Affordable and Sustainable Design for Rural Houses in Cambodia

by

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Submitted in partial fulfilment of the requirements
for the degree of Master of Architecture

at

Dalhousie University
Halifax, Nova Scotia
March 2014

CONTENTS

ABSTRACT

This thesis investigates a new prototype for housing in rural Kampot, Cambodia with a focus on the health and safety of the inhabitants. This study came about because traditional Cambodian houses are rapidly disappearing and being replaced with concrete walls on the lower level, a space that was previously left as open- concept and was comfortable as such in the Cambodian culture. By studying both traditional and contemporary houses during my research time in Cambodia, I discovered that it was not the vernacular home-making techniques that needed improvement, but rather the concerns of health and safety that needed to be addressed.

My thesis proposal is to design an affordable and sustainable home in rural Cambodia with the primary focus on the following issues: waste management, water collection/filtration, Cultural adaptability, local material palettes, light quality, airflow, cooking suitability, and security.

ACKNOWLEDGEMENTS

I would like to extend my sincere gratefulness to my supervisor, Richard Kroeker. Richard used his extensive knowledge of vernacular architecture to catapult my ideas and representations to the next level. His steadfast support allowed me to extend the depth of my research and challenge me to go beyond my own expectation.

I would also like to express my sincere appreciation to my advisors, Sarah Bonnemaison and Cristina Verissimo. Beginning as my tutor, Sarah has been witness to my research from its birth, supporting my ideas and guiding me. Cristina always made herself available to discuss my thesis, and encouraged me to think about the proportional design details of my structures.

I express deep gratitude to the Estate of Bruce and Dorothy Rosetti for the scholarship that I received in 2013. Without this scholarship I would not have been able to travel to Cambodia, my birth country, to expand my research through the eyes of a Cambodian Canadian architect.

Finally, I would like to thank my dear family and friends. They have stood by me and supported me from the beginning of my academic journey, and I am sure they will continue to do so well into my future.

CHAPTER 1: INTRODUCTION

Cambodia and Rural Development

There is no universally accepted definition of rural development. One might argue that the term “Rural Development” is to create or improve the standard of living for the people in the rural areas while still respecting their traditional culture, economic changes, social and cultural factors that affect their way of life within their present environment. In the book, “Rural Development: Concept, Approach and Strategy” by B. K. Prasad stated,

> the rural poor, not only because they are the most disadvantage within society, but also because the rural areas in comparison with the urban area...have been relatively neglected... (Prasad 2003, 188)

It was again argued in an architectural journal by doctor Judy Ledgerwood from the Northern Illinois University that in most discussions of Cambodian political and economic development, the focus is around the improvement of the urban center (Ledgerwood 1993). However, generally the majority of peasants who are living at subsistence levels remain invisible and silent. This project is intended to use architecture as one of the tools to help the rural poor that make up most of the total population. It explores rural development as a strategy for improving the living conditions in rural Kampot, which ultimately can be replicated in any other rural province in Cambodia. The purpose of this work is to create an affordable and sustainable home while providing knowledge and understanding regarding health and safety to the rural community members.

Context

Cambodia

Map of South East Asia
(Wikipedia 2013)

Most Cambodians consider themselves to be Khmers and their language is also known as the Khmer language. Cambodia was once a great empire called the Angkor Empire that extended over much of Southeast Asia; however, the empire reached its zenith between the 10th and 13th centuries. Its downfall was caused by the attacks from Thailand and Cham (present-day Vietnam), ushering in a long period of decline. In 1863, the king, Norodom Sihanouk, asked the French for protection. As a result, in 1887 Cambodia became a part of French Indochina. Following the Japanese occupation in World War II, Cambodia regained its full independence in 1953 and the country resumed its economic development (Central Intelligence Agency 2014).

Map of Cambodia and neighbouring countries
(Picasaweb 2008)

Khmer Rouge

On April 17, 1975, Phnom Penh, the capital city of Cambodia fell under the control of the Khmer Rouge, the communist guerrillas led by a despot, called Poll Pot. The gaps between rich and poor were widened and the city residents were forced to move out from the centre of the city into the countryside, some into labour camps (Duong 2010).

On April 17, 1975 when the Khmer Rouge conquered the entire city of Phnom Penh, Pol Pot, the leader of this organization proclaimed it “Year Zero.” He immediately directed a ruthless program to “purify” Cambodian society of capitalism, Western culture, religion and all foreign influence. Pol Pot’s ultimate goal was to mould Cambodia into an isolated and completely self-sufficient agrarian state. This notion was very similar to the ‘Maoism’ ideology, which was the communist doctrine of Mao Zedong (1893–1976) as formerly practised in China. Those who were opposed were killed. Foreigners were expelled, embassies closed, and the currency abolished. Markets, schools, newspapers, national libraries, religious practices and private properties were forbidden, burned down or destroyed (Duong 2010).

The Killing Fields site - Stupa

Moreover, before departing from the city, members of the middle-class, educated individuals, ethnic Vietnamese, Christian clergy, Muslim leaders, members of the Cham Muslim minority, government bodies, police, and military officers were identified and simply executed. This was to make it easy to control the rest of the 'herd.'

During the three years, eight months, and twenty days of Pol Pot's rule, Cambodia experienced the darkest days of its history and an estimated 2 million Cambodians or 30% of the country's population died by starvation, torture or execution. This gruesome holocaust caused at least one loss of a relative in every Cambodian family (Duong 2010).

This horrific period of history still has effects on the people. This can be seen in rural houses where there are metal bars on the windows and concrete walls to protect their families and belongings. To transform this feeling of fear, architectural details such as hiding the metal bars with bamboo and creating a soft light filter are one of the many contributions design can make.

Windows with iron bars.

Kampot Province

Geography

Kampot is situated in Southern Cambodia on the coast of the Gulf of Thailand. It borders Kampong Speu to the North, Takeo and Vietnam to the East, the Gulf of Thailand to the South and Sihanoukville and Koh Kong to the West. The province has an area approximately 4873 square kilometres. The topography of the province is variable, from the coastal region on the southern border to the extensive lowland of paddy fields. Kampot is classified as a rural province of Cambodia (World Food Programme Fighting Hunger Worldwide 2014).

Geology

The climate and the type of soil are very good for growing vegetables and fruit trees. That is why most people grow most of their food right around their home.

In Kampot, the prominent soil is Acid Lithsol. This type of soil is good for drainage, which is suitable for planting rice and other plants around the house. My design is intended to support this sustainable aspect of the culture.

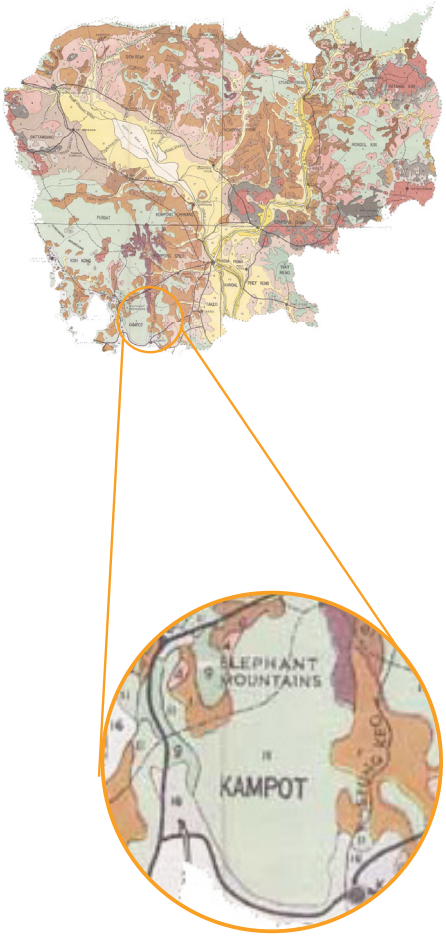
Soil pH

Acid soils (pH < 6.5) tend to be soils with moderate to high deep drainage rates. Generally, the more acidic the soil is, the greater the deep drainage rate.

Neutral pH soils (6.5–7.5) are generally reasonably permeable.

• Red-Yellow Podzolic soils are developed, well-drained acidic soils having thin organic and organic mineral.

• Lithsol is a group of shallow soils lacking well-defined horizons that consisting of partially weathered rock fragments, usually on steep slopes.



Legend

Acid Lithosols

Red Yellow Ponzls

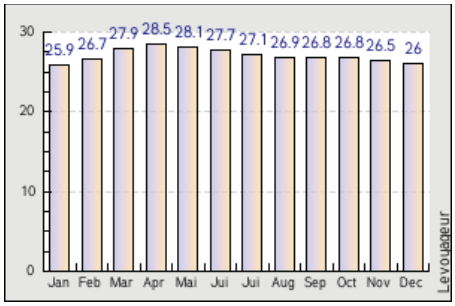
Geology Map - Kampot, Cambodia
(The Soil Maps of Asia 2011)

Climate

It is important to know the particularities of climate in rural Kampot because it helps to understand the shape of the roof structure that adapts to the heat and humidity during the dry season as well as collecting rainwater during the wet season.

Temperature

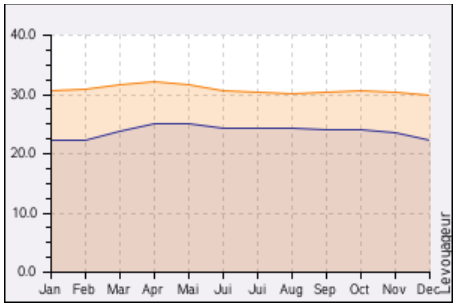
Throughout the month of August, daytime temperatures generally reach their highest at 30°C (85°F). At night, the average minimum temperature drops to around 24°C (75°F). In recent times the highest recorded temperature in August has been 39°C (101°F), with the lowest recorded temperature of 17°C (62°F).



Average Temperatures

Relative Humidity

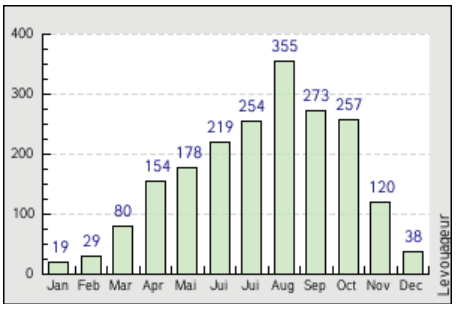
The average daily relative humidity for August is approximately 85%.



Minimum & Maximum Temperatures (Levoyageur 2013)

Precipitation

The average monthly amount of precipitation has been recorded at around 339 mm (13 inches). Throughout the month you can expect to see rain or drizzle falling 20 days of the month.

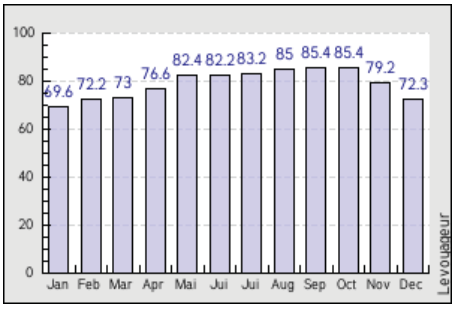


Rainfall in mm

Wind

The average daily wind speed in August has been 17 km/h. In recent years the maximum sustained wind speed has reached 57 km/h.

During my site research it became clear that drinking water filtration and treatment is desperately needed. Therefore, this thesis will explore architectural solutions in the interface between the roof as rain collector and the immediate surroundings of the house.



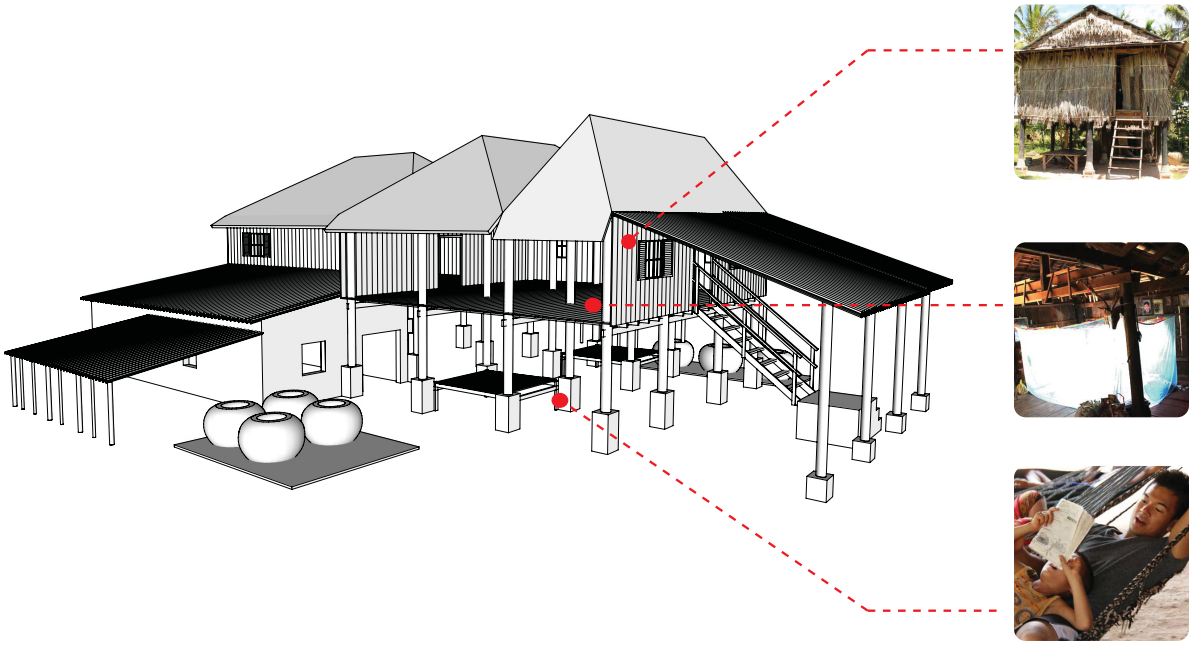
Humidity
(Levoyageur 2013)

CHAPTER 2: BACKGROUND

Existing Architecture

The Vernacular

After my research trip to rural Cambodia, I believe that traditional architecture has been deeply influenced by everyday life, cultural values, and vernacular construction methods. It was clear to me that what is classified as ‘vernacular architecture’ is solely based on material culture and ways of dwelling and living in that environment. However, with the shifting in technology of modern materials, economy, and with social and cultural factors these traditional buildings are slowly disappearing.



A traditional home with a concrete box near the main structure.

Architecture of Kampot Province

Wall Envelope

Different ways to keep the weather out depends on the financial means of the family and the materials available. Low-income farmers tend to have a simple house and walls made of woven palm leaf matting, which is sufficient to keep the interior space dry during the wet season. The process of palm leaf matting is labour intensive, but it does not rely on imported materials and it does not cost any money. A more expensive house would have wooden boards for the exterior envelope aligned mainly in a vertical direction to prevent the wood from rotting. The boards are butt jointed; in some cases joints are covered with a strip of bamboo.

Traditional palm-matting envelope

Open Floor Plan

Cambodian people prefer to have an open floor plan, because it creates a more spacious room. This concept also allows families to adapt to a variety of family member size, storage, a place for guests to sleep, and a safe place to retreat at night. If a family has a daughter, she will have an enclosed bedroom at the end of house. The parents usually sleep at the front bay of the house facing south or north, closer to the door for more protection. This simple floor plan also provides a free flow of natural ventilation, which is essential for this hot climate as well as preventing the materials from rotting during the monsoon season.

Open plan - bedroom for a son

Interstitial Space

It is common practice for the rural Khmer people to have a house on stilts in response to the seasonal floods or during the monsoon season. The other reasons could be to protect the family members from wildlife, such as snakes, and to create a cool shelter under the house during the warm, dry season. With temperatures ranging around 38 degrees Celsius and 80% humidity during the day, the house functions as a large umbrella for the interstitial space below. Work and life go on at ground level, in the breathy and shaded space. This area is used for eating and resting, as well as craftwork and various other tasks.

Living/relaxing space down below

Kitchen

Cambodian culture differentiates between cooking, living, and sleeping zones. Generally, the kitchen of Khmer houses is located at the back of the house, either a couple of steps lower than the upper floor or enclosed away from the living and sleeping spaces. Often the kitchen is situated in a separate building near and behind the main house. However, recently, most people have moved the kitchen below the house to eliminate going up and down the stairs.

Traditional open fired kitchen

Furniture

The Khmer people in the rural communities do not have many possessions. However, an essential item - found in all houses - is a low wooden bed (Westerners would refer to it as a platform). This multifunctional piece of furniture is set one foot off the floor when it functions as a bed upstairs and is set two feet off the floor when it functions as a place to sit and eat underneath the house. Since the climate is very warm, especially in the afternoon, resting in a hammock under the house is a vital part of every household. There may be some other furniture on the upper floor, but it tends to be moved and placed against the walls to open central living space. Finally, a simple shrine for a Buddha or the urns of members of the family that have died are housed on a sideboard. This is very important to the culture.

Traditional wooden bench/bed

Access

Access to the upper floor is a special feature of Khmer houses. It is a transition from the eating and cooking space to the living and sleeping area. The shoes must be removed and sometimes there is water pottery near the stairs for washing the feet before going up the stairs. The simplest form may be a wooden ramp and ladder with partially built-in masonry. This means that these modes of vertical access were formerly handmade. Today, prefabricated concrete stairs are cheaper and more widely used than full wooden stairs.

Main access (concrete block and wooden stairs)

Adaptability

A rural house consists of a supporting frame, where each post stands on an individual concrete foundation. There are no bracing or shear walls to strengthen the structure. The roof is built before the wall cladding is applied. Sometimes a family cannot afford to include the envelope so the house remains without sides until they can afford it. In traditional houses, transverse and longitudinal rigidity is achieved by placing the horizontal joists through a gap in the piles, in close proximity, one above the other. Wedges are used to lock the joists in position. Nowadays, this labour intensive technique is less used; instead the joists consist of two identical beams that are placed on either side of the pile. They are then fixed by screws or nails. Most importantly, rural Khmer houses are built to accommodate adding an additional bay structure to the old structure as their family grows. The traditional way is to disassemble the house into components and move it to an area with a bigger lot to build a larger house for the family.

Construction of a traditional home

Transitions of Traditional Khmer Houses

The architecture of the traditional Khmer house and the spiritual meaning of the home play an important role at the centre of Khmer culture. However, with the advent of modernization, urbanization and industrialization, traditional Khmer houses have undergone changes. The interstitial space below the house for example, is being enclosed by concrete walls, a space that was previously left open. The upper structure of the building was wood, with handmade palm or bamboo matting. Most of the middle class houses now use wood boards for wall cladding. For the roof, clay tiles and corrugated tin panels replace the conventional thatched roof that simply provided protection against the sun. One of the concerns is that with the use of modern building materials this may alter the basic structure and leads to a significant decrease of much needed ventilation.

Traditional to Modern

Khmer Houses

Bet House

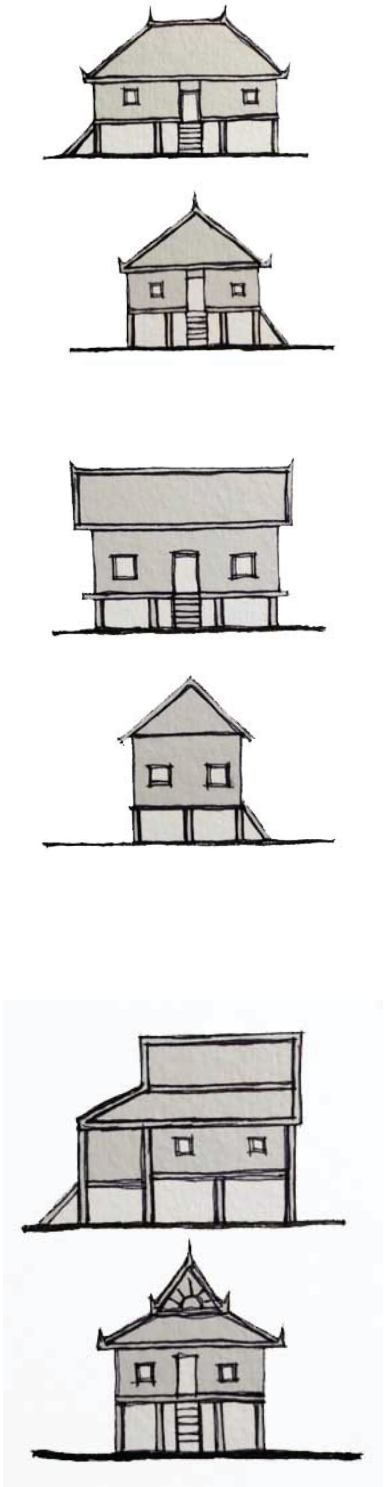
This house has a hip roof where all sides slope fairly gently downwards to meet the pillars or the walls. Therefore it is a house with no gables or other vertical sides to the roof.

The Kantaing House

This type of house usually has no front or back porch. A long Kantaing house is built ten by six meters with three main columns supporting ridgepoles, whereas a short Kantaing house, six by four meters, requires just two center columns. The popularity of this type of house is shorter in length with a gently sloping roof for easier construction. Today it is popular amongst Cambodians, but in the past century it was housing used more by the Chinese and Vietnamese.

The Khmer House

The type of house style begins with the erection of four lines of pillars and crossbeams. A King post is the crucial structure used to build the roof. This type of house combines a high steeply sloped roof and a big lower gable. The high roof gives a beauty to the house and has a resemblance of the roof to a temple from a distance. The same is true with other types of Cambodian traditional houses; the top floor or enclosed floor is used for living and sleeping at night and the open floor below is used for working and relaxing during the day. They usually build this kind of house small and short, approximately four by six meters.



Rural Khmer Houses.
(Khmer House 2011)

Roong Daol House

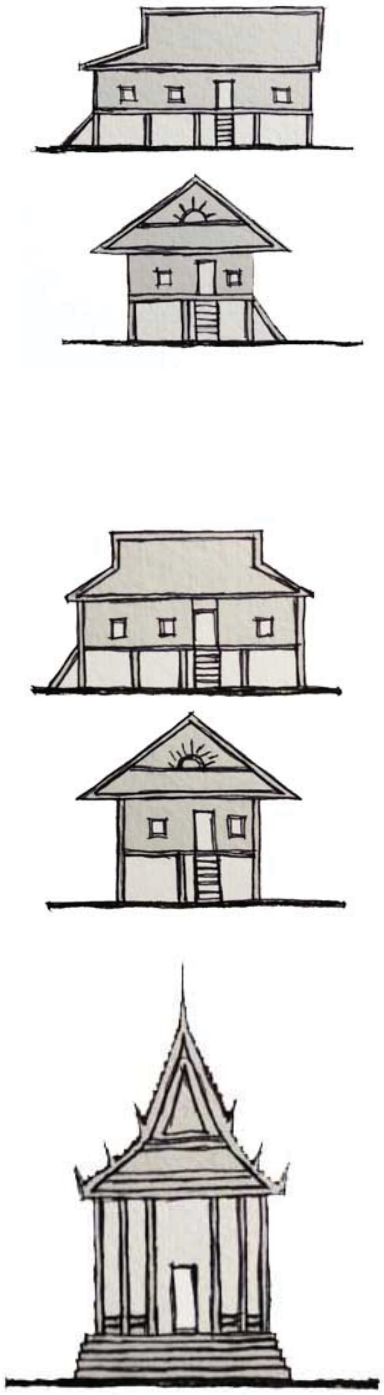
This type of house is built into a long shape with shoulders for carrying the weight of the house: joining the roof-rafters. There is a small gable at the intersection to create a front porch. For a smaller family, people tend to build this one with three center pillars and four compartments. A larger family might desire a building with four center pillars and five compartments.

Roong Doeung House

This type of house has a large roof with both awning end pieces at the front and the back of the house. The back end piece of the roof creates a shelter for a rice mill for agricultural use. Most of these houses have three lines of pillars, which provides four compartments.

Keng House

This type of house is very rare for people to build for living purposes. A Keng House is built mainly for monks or royal monks. A very similar style is also used to house statues of the Buddha for religious purposes.

