Floating Community

Designing a floating module for a resilient community in Manila, Phillipines

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Megatrends

The increasing frequency of climatic disasters, especially **water related**, coupled with the megatrend of **urbanization**, leads to a sense of urgency to offer long-term resiliant solutions in the urban context.

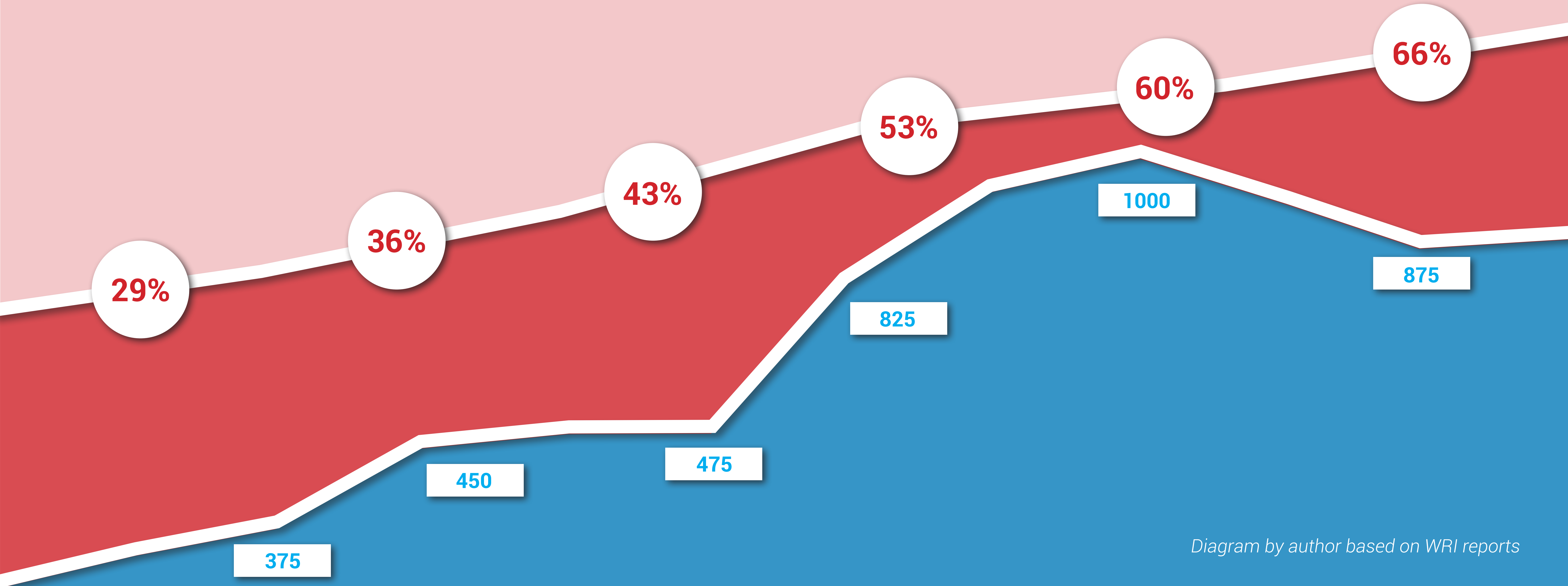
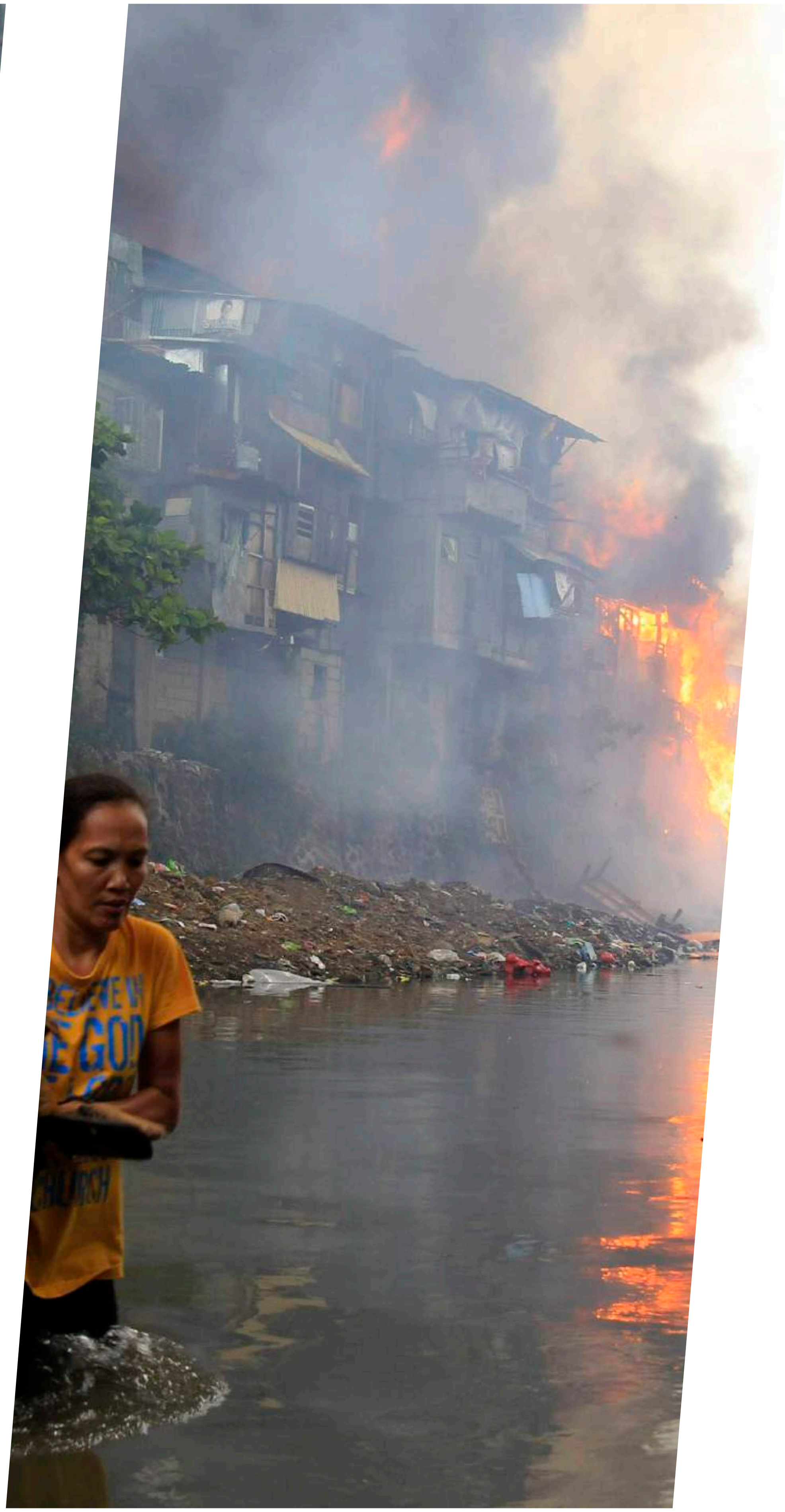


Diagram by author based on WRI reports



Cycle of Vulnerability

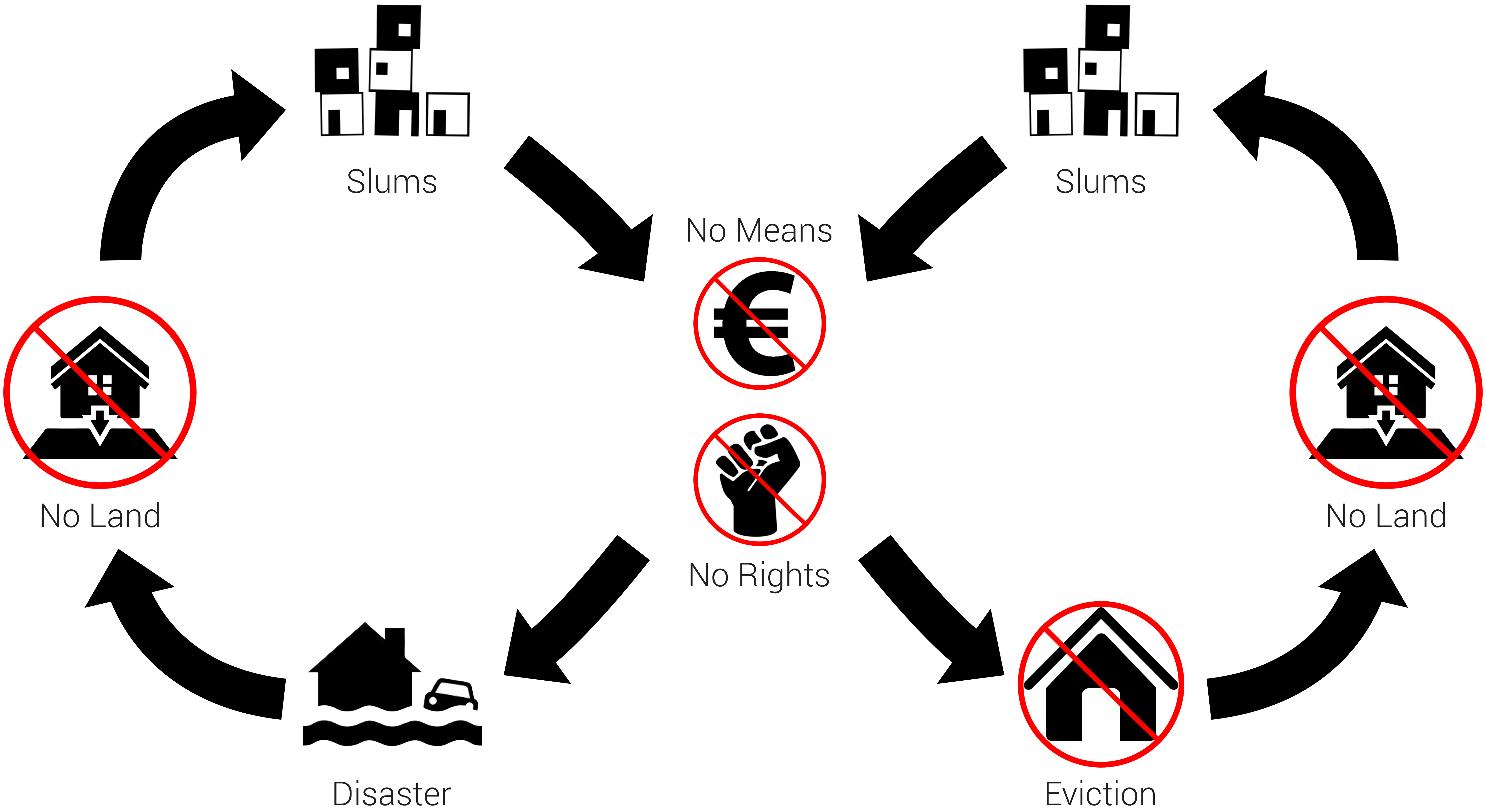
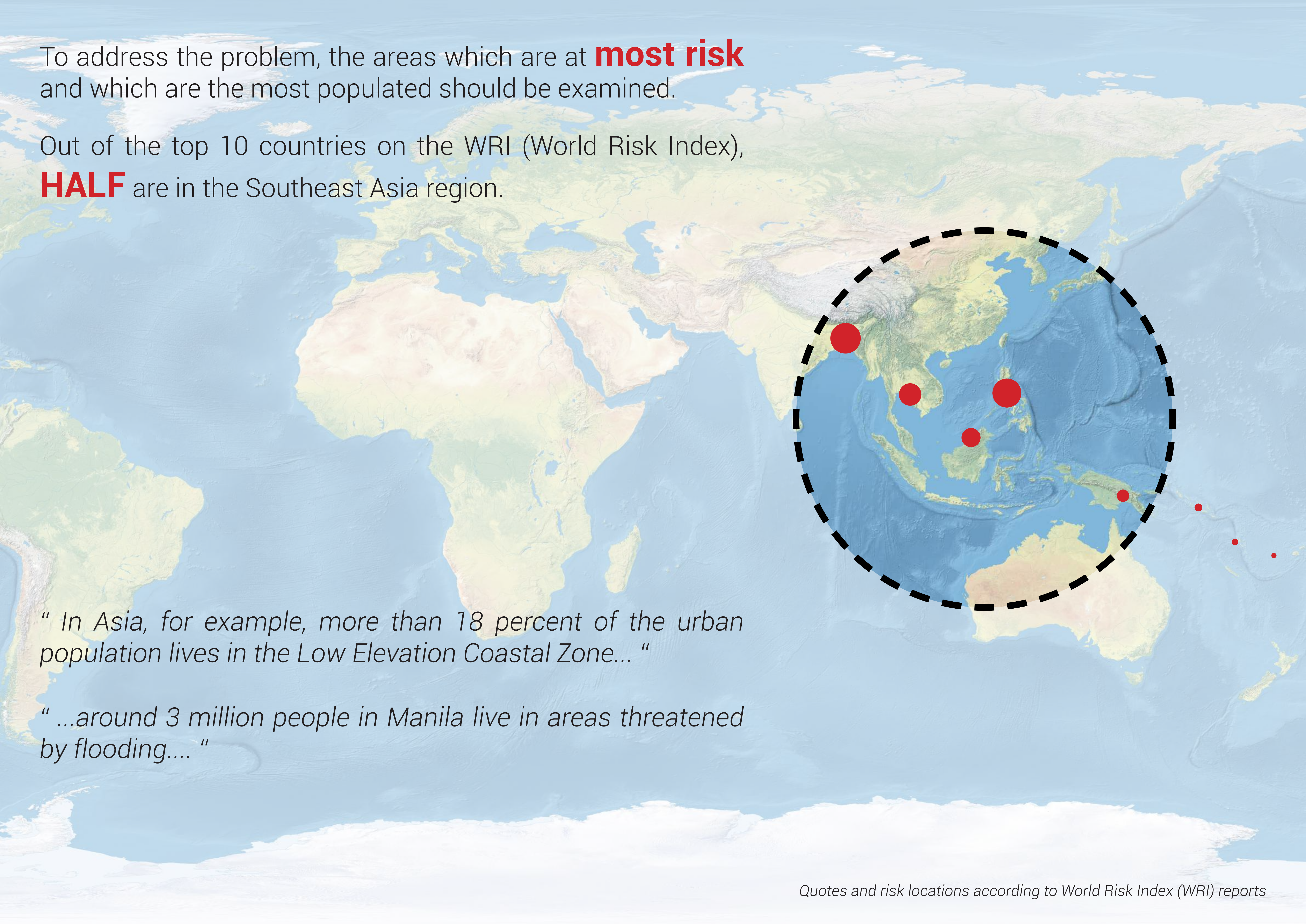


Diagram by author



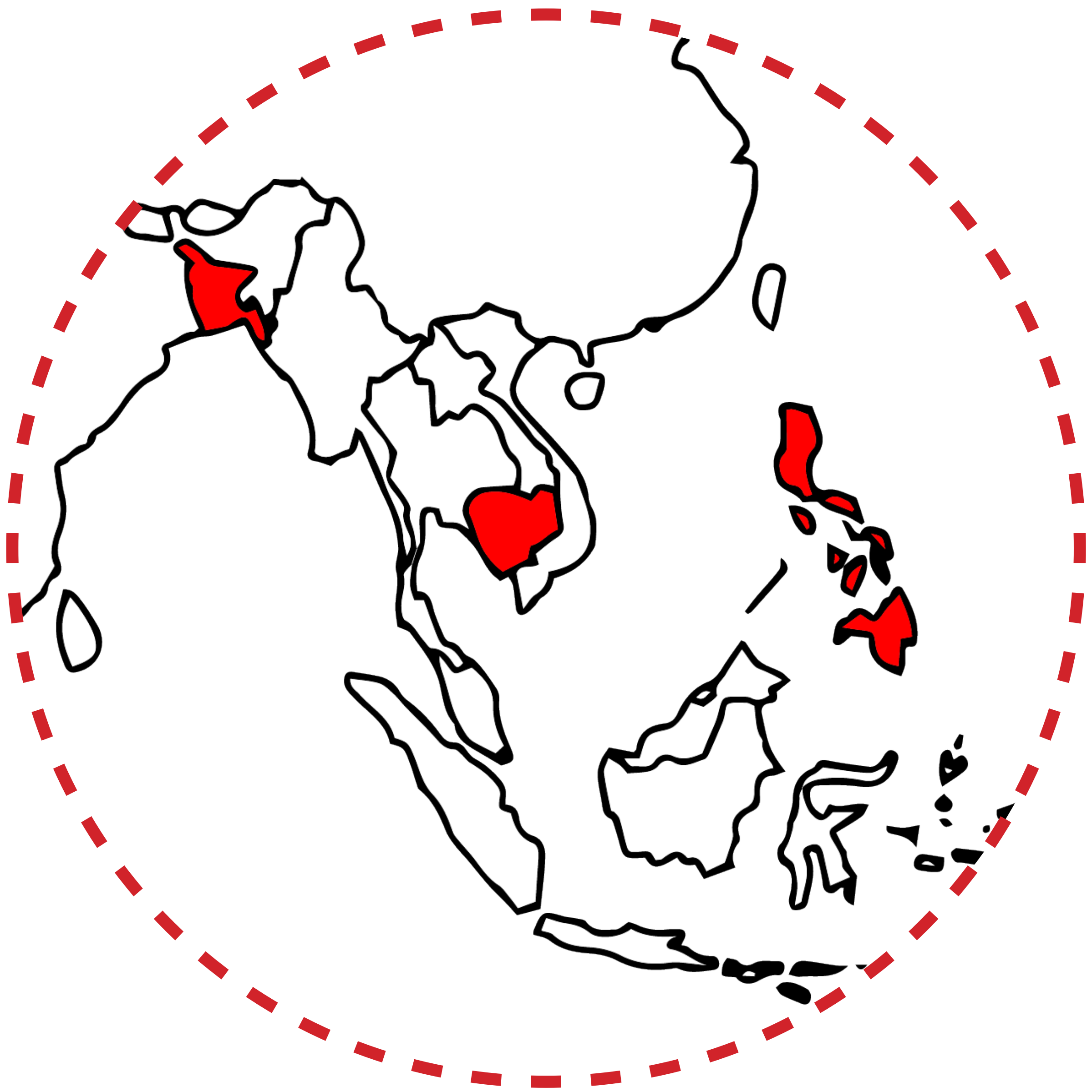
To address the problem, the areas which are at **most risk** and which are the most populated should be examined.

Out of the top 10 countries on the WRI (World Risk Index), **HALF** are in the Southeast Asia region.

" In Asia, for example, more than 18 percent of the urban population lives in the Low Elevation Coastal Zone... "

" ...around 3 million people in Manila live in areas threatened by flooding.... "

Quotes and risk locations according to World Risk Index (WRI) reports



World Risk Index (WRI) top 10:

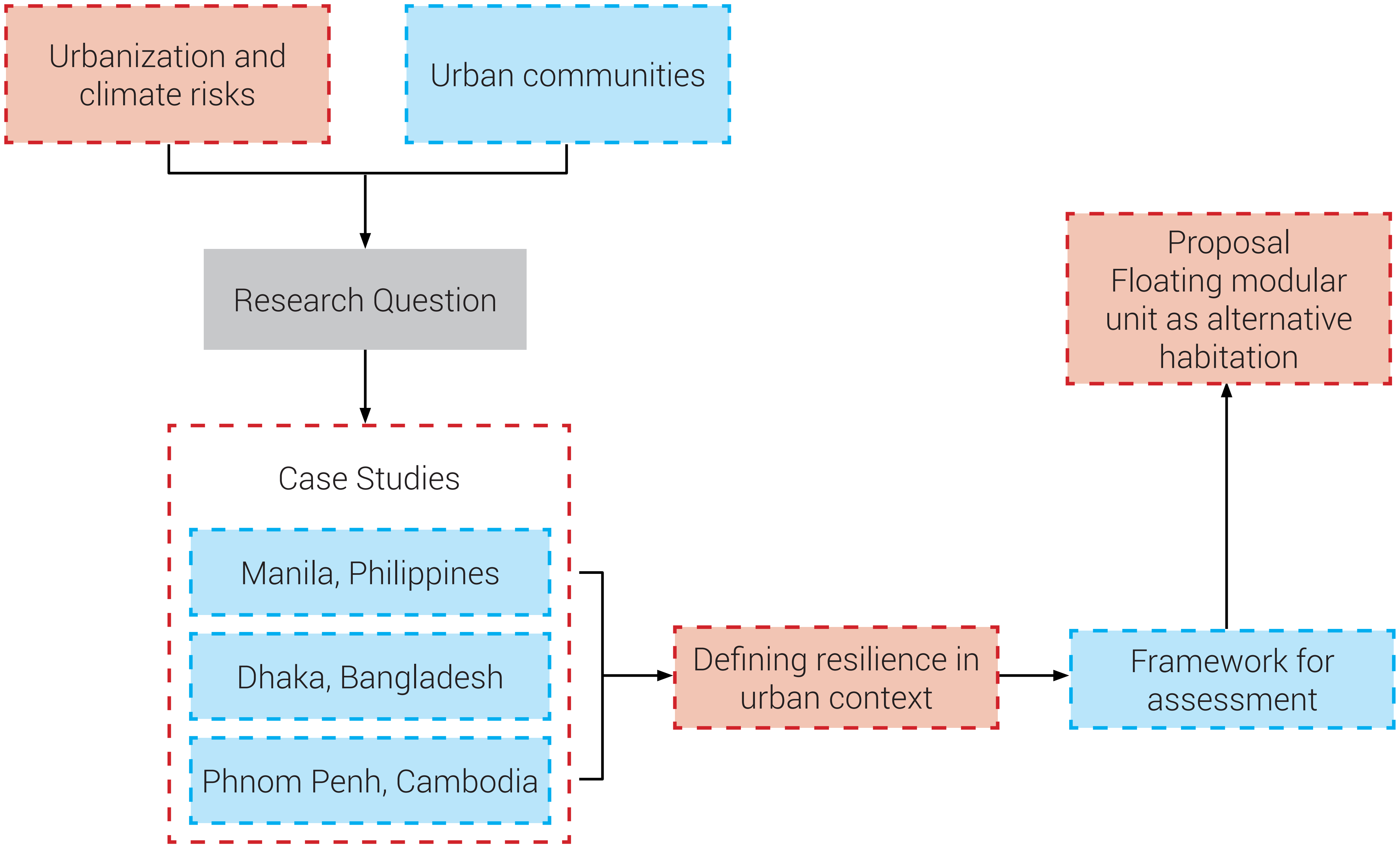
Country:	% risk:
Vanuatu	36.28
Tonga	29.33
Philippines	26.70
Guatemala	19.88
Bangladesh	19.17
Solomon Islands	19.14
Brunei Darussalam	17.00
Costa Rica	17.00
Cambodia	16.58
Papua New Guinea	16.43

“ [...] urbanization pressure leads to urban growth rates that exceed the capacity of government authorities to adequately develop and operate urban infrastructure e.g. for healthcare, flood protection, storm evacuation... “

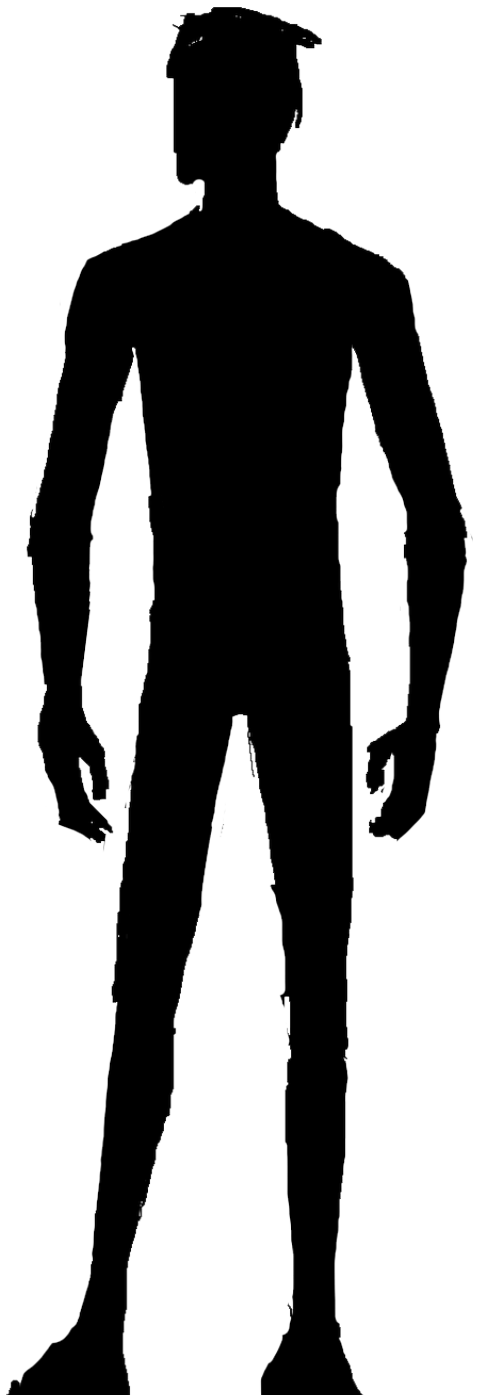
World Risk Index Report 2014 - City as a Risk Area

Research process

How can sustainable interventions in **dense coastal vulnerable communities** help improve urban and environmental **resilience**?



