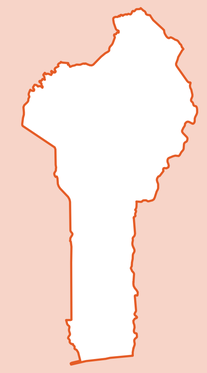
PROJECT VISION

A SUSTAINABLE VISION FOR HOUSING IN BENIN; COTONOU

My vision for sustainable housing development in Benin, Cotonou

At the same time that we are solving climate change, we are building cities for another 3 billion people by 2050. That's a doubling of the urban environment.

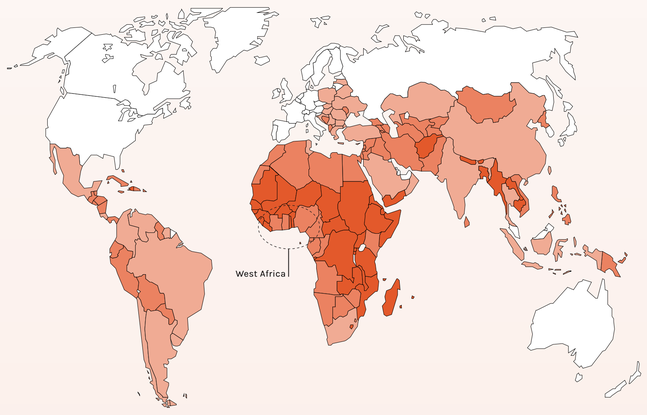
Most of this construction, especially housing projects, will take place in emerging and developing countries in the coming decades, and if we don't get a handle on this, all the world's climate solutions will come to nought. As architects, engineers, builders, and government officials, we have the opportunity and the great responsibility to shape our future.
Our decisions impact not only the environment but also our social well-being, our economic vitality, our sense of community and connectedness.



WHY & WHERE ?

EMERGENT AND DEVELOPING COUNTRIES

HOUSING PRIORITIES



Least Developed Countries
Other Developing Economies
Emerging Industrial Economies
Industrialized Economies

The most extensive housing projects will take place outside the industrialised countries in the coming decades.

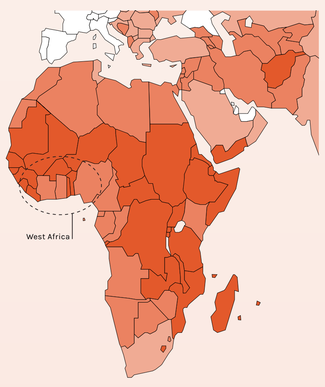
1.26 BILLION URBAN DWELLING IN AFRICA BY 2050

AFRICA BUILTS MORE

WEST AFRICAN REGION

80% OF THESE BUILDINGS IN SUB-SAHARAN AFRICA ARE NOT YET BUILT, COMPARED TO 30% IN EUROPE

West Africa current housing shortage estimate = 3.5 million units



CURRENT GOVERNMENT HOUSING PROGRAMS

5 to 10 year construction

SENEGAL +100K
TOGO +20K
GHANA +100K
MALI +50K
NIGERIA +300K
BENIN +20K
BURKINA FASO +40K
ETC...

TODAY'S CHOICES WILL HAVE AN IMPACT ON THE DECADES TO COME

WHAT ?

IDEA DIAGRAM

A VISION FOR SUSTAINABLE HOUSING DEVELOPMENT IN BENIN

PROBLEM STATEMENT

Priorities in Housing

RAPID URBANISATION
Highest population growth rates in Emerging and developping countries
FROM 2 to 4 Billion ppl until 2030

CONTEXT
TROPICAL CLIMATE
WEST AFRICA
BENIN, COTONOU

Benin Housing Challenges

1. lack of consideration of the regional climate
2. materials choices and architectural typologies do not reflect social and cultural identity
3. Few sustainable construction methods / No or incorrect use of locally available materials
4. Interruptions in supply / lack of urban technical infrastructure
5. Lack of urban technical services

Research Questio n

Is it possible to develop autonomous housing for urban areas in Benin, and how can architectural design support this goal?

Which passive design strategies are suitable for regulating the indoor climate in housing projects in Benin?

+20K Housing — **BENIN** WEST AFRICA — Mapping

1. What are the climate characteristics in the coastal region of Benin?
2. What is the current housing situation?
3. Which passive design strategies can be used to cool neighborhoods and houses in Benin?

Climate Analysis — Weather Data
Current Housing in the cities — Photo Docu, Site Visit, Interviews
What Passive Design Strategies? — Design Strategy

Design Criterias — Apply

Energetic and management Autonomy?

Energy Harvesting? — Calculations
Water Storing?
Trash Management?

Feasibility Study for autonomous dwelling in Benin

Beninese architectural typology
Conclusion feasibility study — Conclude
Reasses Hypothesis

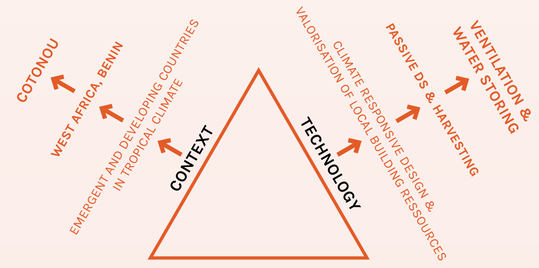
Architectural Response — Apply

HOW?

PROJECT GOAL

CHALLENGE	GOAL	PROJECT
• Massive urbanization • Outdated conceptual approaches from other socio-cultural environments • Interruptions in supply are the order of the day (water, electricity)	• Sustainability driven and appropriate architectural solutions • A culture appropriate architectural vision for Benin • Climate driven design , Reducing energy needs	• Contributing to the architectural discourse • A Sustainable building vision, independent from the urban supply grid • Improve the indoor climate and overall quality of life of the middle class

TRIANGULAR APPROACH



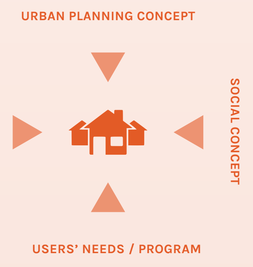
DESIGN PROGRAM

SUSTAINABLE LONG TERM HOUSING FOR BENIN

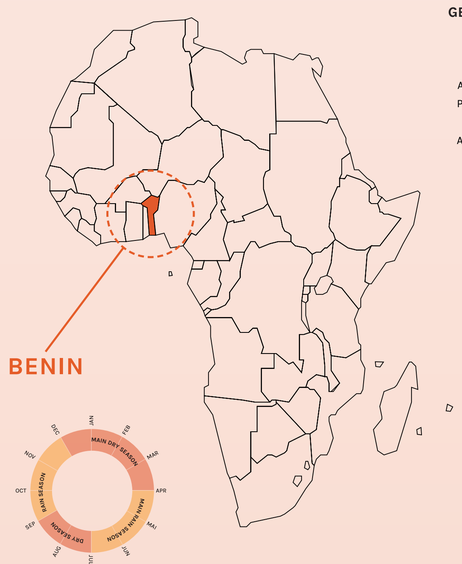
URBAN SOLUTIONS

HOUSING

FOUR PILLAR STRATEGY



PLACE OF FOCUS

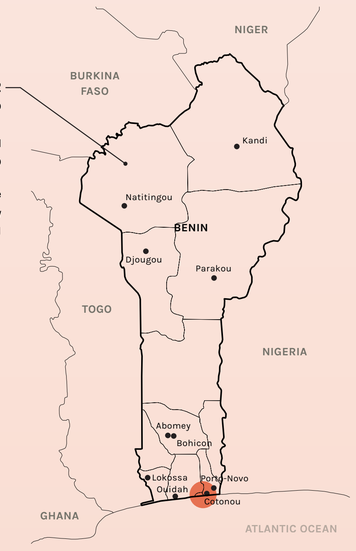


GENERAL INFO

Area **114 763 km2**
Population **12.5 Mio**

Administrative Capital
Porto-Novo

Capital of Trade and Largest City
Cotonou



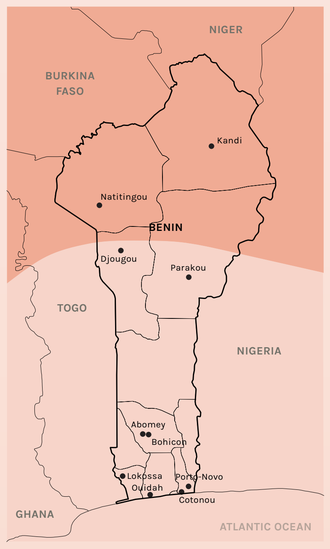
CLIMATE CONDITIONS

HUMIDITY
Constantly above comfort limit
84% avg

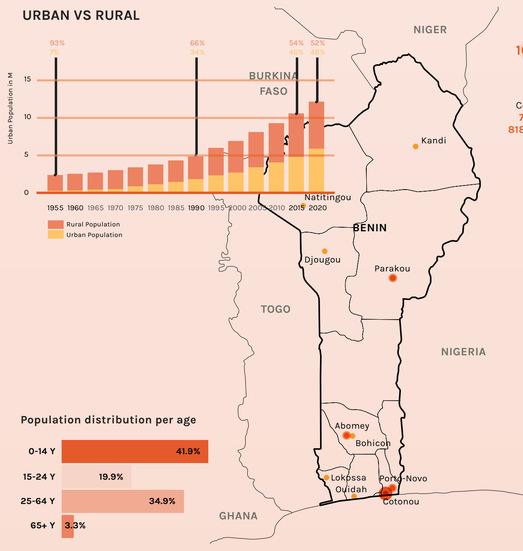
TEMPERATURE
Consistently high outdoor temperatures throughout the year, low night cooling
27,5 avg

WIND DIRECTION
One primary wind direction from the sea
South West

PRECIPITATION
Strong and highly varying rainfall
1245 mm avg



URBAN VS RURAL



10355	2130	516
Cotonou	Porto-Novo	Parakou
79km2	110km2	441km2
818.100 ppl	234.300 ppl	97.000 ppl

Population distribution per age

0-14 Y	41.9%
15-24 Y	19.9%
25-64 Y	34.9%
65+ Y	3.3%

10 Largest cities

+ 500k
1. Cotonou

+100k-500k
2. Porto-Novo
3. Parakou
4. Abomey

<100k
5. Djougou
6. Bohicon
7. Kandi
8. Natitingou
9. Ouidah
10. Lokossa

SITE CONTEXT

Cotonou, Benin

SOCIAL RESPONSE

URBAN CLUSTER - NEW OLD VISION FOR LIFE IN THE CITY

City as neighbourhood >> neighbourhood as a village

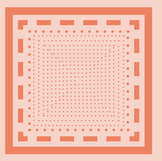
African cities are undergoing significant transformation processes as a result of immigration and growth. Informal settlement areas are being transformed into formal urban districts through urbanisation projects. People want a modern, hygienic and spatially sophisticated living environment and housing of the same standard.
They need to recognise themselves in these dwellings and the surroundings to find their way around. The reference to traditional (village) spatial structures as an all-around orientation is great in the general population. Urban planning must consider this reference as a compass so that people are not uprooted. They keep cultural/ethical references in the immediate environment. This leads to identification.