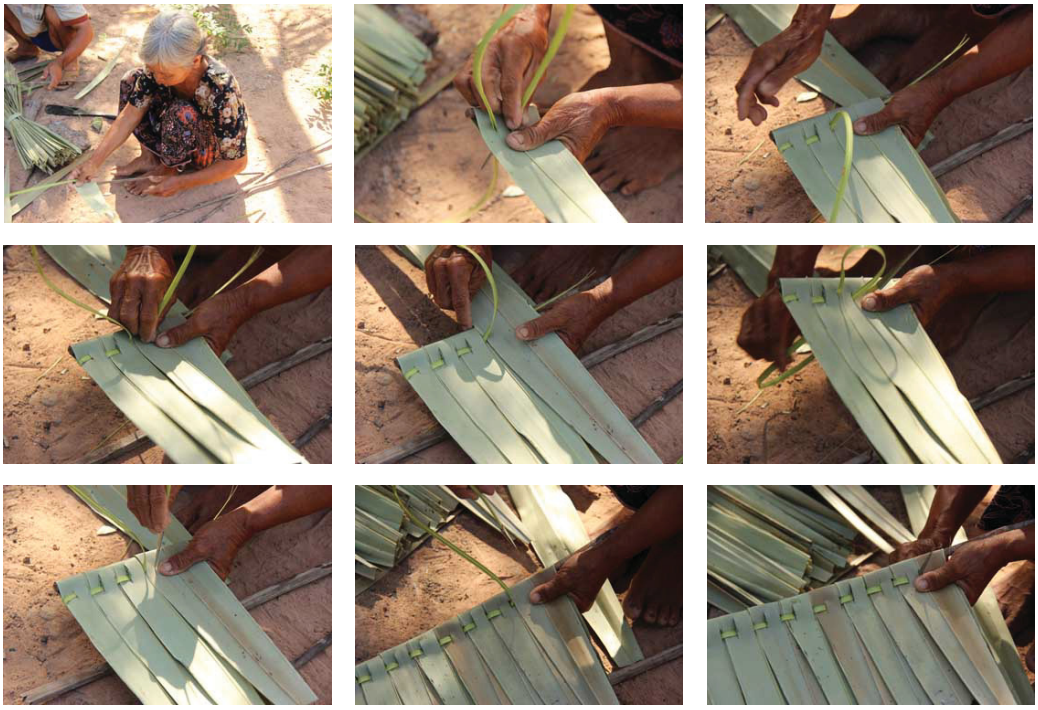


Rural Khmer Houses.
(Khmer House 2011)

Cultural of Making

Wall Envelope/Roof - Palm Leaf Matting

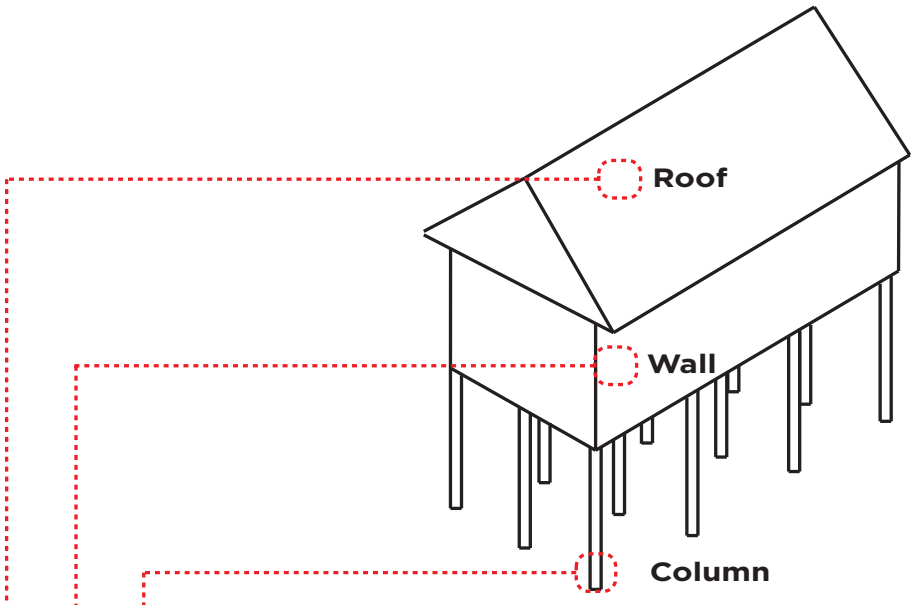
Palm leaf matting is the simple construction for an envelope or a roof of the house. It was very interesting to learn that in order to preserve the palm leaf matting from being so brittle, one should soak the leaf in water for a couple of nights and then dry them in the sun before starting to stitch them together. Moreover, it was evident when I was in Kampot for my research that the knowledge of making these is slowly disappearing with the new generation. That means only the elders know best how to do this matting. Therefore, it is very important that the new design will integrate traditional methods of construction while incorporating other types of construction using local materials.



Sequence of stitching sugar palm leaves

Materials Palette

Local Resources in Rural Kampot




Wood Post and Rock


Wood Column


Wood and Concrete


Concrete Column


Palm-Leaf Thatch


Woven Reed


Wood Siding


Brick and Concrete


Palm-Leaf Thatch


Woven Bamboo

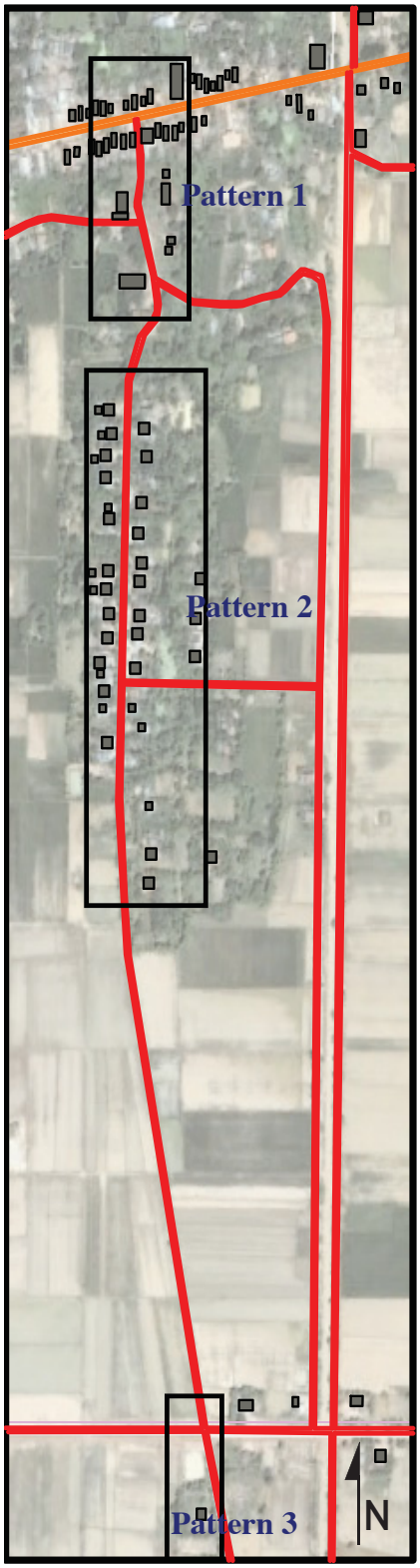

Clay Tiles


Corrugated Metal

Case Study of a Rural House

Tuk Meas, Kampot, Cambodia

Three Types of Settlement Patterns in Kampot Province



Three settlements patterns in Kampot province

Legend

- Residential Buildings
- Communal Buildings
- Roof Orientation
- Building Entrance
- Main Road
- Street

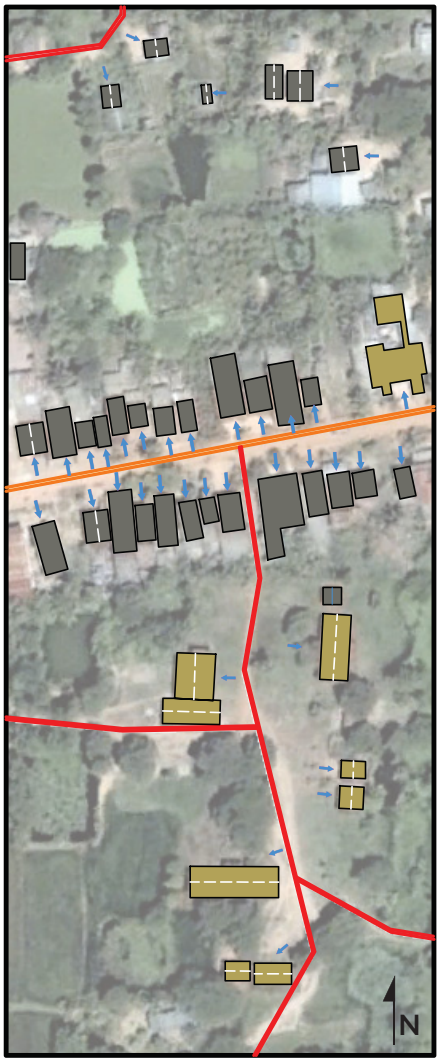
First Type of Settlement Pattern

* Houses are situated in a linear pattern along the main road.

* Houses are narrower than the second settlement and have a tendency to be concrete and have flat roofs.

* Entrances face the main road.

* Houses are built on the ground.



Settlement pattern that is close to the main road

Second Type of Settlement Pattern

* This settlement is arranged in a linear pattern along the street.

* Rooftops are parallell to the street.

* Houses still have the main entrances facing the street and are on stilts.

* Lots are bigger than the first settlement, because they are not on the main road and therefore less expensive.

This thesis will be focusing on this type of settlement pattern.

Settlement pattern that is close to a busy street

Third Type of Settlement Pattern

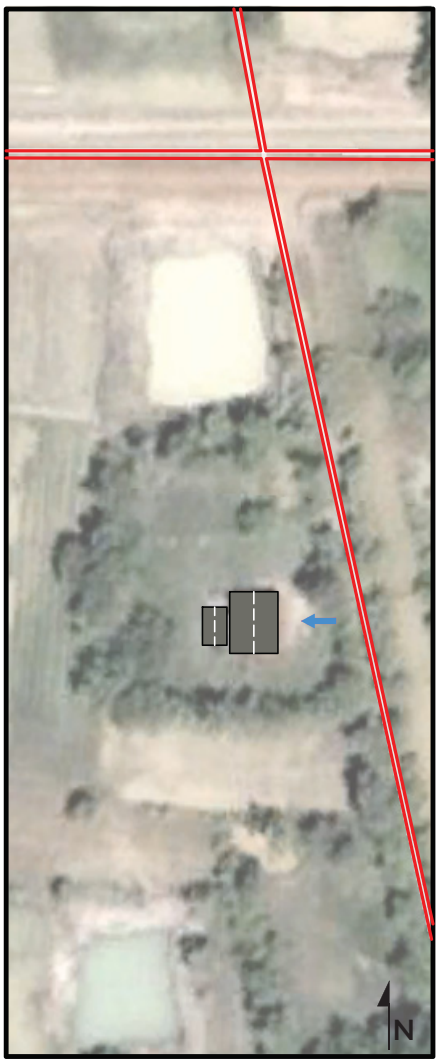
* This single dwelling has the entrance facing east, which is part of the culture.

* There are banana trees, coconut palms, sugar palms and a garden.

* The house is mainly made out of wood and elevated off the ground.

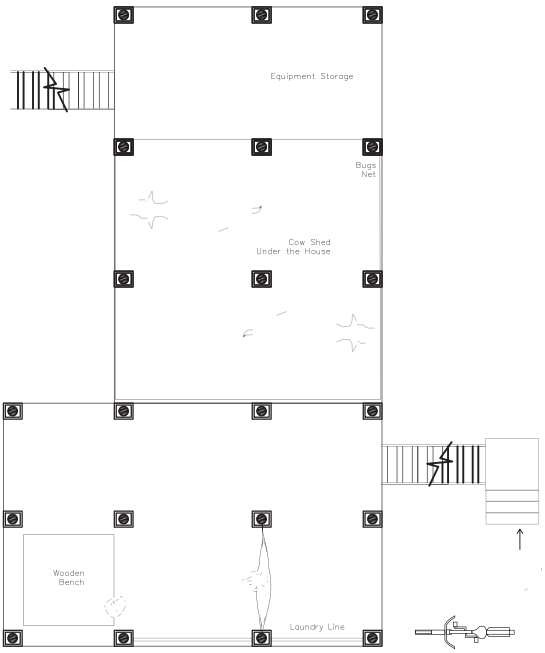
* The inhabitants always sleep facing North or South.

This thesis will be focusing on this type of settlement pattern.

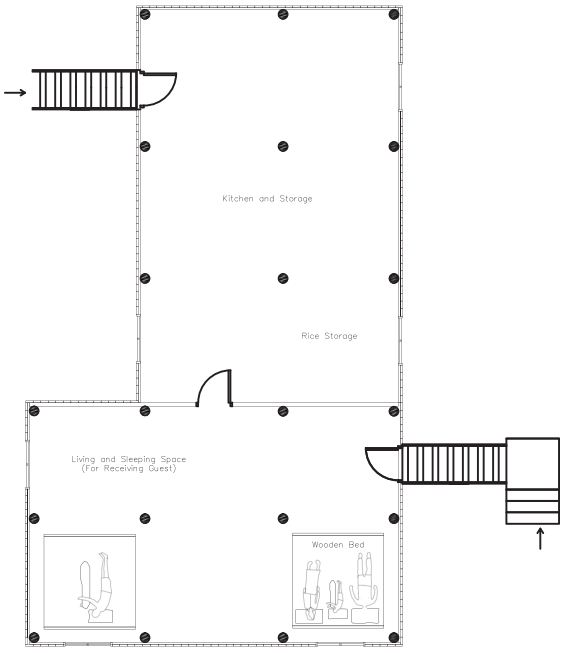


Settlement Pattern that is far from a busy street

Year 1999
Ground Floor

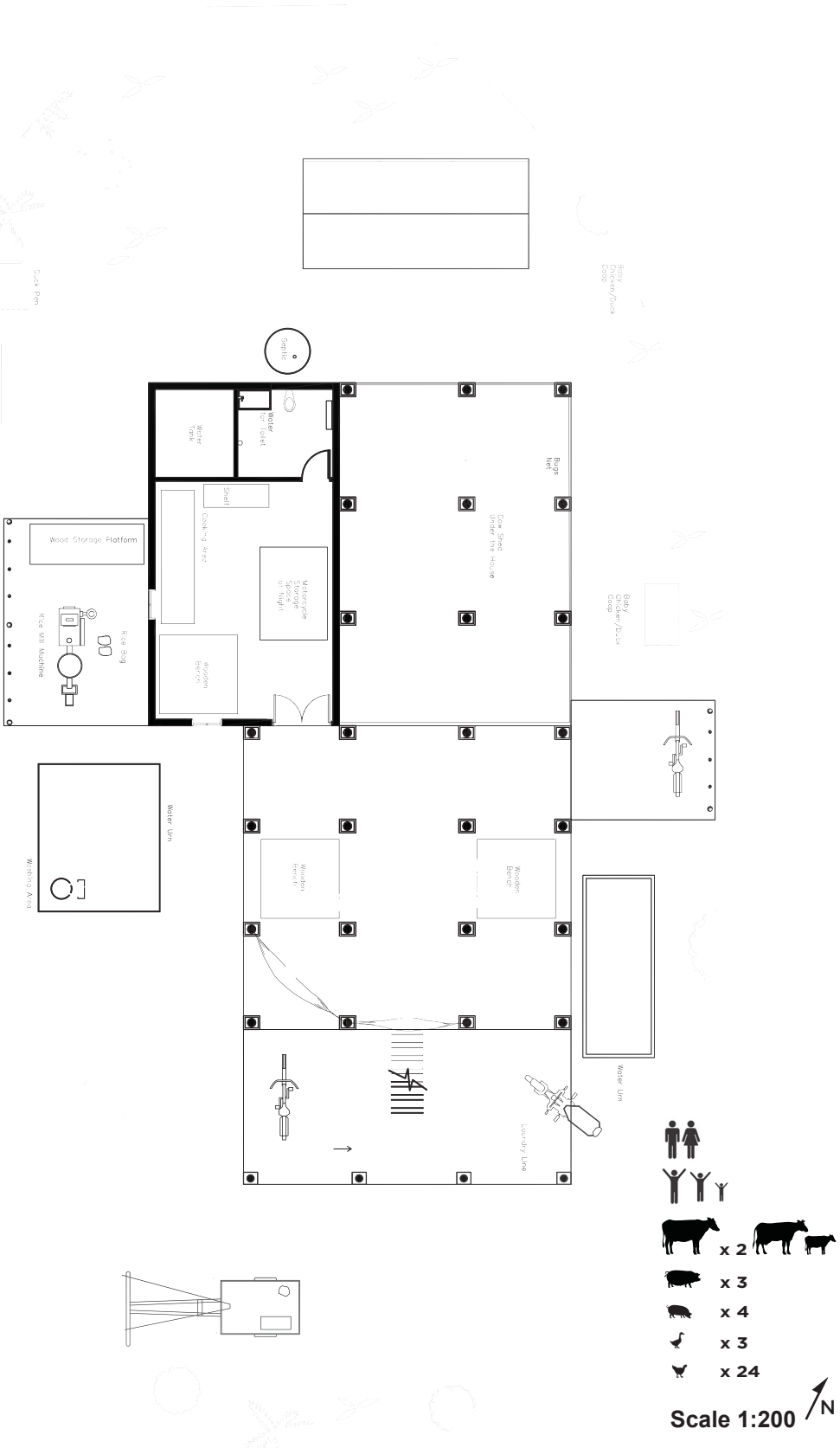


Year 1999
First Floor



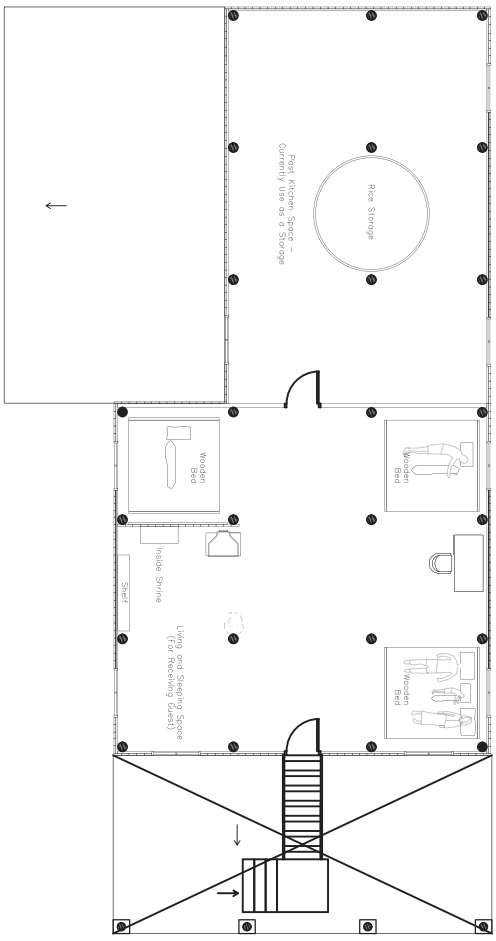
Scale 1:100 N

House Plans - Before Moving



Year 2013
Ground Floor

House Plans - Current Condition



Year 2013
First Floor

x 2
x 3
x 4
x 3
x 24

Scale 1:200 N

House Plans - Current Condition

House Section Elevations - Current

Year 2013
East Elevation

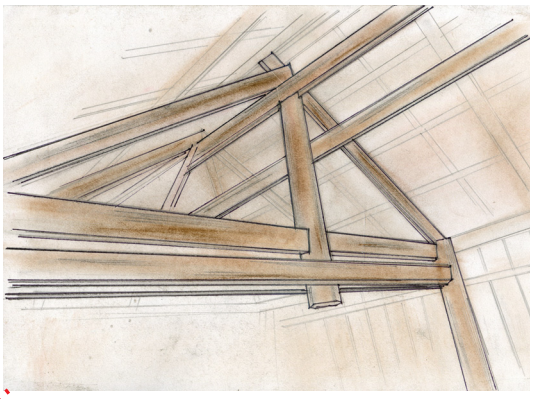
This sectional elevation intends to show the relationship between the ground/rice fields and the house. Most of the rural houses are built on stilts for seasonal flooding, however for some people it is simply a cultural way of building or living. This drawing shows the house is on a higher ground, approximately three to four feet above the rice fields.

Year 2013
South Elevation

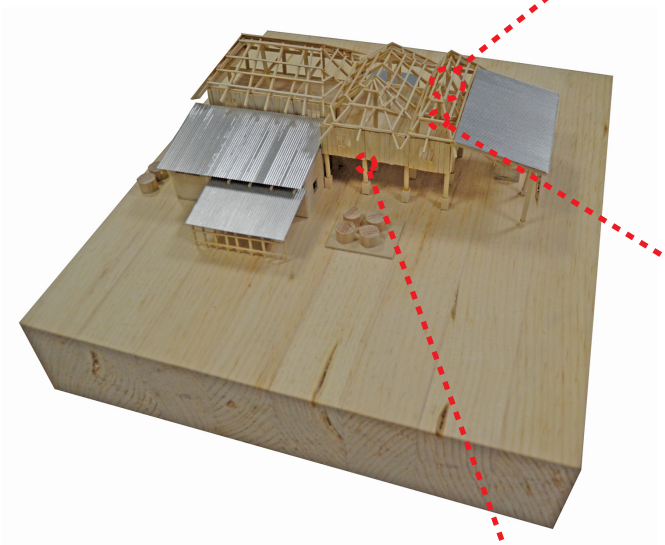
This model elevation aims to express the openness of the house to the surrounding environment. The south envelope of the house in the model is left open in order to show the open concept plan that is common to many Cambodian families, because it provides a more spacious area.

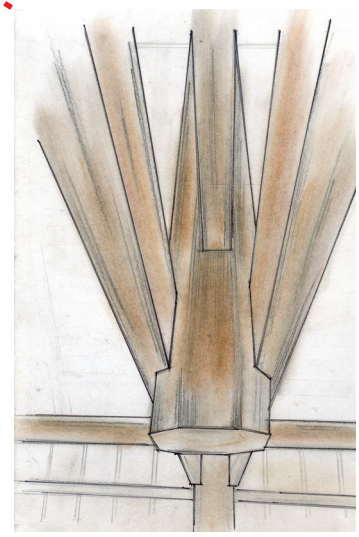
House Details - Current Condition

It is important to understand what are permanent and what are temporary spaces when designing a rural home. This detailed drawing intends to express the simple connections between column to floor, column to wall and column to roof with the slot and joint method of construction. This means the materials can be reused in the future.

