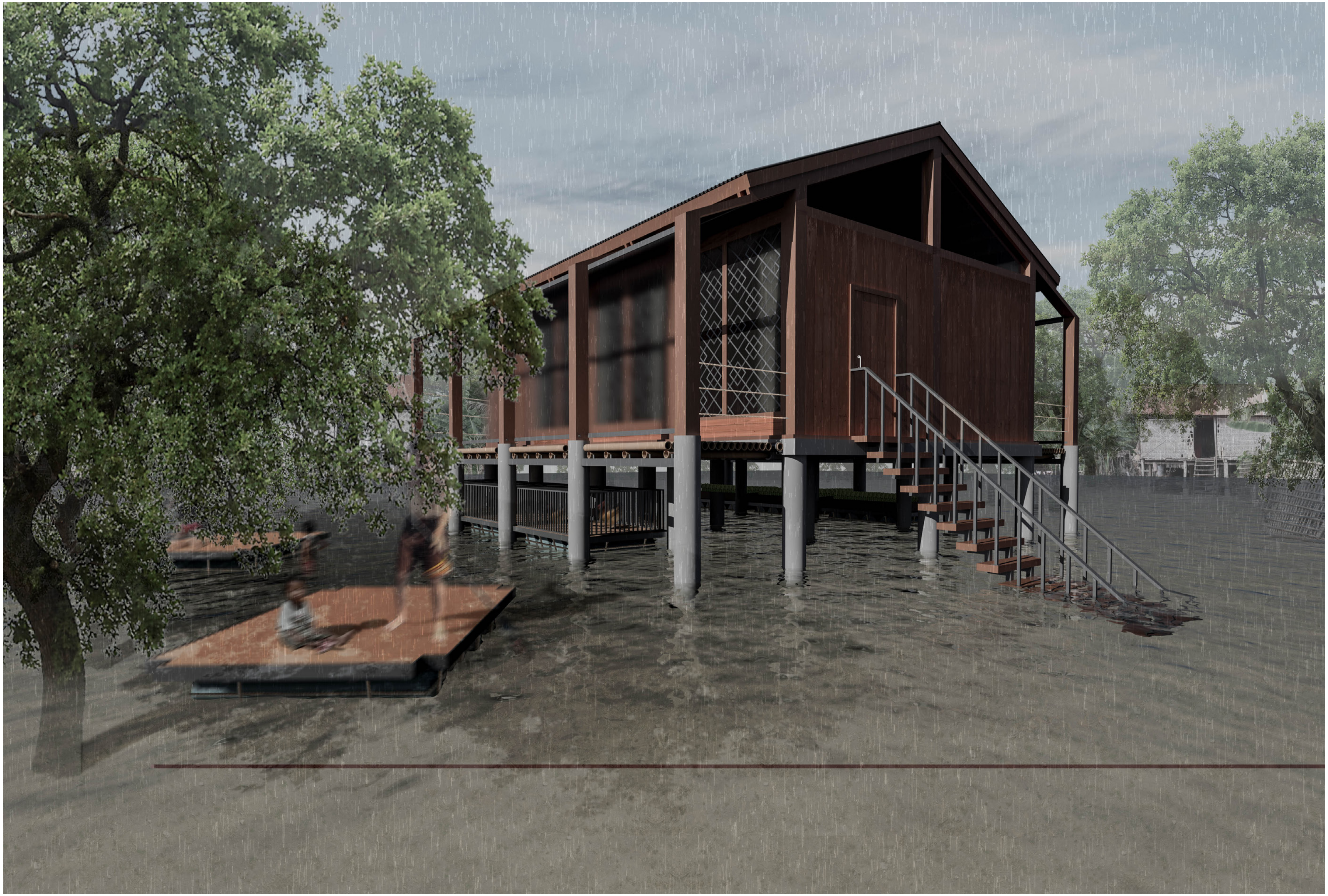


Figure 73. Final concept design – wet season.

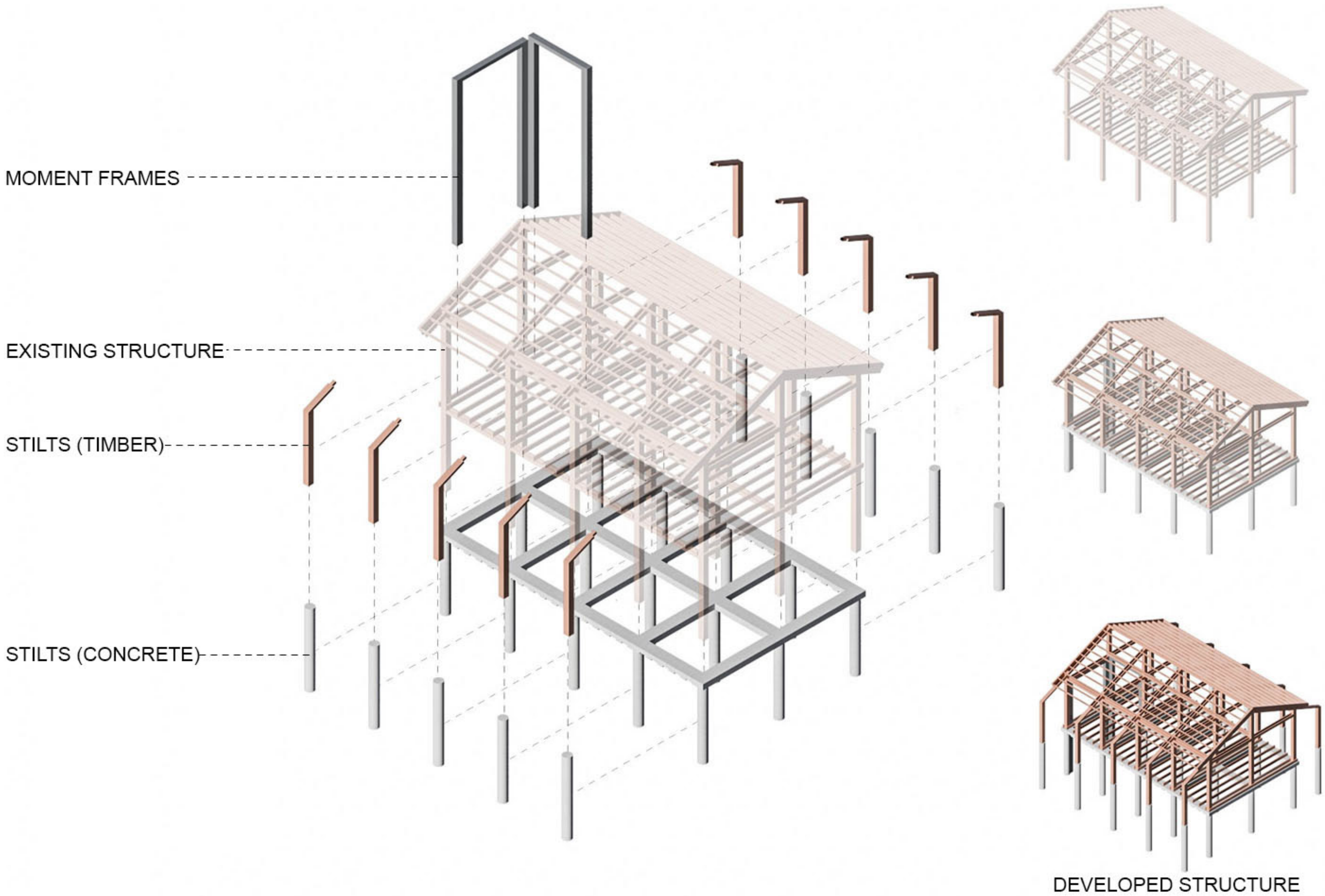


Figure 74. Final concept design – structure.

5.3 CONCEPT BREAKDOWN

STRUCTURE

Participants mentioned that their houses are very unstable during floods and move when there are strong water flow or wind conditions. This is generally caused by the wetting of the wooden stilts from past floods (Lee and Bava, 76). Sheer walls are incorporated into the design. One sheer wall will be placed along the length and one will be placed along the width of the house. This will stabilise the house and enable it to withstand force from any direction.

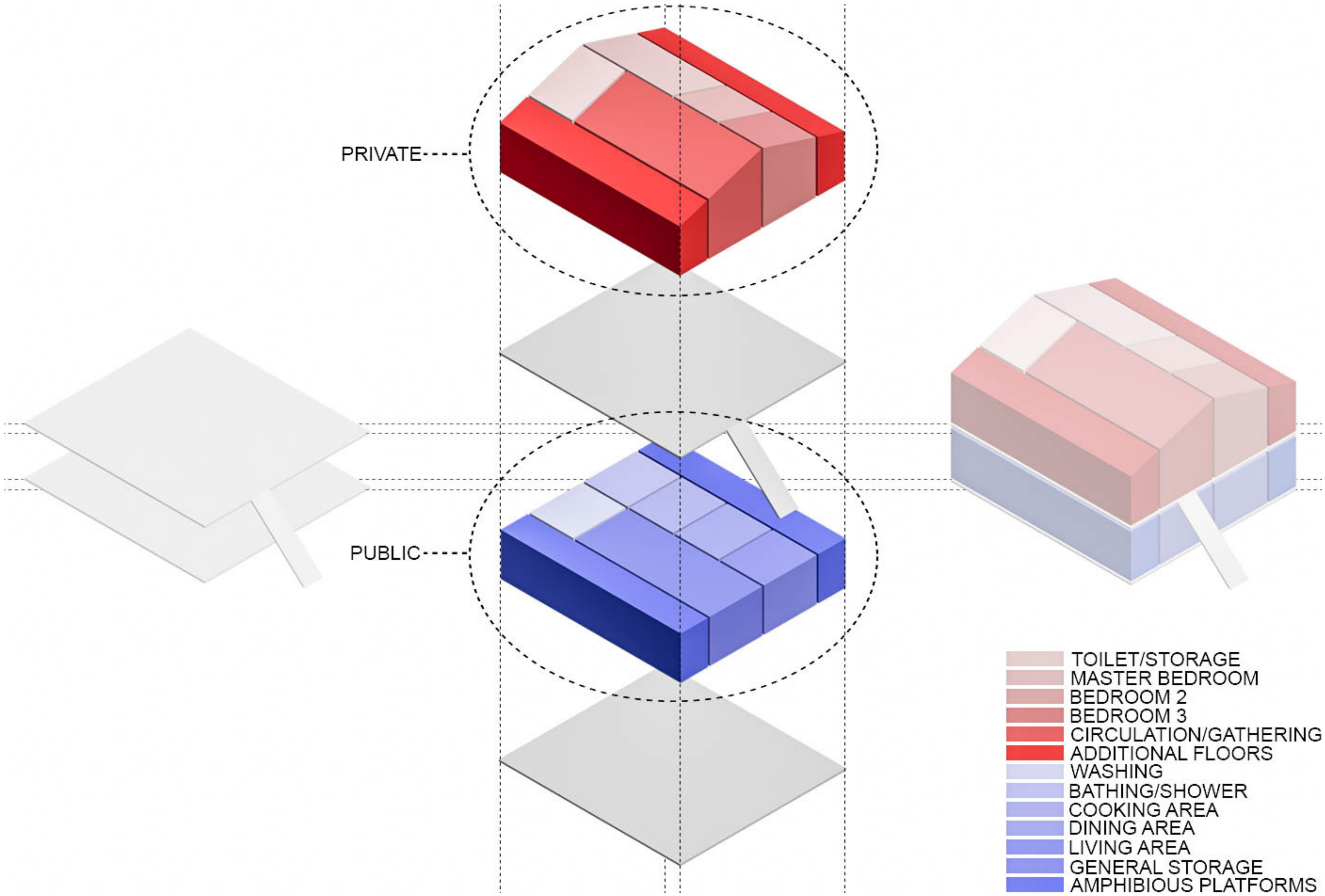


Figure 75. Final concept design – layout.

LAYOUT

The layout of the house will incorporate the traditional way of living of the Cambodian people. This means that public spaces will remain on the bottom floor and private spaces will remain on the top floor.

