



# STRENGTHEN FROM WITHIN

P5 PRESENTATION

**A Cluster Scale Decentralized Water Management System in Sint Maarten**

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Delegate of the Board of Examiners: Steven Steenbruggen

24-01-2020

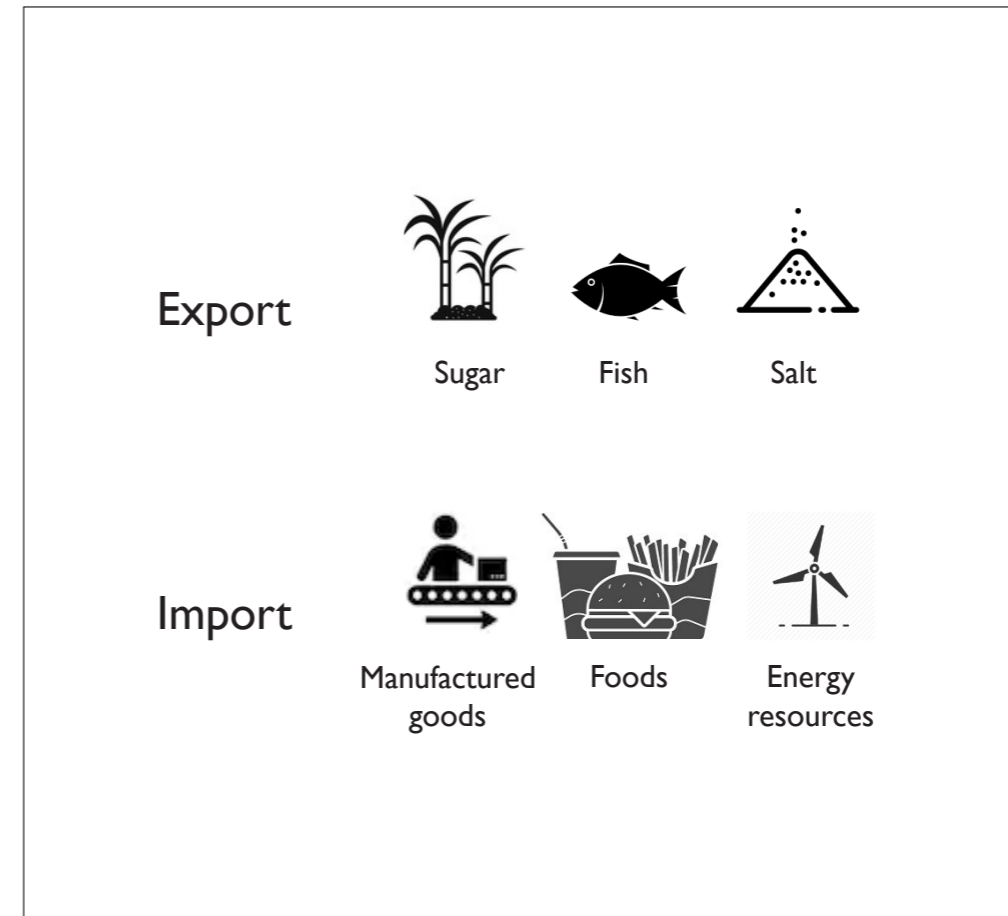
# Context

## Location



# Context

Limited resources



Sint Maarten:  
Population: 40911;  
Area: 34 km<sup>2</sup>;  
Main Town: Philipsburg

A lot of resources depend on imports.

# Context

## Hurricane Issue

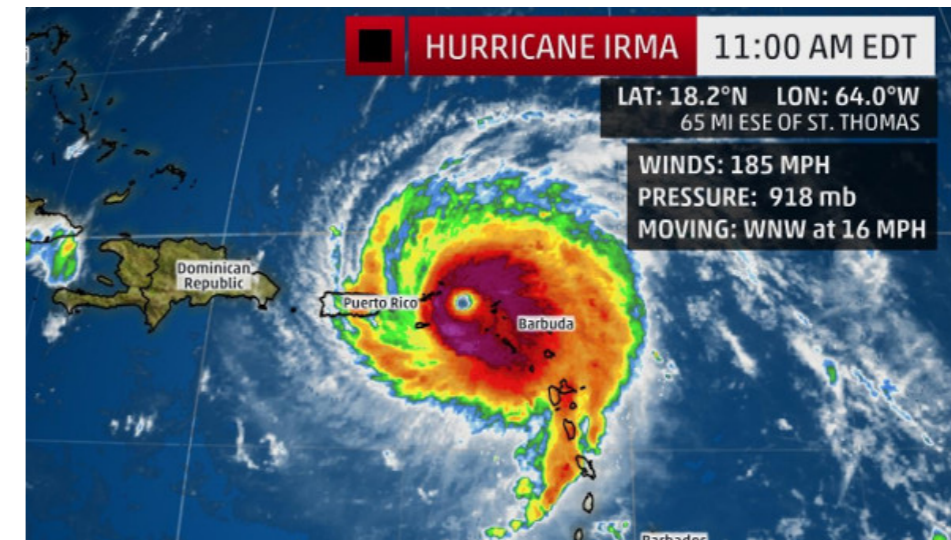


Table 4. Summary of Damages, Losses, and Needs by NRRP Components

	Cost (USD)		
	Damages	Losses	Needs
<b>Community</b>			
Housing *	442,000,000	22,101,000	533,750,000
Health	4,267,000	1,916,000	50,212,000
Education, Culture, Youth, and Sport	60,228,000	1,711,000	119,978,000
Sanitation and Solid Waste Management	604,000	-	195,360,000
Employment, Livelihoods, and Social Protection	-	91,004,000	101,767,000
Environment, Ecology, and Biodiversity	574,000	5,423,000	5,840,000
<b>Community Totals</b>	<b>507,673,000</b>	<b>122,155,000</b>	<b>1,006,907,000</b>

Sint Maarten gets 'brushed or hit' by a hurricane every 2.67 years.

Hurricane Irma hit the island in September 2017, hitting the houses, infrastructure and economy.

# Reconstruction Situation

Coastal communities (Tourist-oriented)



The construction is basically completed, and the number of tourists increases year by year.

# Reconstruction Situation

## Inland communities (Resident-oriented)

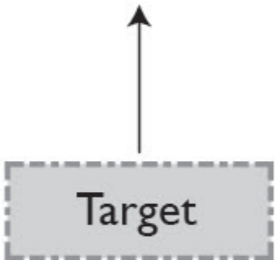


The construction process is pretty slow, many people still need help to fix their room, especially the roof.

# Focus Point

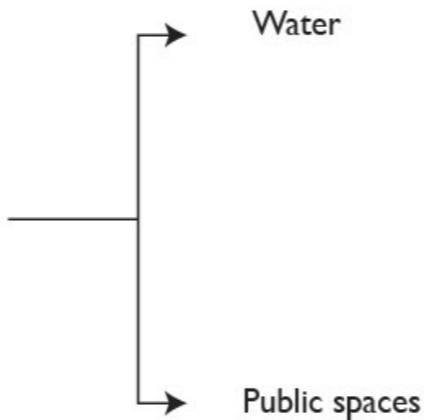


Inland communities for local residents



Improve living conditions  
Revitalize the community

Intention



# Belvedere Community

Design pilot



Sint Maarten Map



Bervedere Map



# Belvedere Community

Who lives there



Private  
Housing

Local family  
(Local business // home industry // Farmer)



Social  
Housing

Volunteers // The seniors // Poor people

This community is inhabited by people of all social classes.

# Belvedere Community

The example of community repairing



Housing repairs have been completed



School



Basketball Court



Community Center



Assembly Hall



Church

Well-planned and public buildings

It is an example and goal of the government for community reconstruction

# Public Spaces



Empty plots



Waste grass



Public functions

Mark on the map // Three types of public spaces.

# Social Issue

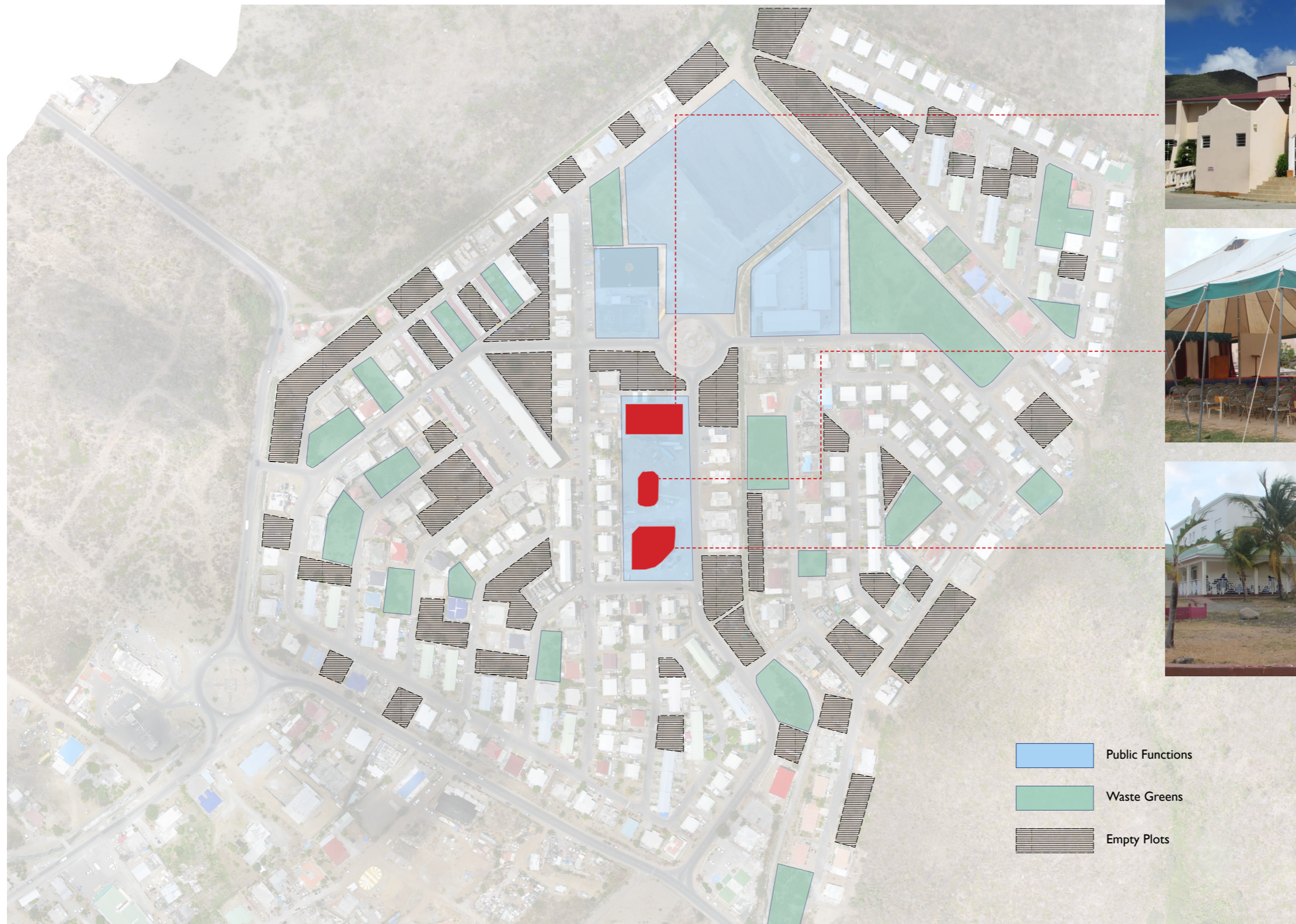
Low use of public space



Public spaces are there but people are not there.

# Social Issue

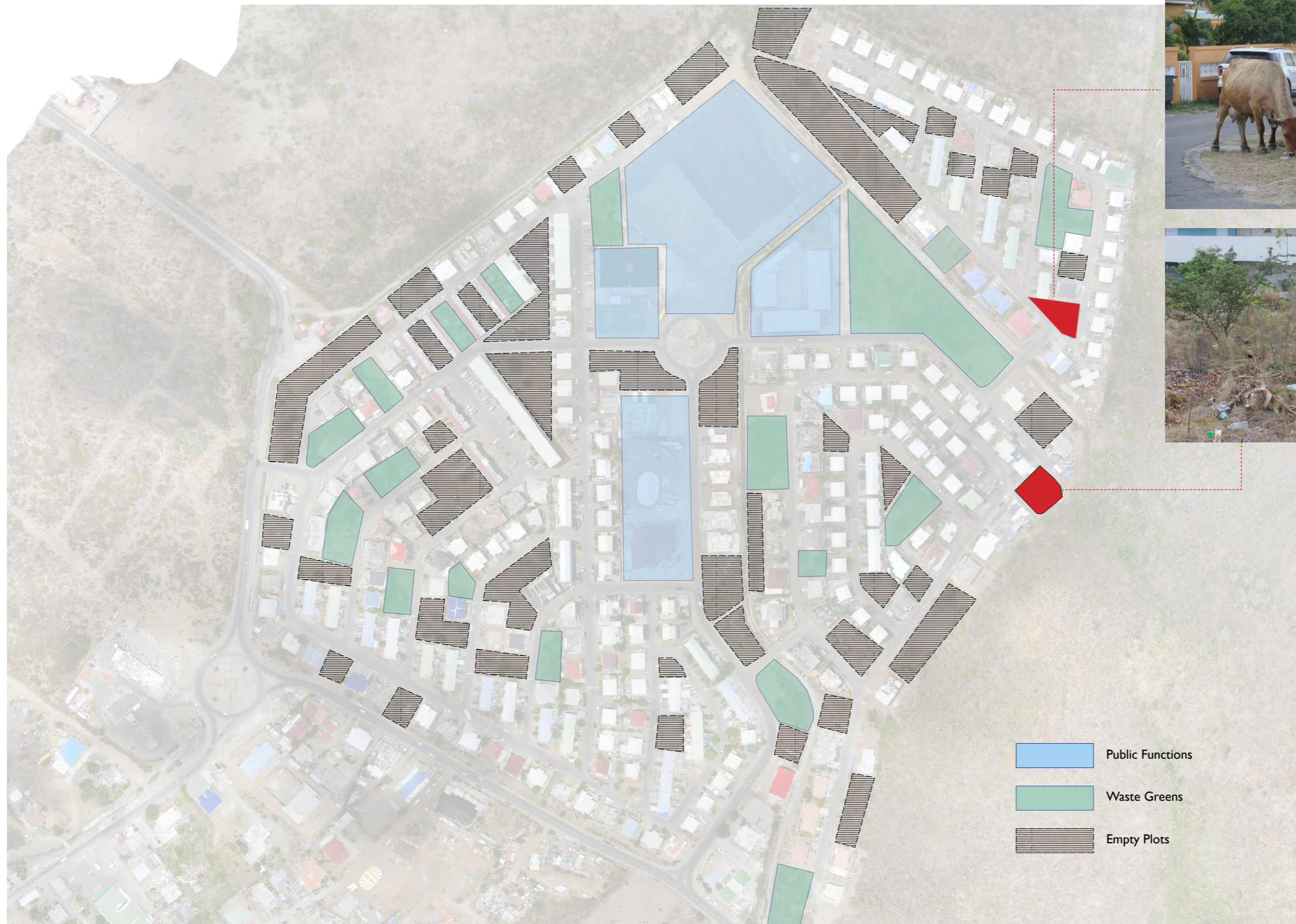
Limited public activity and space



Some buildings are only open in a fixed time.

# Social Issue

## Missing management and maintenance



The green lands were deserted and turned into a canteen for animals.



# Water Issue

## Limited water amount



**Cole Bay Plant:** 3.3-3.6 million gallons

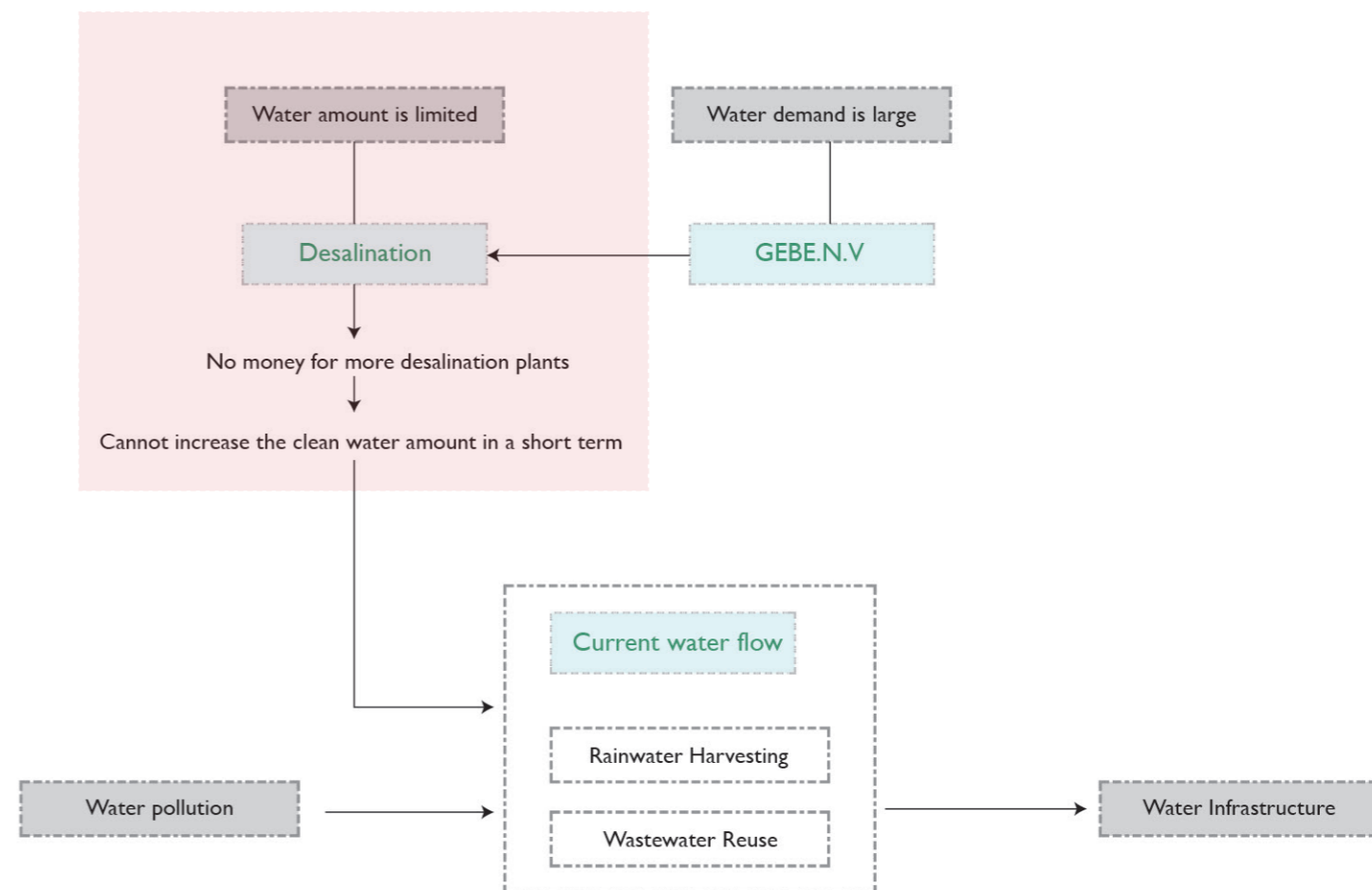
**Point Blanch Plant:** 2.2 million gallons

**Cupecoy Plant:** 1.1 million gallons.

**Seven Seas Water Company** provides 6.6-6.9 million gallons water (approximate max. 26119 m<sup>3</sup>) in total per day.

As the main source of fresh water, **desalination does not fully meet the needs of Sint Maarten.**

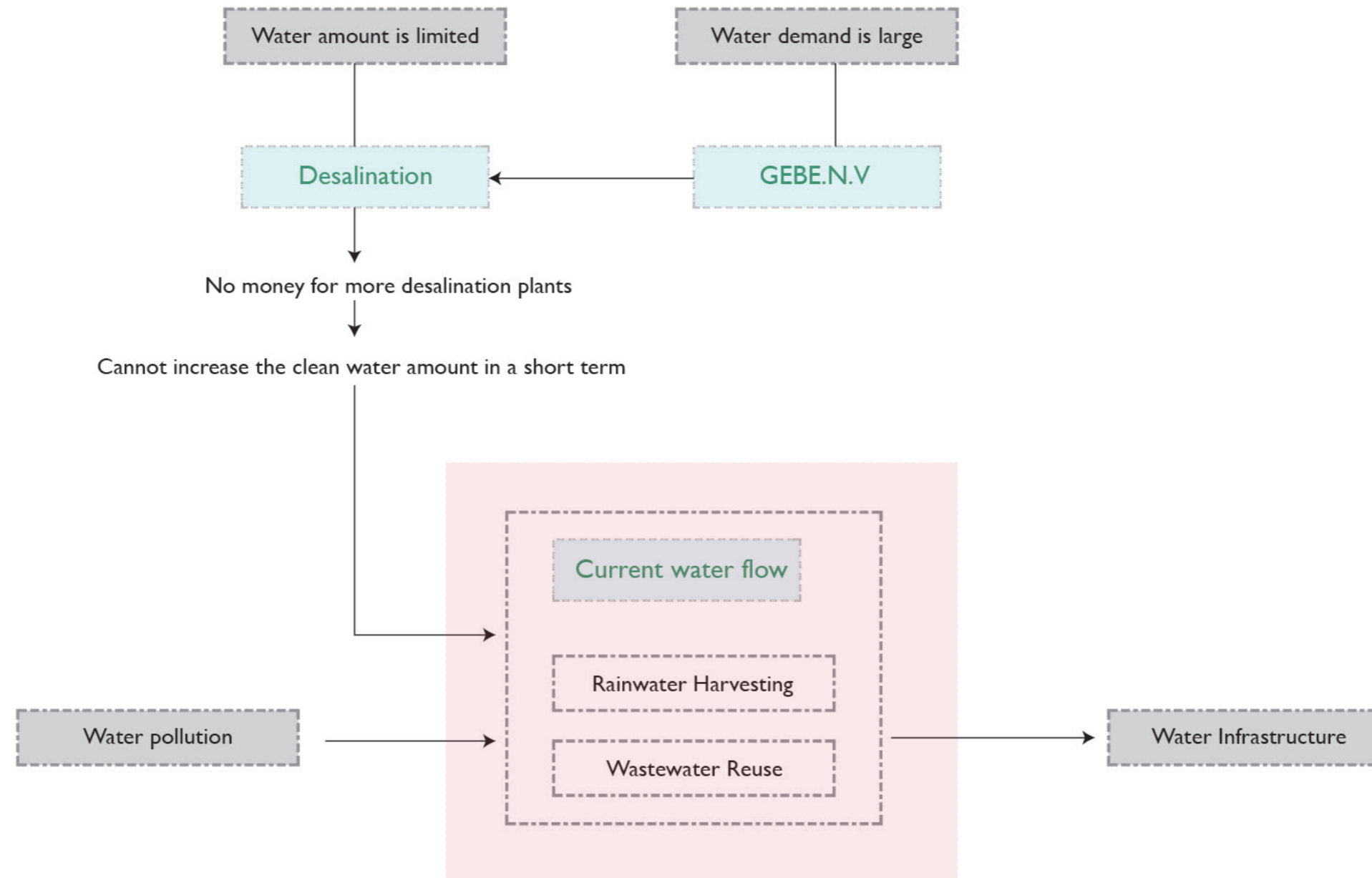
Sint Maarten has no money and no place for a new desalination plant. Which means the clean water amount cannot be larger in a short term.





# Water Issues

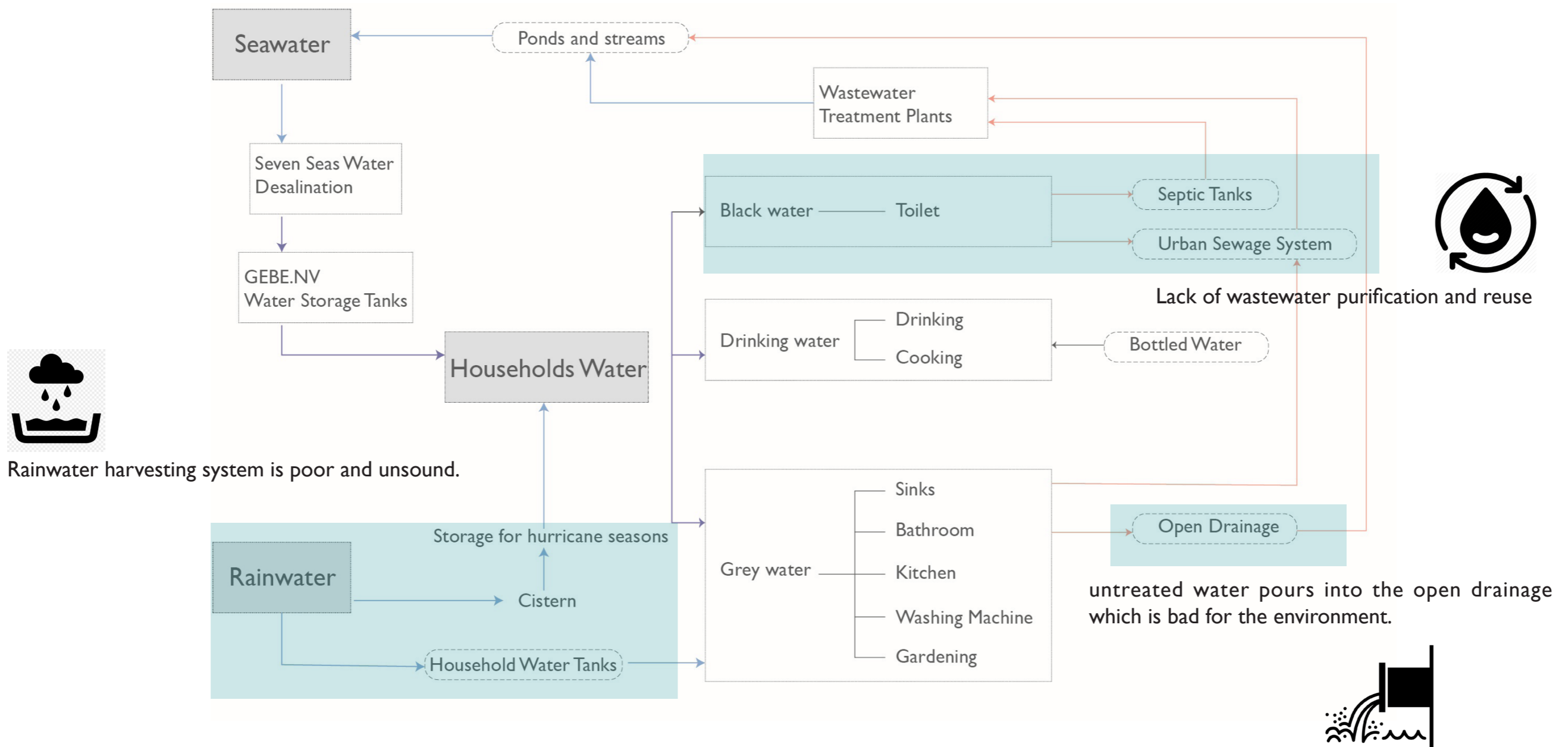
## Current water flow



We can find opportunity by improving the current water flow.