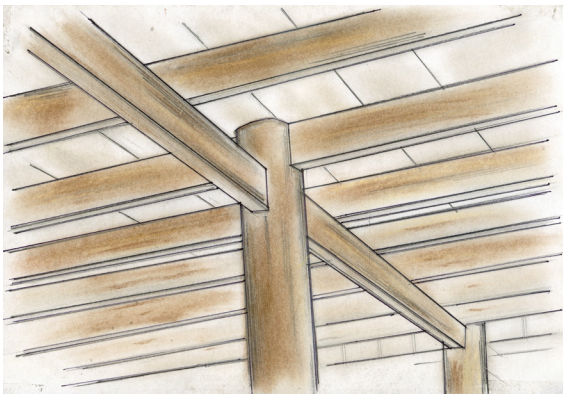


Column to Roof





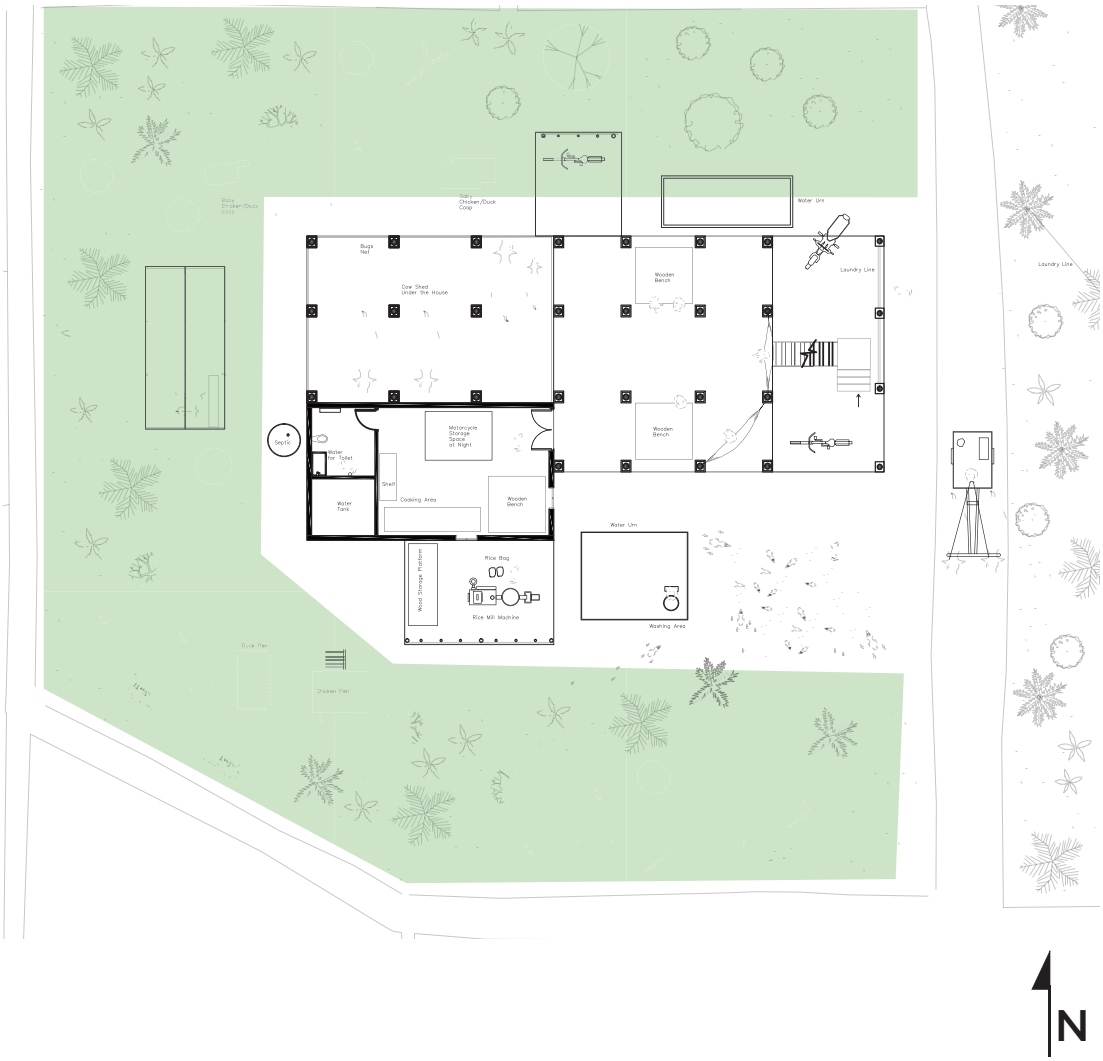
Column to Wall



Column to Floor

Cultural Findings

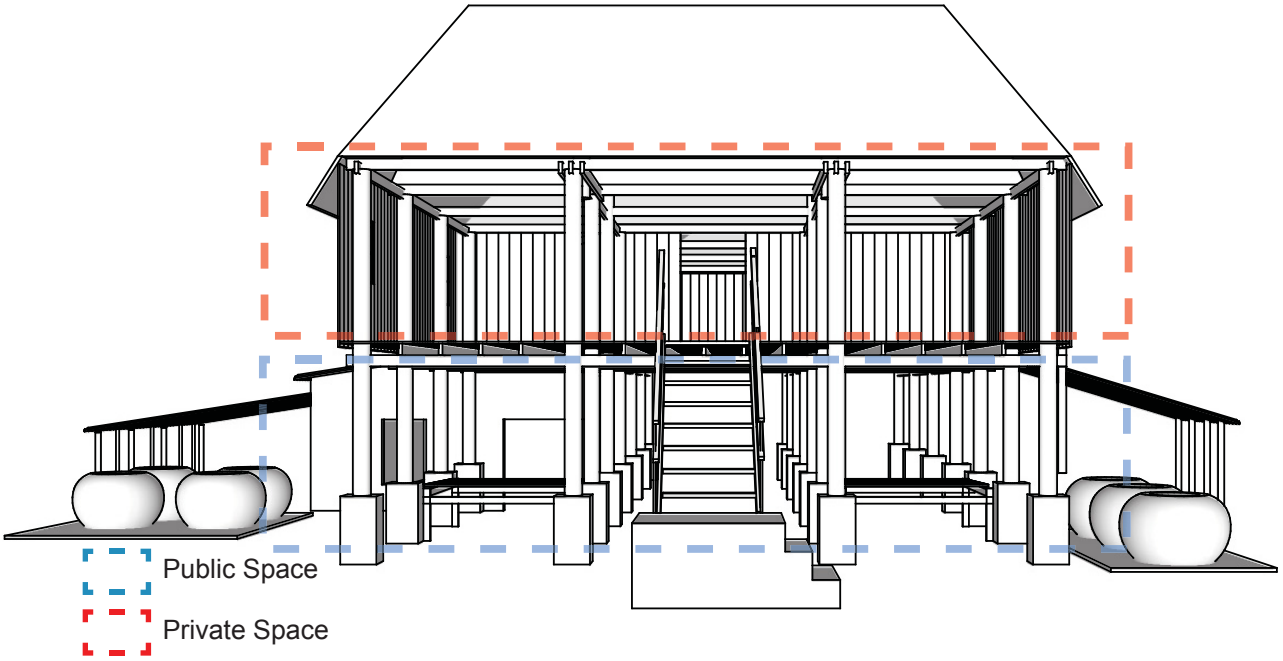
Traditional Living in a Rural Area



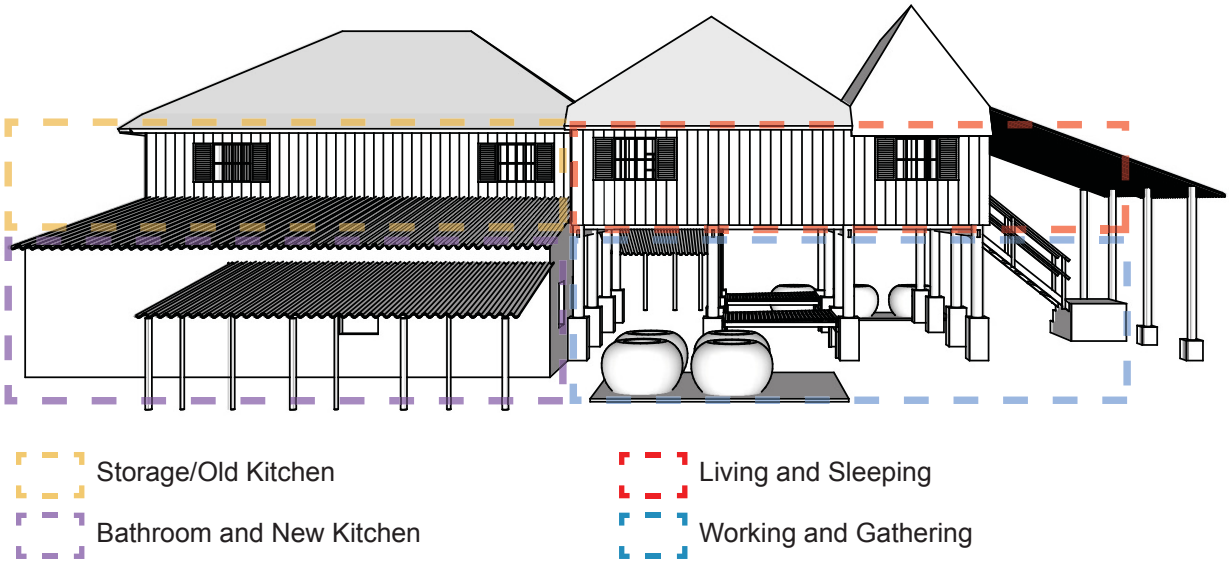
Coconut palms, sugar palms, banana trees, and critters

* Note: These plants around the house also provide a sense of security for the inhabitants.

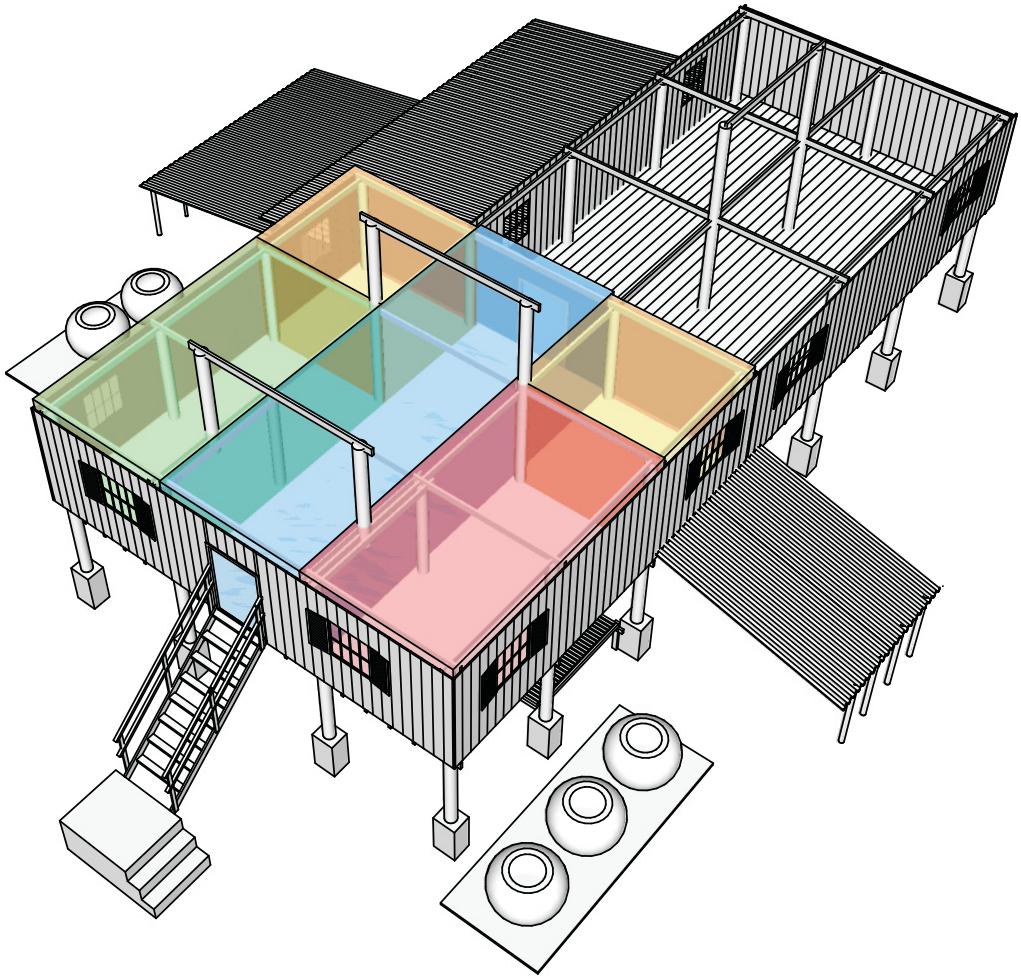
This diagram shows the way of living in rural Cambodia. Since it is very hot in Cambodia, most houses have banana trees, coconut trees, palm trees and other plant species that provide shade and fruits. If one looks closely, there are chicken pens, duck pens and pigpens around the house. It is a way to generate some extra income beside planting rice as well as sustaining the family.



This diagram intends to express a clear separation between public and private space for a rural home. The public space below is used mainly for working, gathering, and relaxing. The private space above is used for family gathering at night and sleeping.



This elevation diagram is aiming to show the complexity of this house as a case study, however, it is very important since it can be applied to every other house in the rural area. The yellow dashed rectangle shows the old kitchen that used to be in a separate house, which is now moved down to the space below constructed with concrete for security purposes, highlighted by a purple dashed rectangle. In the red dashed rectangle, it shows two different roofs, which means it is an addition to the main house.



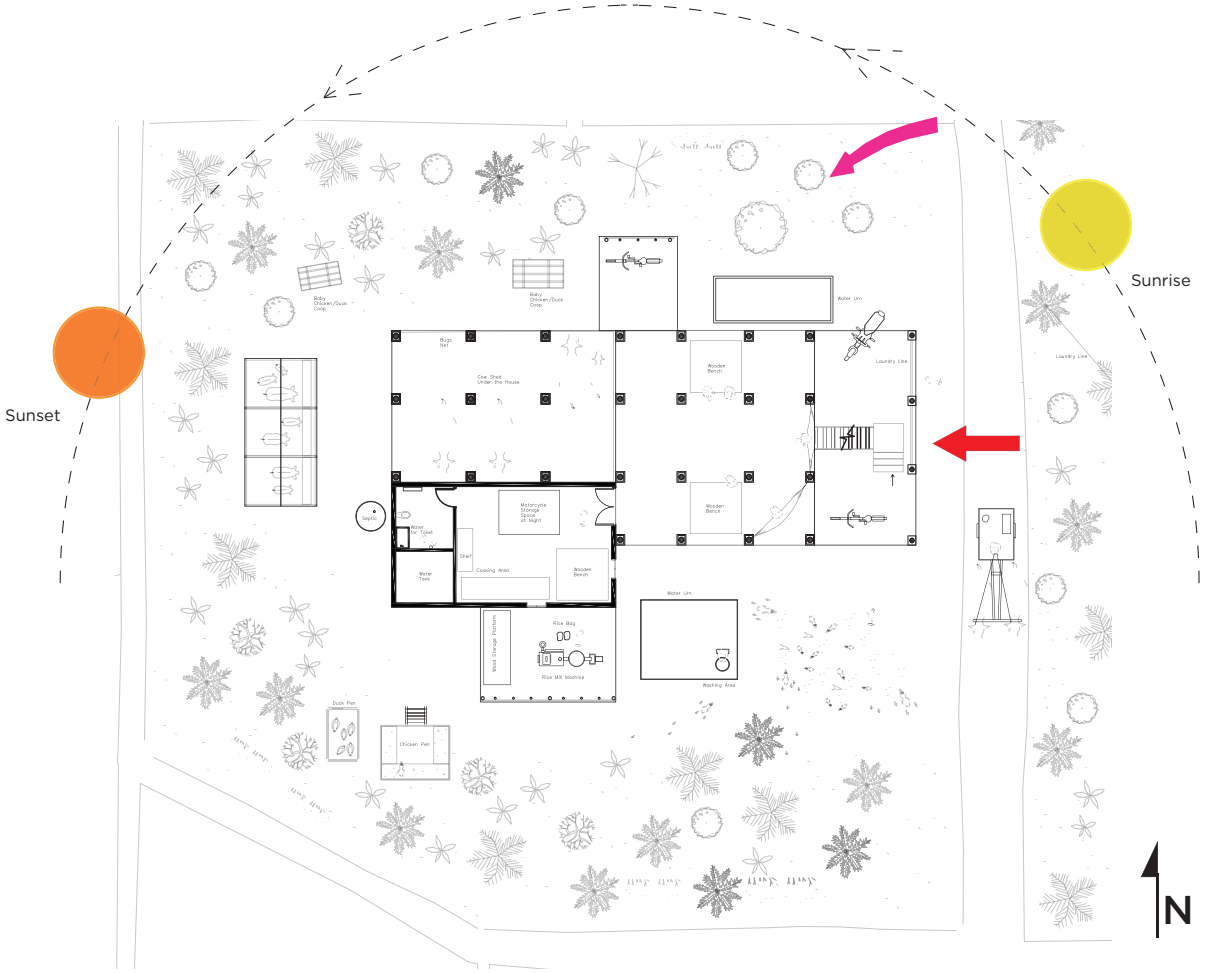
Parents' Sleeping Space

Living or Family Space at Night

Children's Sleeping Space

Mainly a Circulation Space

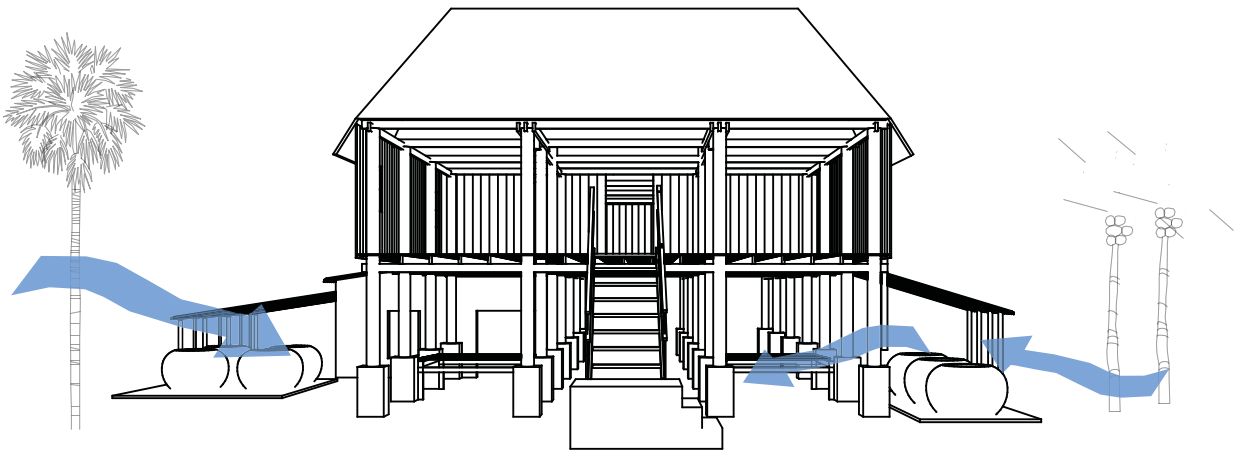
This bird's - eye - view diagram intends to show how a family would occupy the private space up above. Each space is highlighted by a different colour to represent its use. The parents usually sleep close to the door to guard the house just in case there is an intruder.



Main Entrance (It is a cultural belief that the entrance of the house brings in the main energy, therefore the entrance is almost always facing East).

Prevailing Wind

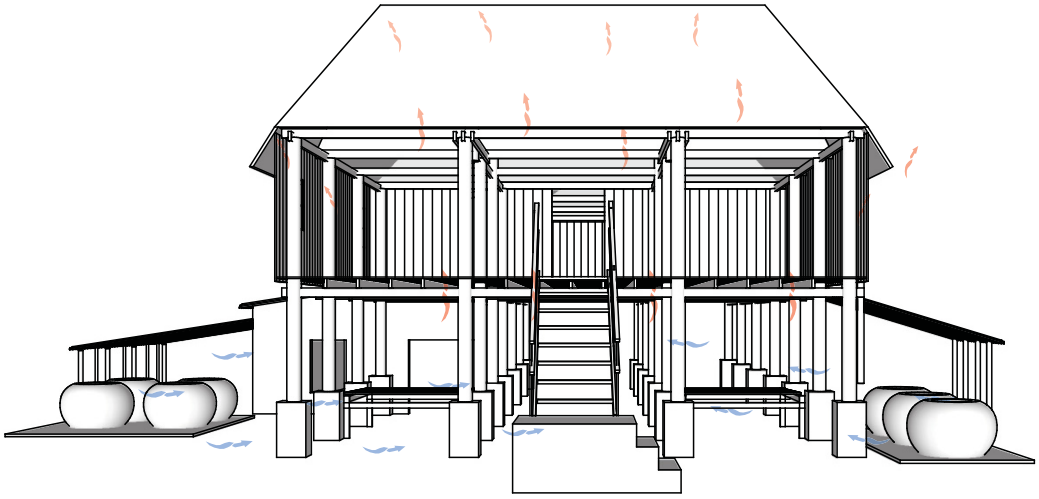
This plan illustrates how a rural house or third settlement pattern in a rural area would be situated. The entrance is facing east to get the morning sun and it is a belief that it would draw a good energy into the house. In Southeast Asia, the prevailing wind is coming from the northeast; therefore people plant trees to get protection from the wind.



Cool Air

Note: High Trees: the breeze descends and cools.
When a tree is 3 meters from a house, more cool air enters.

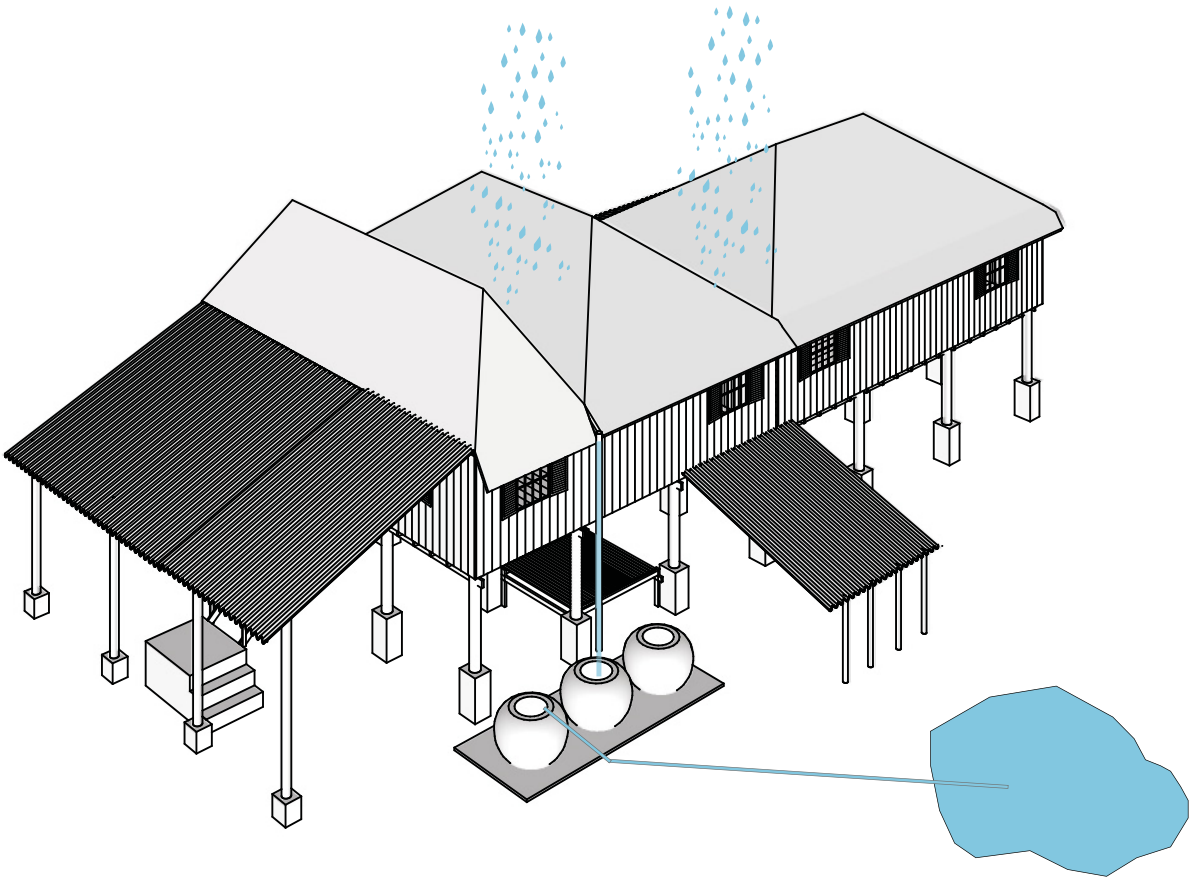
This sectional perspective diagram shows how people would plant trees around their house in order to draw a cool breeze to the bottom part of the house. When there are high trees around the house the breeze tends to descend down and create more cool air.



Cool Air

Warm Air

This diagram illustrates how cool air moves in the interstitial space below the house as warm air being pushed and rose higher to the first floor above. Therefore, during the day Cambodian people spend most of their time working and relaxing with family and community members under the house, because it is shaded and cool.