Following tradition, the bottom floor will accommodate sleeping, living and bathing areas. These spaces are private areas for family gatherings. Similarly, the top floor will also follow traditions, accommodating cooking, dining, washing and storage areas. However, in flooding conditions these areas will have to be moved upstairs.

Iterations of the plan were undertaken to identify the best way to lay out the space. The iterations incorporated the tradition and culture of Cambodia in order to create a living environment to which people can relate and also considered ways to allow for convenient living.

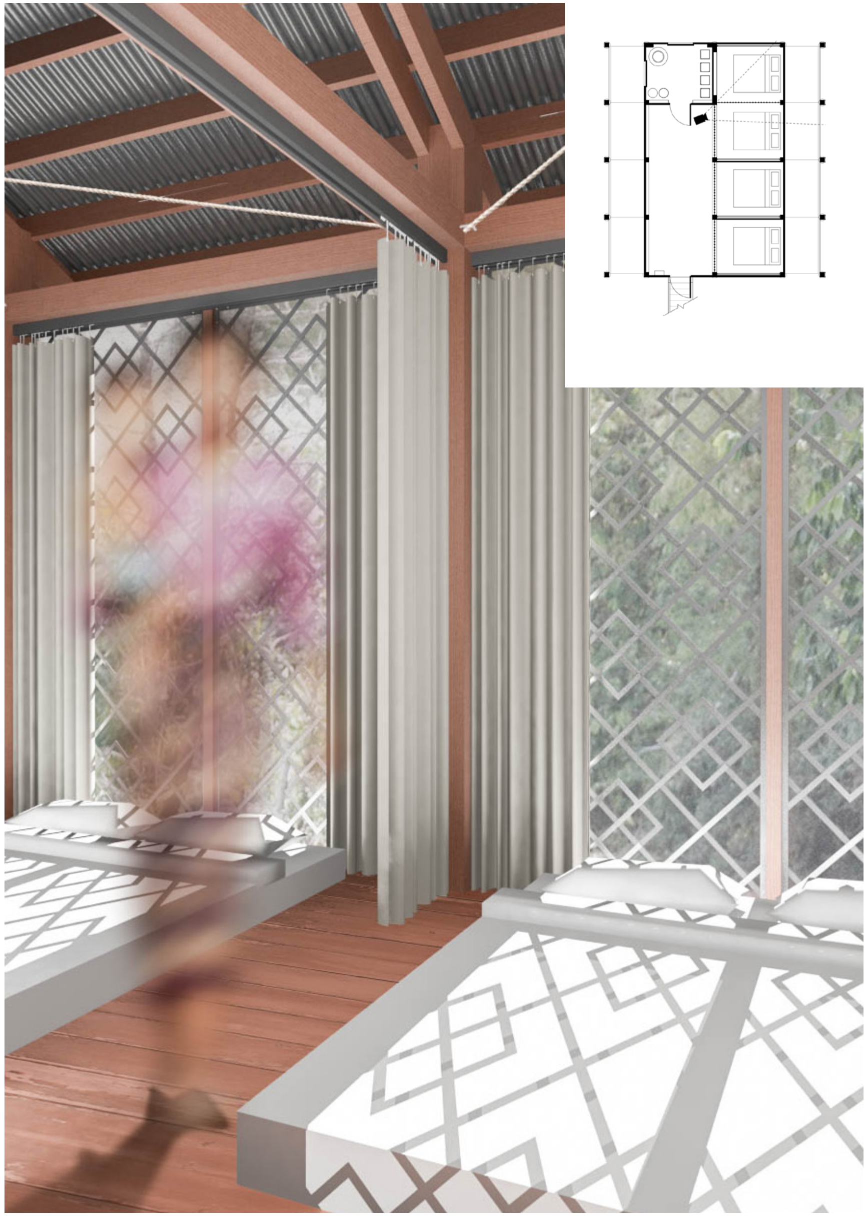


Figure 76. Final concept design – master bedroom.

Figure 77. Final concept design – bedroom.

SLEEPING

Following the site visit, it was evident that the sleeping spaces required attention. The sleeping spaces are scattered around the house and do not allow sufficient privacy. Generally, the son does not have a proper sleeping space at all. It is important to provide privacy for everybody because it a physical human need (Georgiou, 13). To overcome this issue, sleeping spaces will need to be more organised.

Figure 78. Final concept design – additional floor.

COOKING

It was brought to my attention that cooking is an issue in flooding conditions. During floods, the whole of the bottom floor is filled with water, leaving no space for the kitchen area. An alternative cooking area will be designed on the top floor to overcome this issue. Additional floors will be added so that cooking can be performed on this floor during floods. As cooking traditional cooking equipment is portable, such as the clay ovens, moving it upstairs requires minimal effort.

Figure 79. Final concept design – circulation/gathering area 1.

Figure 80. Final concept design – circulation/gathering area 2.

LIVING

Similar to the cooking area, the living area will also be flooded in the rainy season. An alternative space will be designed on the top floor to overcome this issue. It will be an open, multi-purpose area in which the family can gather and which can be used for meetings, dining, study, prayers and welcoming guests. It will also act as a corridor, allowing family members to access the bathing area, which is located at the back of the house. This means that family members will be able to circulate easily around the house.

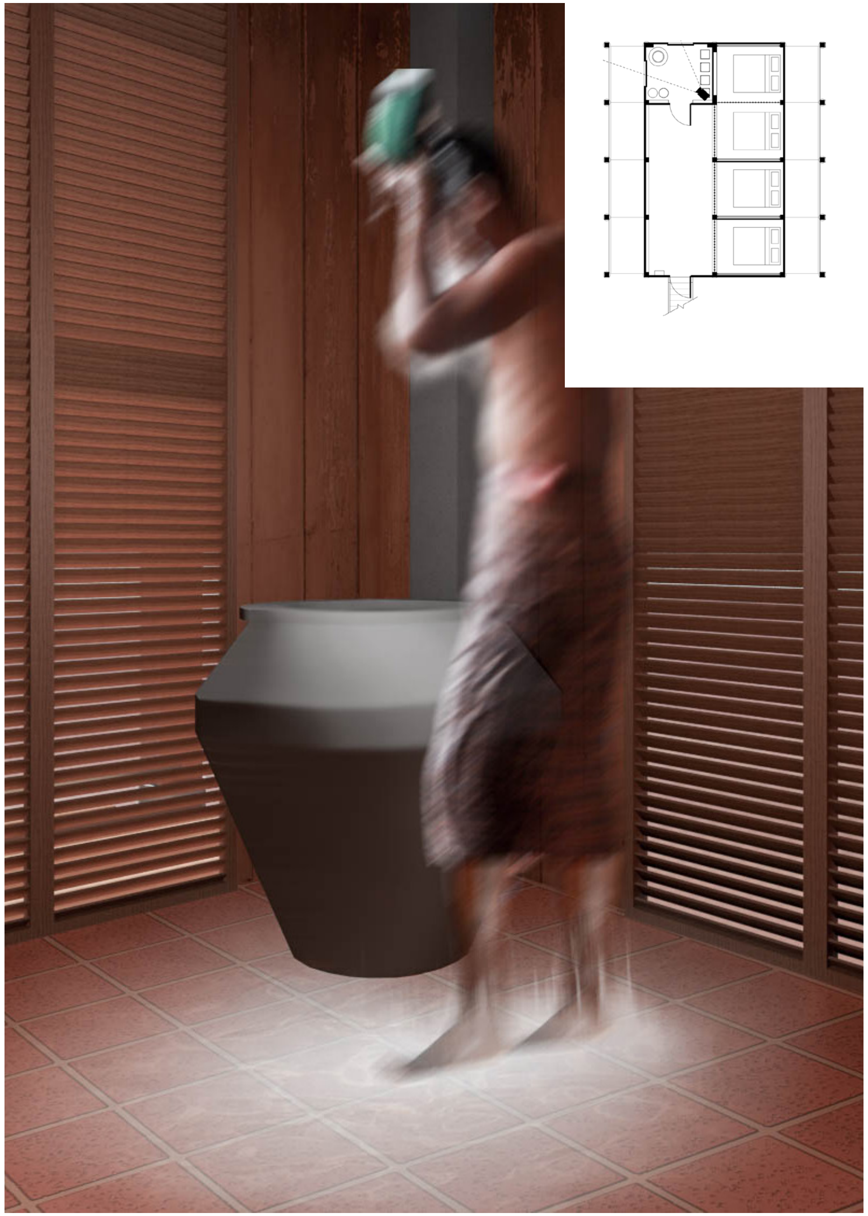


Figure 81. Final concept design – toilet/storage 1.

Figure 82. Final concept design – toilet/storage 2.

BATHING

Traditionally bathrooms are a walking distance away from the house. This is an issue in flooding conditions. In the rainy season an alternative bathing space can be quickly installed on the top floor to allow for easier living. The bathroom will include a portable water storage system and camping toilets. However, in the dry season, the bathroom can be used as storage space because the traditional bathroom will be used instead.

Figure 83. Final concept design – amphibious platform 1.

Figure 84. Final concept design – amphibious platform 2.

5.4 SYSTEMS

AMPHIBIOUS PLATFORM

Families mentioned that vegetation and animals suffer in flooding conditions. The floodwaters destroy vegetation, and animals have no place to live. These aspects affect the families as they are their main sources of income. The additional rows of stilts create space to allow for amphibious platforms to be installed.

Originally the platforms were to be made from timber as one whole timber unit, with steel frames to support plastic containers. After calculating the price, it turned out to be too expensive so the choice of materials needed to be reconsidered in order to reduce cost and avoid rusting.

After design adjustments, the platforms will be made of bamboo canes due to the price and availability of bamboo in the region (Pellechi). Twine ropes will also be an alternative material to hold the plastic containers in order to avoid the steel rusting (Junk Raft).

As the main issue of flooding in Tboung Khmum is damaged crops and the deaths of animals, the platform will be a temporary space to keep animals and vegetation above the floodwater. This may not protect everything but it will stabilise incomes and avoid food shortages.

The platform can also be used as a raft for transportation on water. This will allow families to get to places without difficulty and they will no longer have to walk through floodwater to get to local markets. This enhances living standards and may prevent diseases.

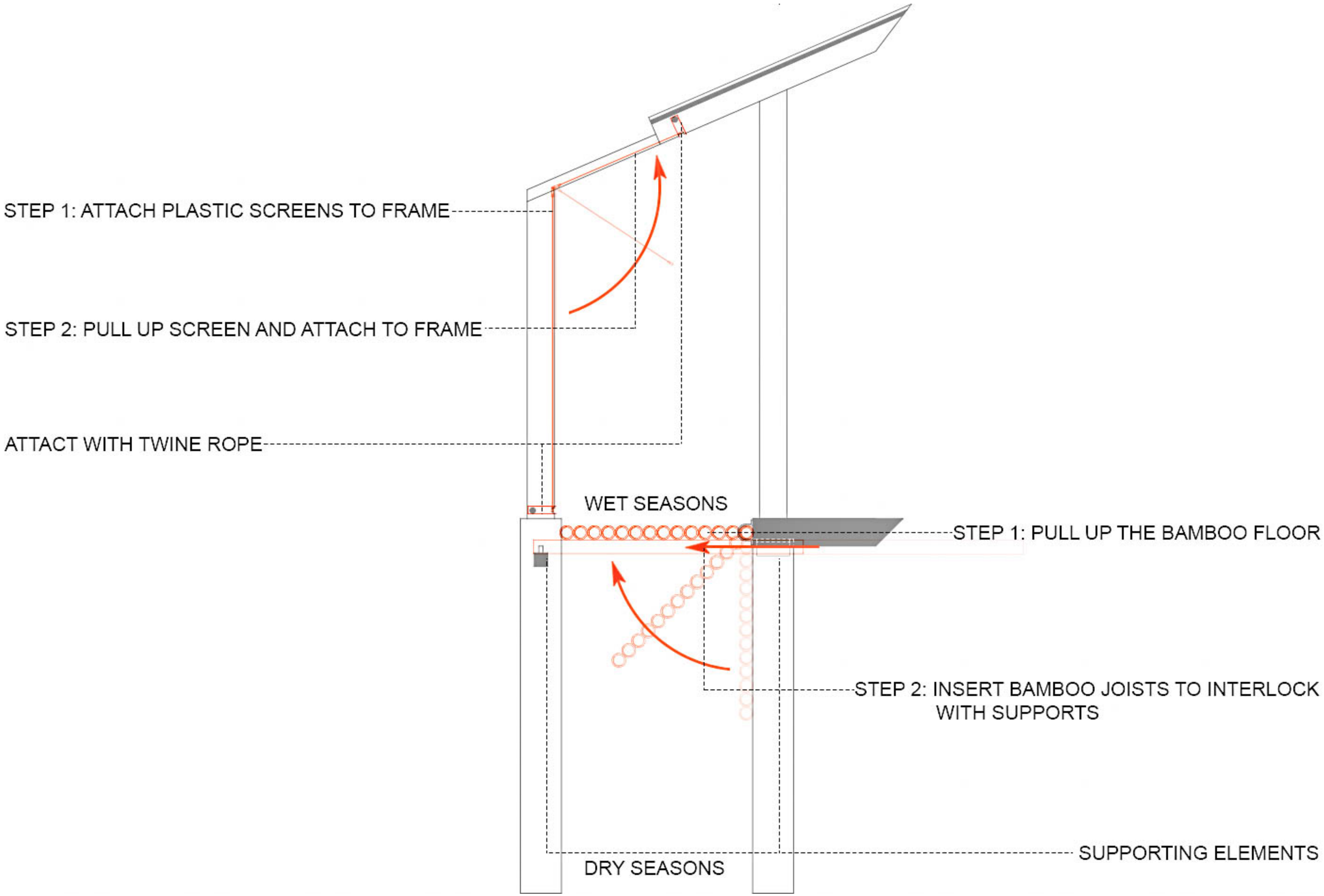


Figure 85. Diagram showing how the folding floor system works.