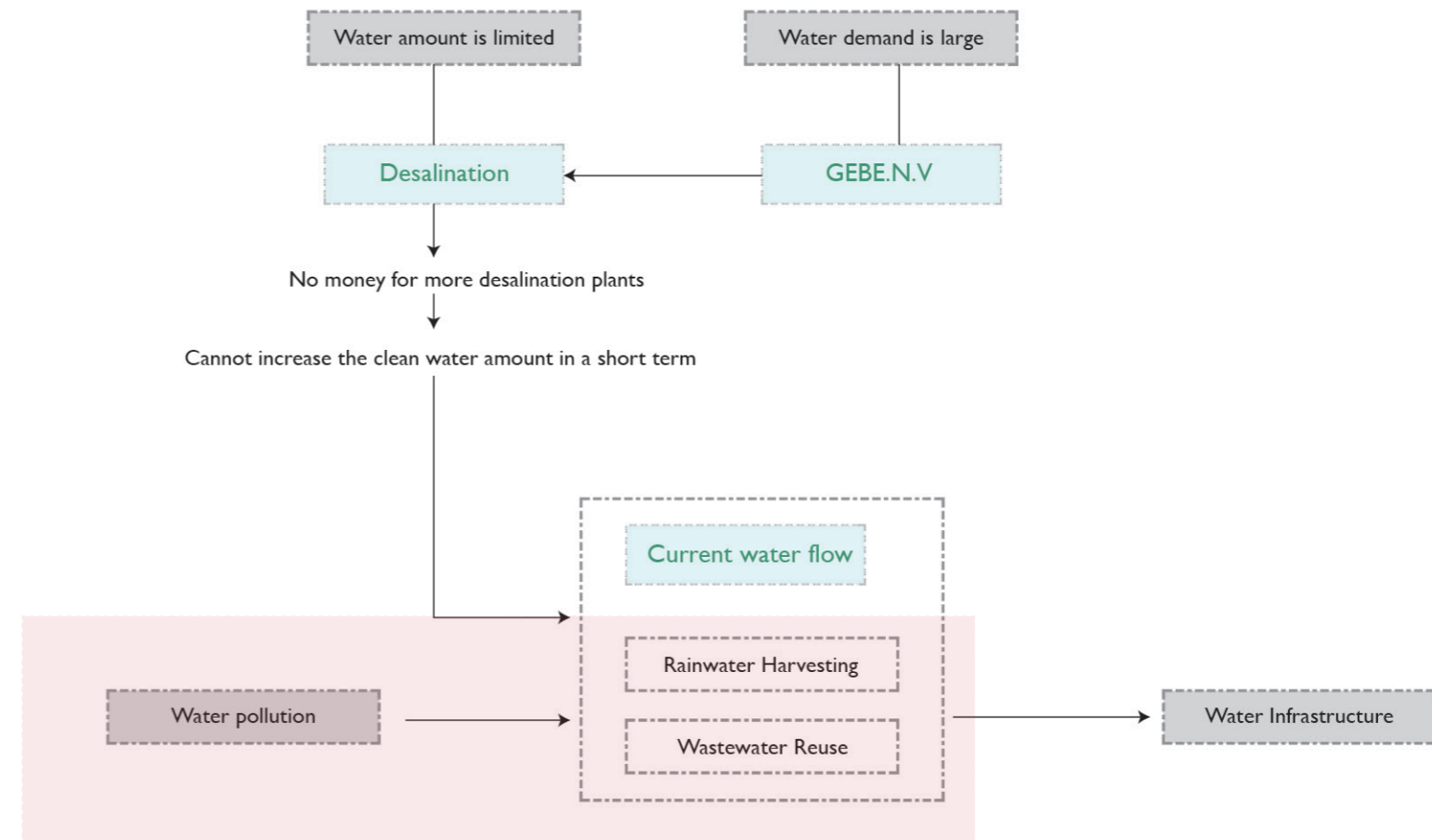
# Find Problems

## Problems in the current water flow

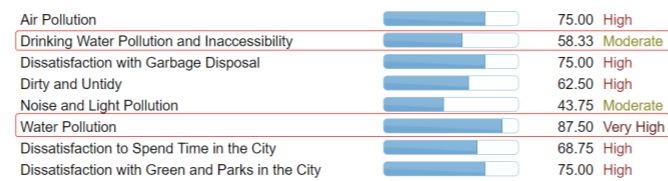


# Water Issues

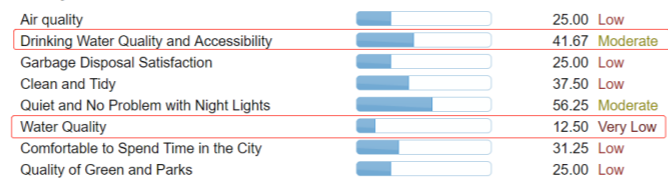
## Water pollution and poor water quality



### Pollution in Sint Maarten



### Purity and Cleanliness in Sint Maarten

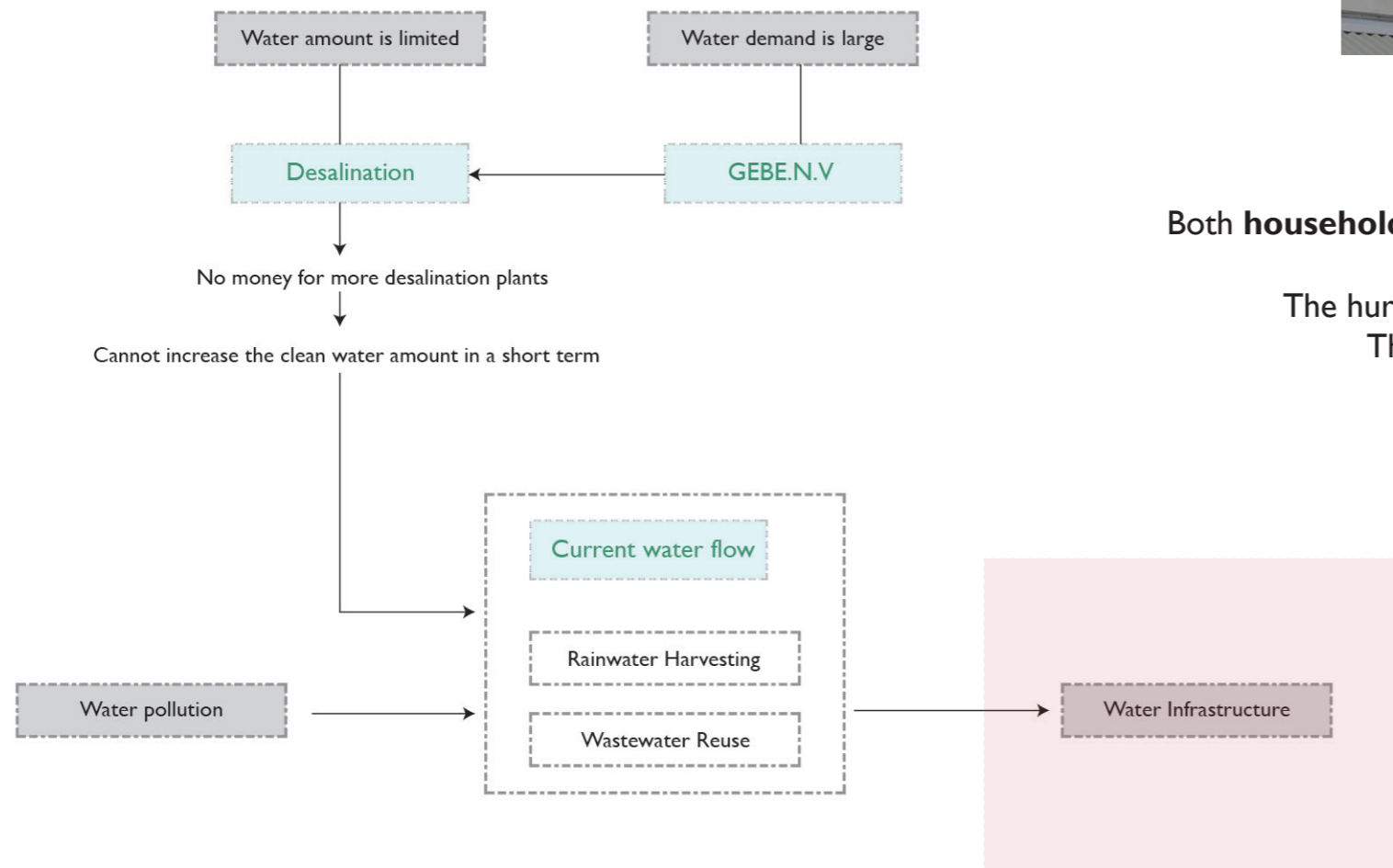


Water pollution has become one of the most serious pollution problems.

It can also be partly solved during the wastewater purification process.

# Water Issues

## Incomplete water infrastructure



Useless roof gutter



Wastewater tanks under construction

Both **household and community water management facilities** are very old and incomplete.

The hurricane has also caused a certain degree of damage to water infrastructure.  
The municipality cannot support enough money for all the upgrades.

# Research Question

Technical questions

Water Infrastructure



Decentralized water management system

**How can a cluster scale decentralized water management system solve water challenges in the hurricane-prone environment of Sint Maarten?**

Find problems



Find out the problems in current water flow.

Study about technical methods



Research to the working process of different water management facilities.

Draw conclusion

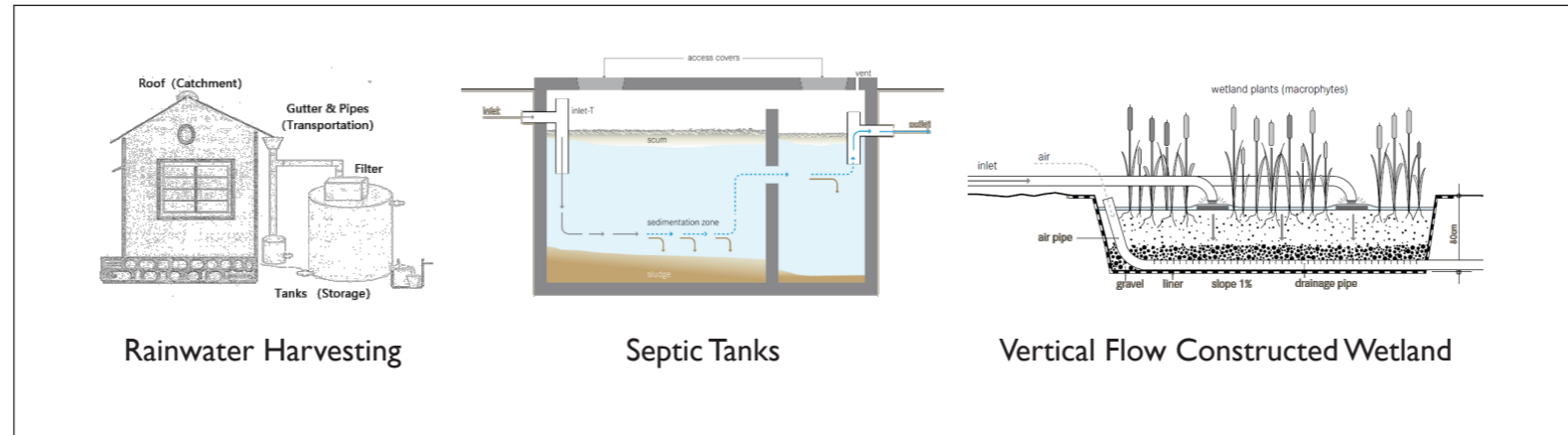


Conclude a proposed new water system to improve the local water environment.

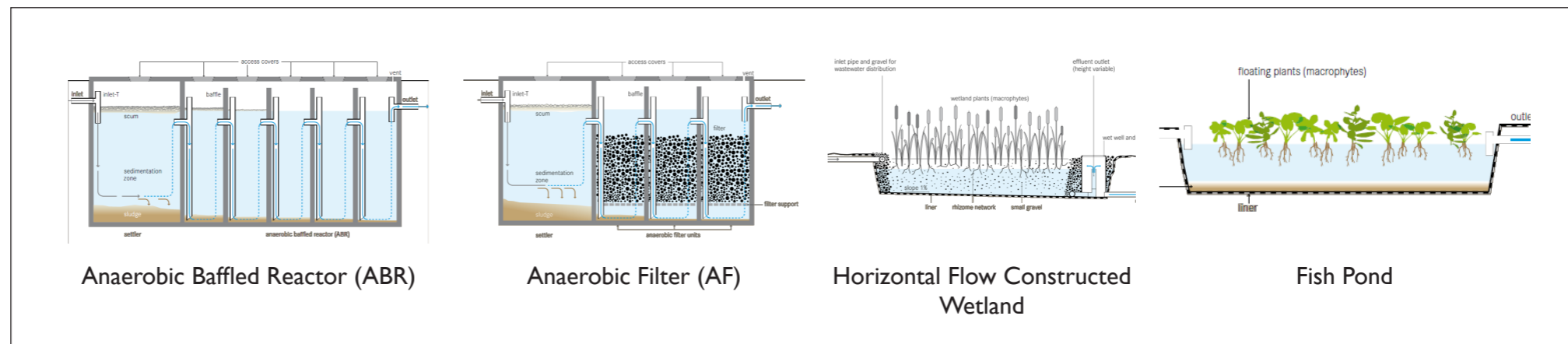
# Case Study

## Research to different water facility

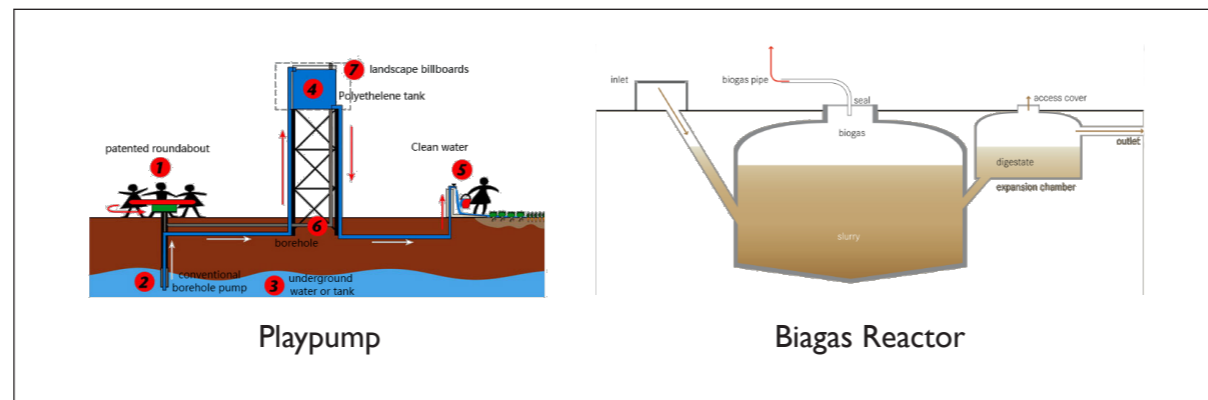
Agua Carioca, Brazil



Anil Agarwal Environmental Training Institute, New Delhi.

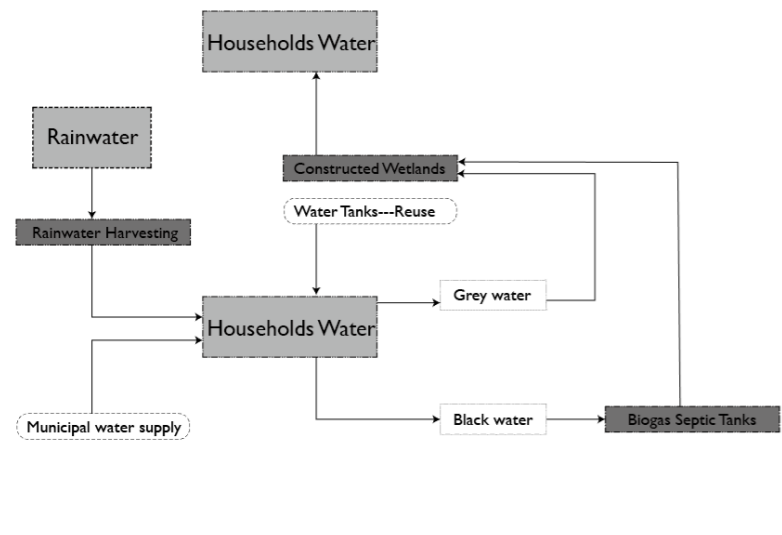


Accar Water Management System Project, Ghana.

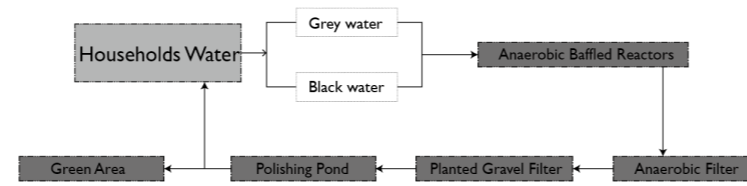


# Case Study

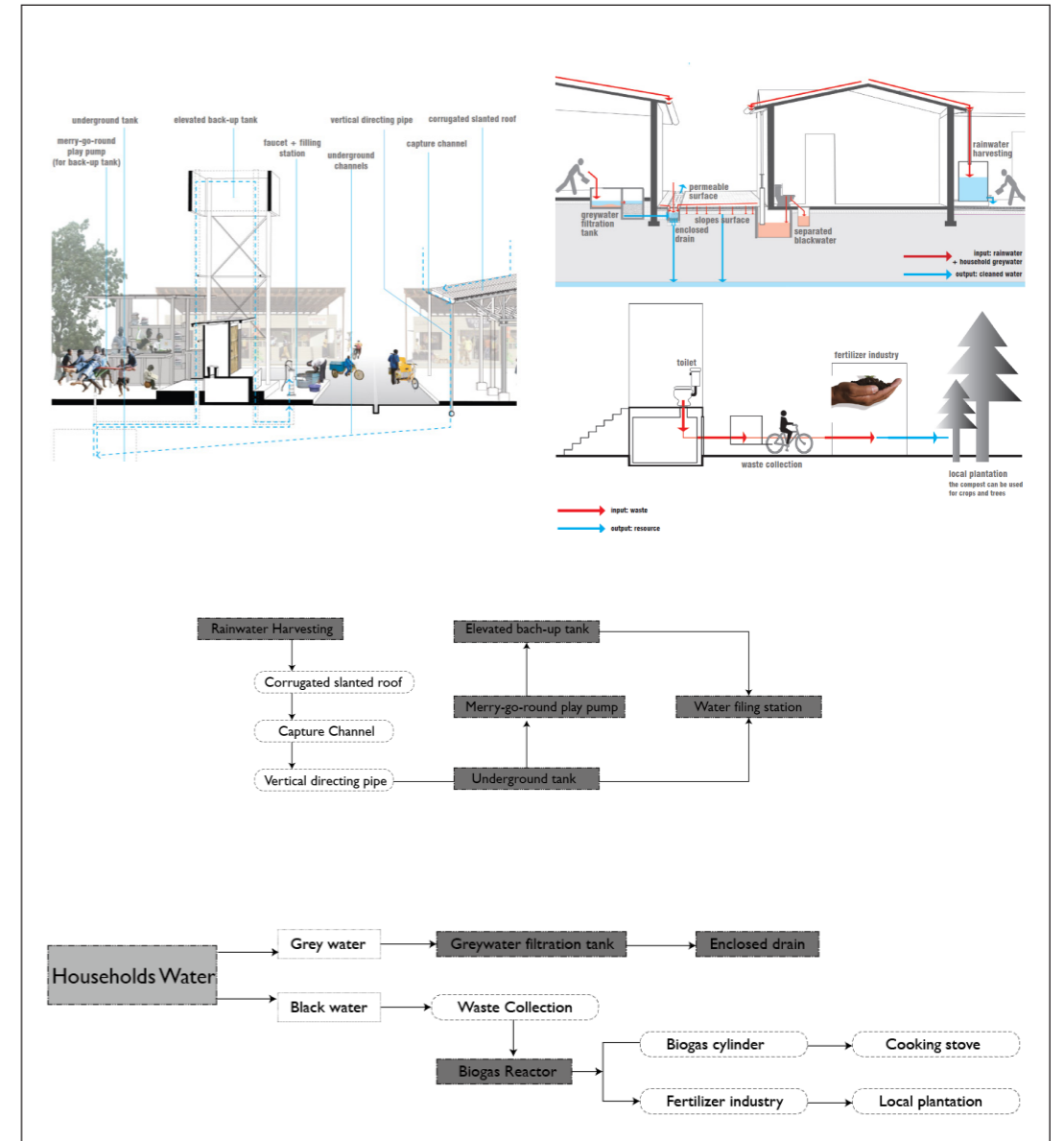
## Research to different water facility



Agua Carioca, Brazil



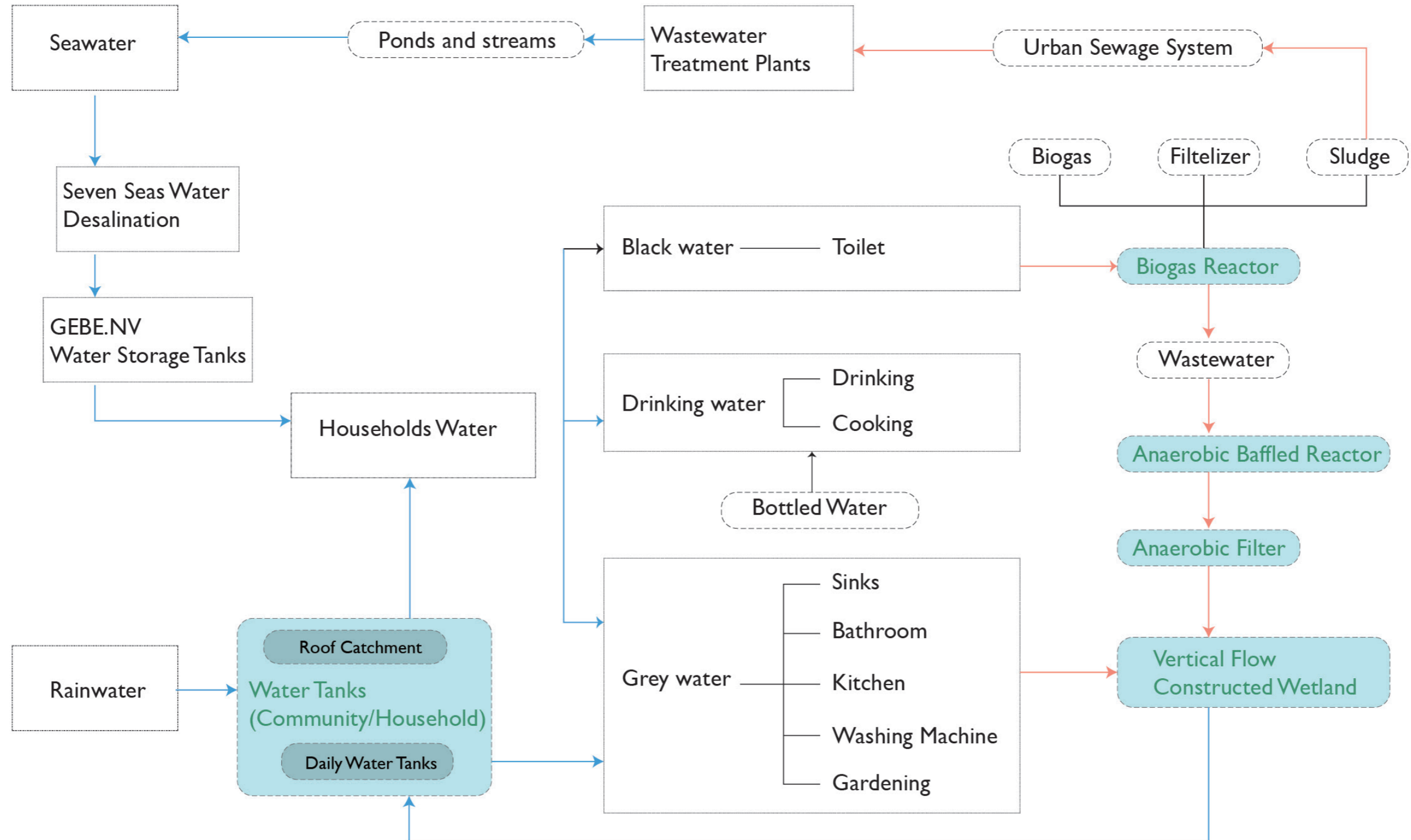
Anil Agarwal Environmental Training Institute, New Deli.



Accar Water Management System Project, Ghana.