Informal housing inhabitants



Age: 28

Previous Occupation: Rice farmer

Current occupation: Rubbish collector

Highest education: none

Family size: 6

Housing location: Canal slum

House size: 22 m2

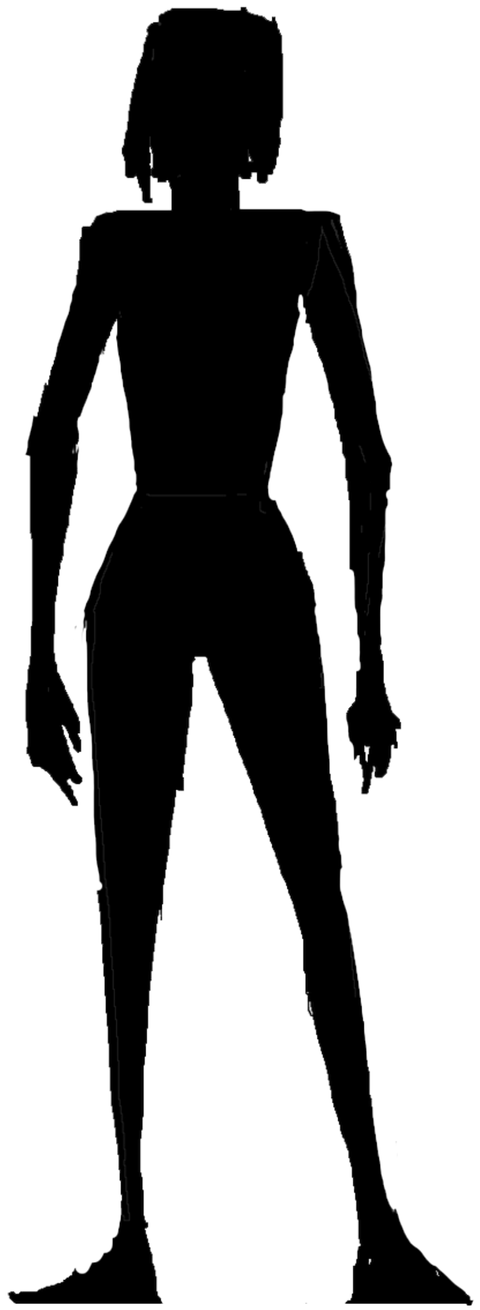
Shared with: 6

Running water: no

Toilet: no

Stove: no

Flooring: yes



Age: 23

Previous Occupation: Midwife

Current occupation: Food vendor

Highest education: secondary

Family size: 5

Housing location: Coast slum

House size: 14 m2

Shared with: 5

Running water: yes

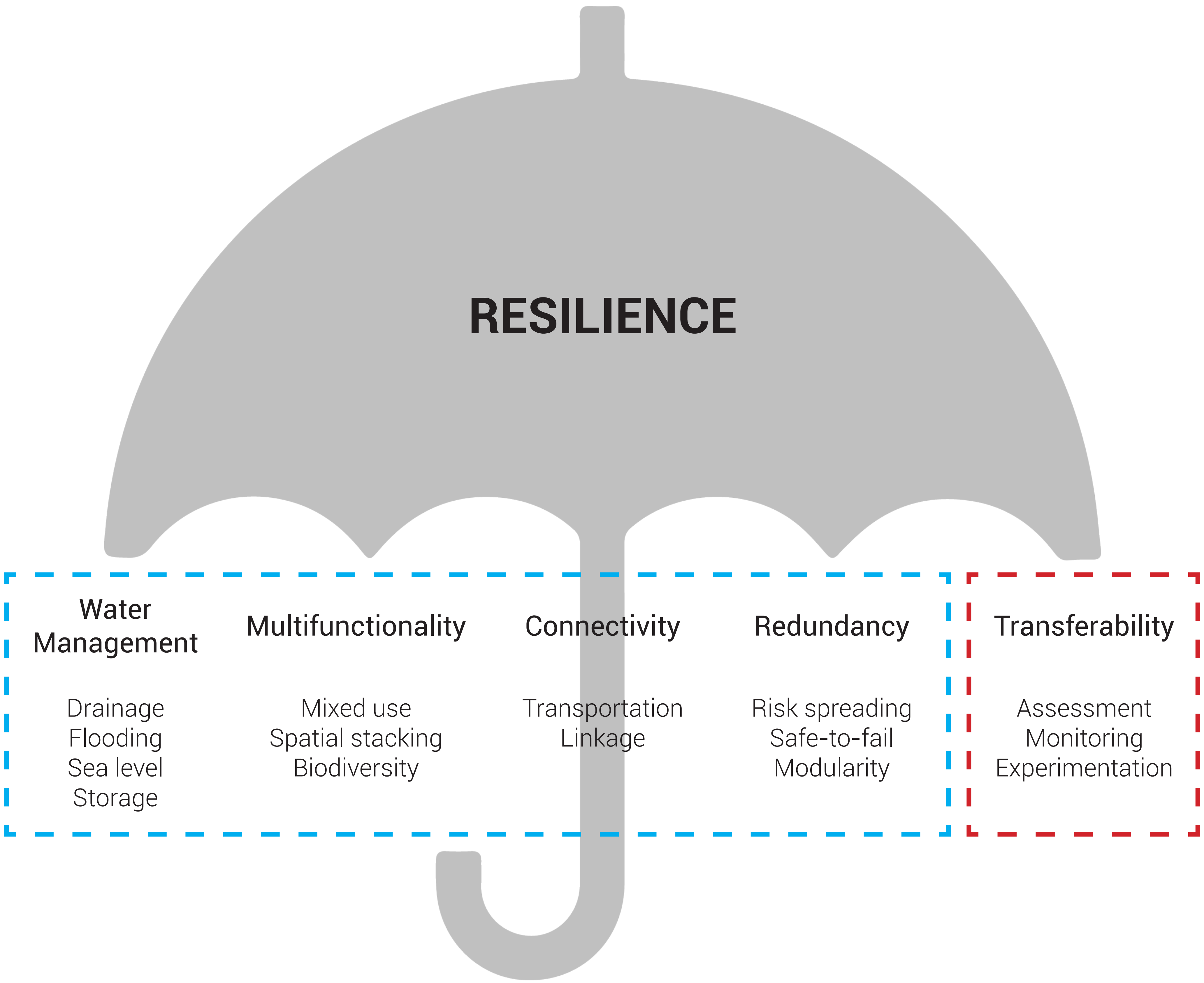
Toilet: yes

Stove: no

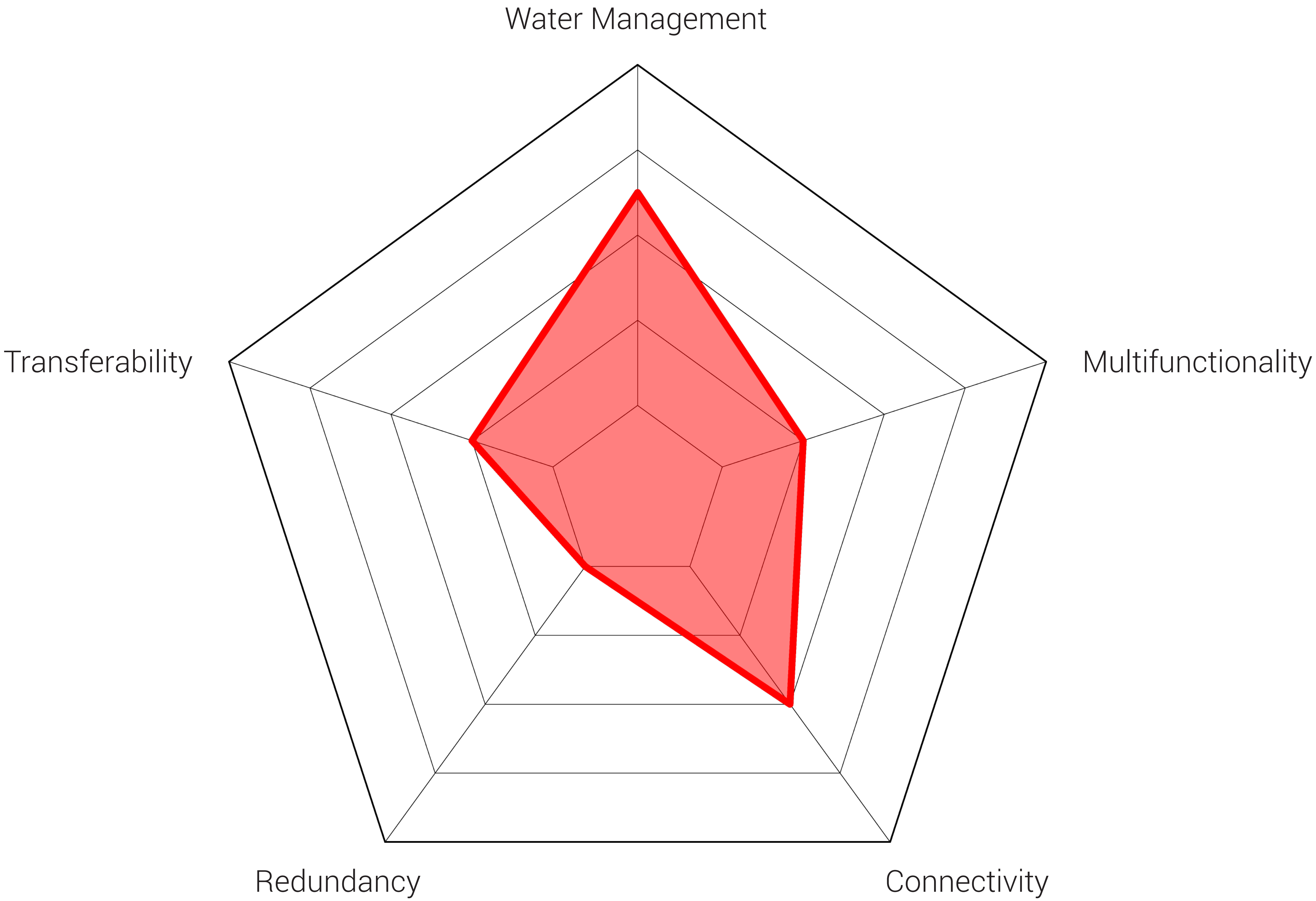
Flooring: yes

Based on data from the Philippine Institute for Development Studies, Asian Development Bank 2000 and 2009 reports

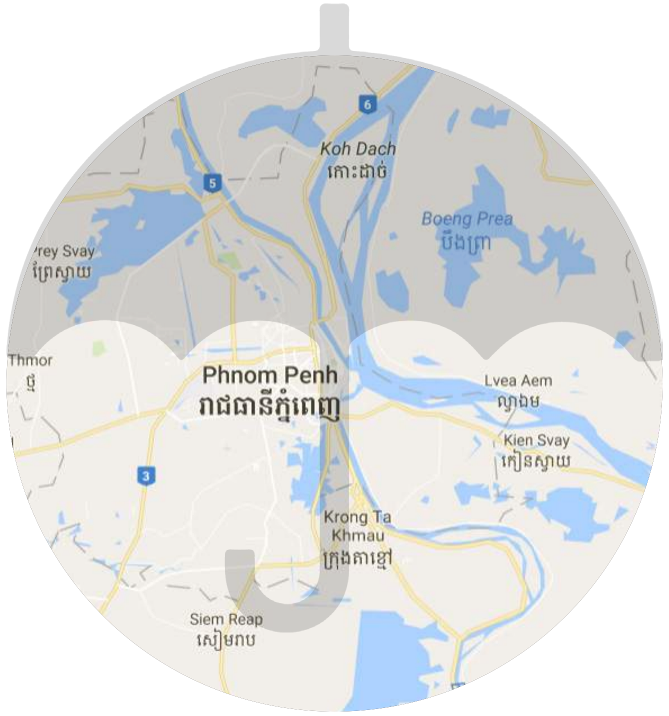
Adaptive design for urban risk



Assessment of Resilience



Phnom Penh, Cambodia

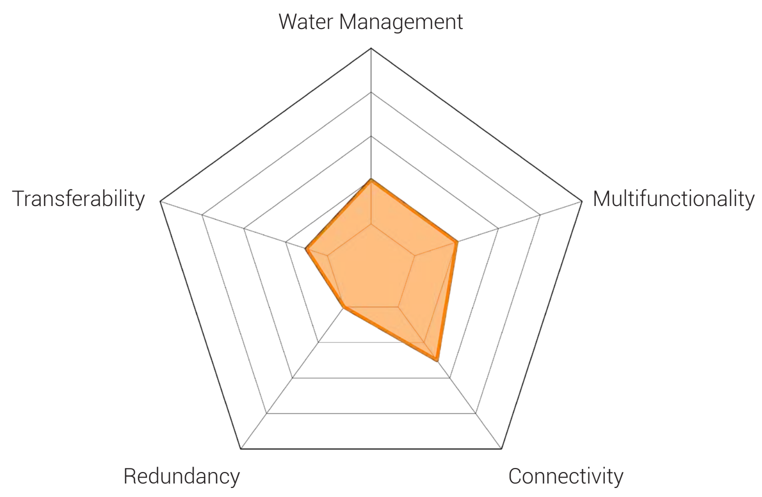


ACTIONS

No effective action has been implemented or properly organized to deal with flood-risk and climate change in the Phnom Penh urban context.

- Ineffective or partially successful drainage improvement projects by Japan International Cooperation Agency (JICA) since the early 2000's totalling € 300 million.

- Habitat For Humanity (HFH) conducted 600 house improvements since 2004.



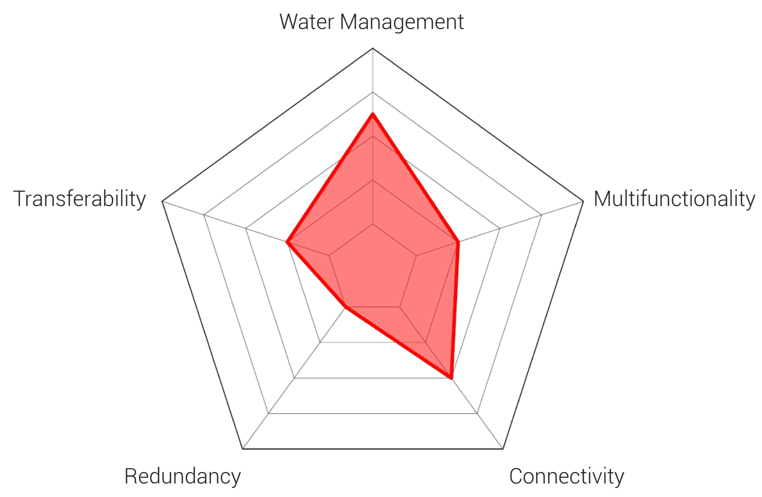
Manila, Philippines

ACTIONS

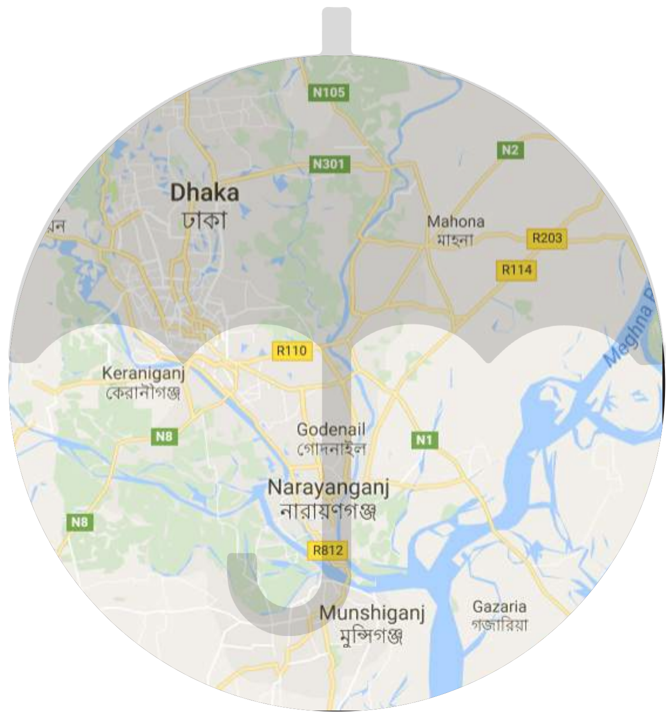
- 2011 declogging of 39,436 linear meters of waterways to improve flood drainage.

- Relocation project for informal settlers for a 5-year plan costing € 1 billion. About 10% were relocated.

- Long term (until 2035) master plan of dams and river improvements at cost of € 6.5 Billion.



Dhaka, Bangladesh

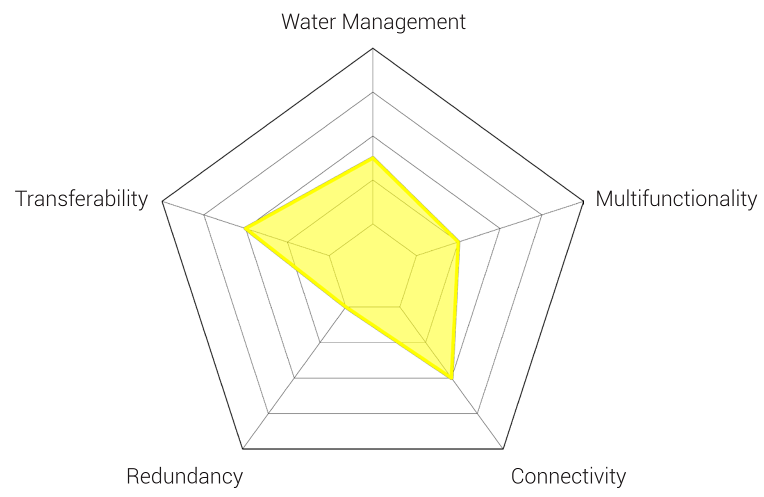


ACTIONS

- Failed "Action Plan" of 1990 to embank rivers in Bangladesh. Cost is € 140 Billion.

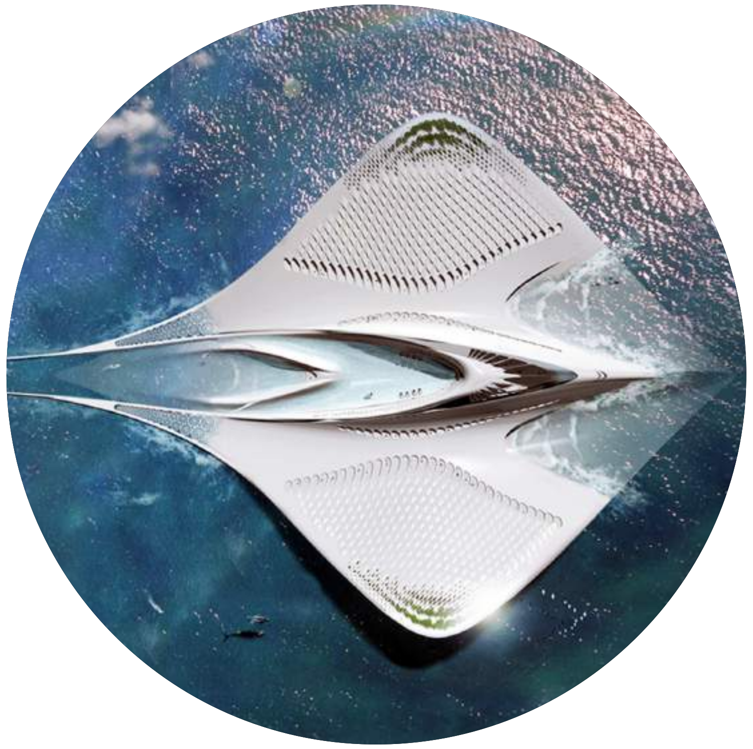
- United Nations Development Programme's Early Recovery Facility (ERF) innovation of dismantable housing units from wood and metal sheets for relocation during disaster and flooding. 200 units so far.

- ERF and UNDP program to raise housing above flood levels. 2,250 houses raised so far.



“Urban Land that does not Flood”

NOT utopic

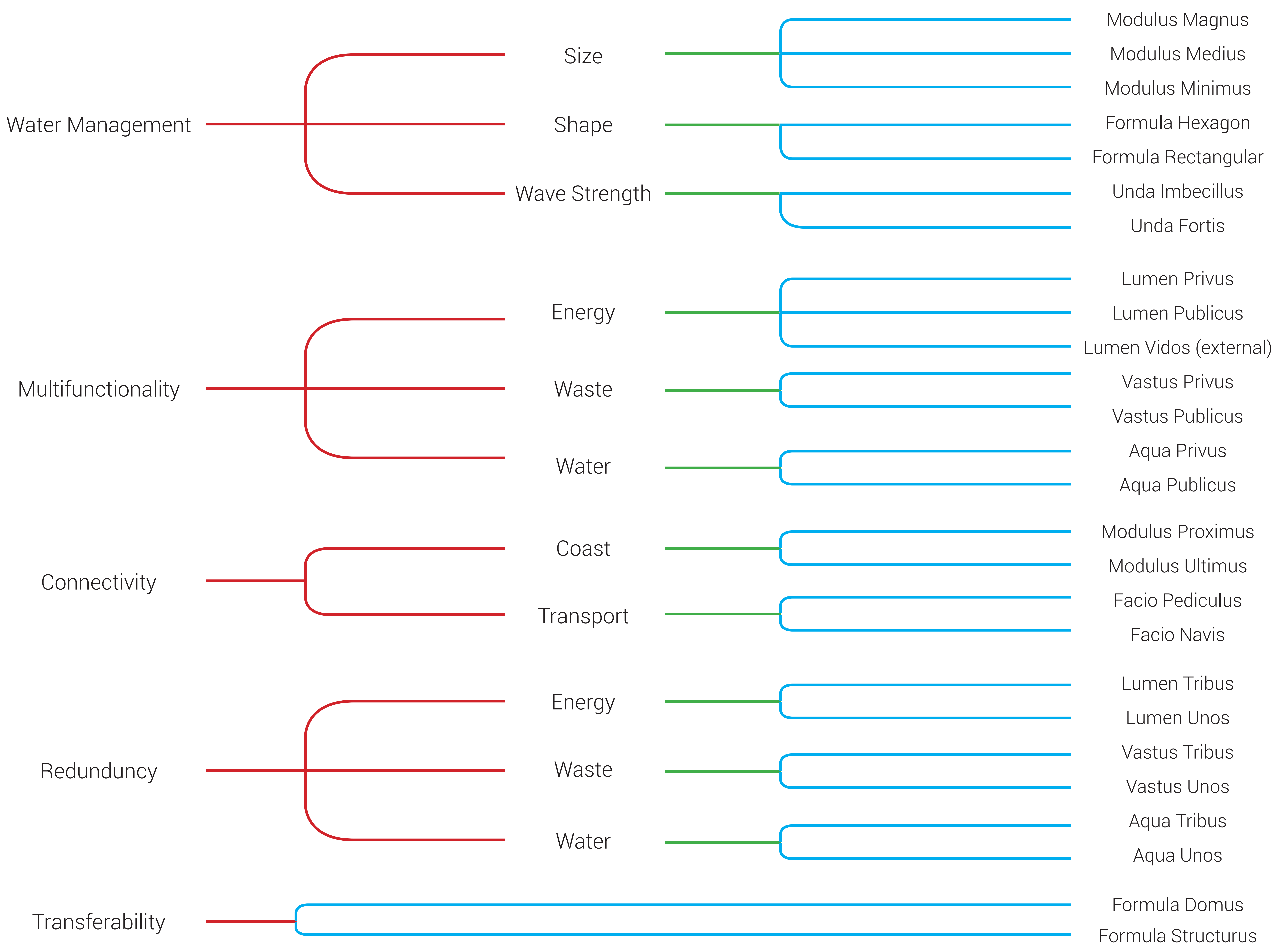


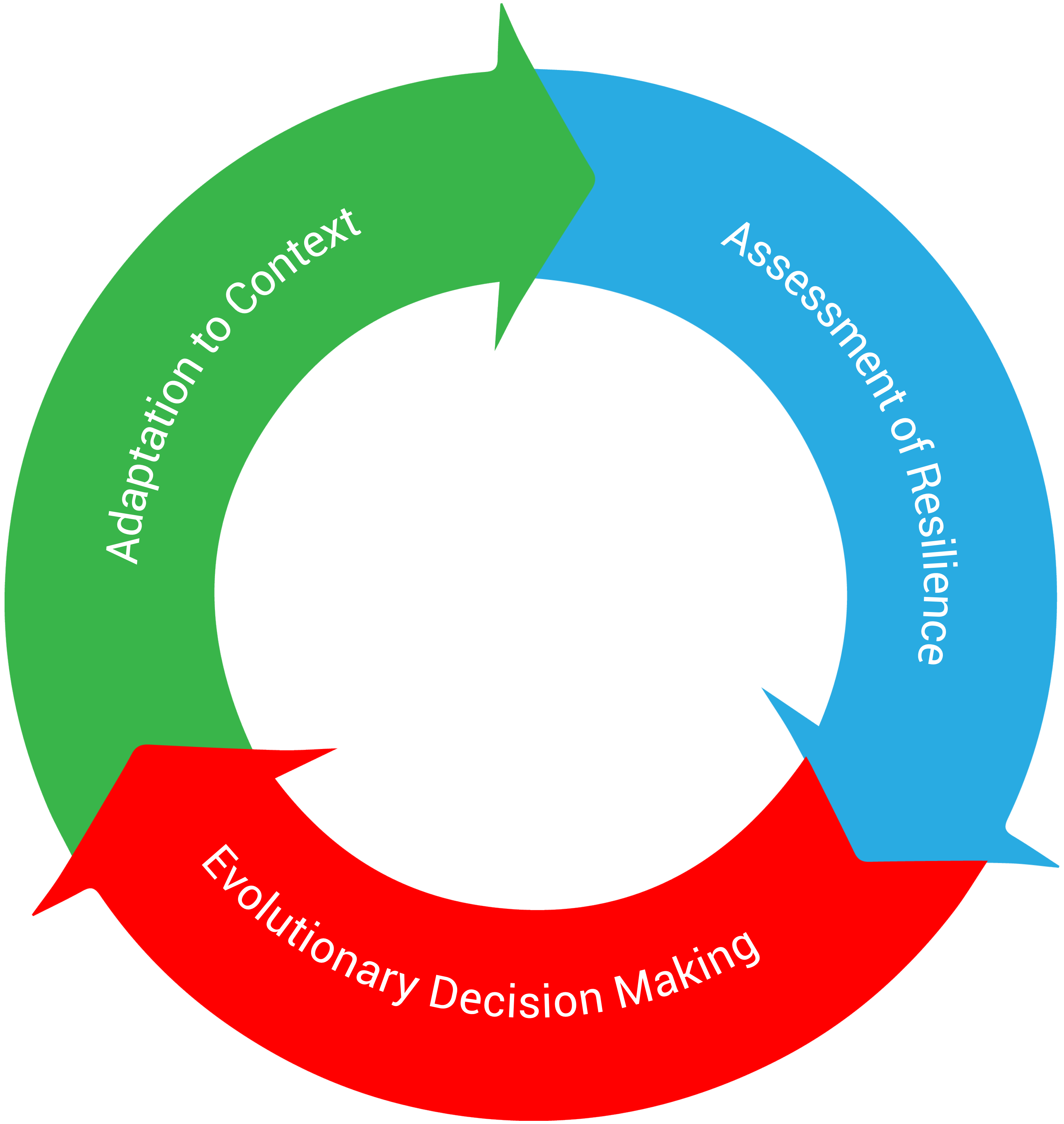
NOT isolated

NOT expensive

NOT enormous

Evolutionary Adaptivity




Adaptation to Context
Assessment of Resilience
Evolutionary Decision Making

Site Selection

Manila, Philippines

One of the **major metropolis** in Southeast Asia, Manila has a water network which includes both **coast and river**, which offers opportunities to analyze and address the needs of vulnerable urban populations from multiple aspects and can inform future contexts.

Manila, Philippines

Avg. elevation - 16m

Metropolitan population
12,877,253

Density
42,000 / km^2 (1st)

Poor population
4 million

Tropical region

High humidity

24 - 32 °C

Comfort temperature
10% too hot
3% too cold

July - October

5-10 storms / year

30% of rainfall

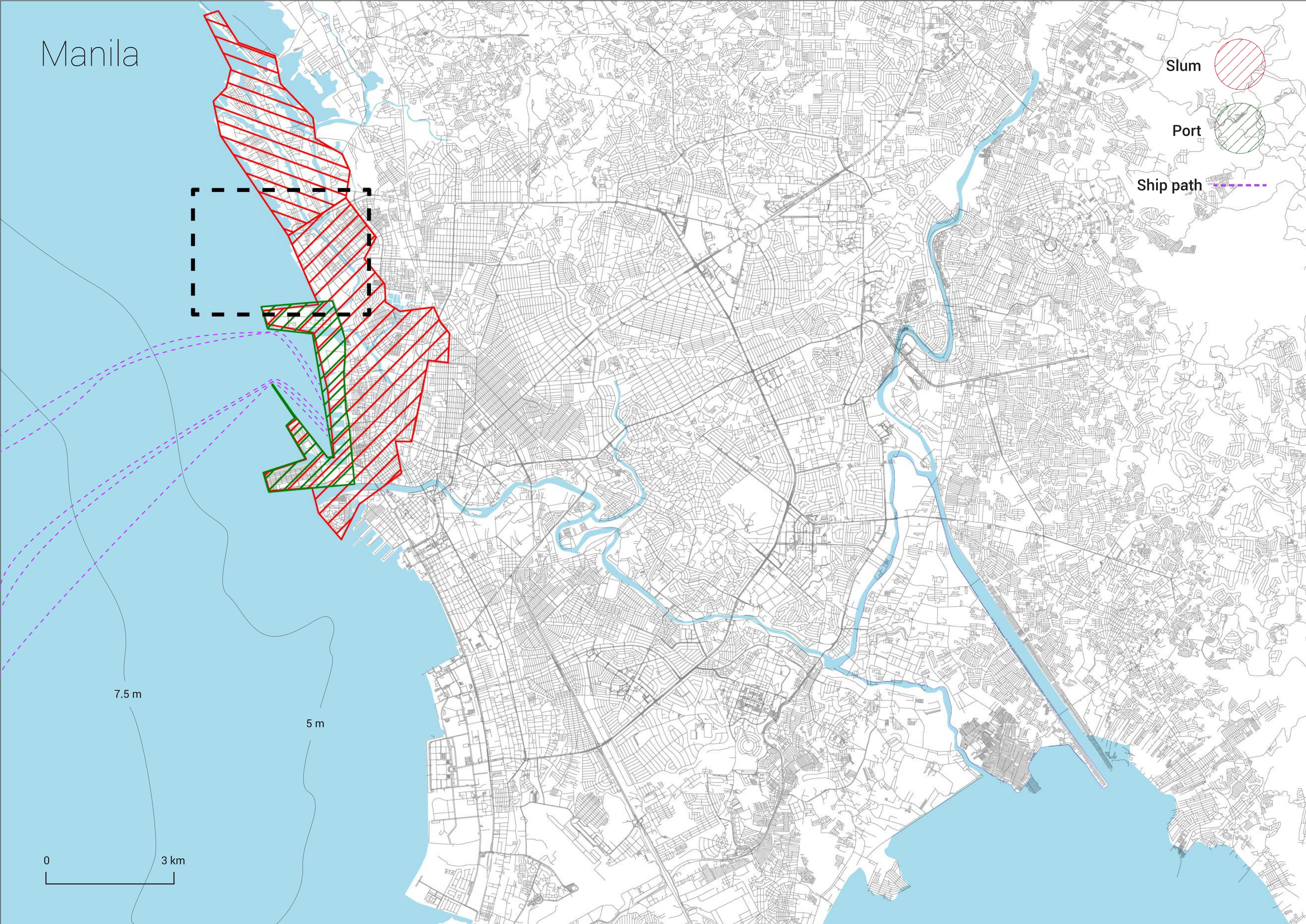
Typhoon Haiyan
November 2013
6,300 dead
2 Billion USD

Approach to existing urban fabric

Rural populations **in need** of land arrive to the city in search of new economic opportunities.

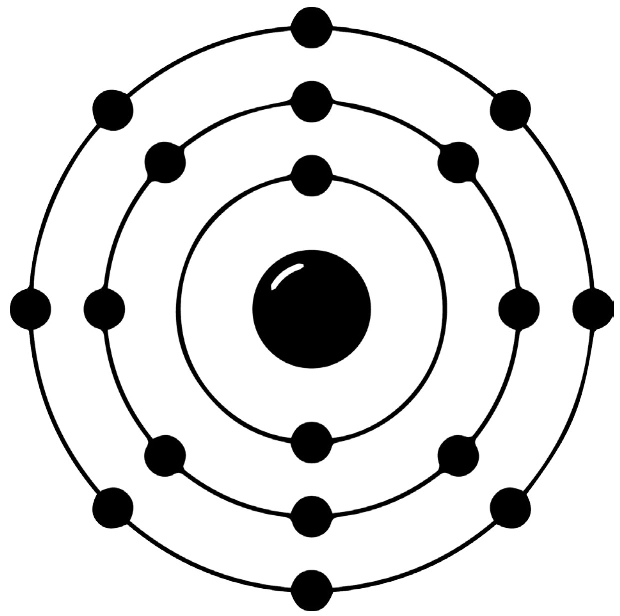
They would benefit from a location only in the **proximity** of the existing city center.