FOLDING FLOORS

From the qualitative data gathered, families endure hard times during the rainy seasons, when areas on the bottom floor are filled with floodwater. This makes it impossible for families to do their daily chores, such cooking and washing.

Extra floor space will be added to the design. It will be connected to the sides of the top floor. The extra floor spaces will be used for daily chores during flooding conditions, meaning that families will have to move cooking and washing equipment upstairs.

In dry seasons, cooking and washing equipment will be moved back downstairs to follow tradition. The floor will also be folded down and act as a sunshade for the bottom floor. I believed that the folding floor is a convenient design element as it has a purpose in both the wet and dry seasons.

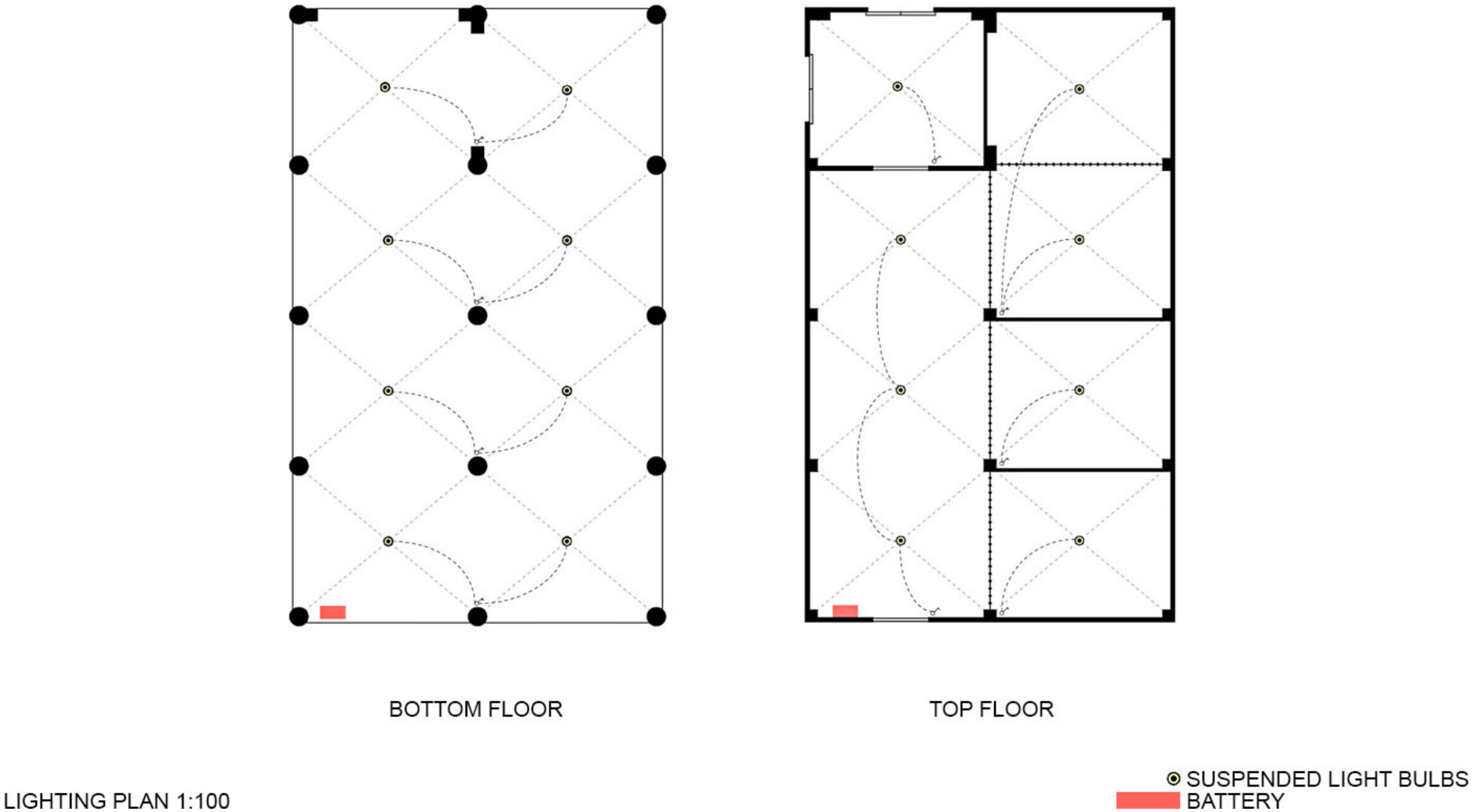


Figure 86. Final concept design – Lighting plan.

5.5 LIGHTING

In order to reduce energy consumption for sustainable living, it is important to make the most of daylight. Because of Cambodia’s location, sunlight comes from directly above. Openings will be placed along the left and right façades to maximise daylight. Silk curtains will be installed to reduce glare and overheating.

Battery-operated electric lighting will be placed in each room to provide light in the evening and at night. This is a cost-efficient and traditional way to light rural houses (Yim).

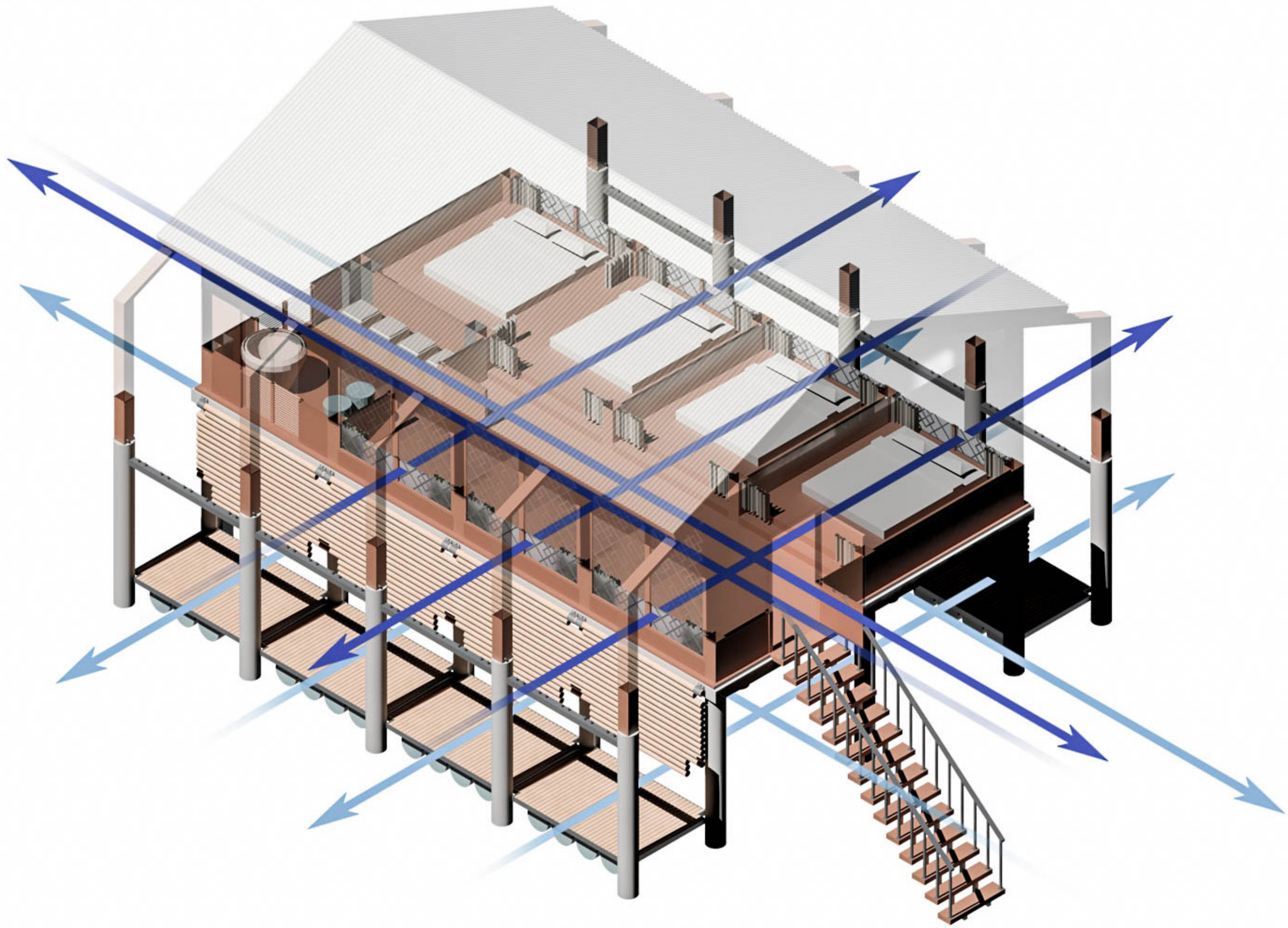


Figure 87. Diagram showing the wind path (cross ventilation).

5.6 VENTILATION

Due to the hot Cambodian climate, the house will have openings on all sides. This will allow for natural cross-ventilation to occur and is an effective design method to help cool down the internal space (Alvarez et al., 243). In addition, the frame will incorporate tradition patterns that are seen in Hol. This will create a living environment to which the families can personally relate.

CHAPTER 6: CONCLUSION
CONCLUSION

Figure 88. Boat crossing the Mekong river.

6.1 CONCLUSION

This aim of this research was to find a design solution that prepares for annual flooding while incorporating traditions in order to enhance the living standards of families in the Tboung Khmum district. Tboung Khmum is known to be affected annually by floods as it is intersected by the Mekong River. According to statistics, thousands of houses are damaged and displaced every year. As a Cambodian myself, this project allows me to propose a design solution to help my home country overcome this devastating situation.

This research began by understanding the background of the country. This step has provided the opportunity to gather information about the culture, traditions and beliefs of the Cambodian people. The information gathered is a good starting point because it allowed me to learn about the existing site. It also expressed the important aspects of the culture and traditions of Cambodian architecture.

The subsequent site visit gave me the opportunity to speak personally to various families within the affected region. The experience was another important stage of the project as it allowed me to listen to their views of life in flood-prone areas of the country. Qualitative data was gathered to construct a design brief that would help to overcome the negative aspects in order to enhance living standards and reduce damage overall.

A material study was undertaken while I was in the region. The intention was to apply traditional and cost-efficient materials that are available locally. It was clear that bamboo, bricks, concrete, wood and silk are available locally; other potential materials must be imported from neighbouring countries. However, as Cambodia is part of the ASEAN community, no import or export taxes apply. This study has helped me to gather quantitative data that will contribute further to the design brief.