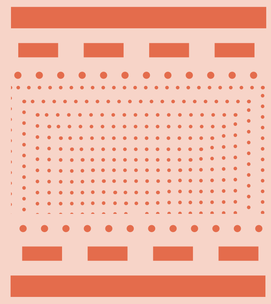
We are essentially creating a city as a neighbourhood and a neighbourhood as a village, where residents can feel at home and keep their traditions and sense of identity.

Grown Structure **vs.** ***Planned Structure*** **=** ***Hybrid Structure***

Expresses the needs of the users

Meets the requirements of a modern city





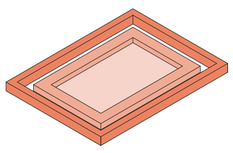
BLOCK CONCEPT

HOMES CREATED
+ 275 HOMES
+ 1700 PPL

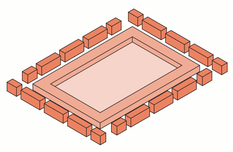
PASSIVELY COOLING NEIGHBOURHOOD
+ NO NEED IN COSTLY AC

WATER COLLECTED
+ 40.500 M3 PER YEAR
= 16 OLYMPIC SWIMMING POOLS

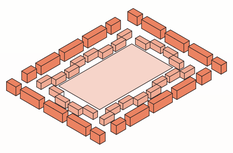
ENERGY HARVESTED
+ MIN **5180 KWH/YEAR** PER HOUSEHOLD



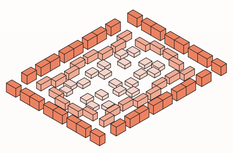
1. 3 LAYERS



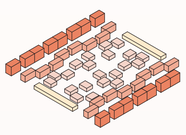
2. DIVIDE FOR CIRCULATION AND VENTILATION



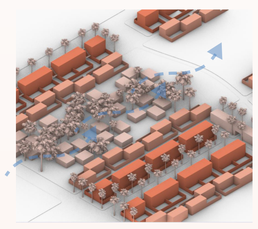
3. SHIFT FOR VENTILATION



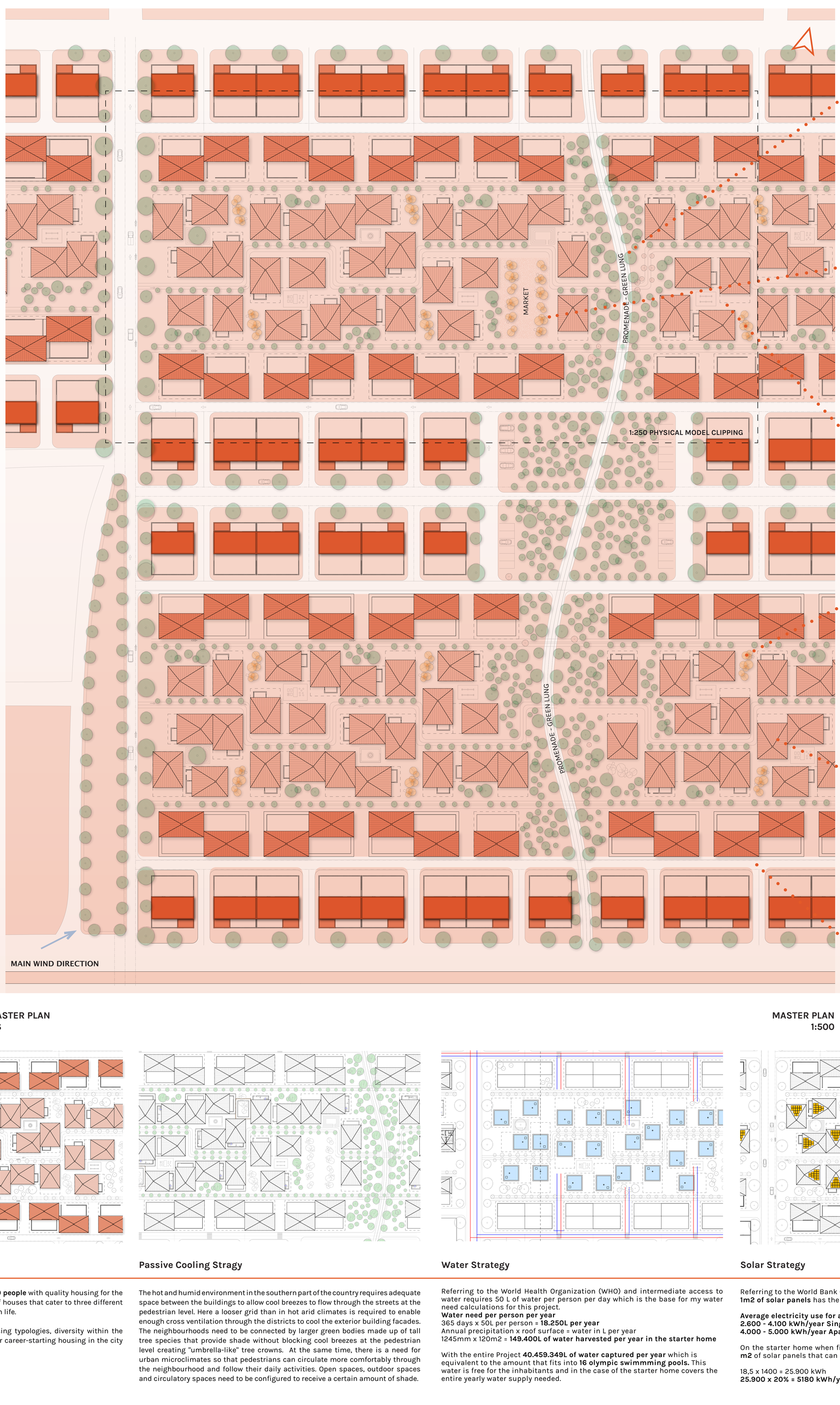
4. SCATER AND CLUSTER



5. LOWER THE EDGES



6. ADD VEGETATION



LEGEND

- Main roads
- Boardwalks, secondary pathways, housing etc.
- 1story houses
- 2 story houses
- 3 story houses
- Trees

TYPICAL SPATIAL SITUATIONS

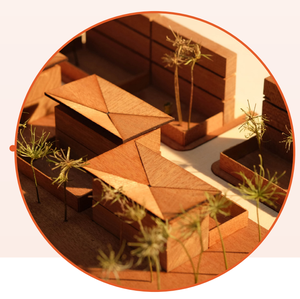
GREEN LUNG

MARKET

HOUSING EXTENSIONS

IN-BETWEEN SPACES

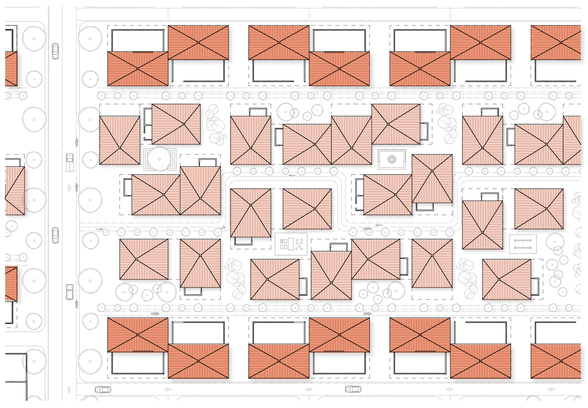
COLLECTING WATER

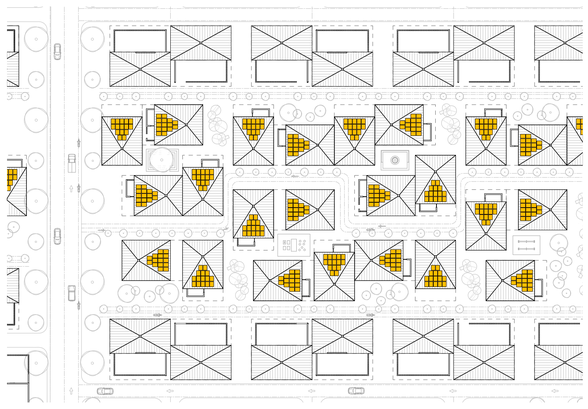


BLOCK EDGES

QUANTIFIABLE BENEFITS OF THE MASTER PLAN FOR THE CITY AND ITS INHABITANTS

MASTER PLAN
1:500





Housing Strategy

The proposed intervention provides about **1700 people** with quality housing for the broad middle class. Provided are three types of houses that cater to three different types of users, reflecting their various stages in life.

By developing three inherently different housing typologies, diversity within the housing block is guaranteed, and affordable or career-starting housing in the city is preserved long-term.