Therefore the module is not created as a separate entity but **new land in connection to the existing fabric.**

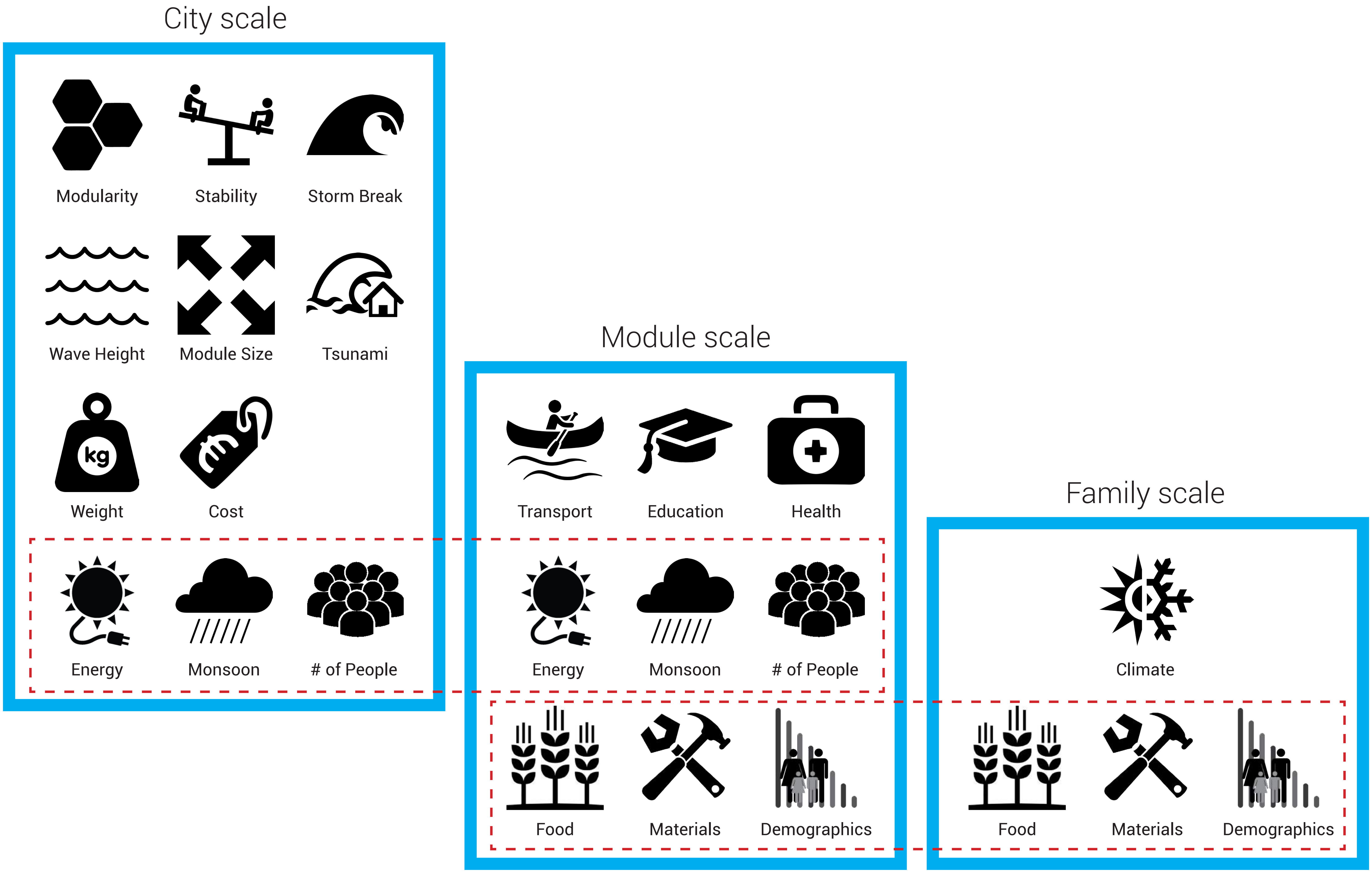

Manila
Slum
Port
Ship path
7.5 m
5 m
0
3 km

Navotas Slum

Elements of the Design



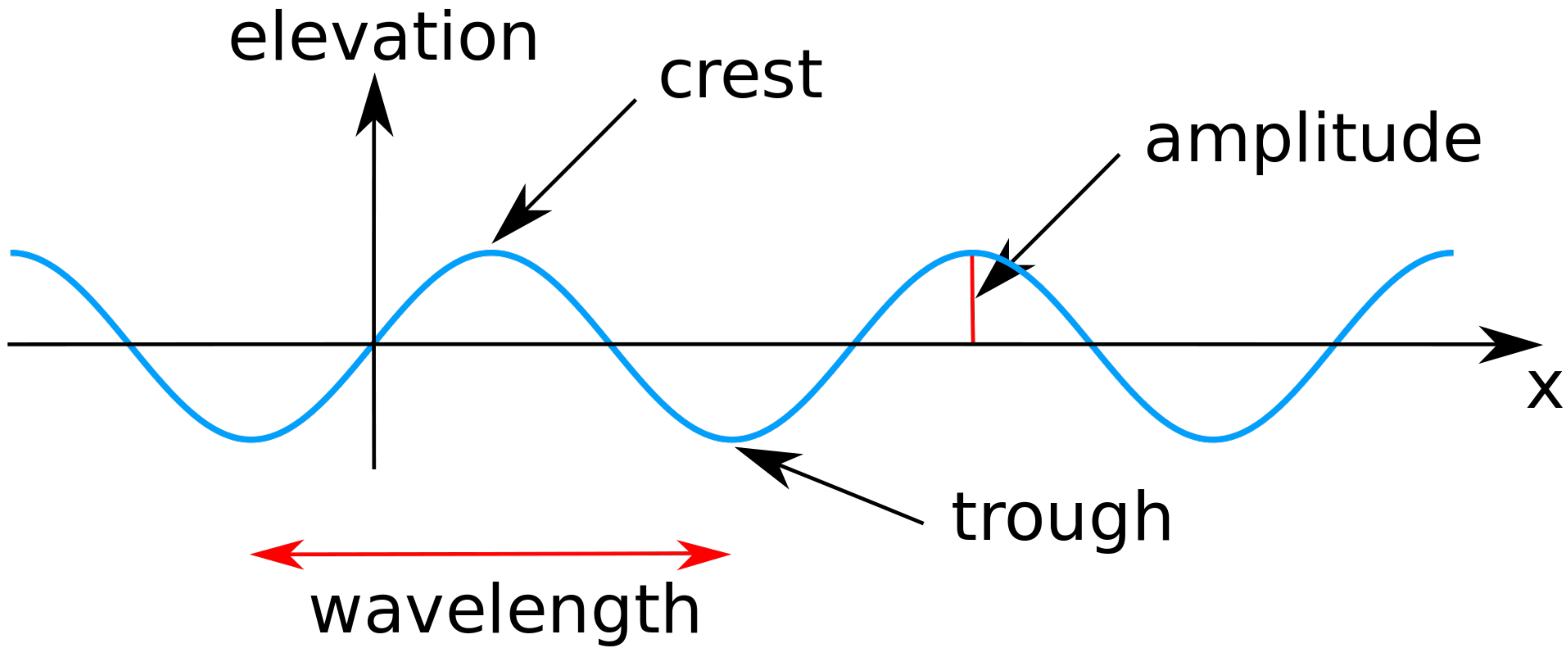
Elements of Value



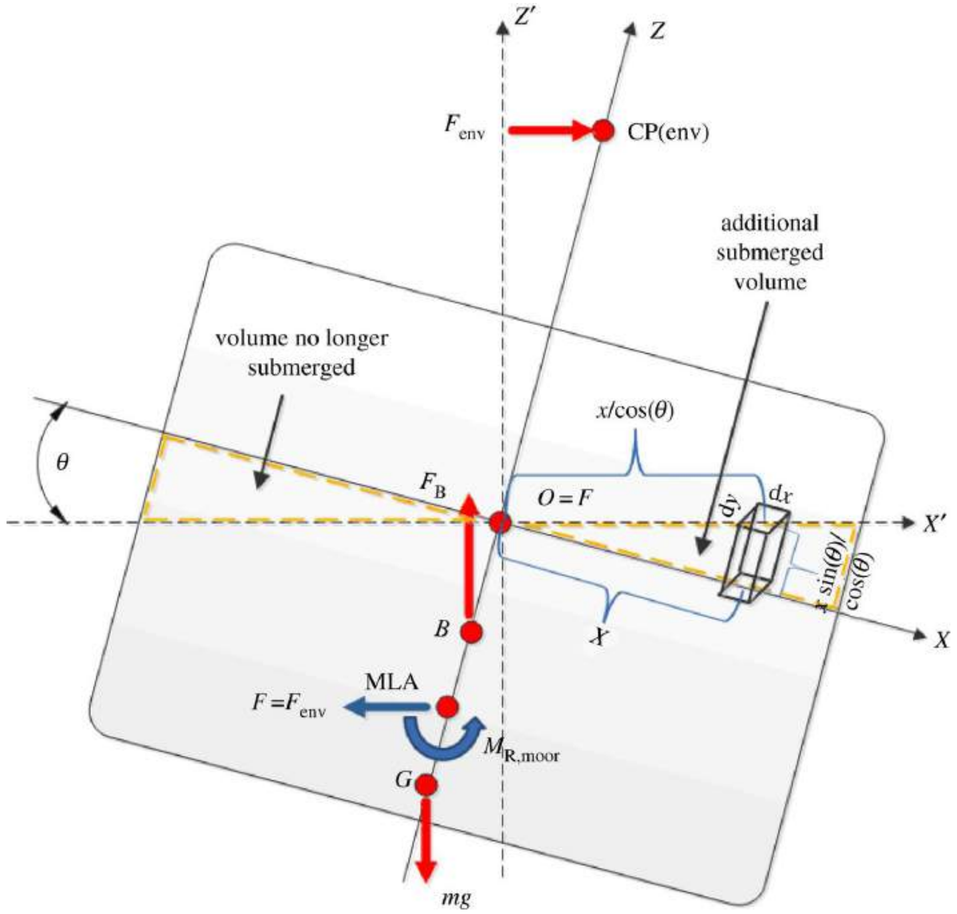
How will it float?

If the structure is **more than twice the wavelength** in extent, its response will tend to zero.

- Seasteading engineeing report (2011)



A platform with very high width to depth ratio will have a very large **metacentric height**, adding to its stability.



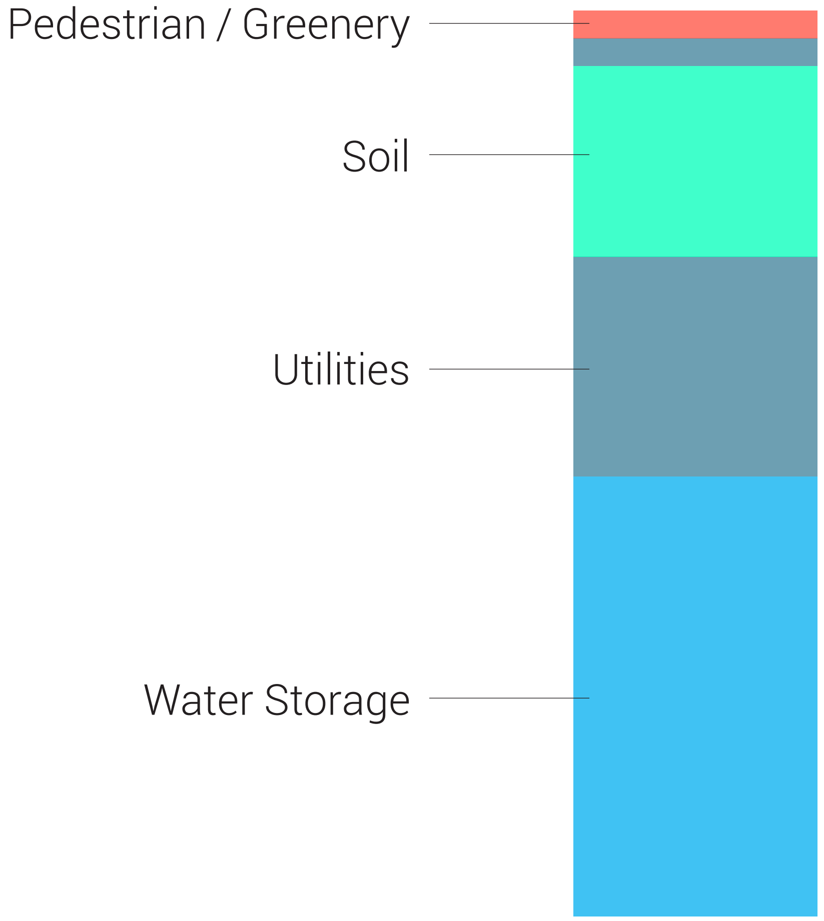
Modularity = Value

Multifunctionality

Risk-spreading

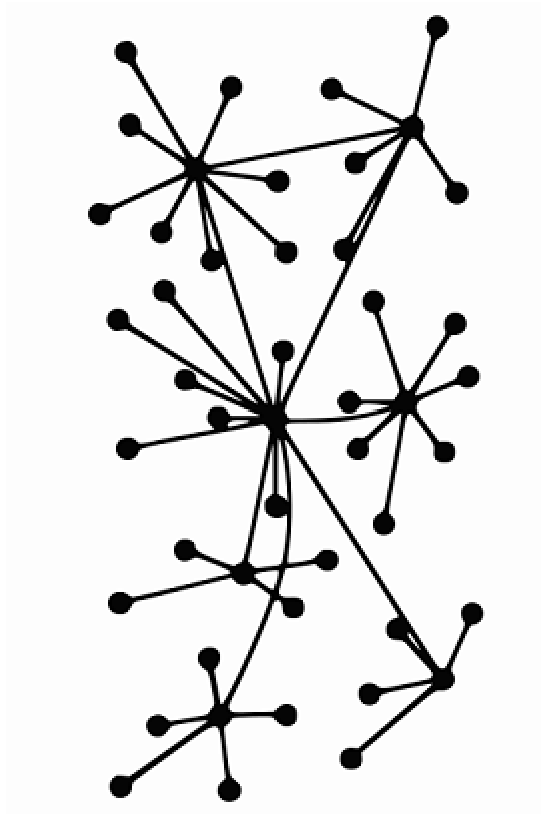
Efficiency

Functional stacking

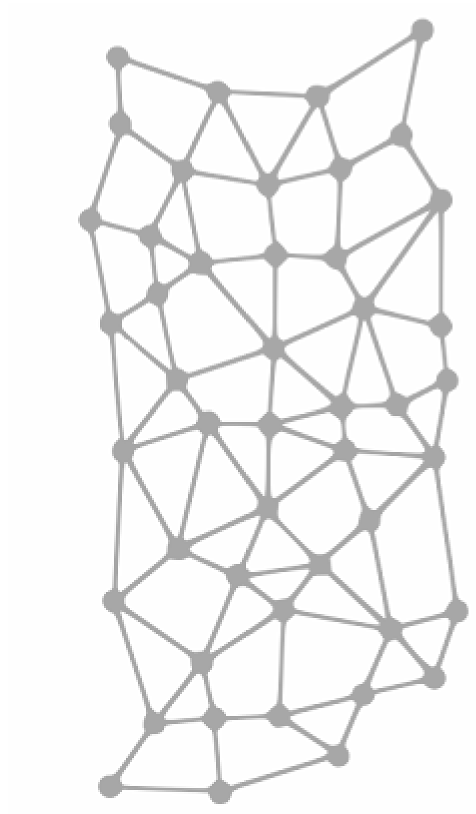


Decentralization of utilities

Centralized



Decentralized



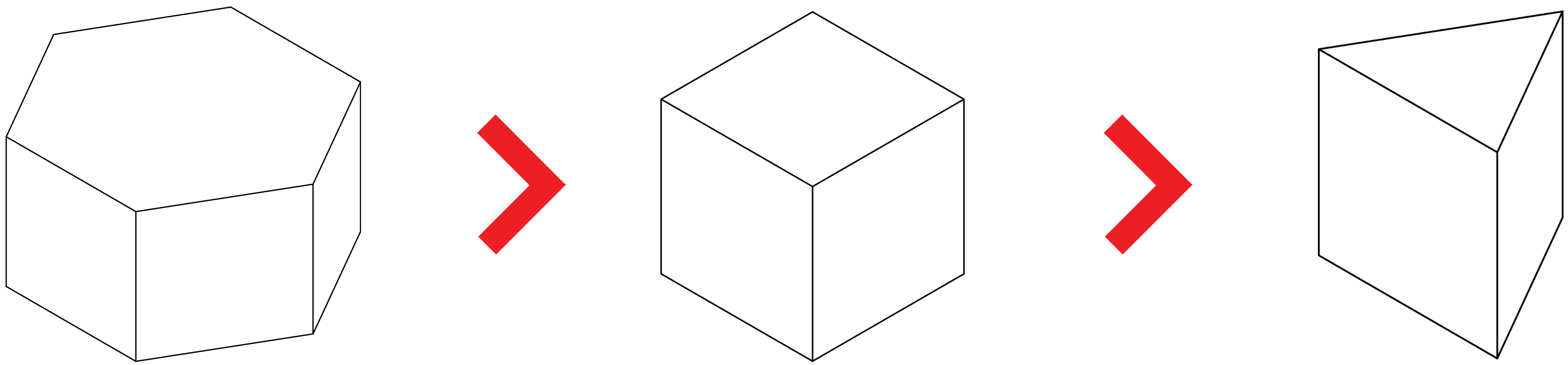
Distributed

Volume to Surface ratio

Storage capacity

Material efficiency

Bouyancy



1.166 0.833 0.56

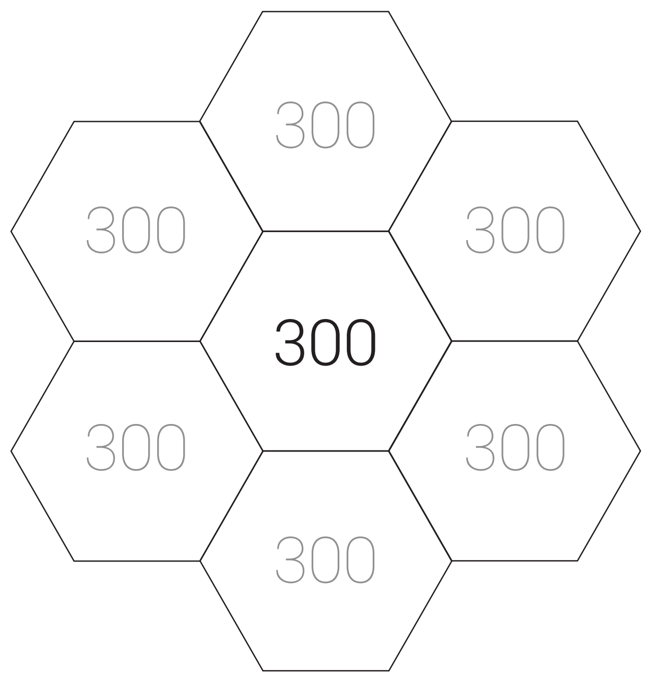
Community

Barangay
Administrative urban unit
> 2000 people

Human social unit
Dunbar's number
~150 people

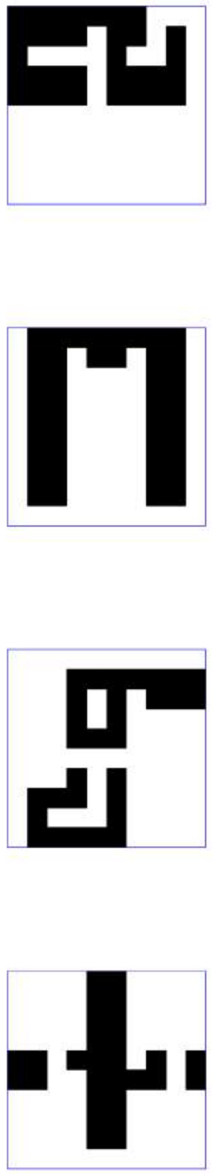
Density of Manila City
300 people / ~7000 m2