Water - Rainwater Collection and Pond Water Collection

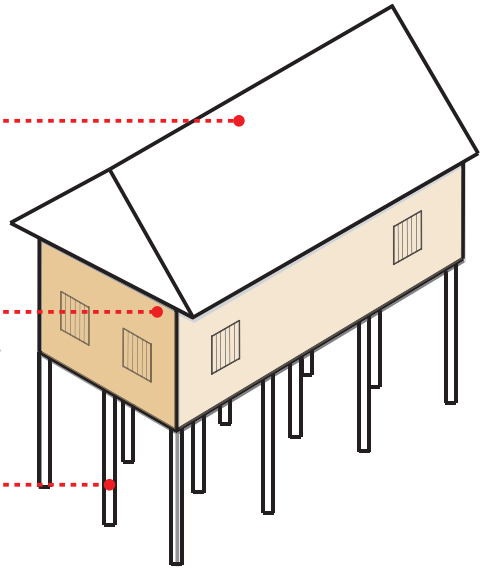
This diagram expresses two simple ways of water collection to sustain life in the rural area of Cambodia. The first way is to collect rainwater from the roof and store it in the water urns beside the house. The second method is to pump the water from the nearby water vessels. Only some families are fortunate enough to have a generator, but most people have to carry the water. These two ways are very sustainable, however, the main issue is that the water needs to be purified and is not potable without purification techniques applied.

Traditional Home

- Palm-Leaf Thatch/
- Woven Bamboo/
- Clay Tiles/
- Corrugated Metal

- Palm-Leaf Thatch/
- Woven Reed/
- Wood Siding

- Wood Post and Rock/
- Wood Column/
- Wood and Concrete/
- Concrete Column



Advantages:

- Some materials are cheaper
- Local resources
- Cultural Adaptability
(Less Permanent)

Disadvantages:

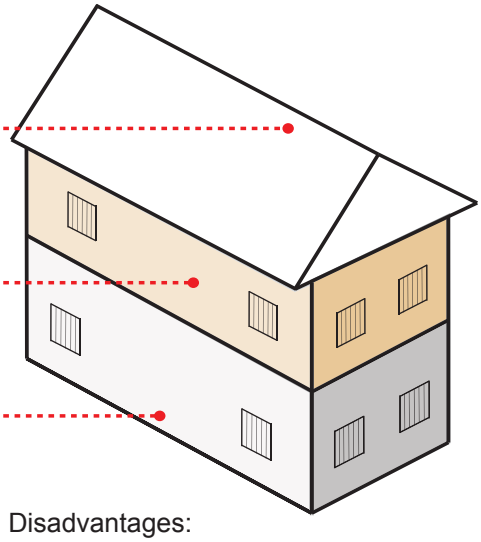
- Some materials need to be replaced every 4-6 years

Contemporary Home

- Clay Tiles/
- Corrugated Metal

- Wood Siding

- Bricks (Rendered on Both Sides)/
- Concrete Blocks



Advantages:

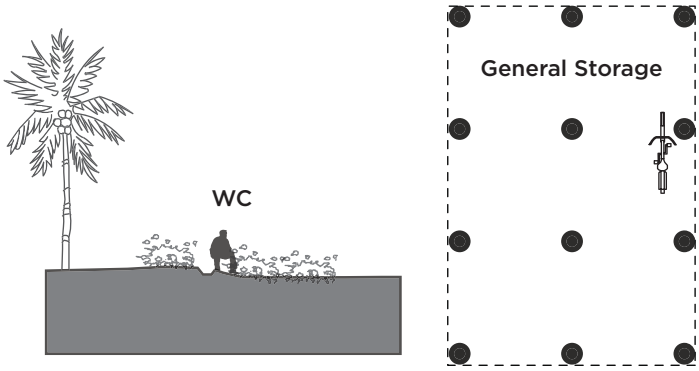
- Some resources are local
- Certain resources portray a higher status

Disadvantages:

- Some materials are more expensive
- Some resources are not local
- Choices in materials are limited
- Cultural Adaptability
(More Permanent)

Materials Palette

Traditional Home



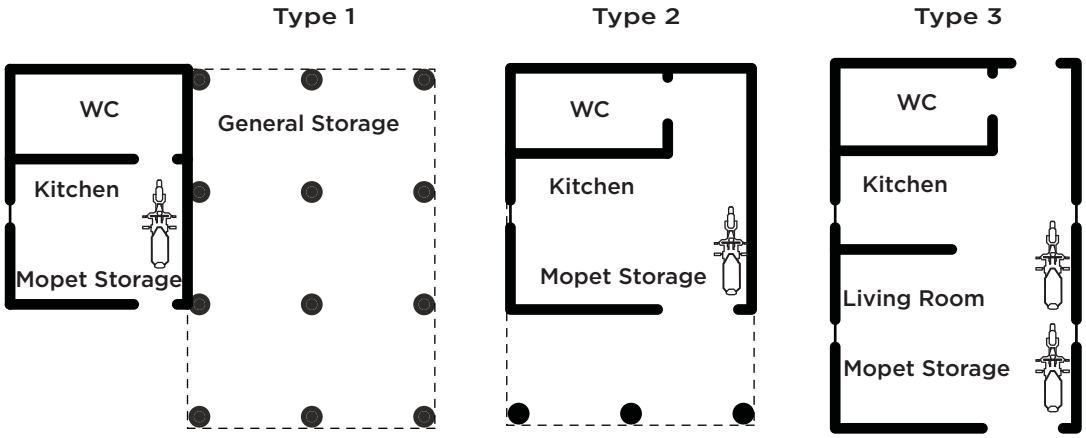
Advantages:

- Open concept plans
- People work under the house (Out of the elements)
- Better views when walls are not present

Disadvantages:

- No secure storage space
- Kitchen upstairs (Open Fire)
- No Waste Management

Contemporary Home



Advantages:

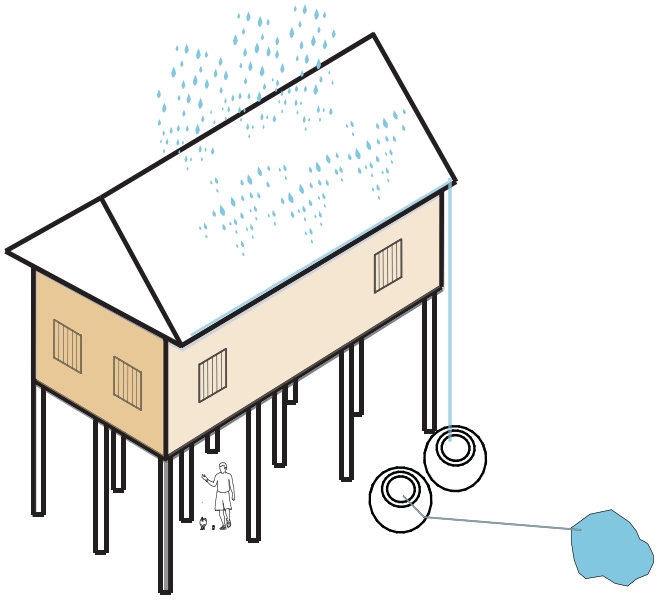
- Secured Storage Space
- Indoor Living Space Under the House
- Kitchen is on the Ground Floor
- Indoor Septic Washroom

Disadvantages:

- Walled in for Space under the House
- Kitchen Downstairs (Still Open Fire)
- Inadequate Lighting
- Inadequate Ventilation

Waste Management

Traditional Home



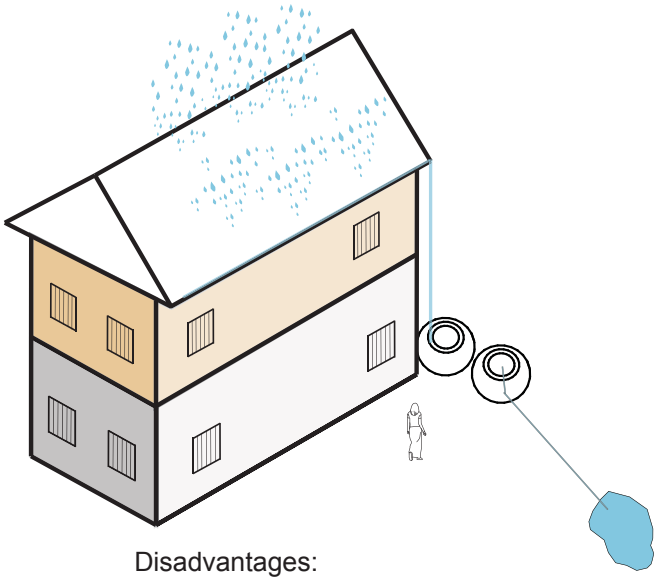
Advantages:

- Collecting rainwater from the roof
- The upper level functioning like an umbrella
- Collecting water from nearby water vessels

Disadvantages:

- No waste management
- No proper water storage
(Some water storage containers have Covers)
- No Water Purification System

Contemporary Home



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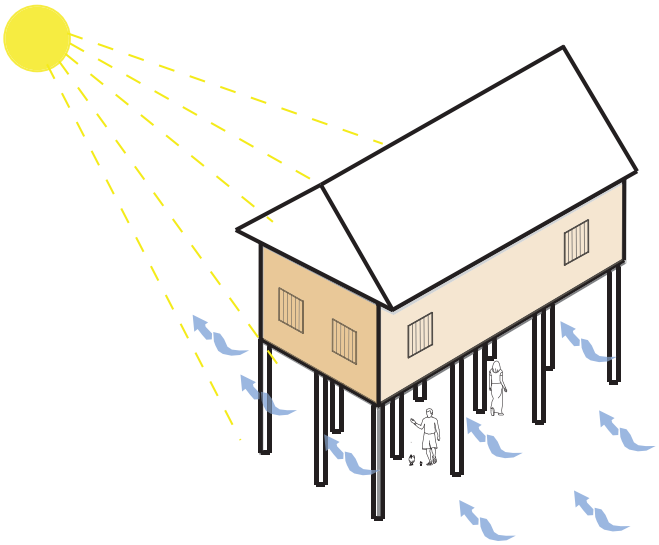
Water Collection

Traditional Home



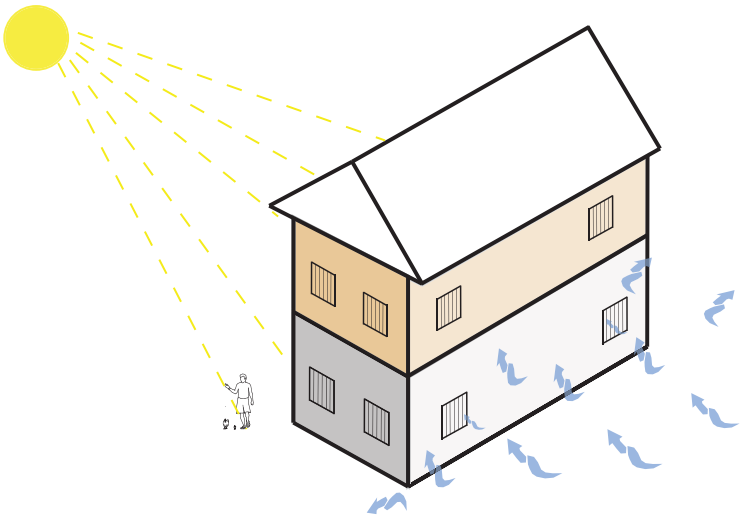
Advantages:

- Better lighting quality available
- Better air circulation
- Better flow for both warm and cool air

Disadvantages:

- Exposed to strong wind during monsoon season

Contemporary Home



Advantages:

- Less Exposure to strong wind

Disadvantages:

- Inadequate lighting quality
- Inadequate flow for both warm and cool Air
- Inadequate Air Circulation

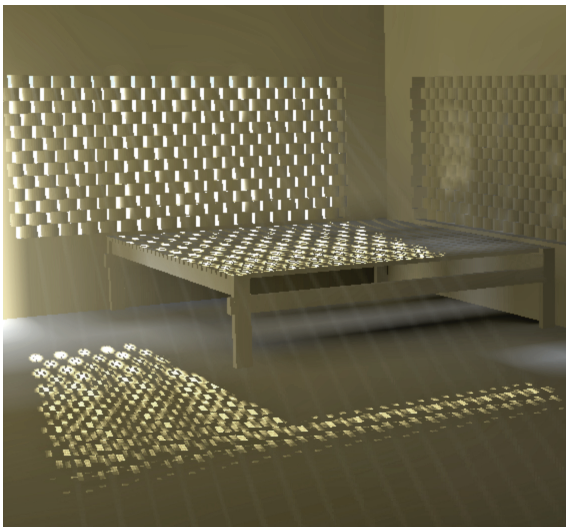
Light Quality and Air Flow

Design Intervention - Windows

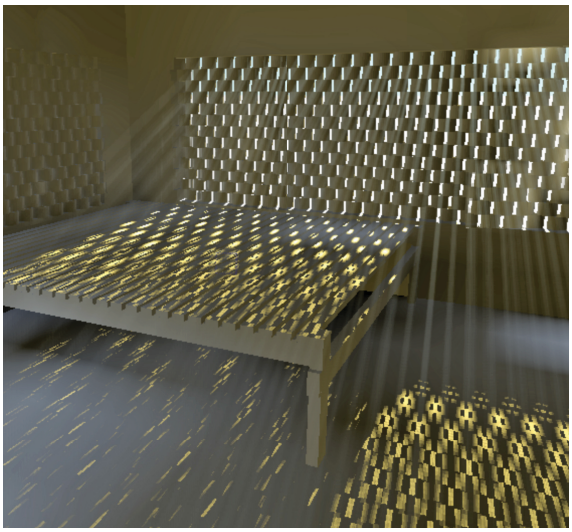
Proposed Design

Current Design - Iron bars

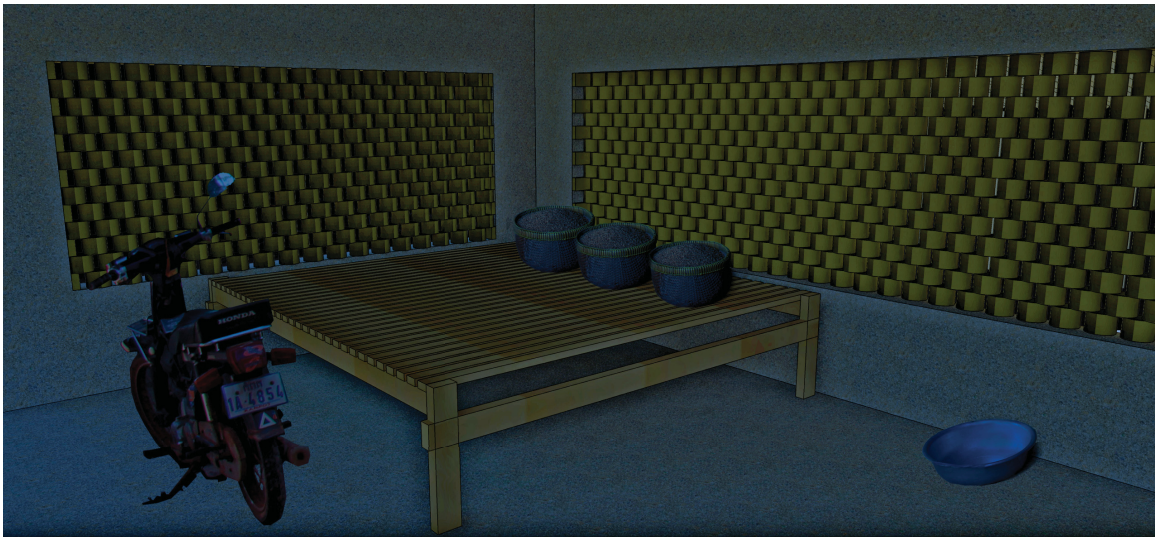
Proposed Design - hidden iron bars with cross section bamboos



At 8 A.M.



At 1 P.M.



At Night

As view from the interior

As seen from the outside

Building Systems

Solutions - Rainwater Collection

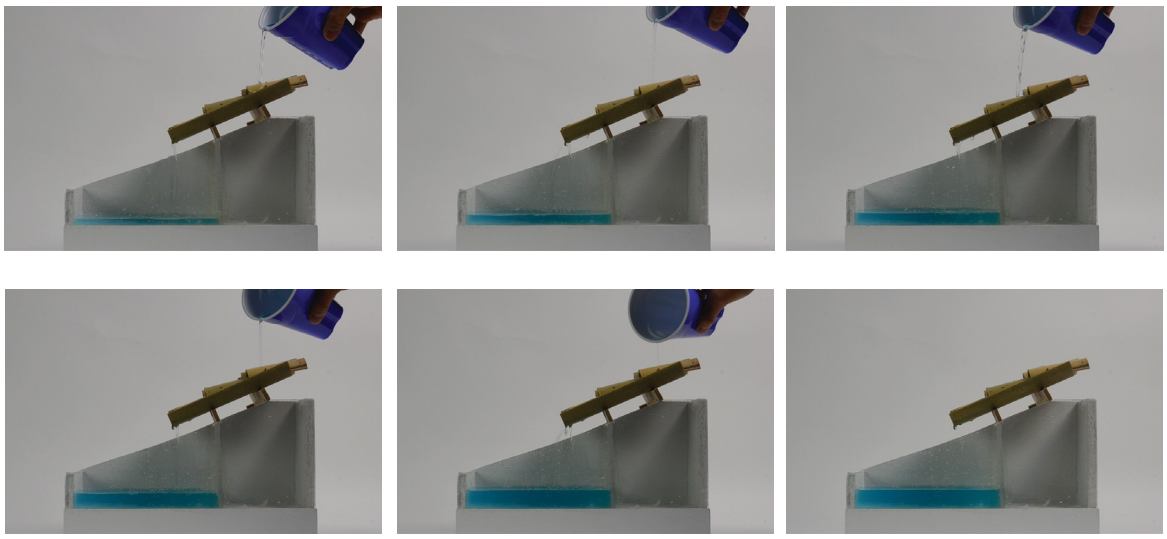
Bamboo Tile Roof

Bamboo is one of the local materials in rural area of Kampot province. However, this choice of material is diminishing and being replaced by clay-tile roof or even corrugated roof. I would like to investigate on the use of bamboo as a roofing material with an inexpensive construction method to collect rainwater for the rural poor.

Bamboo Roof Model

Bamboo Roof Testing

The images below illustrate the use of bamboo roof. The first compartment from the right has no water that means the roof is not leaking therefore it is working. The second compartment is being filled as the water is traveling down the channels of the bamboo roof.

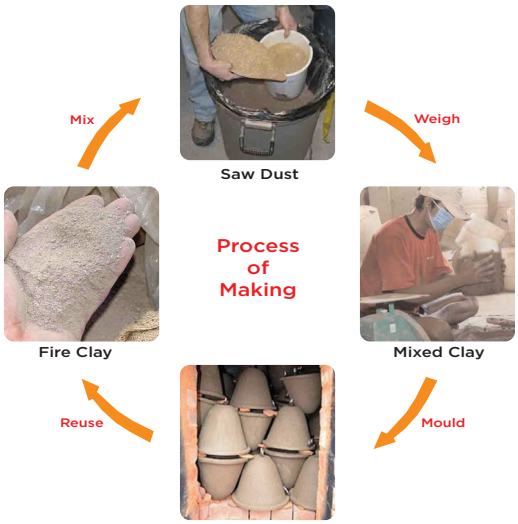


Bamboo Roof Water Experiment

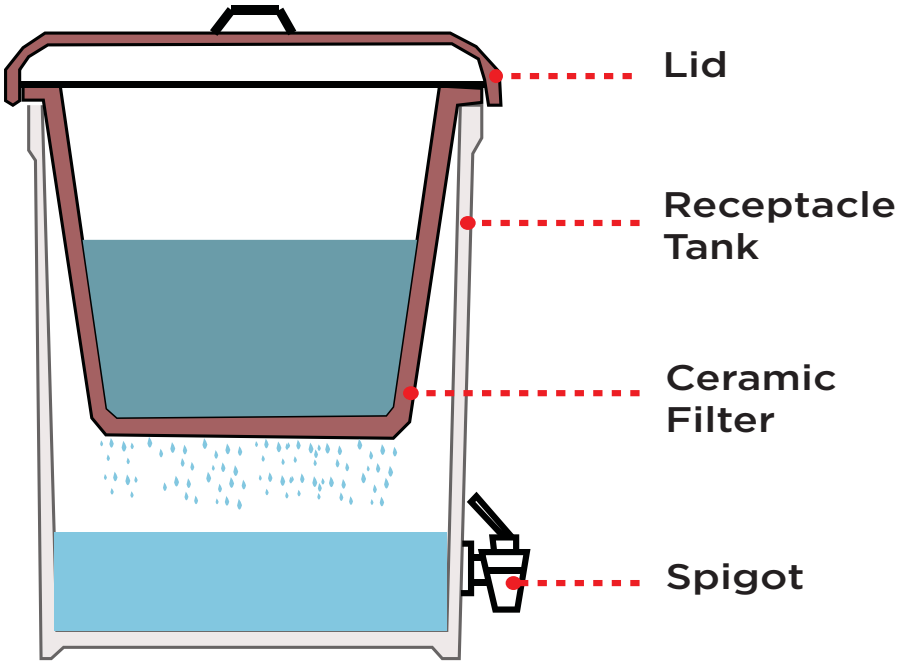
Solutions - Water Filtration Systems

Ceramic Water Purifier

During my time in Kampot, it was evident that many people have an expertise in making fired pottery. Cambodian people also have a long tradition in making fired pottery for many other uses such as a stove to cook rice or a teapot to steep tea. This thesis research will investigate the use of ceramic filter, which is the use of porous clay as the main ingredient to create. This system will be used to filter water while still using a local resource and traditional way of making.



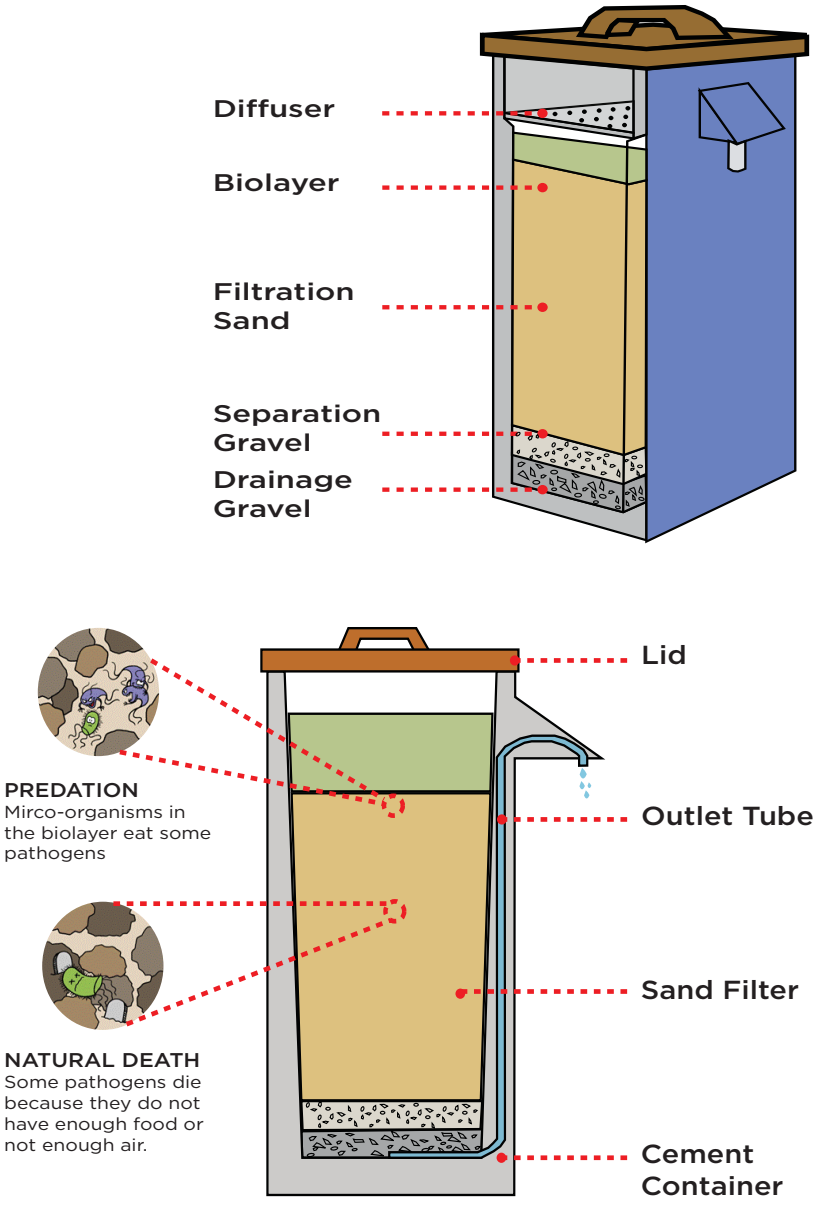
The Process of Making Ceramic Purifier



Sectional Illustration of a Ceramic Purifier

Sand Water Purifier

Sand filter is another low-cost system that is being implemented in the rural Cambodia. Khmer people become more familiar with this filtration since it is a household-scale. Therefore, this water purification method will be a secondary option in designing this sustainable and affordable home for the rural poor.