# Improved Water Flow

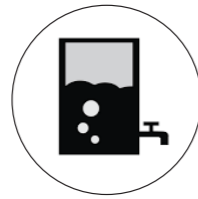
Apply to a new water flow





# Design Ambitions

Provide opportunities



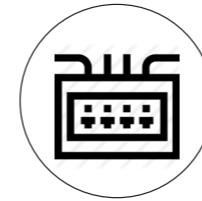
Water Tanks:  
Water storage



Water tower:  
Water storage



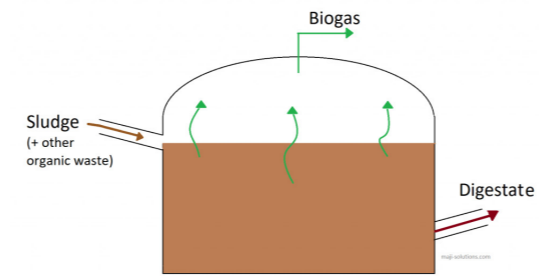
Biogas Reactor:  
Biogas production



ABR/AF:  
Water purification



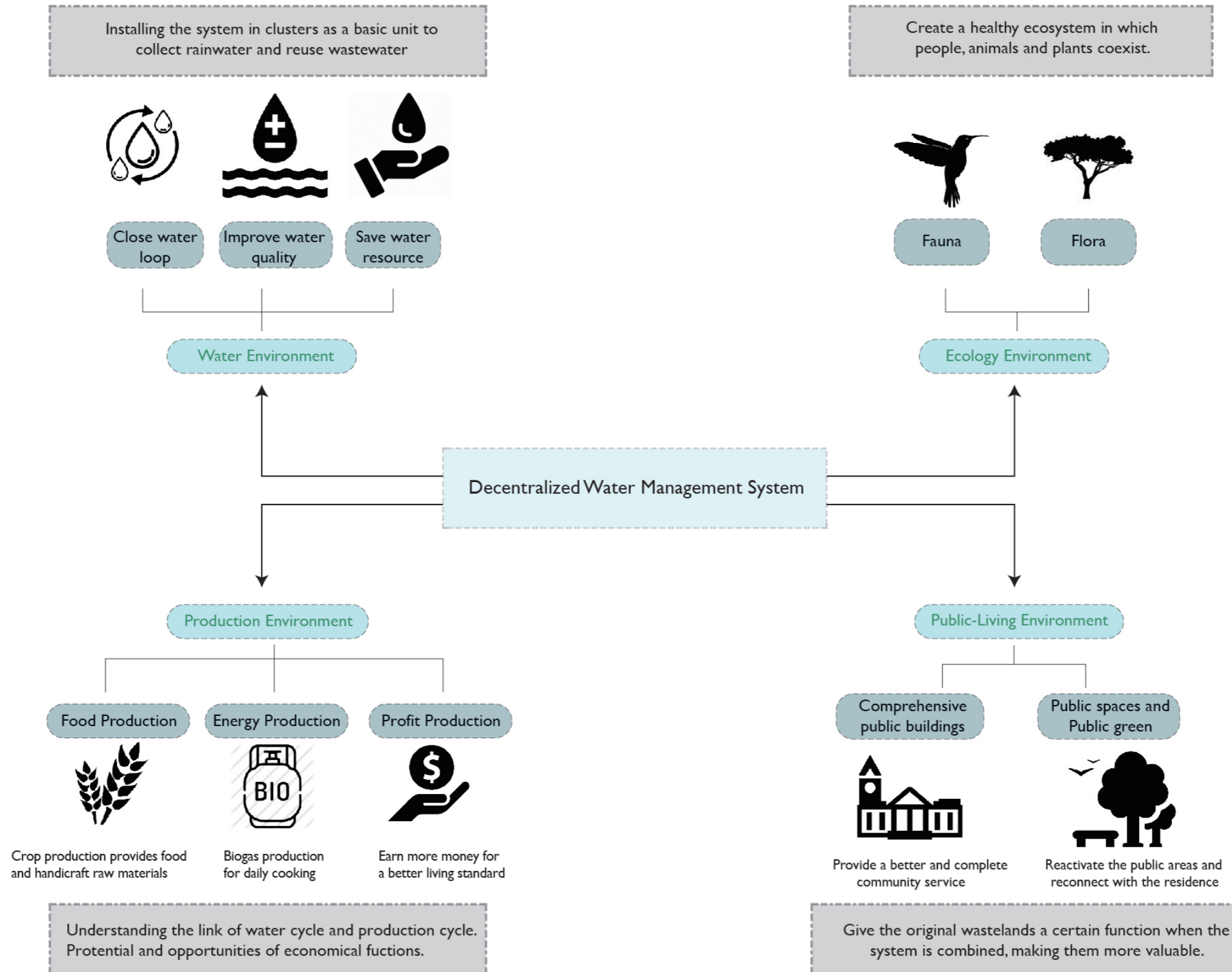
Wetlands:  
Crops and trees



There are many opportunities not only to improve the current water environment but also improve ecological and economic aspects.

# Design Ambitions

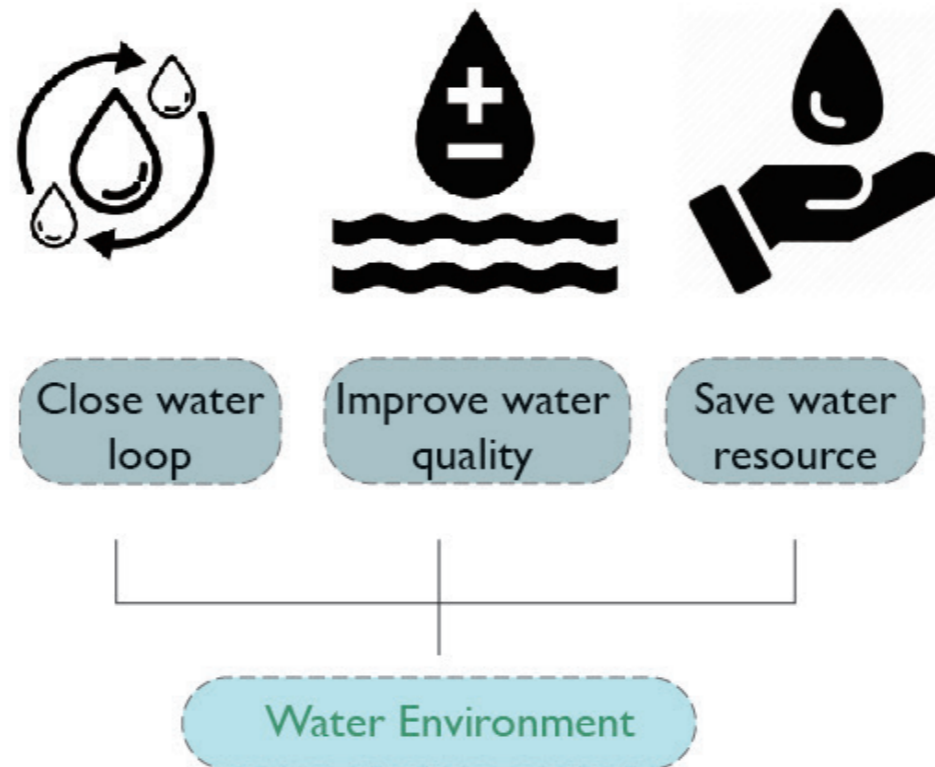
What can the system bring back to the community?



# Design Ambitions

Water ambition

Installing the system in clusters as a basic unit to collect rainwater and reuse wastewater



# Design Ambitions

Ecology ambition

Create a healthy ecosystem in which people, animals and plants coexist.



Fauna



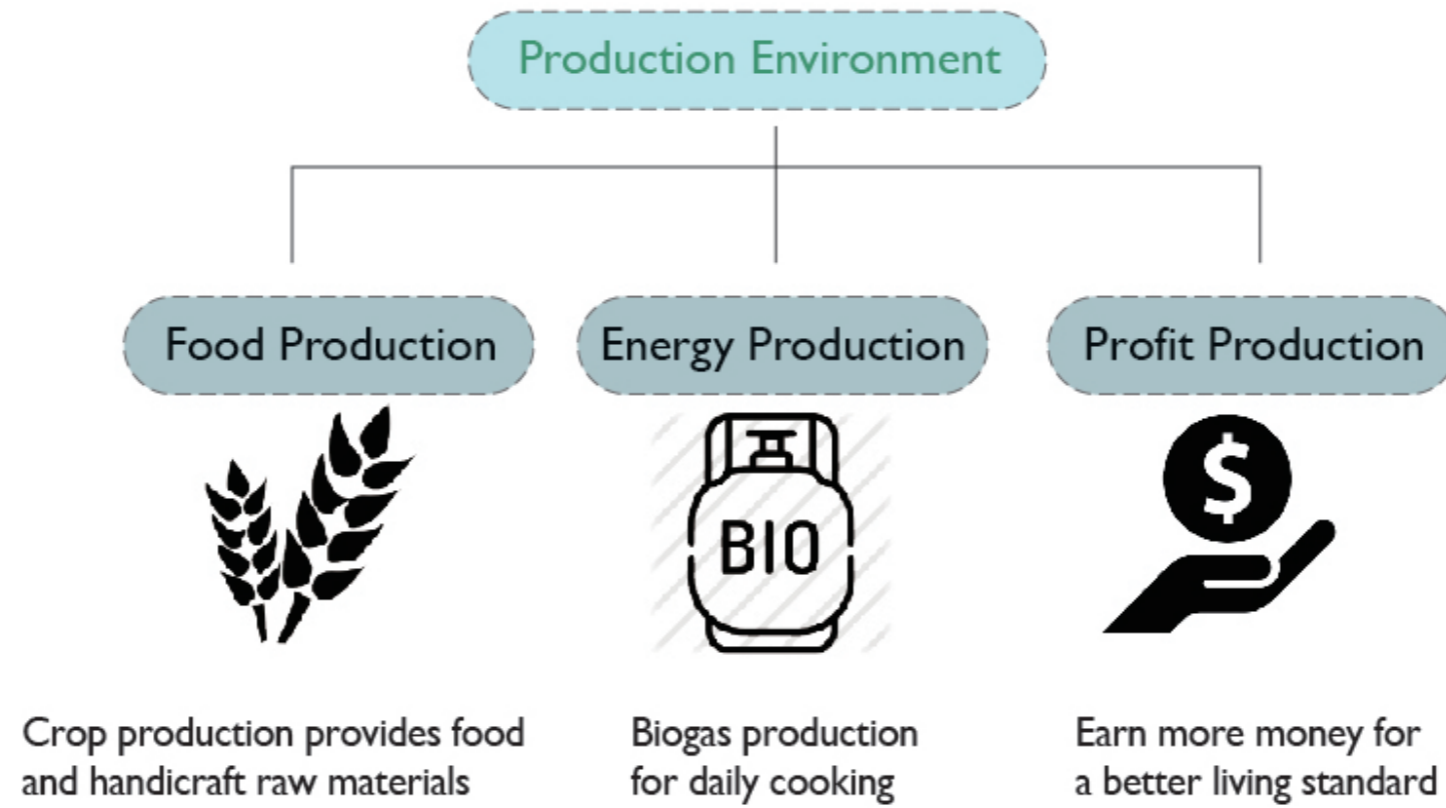
Flora



Ecology Environment

# Design Ambitions

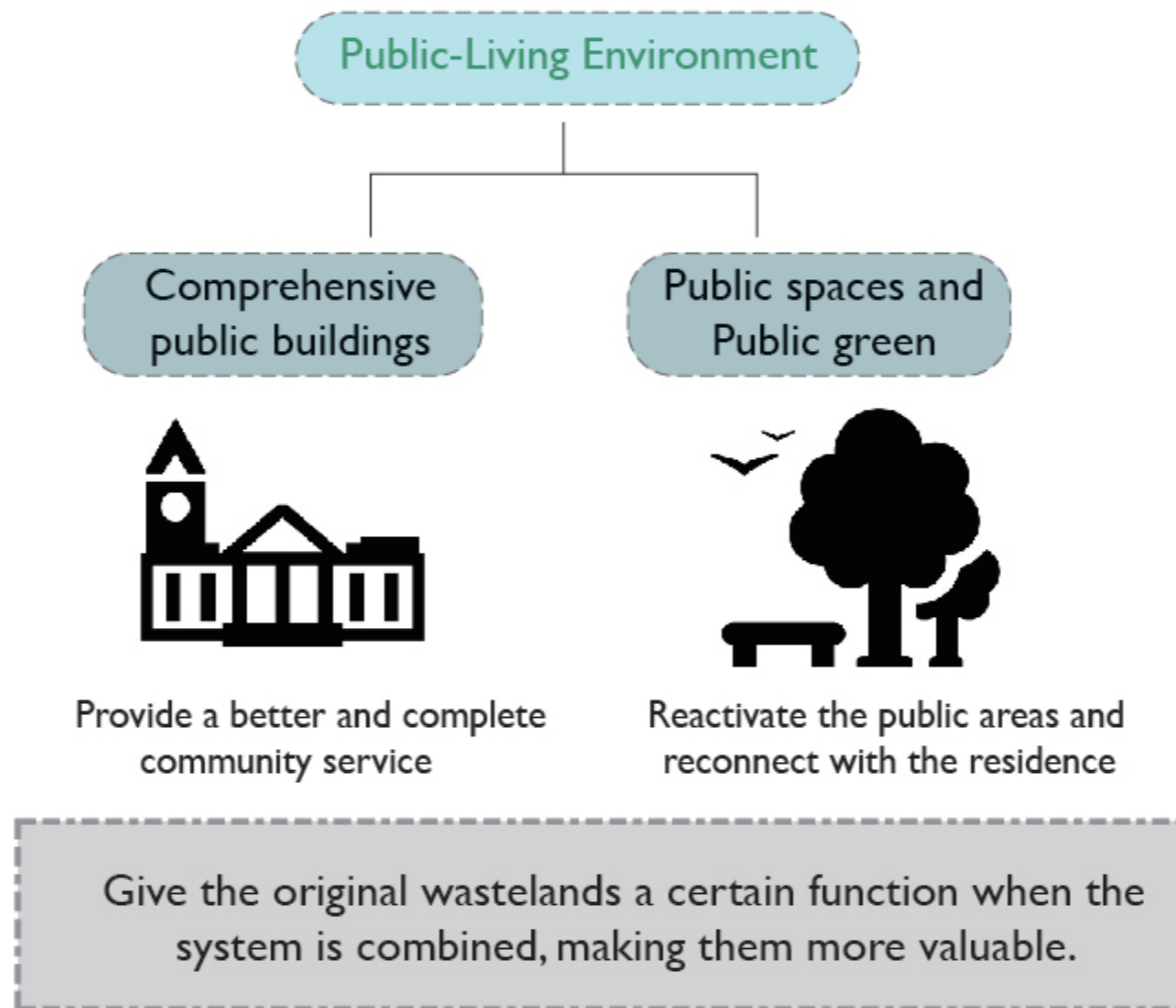
Production ambition



Understanding the link of water cycle and production cycle.  
Potential and opportunities of economical functions.

# Design Ambitions

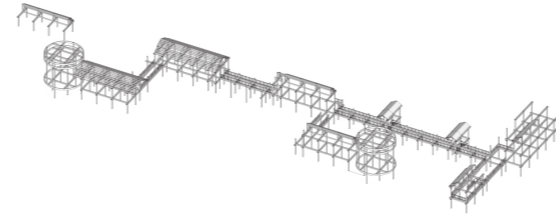
Public-Living ambition



# Design Elements

In a cluster scale

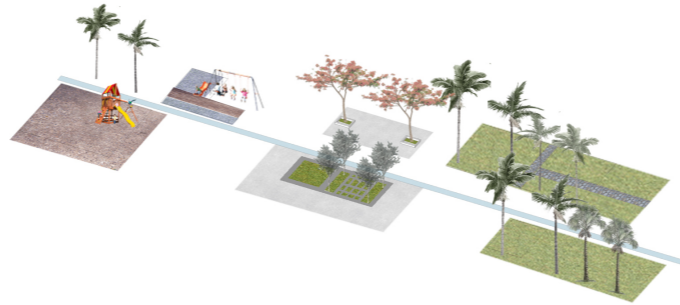
Building Structure



Public-Living Ambition

Improve public space and activities

Landscape



Ecology Ambition

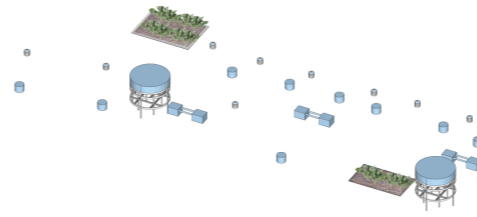
Trees plantation



Public-Living Ambition

Improve public green

Water Infrastructure



Water Ambition

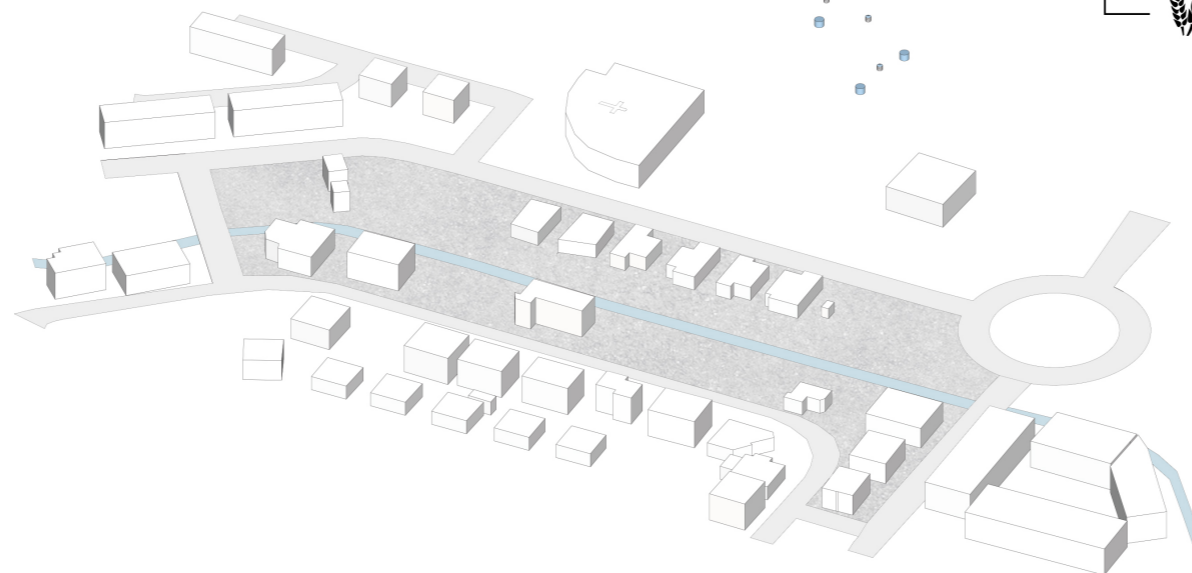
Improve water environment



Production Ambition

Wetlands plant food and materials

Existing Context



13 Households



About 50 persons

# Design Strategy

## Water infrastructure

Item	Formula	Number
<b>Daily water consumption</b>		
Proposed households numbers in a cluster		12-15
Max.Population		60
Water amount per person per month		4.5 m <sup>3</sup>
Monthly water consumption amount	4.5x60	270 m <sup>3</sup>
Monthly greywater amount	0.1325x60x30	238.5 m <sup>3</sup>
Toilet waste	0.0015x60x30	2.7 m <sup>3</sup>
Monthly black water amount	0.03x60x30	54 m <sup>3</sup>
	54-2.7	51.3 m <sup>3</sup>
ABR, AF and BR water loss	51.3x(100-15%)	43.61 m <sup>3</sup>
Proposed volume of community ABR, AF		44-45 m <sup>3</sup>
Proposed number and size of ABR, AF	3x15 m <sup>3</sup>	3x2.5x2 m
	2x22 m <sup>3</sup>	3.6x2.8x2.2 m
Wastewater amount	43.61+238.5	282.11 m <sup>3</sup>
CW water loss and water amount for reuse	282.11x80%	225.70 m <sup>3</sup>
Reused water for each household	225.70/15	15.05 m <sup>3</sup>
Proposed size of household water tanks		
Minimum CW area in total	(225.70/1x10) /30 m <sup>2</sup>	Min. 80 m <sup>2</sup>
<b>Minimum rainwater harvesting in hurricane season</b>		
Number of days		15
Minimum water demand per person per day		0.05 m <sup>3</sup>
15 days minimum water storage amount	0.05x60x15	45 m <sup>3</sup>
Average monthly rainfall		0.087 m <sup>3</sup>
Minimum catchment surface	45/0.087	517 m <sup>2</sup>
Back-up tanks volume	3.14x1.2 <sup>2</sup> x2	9 m <sup>3</sup>
Back-up tanks amount		3

Water Consumption Calculation

Objective	Cost	Load Capacity
Constructed Wetlands	80-100 euro per m <sup>2</sup>	<ul style="list-style-type: none"> <li>A surface area of about 1-3 m<sup>2</sup> per person is usually required.</li> <li>1 m<sup>3</sup> water needs 10m<sup>2</sup> land per day.</li> </ul>
ABR and AF	2800-3500 euro for an ABR; 900-1200 euro for an AF;	<ul style="list-style-type: none"> <li>In general the daily inflow is 2-200 m<sup>3</sup>. the following aspects.</li> <li>The hydraulic retention time should be 48-72 hours.</li> </ul>
Biogas Reactor	110-130 euro for a household BR	The hydrostatic residence time should be at least 15 days in hot climates.
Water Tower	500-600 euro for a concrete water tower.	50-70 euro for a 3-4 m <sup>3</sup> household water tank.
Household water tank	60-70 euro for a 3 m <sup>3</sup> household water tank	3-5 years need to maintain or replace the water tank.

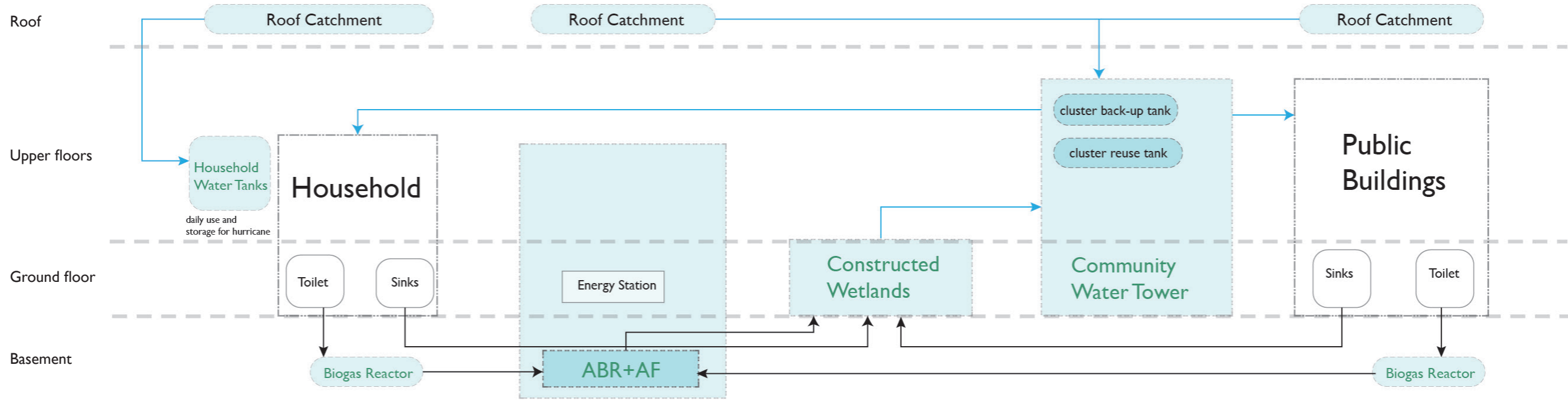
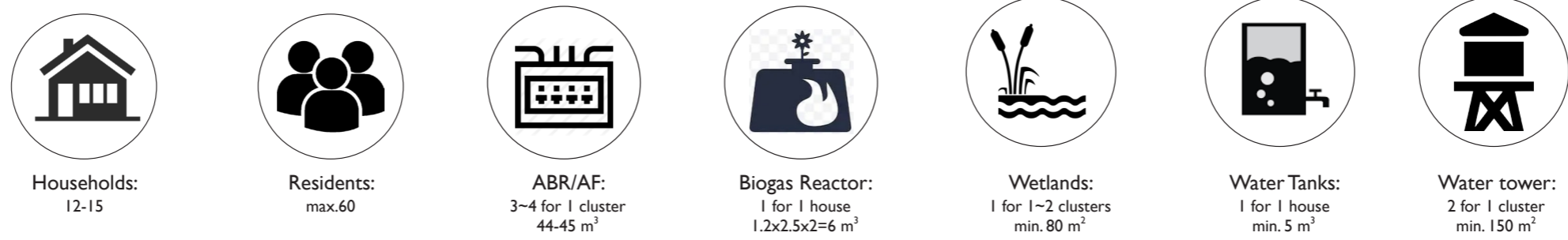
Cost-benefit and Load Capacity Calculation



# Design Strategy

## Water infrastructure

### Conclusion of a cluster scale



Vertical and horizontal water flow in new facilities

# Design

How a cluster?



Method --- Follow the streets and rivers

# Design Strategy

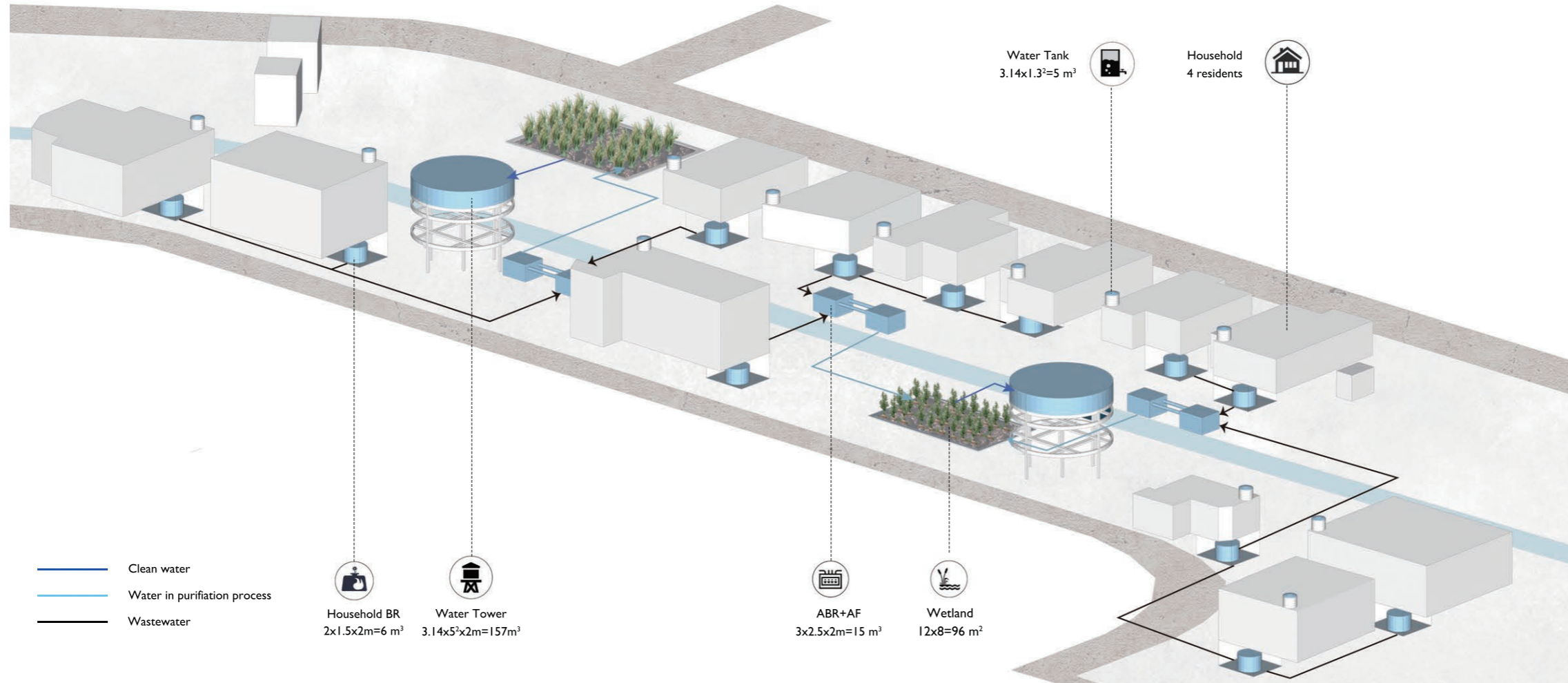
## Water infrastructure



Cluster Division

# Design Strategy

## Water infrastructure



Water facilities in a cluster

# Design Strategy

## Building structure

Water infrastructure



Wetlands:



Water Tanks:



Water tower:



ABR/AF:



Biogas Reactor

+

Spatial functions

Leisure functions  
meet, play



Ecological functions  
birds nest, planters.