Passive Cooling Stragy

The hot and humid environment in the southern part of the country requires adequate space between the buildings to allow cool breezes to flow through the streets at the pedestrian level. Here a looser grid than in hot arid climates is required to enable enough cross ventilation through the districts to cool the exterior building facades. The neighbourhoods need to be connected by larger green bodies made up of tall tree species that provide shade without blocking cool breezes at the pedestrian level creating "umbrella-like" tree crowns. At the same time, there is a need for urban microclimates so that pedestrians can circulate more comfortably through the neighbourhood and follow their daily activities. Open spaces, outdoor spaces and circulatory spaces need to be configured to receive a certain amount of shade.

Water Strategy

Referring to the World Health Organization (WHO) and intermediate access to water requires 50 L of water per person per day which is the base for my water need calculations for this project.
Water need per person per year
365 days x 50L per person = **18.250L per year**
Annual precipitation x roof surface = water in L per year
1245mm x 120m2 = **149.400L of water harvested per year in the starter home**

With the entire Project **40.459.349L of water captured per year** which is equivalent to the amount that fits into **16 olympic swimmming pools.** This water is free for the inhabitants and in the case of the starter home covers the entire yearly water supply needed.

Solar Strategy

Referring to the World Bank Group:
1m2 of solar panels has the potential to produce **app 1400 kWh in Benin**

Average electricity use for a 4 people household per year in Germany:
2.600 - 4.100 kWh/year Single-family house
4.000 - 5.000 kWh/year Apartment house

On the starter home when filling one roof slope with solar panels we have **18,5 m2** of solar panels that can produce **5180 kWh/year at an efficiency of 20%.**

18,5 x 1400 = 25.900 kWh
25.900 x 20% = 5180 kWh/year

SOCIAL RESPONSE
HOUSING BLOCK

Housing block as microcosmos

Within the housing block, the population and inhabitants circulate, live and experience green in 3 different ways.

Due to the hot and humid climate the housing blocks need to allow for enough air to enter the neighbourhood. Therefore the urban grid is more loose then in hot and arid climates. At the same time this urban grid needs to be shaded in order to cool down the neighbourhood as much as possible. In the urban planning there are 3 types of green spaces which go from the urban to individual housing scale. A large green lung and promenade inserted in the middle connects the housing blocks so that pedestrians can circulate in safety away from the pollution of the cars and under the cooling shade of the local tree species.

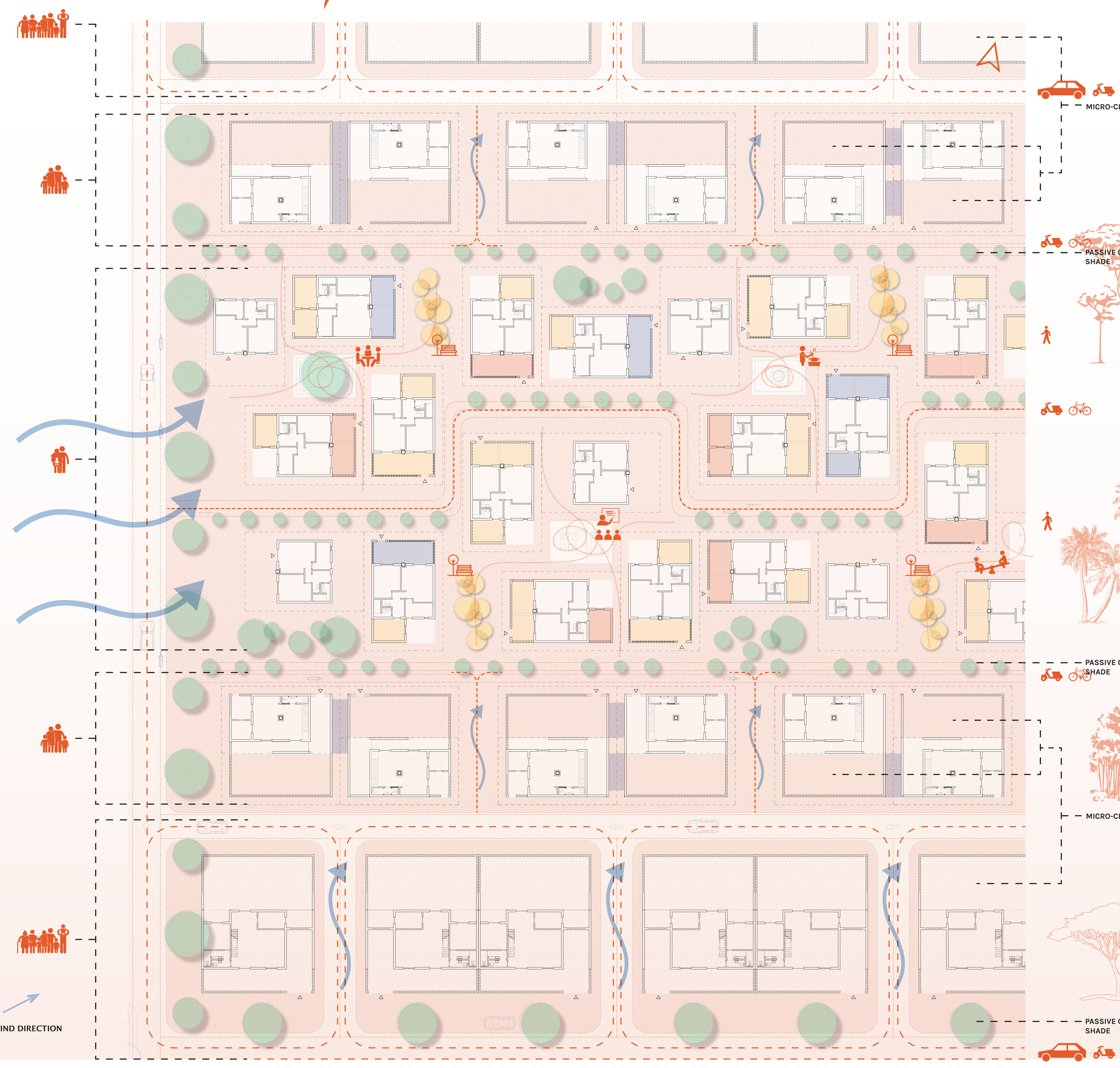
BLOCK CONCEPT

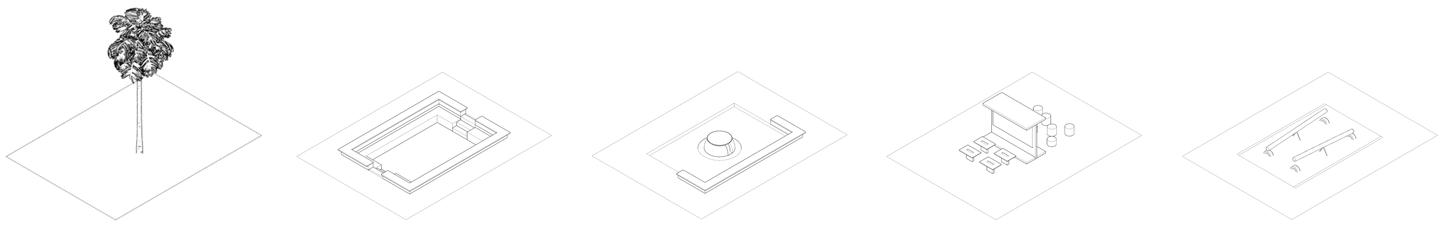
3 TYPES OF HOMES

3 TYPES OF CIRCULATION

3 TYPES OF GREEN SPACES

3 TYPES OF COMMUNAL & IN-BETWEEN SPACES





UNDER A TREE
In Africa, a palaver tree is a traditional place of gathering, in the shade of which one expresses oneself on the life in society, the problems of a village or political life.

GATHER
A formal place of gathering that can be used day and night. A place to have a simple conversation between neighbours and a place to hold festivities, ceremonies etc.

OUTDOOR COOKING
Until today most cooking takes place outside as many people do not own a stove and or prefer to cook outdoors over charcoal. Public traditional outdoor cooking pits are offered to prepare meals

EDUCATION
A place to do homework and after-school tutoring. In Benin, it is common for families from the upper middle class to organise private tutoring for their children. The education space allows starter families to finance a tutor together and gives them a space for group tutoring.

PLAYGROUND
Besides the informal streets as playgrounds, this public space is a formally designated outdoor area for children to play. This public space also gives the opportunity to install fixed objects like a seesaw, a climbing frame, an outdoor gym etc.

URBAN CLUSTER
1:200

LEGEND

- Housing extensions
- Roads accessible by car
- Roads accessible by bike or scooter*
- Pathways accesible by walking
- Ventilation
- Trees

Housing Concept

People and families from different social classes live in the housing block. Accordingly, I have developed three different types of houses that reflect separate incomes but, most importantly, different stages in life.
The starter home - A xxxm2 house designed for 1-3 people but can accommodate up to 6 individuals. This house surface can be extended over time up to xxxm2. **The family house -** A classical one-family household two-story home with a private garden and parking space. It is designed for a household of 4-6ppl that is a mid-career. **The generations house -** Derived from the Beninese culture of living together. Here a family from grandparents to grandchildren can live under one roof while having separate entrances to allow for some privacy and to rent to

Access Concept

The overall circulatory concept of this project consist of 3 types of access.
Access by Car - The generation's house and family house are fully accessible by car and are provided with a parking spot on their property. **Access by Scooter -** Beyond the point of family houses, traffic is slowed down, and we are entering a zone accessible by scooters and bikes, allow to easily access the flats in the inner part of the block. **Pedestrian Zone -** The centre part of the housing block is reserved for pedestrians. Here the residents can gather, and children can play safely.

Climate Concept

The horizontal streets of the overall housing block are oriented Southwest. The block is structured as a valley to protect the neighbourhood from the noise of the road while dragging the air inside the block through the streets used for circulation. A green lung at the centre of the block is becoming a place for social activities, gatherings, or a path for crossing the block shaded by the sun: the family house and generation house benefit from their own micro-climate within the property due to a garden.