Area of stable module
6500 m2

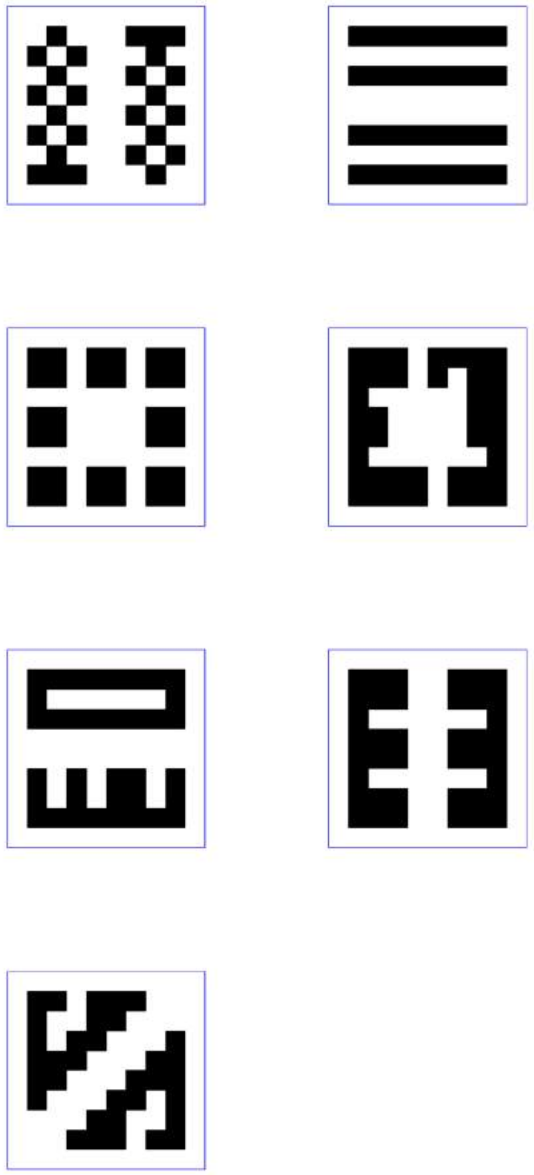


General types of Modules

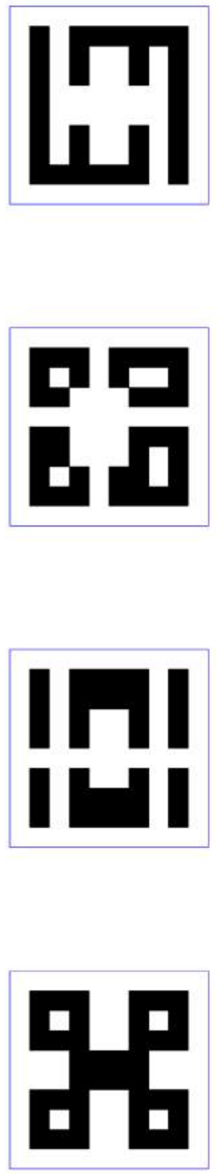
Large public space



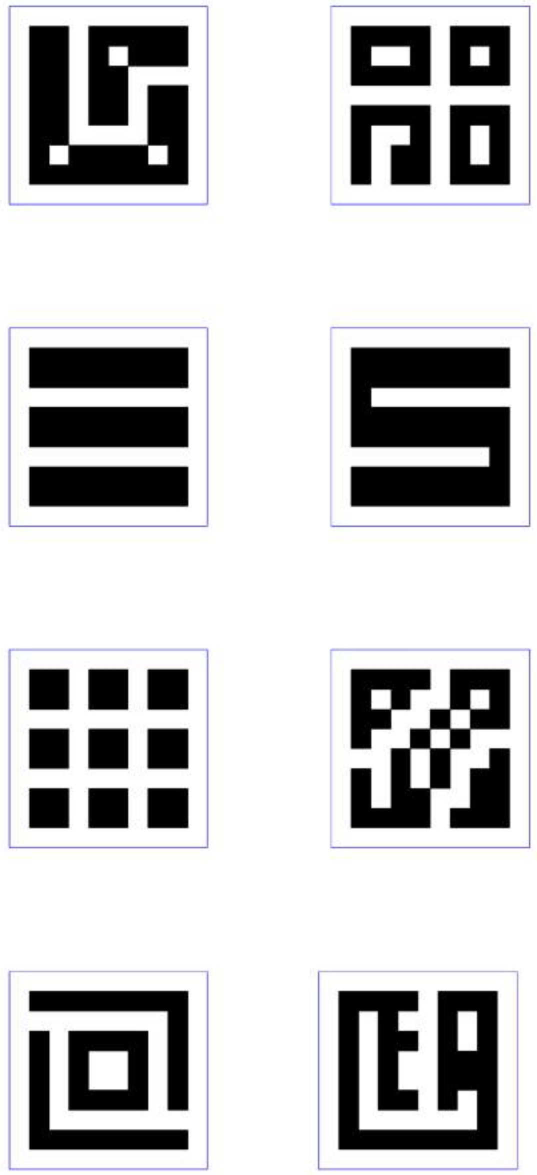
Medium spaces



Small spaces

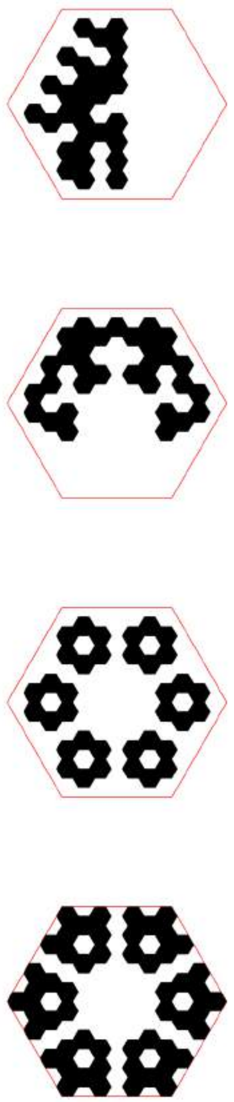


Dense housing

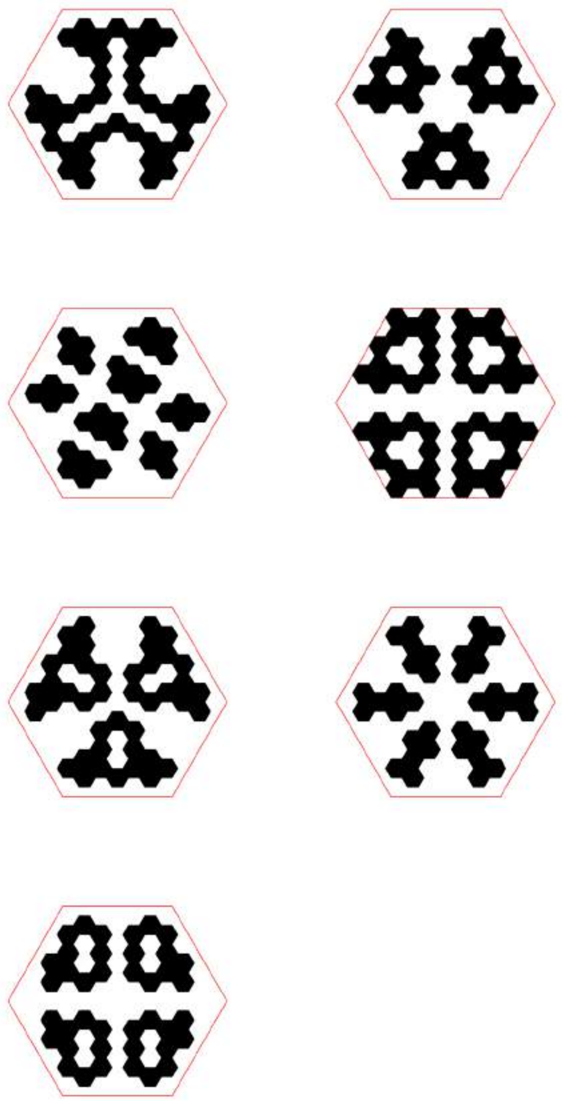


General types of Modules

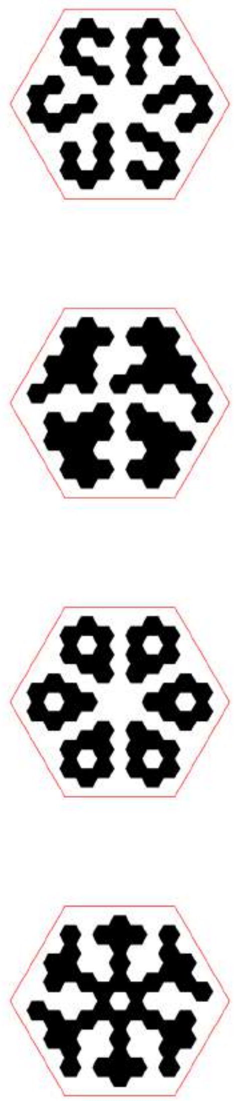
Large public space



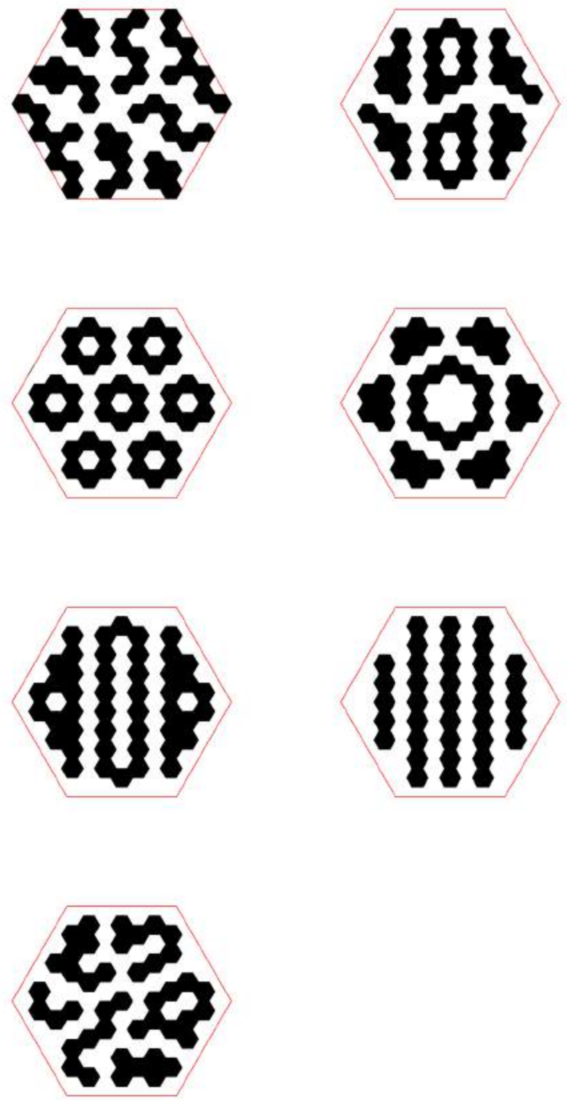
Medium spaces



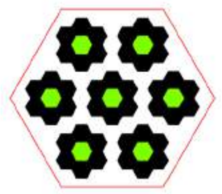
Small spaces



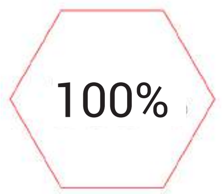
Dense housing



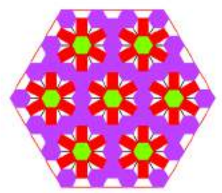
Requirements for selection



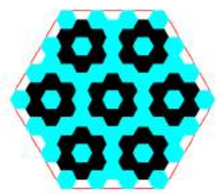
Number of Units



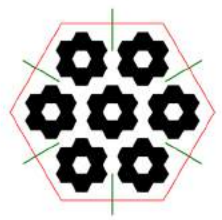
Courtyard Access



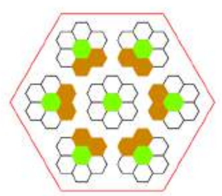
Public Space



Water Collection



Accessibility

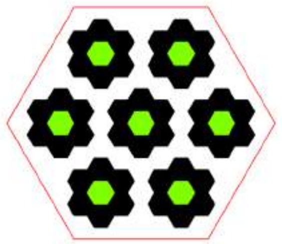


Quality of Views

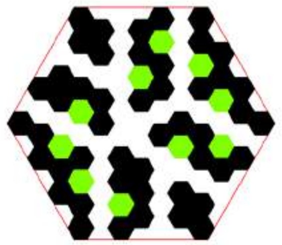
Adaptation of Manila

	Number of Units	Courtyard Access	Public Space	Water Collection	Accessibility	Quality of Views	Score	Weight
Number of Units		1	1	1	1	1	5	3
Courtyard Access	0		1	1	1	1	4	3
Public Space	0	0		0	0	1	1	1
Water Collection	0	0	1		1	1	3	2
Accessibility	0	0	1	0		1	2	2
Quality of Views	0	0	0	0	0		0	1

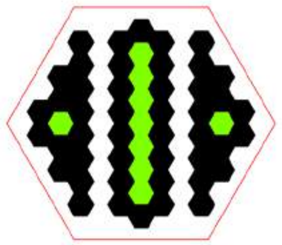
2.583



2.25

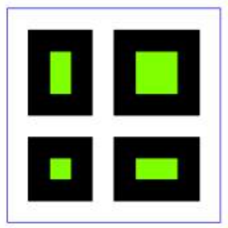


1.917



1.667

1.667



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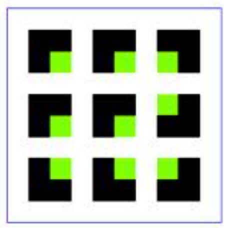
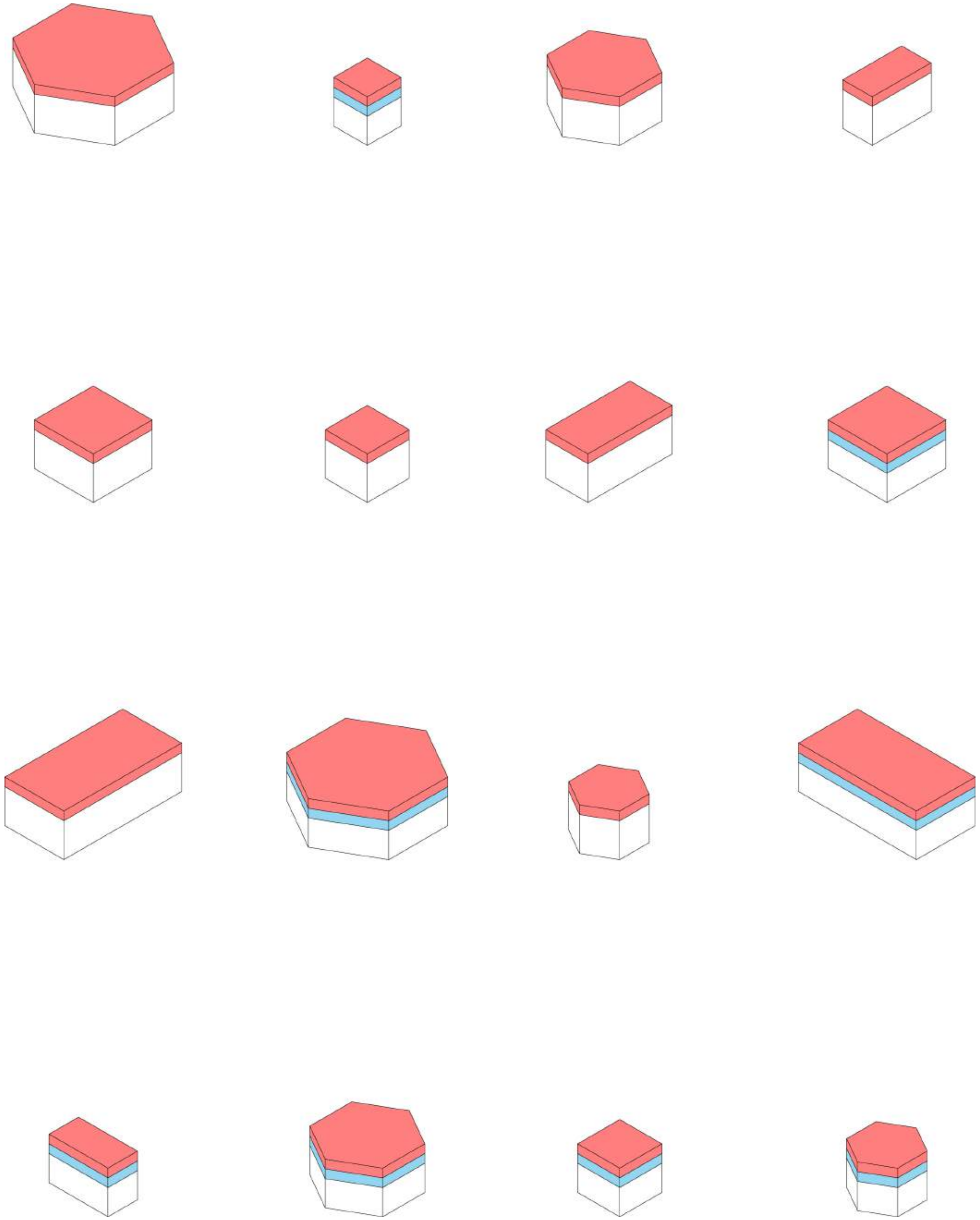
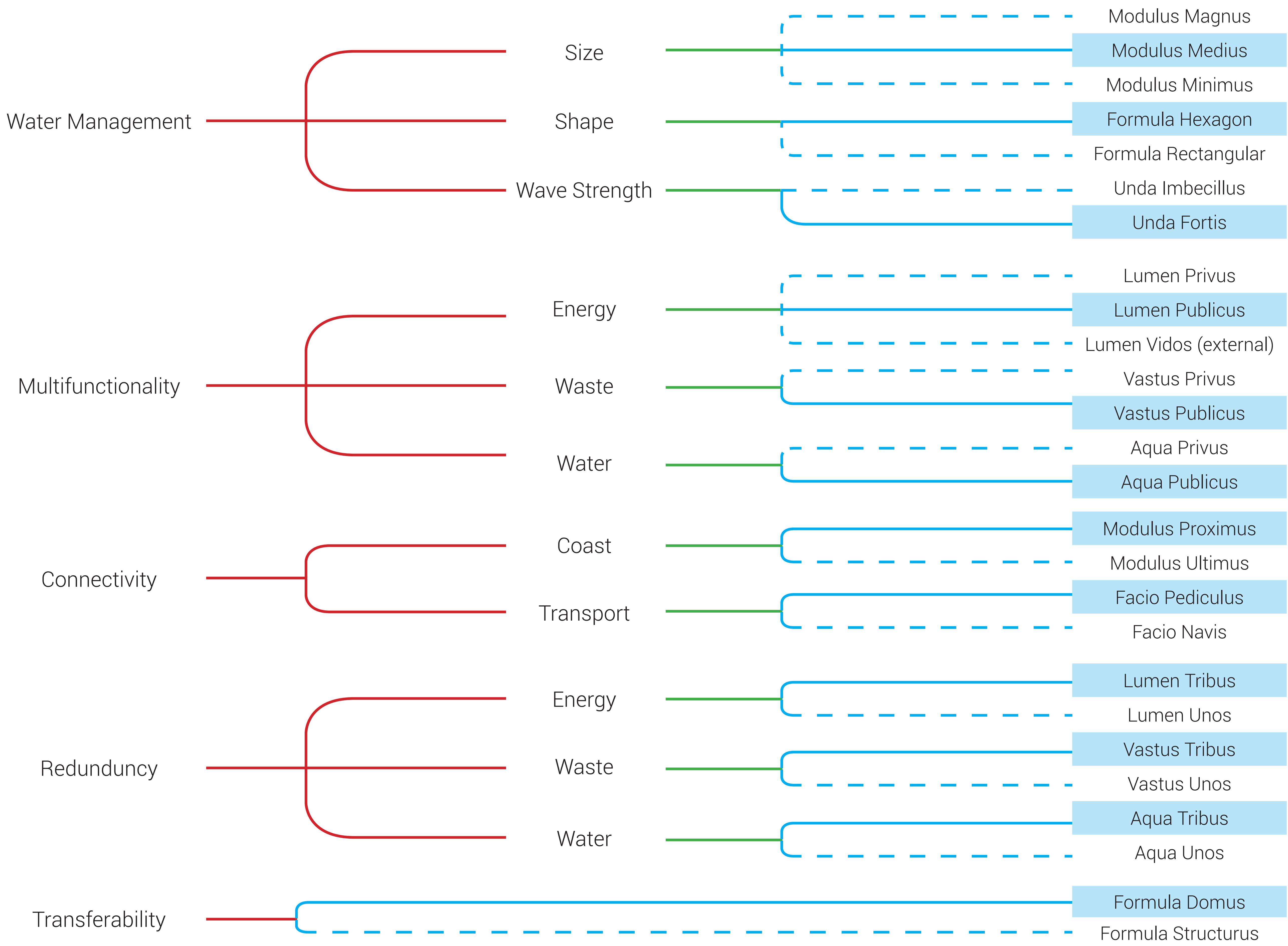


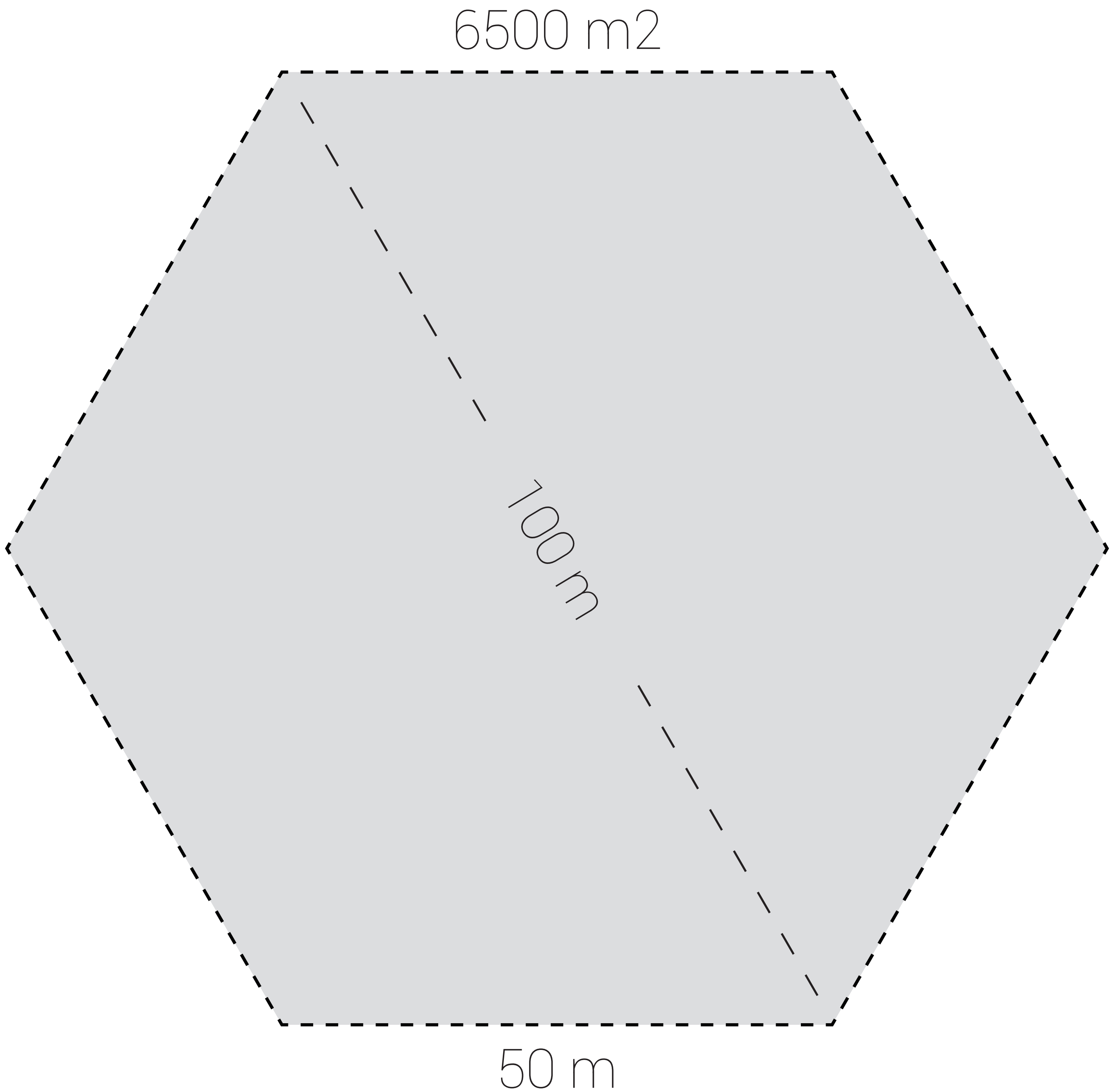
Evolutionary Variations



Adaptation of Manila

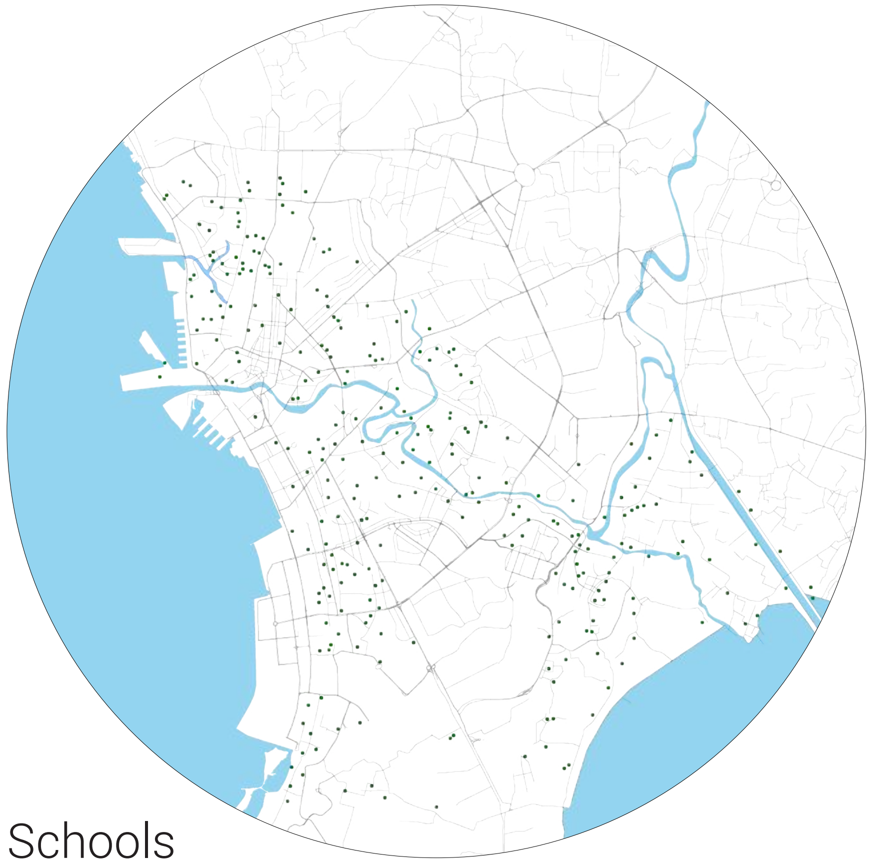


Size of prototype community

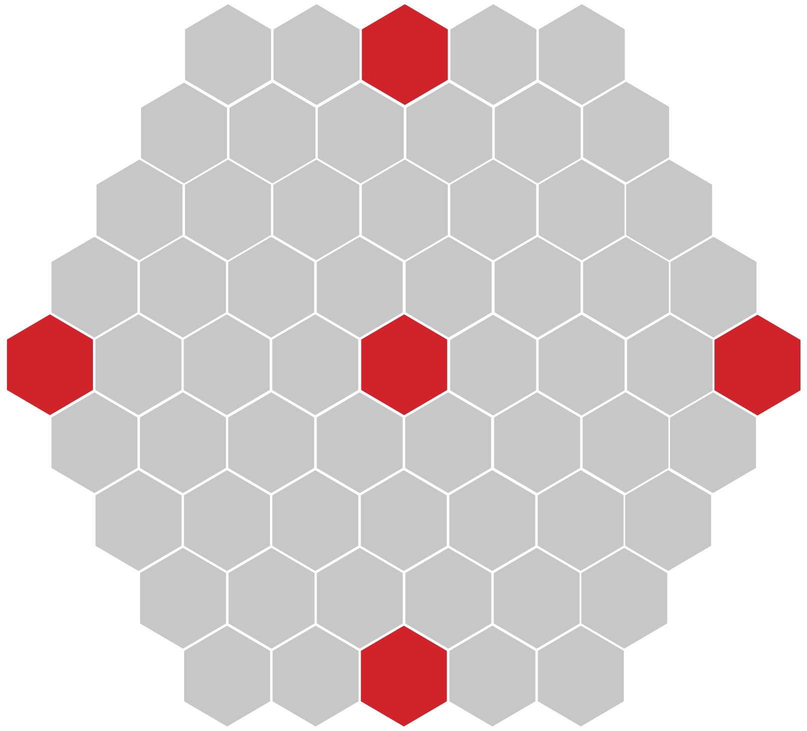


Infrastructure

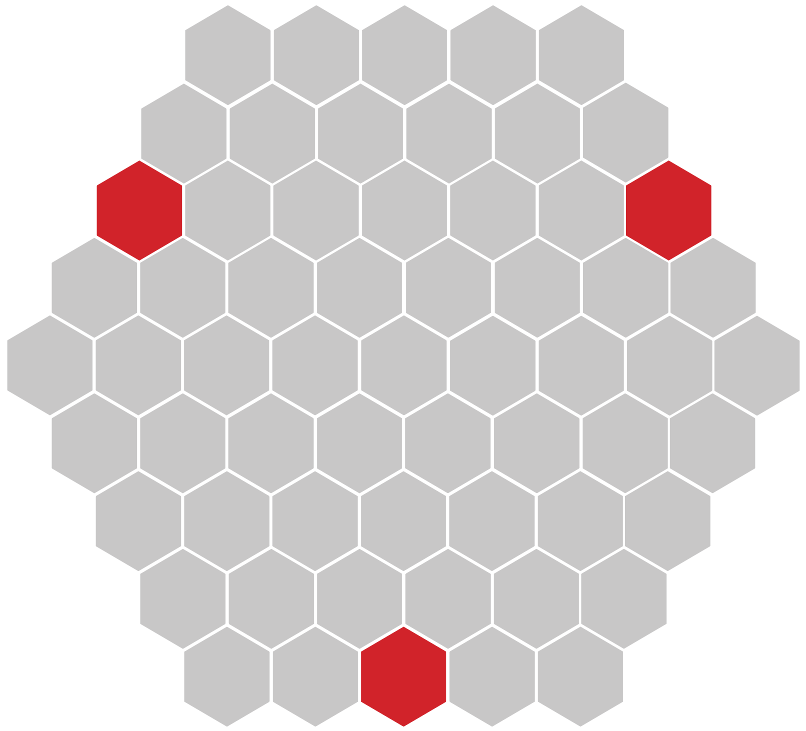
Distribution of urban services



Schools



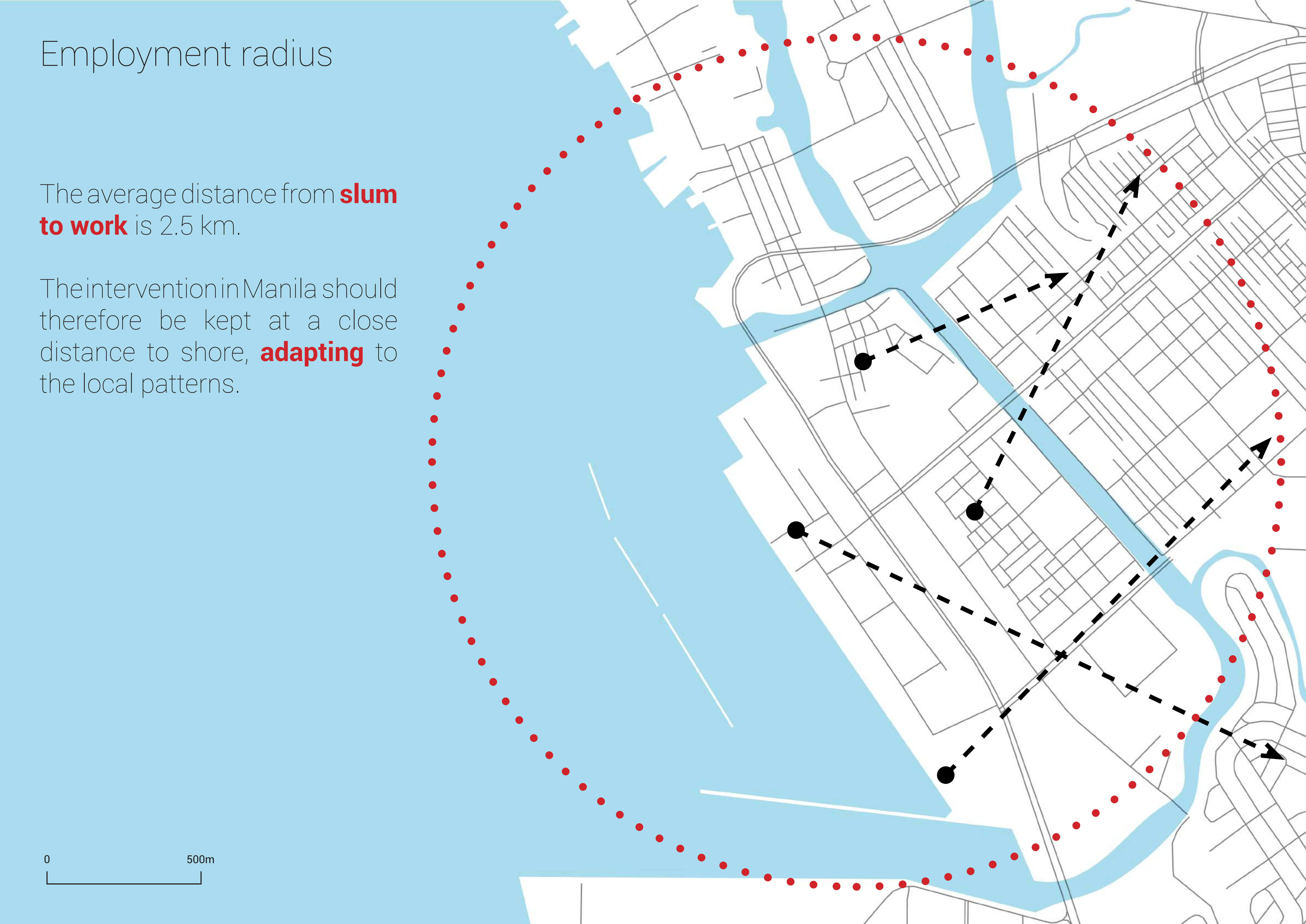
Hospitals



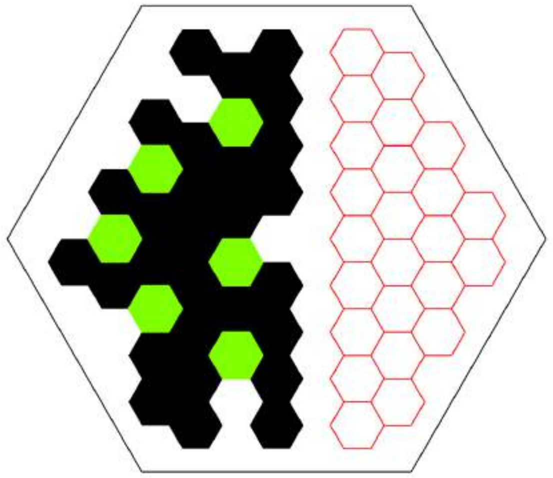
Employment radius

The average distance from **slum to work** is 2.5 km.

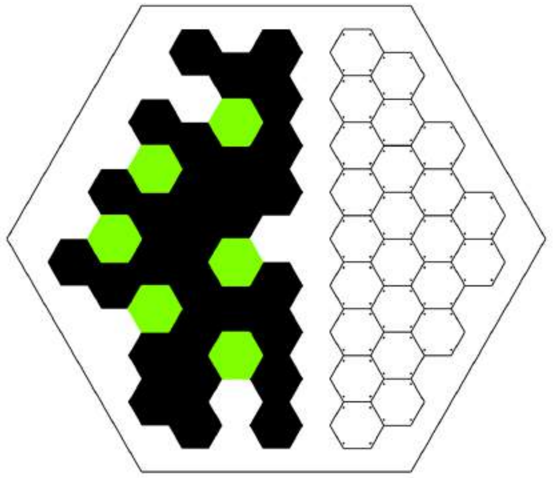
The intervention in Manila should therefore be kept at a close distance to shore, **adapting** to the local patterns.