Public functions  
schools, sports center, medical center...



Economical functions  
workshop, shops, restaurant.

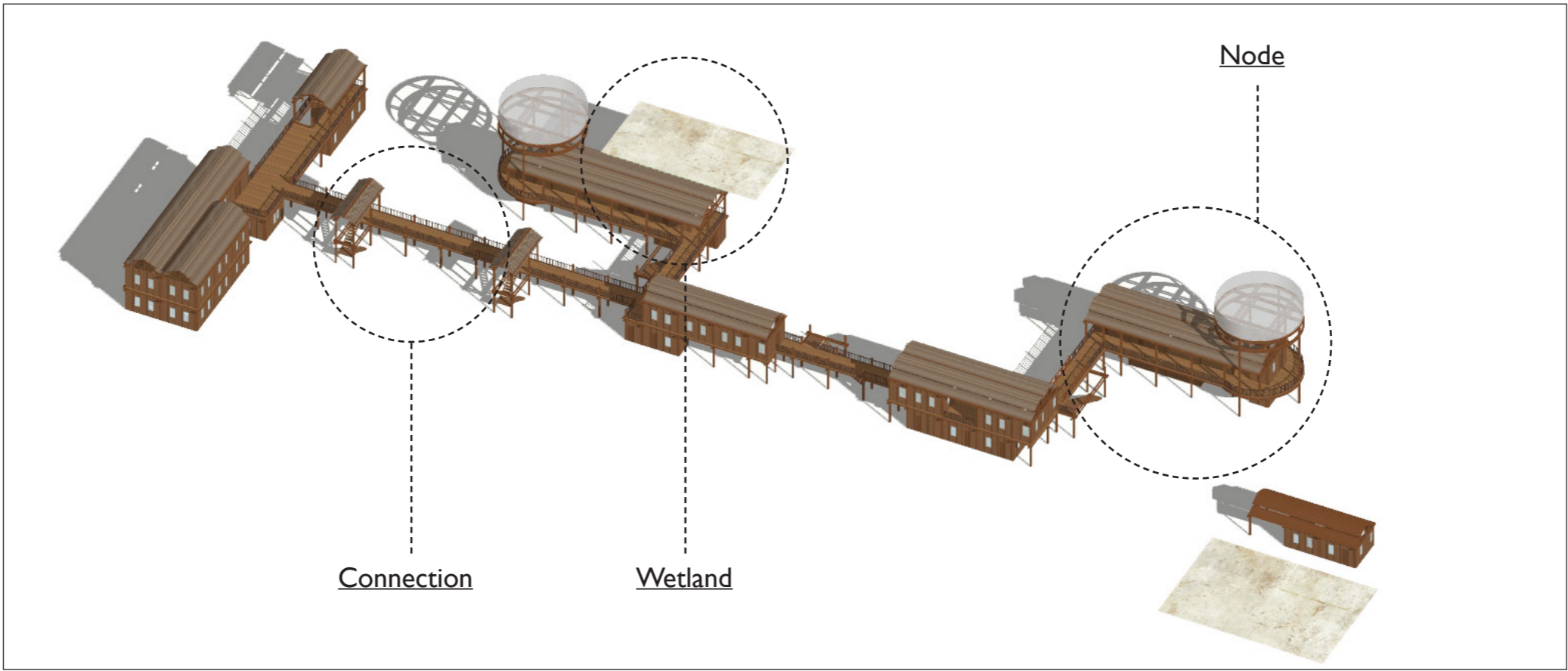


Connection functions  
Service, logistics



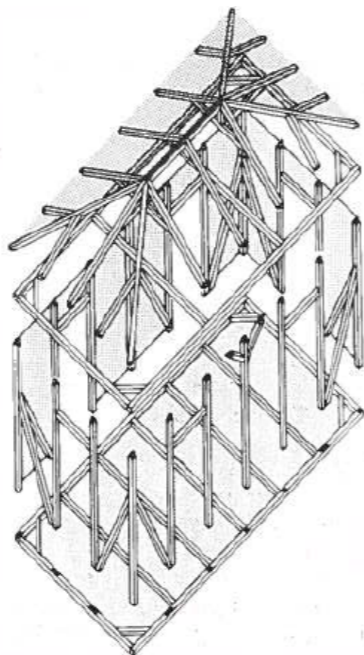
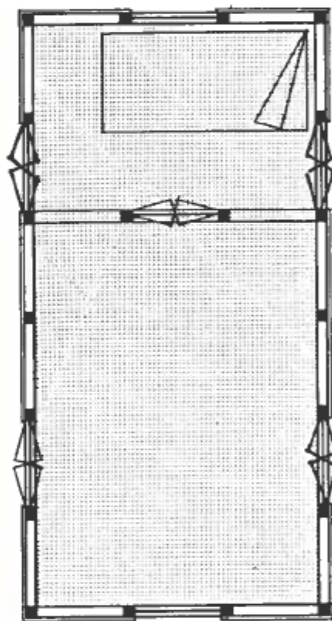
||

Three Types

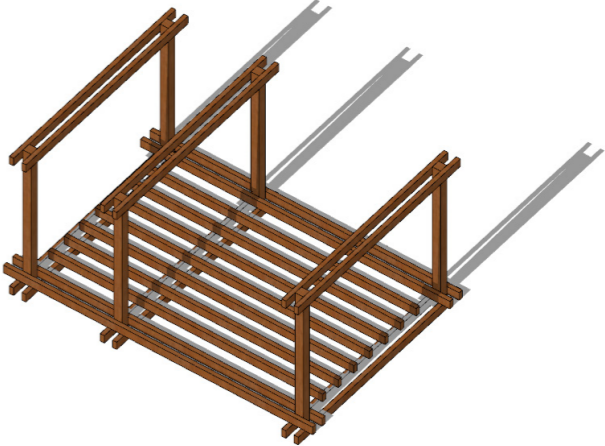
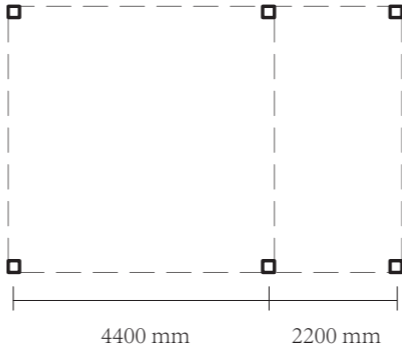


# Design Strategy

Type I: Node



**Traditional Caribbean Houses**  
Floor plan and structure

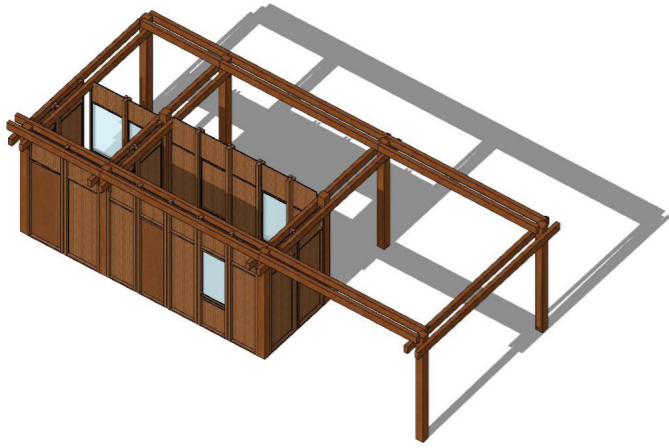
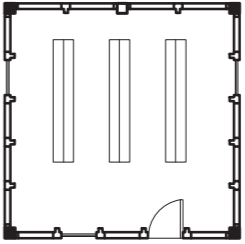
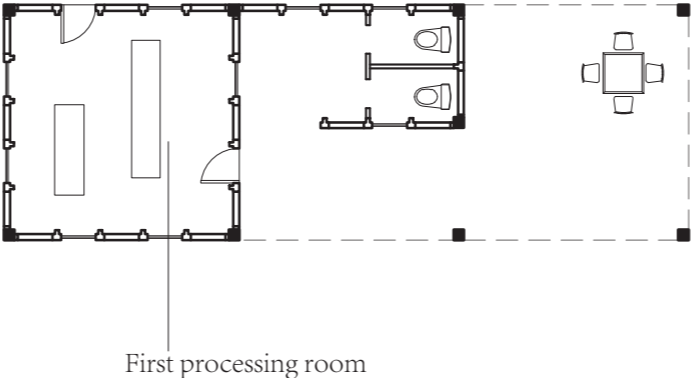
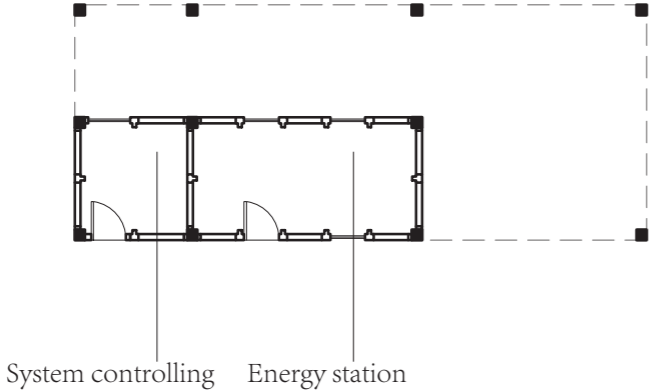


**Shape and Measurement of a Node type**

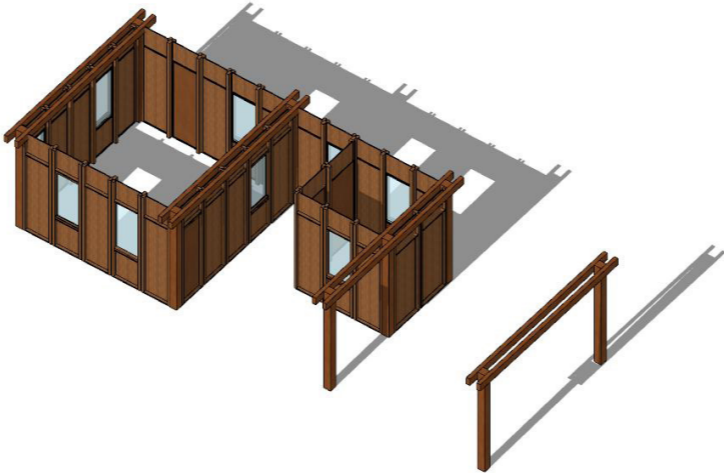
# Design Strategy

Type I: Node

## The Ground Floor



System Room



Processing Room

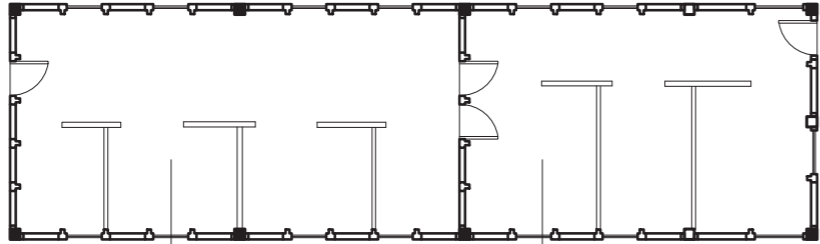


Shop

# Design Strategy

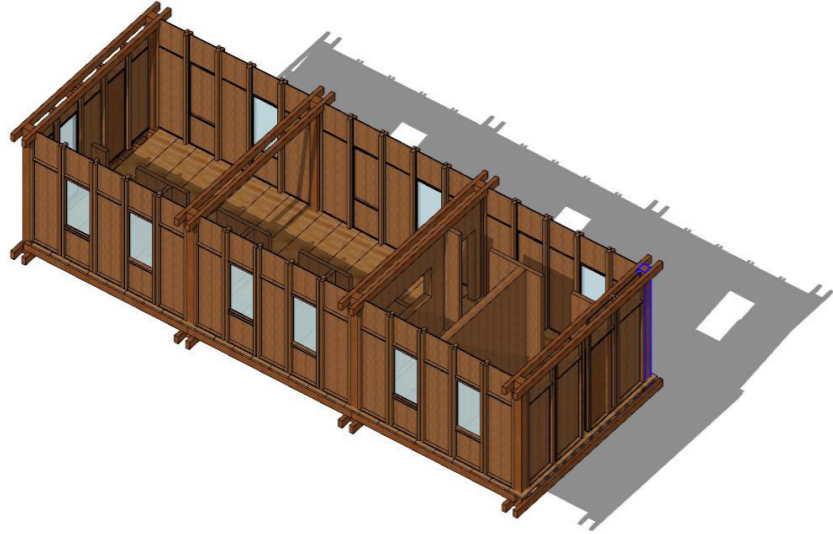
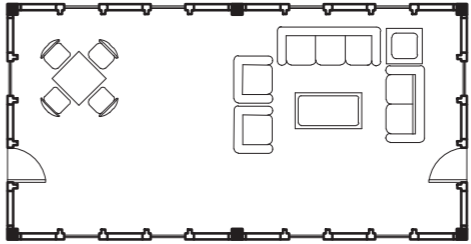
Type I: Node

## The First Floor

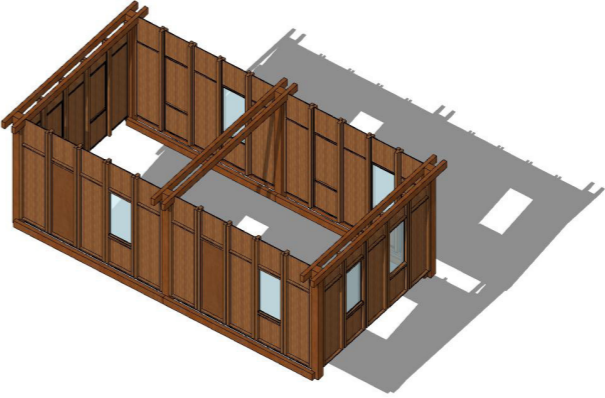


Display and retailing

Processing



**Food & Material Workshop**



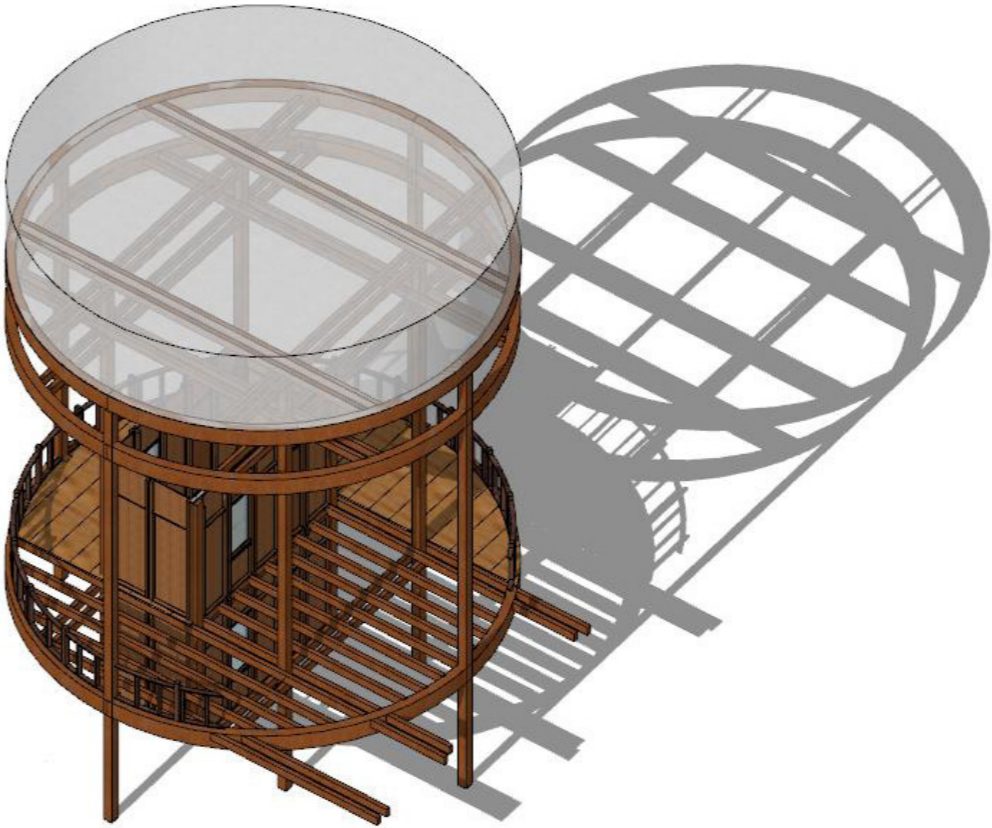
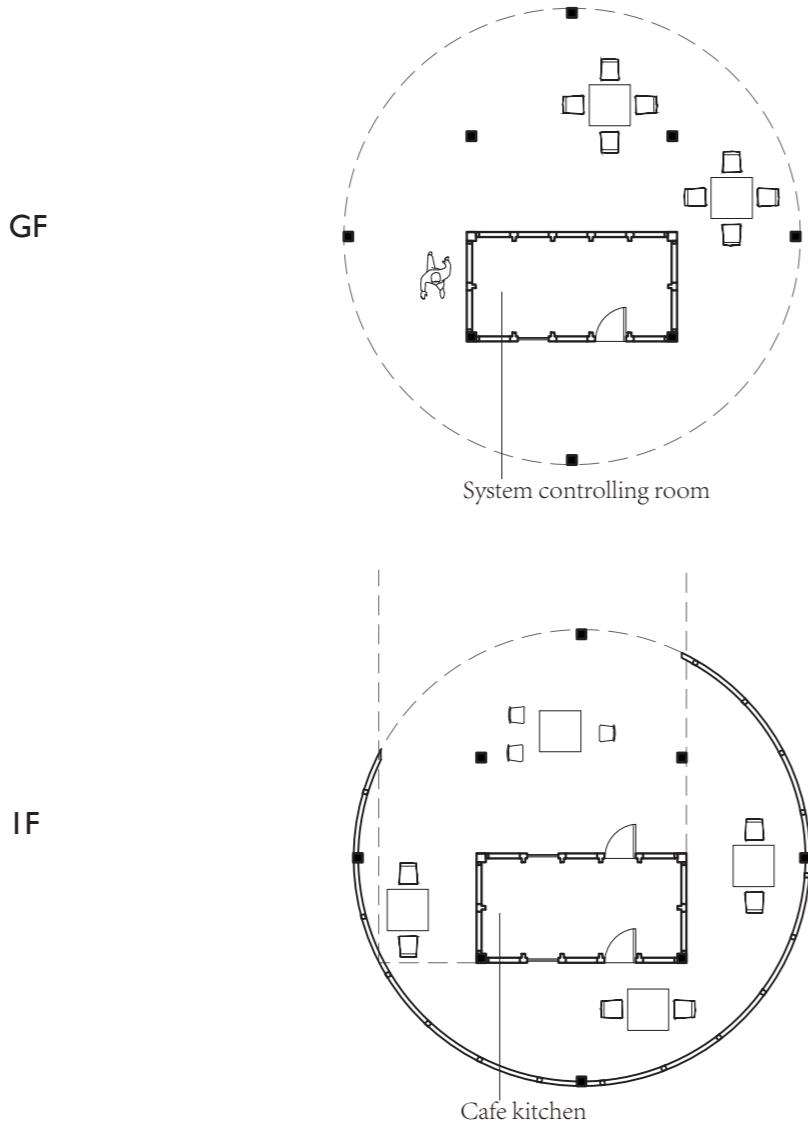
**Common Room**



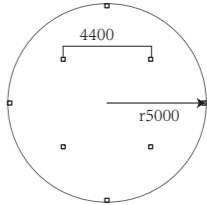
# Design Strategy

Type I: Node

## Individual Buildings



Plastic water tank (lightweight and flxible to store a bit more water)

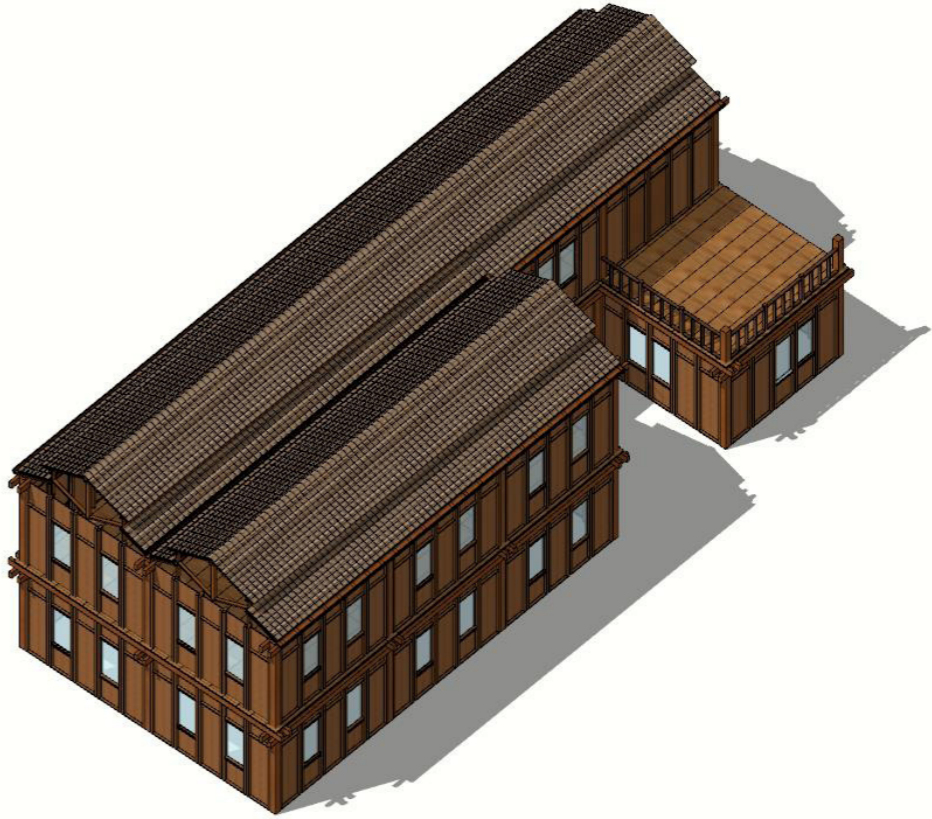
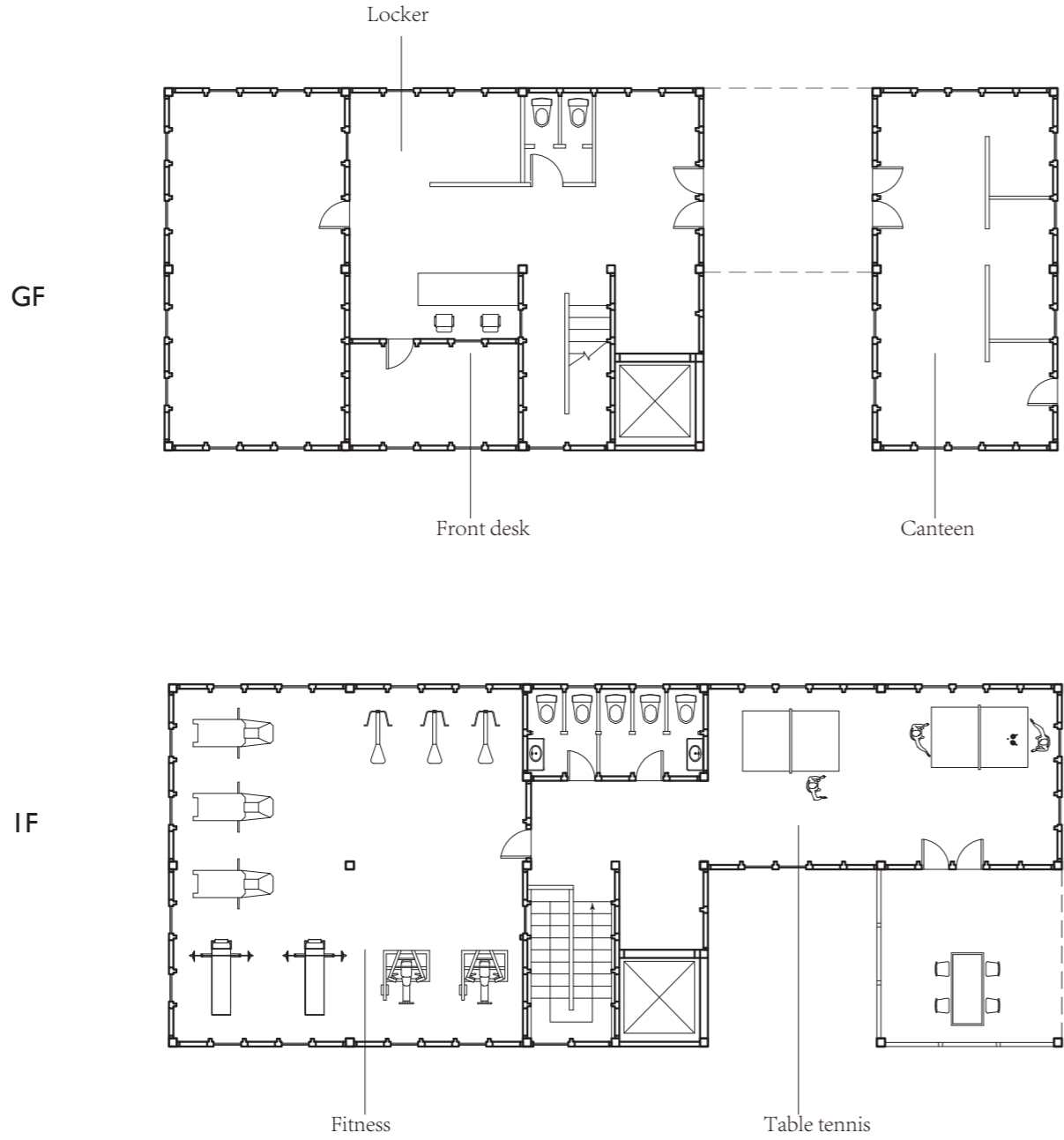