Social Concept

Within the housing block, we can find a variety of public spaces, social spaces and spaces that give opportunities for street vendors to continue their business. From simple spaces of gathering, educational spaces, playgrounds, and outdoor cooking areas to larger marketplaces and tree-covered promenades, the in-between spaces in the housing block are activated. Beyond the car-accessible roads, an entire community exists. Not only does that allow a more flexible arrangement of housing but it also makes the space between the houses safer and becomes the inhabitants extended living space. In short, the barrier becomes the meeting point (vorgänger der Spielstrassen).

HOUSING RESPONSE
STARTER HOUSE

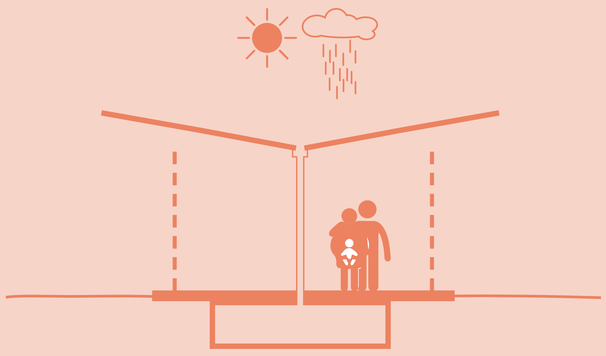
A roof as a starting point for living

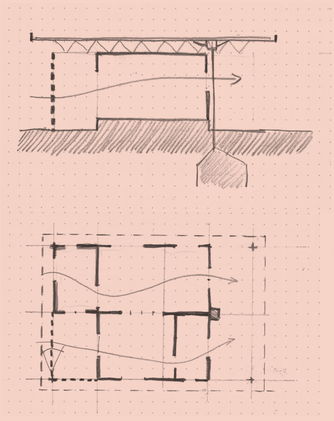
The starter home is designed for people who have a low income or are at the beginning of their careers. I had to develop a strategy guaranteeing a certain quality of life. Therefore, I resorted to the primitive hut or simple shelter, which reduces the architecture to the bare minimum.

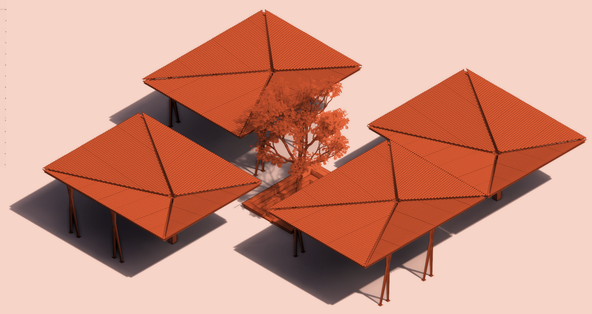
I decided that the starting point of my housing concept would be the roof. An element that protects from heavy rain but also provides shade from the burning sun and indicates each plot's property boundary. In the case of my project , the roof structure not only protects from rain but also captures the rainwater in a below-ground water tank. This first part of the construction process is government funded and guarantees every citizen a high-quality roof and uninterrupted water access.

Small family/ Couple

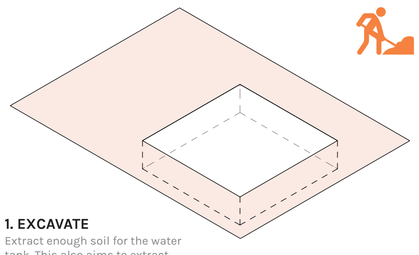
1 Floor
Type: 1 flat
Plot size: 80 m2
Habitable Space: 68 m2
Persons: 1-3



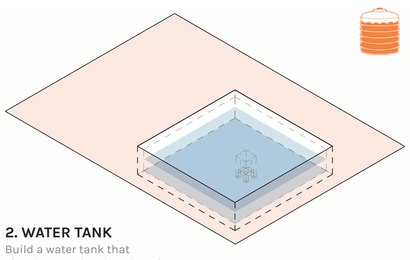




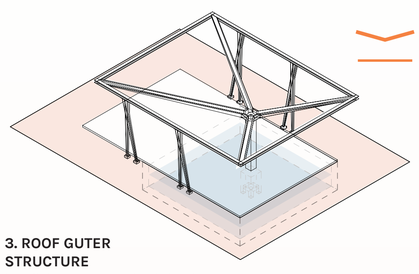
CONSTRUCTION PROCESS



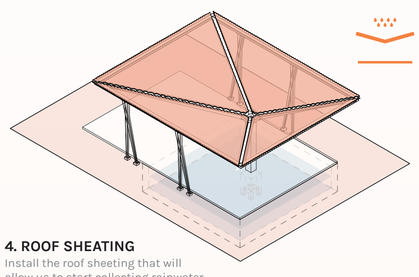
1. EXCAVATE
Extract enough soil for the water tank. This also aims to extract soil that can be used to construct compressed earth bricks.



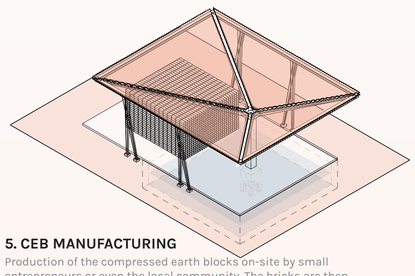
2. WATER TANK
Build a water tank that simultaneously takes the role of the main foundation of the building.



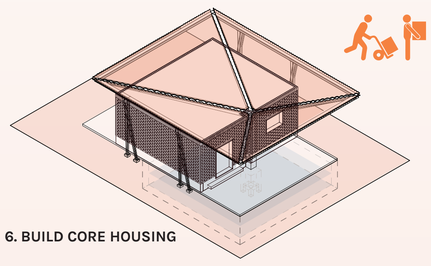
3. ROOF GUTER STRUCTURE
Install the government-funded roof structure with an integrated gutter system.



4. ROOF SHEATING
Install the roof sheeting that will allow us to start collecting rainwater that can be used on the construction site. Now the building structure is ready to be sold.

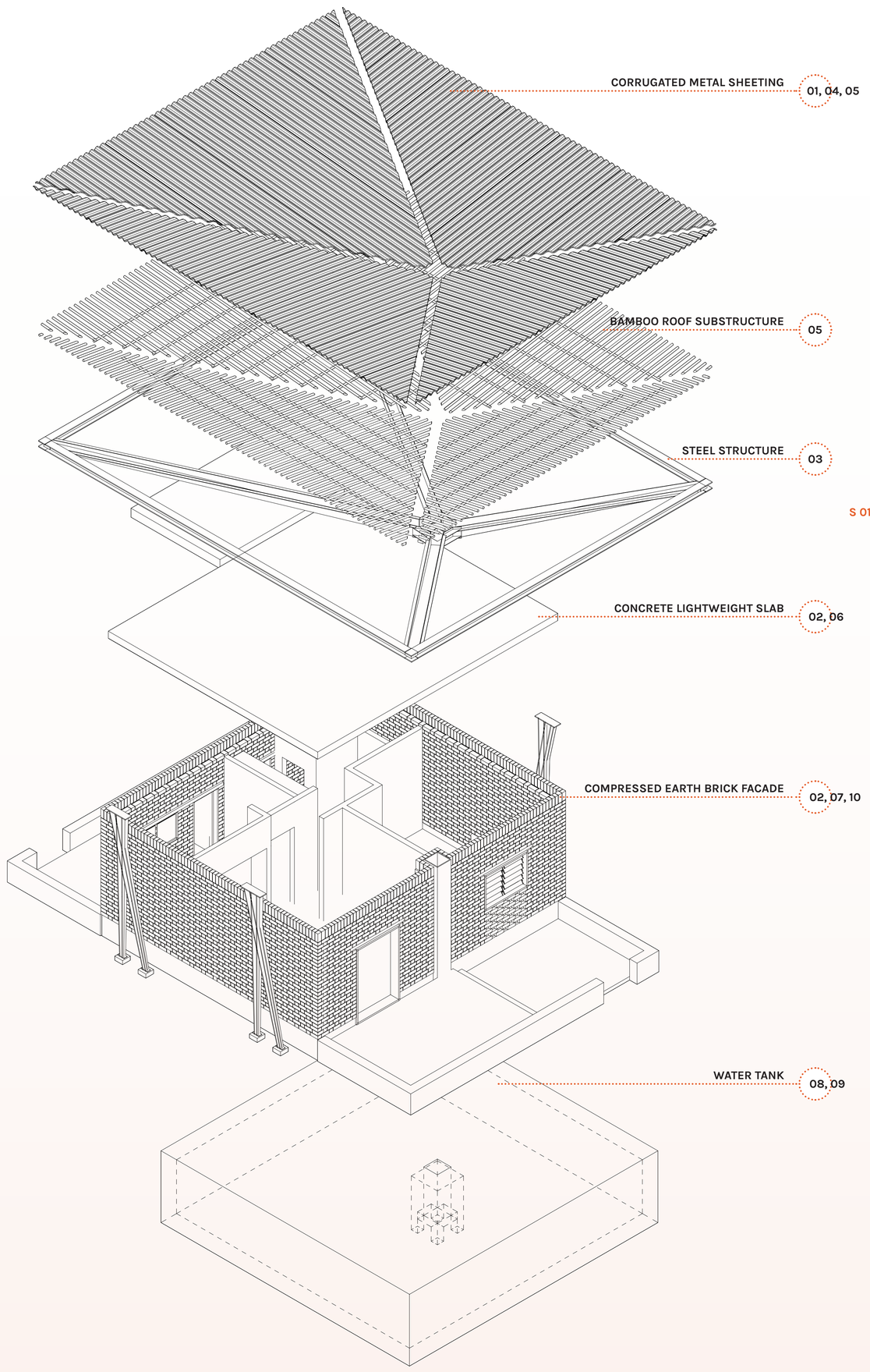


5. CEB MANUFACTURING
Production of the compressed earth blocks on-site by small entrepreneurs or even the local community. The bricks are then stored in the shade under the already present roof structure to prevent them from drying too fast and cracking and protect them from heavy rain if built during the rainy season.