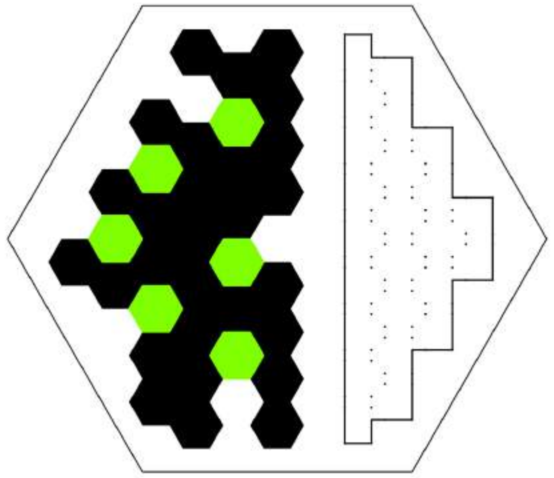
Public buildings



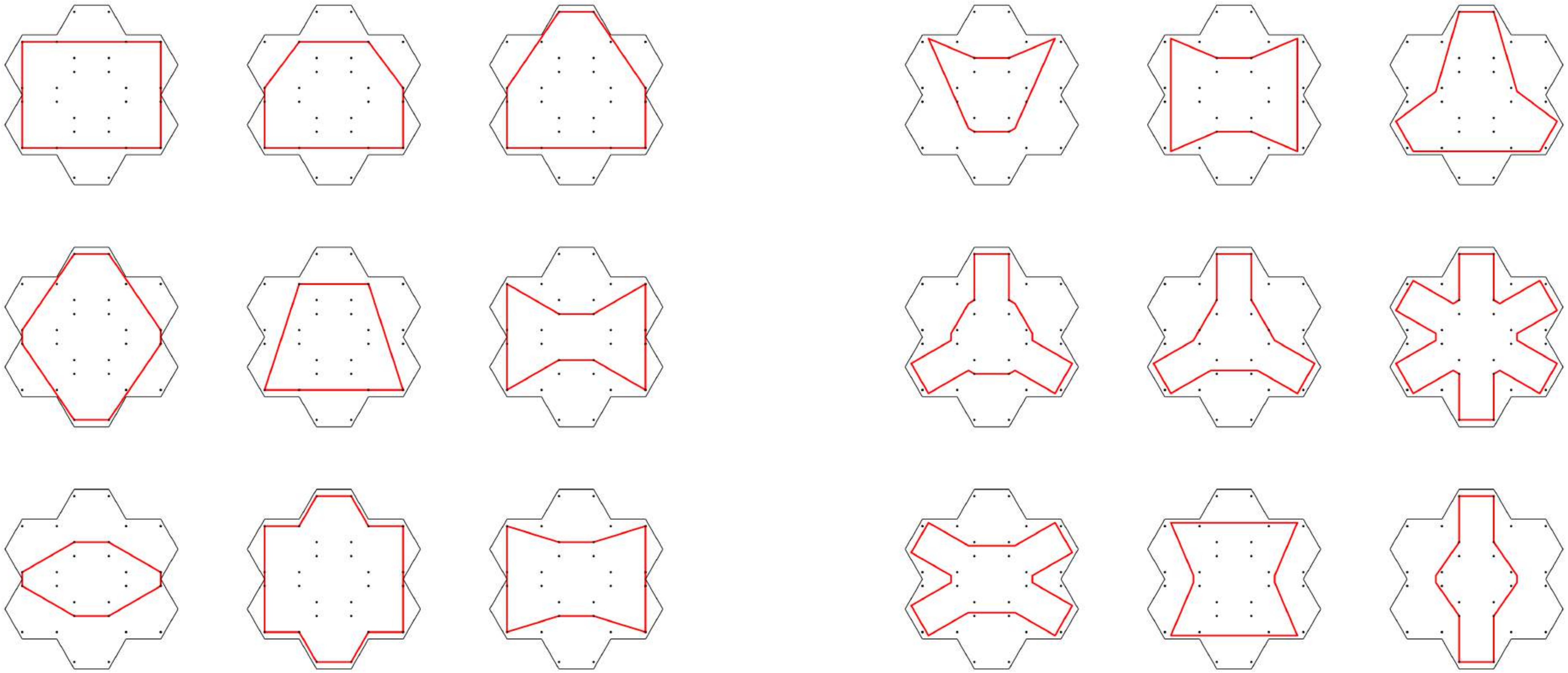
Area



Columns



Footprint



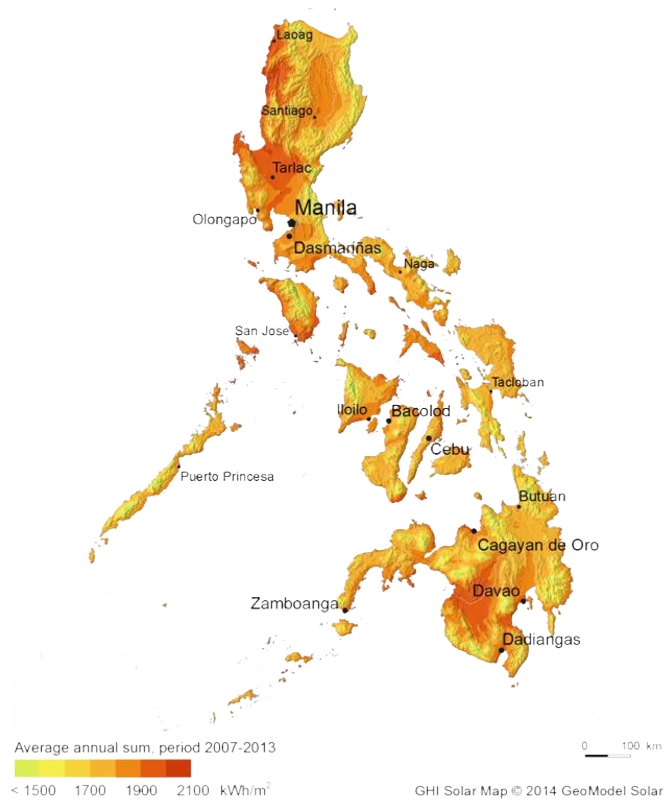
Power to the people

Manila - W / m2 / Day
~1800

Solar Panel Tilt (Avg.)
20 degrees from Horizontal

Typical Solar Panel
1.64 m2 - 17% efficiency

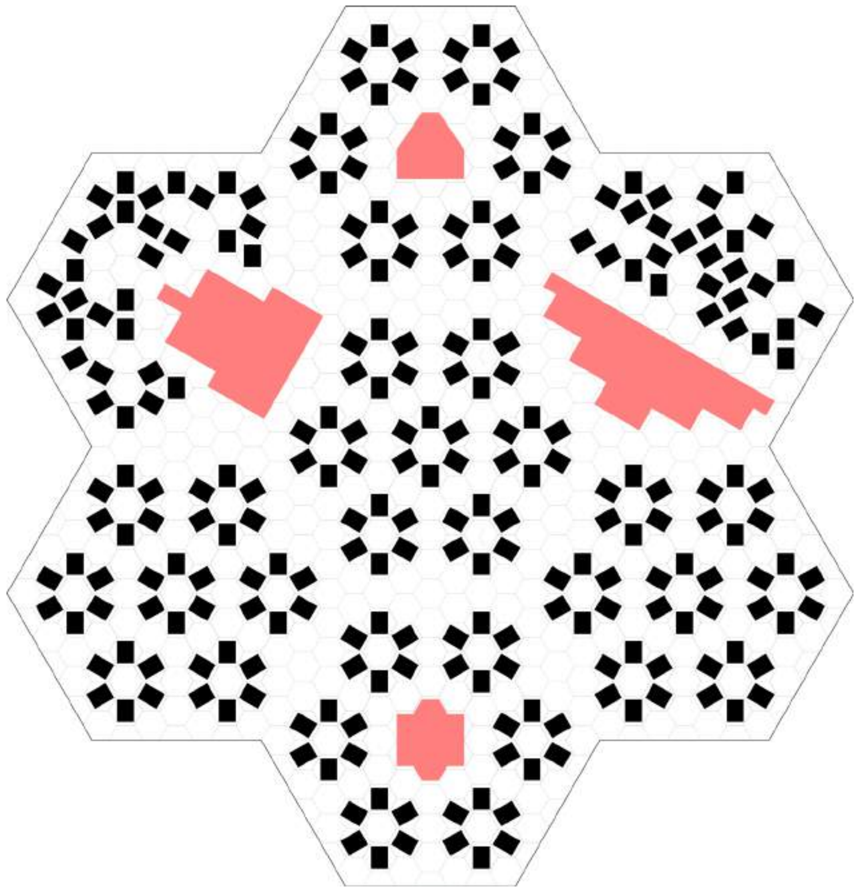
Output / Day
~1 Kwh

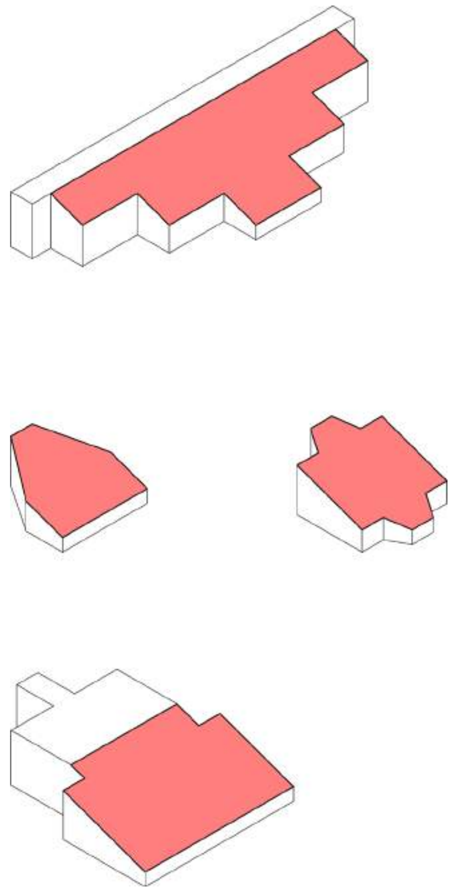


Map of Global Horizonal Irradiation (GHI) by SolarGIS

	w/hour MIN	w/hour MAX	Hours / day	Kwh/day MIN	Kwh/day MAX
Ventilation Fan	10	25	6	0.06	0.15
Lightbulb	25	100	6	0.15	0.6
TV	80	400	6	0.48	2.4
Refrigerator	100	400	24	2.4	9.6
Electric Stove	1000	1500	1	1	1.5
Total				4.09	14.25

Power to the people



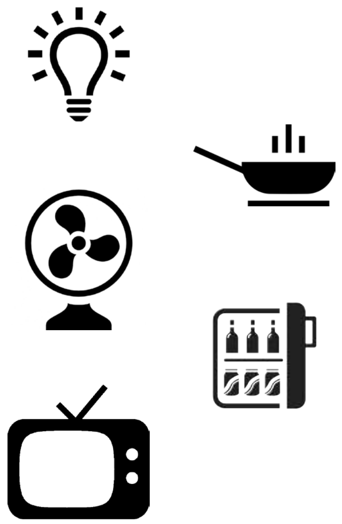


Roof area : 2508 m2

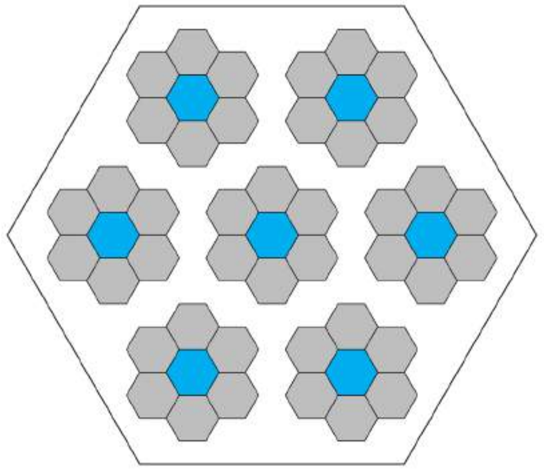
Families : 257

Solar panels : 1529

Kwh / Family : 5.95

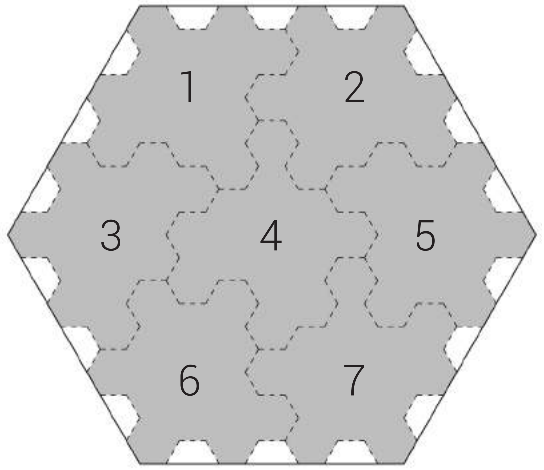


Water from the sky

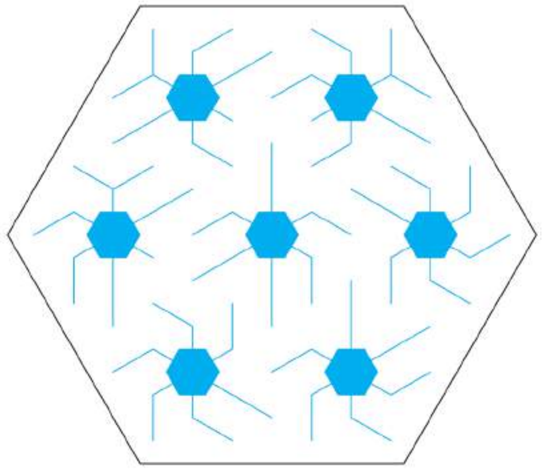


Storage

325m3 / Pod



Sectors

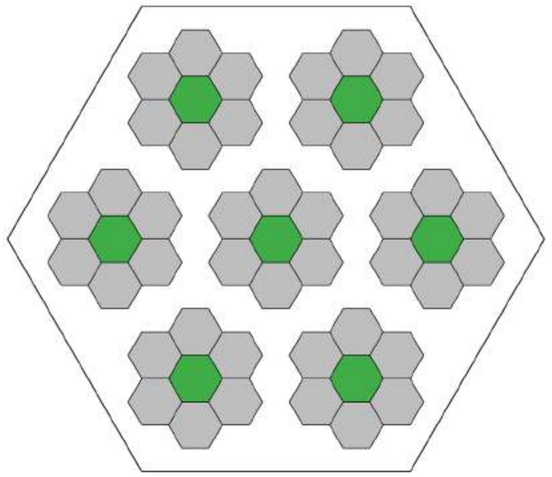


Pipes

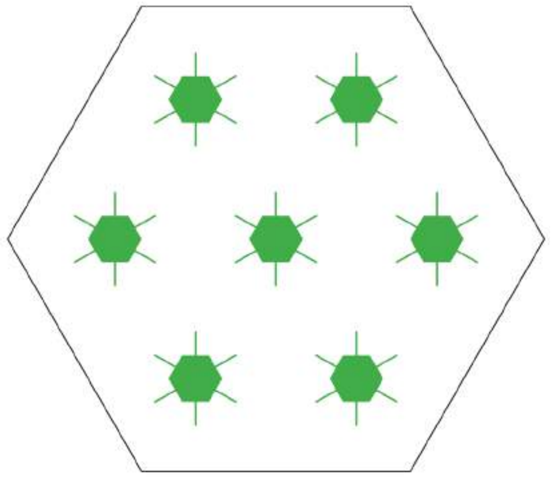
Liter storage over time

	July	August	September	October	...	...	June
1 Pod	23010	30810	26065	11830			18655
2 Pod	28020	71640	105770	111430			51930

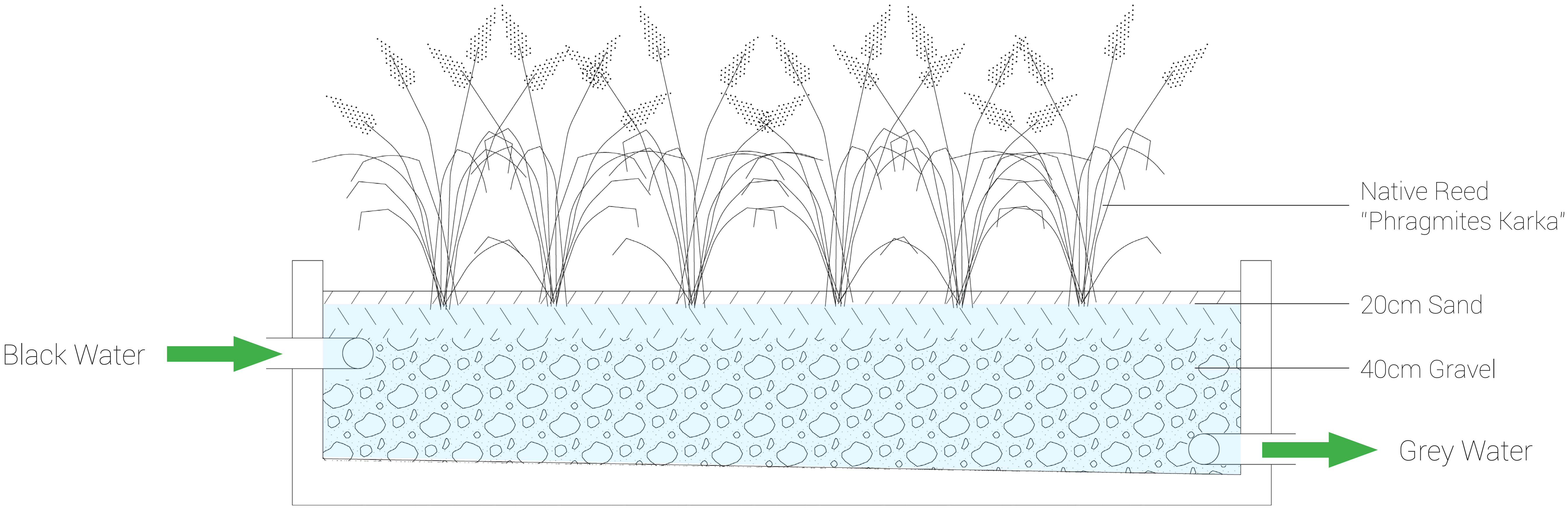
Constructed wetland



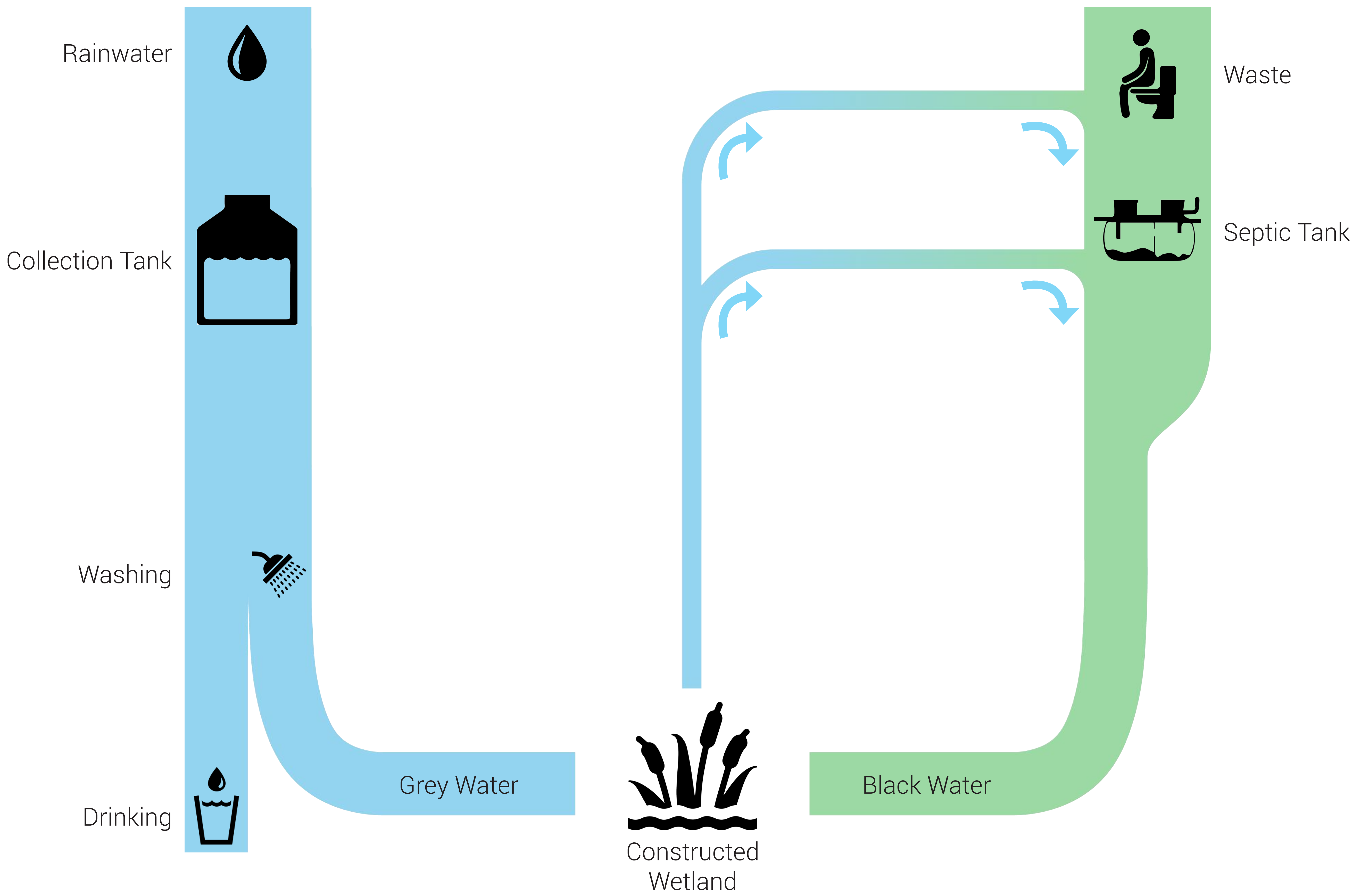
Common Gardens



Pipes



Water and Waste flows

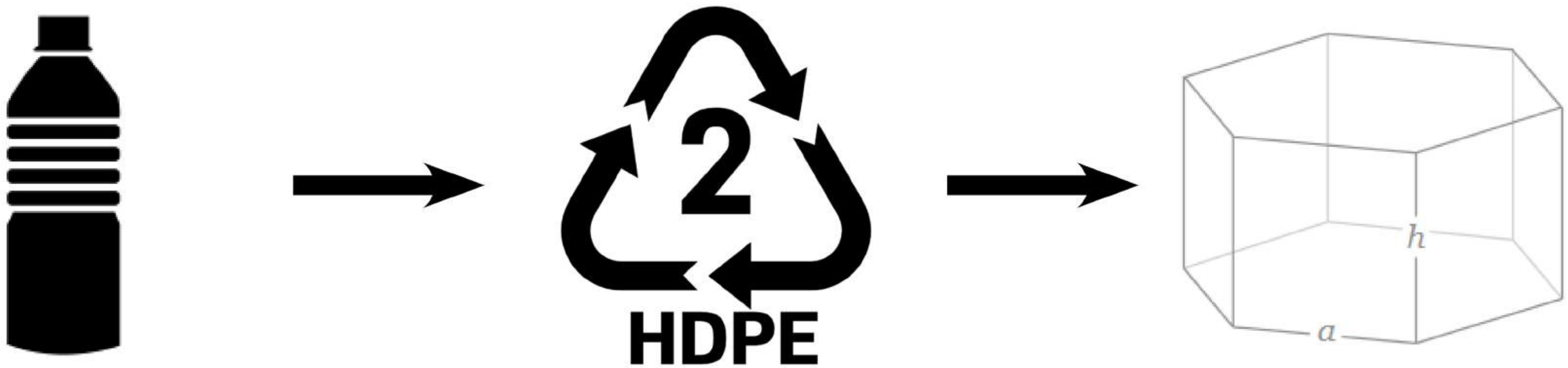


How to make a “module”?

Employment

Local materials

Circular usage



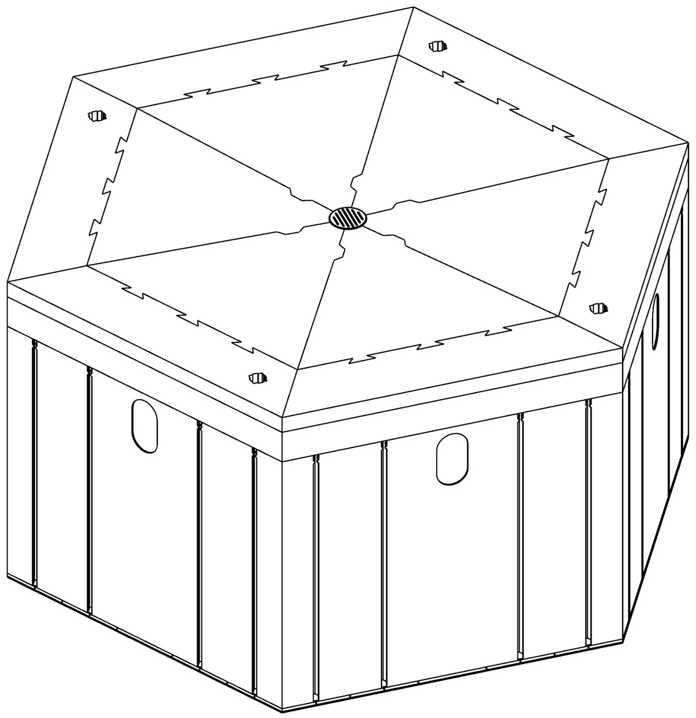
Choosing a material for modular pod

	HDPE (plastic)	Concrete	Wood	Steel
Weight	Good	OK	Good	Bad
Durability	OK	OK	Bad	Bad
Sustainability	Good	OK	OK	Bad
Strength	OK	Good	OK	Good
Cost	OK	OK	OK	Bad