Sectional Illustration of a Sand Filter

CHAPTER 3: DESIGN

Affordable and Sustainable Home

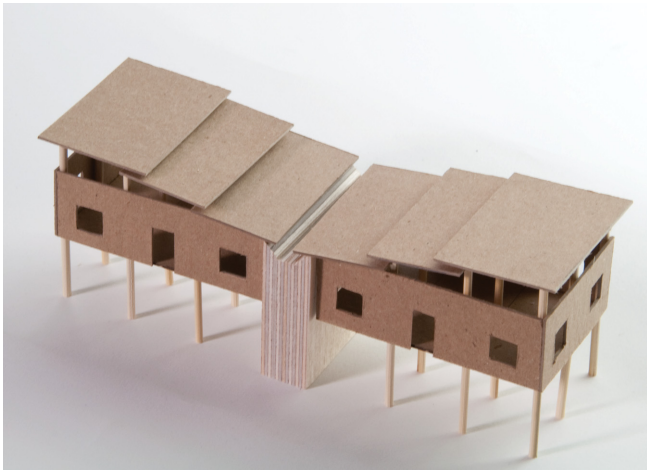
In the book, *Architecture for the Poor*, Hassan Fathy argued,

> It seemed to me that we could not cure the general crisis in Egyptian architecture simply by building one or two good model houses as examples, nor even a whole village. Rather we should have to try to diagnose the disease, to understand the root causes of the crisis, and to attack it at these roots. (Fathy 1973, 11)

This is what motivated me to apply for a grant to travel to rural Cambodia for my thesis research. I returned to my roots in order to understand the fundamental problems in wooden traditional houses that are disappearing and to cure this disease of cultural decay. I hoped to gain a deeper understanding of the issues and accepted the ways of living with the shift in social and economic structures. There must be hope in restoring the old while integrating the new and still anticipating cultural, technological and economic changes.

This thesis design is based on personal background and documented research with an optimism to create a new mode of architecture in the form of sustainable and affordable Cambodian housing.

Conceptual Models - First Series



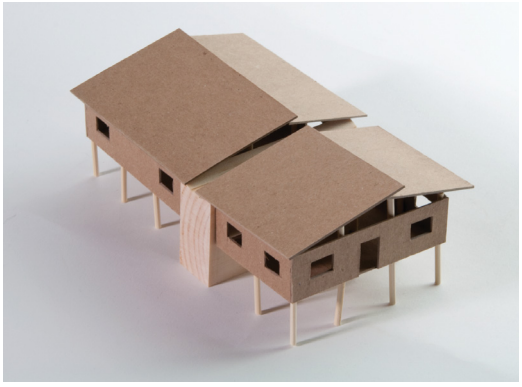
Conceptual Models - Second Series

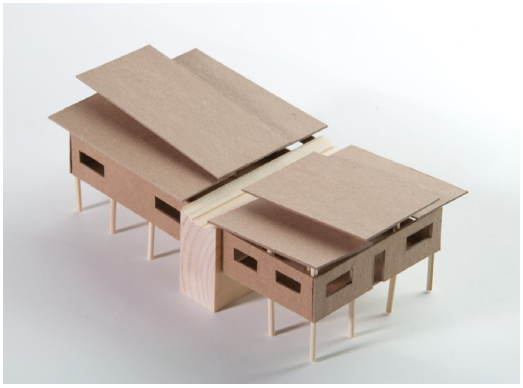
The intent is to create a building, a place where people feel comfortable and deep seated in respect for themselves. To quote Christopher Alexander,

> Places outdoors where people eat, and dance; old people sitting in the street, watching the world go by; places where teenage boys and girls hang out, within the neighborhood, free enough of their parents that they feel themselves alive, and stay there…work going on among the families, children playing where work is going on, and learning from it. (Alexander 1979, 135)

This future building focuses on the cultural ways of living while still accommodating the changes through architectural design.

The main objective for this thesis is to gather all the learning from the research and the case study to design a sustainable and affordable home that stem from cultural methods of construction, surrounding architecture, climate, local customs and most importantly the pattern of the language of living in a rural Cambodia.





Conceptual Models - Third Series

Site Strategy

The site is situated in the rural area of Kampot province. However, this proposal could work in every other province since the rural setting of Khmers' home would be the same across the country. It was prominent in my research that presently a rural Khmer house is located between a main street, to the front, and the rice fields at the back. The back of the house is used, as a private space where a washroom/kitchen is found and farming equipment is stored. To generate extra income, chickens, ducks, and pigs are kept in the same area. It is important that the main stairway from the ground floor to the first floor of the main structure is placed perpendicular to the street.

Sometimes, there is a wooden structure in the front of the house near the street, where vegetables and all kinds of goods are sold. The house is situated on the highest ground on the site about three to five feet above the rice fields. A linear pattern along the main street is very typical fashion for this type of settlement. For people who do not have direct access to the rice fields and are cut off from the main street, dwellings remain more separated from each other. This cultural knowledge that was gathered during the research will help to formulate the design and how it will situates on the site. This future sustainable and affordable Cambodian home would respect these findings as they are ingrained in rural Khmers' culture.

Site N

Kampot, Cambodia

Design Intention

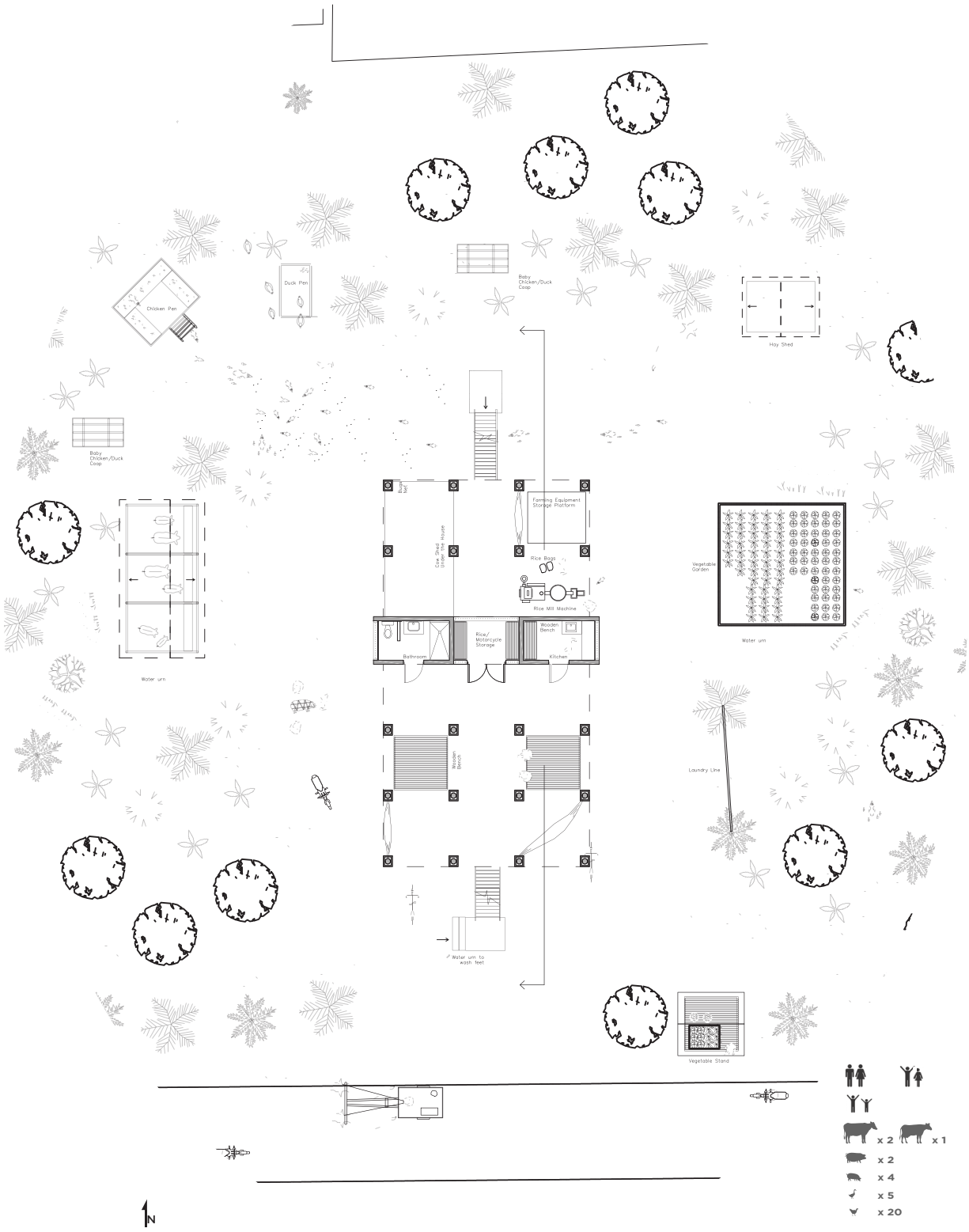
The proposal is designed to allow for the growth and expansion within a family, while still providing an open space on the lower level for working and gathering.

This thesis design does not have the intention of changing the material use and construction methods, but simply to adapt present local material and construction in a more effective way to improve the quality of life.

Cambodia's horrific history still has an effect on the present day population. This can be seen in rural houses where there are metal bars on the windows and concrete walls to protect their families and belongings.

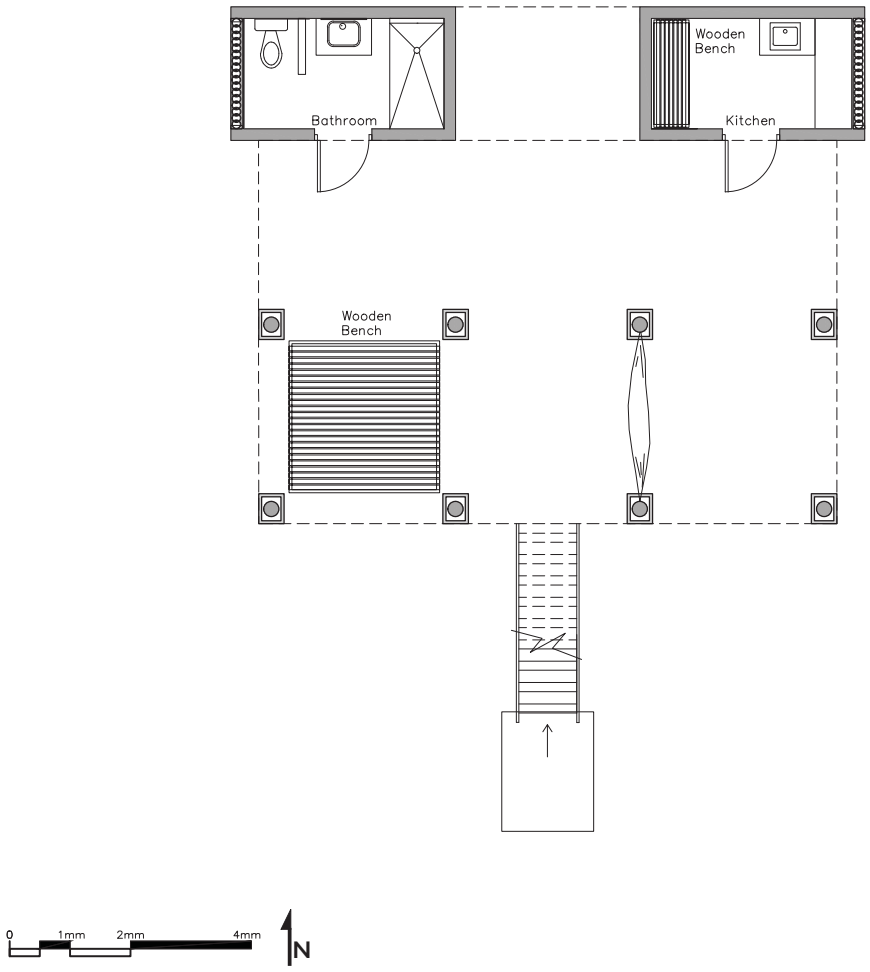
Security is a Cambodian cultural fact originating from its traumatic past. Today's Cambodian family considers the security of their home essential. When thinking about light and ventilation, security takes precedence. To transform this feeling of fear, architectural details such as hiding the metal bars with bamboo and creating a soft light filter, are some of the many contributions design can make. My design blends the need for security while at the same time being visually appealing and effective in household ventilation.