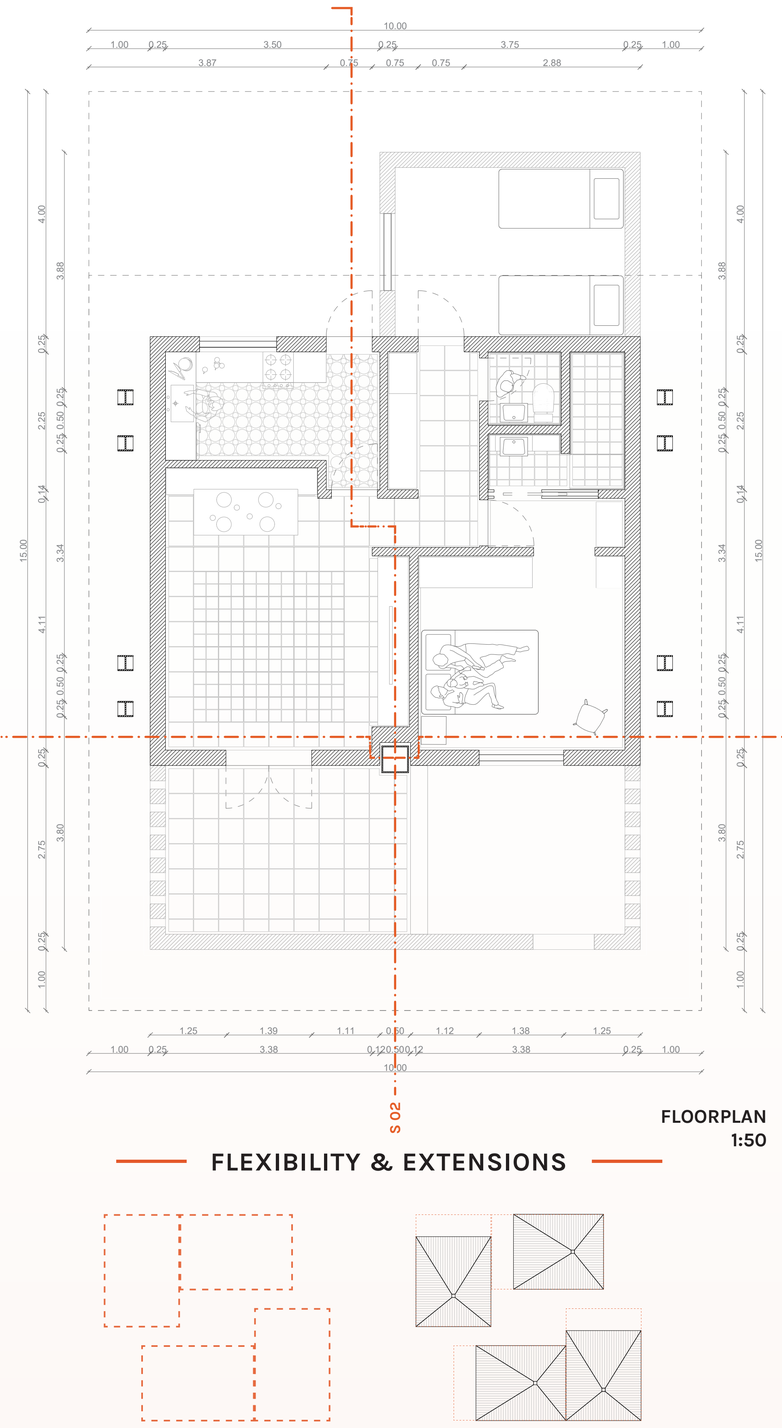
6. BUILD CORE HOUSING

BUILDING COMPONENTS



EXPLODED AXO
1:75

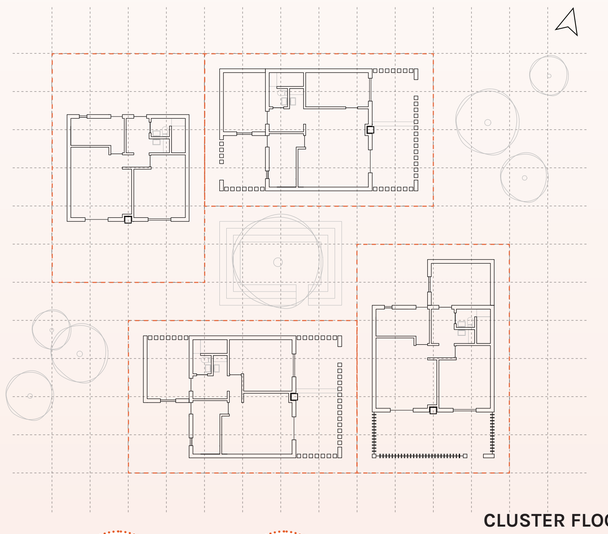
INNER LIFE & USE



FLOORPLAN
1:50

FLEXIBILITY & EXTENSIONS

ORGANISE ORGANISED SHELTER



CLUSTER FLOORPLAN
1:200

SECTION
1:50

HOUSING RESPONSE
FAMILY HOUSE & GENERATIONS HOME

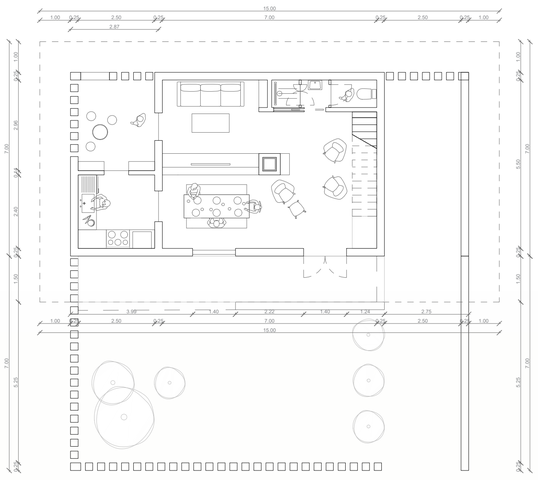
Three housing typologies to nurture personal growth

Every unit is conceived with regard to functional and climatic appropriate strategies. An outdoor living area is determined for every flat that allows for an outdoor covered area used for outdoor comfort, outdoor cooking, etc. The largest apartment has an additional outdoor front and back courtyard.

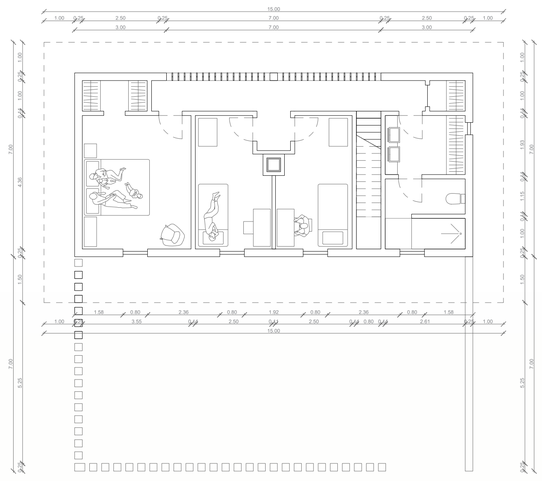
Louvred windows, shutter windows and perforated brick walls allow cross ventilation through the property and the habitable space. Horizontal wind catchers will be installed to direct wind into the areas with the ideal angle.

FAMILY HOUSE

2 Floors
Type: 1 house
Plot size: 168 m2
Habitable Space: 84 m2
Persons: 4-6

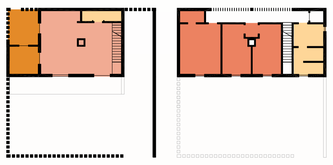


GROUND FLOOR
1:100



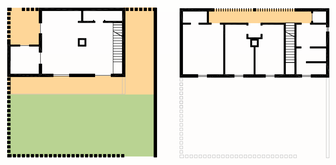
FIRST FLOOR
1:100

Program



Legend
- Living room
- Bedroom
- Kitchen
- Bathroom

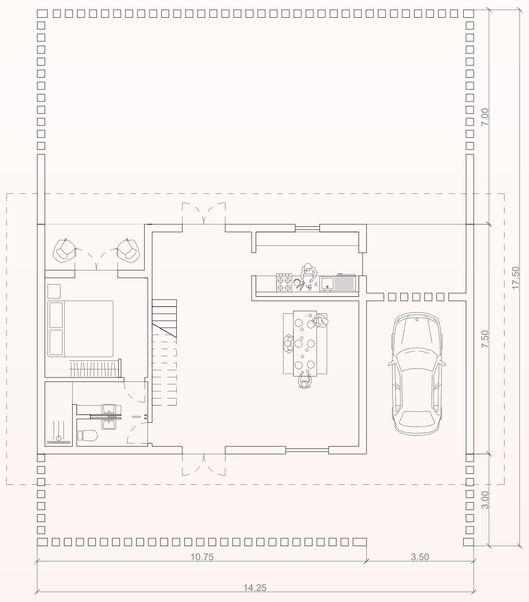
Outdoor Living



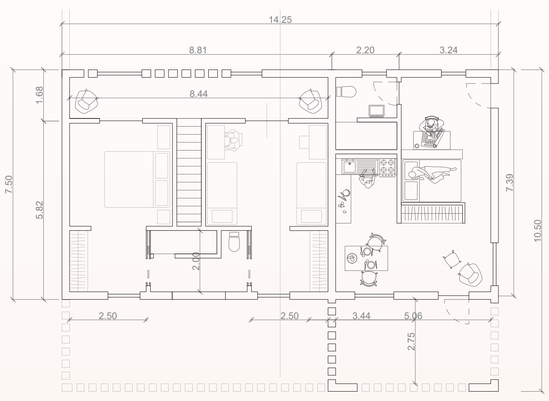
Legend
- Outdoor, garden area
- Outdoor, Terrace, Balcony, niche, corridor