Figure 89. Case study locations.

Further into the project I looked at three different cases that have a similar purpose to what the project aims to achieve (refer to Figure 89). Each case has different design aspects that focus on flood resilience. The design aspects include amphibious systems, materiality and elements. Further research into various literature relating to the design aspects was undertaken, allowing me to obtain a deeper understanding of what has worked in past or existing projects.

These methods of study have helped me to understand and gather qualitative and quantitative data that has been reflected in the design process by constructing a design brief that considers the aim of the research.

I believe that the design concept has achieved its goal; it has considered design aspects that will help to reduce damage in flooding conditions:

- Concrete stilts – prevent wetting of materials.
- Amphibious platforms – protect animals and vegetation.
- Wall openings – allow water to pass through in high floods.
- Mesh – protection from insects and diseases.

It has also considered design aspects that engage culture and tradition to provide a living environment to which families can relate. By achieving this, it also enhances living standards and maintains authenticity.

- Steel frames – resemble traditional patterns.
- Interior layout – adapting to Feng Shui and beliefs.
- Materiality – traditional materials.
- Additional floor spaces – alternative spaces for cooking, washing and storage.
- Rafts – transportation.

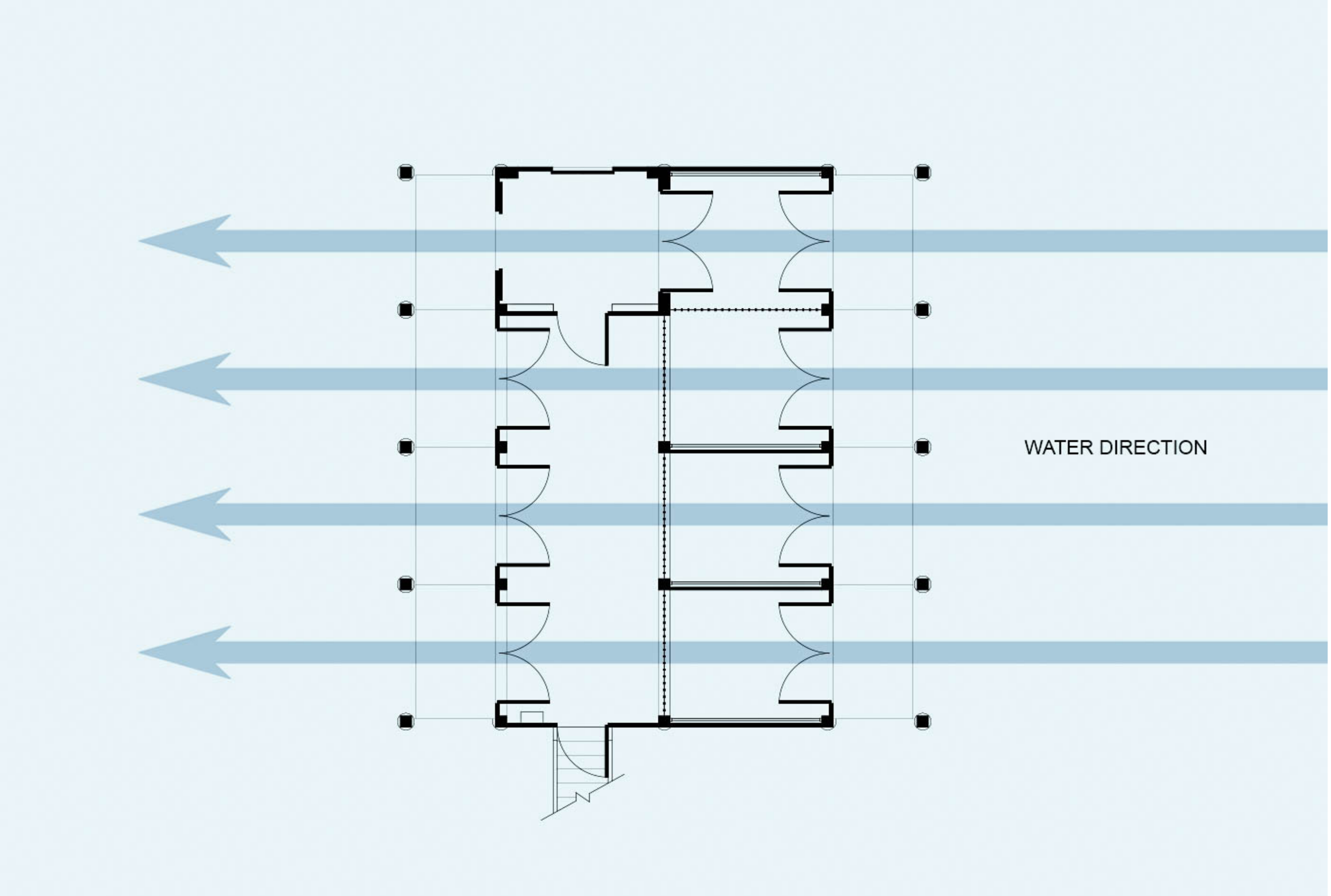


Figure 90. Solution during high-flood conditions.

These design features can be built by the families as they consist of simple construction techniques. According to my calculations (refer to Appendix 4), the overall cost of the development of rural houses is around US$9,000 and requires approximately one month to complete. This amount may seem a lot for the families of the region; however, in the long term it will be more beneficial as there will be no recurring damage. I also believe that the estimated cost is reasonable as it matches other similar projects like the Lift house in Dhaka, Bangladesh.

In low-flood conditions the concrete stilts will stabilise the houses and prevent any damage to the structures. However, items or belongings must be moved upstairs to the additional floor areas.

In high-flood conditions, all doors will open up to allow floodwater to flow through to reduce major damage by decreasing the lateral force against the house (Elpel, 24). Nonetheless, evacuation to higher ground or buildings is mandatory.

This exegesis was designed to provide families in Tboung Khmum with a solution to problems caused by the annual floods. However, during the research process only eight out of approximately 160,000 families were interviewed (Watershed Asia). This means that approximately 0.005% of families participated in the research.

It was unrealistic to get more than 1% (approximately 1,600 families) of families involved due to the time allowed for this research; however, if more families participated and more data was obtained, the final concept could be developed further. Nonetheless, with the data that I gathered, I believe that this design concept meets the requirements of families who participated.

For further research opportunities, I recommend interviewing families in other districts of Kampong Cham. This will allow for additional data based on varying flooding conditions that may allow room for further design intervention.

Another research opportunity is to base the research around floating homes, a new way of living that has been adapted by locals in Kampong Cham. I believe that this could be a very rewarding area of research because the seasons would no longer affect the ways that live.

Overall, I believe the design of the house is a sensible solution that responds to the research statement. It has provided a flood-resilient solution to prevent recurring damage. It has also provided an interior fit-out that considers traditional and cultural aspects and creates a living environment to which families can personally relate. It also helps to maintain the authenticity of Cambodian architecture.

In the future I intend to visit the families who have participated in my research and show them the final design. I will gather each and every opinion and conclude with a final statement.

REFERENCE SECTION

REFERENCES I BIBLIOGRAPHY I APPENDICES

Figure 91. Man collecting recycled wood for home repairs.

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APPENDIX 1 – ETHICS

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Phone 0-4-463 5480
Email susan.corbett@vuw.ac.nz

MEMORANDUM

TO	Vety Meng
COPY TO	
FROM	AProf Susan Corbett, Convener, Human Ethics Committee
DATE	20 April 2016
PAGES	1
SUBJECT	**Ethics Approval: 22800** Moving Forward

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 30 September 2017. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards

[redacted]

Susan Corbett
Convener, Victoria University Human Ethics Committee

Figure 92. Confirmation of ethics application.

APPENDIX 2 – QUESTIONNAIRE

Interview Questions – Participants and Home Owners

Name of Occupant:

1- What is the overall cost to build your home?

2- Which are the materials involved?

3- What was the overall construction time for your home?

4- Describe the positive and negative aspects of lifestyle in the rural country side?
- Positive:
- Negative:

5- During a rainy season, how did the events listed down below affects your home?
- Heavy rain:
- Flooding:

6- During these events, what actions do you take in order to avoid it?

7- Which of the events occur the most within a one year time frame?

8- Which are the stronger and weakest areas of your home?

9- In your opinion, what do you think the best the best solution for you home would be in order to avoid these events?
- Heavy rain:
- Flooding:

Figure 93. Questionnaire.

APPENDIX 3 – DEVELOPMENT SKETCHES AND MODELS

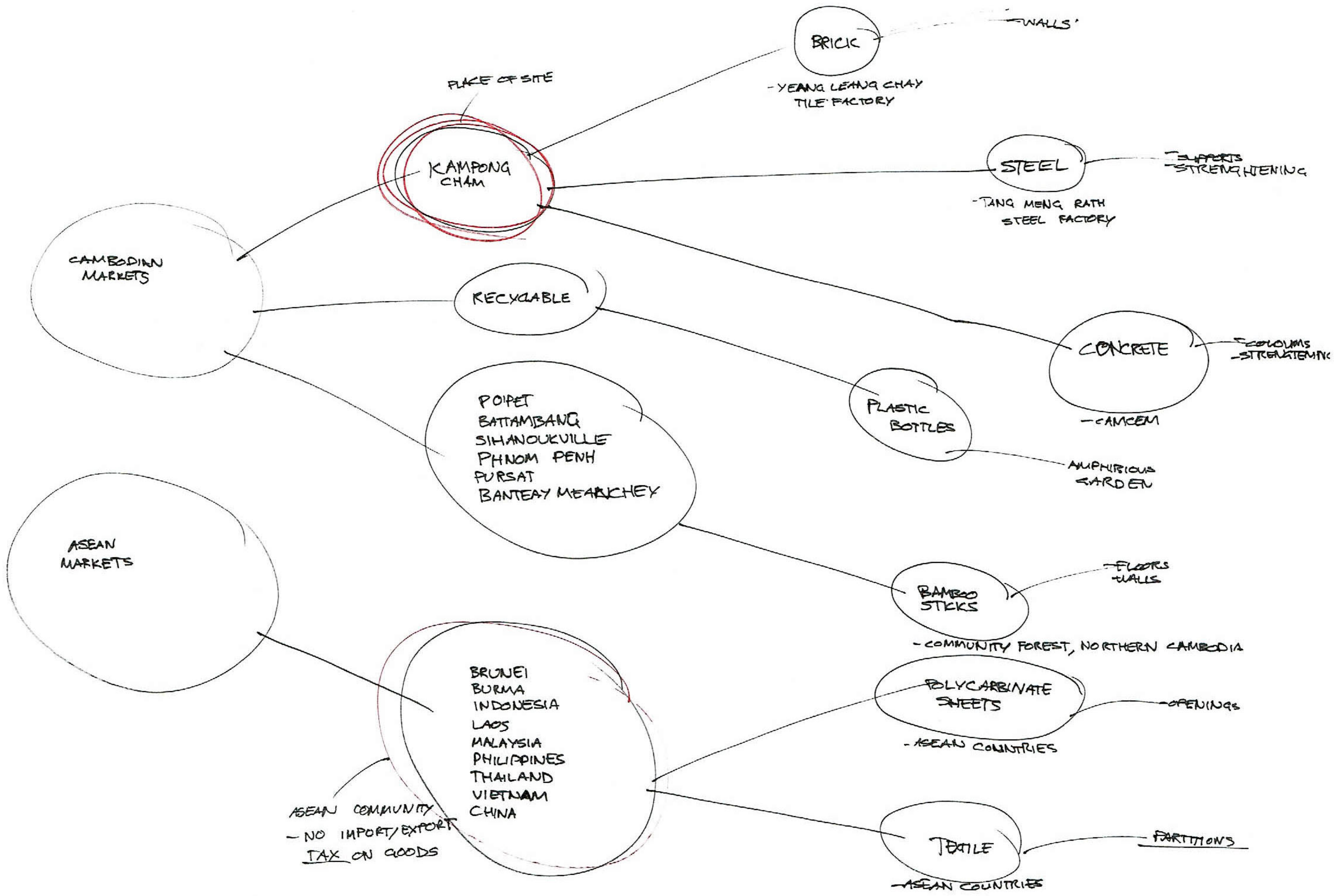


Figure 94. Material palette.