Architectural Drawings

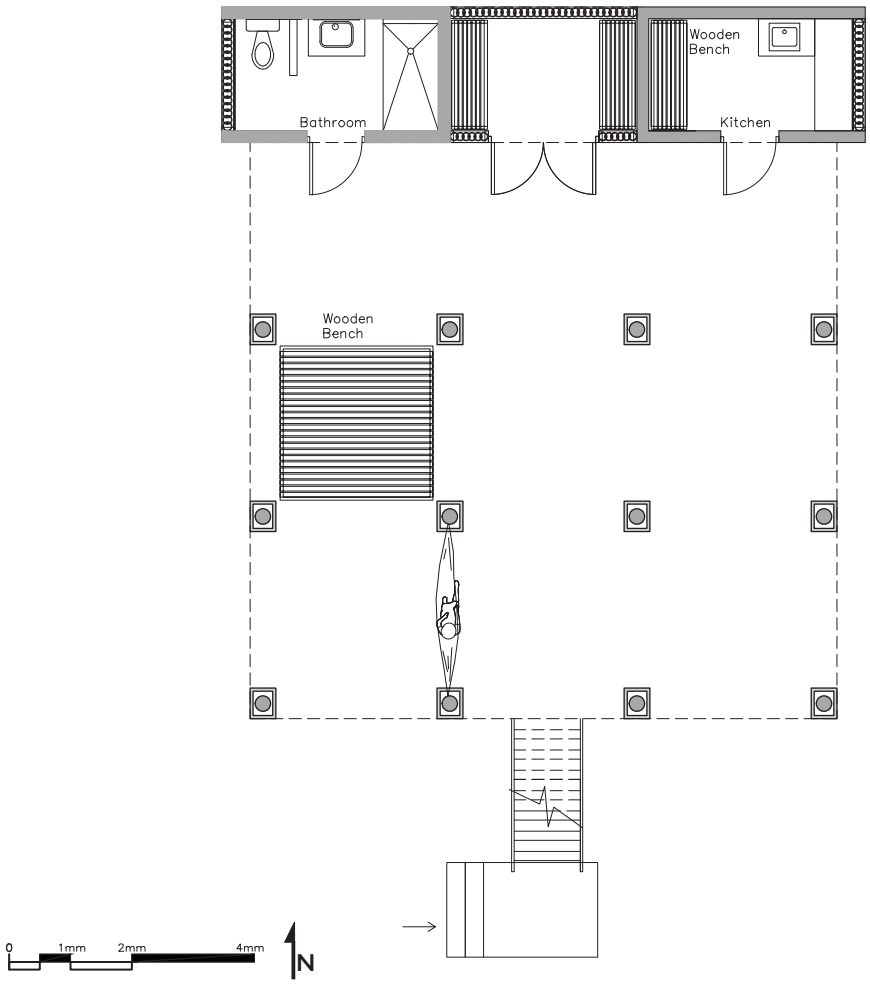


Ground Floor Activities

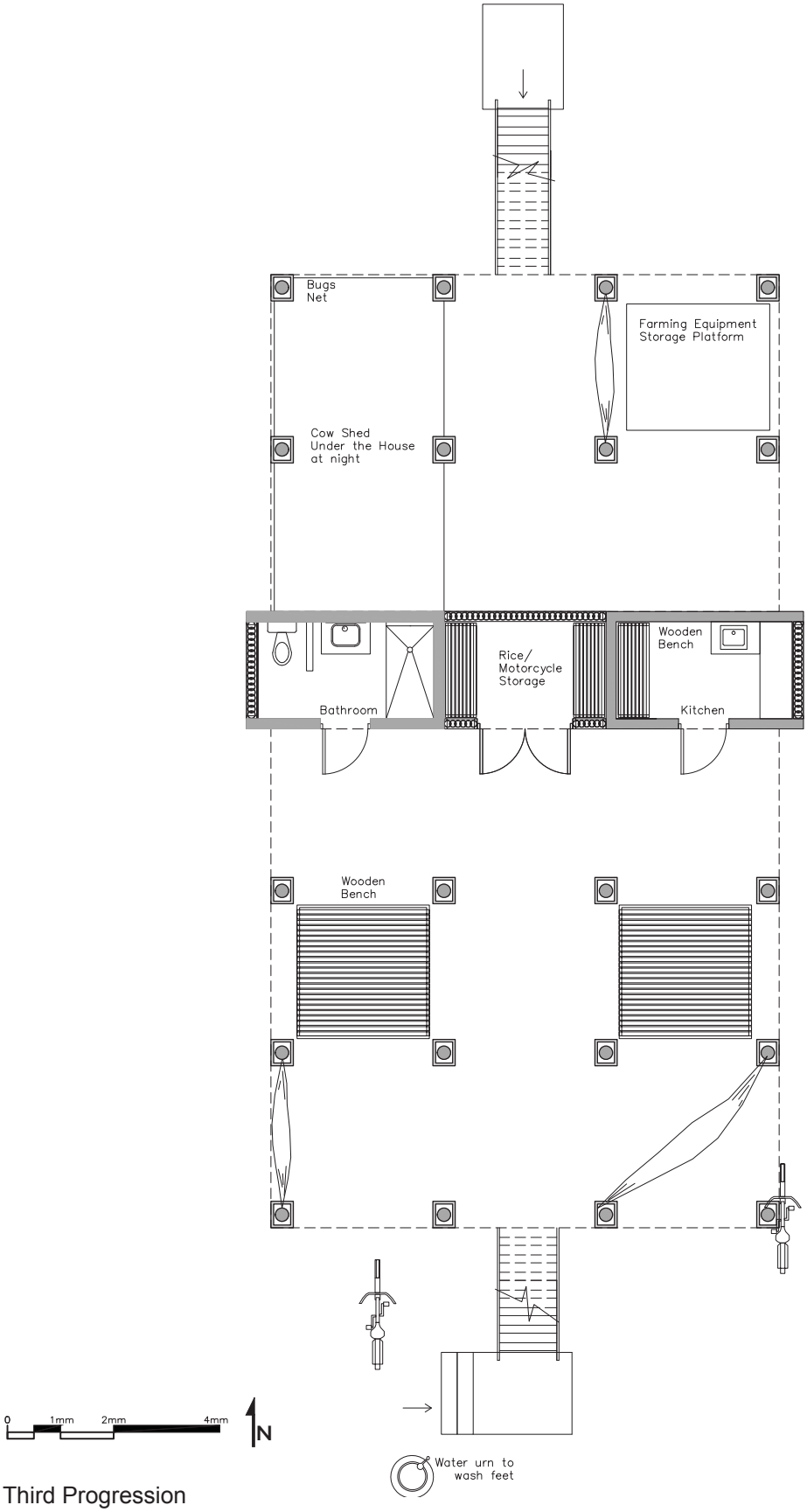
Progression of Growth



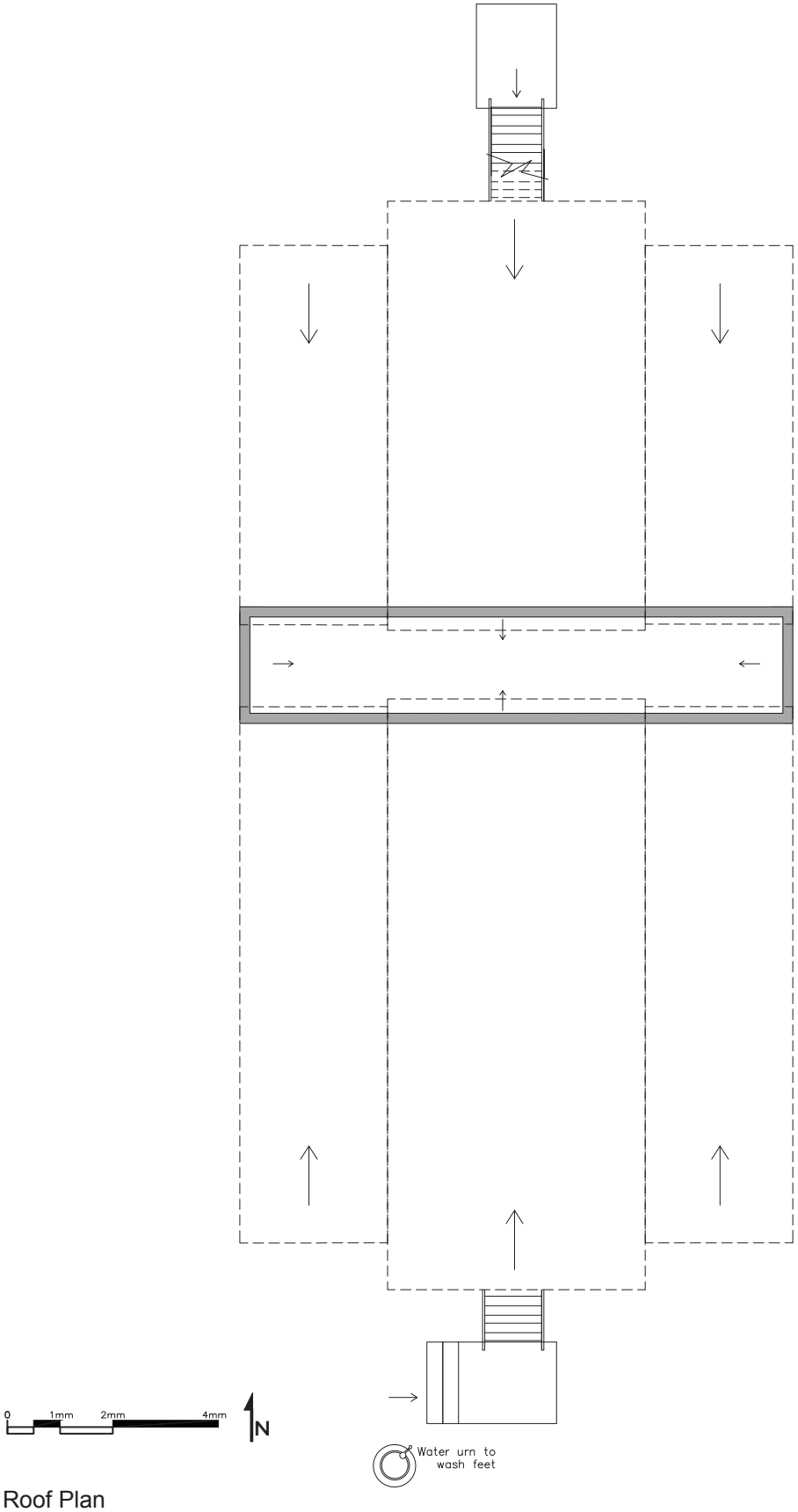
First Progression



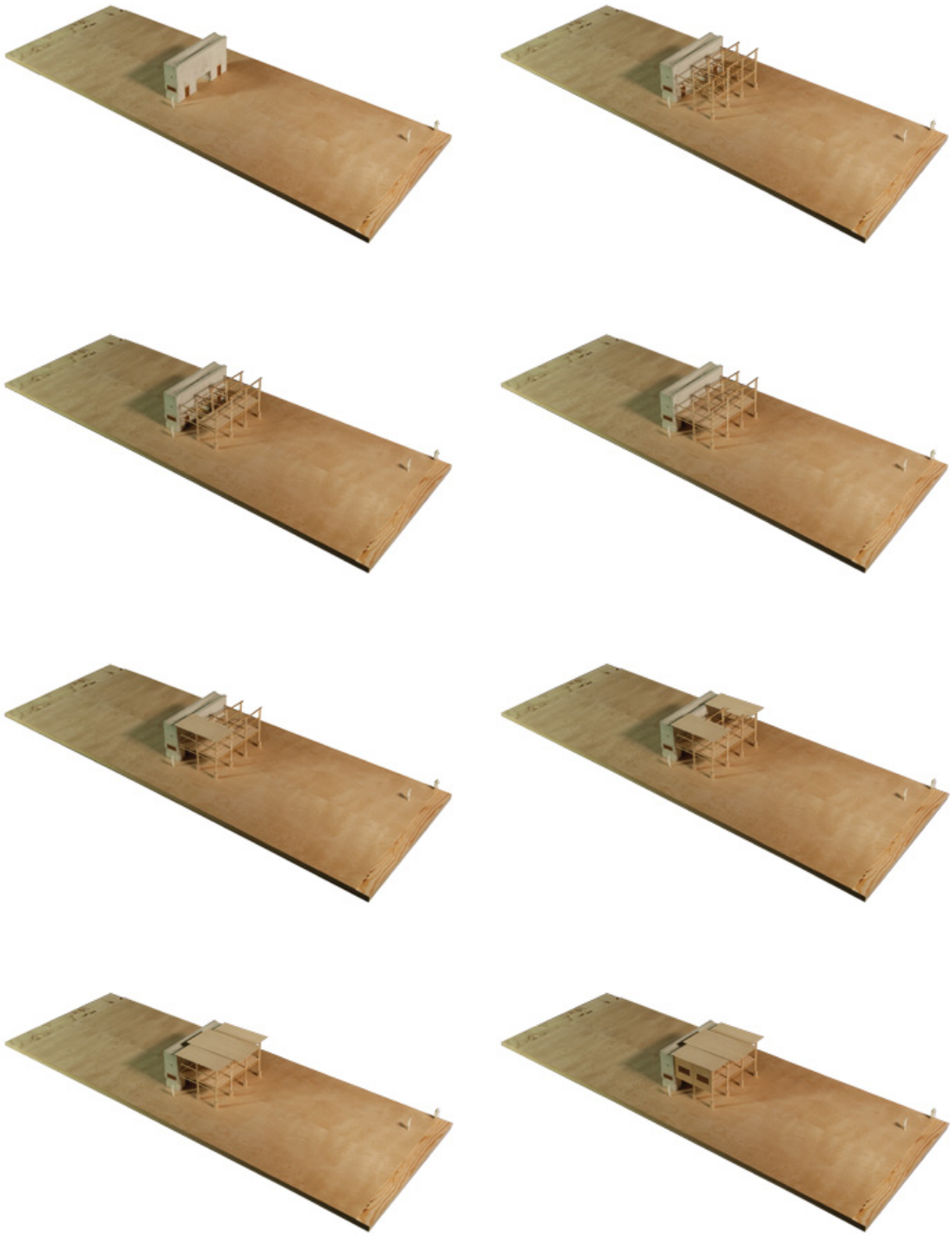
Second Progression



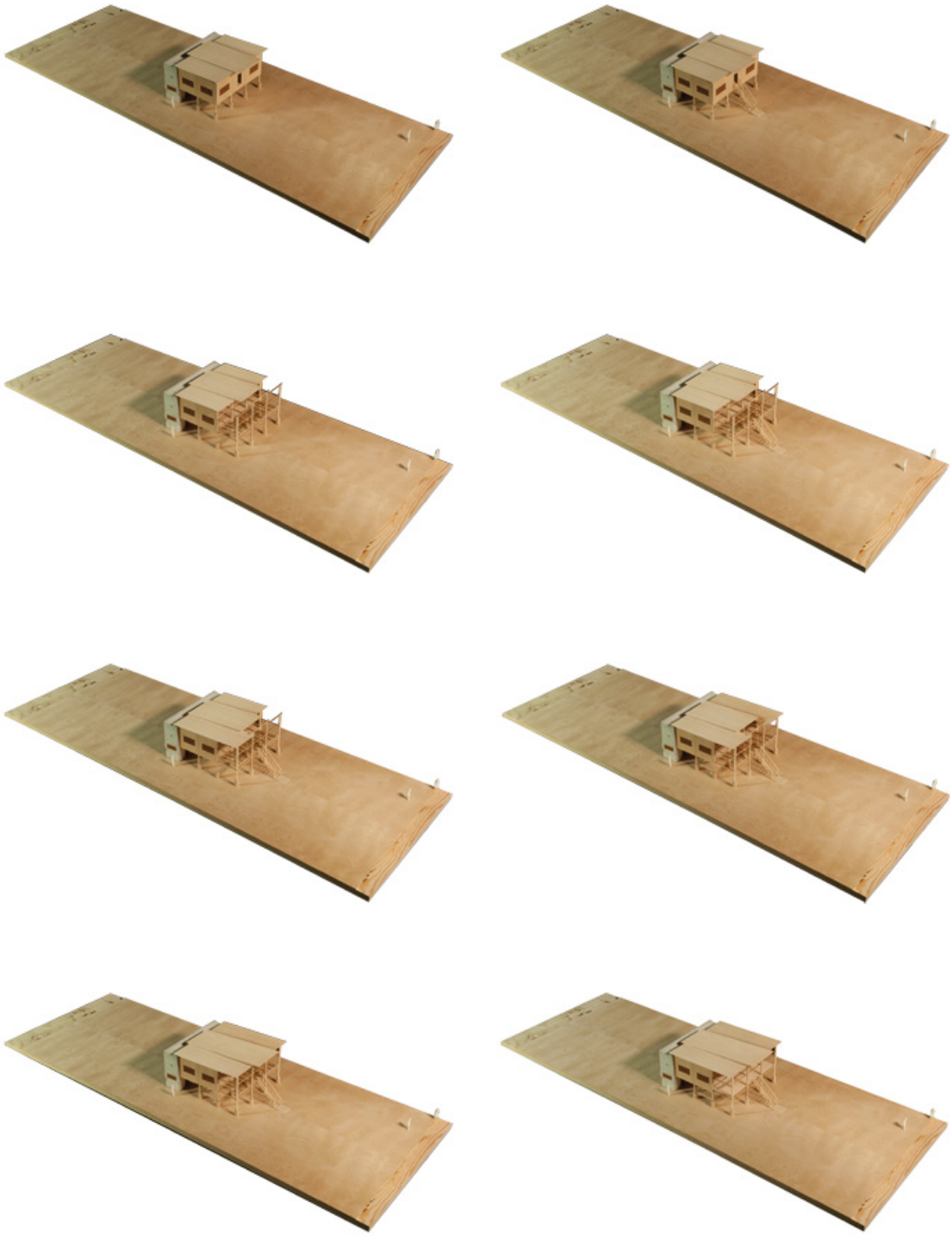
Third Progression



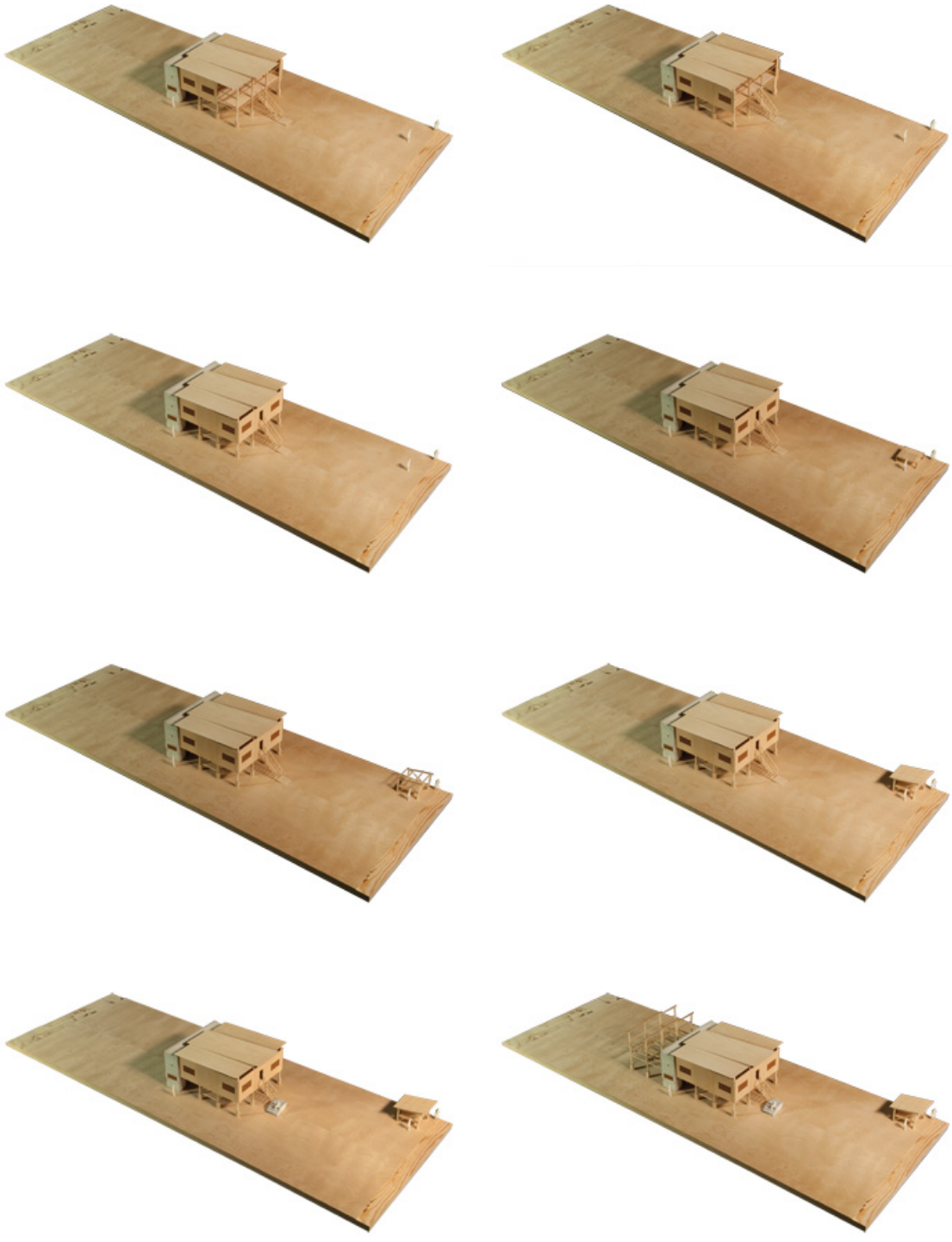
Roof Plan



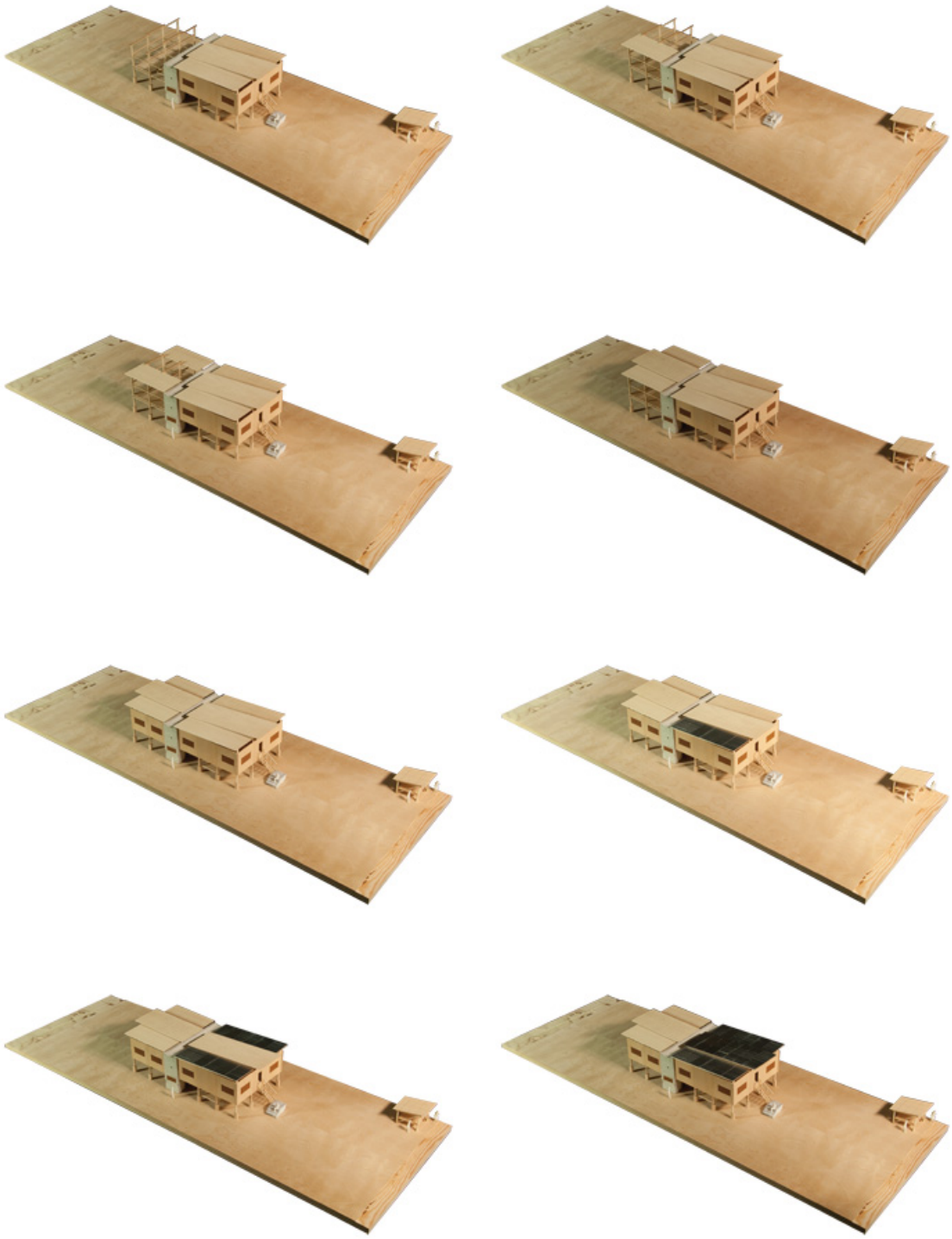
Evolution - Sequence one



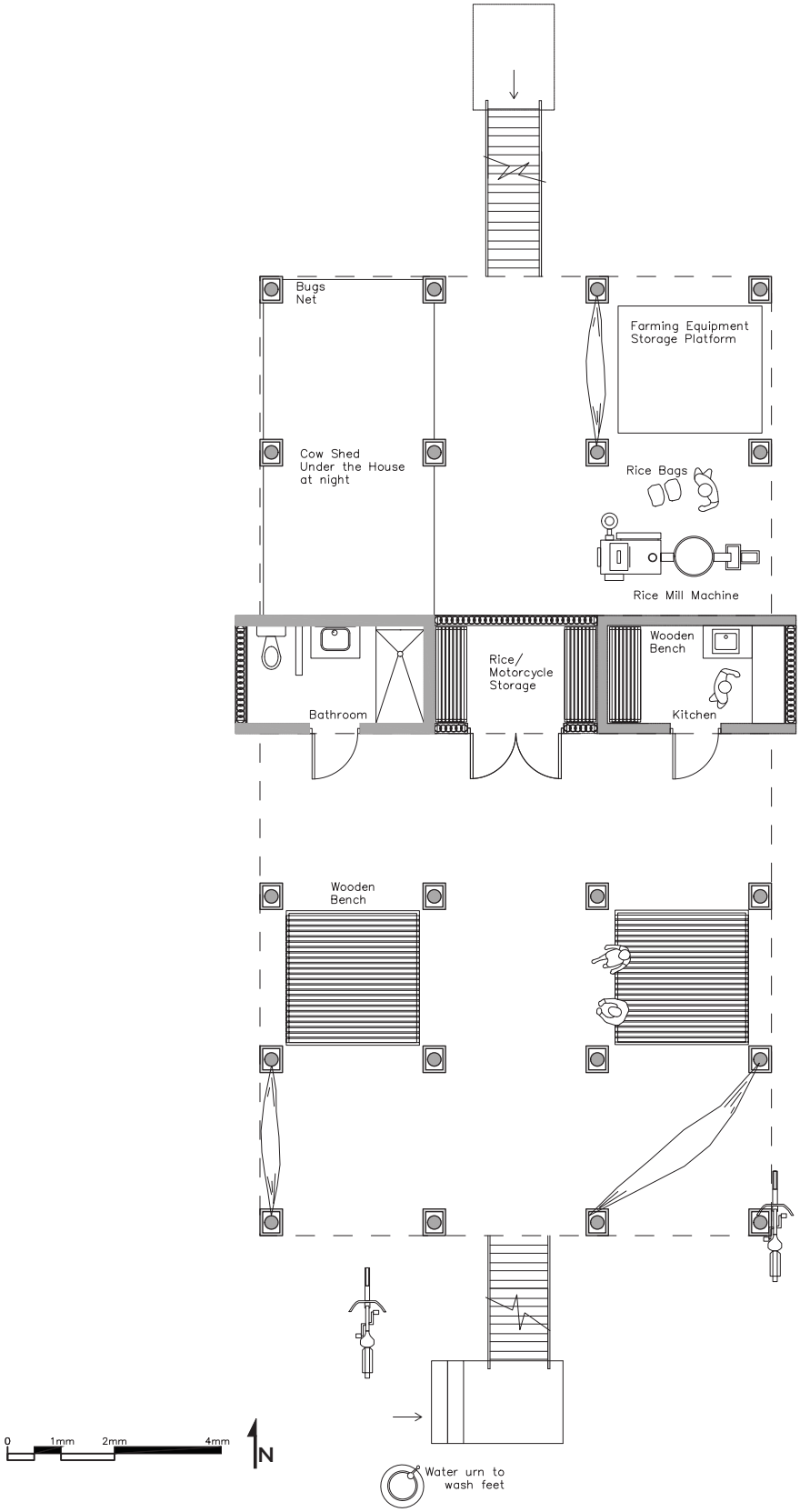
Evolution - Sequence two



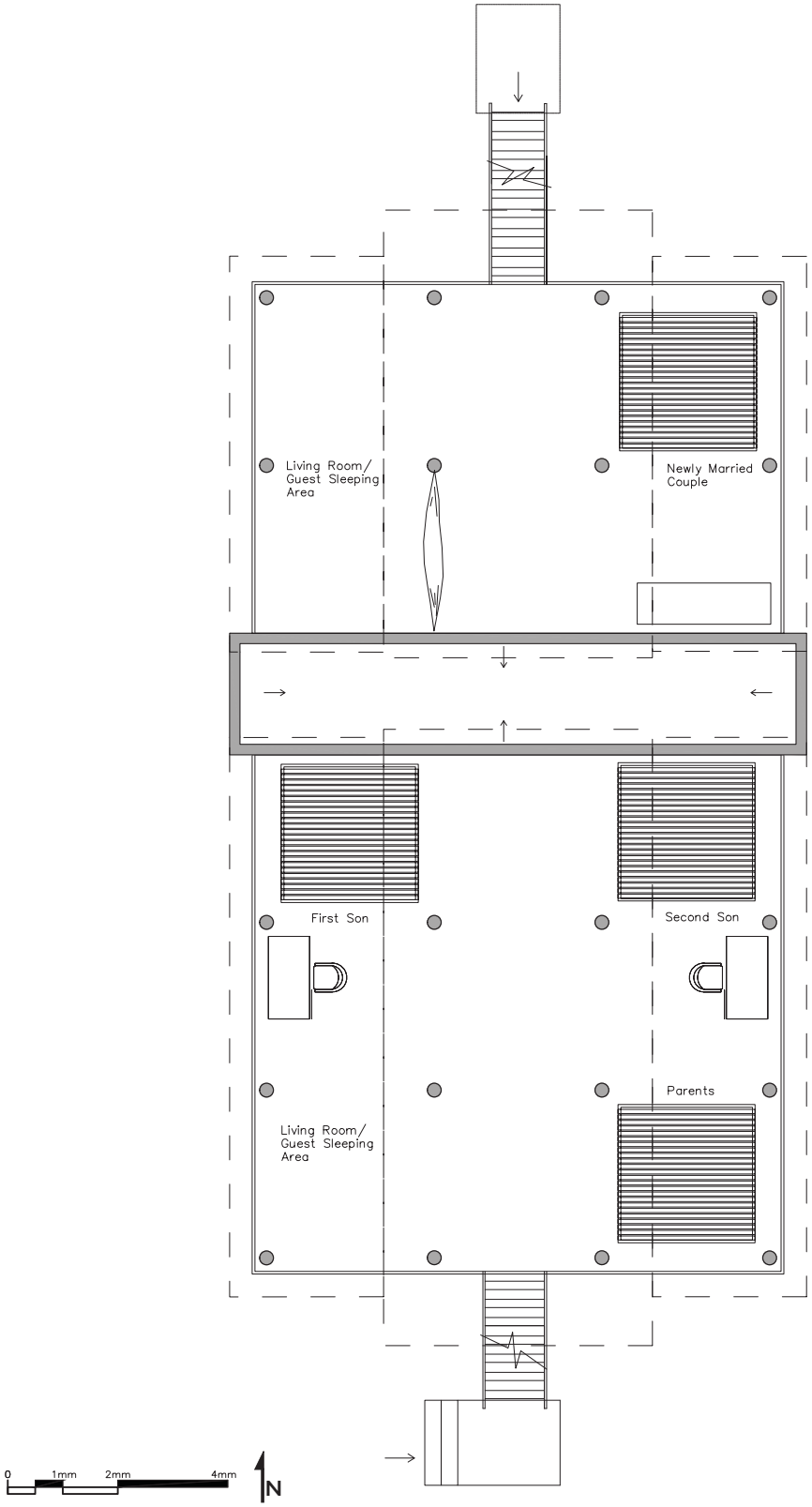
Evolution - Sequence three



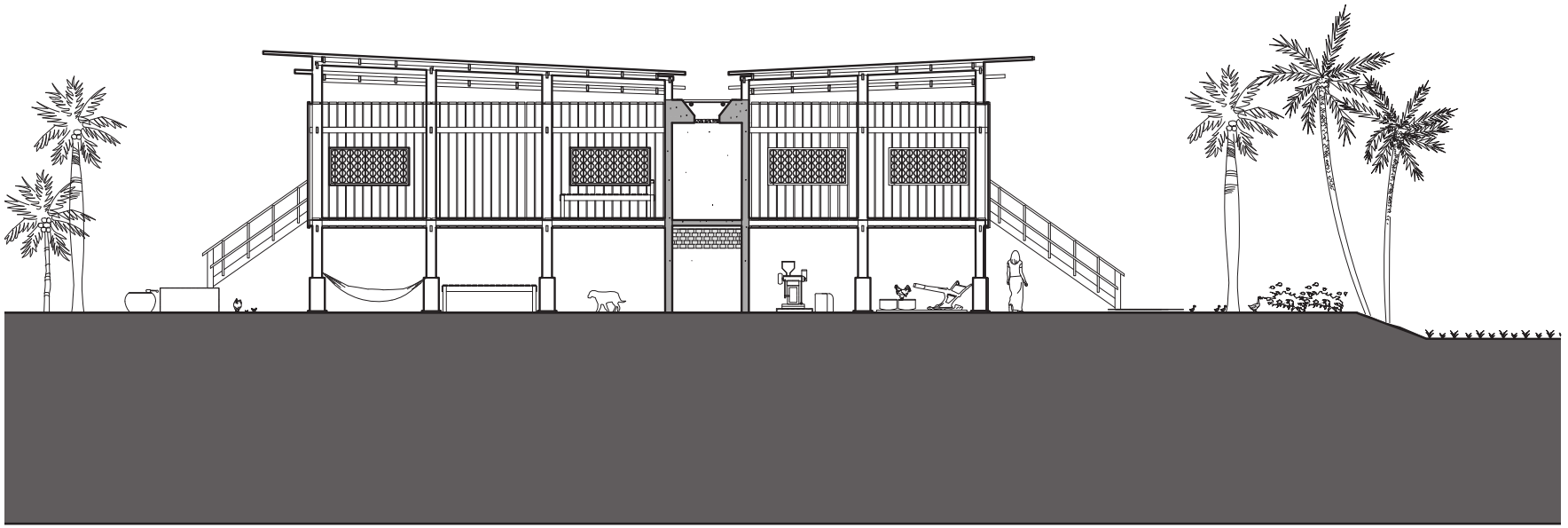
Evolution - Sequence four

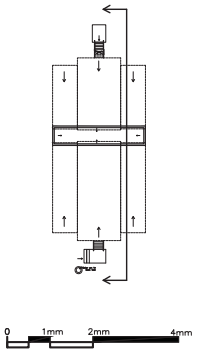


Ground Floor


Living Room/
Guest Sleeping
Area
Newly Married
Couple
First Son
Second Son
Parents
Living Room/
Guest Sleeping
Area
0
1mm
2mm
4mm
N