- Good
- OK
- Bad

Pods and Caps

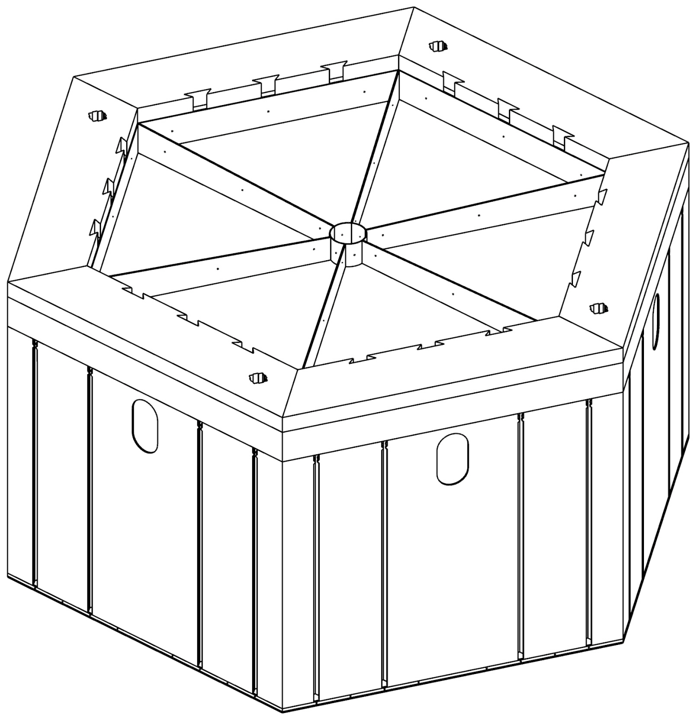
Street Pod



1% slope IN

Bouyancy chamber

Wetland Pod

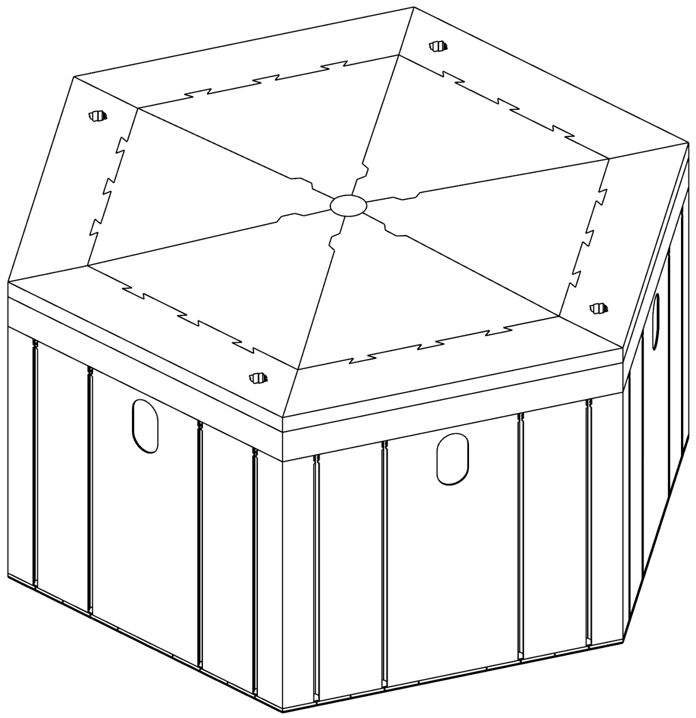


Wetland soil

Rainwater tank

Septic tank

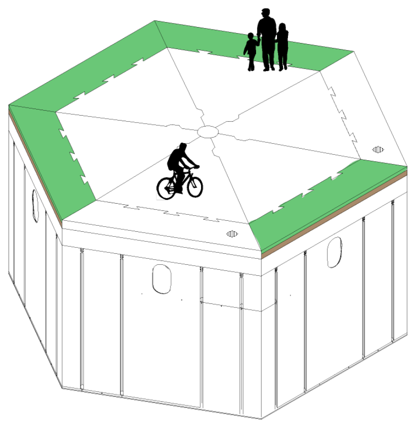
Family Pod



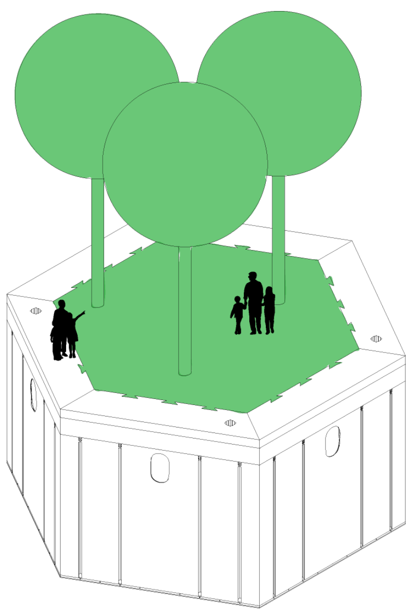
1% slope OUT

Bouyancy chamber

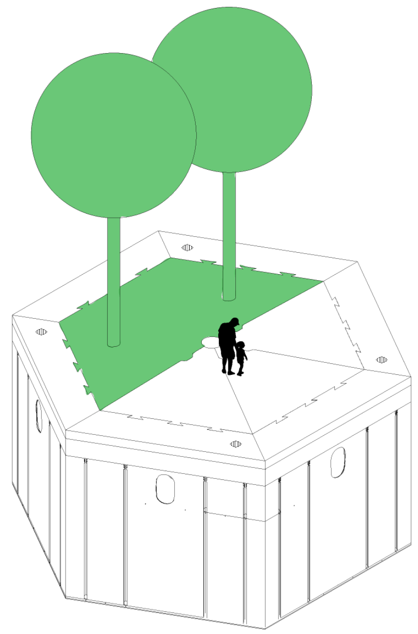
Multiple uses



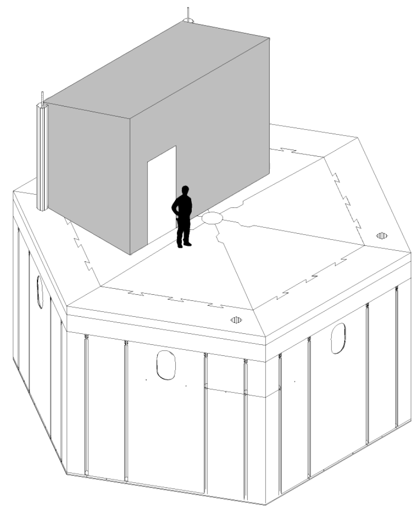
Low green



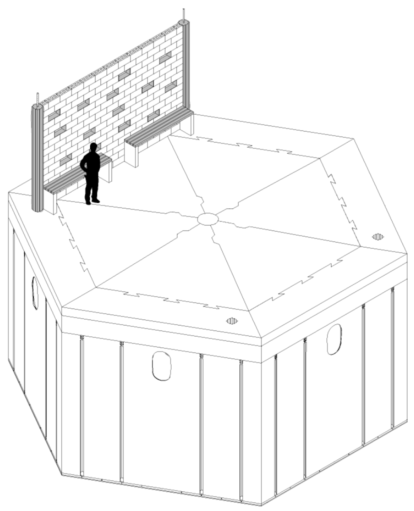
Trees



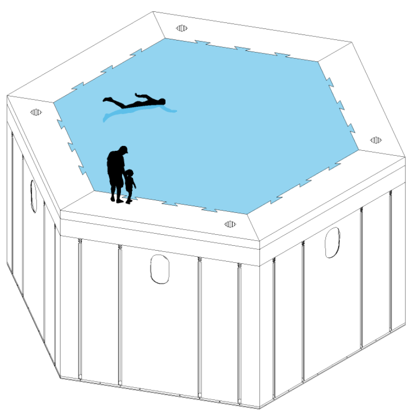
Trees + Street



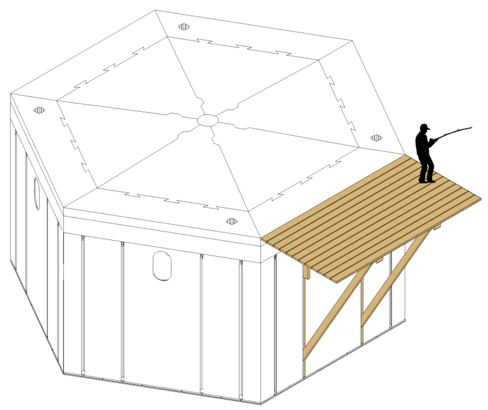
Public bathroom



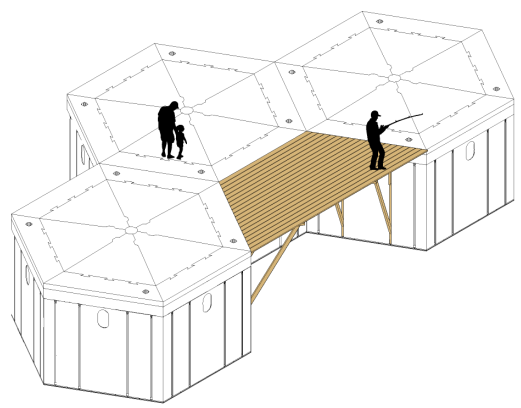
Socializing



Water feature

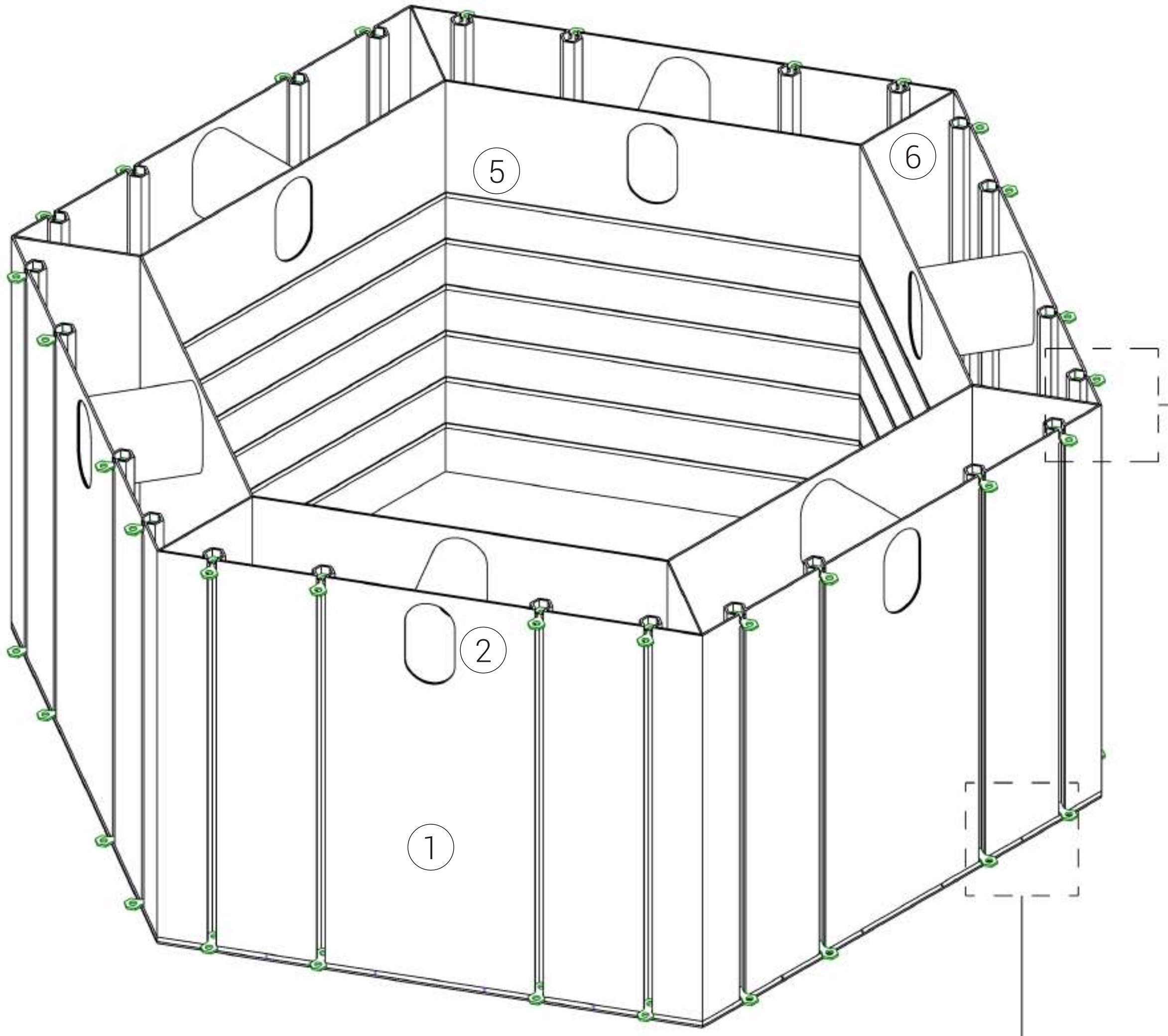


Small deck

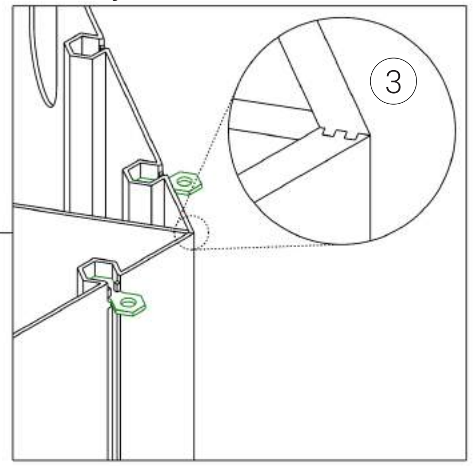


Large deck

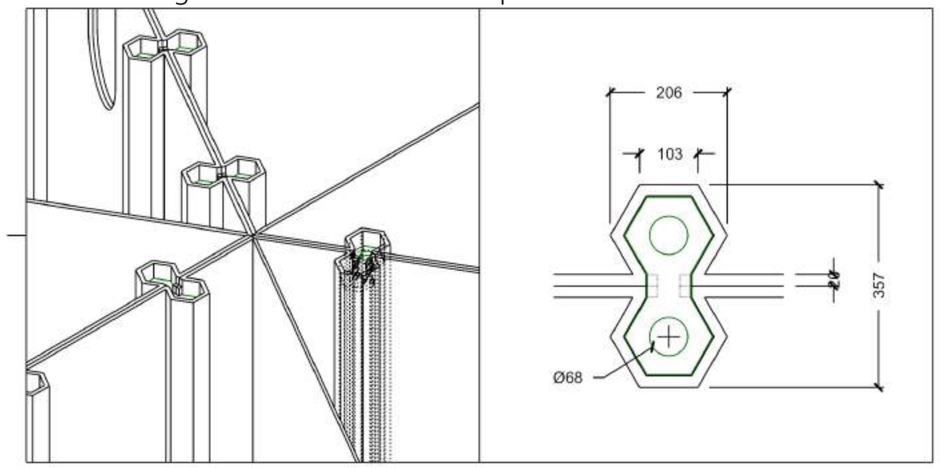
Bouyancy chamber - Pod



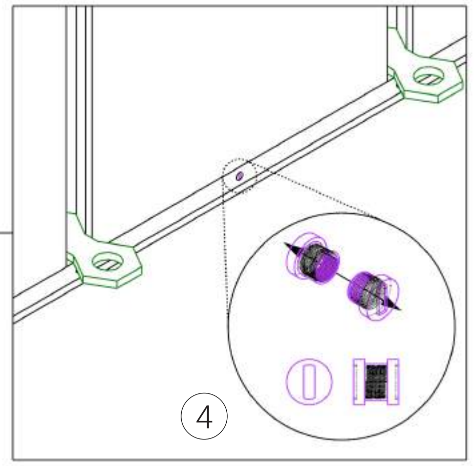
Corner joint



Interlocking mechanism between pods

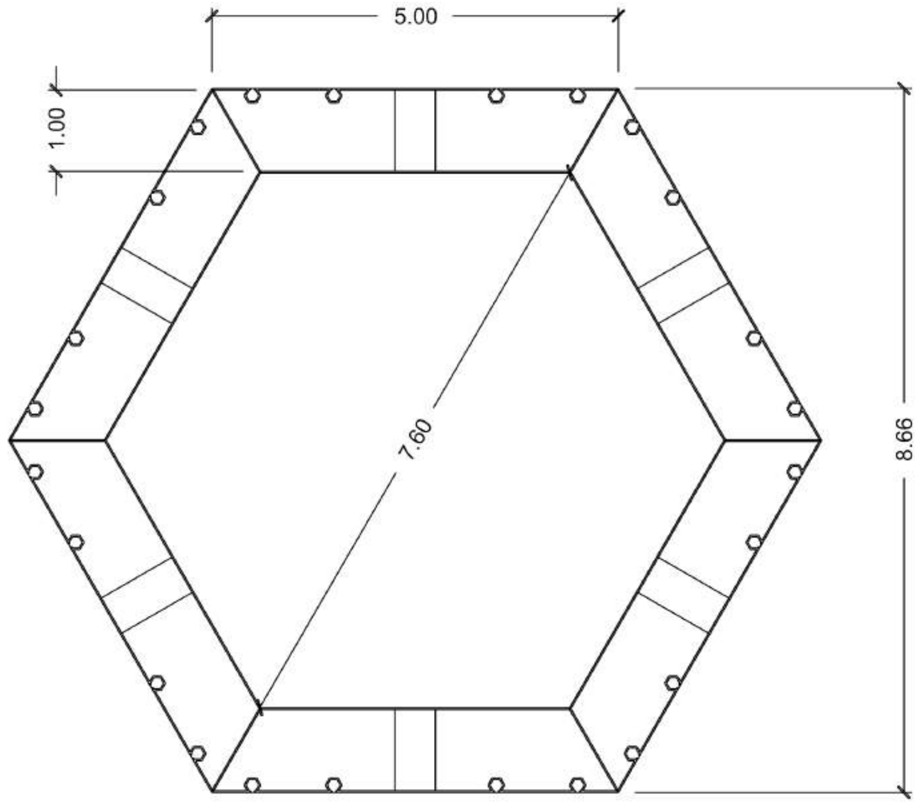


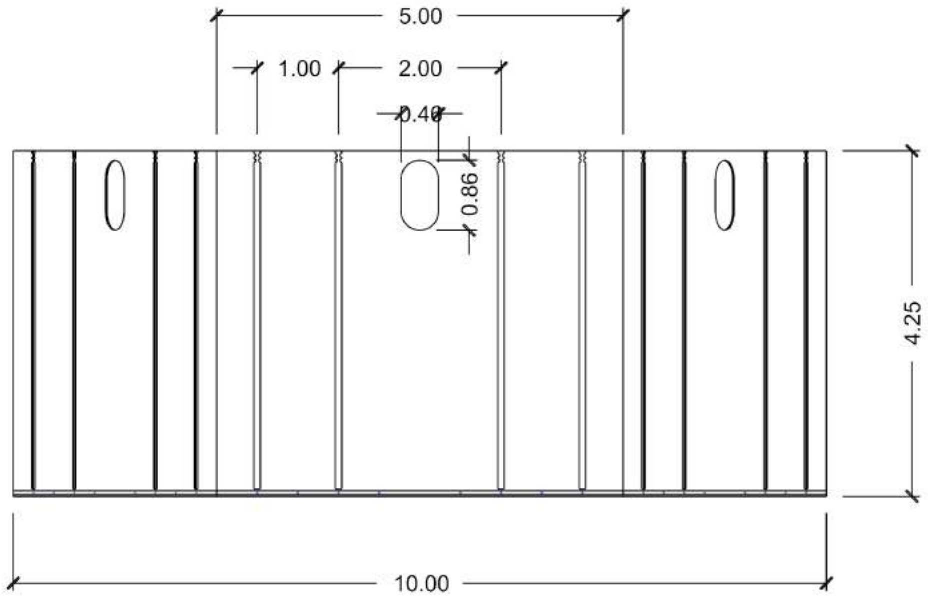
Connecting HDPE bolts

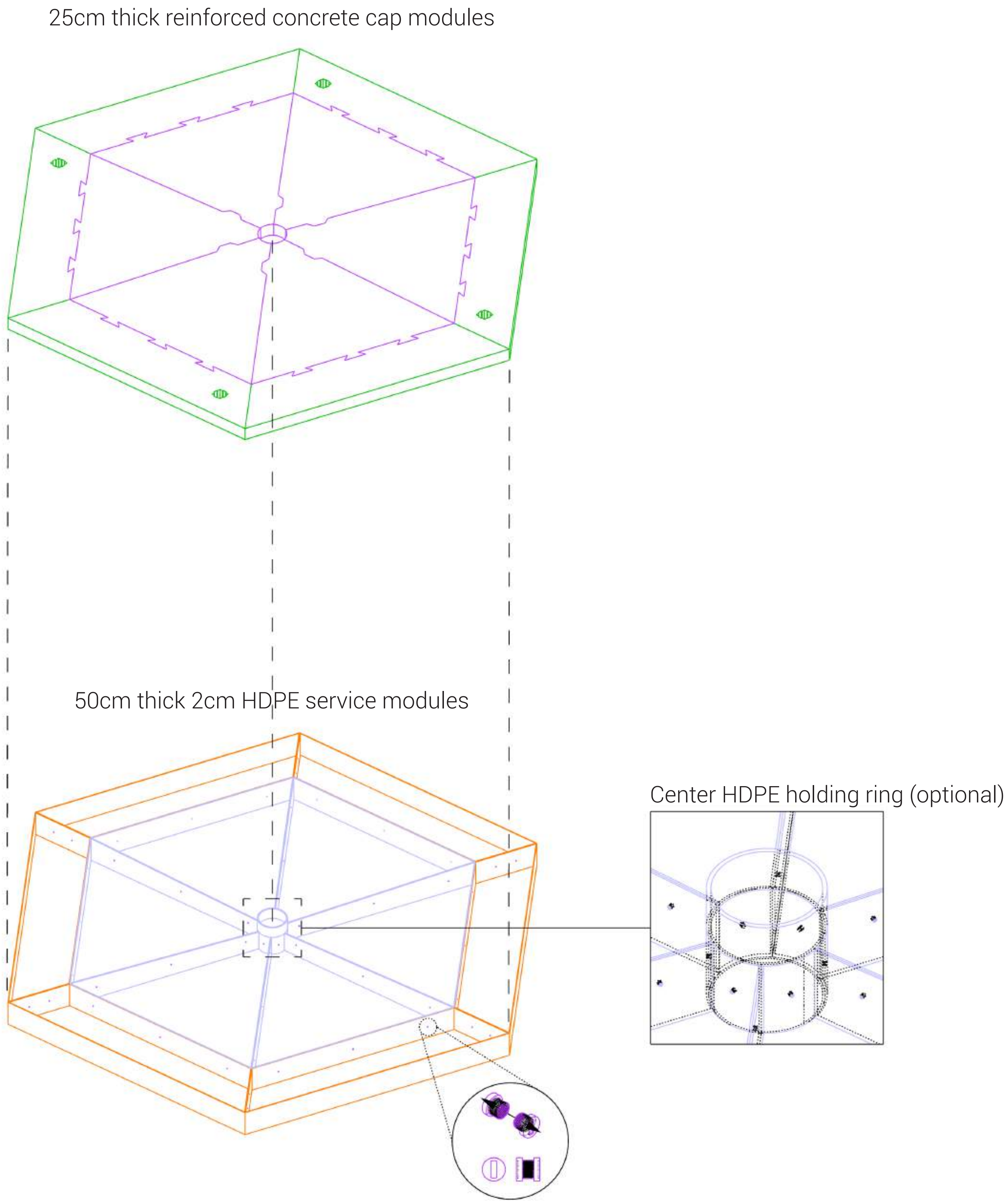


1. 2cm HDPE panel
2. Water and waste service tunnel
3. Zigzag connection between panels
4. HDPE 2cm bolts
5. 2cm inner HDPE panel with reinforcing ribs
6. 2cm corner HDPE panel for rigidness - 1m cavity chamber

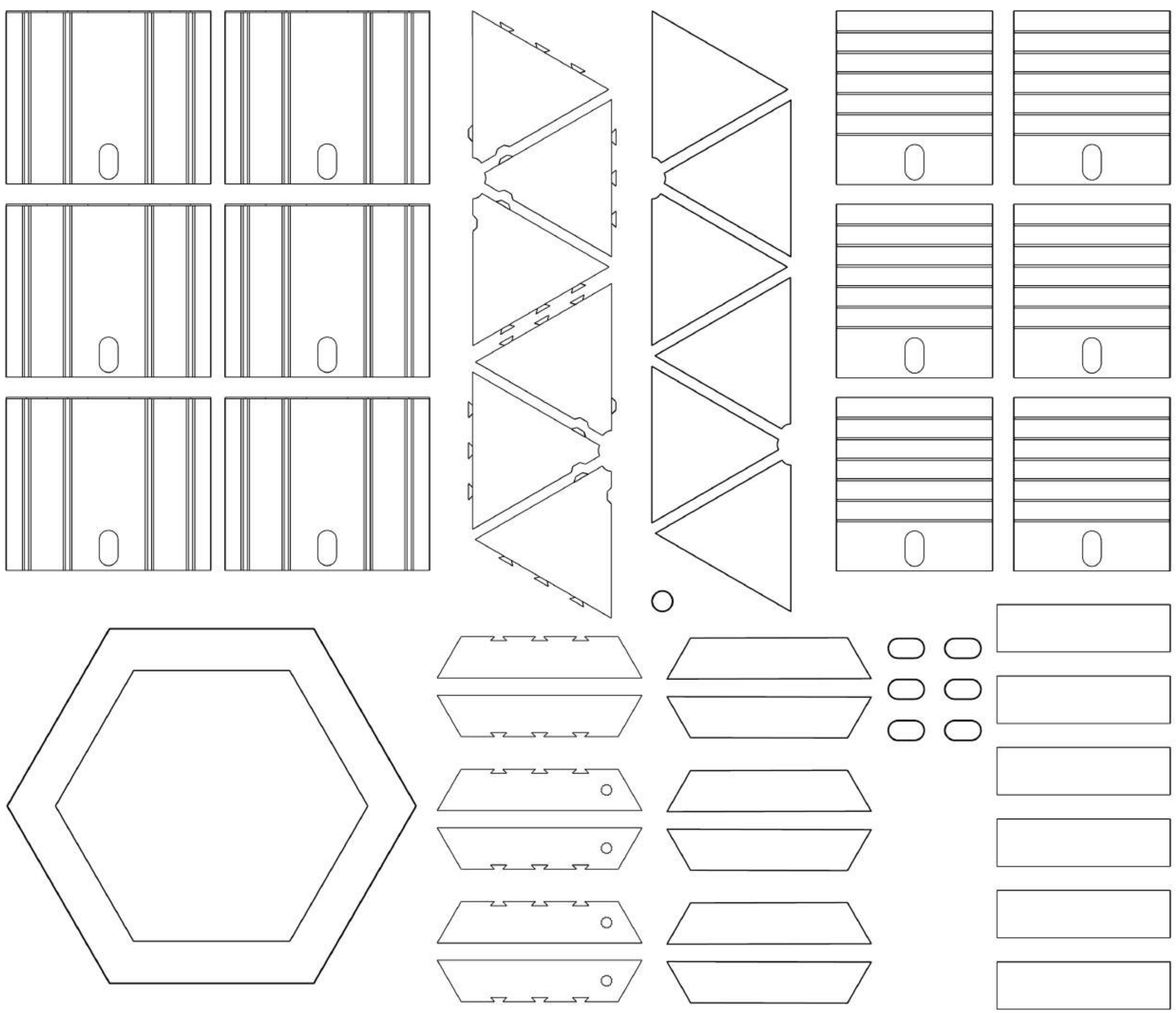
Pod layers

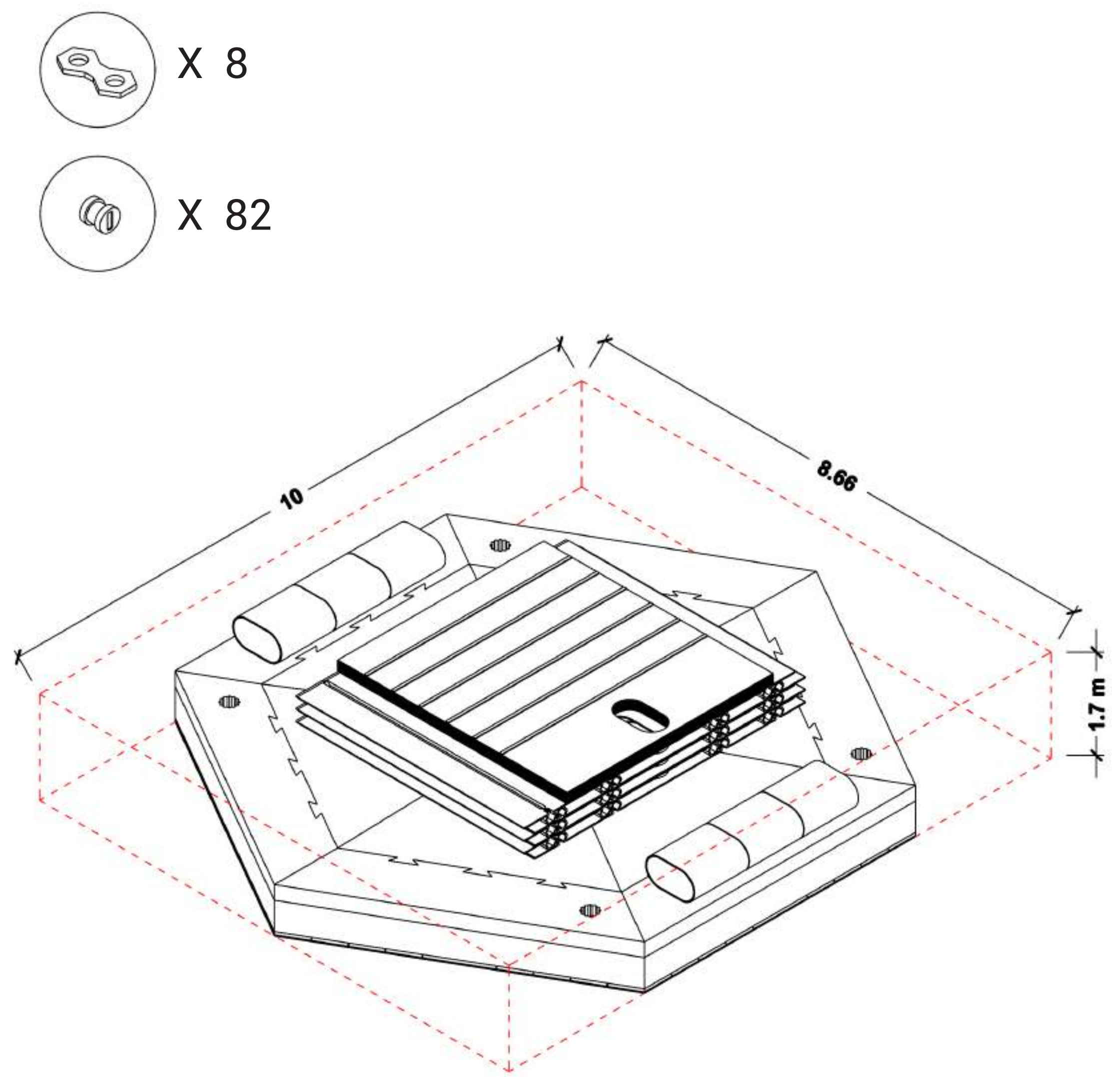

5.00
1.00
7.60
8.66


5.00
1.00
2.00
0.40
0.86
4.25
10.00

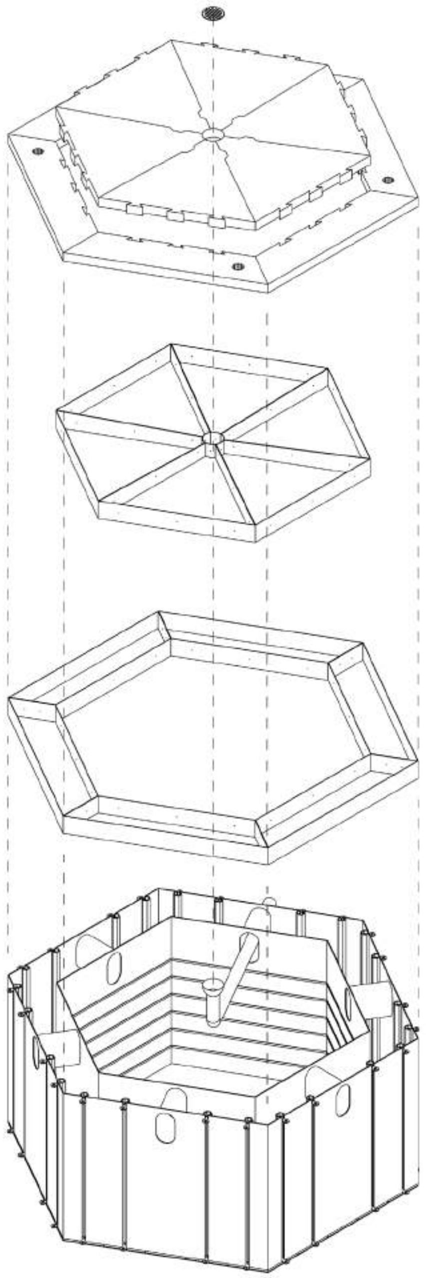

25cm thick reinforced concrete cap modules
50cm thick 2cm HDPE service modules
Center HDPE holding ring (optional)