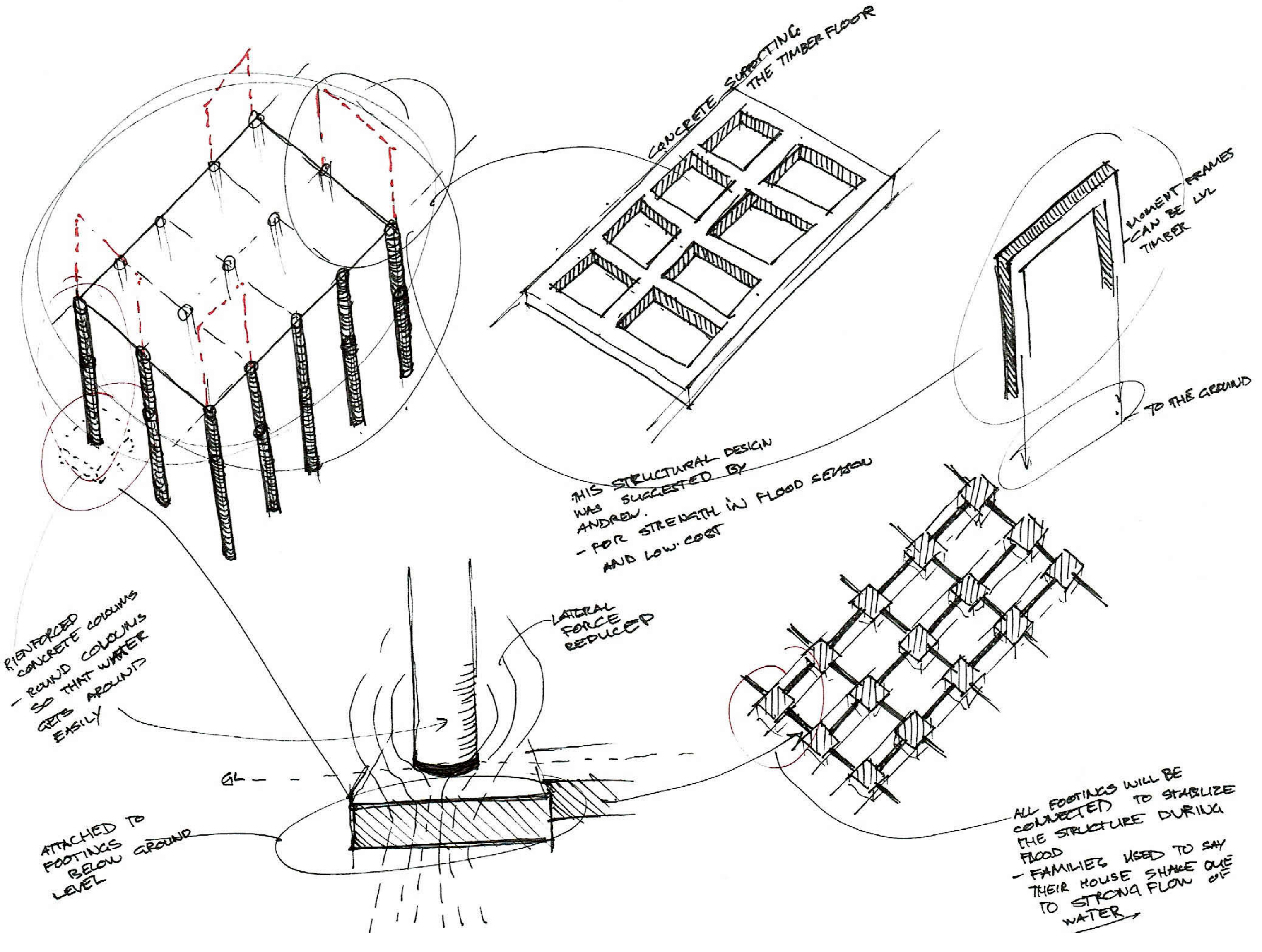


Figure 95. Structural sketches.

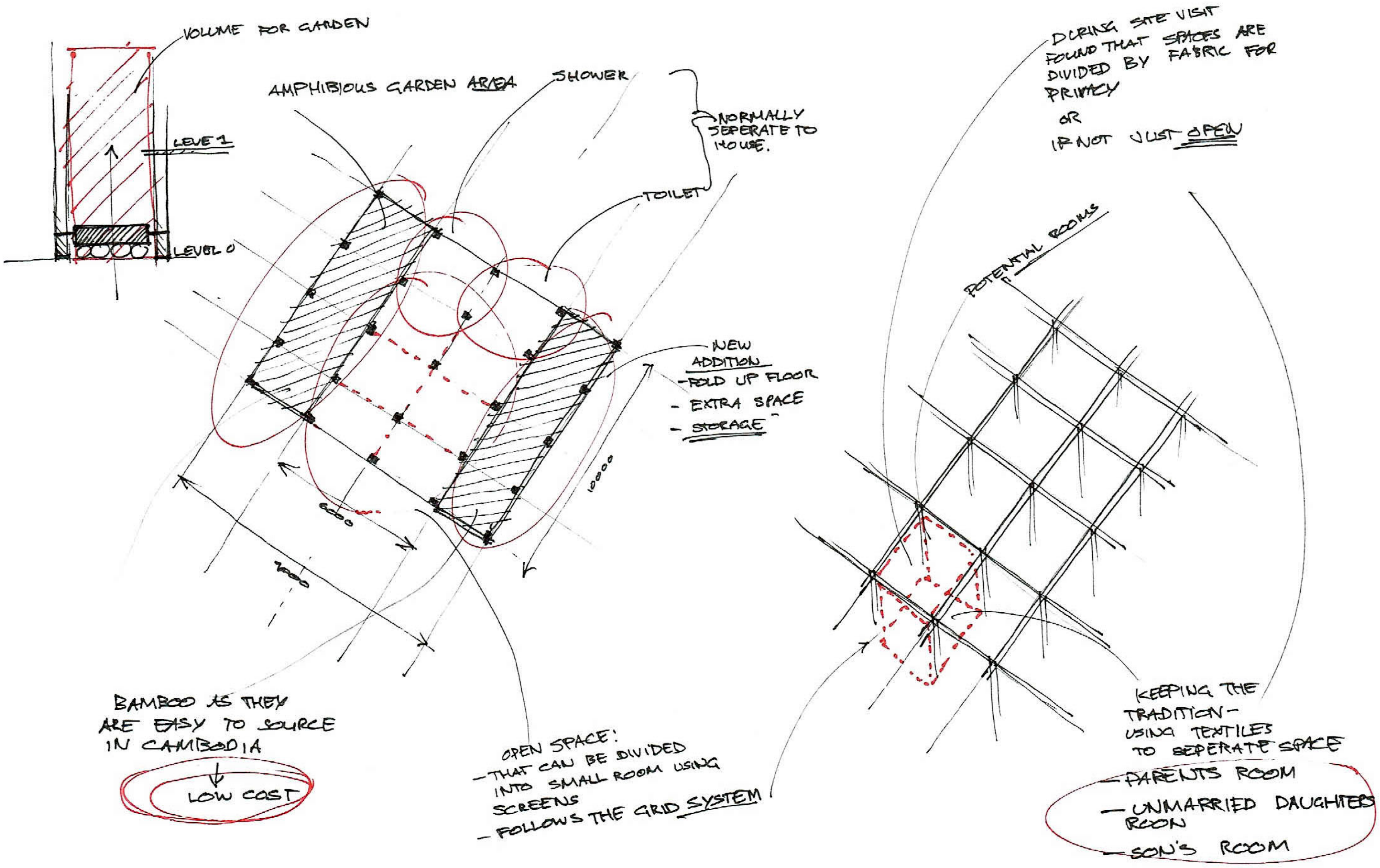


Figure 96. Zoning sketches.

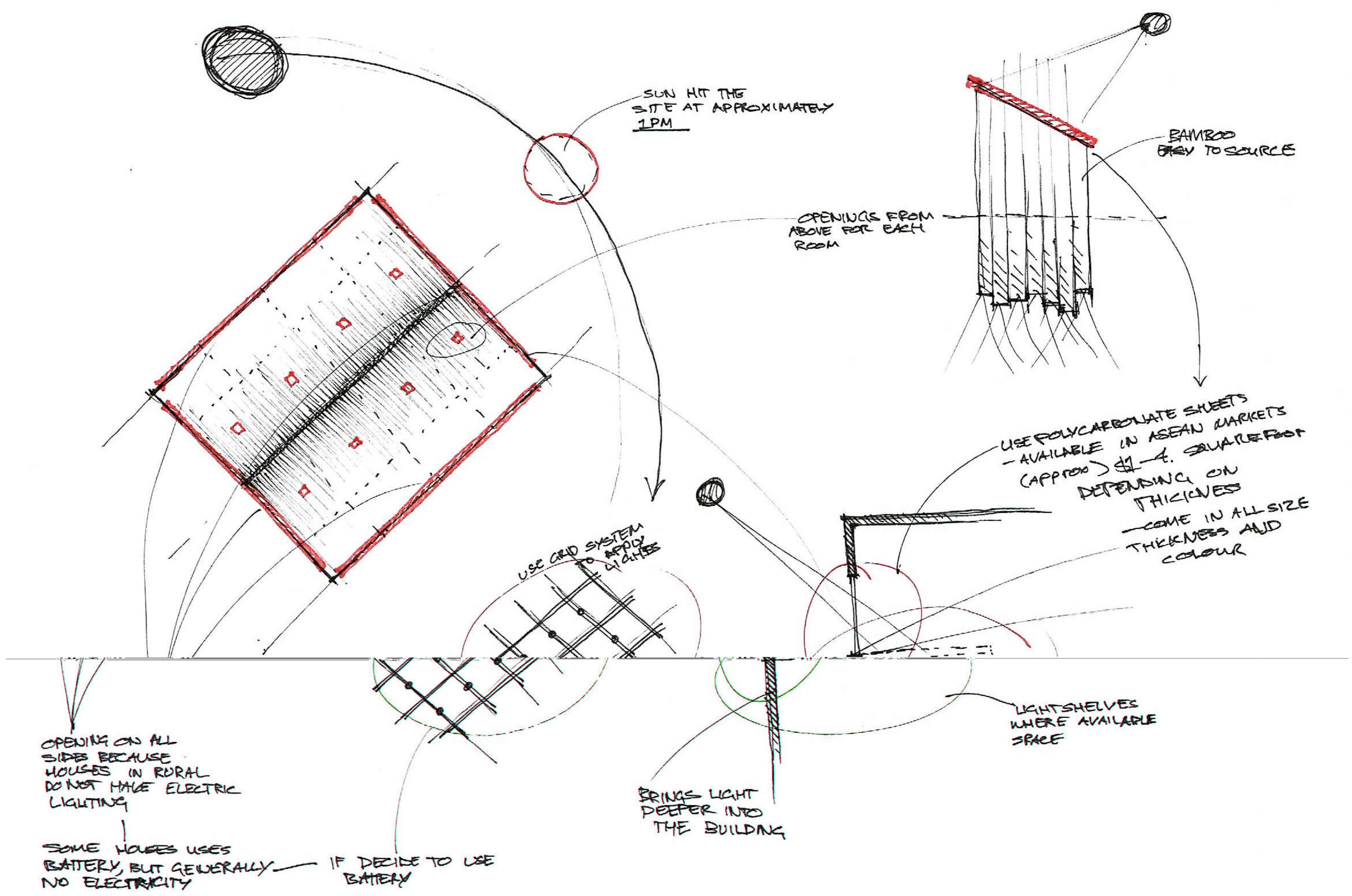


Figure 97. Lighting sketches.