### Water Tower with a kitchen of a Cafe

# Design Strategy

Type I: Node

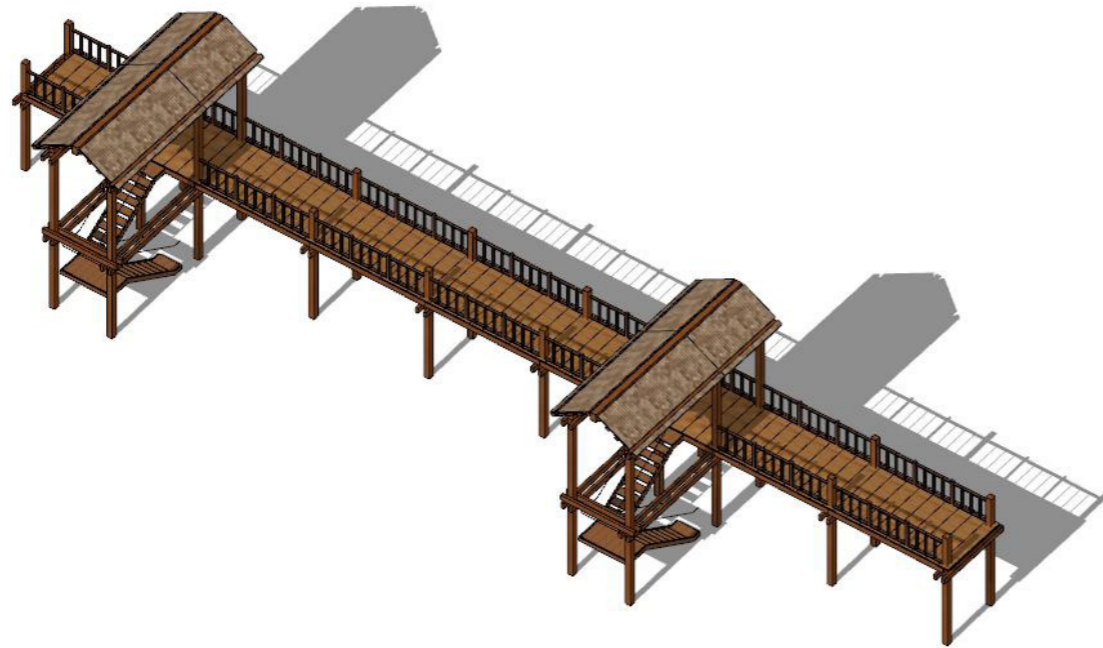
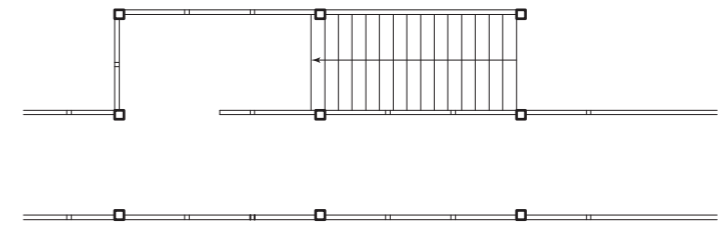
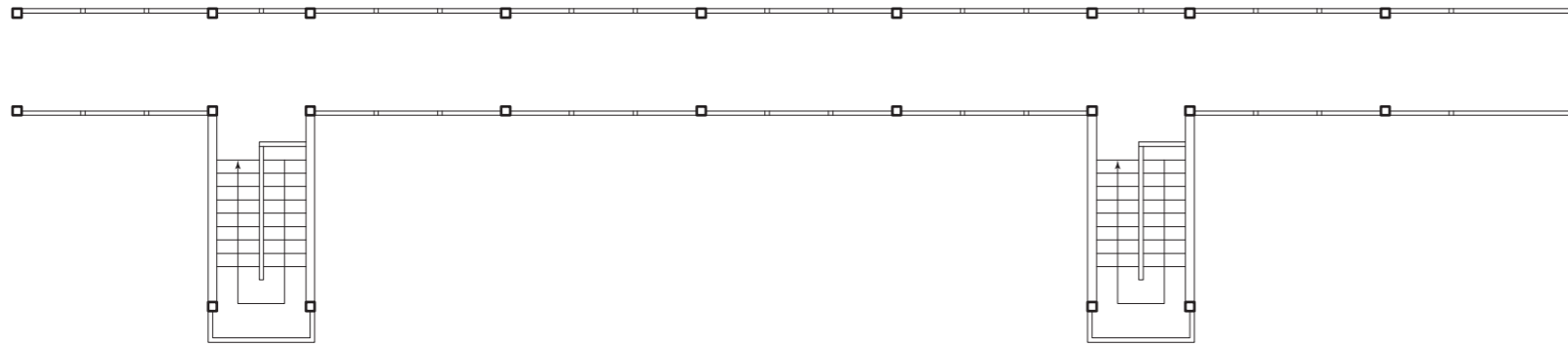
## Individual Buildings



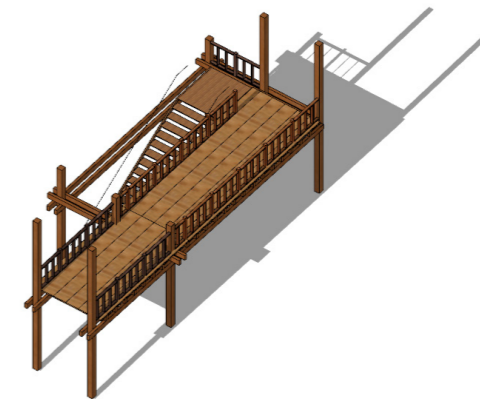
## Public Building --- Sports Center

# Design Strategy

## Type 2: Connection



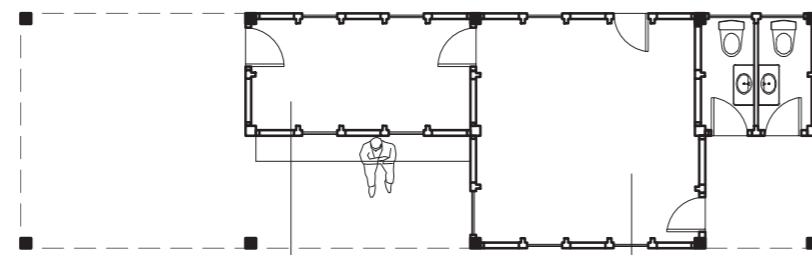
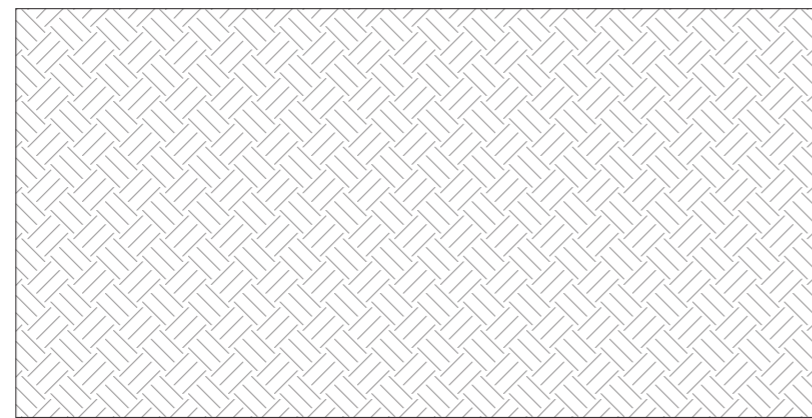
Bridge type 1



Bridge type 2

# Design Strategy

Type 3: Wetland



First processing room

Storage

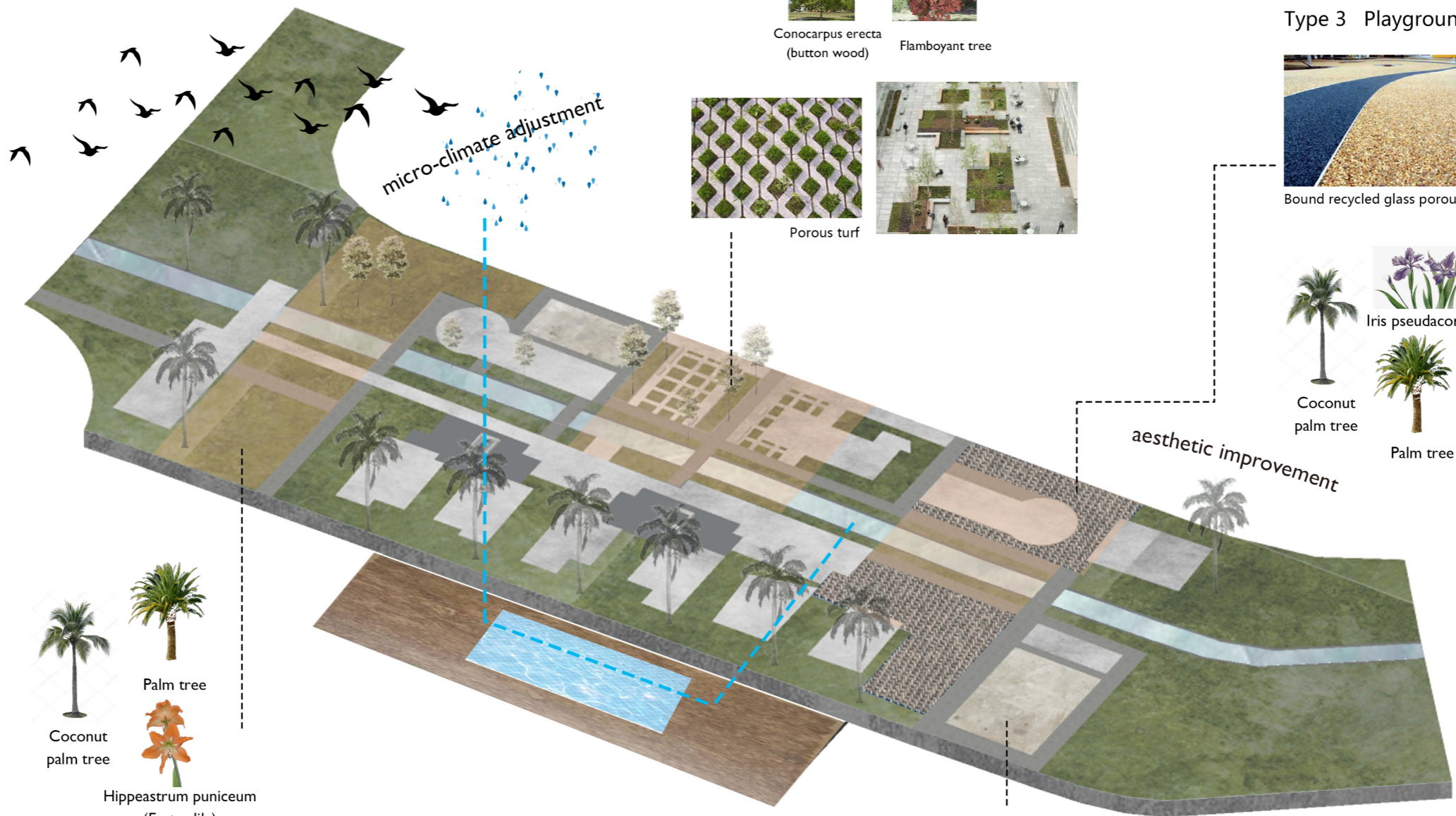


**Constructed Wetland & processing room**

# Design Strategy

## Landscape

- Killdeer (Charadrius vociferus) 
- Great Black-backed Gull (Larus marinus) 
- Willet (Tringa semipalmata) 
- Roseate Tern (Sterna dougallii) 



Type 1 Communal Parks

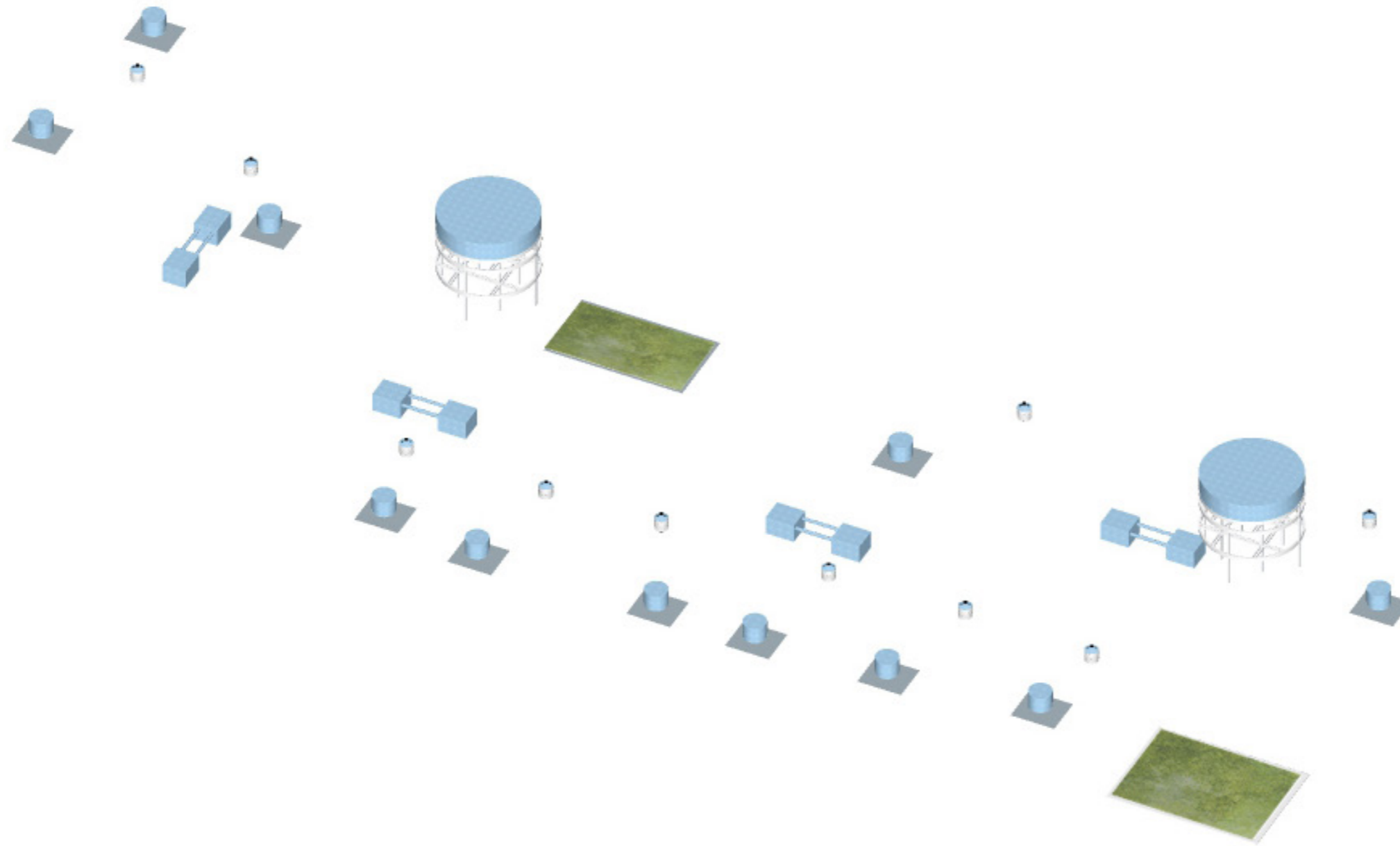


Constructed Wetlands

different type has different fuctions, with trees for birds and pavements

# Design Strategy

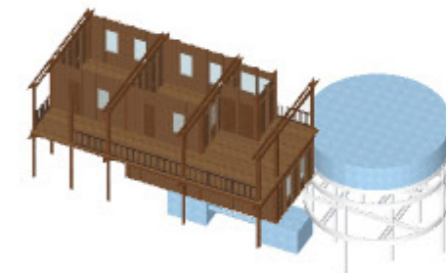
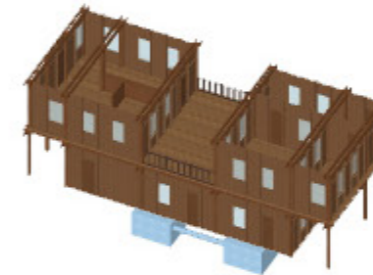
## Steps



**Install the system**

# Design Strategy

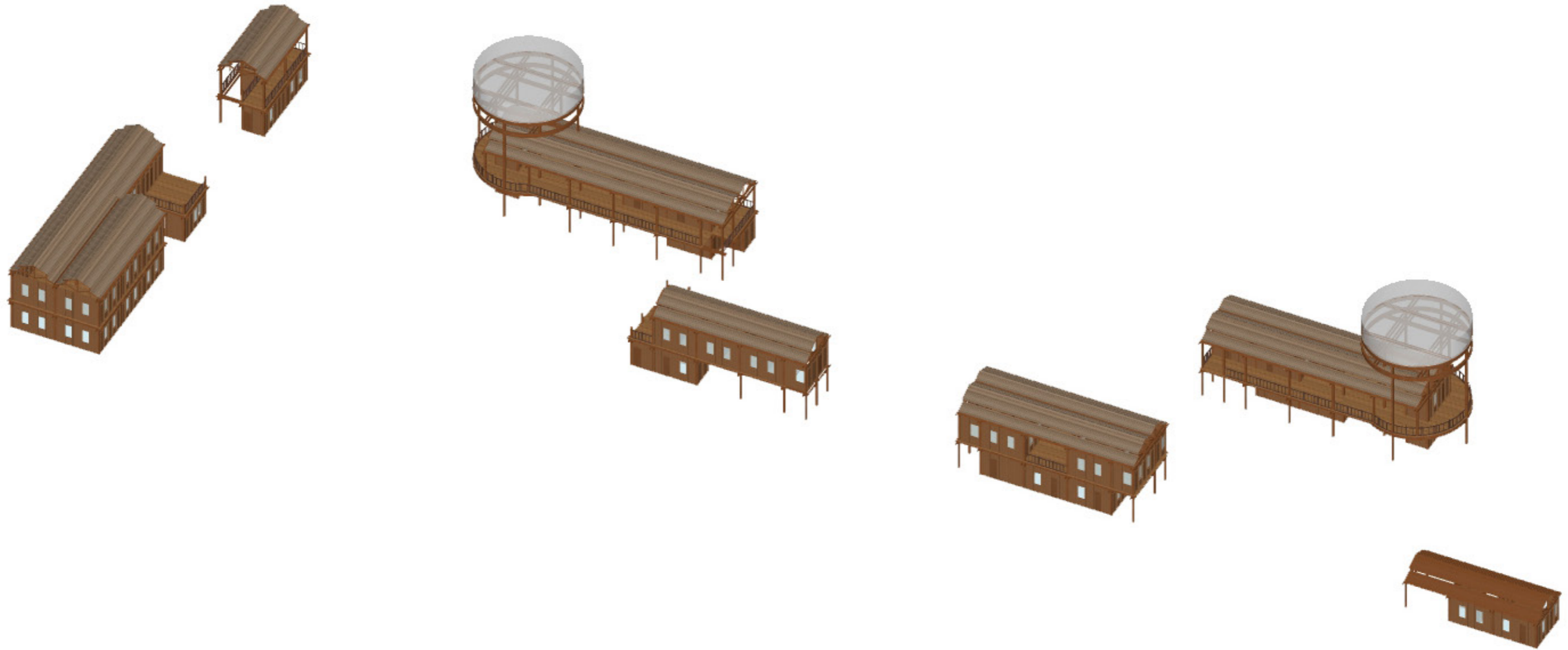
## Steps



Choose "Node" from sholist

# Design Strategy

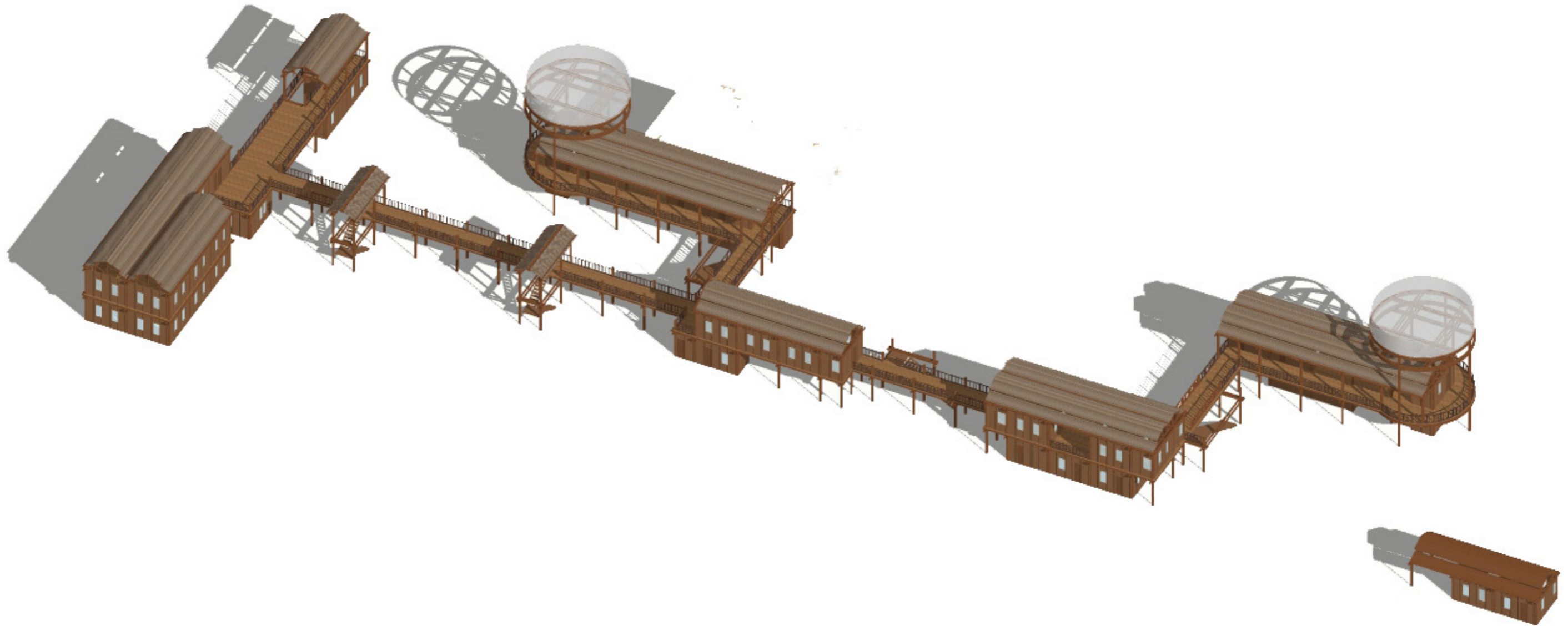
## Steps



**Add individual buidings (water towe and public buildings)**



# Design Overview



**Add "Connection" between "Node"**

# Design

## Birdview



**Add Landscape**

# Design

## Site Plan



# Design Analysis



**Two routes with different atmosphere**

# Design Analysis



Two routes with different atmosphere

# Design Analysis



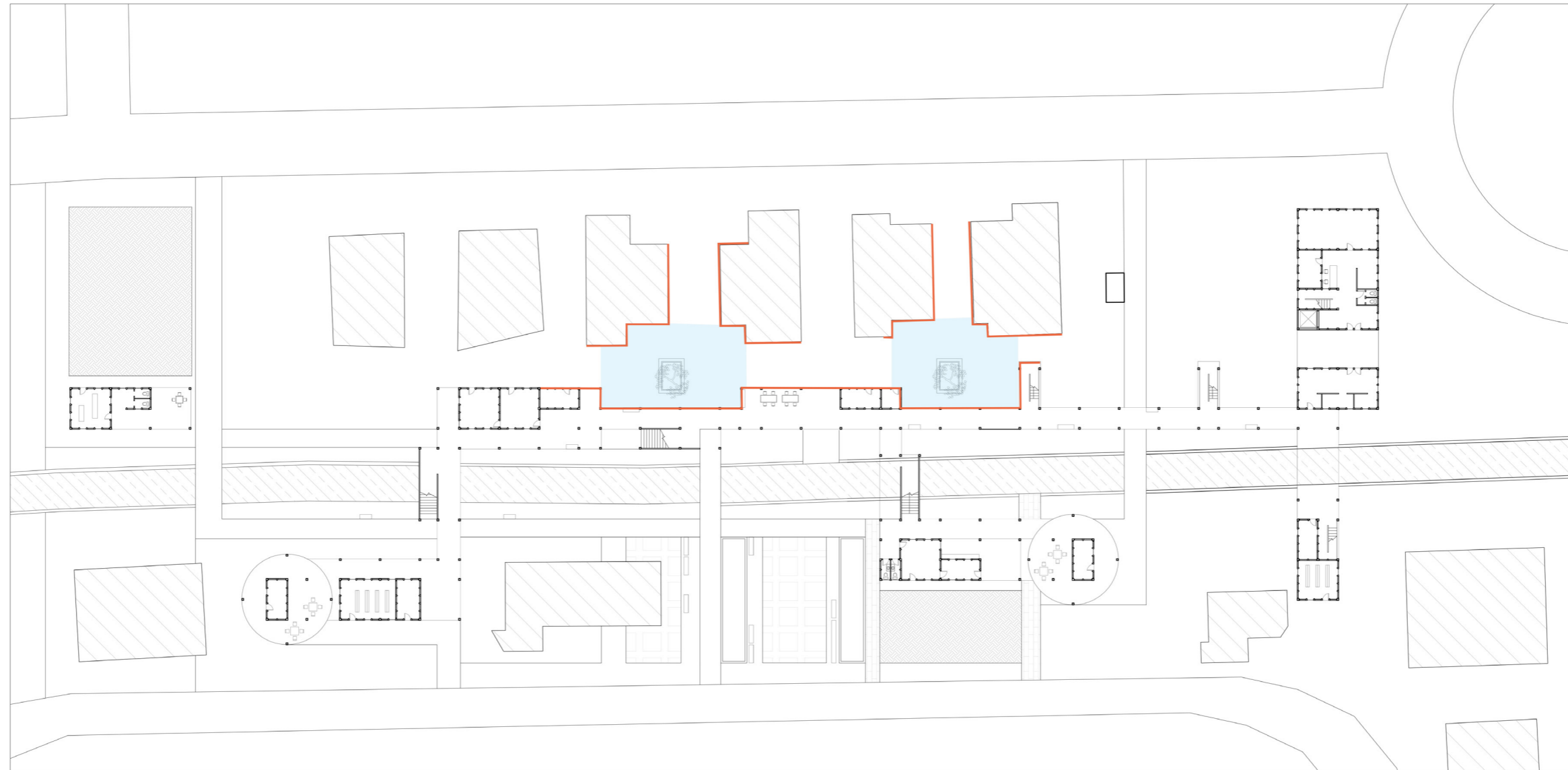
**Path through the building visually and physically**