GENERATIONS HOME

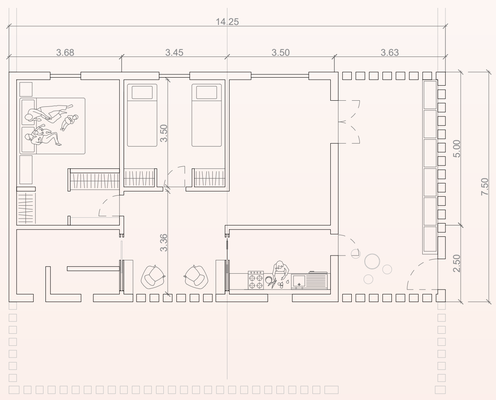
3 Floors
Type: 3 flats
Plot size: 224 m2
Habitable Space: 240 m2
Persons: 10-12



GROUND FLOOR
1:100

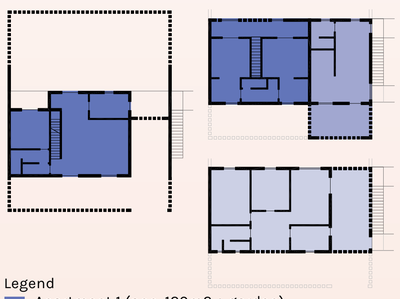


FIRST FLOOR
1:100



SECOND FLOOR
1:100

1 House 3 Apartments



Legend
- Apartment 1 (app. 120m2 + garden)
- Apartment 2 (app. 35m2)
- Apartment 3 (app. 85m2)

Program

Legend
- Living room
- Bedroom
- Kitchen
- Bathroom

Outdoor Living

Legend
- Outdoor, garden area
- Outdoor, Terrace, Balcony, nich, corridor

Family House

The family house is designed for a family of 4-6 ppl. It is probably the housing typology closest to standard western housing typologies. A 2-story house with a garden. The ground floor is reserved for living and the second floor is providing all the sleeping areas. As the starter home the family house benefits from an outdoor cooking area that also acts as a second entrance, and exit to the house, facing the inner part of the housing block. The column rain gutter in this typology is at the centre of the floorplan and is surrounded by a shaft that acts as ventilation (chimney effect).

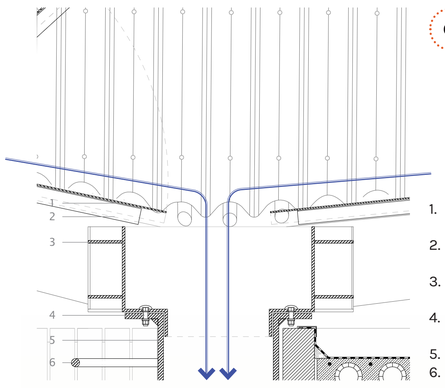
Generations Home

The generations house is though of as a family home that can house up to 12 people. From grandparents to grandchildren there is space for everyone. To allow privacy or also the option to rent out there house is divided into 3 flats. At the ground floor and a portion of the first floor a maisonette style flats with direct access to the courtyard, garden and an inner parking lot. A studio at the first floor and a 2 bedroom apartment at the second floor.
Every unit has a kitchen, living room and bathroom, as well as their own independent entrance. The generations house has a total habitable area of 240 m2.

COMPONENT RESPONSE
DETAIL IMPLEMENTATION

Details to increase the quality of life

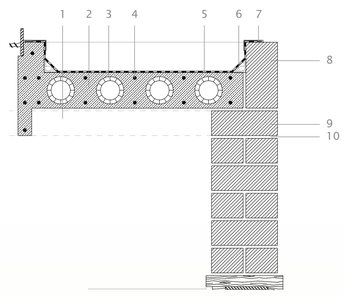
SUSTAINABILITY DETAILS



01

1. Corrugated metal sheeting
2. Bamboo substructure
3. Steel gutter funnel head piece
4. Countersunk bolted connection
5. Steel downpipe
6. Maintenance ladder

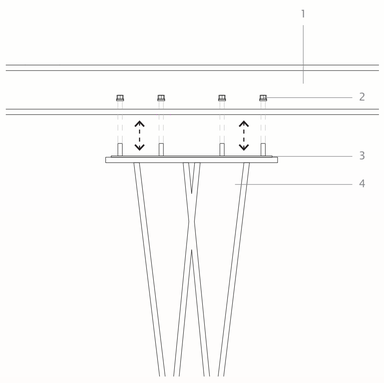
STEEL DOWNPIPE DETAIL 1:10



02

1. Concrete Beam
2. Lightweight concrete slab
3. Bamboo pipe 10cm dia
4. Rebar
5. Bituminous waterproofing membrane
6. Mortar groove
7. Metal profile
8. Vertical CEB
9. Horizontal CEB
10. Mortar joint

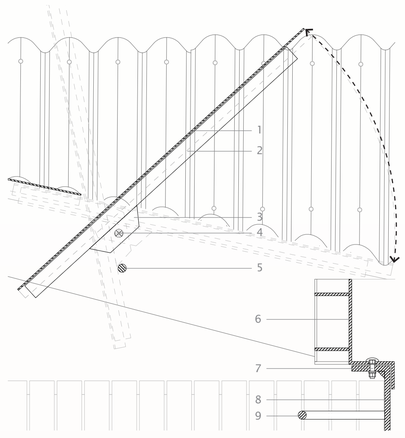
CONCRETE LIGHTWEIGHT SLAB DETAIL 1:10



03

1. Steel ring beam
2. Bolt connection
3. Polyamide plate
4. Steel column

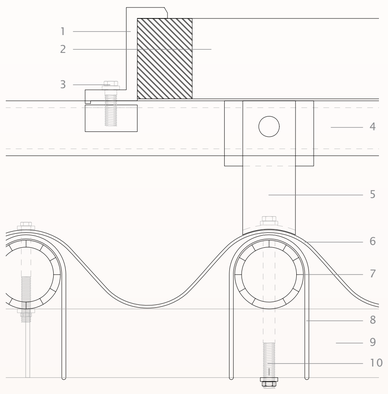
X STEEL STRUCTURE DETAIL



04

1. Corrugated metal sheeting
2. Metal round pipe substructure
3. Reinforcement
4. Bearing
5. Stop to limit opening
6. Steel gutter funnel head piece
7. Countersunk bolted connection
8. Steel downpipe
9. Maintenance ladder

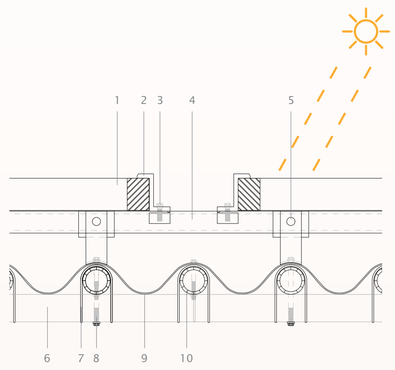
ROOF MAINTENANCE HATCH DETAIL 1:10



05

1. Aluminium clamp with screw fastening
2. Solar panel
3. Bolted connection
4. Aluminium clamping rail
5. Adapter for mounting on corrugated sheet metal
6. Corrugated metal sheeting
7. Bamboo substructure
8. Bamboo plait strips
9. Bamboo substructure
10. Bolt connection

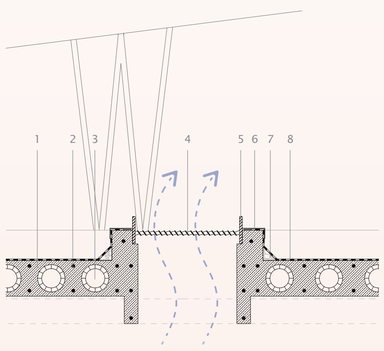
SOLAR PANEL CONNECTION DETAIL 1:5



05a

1. Solar panel
2. Aluminium clamp with screw fastening
3. Bolted connection
4. Aluminium clamping rail
5. Adapter for mounting on corrugated sheet metal
6. Bamboo substructure
7. Bamboo plait strips
8. Bolt connection
9. Corrugated metal sheeting
10. Bamboo substructure

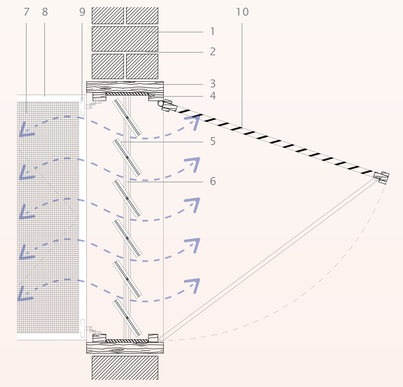
SOLAR PANEL CONNECTION DETAIL 1:10



06

1. Lightweight concrete slab
2. Rebar
3. Bamboo pipe 10cm dia
4. Expanded metal grid with integrated moskito net
5. Metal frame
6. Metal profile
7. Mortar groove
8. Bituminous waterproofing membrane