Assembly package

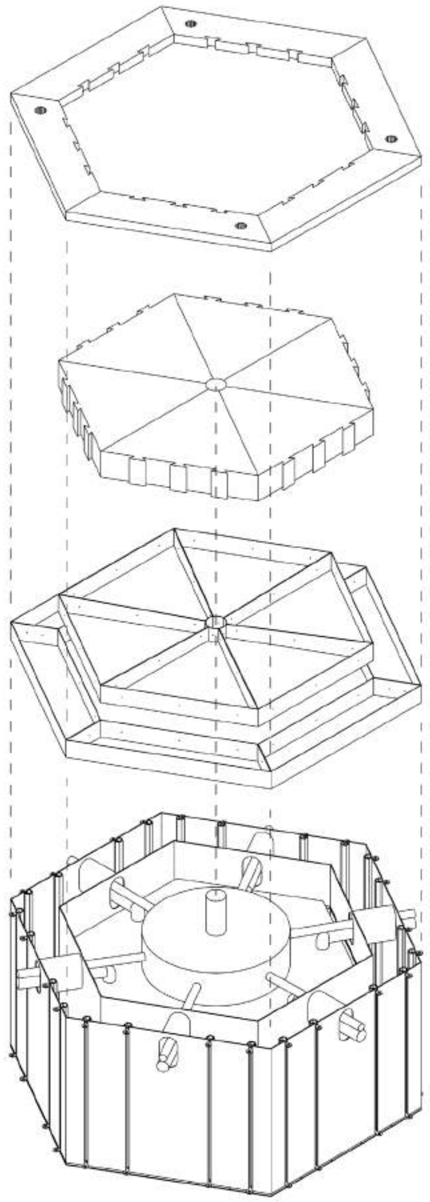




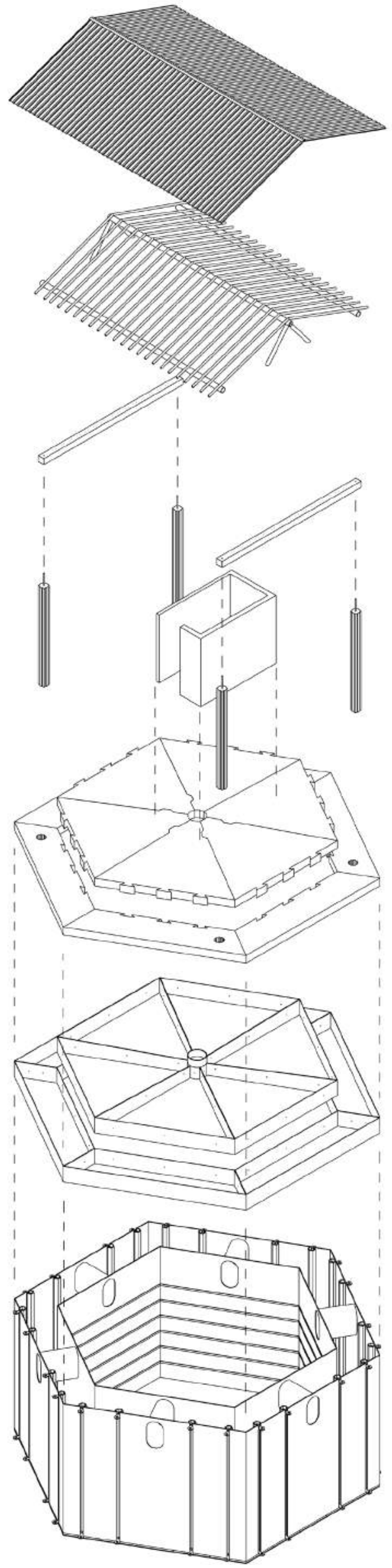
Street Pod



Wetland Pod



Family Pod



Housing for the Urban Poor

Vernacular huts / Vernacular slums

Coco Lumber

Wood Scraps

Nipa Hut

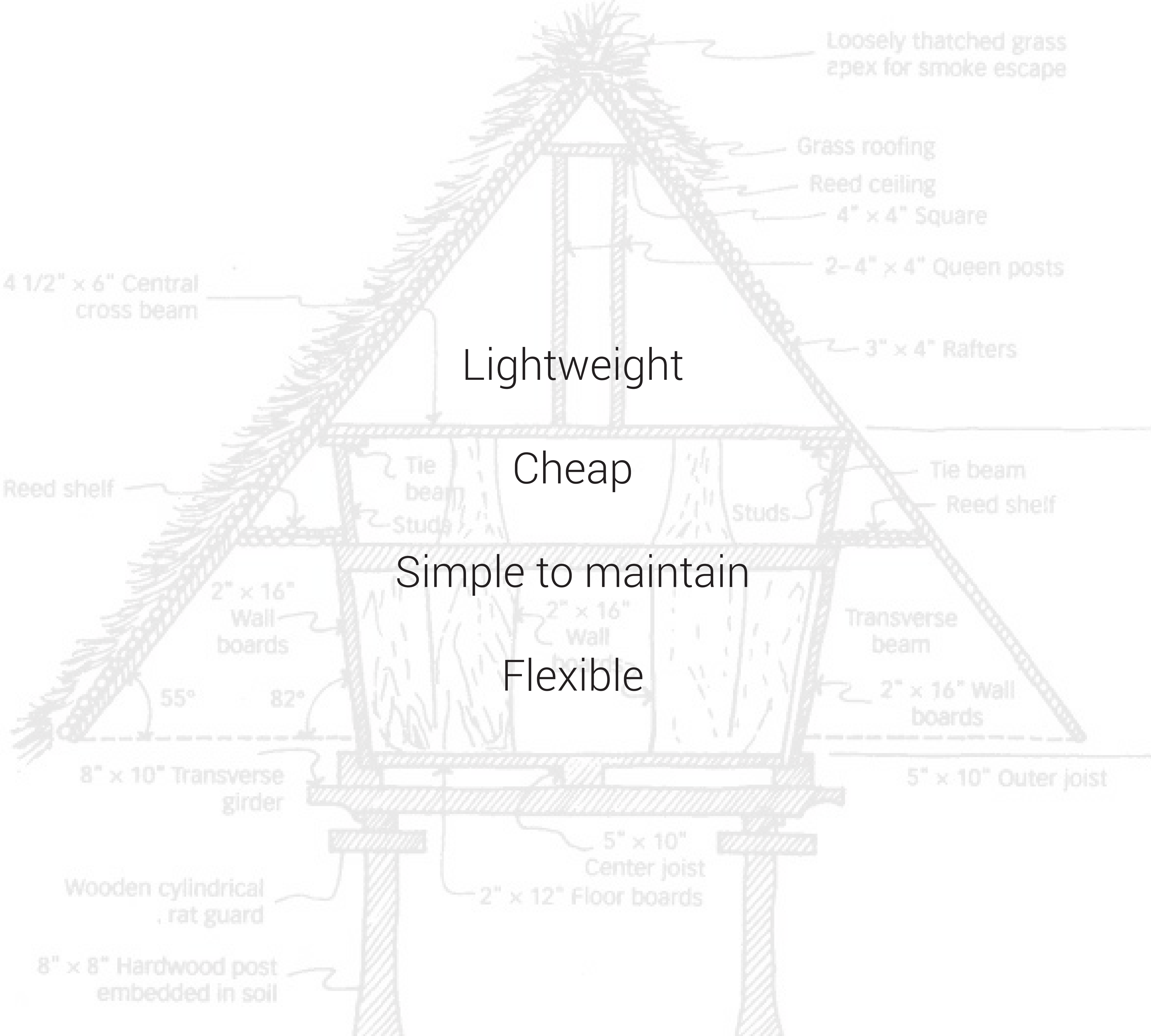
Slum

Bamboo

Plastics

Nipa Palm

Metal Sheet



Lightweight

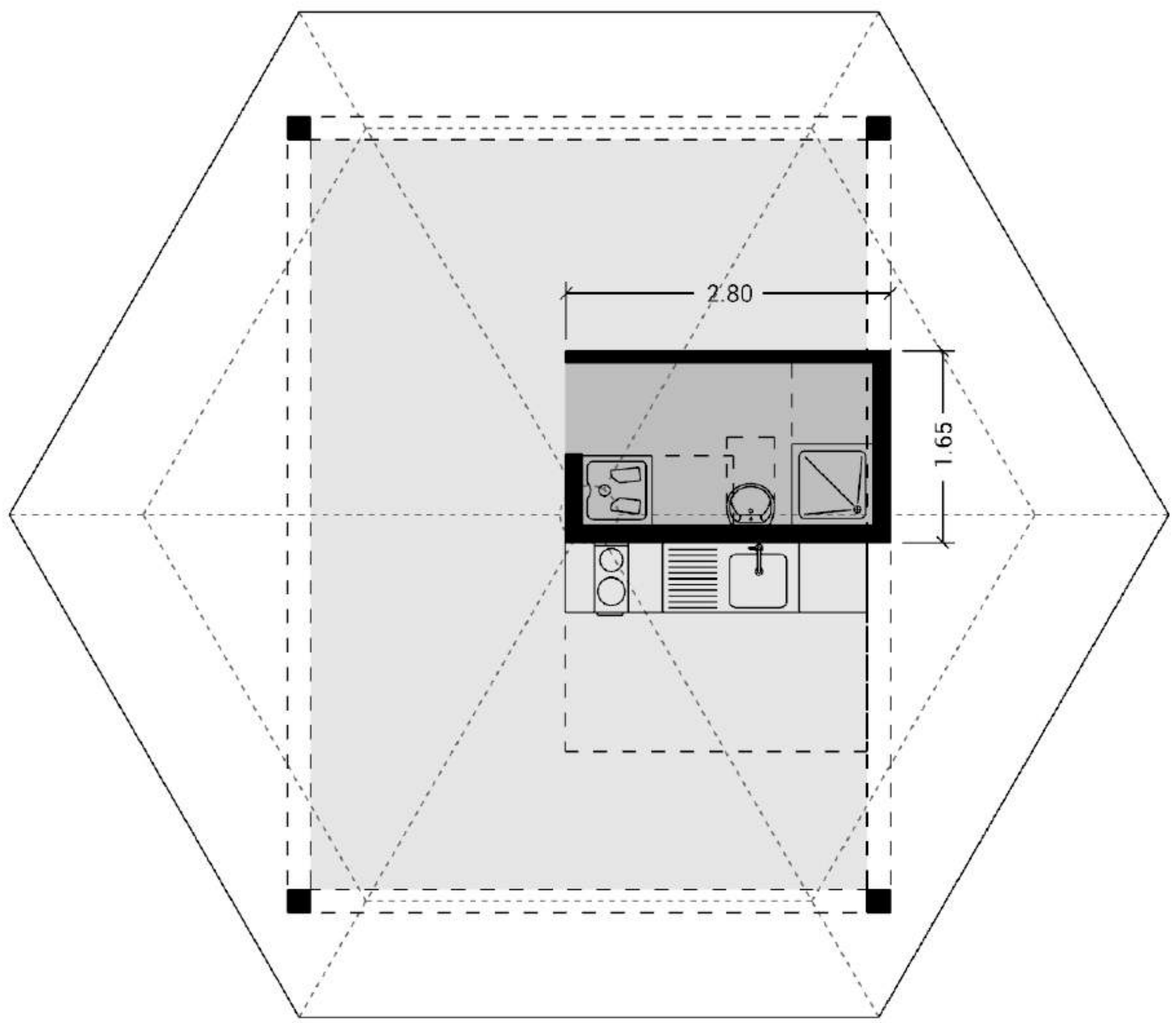
Cheap

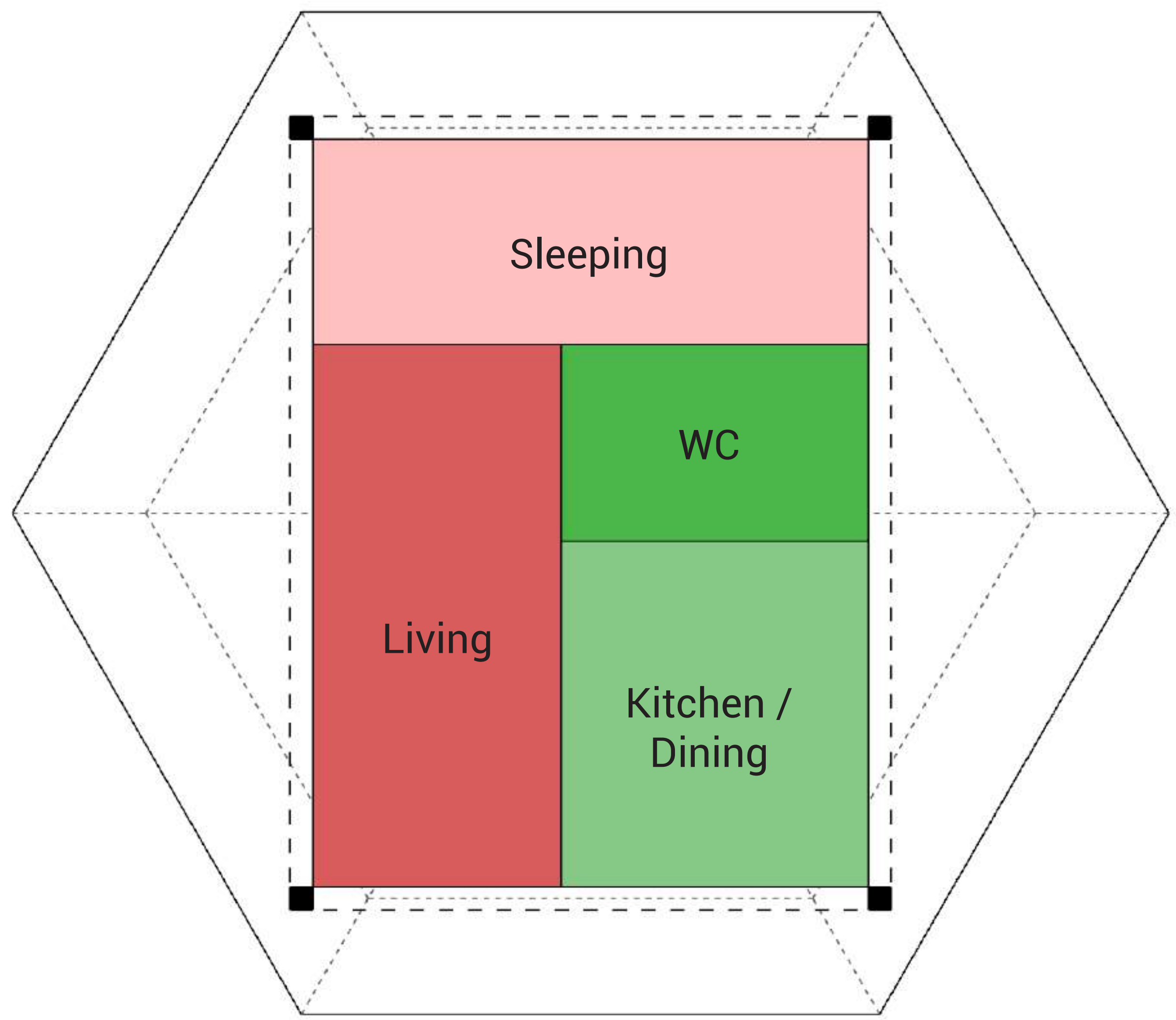
Simple to maintain

Flexible

Kitchen
Shower
Solar Heating
Toilet
35 m2 core

STRUCTURE



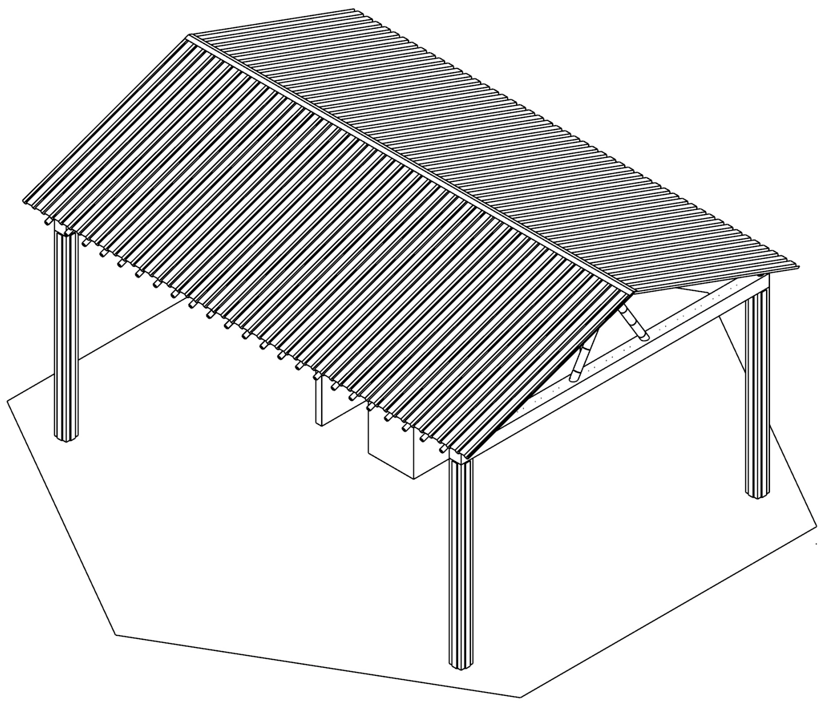


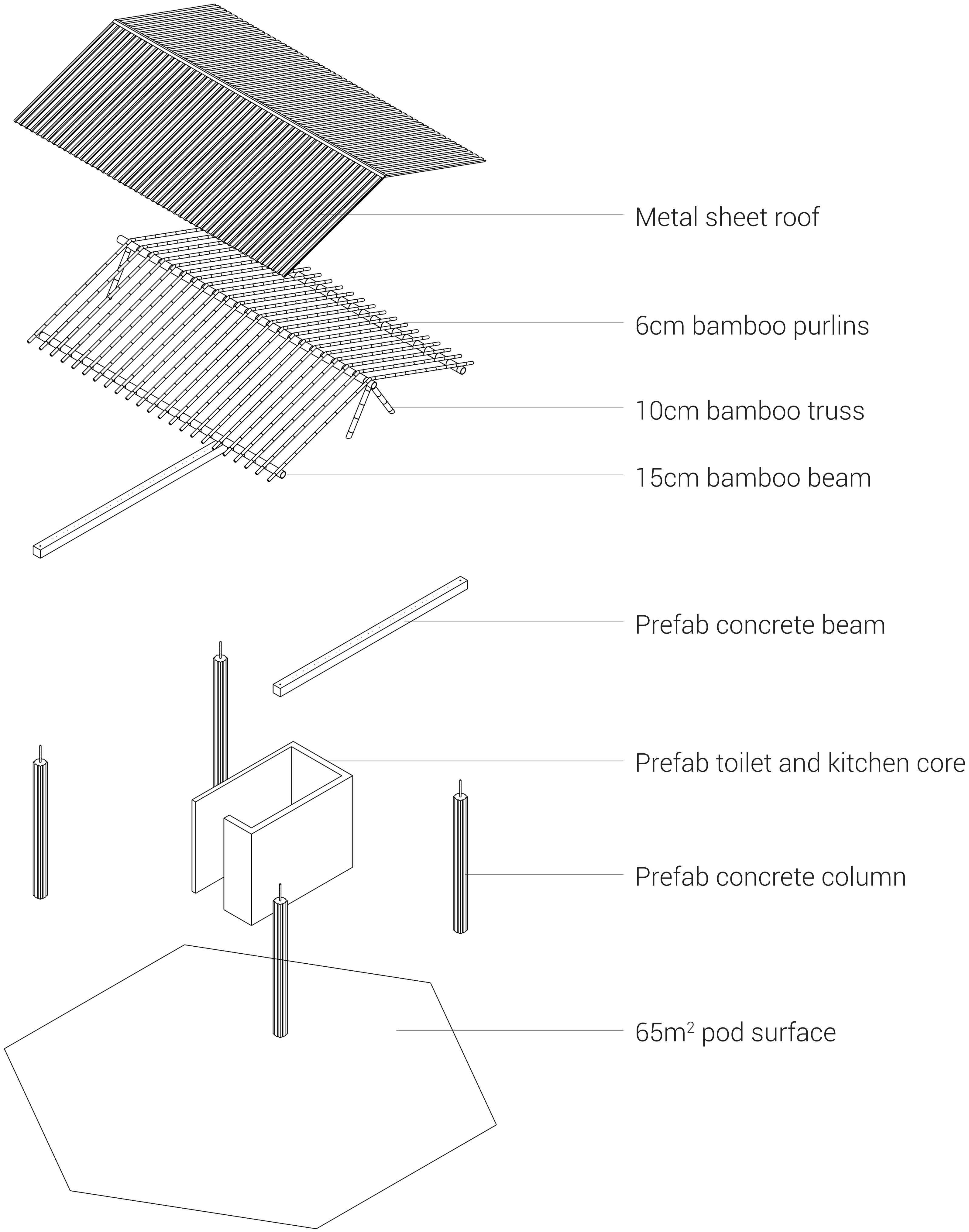
35 m2 / floor

5-7 people

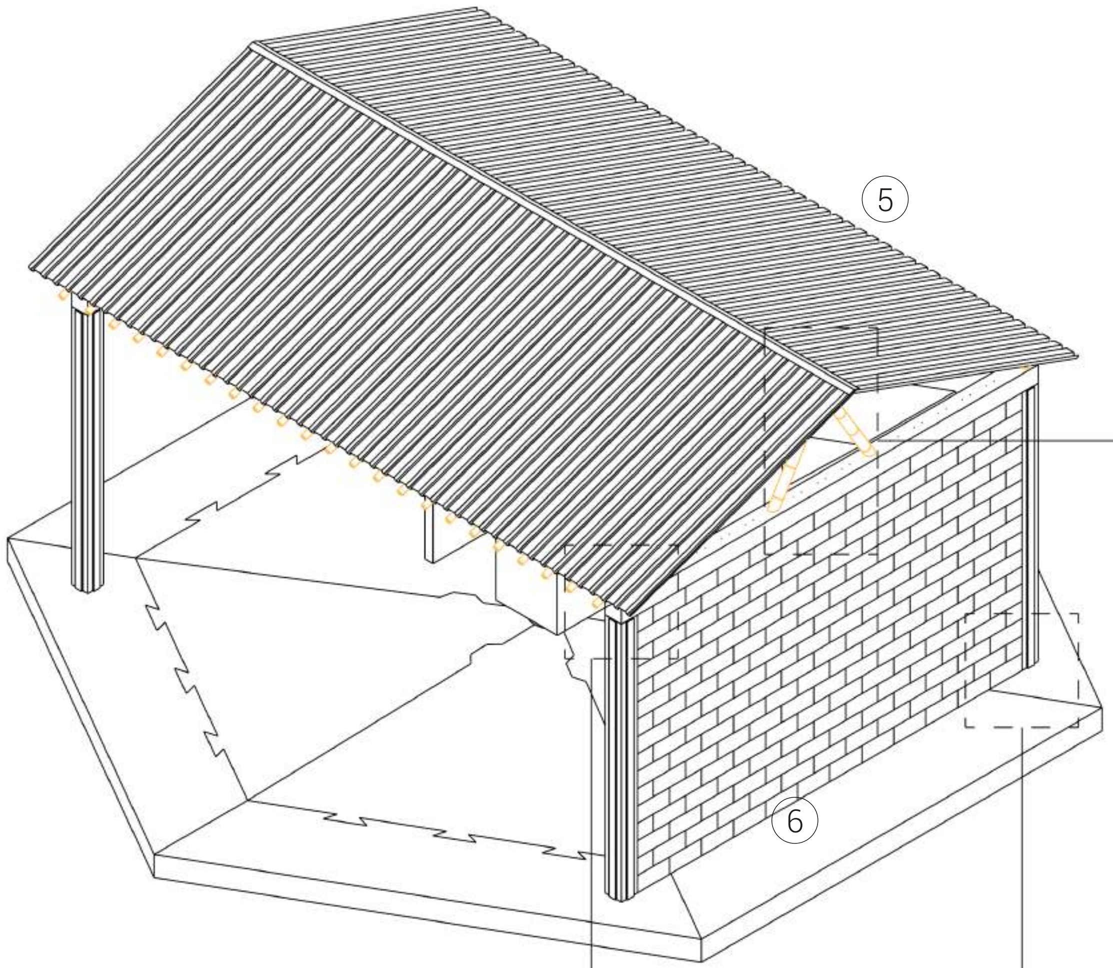
Prefab elements

Local materials

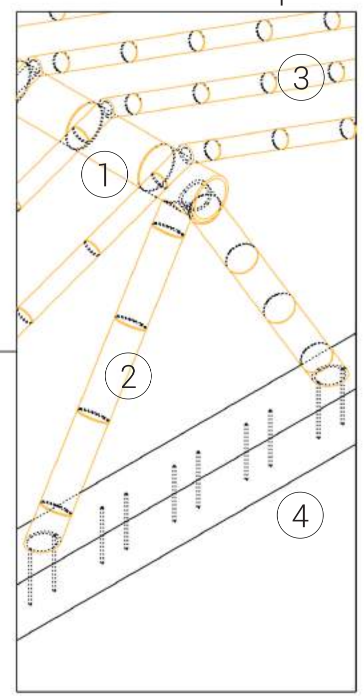




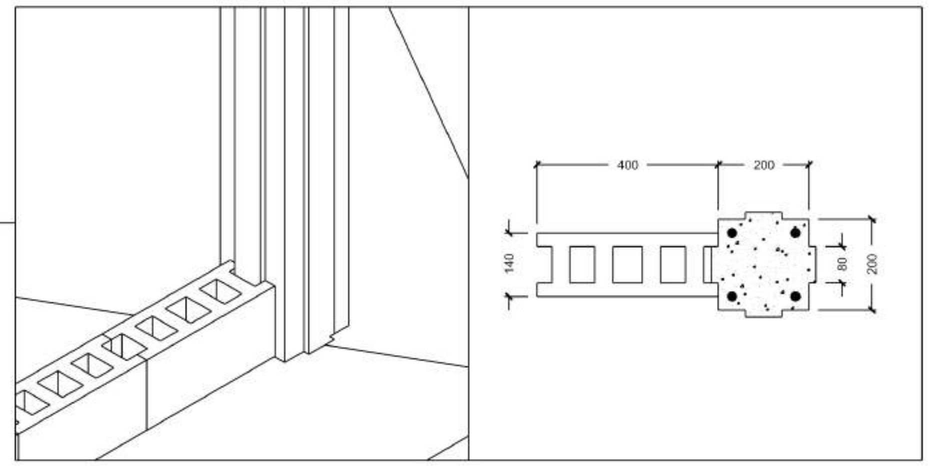
Prefab Columns & Bamboo Roof



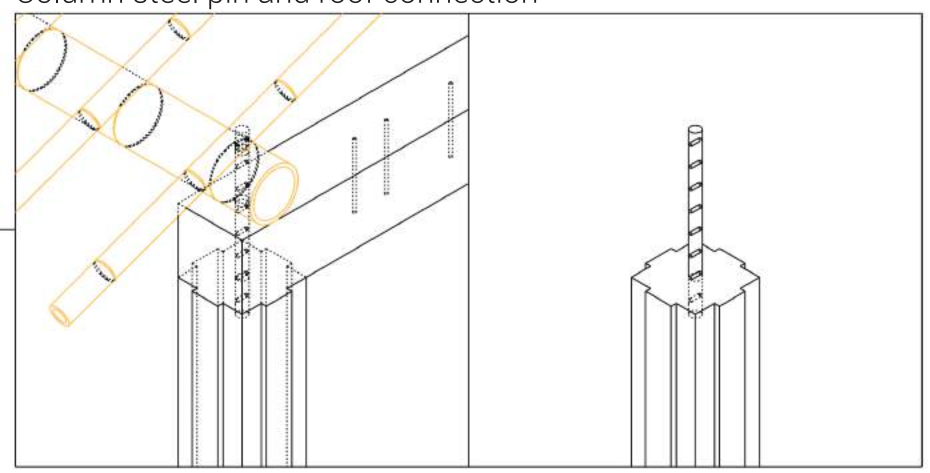
Bamboo truss and purlins



Column section and hollow concrete brick

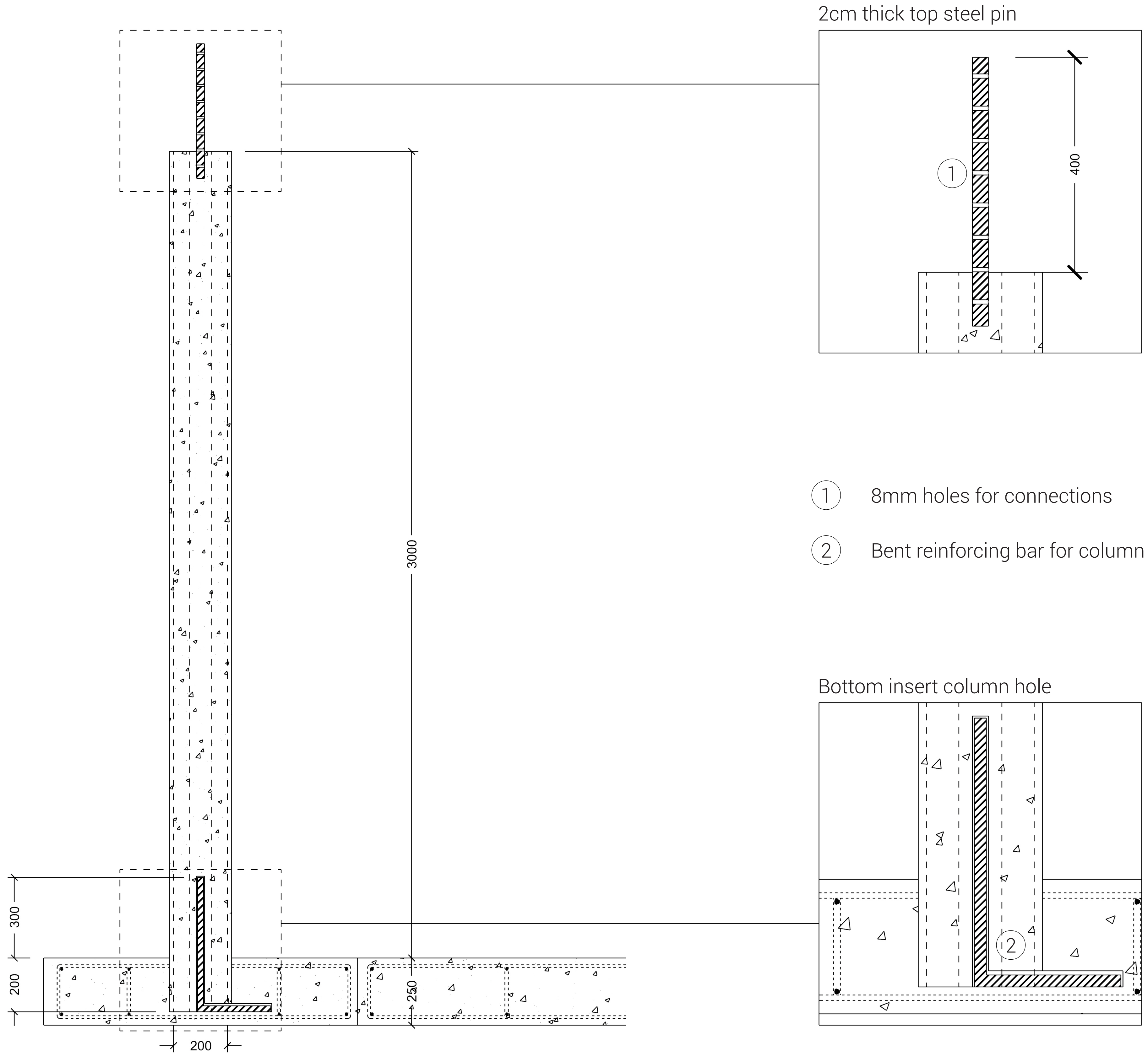


Column steel pin and roof connection



1. 15cm bamboo beam
2. 10cm bamboo beam
3. 6cm bamboo purlin
4. 20x20cm reinforced concrete beam
5. 20 degree angle corrugated steel roof
6. Potential DIY hollow brick wall