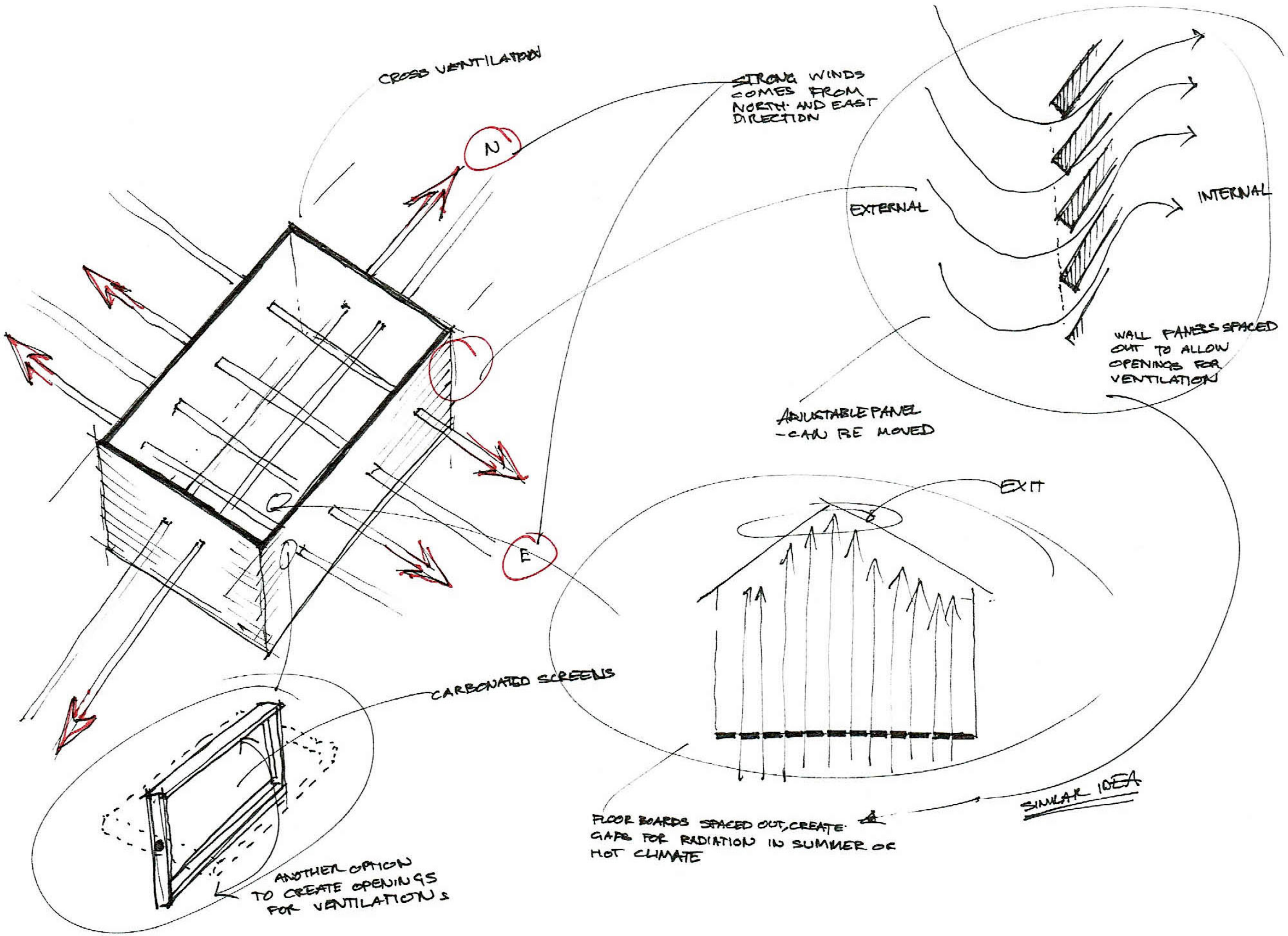


Figure 98. Ventilation sketches.

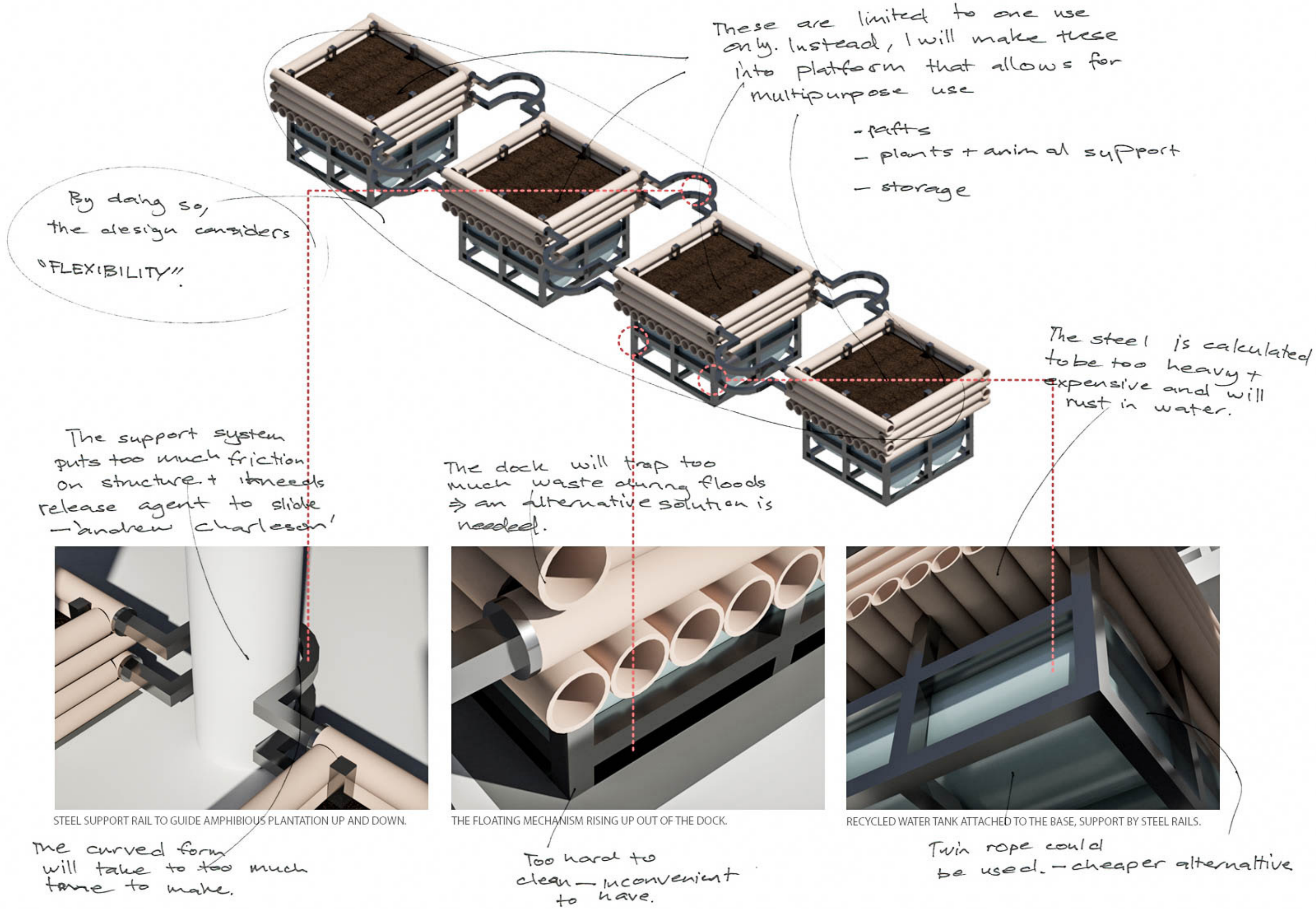


Figure 99. Digital development model – platforms.

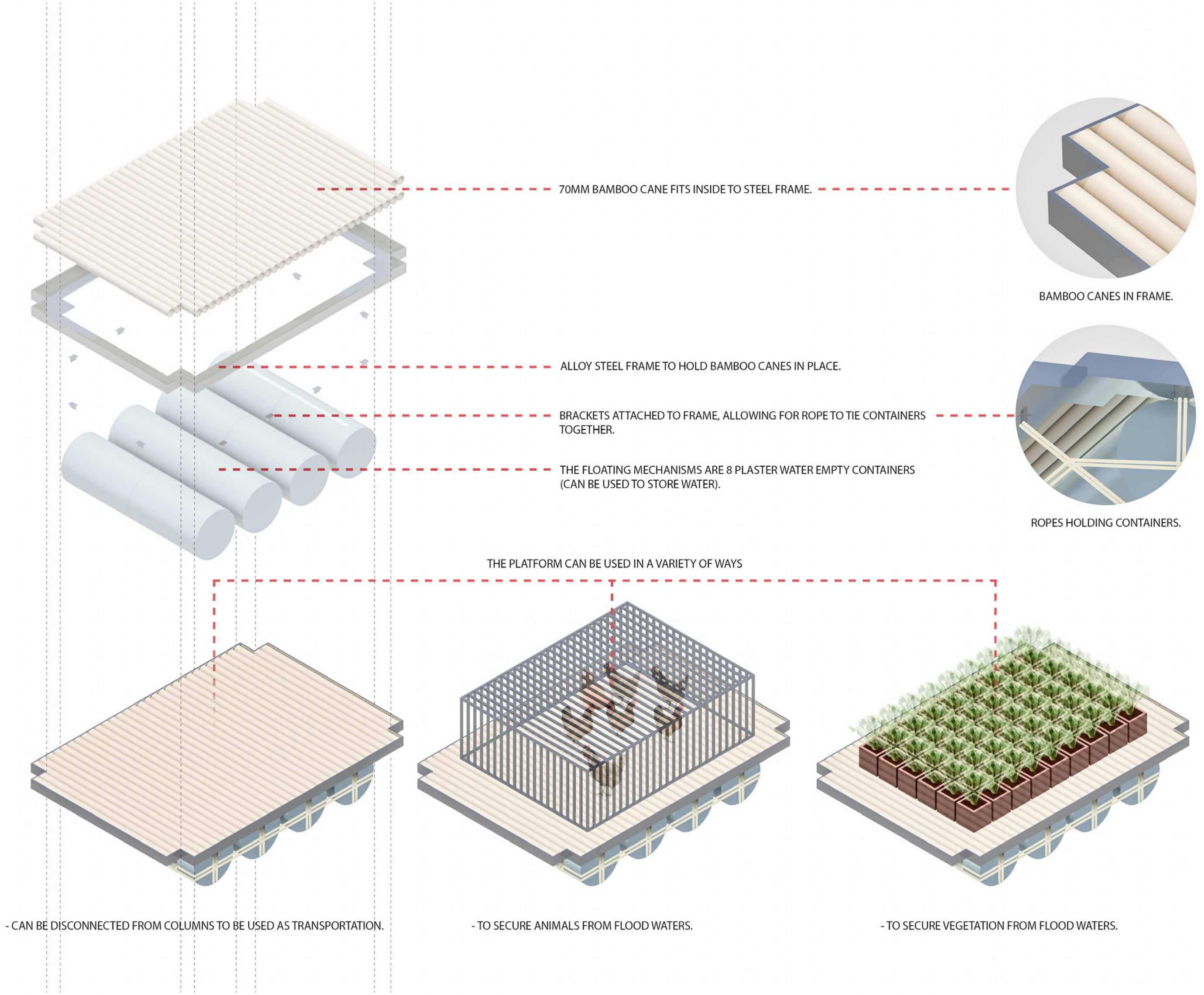


Figure 100. Digital development model – platforms (developed).