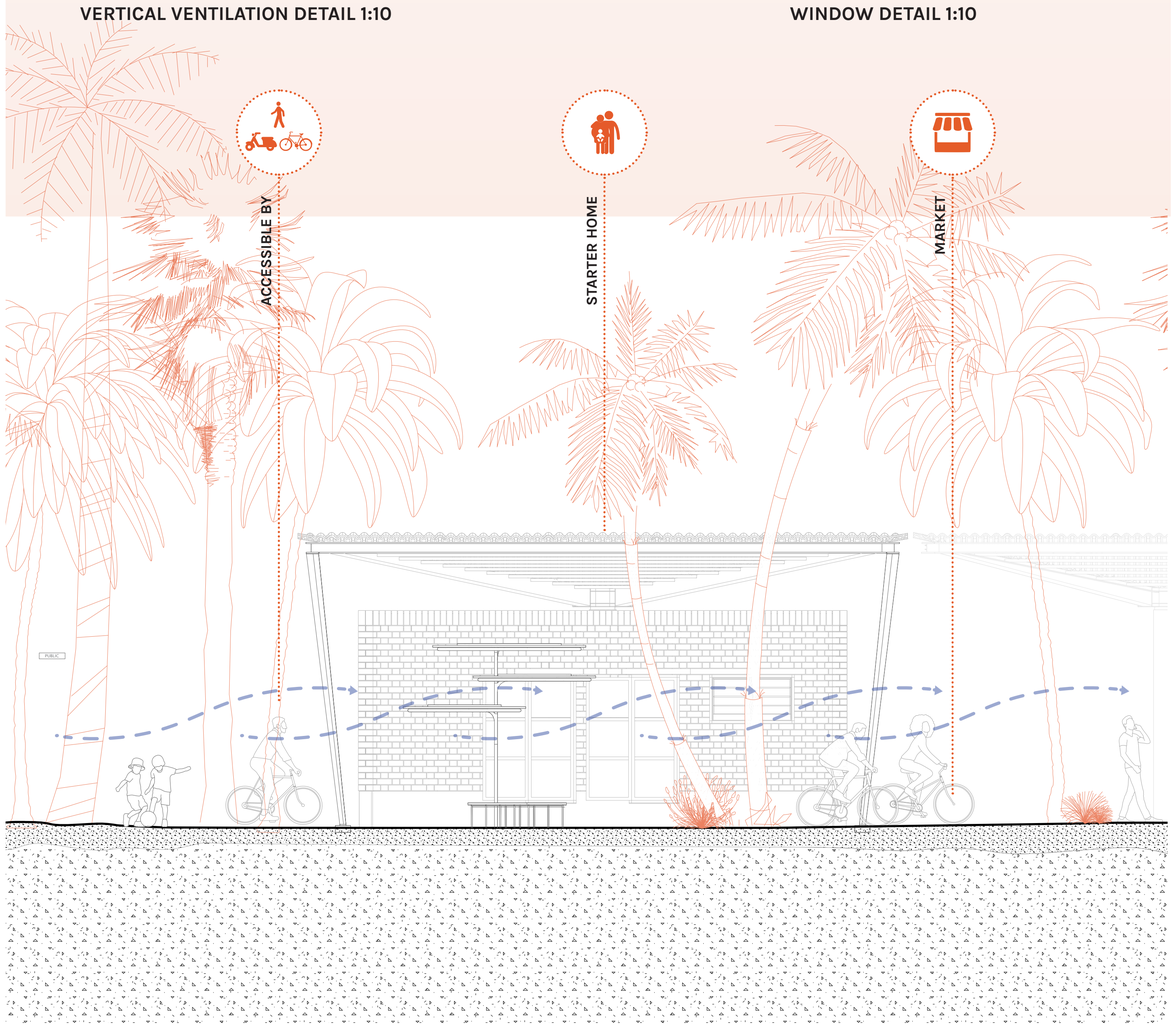
VERTICAL VENTILATION DETAIL 1:10



07

1. Compressed Earth bricks
2. Mortar joint
3. Window wood frame
4. Metal frame hinged shutter
5. Glass panels louvred windows
6. Aluminium frame
7. Moskito net
8. Wood frame
9. Hinges
10. Metal shutters

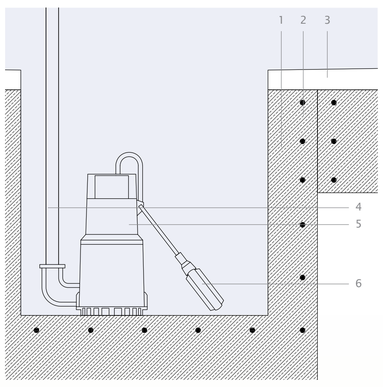
WINDOW DETAIL 1:10



COMPONENT RESPONSE
SYSTEM IMPLEMENTATION

Details to increase the quality of life

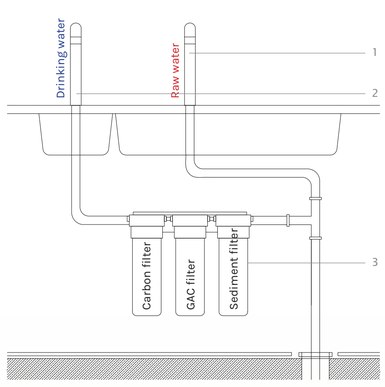
SUSTAINABILITY DETAILS



08

1. Prefabricated concrete pit
2. Rebar
3. 1,5% slope towards pit
4. Water supply pipe to the house
5. Water pump
6. Floater

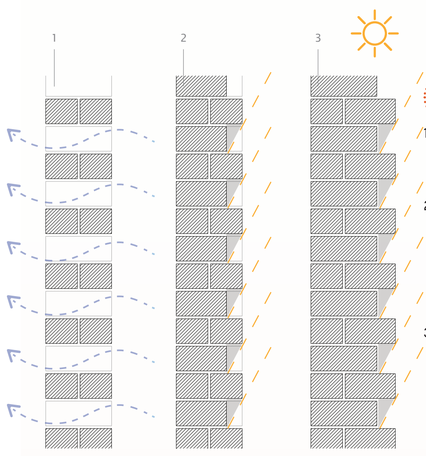
PUMPING PIT SYSTEM



09

1. Raw water
2. Drinking water
3. Reverse Osmosis water filtration system

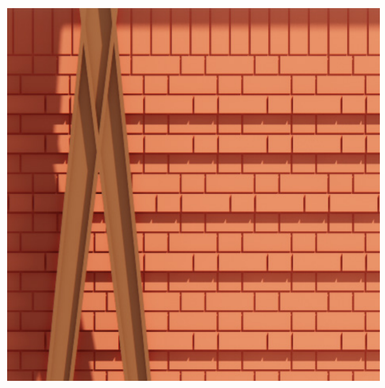
WATER SUPPLY SYSTEM KITCHEN



10

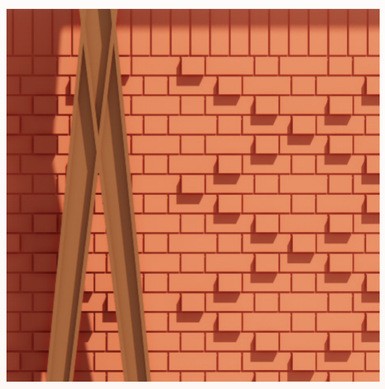
1. Perforated CEB Wall for ventilation (used in housing extensions)
2. Depressed CEB facade for shading and cooling, allows to reduce the amount of bricks needed while shading
3. Extruded CEB facade for shading and cooling, gives opportunity to translate fabric patterns into brick patterns