Upper Floor

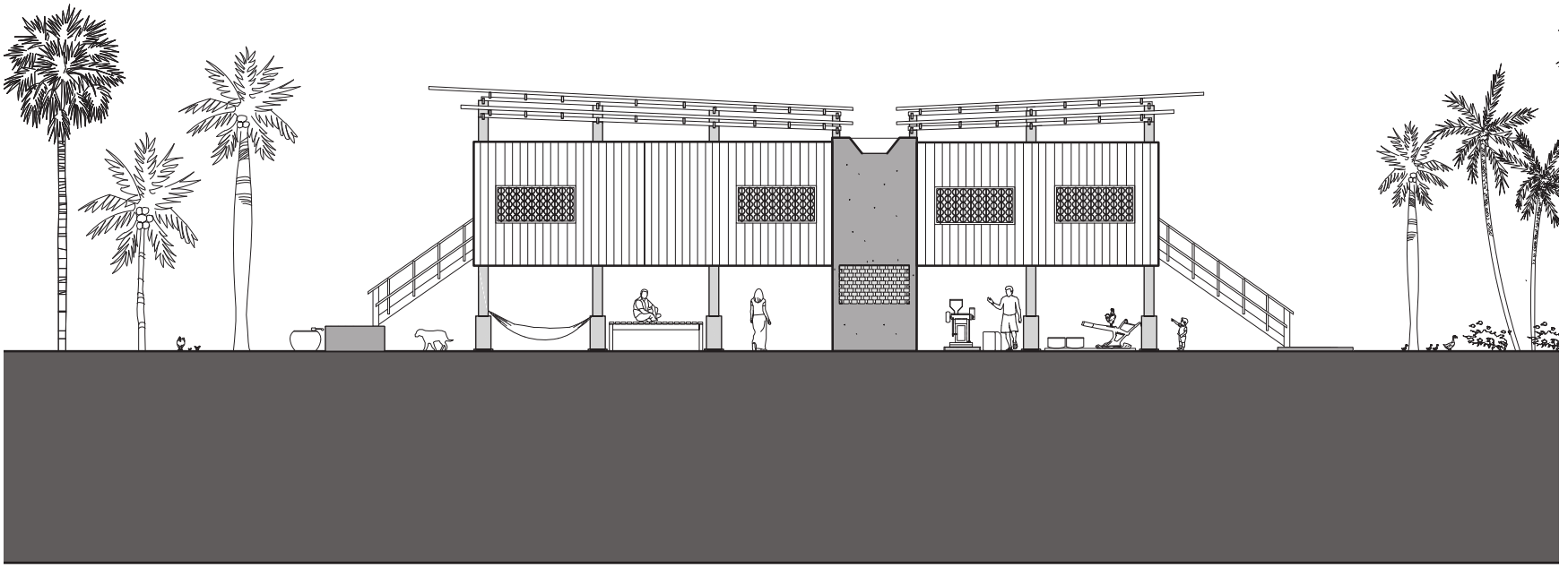




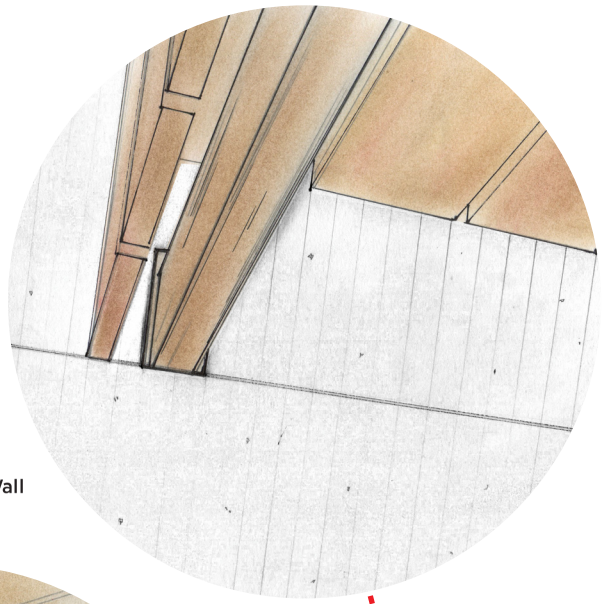
Longitudinal West Section - A House in relation to rice field

0 1mm 2mm 4mm

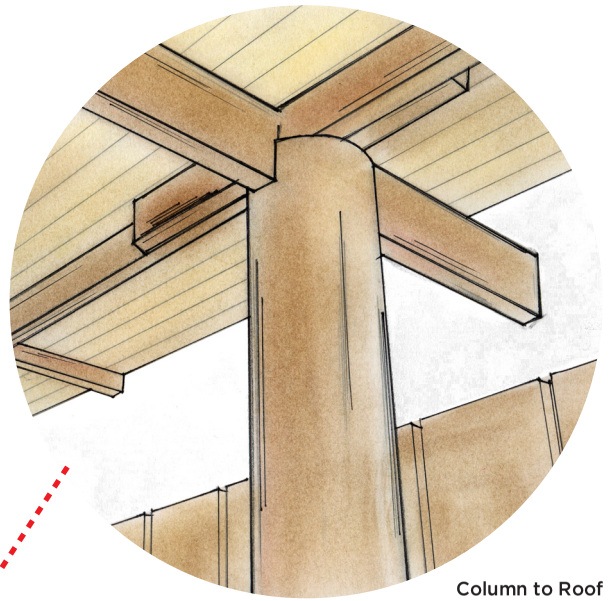
North Elevation - A house in its setting



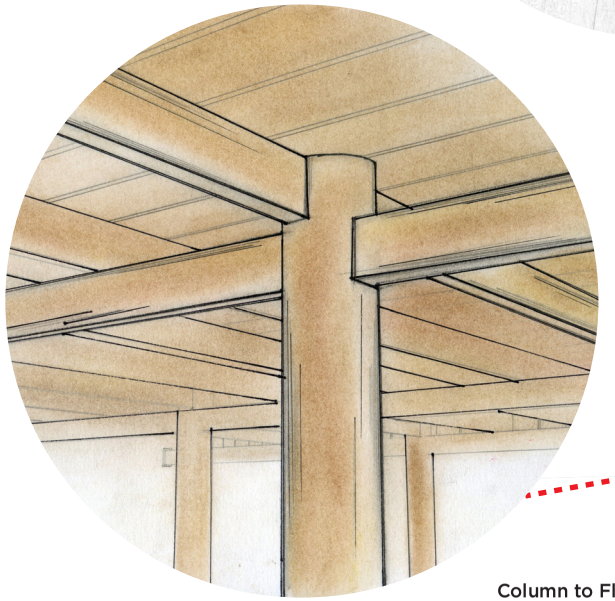
West Elevation - A house and the space down below



Floor to Concrete Wall



Column to Roof



Column to Floor

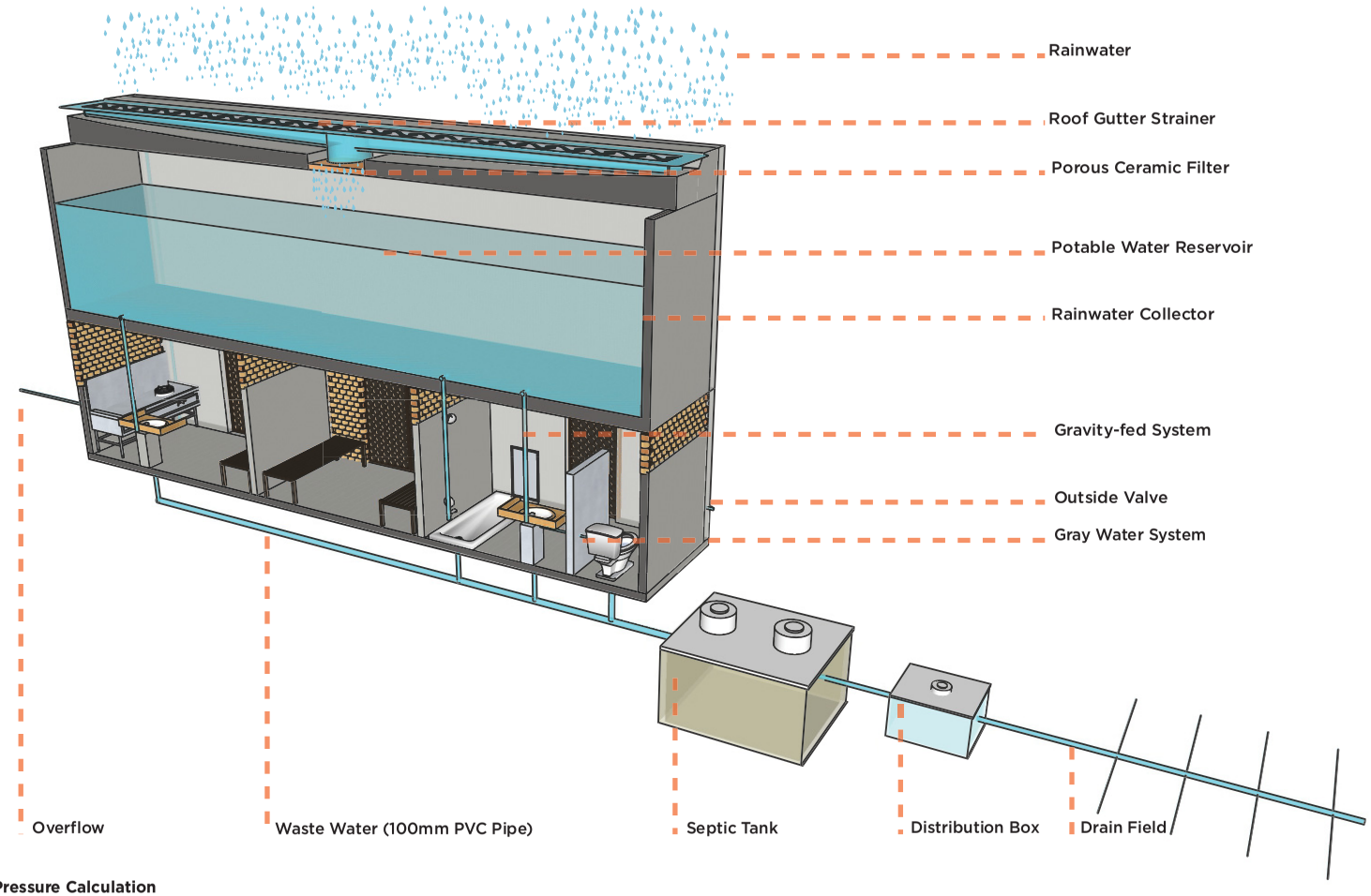
Details

Water Collection/Filtration Core

First the Khmer people in rural areas use the washroom outside. This was not the main concern. As well most Cambodian have a motorcycle and this leads to the need for a more secure space on the ground. Therefore, the concrete box was formed which can be built beside the main structure of the house, either partially under the house or fully enclosed in the space below the house. The problems with this concrete box were inadequate lighting and ventilation.

Most Cambodian Families have large concrete pots for storing water but leave it exposed to the elements in a way that may encourage the growth of bacteria, which have the potential to cause severe health problems. Clean drinking water is an on going issue in Cambodia. During the wet season, water collection may be easier due to rain catchment, but flooding also presents a sanitation concern since human waste may mix with water collection vessels.

The proposed water infrastructure is simple and effective, sustainable with the increasing growth of a family and it is an enclosed system, integrating with the existing rural building design.



Water Pressure Calculation

Volume of the infarstrcutre = Length(32') x Width(6') x Height(10') = 1920ft³ = 54368L
Water Pressure (P) = water density (p) x gravitational force (g) x height of liquid (h)
Density of Water (p) = mass (M) / volume (V)

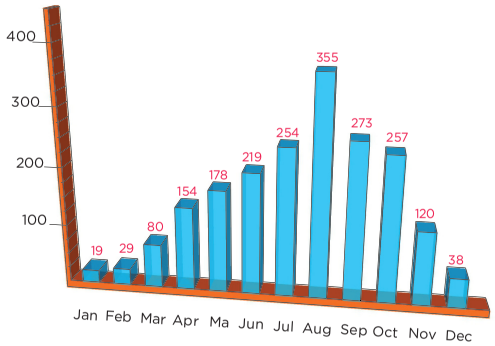
P = p.g.h
= (1008.68 kg/m³)(9.81 m/s²)(5.47m)
= 30081.34 pascals
--> 30081.34 pascals/6894.76
= 7.85 per square Inch (psi)

Current Water Pressure (7.85 psi) < Residential Concrete (2500psi)

Therefore, since the maximum pressure of water is less than the required residential concrete pressure then the infrastructure can withstand the maximum water during the monsoon season.

Sectional Perspective Water Infrastructure Diagram

Average Monthly Rainfall in mm



Water Consumption in Rural Cambodia Per Capita

1. To Drink: 2L
2. To Shower: 20L
3. To Flush: 10L
4. To Cook: 20L
5. To Wash: 25L

Total = 1 +2 +3 +4 +5
= 2L +20L +10L +20L +25L
= 77L x 6 ppl x 30 days
= 13860L

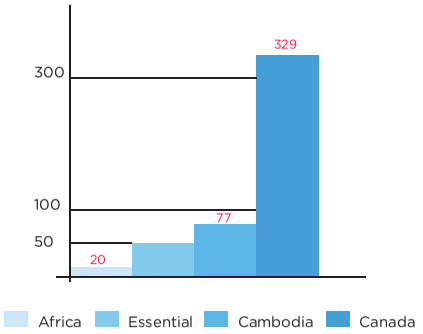
Therefore, the water consumption for a family of six members in rural Cambodia is 13860 L per month.

Rainwater Harvest Calculation (RH)

RH = Roof Area (RA) x Amount of Rainfall (AF) x 0.9

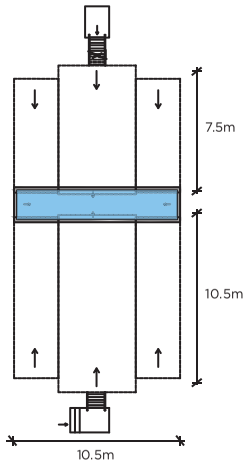
This formula will be used to calculate whether or not the rain catchment is big enough to collect rainwater during the peak of moonsoon season in August until the dry season that last to the end of March.

Average Consumption per Person and Day in Litre



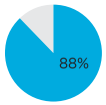
Roof Dimensions

Roof Area (RA) = Length x Width
= 18m x 10.5m
= 189m²



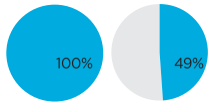
August

RH= (RA)(AF)(0.9)
= (189)(355)(0.9)
= 60,385 -13,860
= 46,525 L



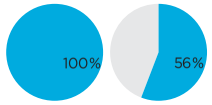
September

RH= (RA)(AF)(0.9)
= (189)(273)(0.9)
= 46,437 - 13,860
= 32,577L+46,525L
= 79,102L-52,920L
= 26,182L For critters



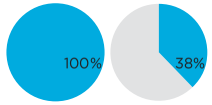
October

RH= (RA)(AF)(0.9)
= (189)(257)(0.9)
= 43,715 - 13,860
= 29,855L+52,920L
= 82,775L-52,920L
= 29,855L For critters



November

RH= (RA)(AF)(0.9)
= (189)(120)(0.9)
= 20,412 +52,920L
= 73,332L-52,920L
= 20,412L For critters

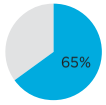


December

RH= (RA)(AF)(0.9)
= (189)(38)(0.9)
= 6,464 -13,860L
= -7,396L+ 52,920L
= 45,524L
To Keep for next month

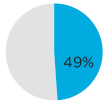
January

RH= (RA)(AF)(0.9)
= (189)(19)(0.9)
= 3,232 - 13,860
= -10,628L+45,524L
= 34,896L
To Keep for next month



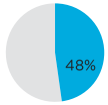
February

RH= (RA)(AF)(0.9)
= (189)(29)(0.9)
= 4,933 - 13,860
= -8,927L+34,896L
= 25,969L
To Keep for next month



March

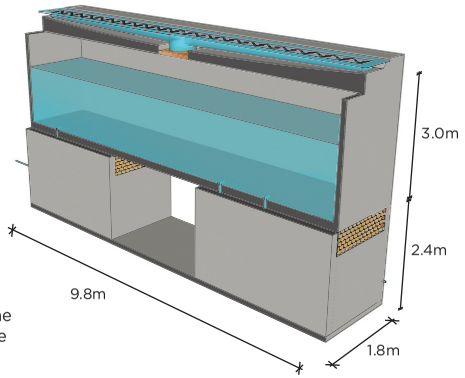
RH= (RA)(AF)(0.9)
= (189)(80)(0.9)
= 13,608 - 13,860
= -252L+25,969L
= 25,717L
For critters



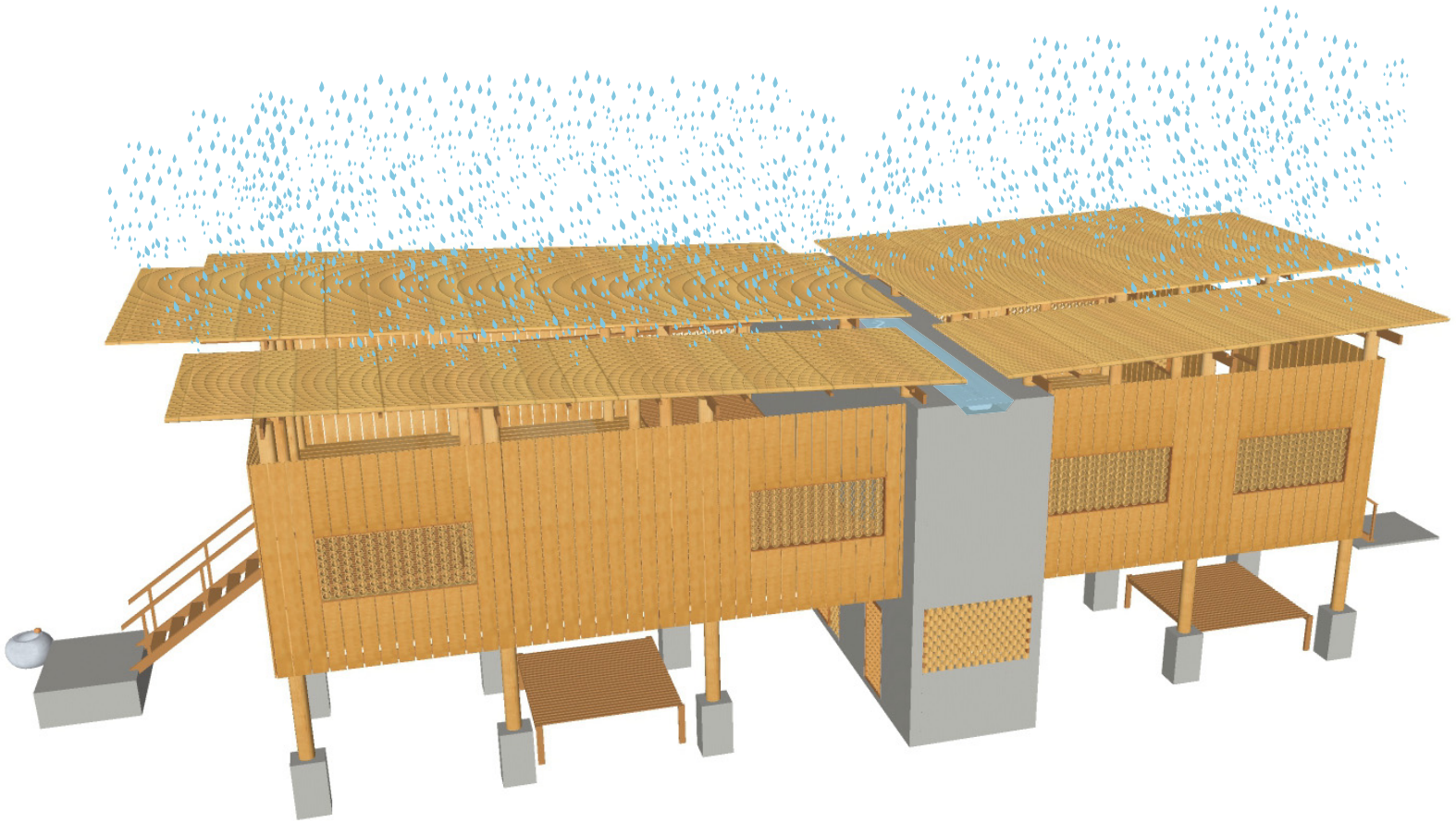
Therefore, the calculations for the eight critical months show that the water infrastructure can hold and sustain the family members during the dry season. It is also clear that the rainwater catchment is designed to hold double the water usage each month for this family of six.