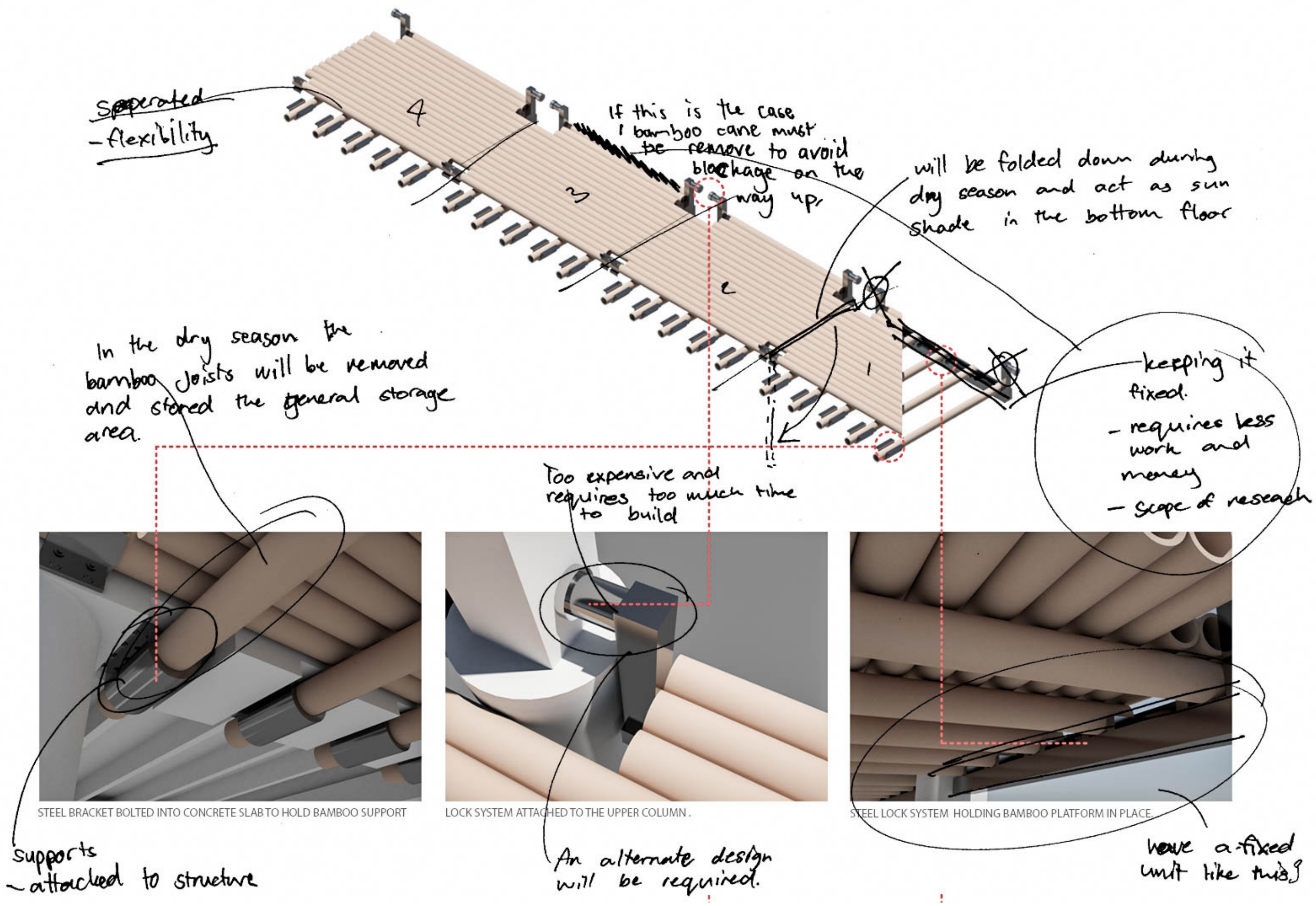


Figure 101. Digital development model – folding floor.

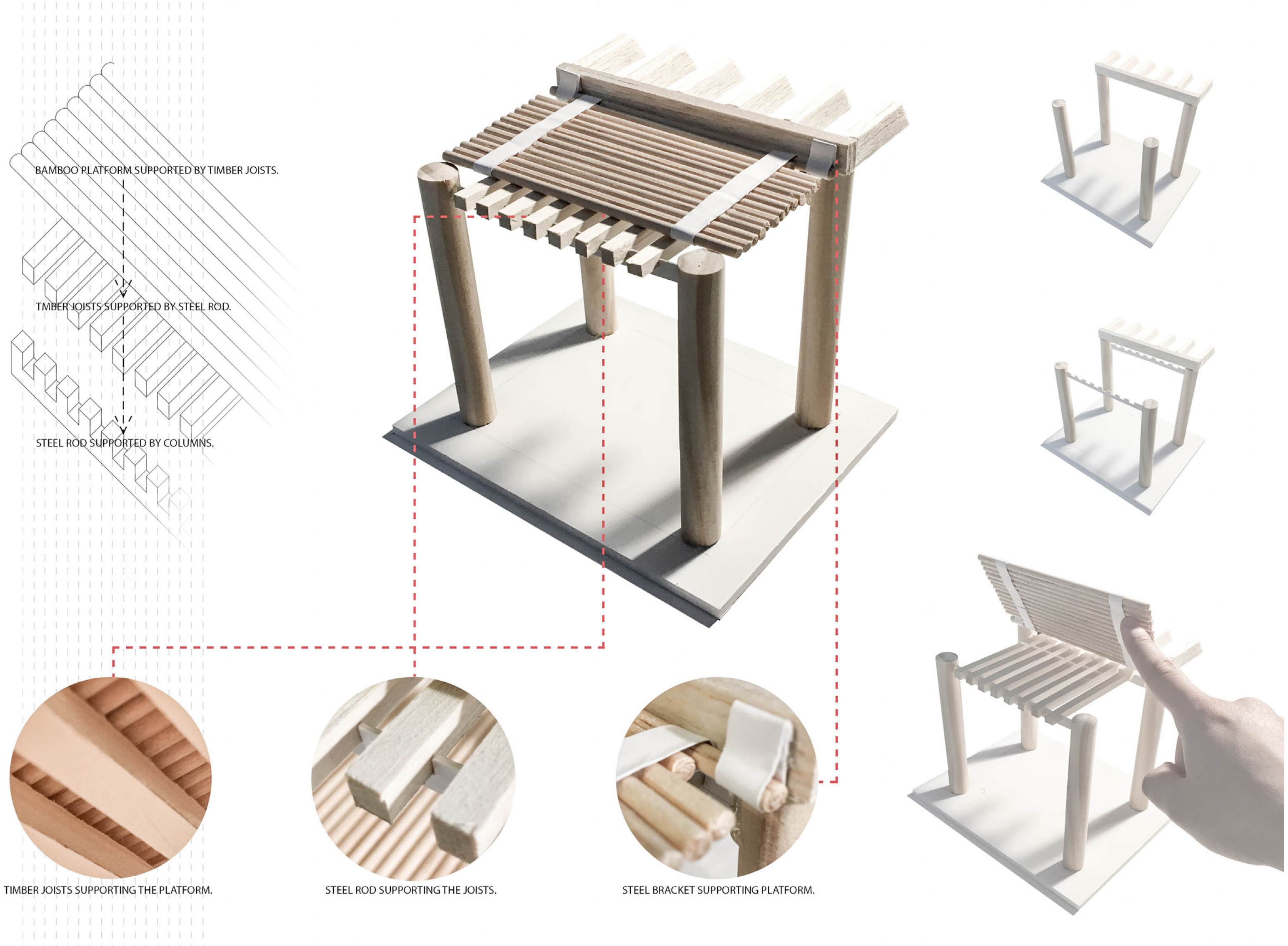


Figure 102. Physical development model – folding floor (developed).

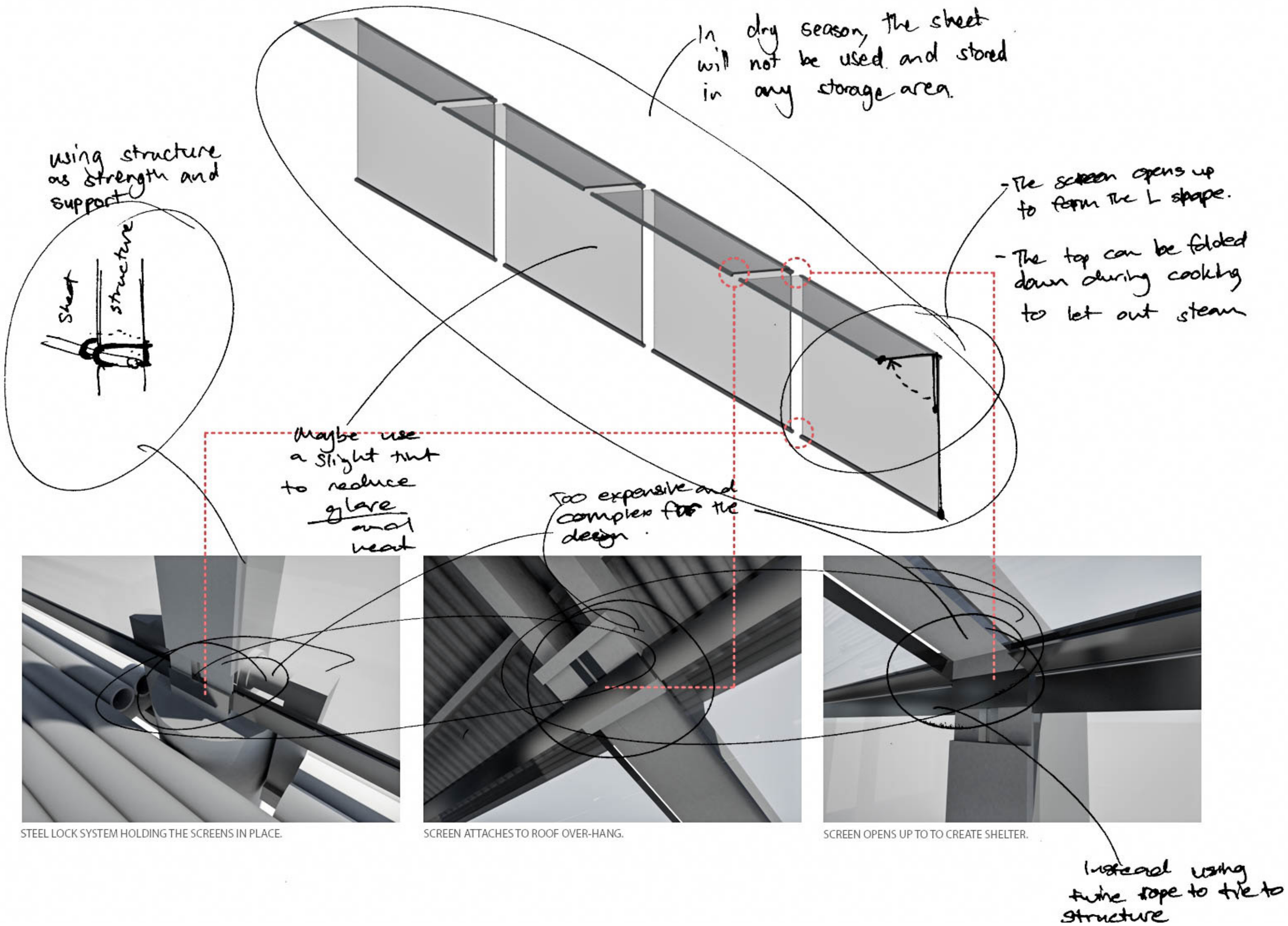


Figure 103. Digital development model – screens.