CEB WALL SHADING & VENTILATION PRINCIPLE 1:10



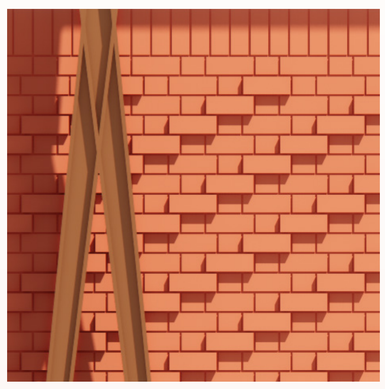
10a

EXTRUDED CEB FACADE



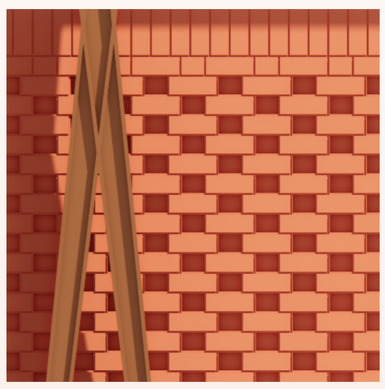
10b

EXTRUDED CEB FACADE



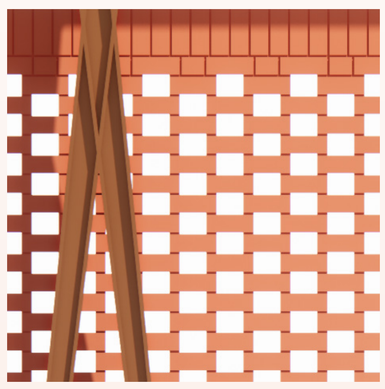
10c

EXTRUDED CEB FACADE



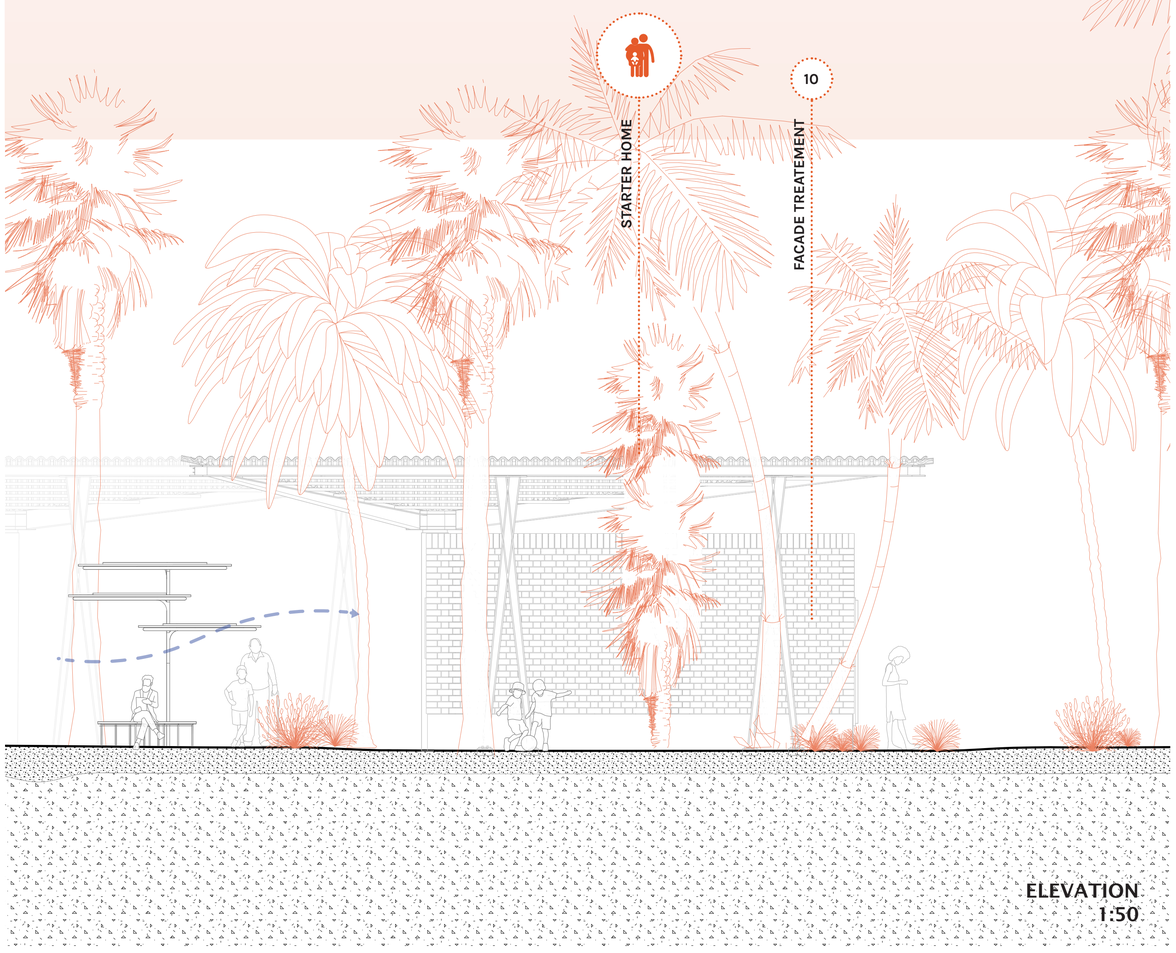
10d

DEPRESSED CEB FACADE



10e

PERFORATED CEB WALL



ELEVATION
1:50

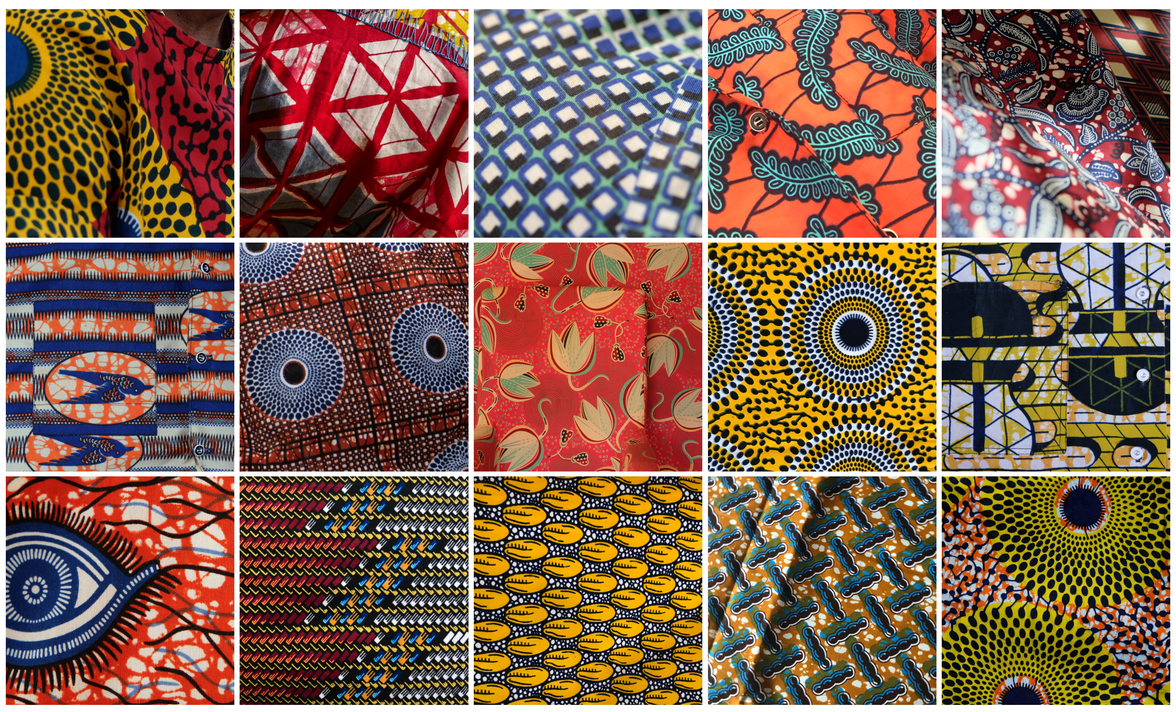
MATERIAL RESPONSE
USE LOCALLY AVAILABLE RESOURCES

Materials to develop the local economy and identity

VEGETATION

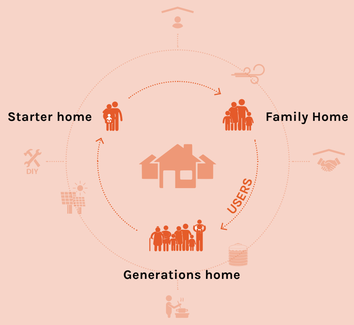
MINERALS, ROCKS, SOILS

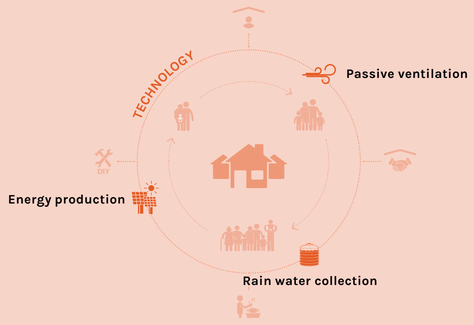
ORGANIC & FIBROUS

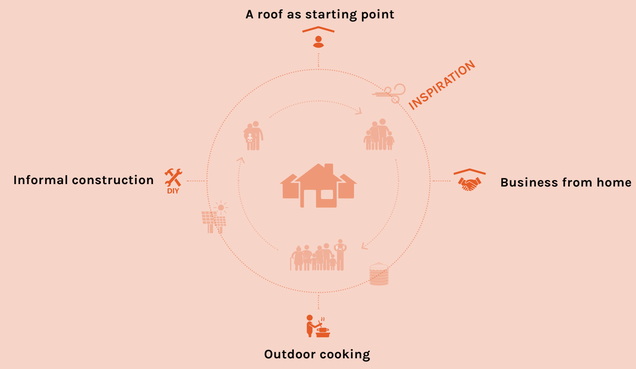


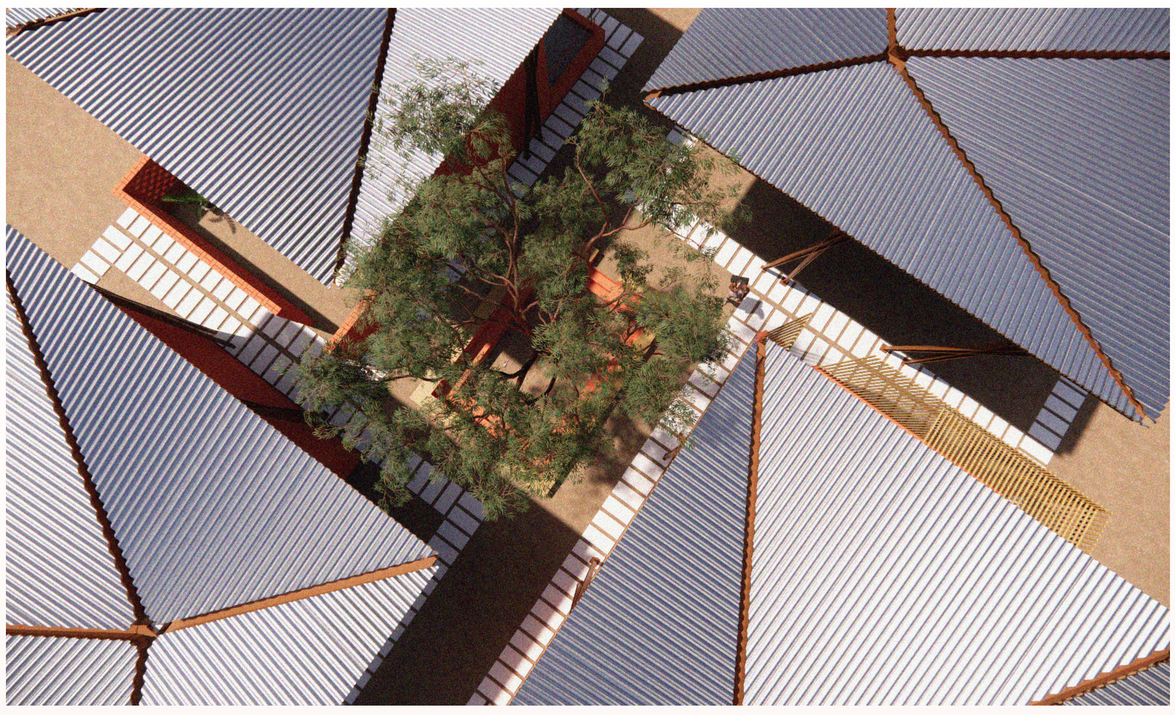
TEXTILES

VISION RESPONSE
LIFE IN THE NEIGHBOURHOOD









PROJECT VISION DIAGRAM