Rain Catchment Dimensions

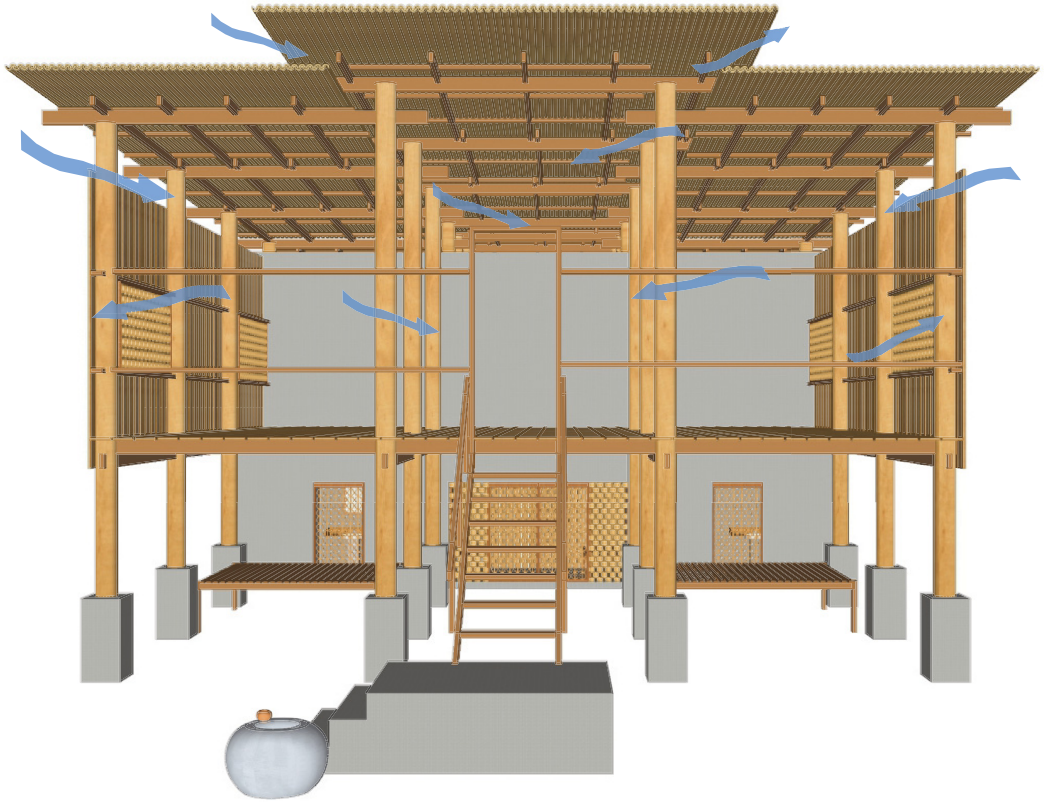
Maximum Volume = Length x Width x Height
= 9.8m x 1.8m x3.0m
= 52.92m³ / 0.001
= 52920L



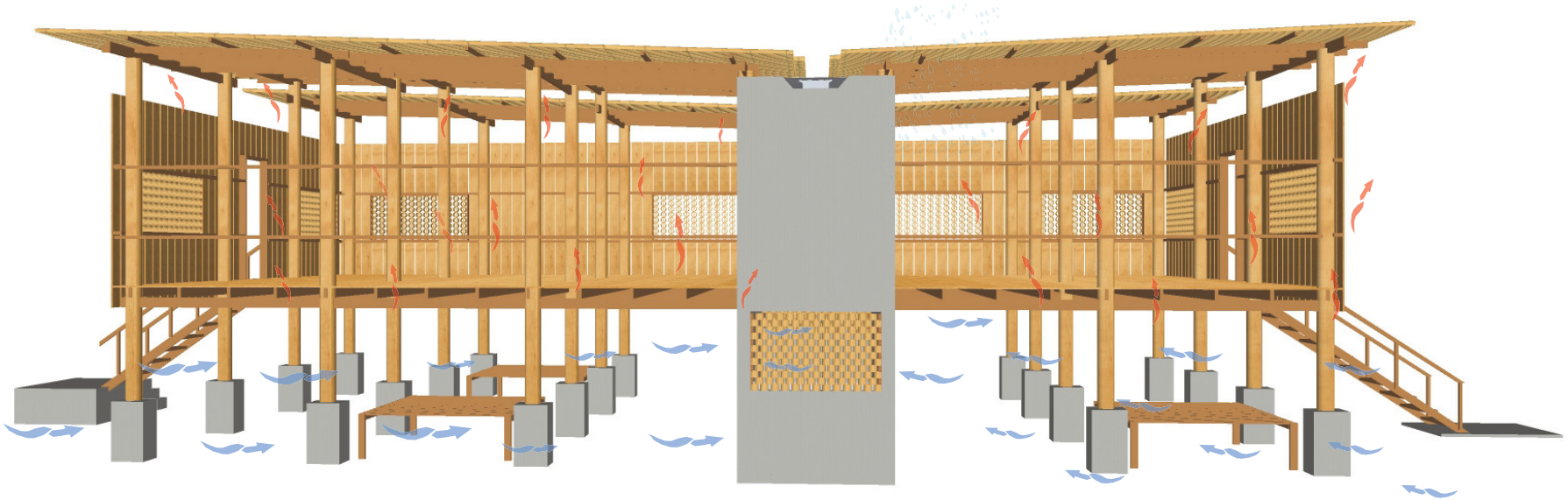
Water Infrastructure Usage Calculation



Rainwater Collection



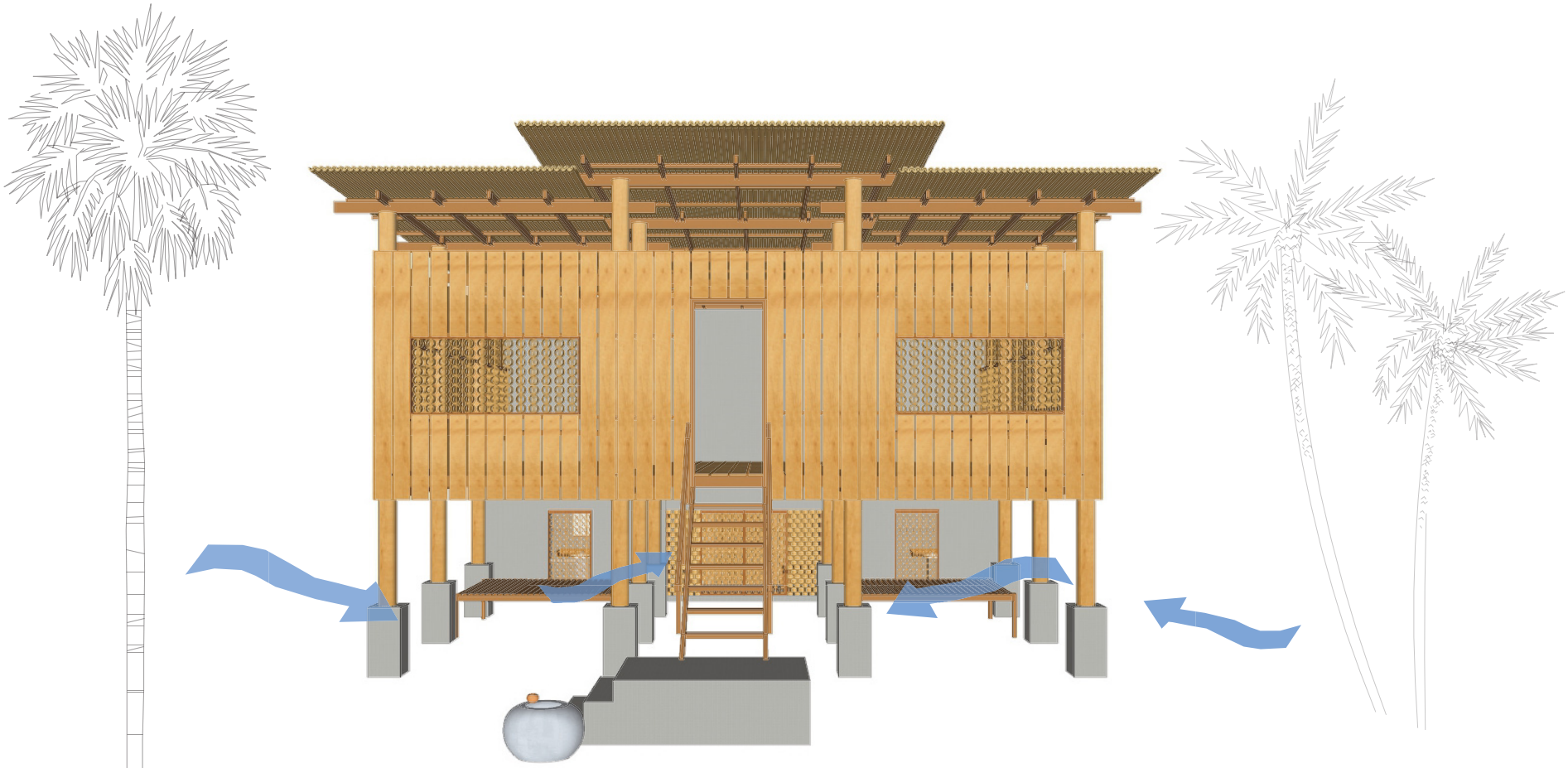
Cross Air Ventilation



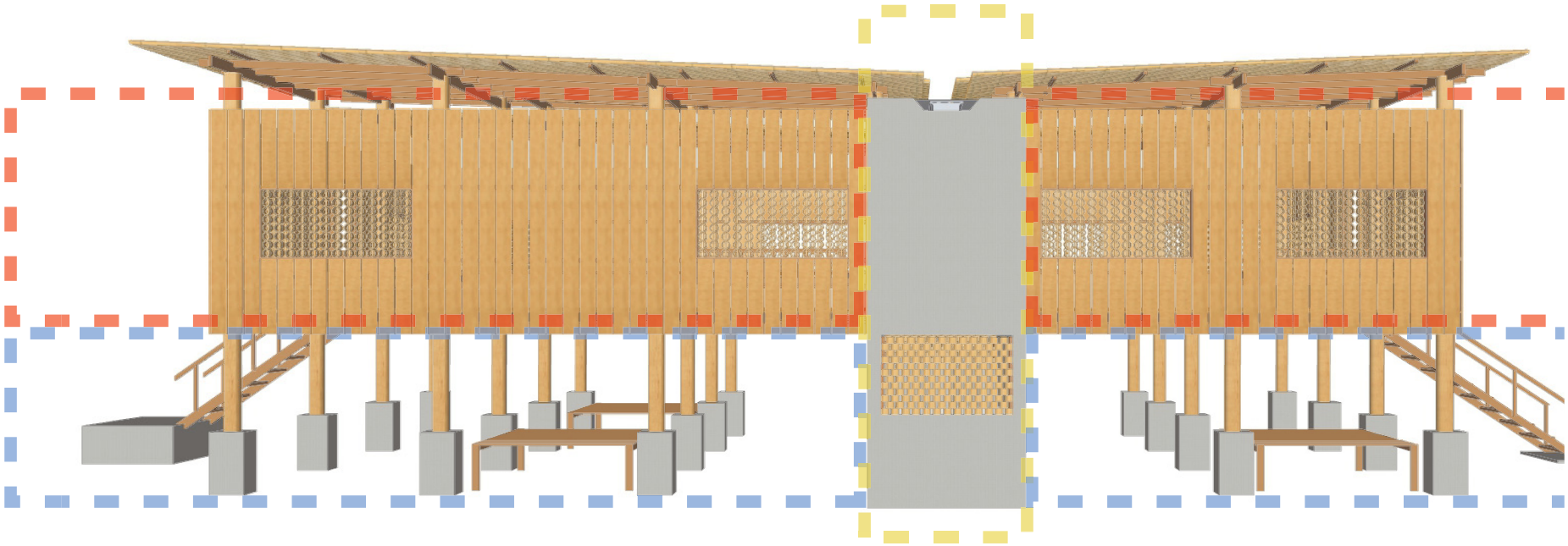
Cool Air

Warm Air

Stack Effect Ventilation



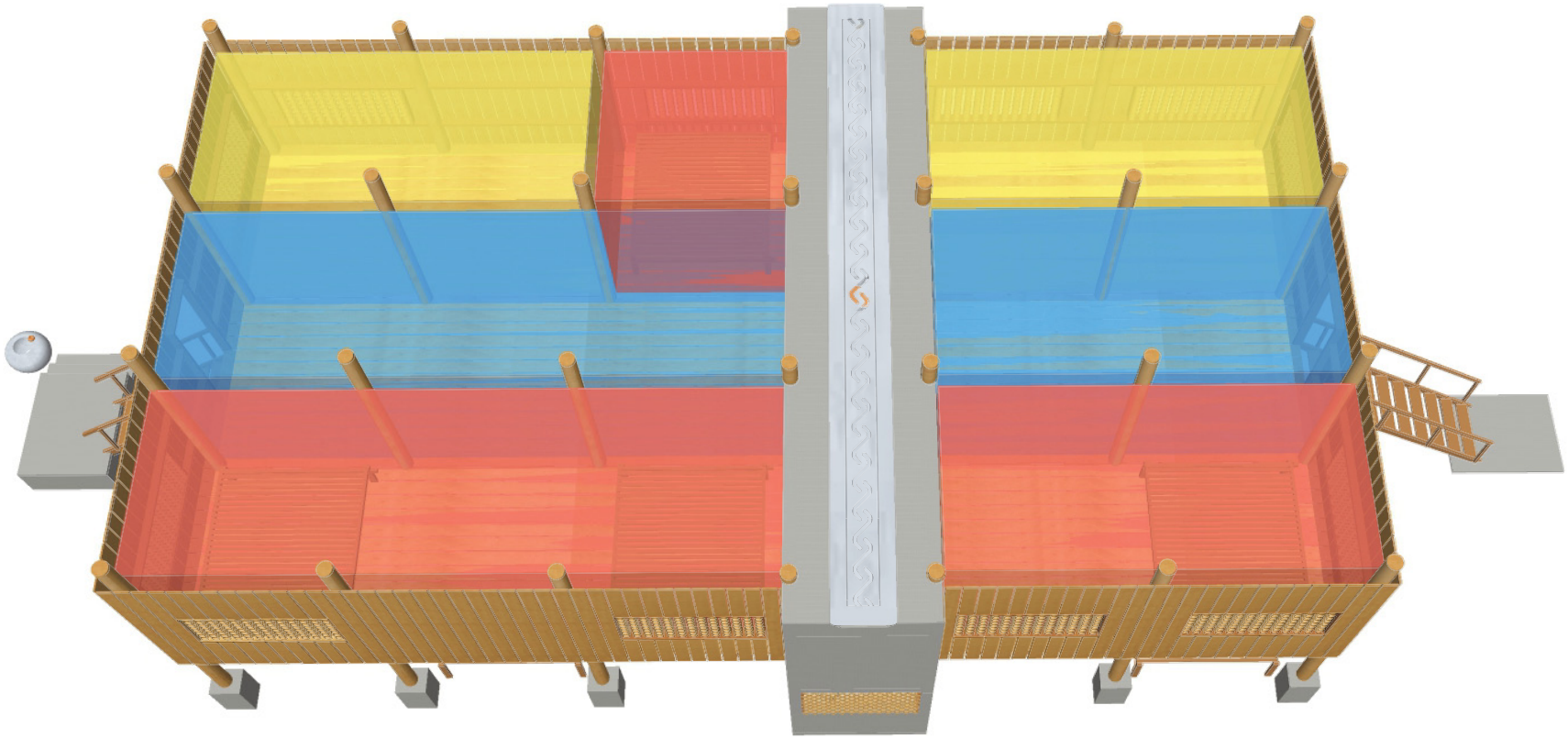
Natural Breeze



Living and Sleeping

Working and Gathering

Water Collection/Kitchen/Bathroom



Sleeping Space

Family Space/Circulation Space

Living Room

Interior Space

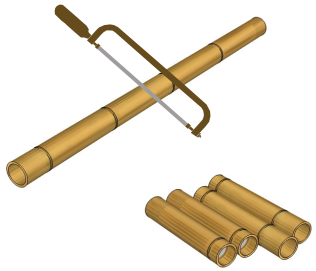
Exterior view - Daily activities

Underneath the house - Rural living

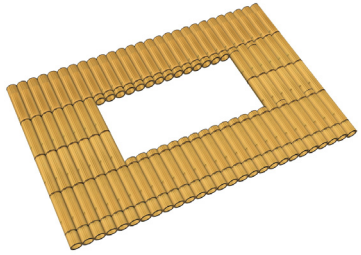
Interior view - Sleeping space

Underneath the house - Rural living

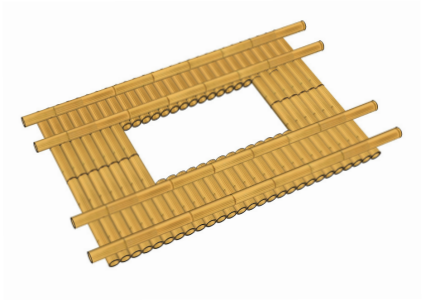
Bamboo is being harvested locally and prepared for the formwork.



Bamboo is being cut to length for an opening (ie. a door or a window).



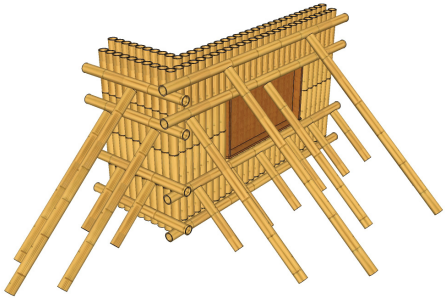
The pieces are then placed on the ground to measure the dimensions.



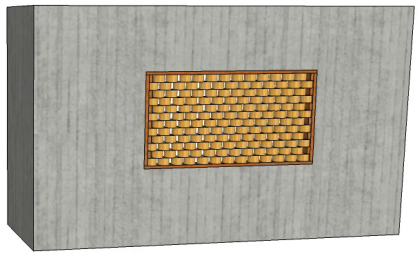
The bamboo pieces are tied down with longer bamboos that run perpendicular to the front face of the platform.

Bamboo platforms are then brought up vertically and connected to one another to create formwork.

If there is an opening in the formwork, it will be covered before concrete is being poured.



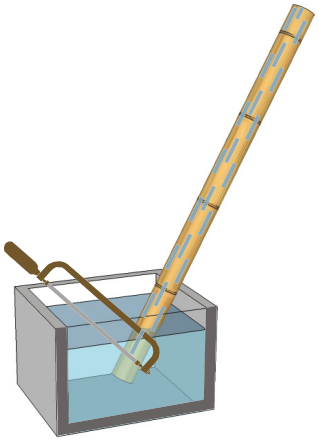
The final step is to brace the formwork, then the concrete is ready to be poured. Note: Bamboo is used as a reinforcement.



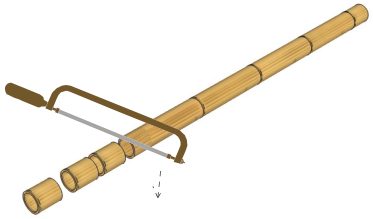
The wall is complete with a vertical bamboo texture that helps to soften the appearance of the concrete structure. The the window can then be put in place.

Bamboo Fabrication Steps - Concrete Formwork

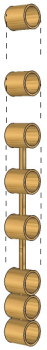
Bamboo is being harvested locally and prepared for a boron-salt solution.



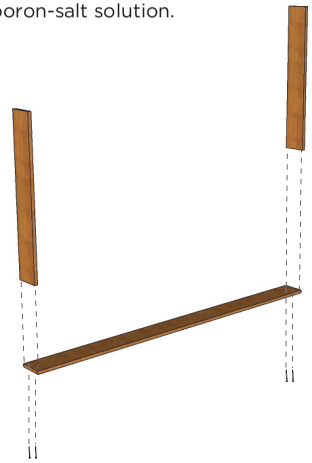
End of the bamboo is cut off in boron-salt solution (Natural Preservation).



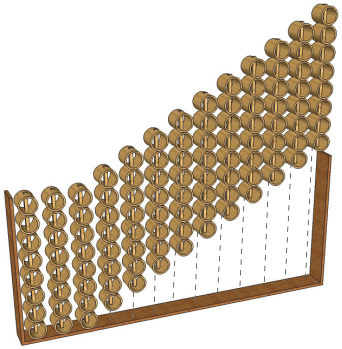
Let the bamboo dry for 2-3 days, then it is ready to be cut to length.



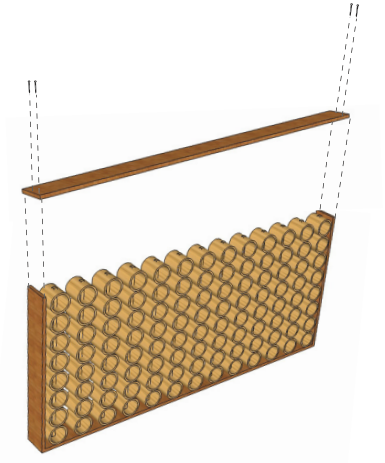
Each section of bamboo is then inserted into squared wood or metal rod for security.



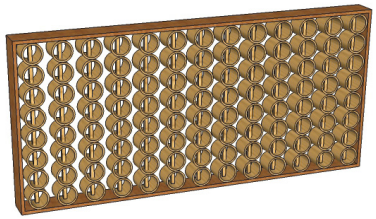
Window frame can be made with nail connections or wire to reduce cost.



Each module of sectional bamboo is then inserted into the marked and drilled window frame.



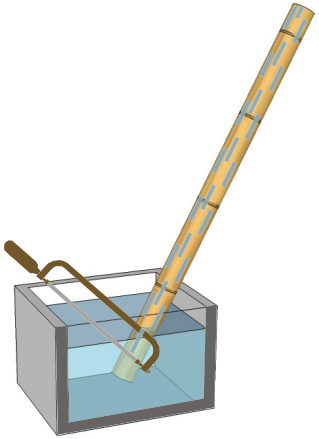
After all modules of sectional bamboo are assembled, the top of the frame can be closed.



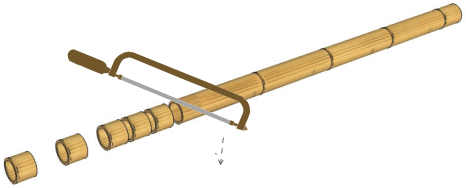
The bamboo window is complete. Each section of bamboo an be rotated and act as an individual shutter.

Bamboo Fabrication Steps - Bamboo Window

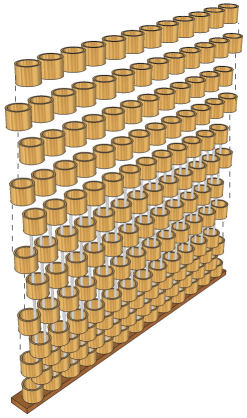
Bamboo is being harvested locally and prepared for a boron-salt solution.



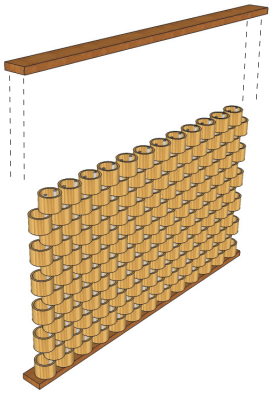
End of the bamboo is cut off in boron-salt solution (Natural Preservation).



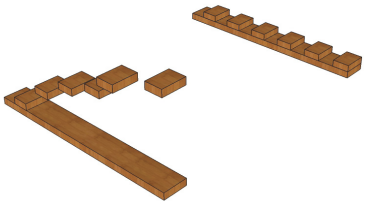
Let the bamboo dry for 2-3 days, then it is ready to be cut to length.



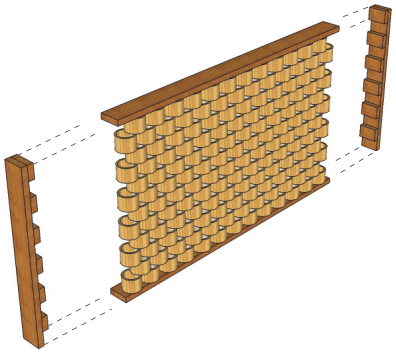
Each section of bamboo is then inserted into squared wood or metal rod for security.



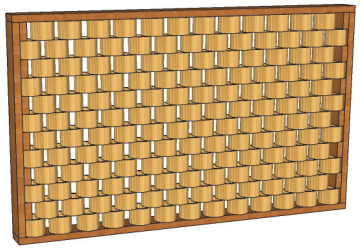
After all modules of sectional bamboo are assembled, the top of the frame can be put in place.



The side frames are made with the spacing, according to the diameter size of the harvested bamboo.



The framed sides are attached with nails to the rest of the frame.



The bamboo screen is complete. This allows adequate air and sunlight to pass through.

Bamboo Fabrication Steps - Bamboo Screen

CHAPTER 4: CONCLUSION

This thesis proposal argues that this new affordable and sustainable house design could resolve the current health and safety issues in the rural areas of Cambodia. The history and cultural factors of this area were fully understood before any design moves could be executed.

The design begins with an understanding of the current issues and proposes solutions. The water infrastructure is a solution example that integrates the water collection/filtration including a kitchen, storage, and bathroom at ground level.

The intention is to use the materials available as well as the local knowledge of construction for this water infrastructure. The members of the extended family can then build a dwelling attached to the main rainwater system. This water infrastructure can also be used as part of the building structure.

This thesis intends to show that architecture is not static and that it changes through time. However, with a creative mind, an understanding of a particular culture and its architecture, one can imagine how it may change over a period of time. Therefore, this thesis design is determined to solve the current health and safety issues in rural areas of Cambodia as well as improve the quality of life and way of living through architecture.

This thesis topic germinates from my interest in connections between culture and architecture, and how they work together in order for a design to be successful. Only with an understanding of cultural design and the culture of a community can an architect be able to propose and improve the way of life for the area.

The method of study and the experience of learning how culture and design work together, are skills that can be transferred to other projects. Even though my thesis has been focused on a housing type in rural Cambodia, the concept or method of study is transferable to any country around the world. All that is needed is for a local population within the community to be taught how to use their own resources in the most effective and sustainable way.

No matter where the design takes place, without an understanding of the cultural needs, a project will never meet its full potential. Architects need to understand the relevant issues, and propose solutions that are well thought-out. This can then blend seamlessly into the fabric of the culture of the community. These solutions should always consider the method of construction using local materials more sustainably and efficiently.

My thesis discusses water collection and filtration, waste management, core infrastructure, and the use of local materials such as bamboo, in order to make a common Cambodian security feature, more esthetically pleasing. These designs are formed from an interdisciplinary study of engineering, sociology, economics, and environmental studies. One must appreciate that every discipline is intertwined with the other. It is this understanding of the importance of different disciplines that will allow architects to express their full creative ability in order to provide better living conditions where needed.

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