# Design Analysis



Path through the building visually and physically

# Design Analysis



**Small squares that follow the shape of existing houses**

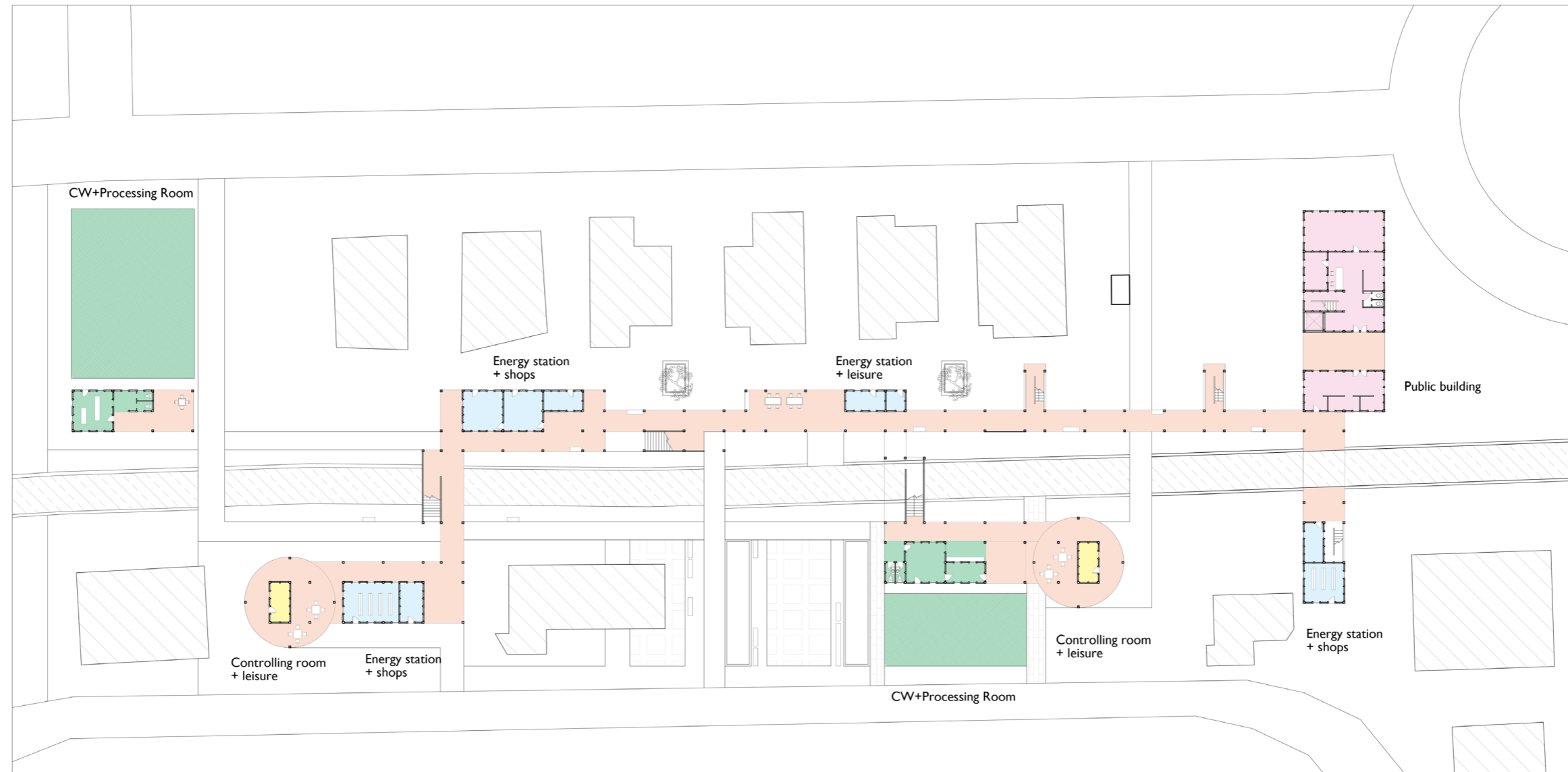


# Design Analysis



**Path through the building visually and physically**

# Design Analysis



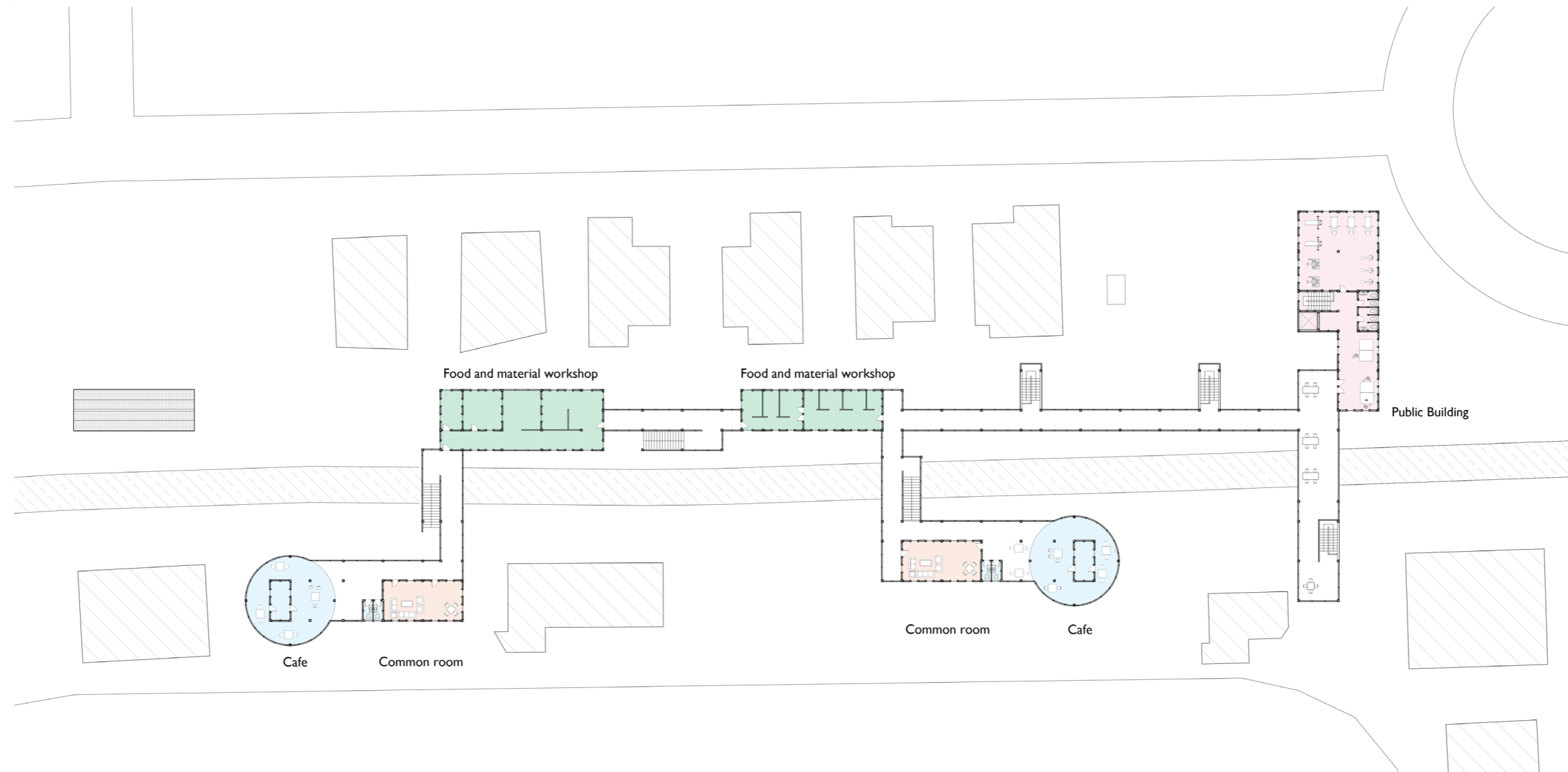
Layout of the ground floor

# Design Analysis



**Path through the building visually and physically**

# Design Analysis



Layout of the first floor

# Design Analysis



**Views on the first floor**

# Design Comparison



# Design Comparison



# Design Comparison





# Design Comparison



# Design Comparison

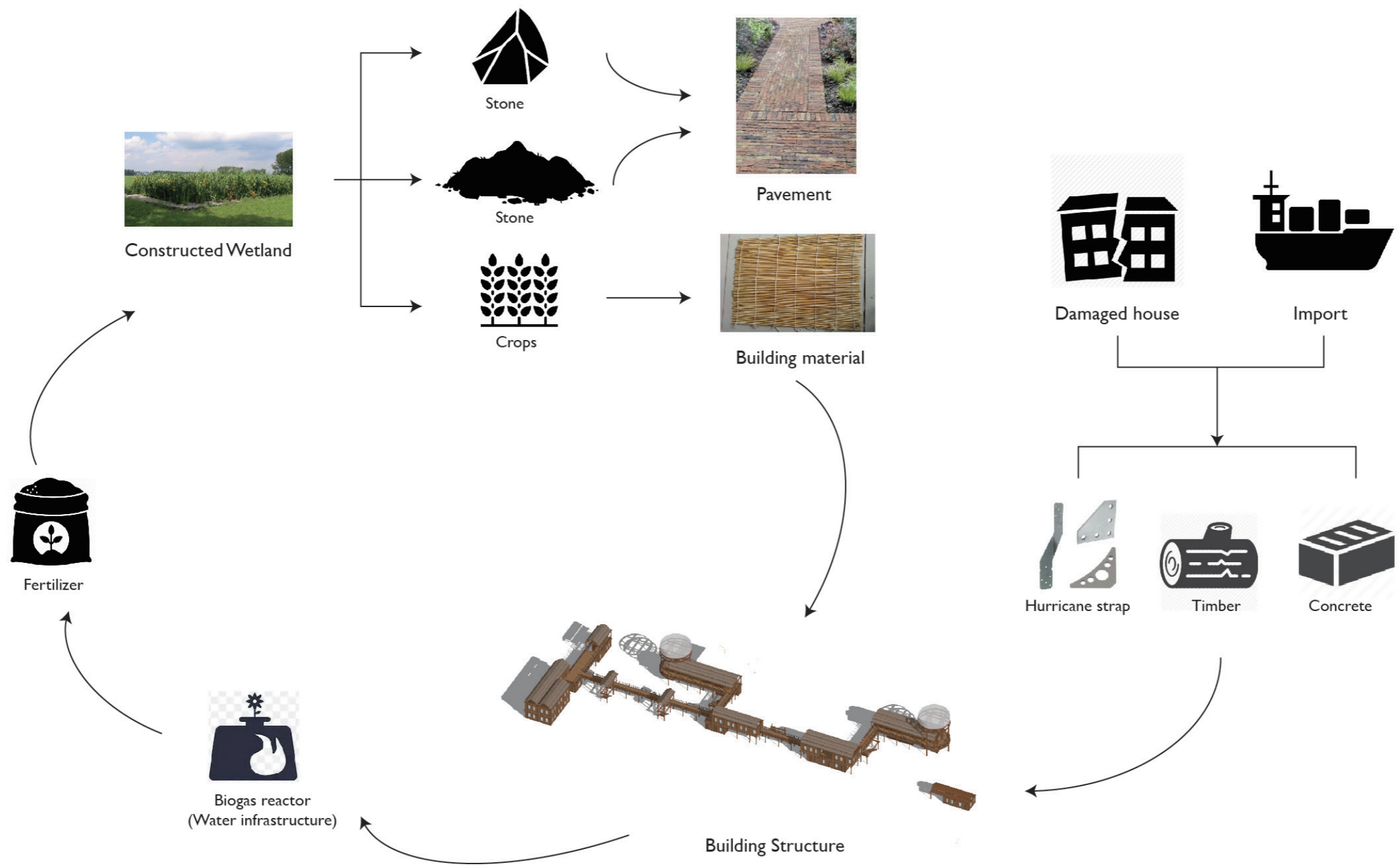


# Design Comparison



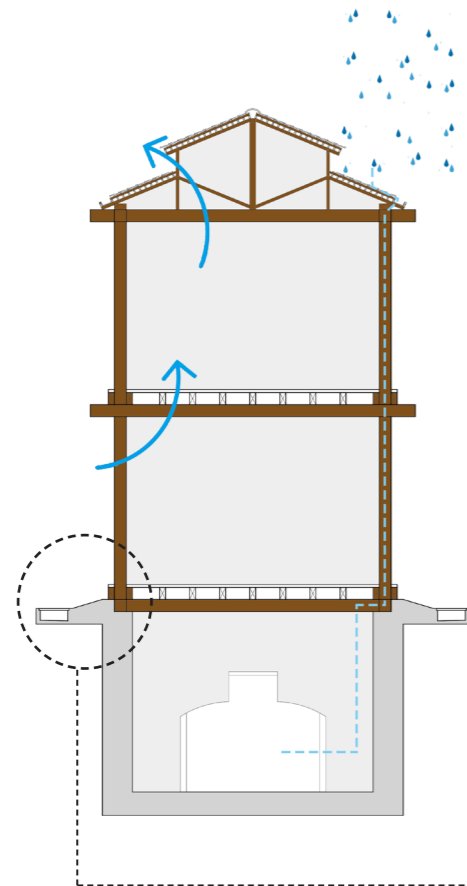
# Building Technology

## Material strategy



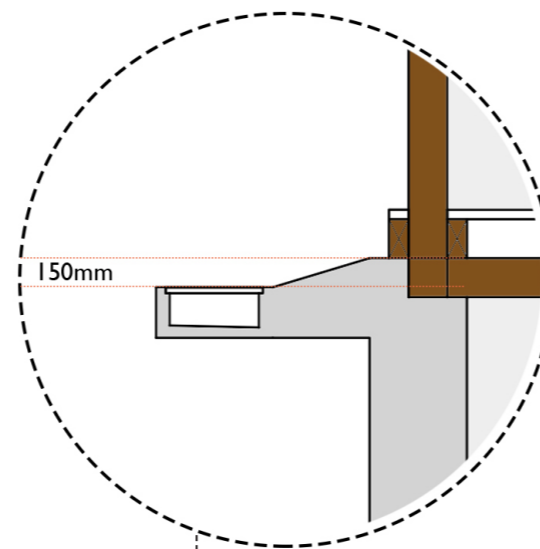
# Building Technology

## Climate and structural strategy



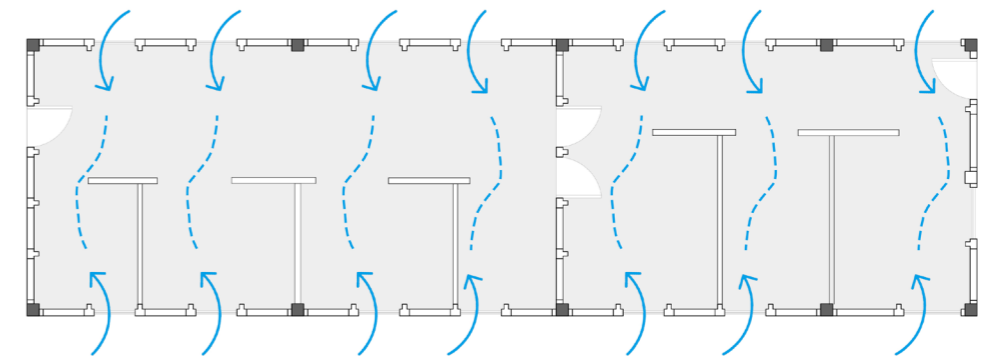
### Sloping roof and skylight

Good for rainwater harvesting and stack ventilation.



### Strong foundation and raise building up

Raise the building 150mm and gutters nearby can prevent water and flooding.

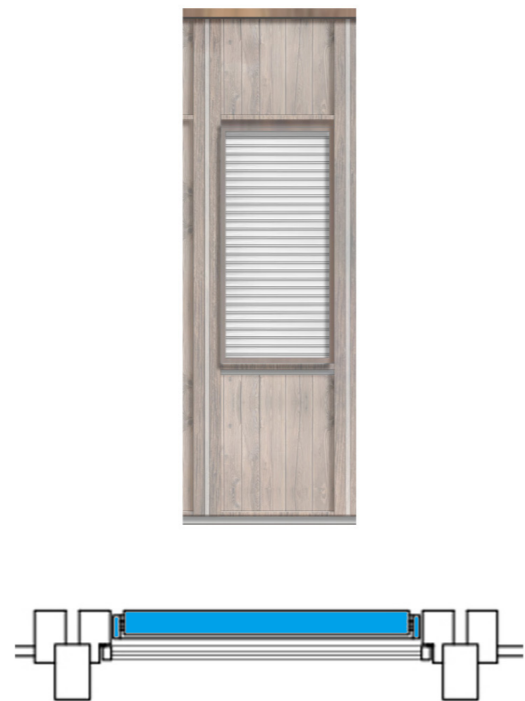


### Open and long narrow floor plan Locate openings on opposite side of building

These can help to promote natural ventilation.

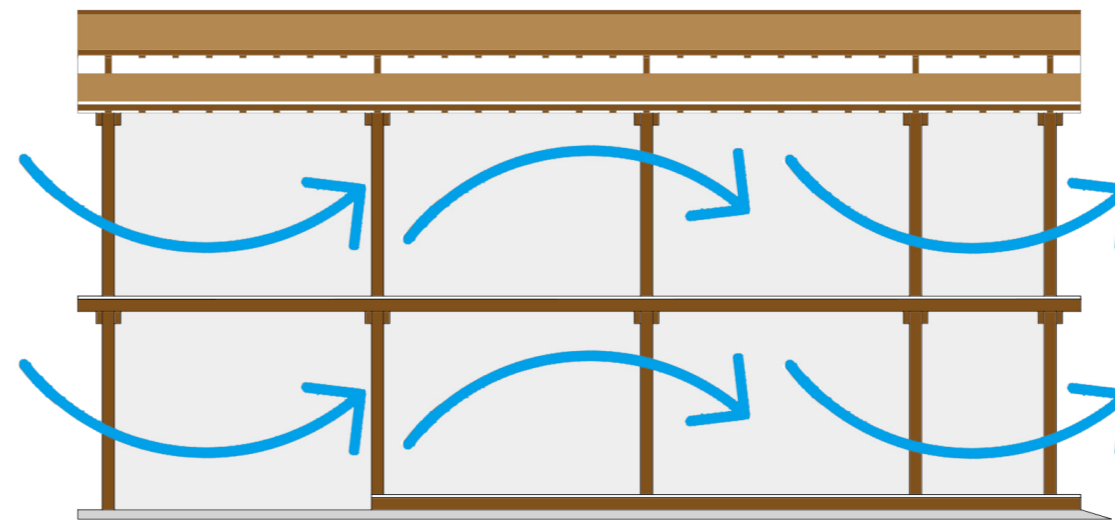
# Building Technology

Climate and structural strategy



**Louvers on the window**

The main method of sunshading.

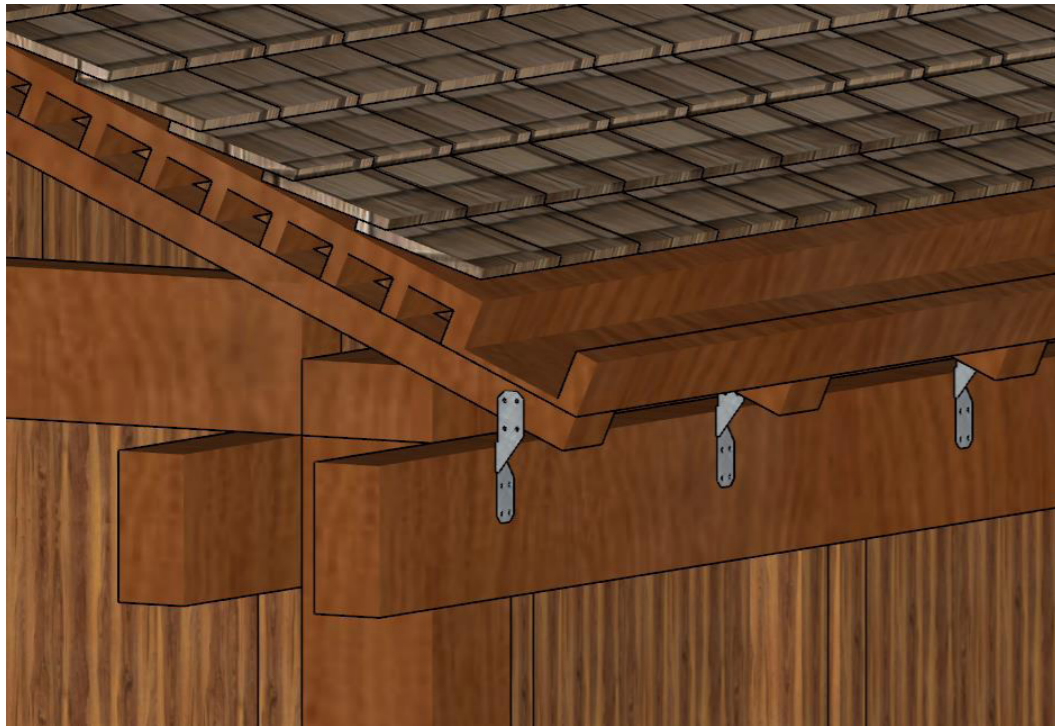


**Wooden framework construction**

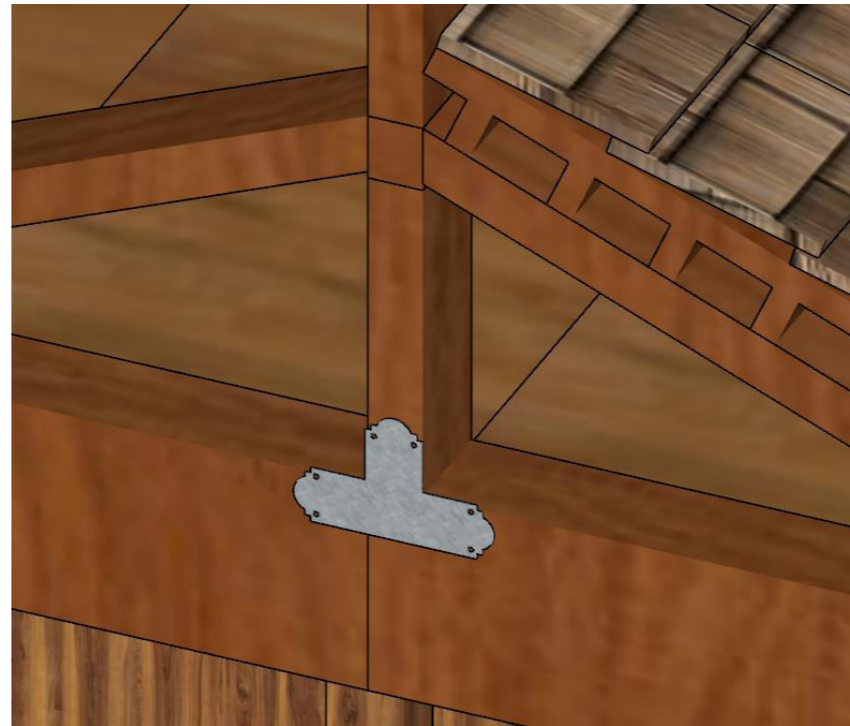
Permeable structure for airflow and open routing.