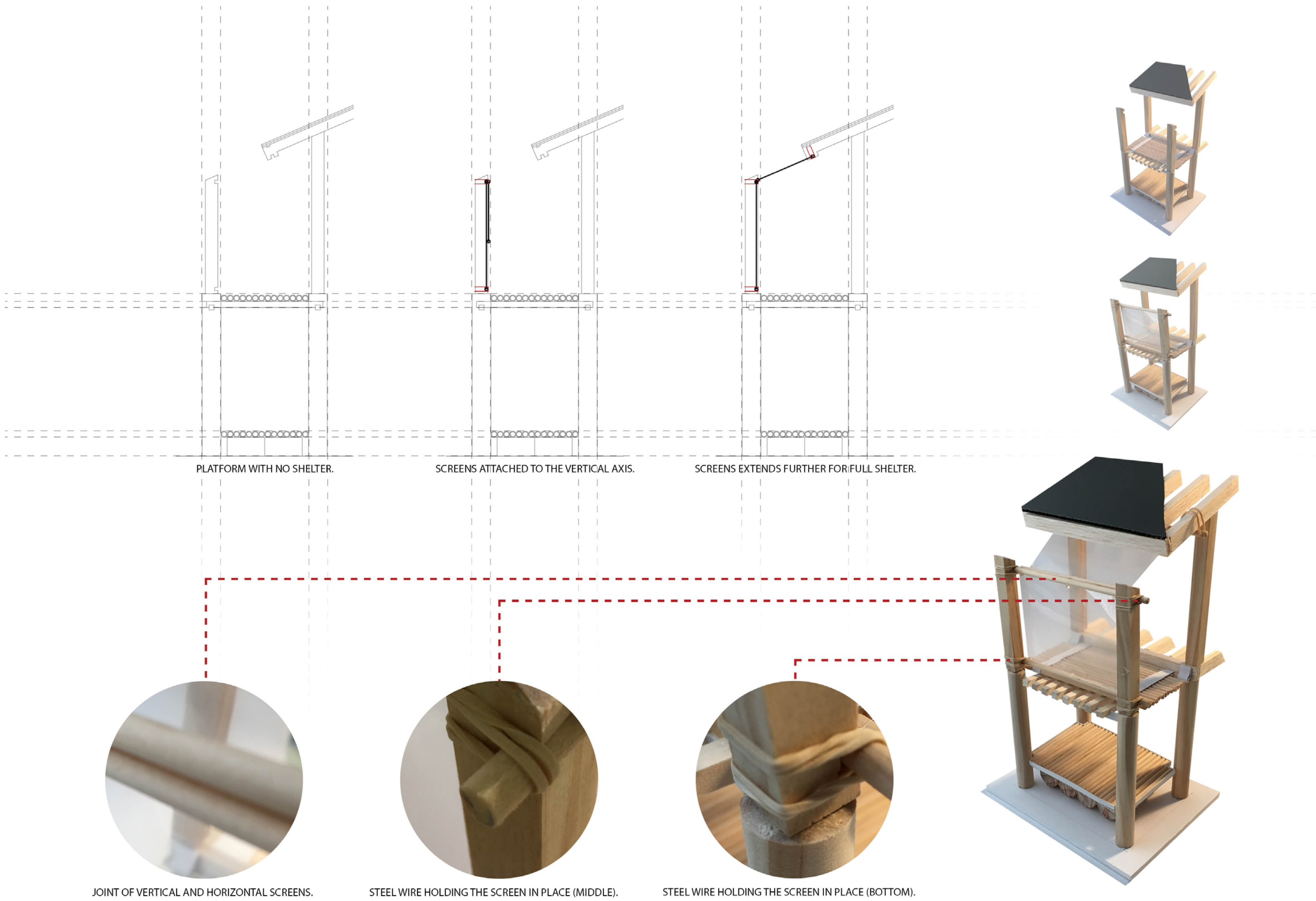


Figure 104. Physical development model – screens (developed).

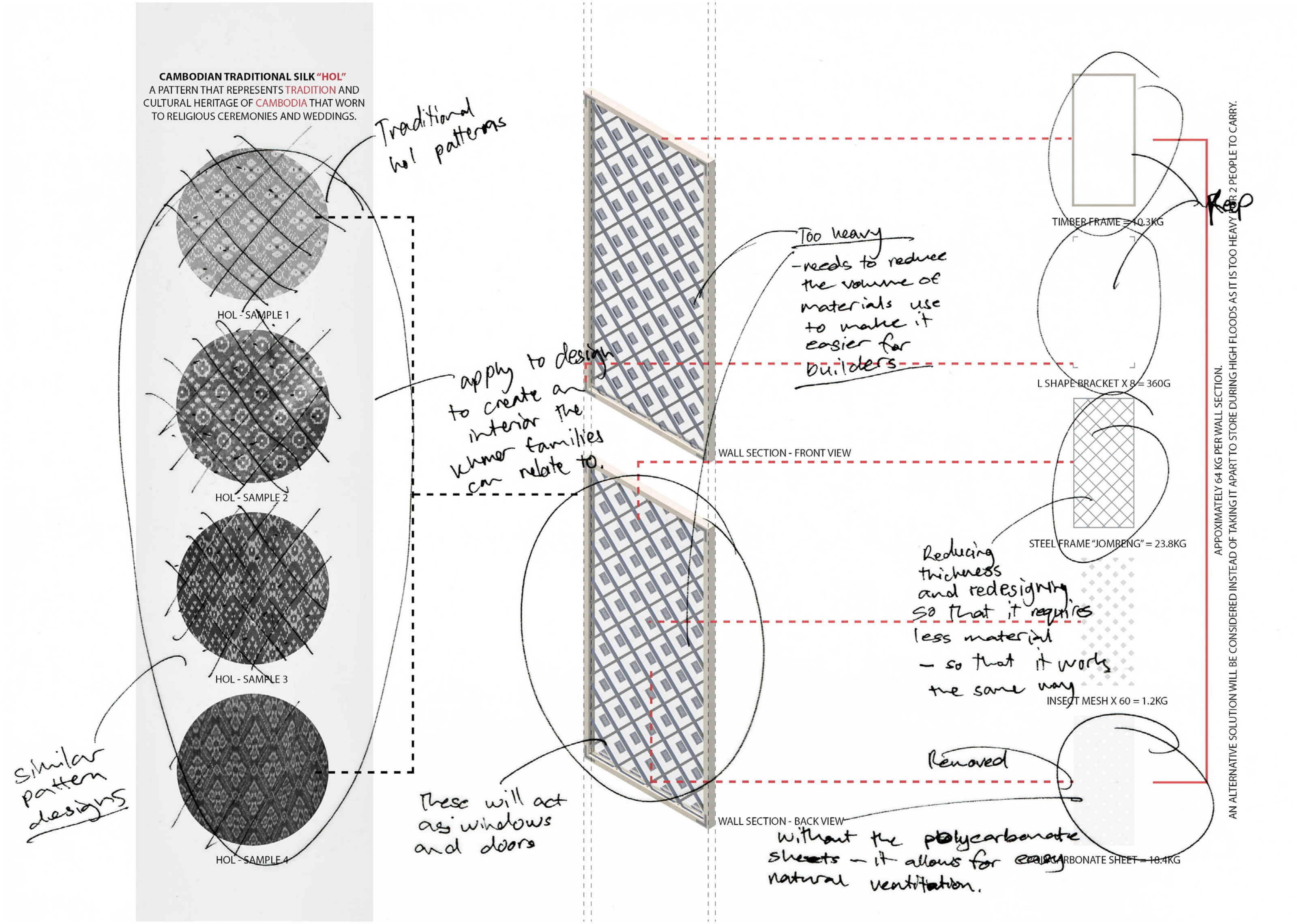
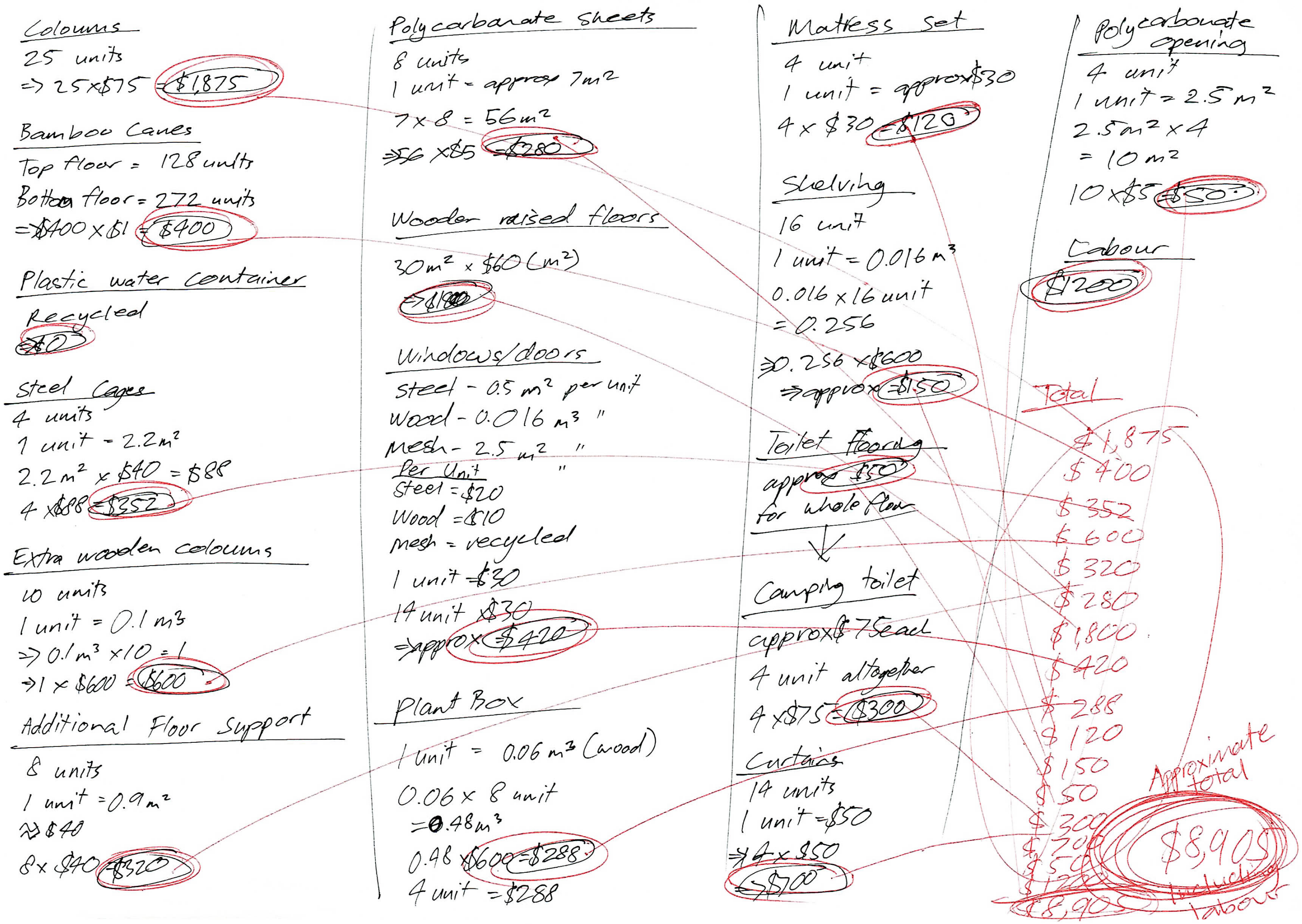


Figure 105. Digital development model – door/window.

APPENDIX 4 – CALCULATIONS



Coloums
25 units
=> 25x$75 = $1,875

Bamboo Canes
Top floor = 128 units
Bottom floor = 272 units
=> $400 x $1 = $400

Plastic water container
Recycled
= $0

Steel Cages
4 units
1 unit = 2.2m²
2.2m² x $40 = $88
4 x $88 = $352

Extra wooden coloums
10 units
1 unit = 0.1 m³
=> 0.1m³ x 10 = 1
=> 1 x $600 = $600

Additional Floor Support
8 units
1 unit = 0.9m²
=> $40
8 x $40 = $320

Polycarbanate sheets
8 units
1 unit = approx 7m²
7 x 8 = 56m²
=> 56 x $5 = $280

Wooden raised floors
30m² x $60 (m²)
=> $1800

Windows/doors
Steel - 0.5 m² per unit
Wood - 0.016 m³ "
Mesh - 2.5 m² "
Per Unit
Steel = $20
Wood = $10
Mesh = recycled
1 unit = $30
14 unit x $30
=> approx = $420

Plant Box
1 unit = 0.06 m³ (wood)
0.06 x 8 unit
= 0.48m³
0.48 x $600 = $288
4 unit = $288

Matress set
4 unit
1 unit = approx $30
4 x $30 = $120

Shelving
16 unit
1 unit = 0.016 m³
0.016 x 16 unit
= 0.256
=> 0.256 x $600
=> approx = $150

Toilet Flooring
approx $50
for whole floor
↓
Camping toilet
approx $75 each
4 unit altogether
4 x $75 = $300

Curtains
14 units
1 unit = $50
=> 14 x $50
= $700

Polycarbonate opening
4 unit
1 unit = 2.5m²
2.5m² x 4
= 10m²
10 x $5 = $50

Labour
$1200

Total
$1,875
$400
$352
$600
$320
$280
$1,800
$420
$288
$120
$150
$50
$300
$700
$50
$1200
$8,905

Approximate total
$8,905
Including labour

Figure 106. Cost of project.