# Building Technology

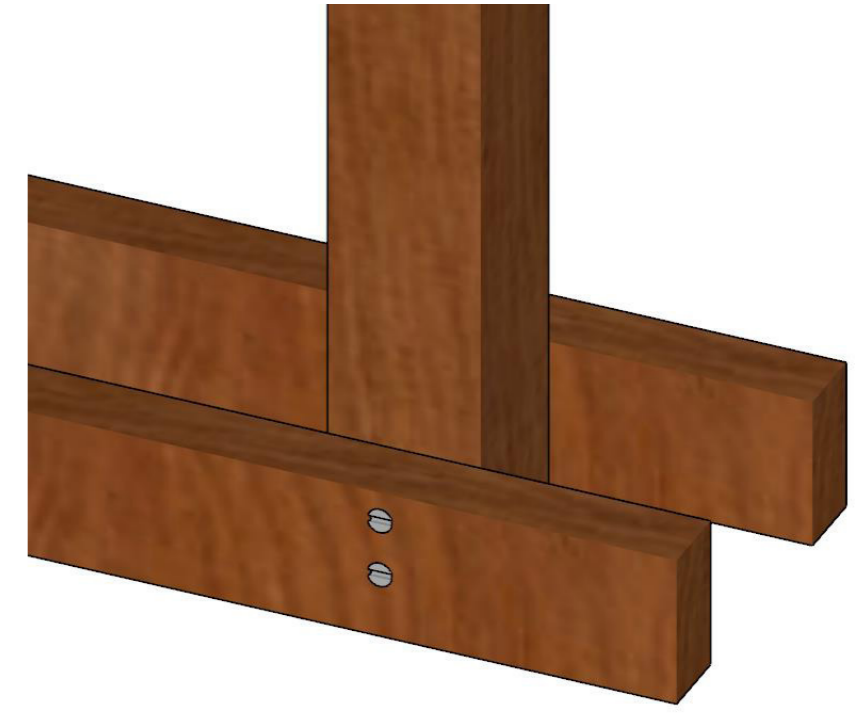
Connection method



Roof --- Hurricane strap



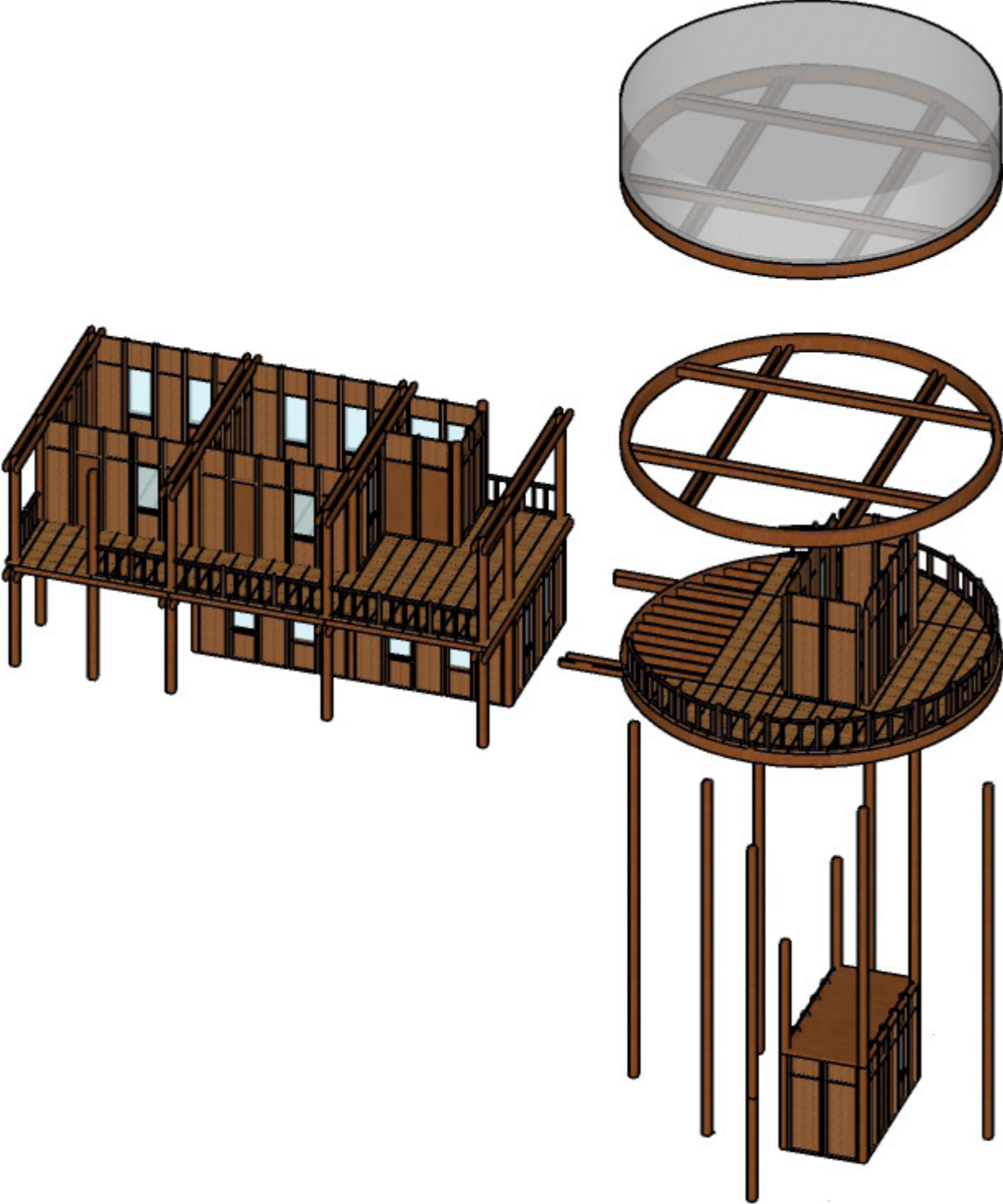
Roof --- Hurricane strap



Structure --- Screw

# Building Technology

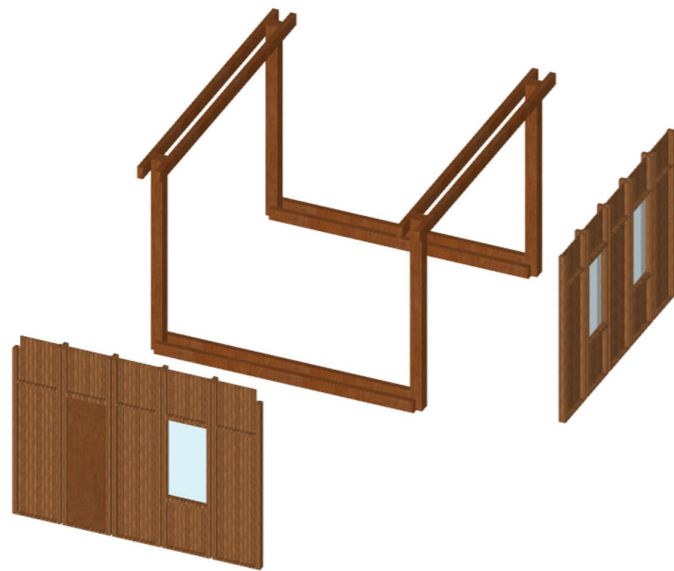
Connection method (water tower)



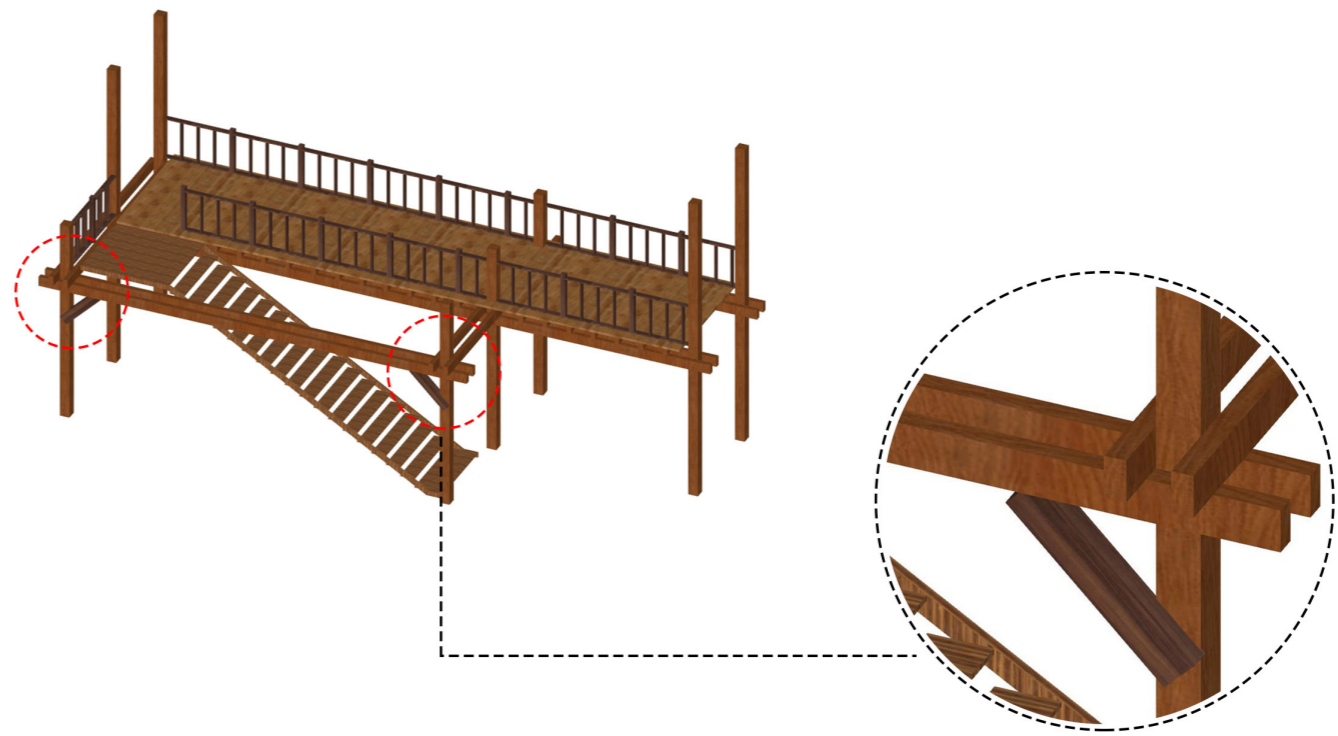


# Building Technology

## Bracing method



Window panels as a bracing

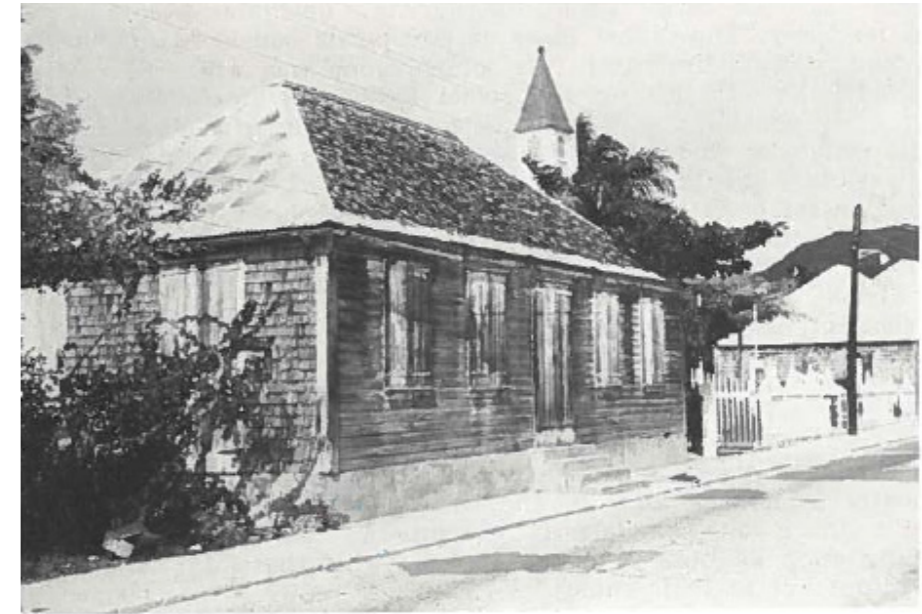
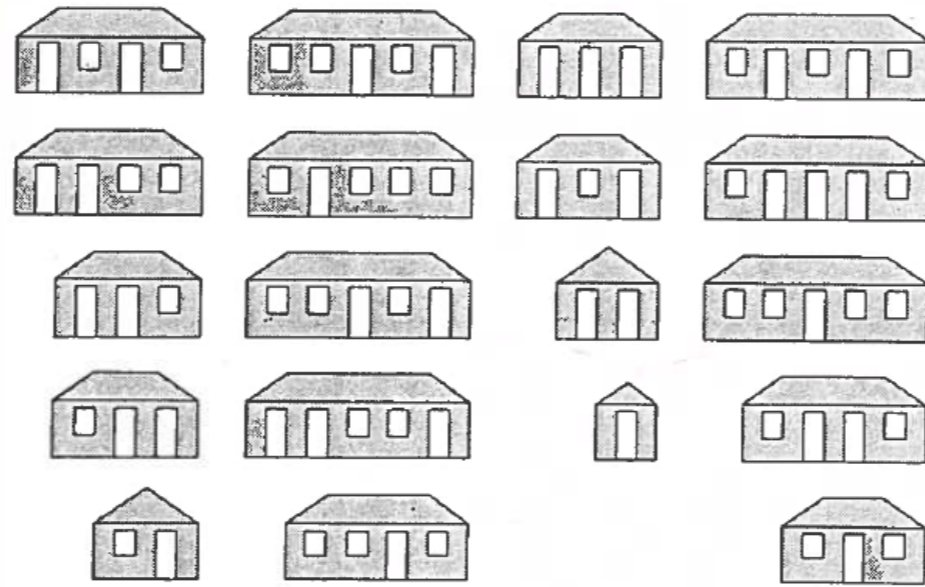


An extra triangular bracing in stairs

# Building Technology

## Facade

Windows and doors  
in the traditional Caribbean housings

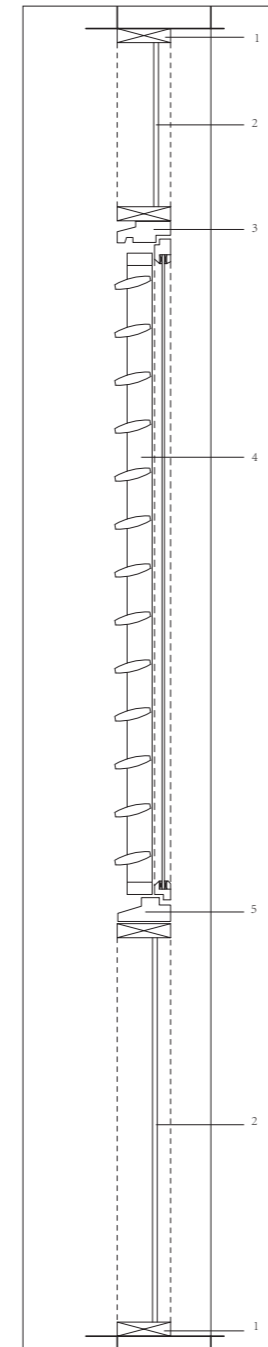
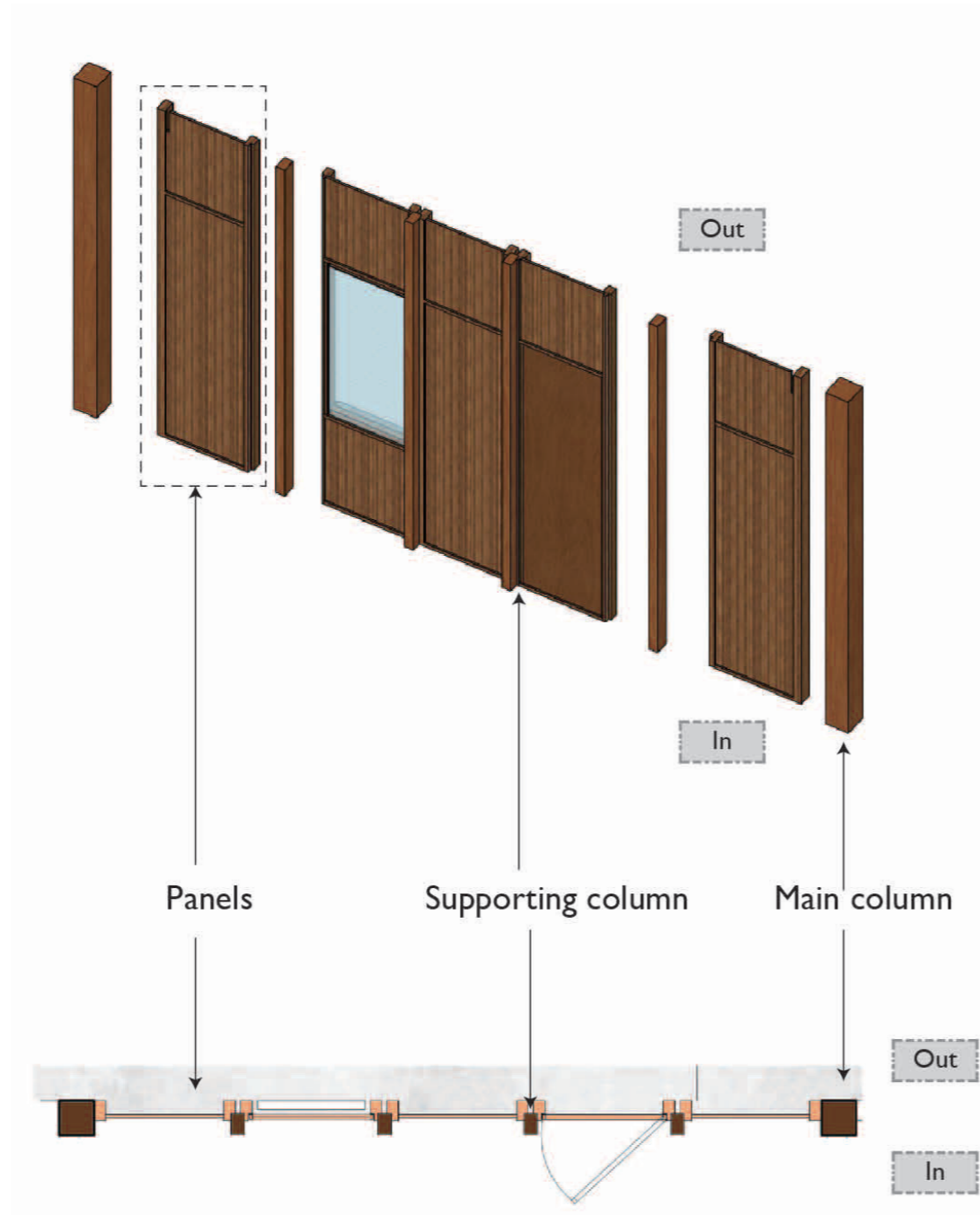


Rhythm of the windows and doors



# Building Technology

## Window and door

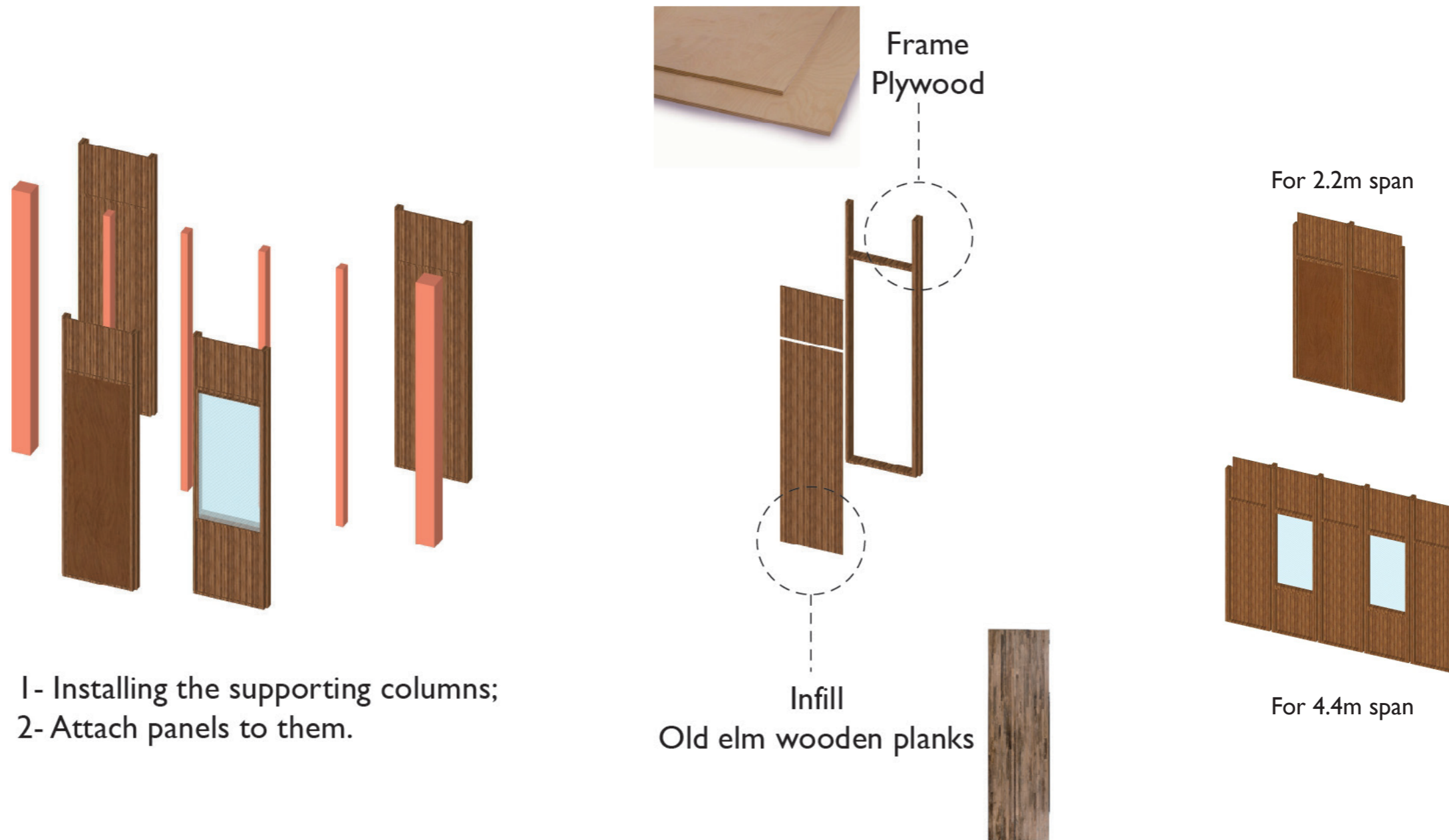


- 1- Plywood frame
- 2- Old elm wooden plank
- 3- Plywood Window frame
- 4- Louver
- 5- Plywood Windowsill

Window demountability

# Building Technology

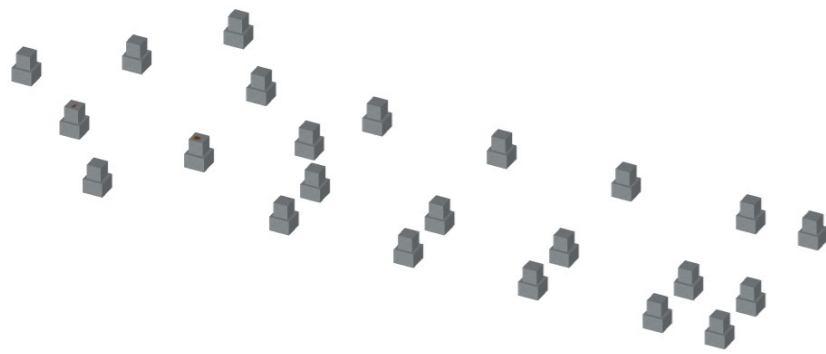
## Window and door



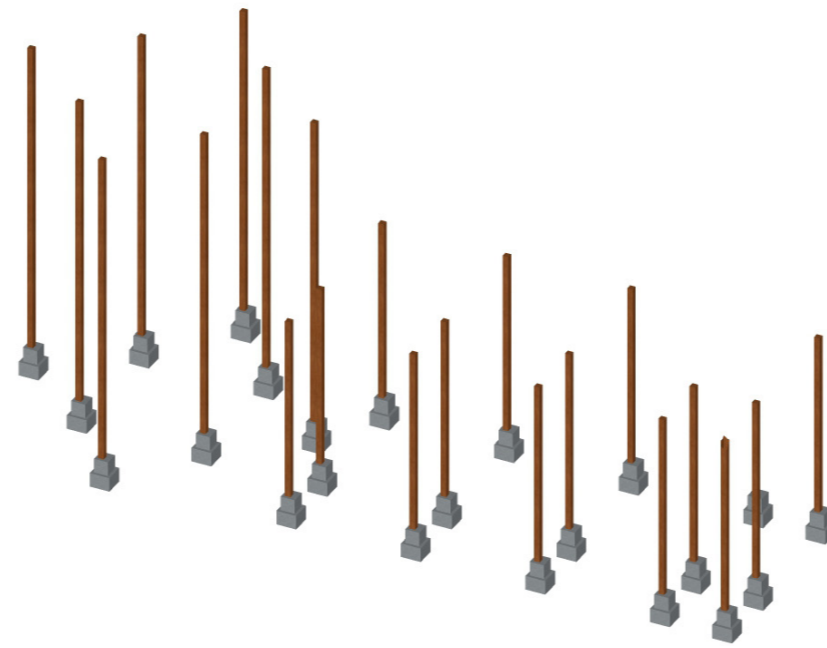
Typology and material

# Building Technology

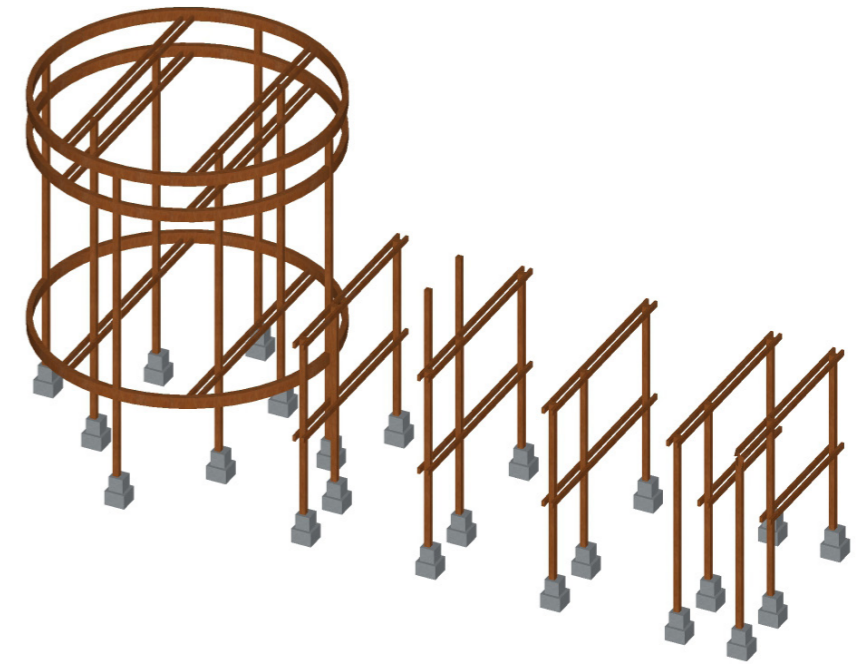
## Construction sequences



Foundations



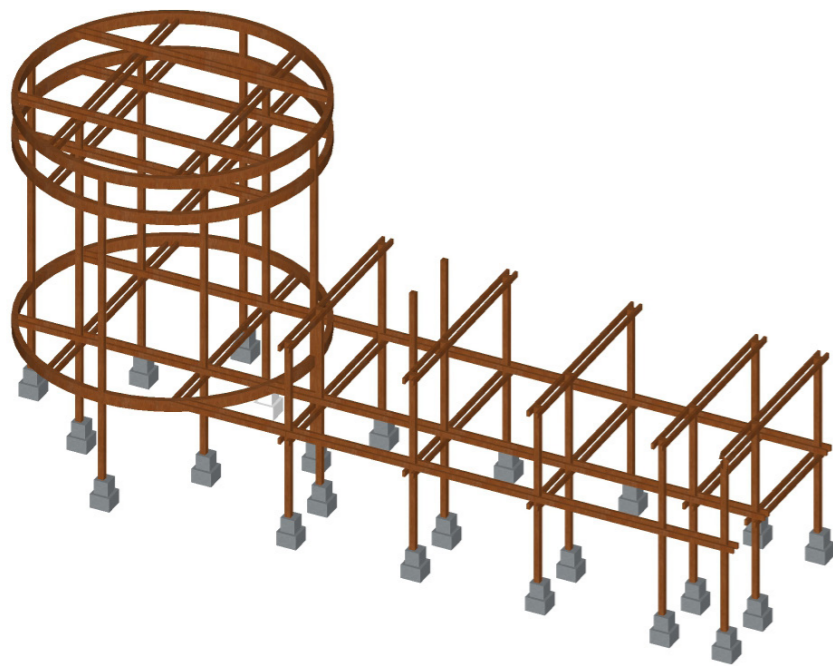
Columns



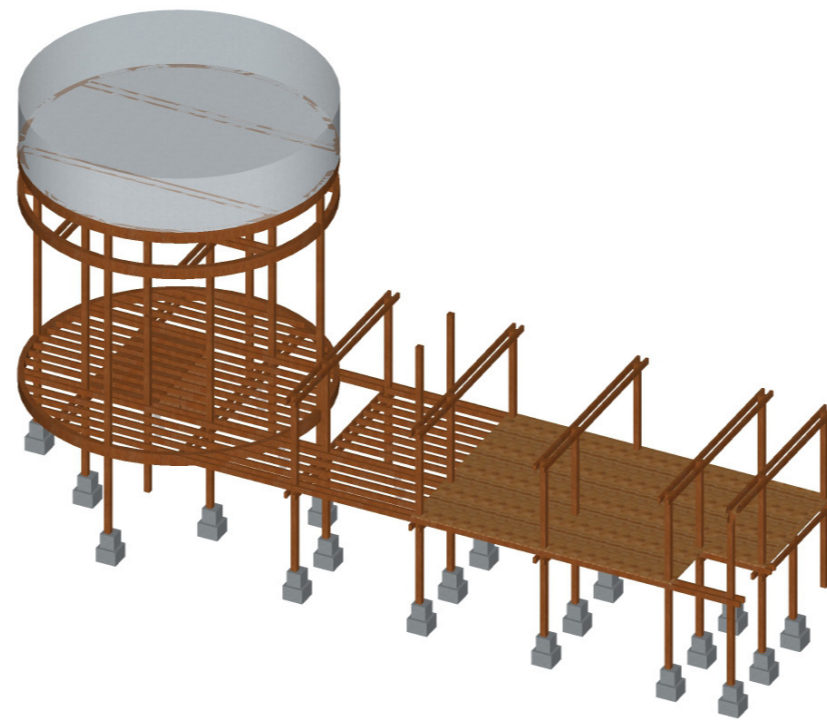
Primary structure

# Building Technology

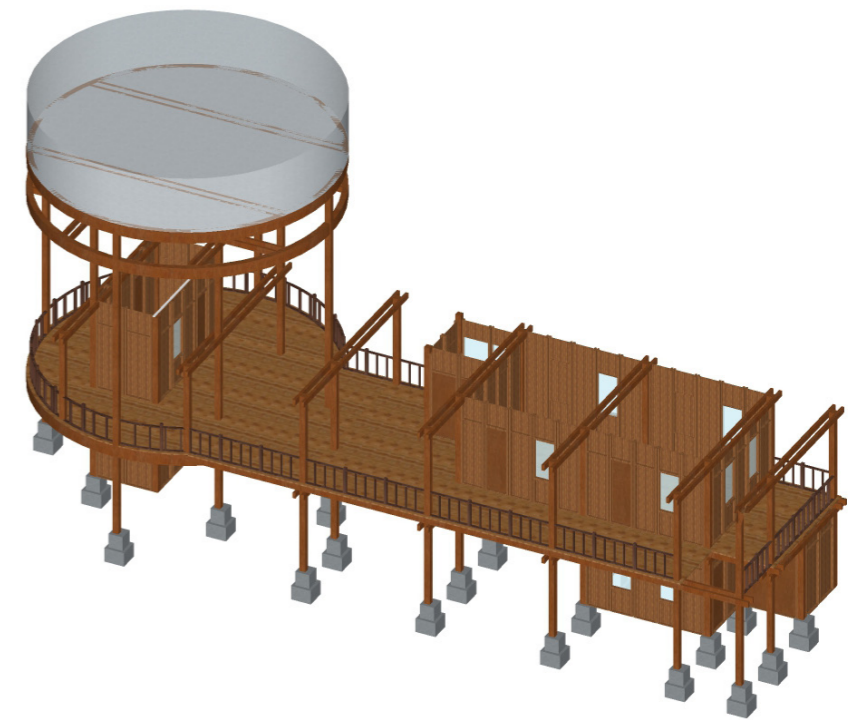
## Construction sequences



Secondary structure



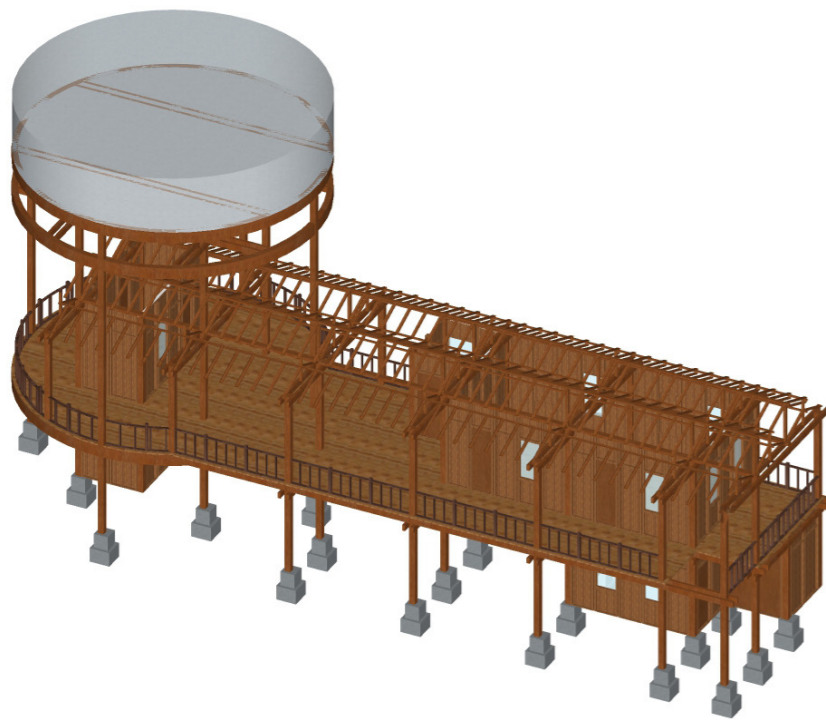
Wooden floor and supporting beams



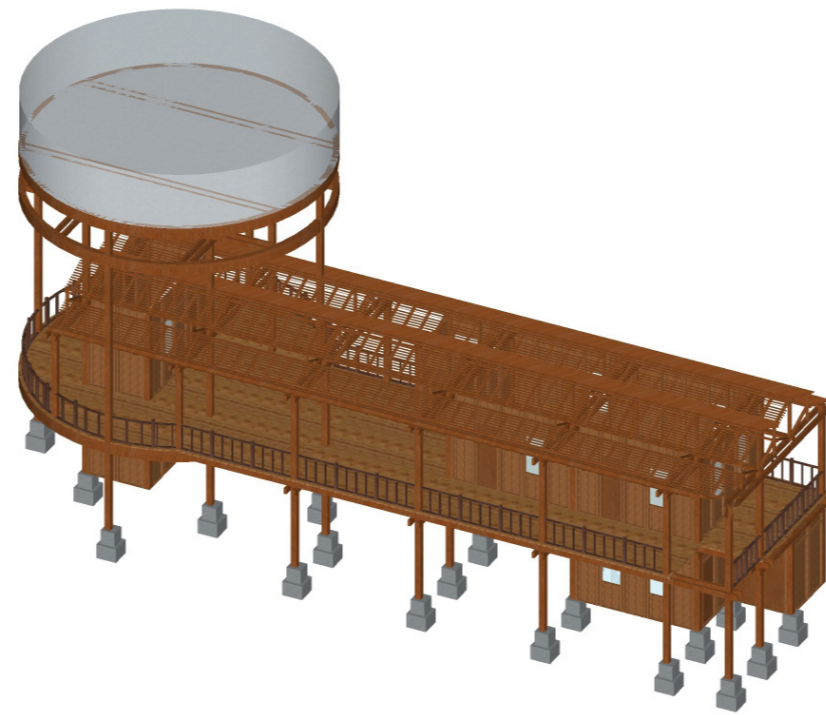
Fence and infill walls

# Building Technology

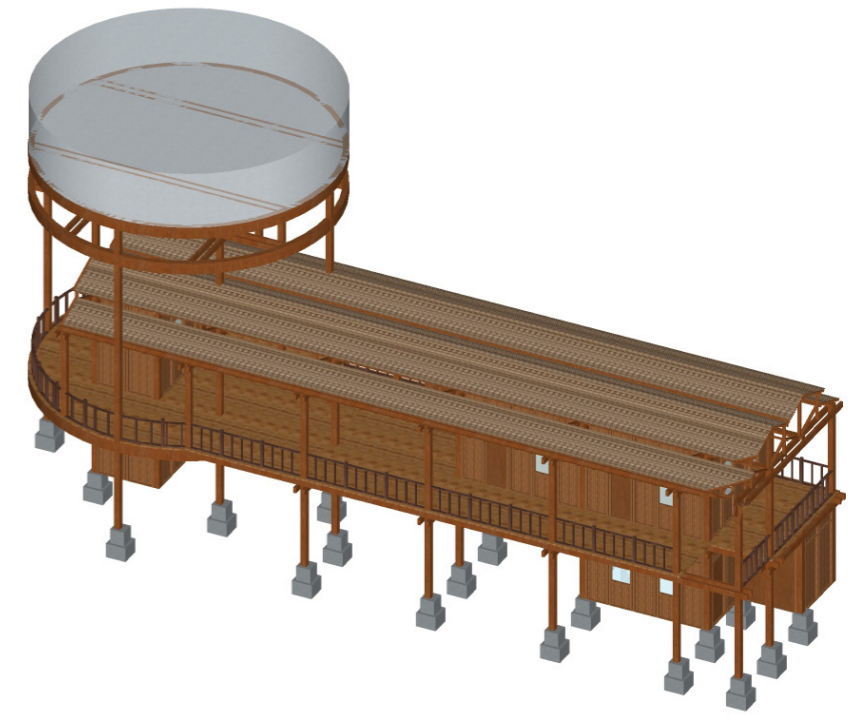
## Construction sequences



Roof truss and rafters



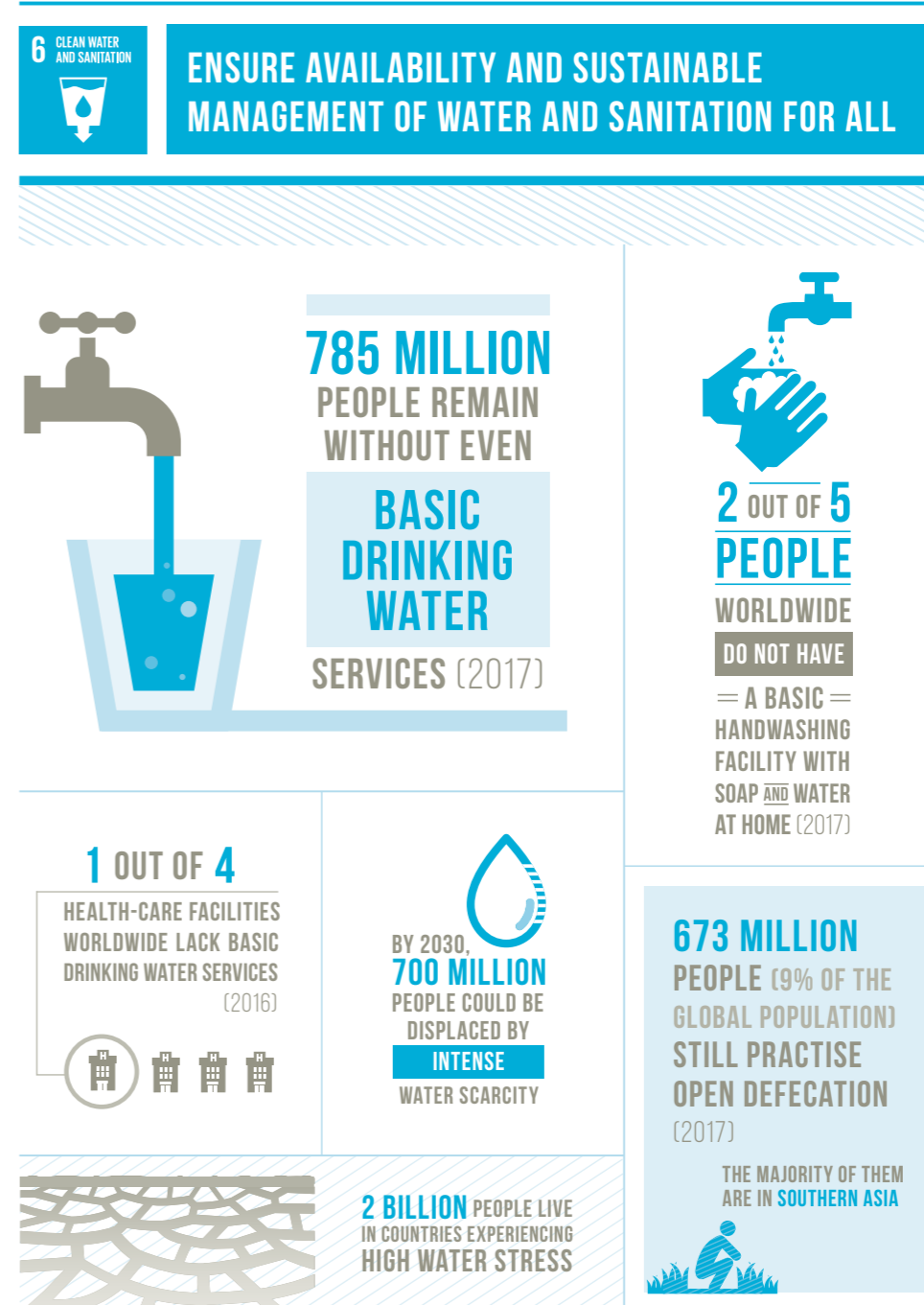
Roof purlins



Plywood plank and shingles

# A Global Issue

## UN 17 sustainable development goals





# Clean Water And Sanitation

## Goal 6 targets

- Home
- About ▾
- Campaigns ▾
- Goals ▾
- Take Action ▾
- Partnerships ▾
- News And Media ▾
- Learn More ▾



### Facts and figures

### Goal 6 targets

### Links

- 6.1** By 2030, achieve universal and equitable access to **safe and affordable drinking water** for all
- 6.2** By 2030, achieve access to adequate and equitable **sanitation and hygiene** for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
- 6.3** By 2030, **improve water quality** by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- 6.4** By 2030, substantially **increase water-use efficiency** across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- 6.5** By 2030, **implement integrated water resources management** at all levels, including through transboundary cooperation as appropriate
- 6.6** By 2020, **protect and restore water-related ecosystems**, including mountains, forests, wetlands, rivers, aquifers and lakes
- 6.A** By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including **water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies**
- 6.B** Support and strengthen **the participation of local communities** in improving water and sanitation management

Safe and affordable drinking water

Sanitation and hygiene

Improve water quality

Increase water-use efficiency

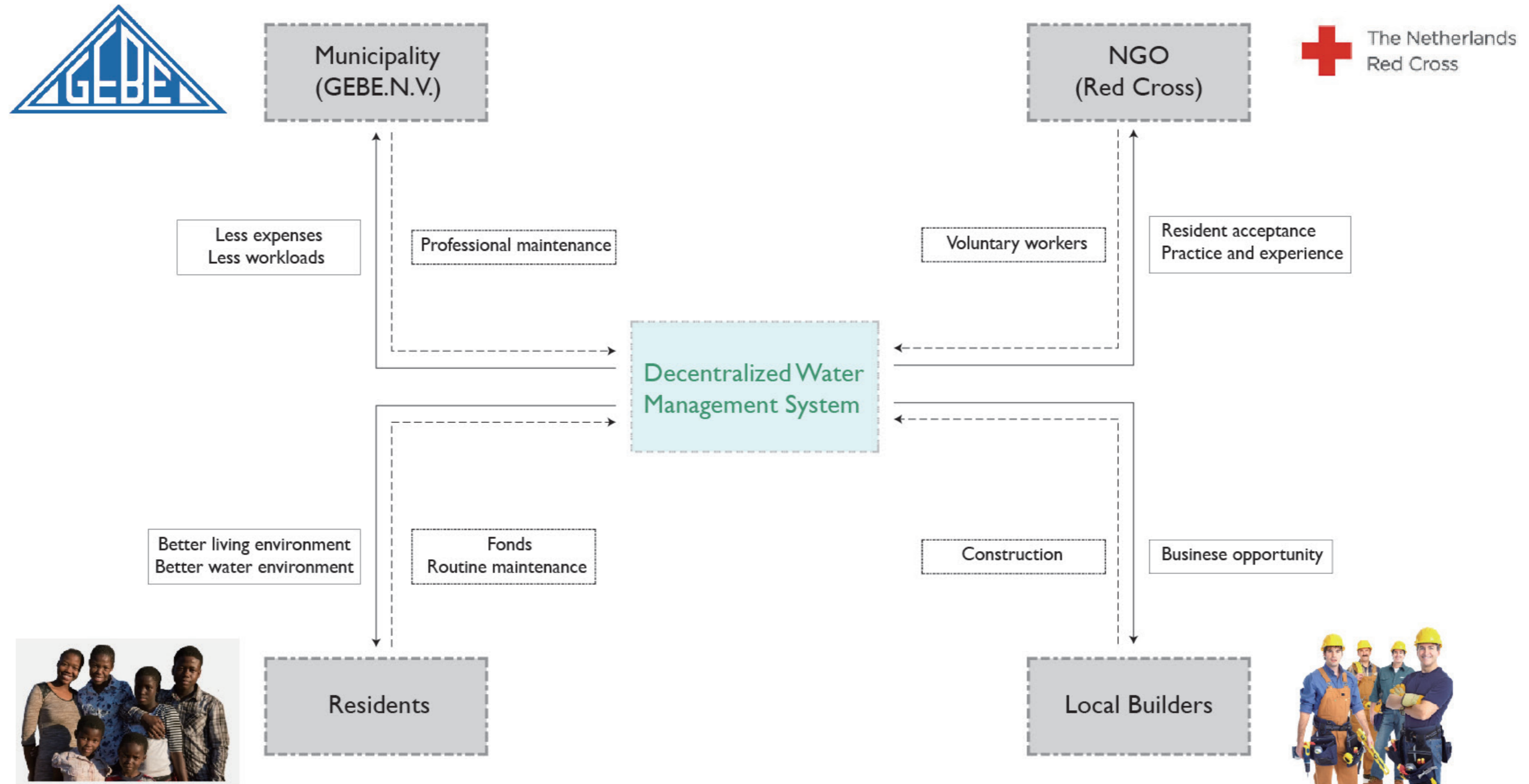
Implement integrated water resources management

Protect and restore water-related ecosystems

Water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

The participation of local communities

# Stakeholders



# Neighborhood Development

Phase I-2



1-2 Months

- + Government cleans and re-plans existing green spaces
- + Resident fundraising for primary facilities

# Neighborhood Development

Phase 3-4



6-8 Months

- + Water collection facilities are completed first (community water tower//household water tanks).
- + Construction of the planned green space begins.

# Neighborhood Development

Phase 5-6



## 10-12 Months

- + Construction of all facilities is completed and the water system is normally used.
- + Planned green space are put in use (community parks and playgrounds).

# Neighborhood Development

Phase I-2



1-1.5 Years

- + The construction of the basic building (Node) is completed, restaurants and shops are opened, and the common room in the community is used.
- + Residents saved a lot of water bills, and some residents were maintained by training and learning systems.

# Neighborhood Development

Phase I-2



2 Years

+ Residents' own businesses and wetland crops began to make profit.

+ Trees increased and living environment improved.

# Neighborhood Development

Phase I-2

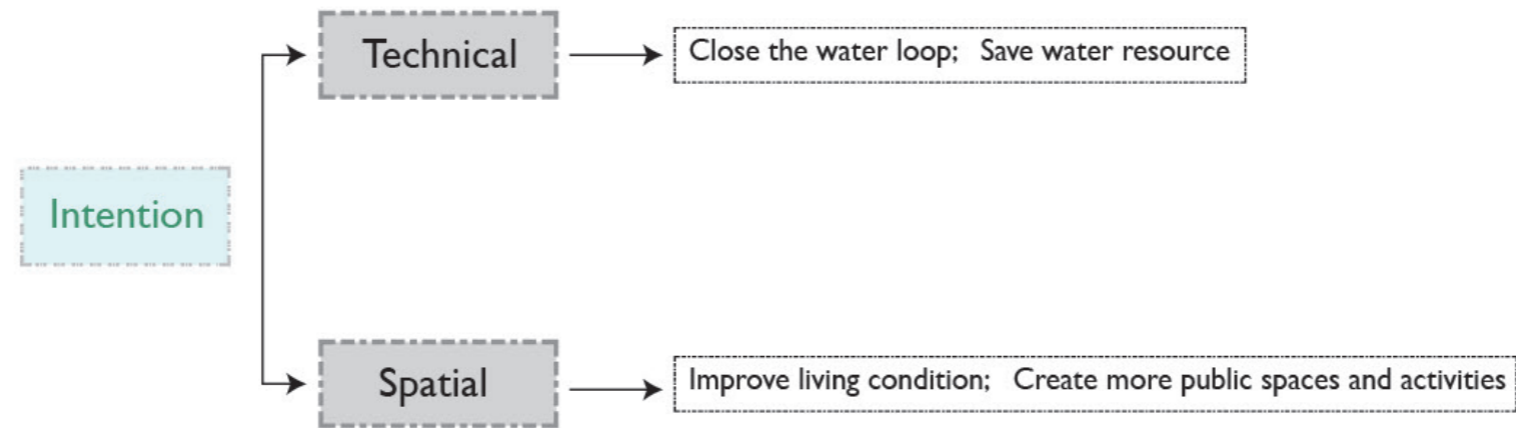


2.5-3 Years

- + Residents chose to build Connections to create more public space.
- + People accept and like this system which is popular.



# Suitable Context



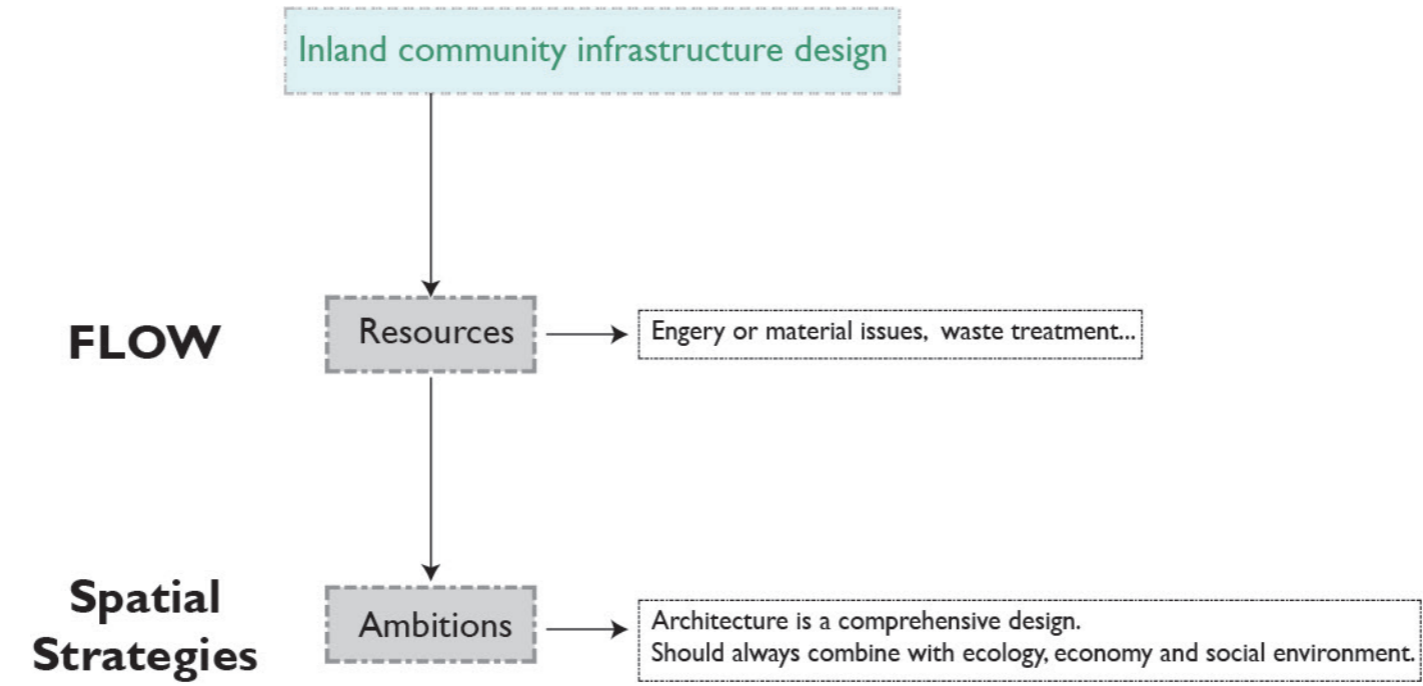
Improve water-use condition  
(Especially for water shortage areas)



Revitalise the community

# Other Community

Different residents and demand



# Other Context

Developing countries

Developing Regions

Housing



Infrastructure



People can easily learn to build their house but they will not to build the infrastructure.

Urban Construction



Water

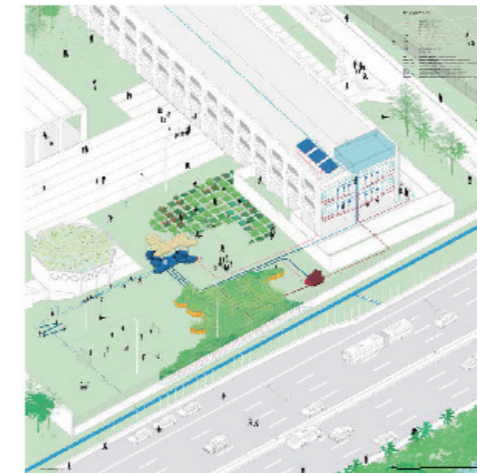


Energy



Vegetation

Decentralized water management method



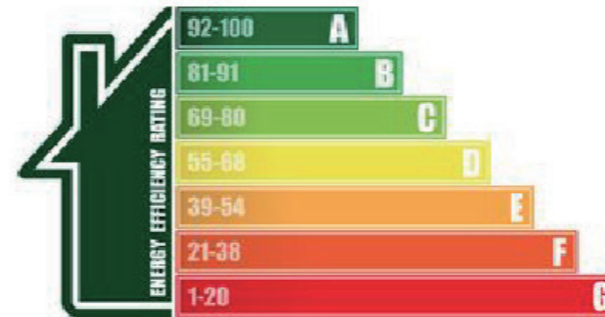
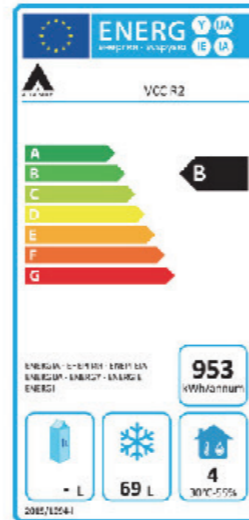
A school which is capable of treating sewage for the whole community.

# Other Context

Developed regions

Developed Regions

Housing  
Water label



Each house has the ability to treat wastewater independently.

Self-managed  
public space



Clarify their respective responsibilities in management and maintenance.

Self-managing and planning functions to public spaces with the help of municipality.



**THANK YOU!**

**P5 PRESENTATION**

**A Cluster Scale Decentralized Water Management System in Sint Maarten**

Hongjie Huang  
24-01-2020