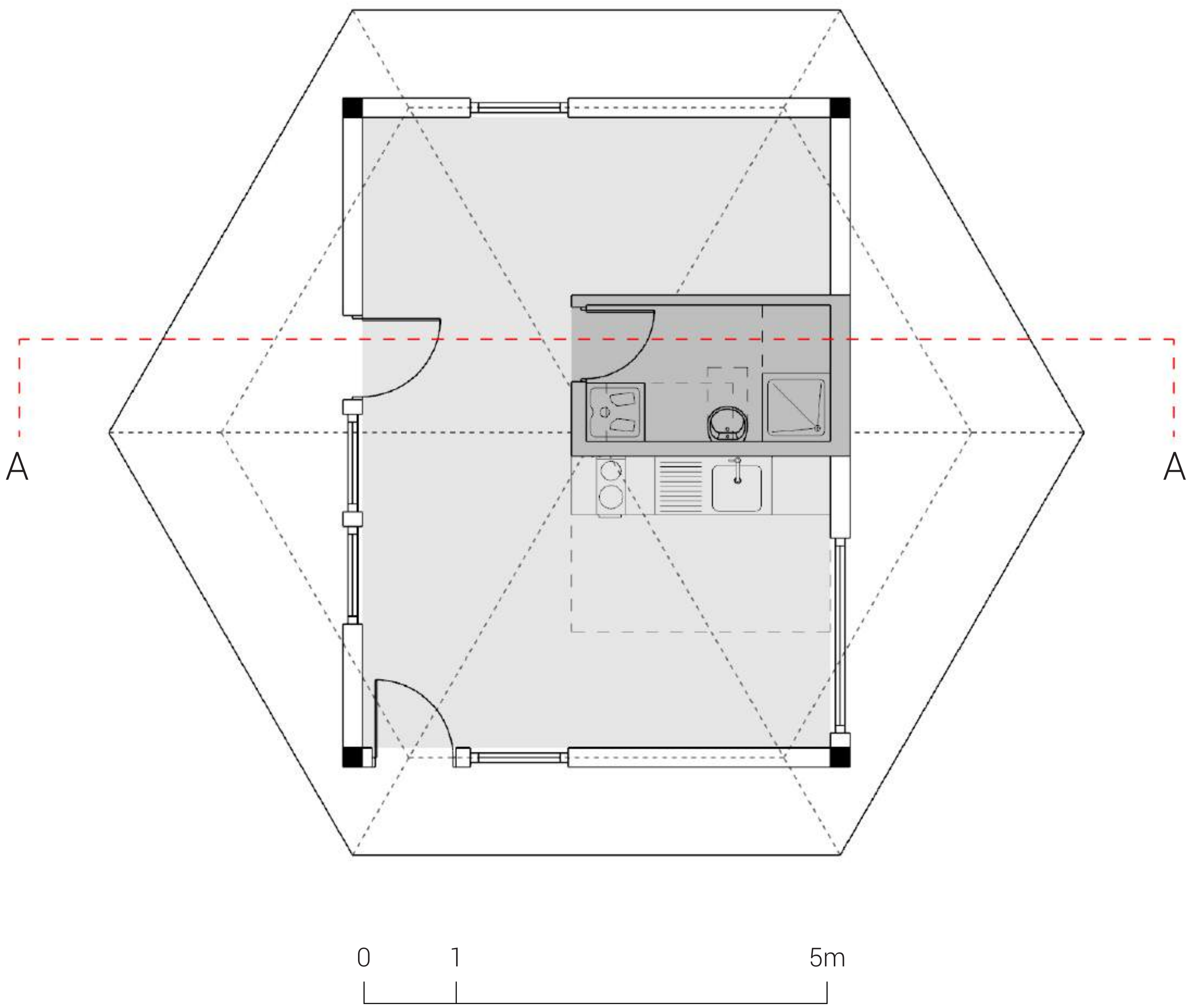
Column to Cap connection

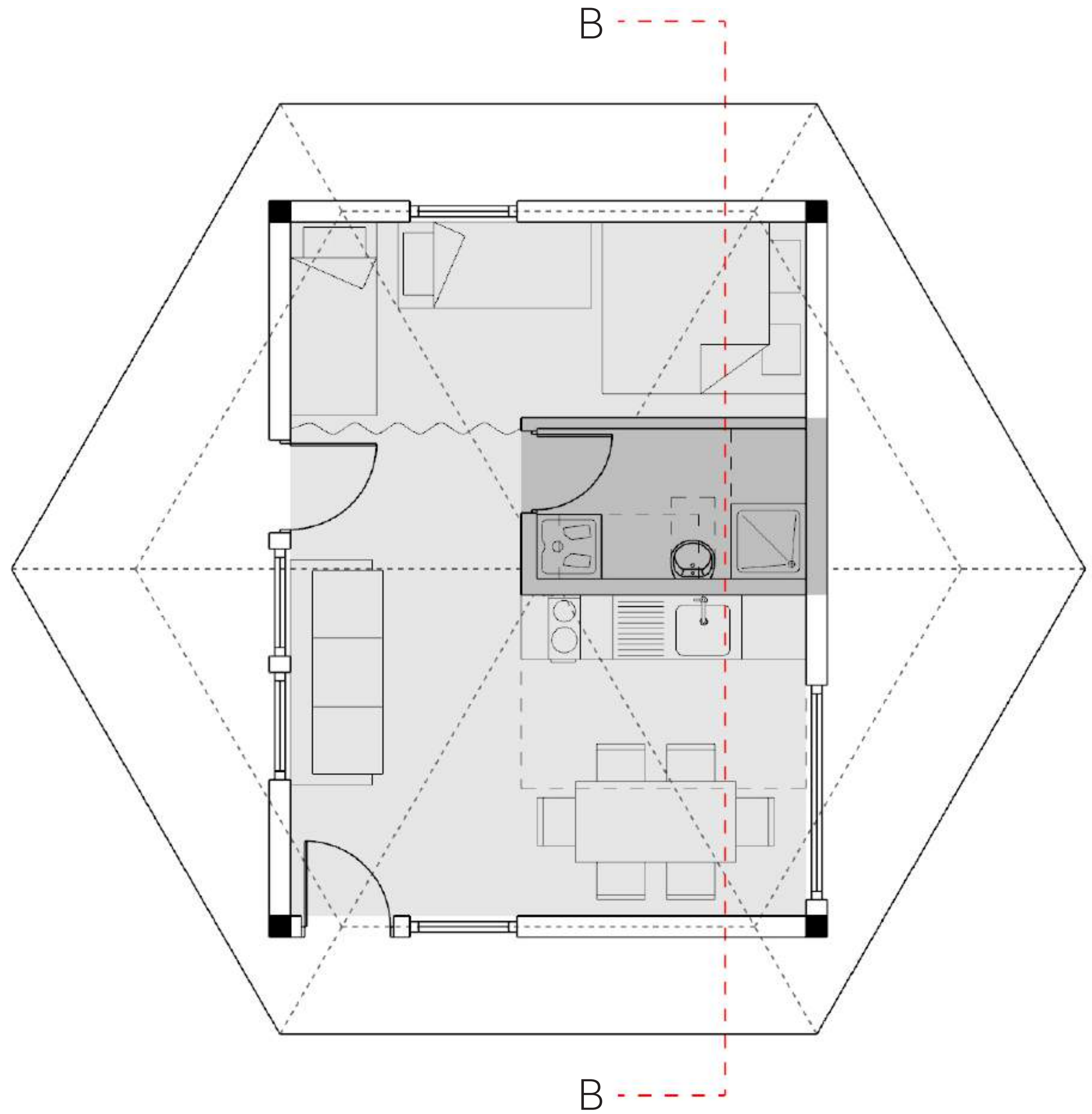


1 8mm holes for connections

2 Bent reinforcing bar for column

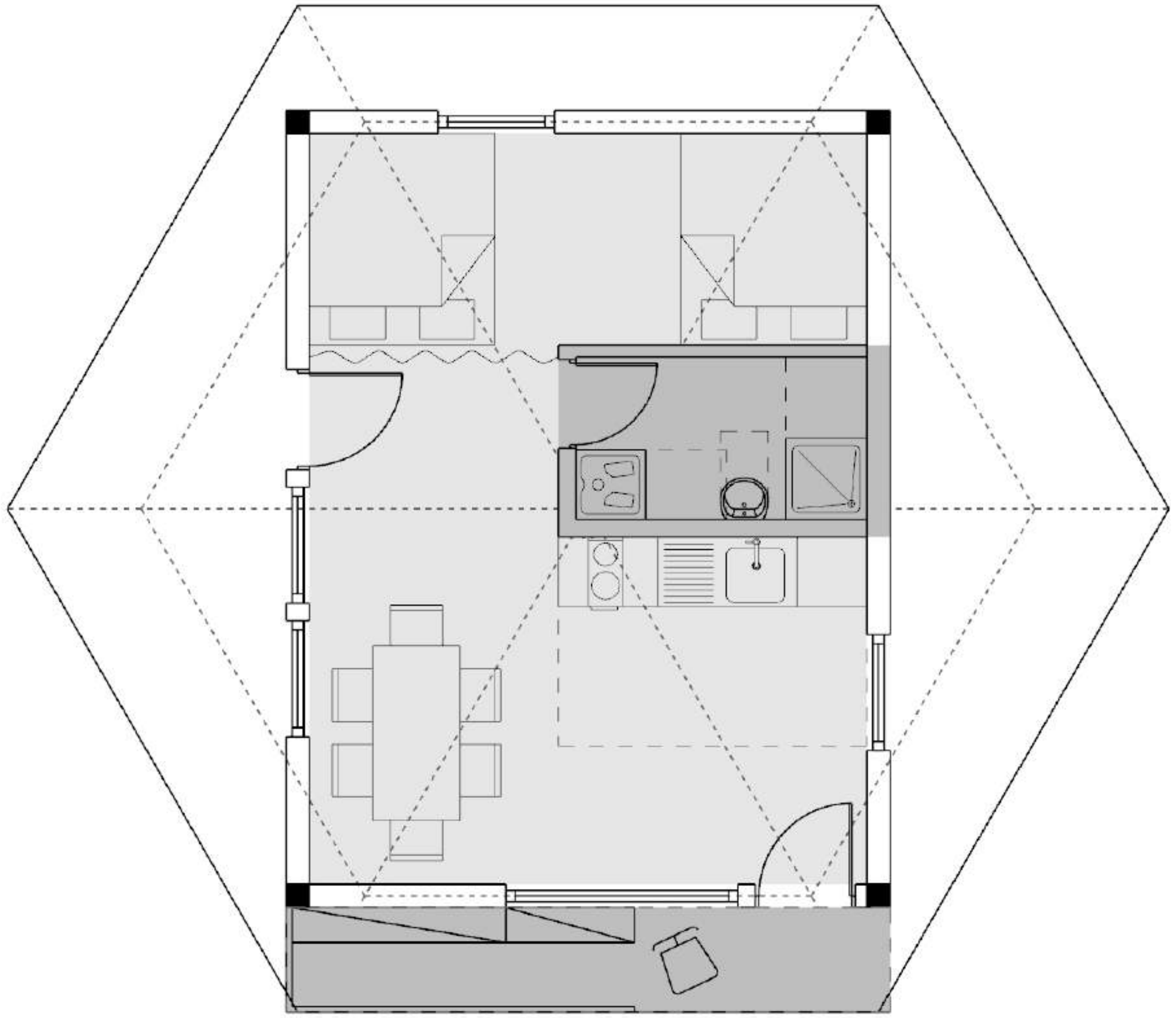
Basic plan



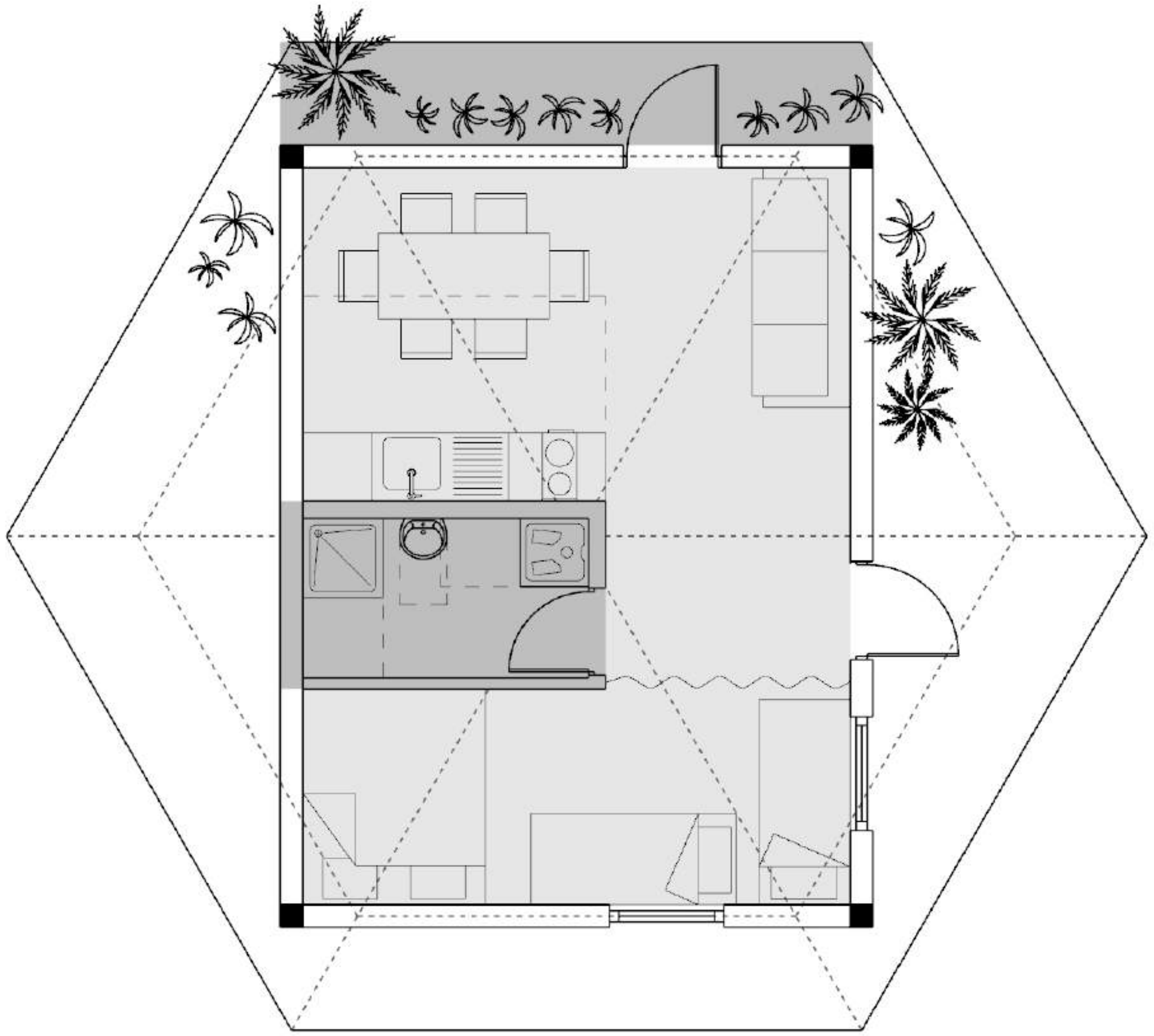


Plan variations

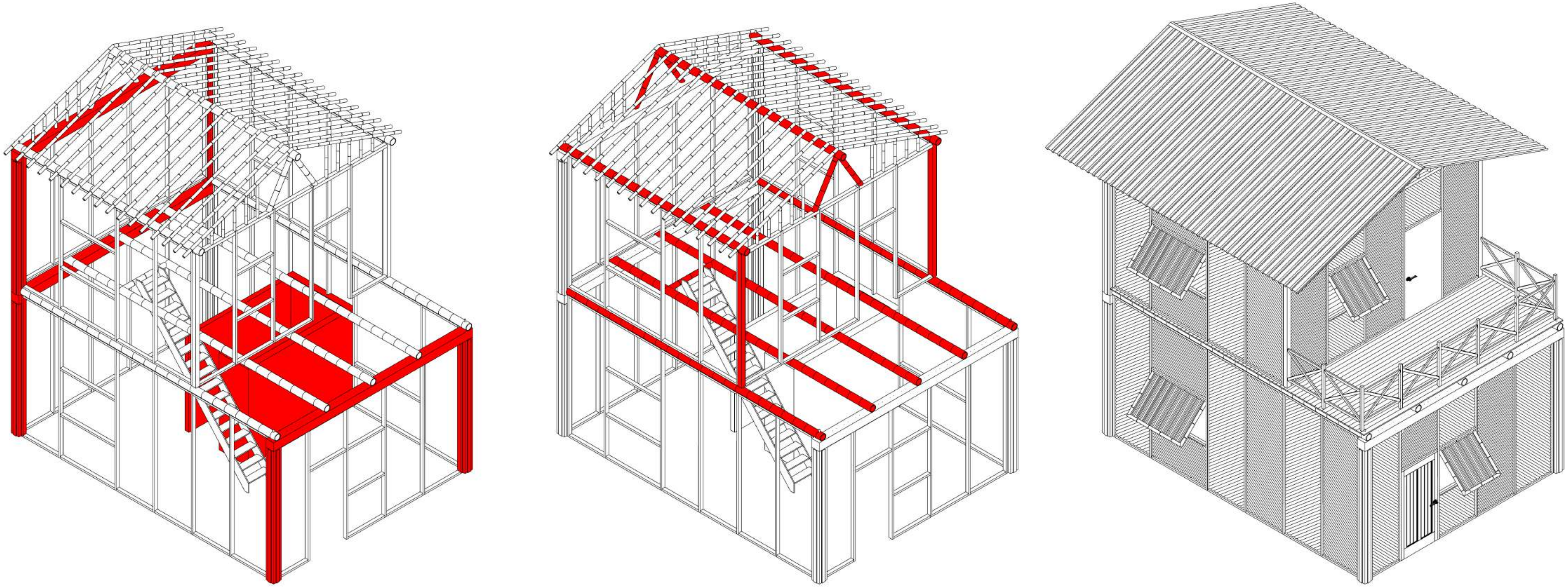
Front shop



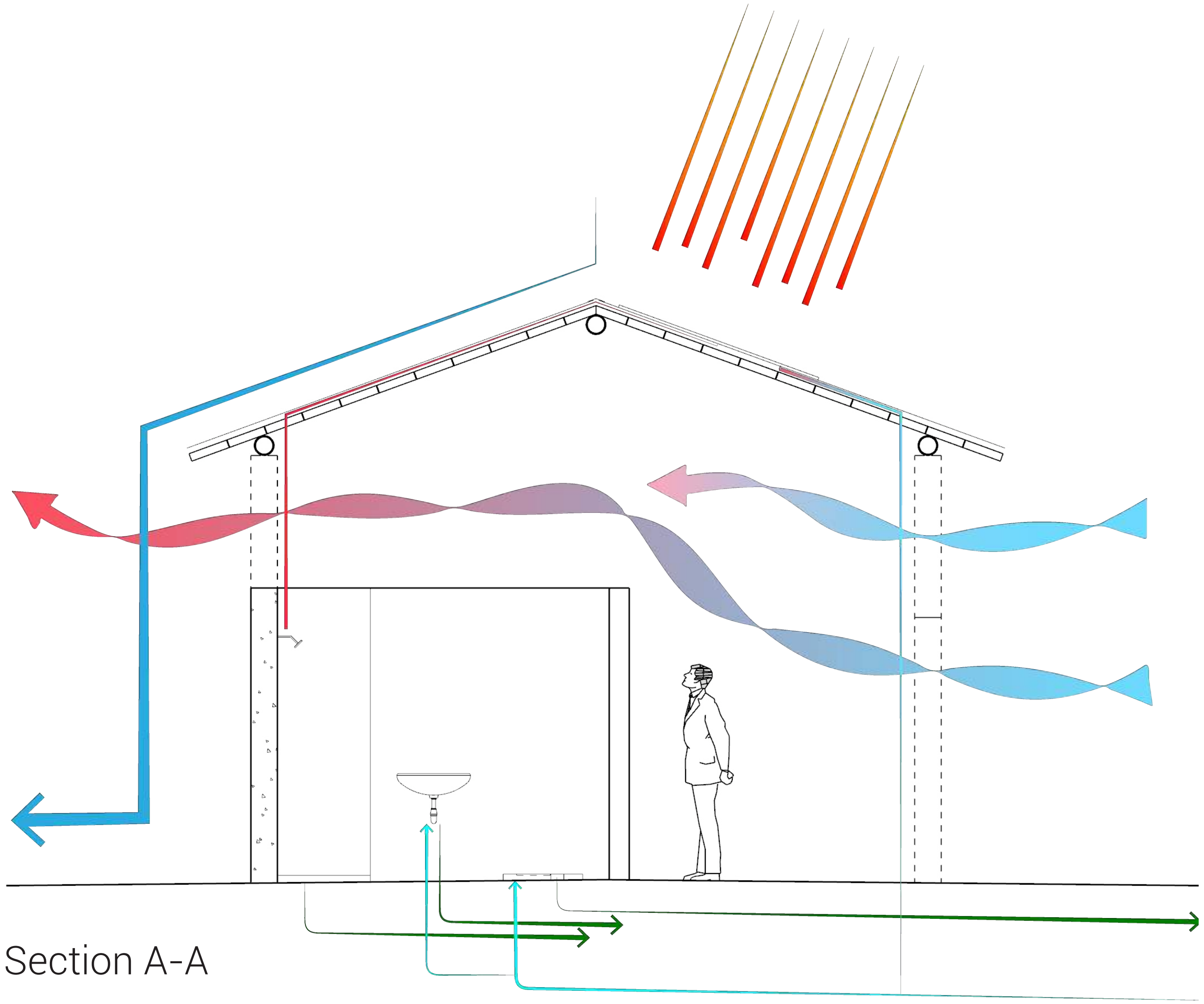
Back garden



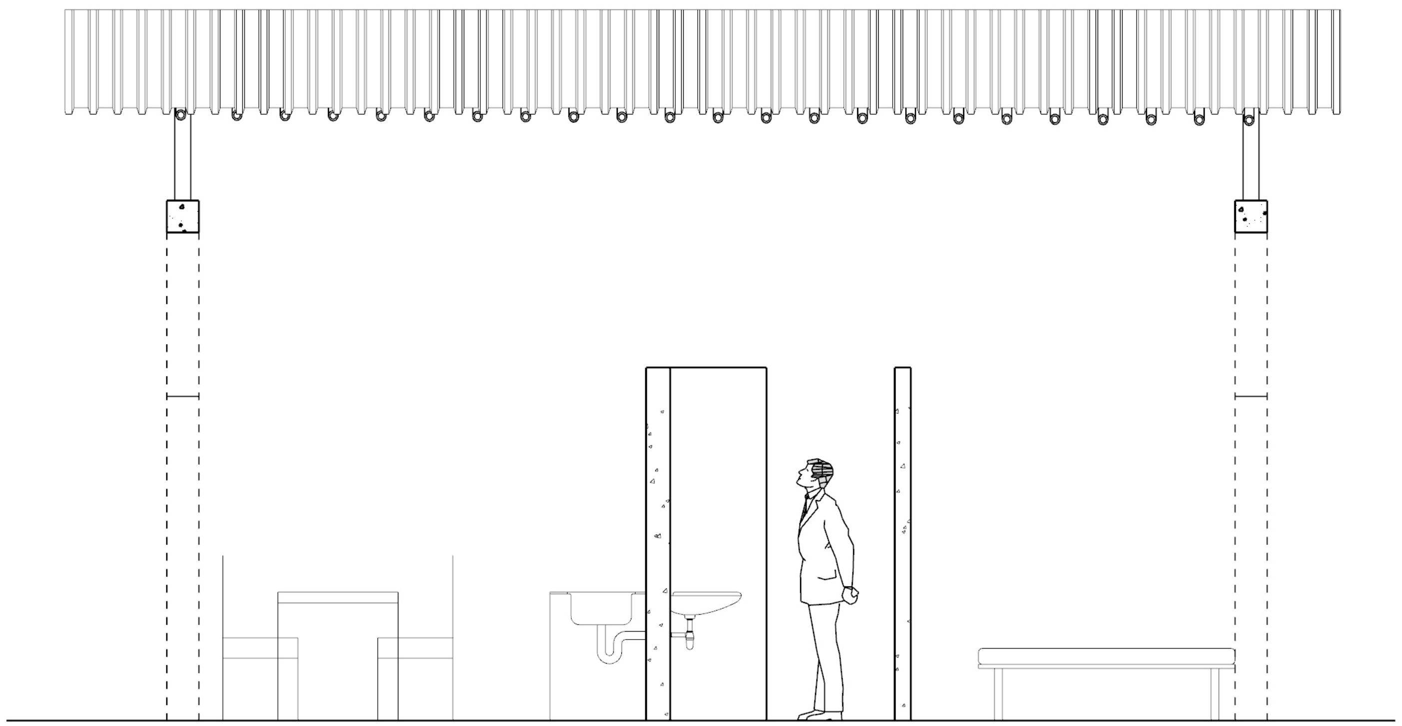
Construction



Climate section

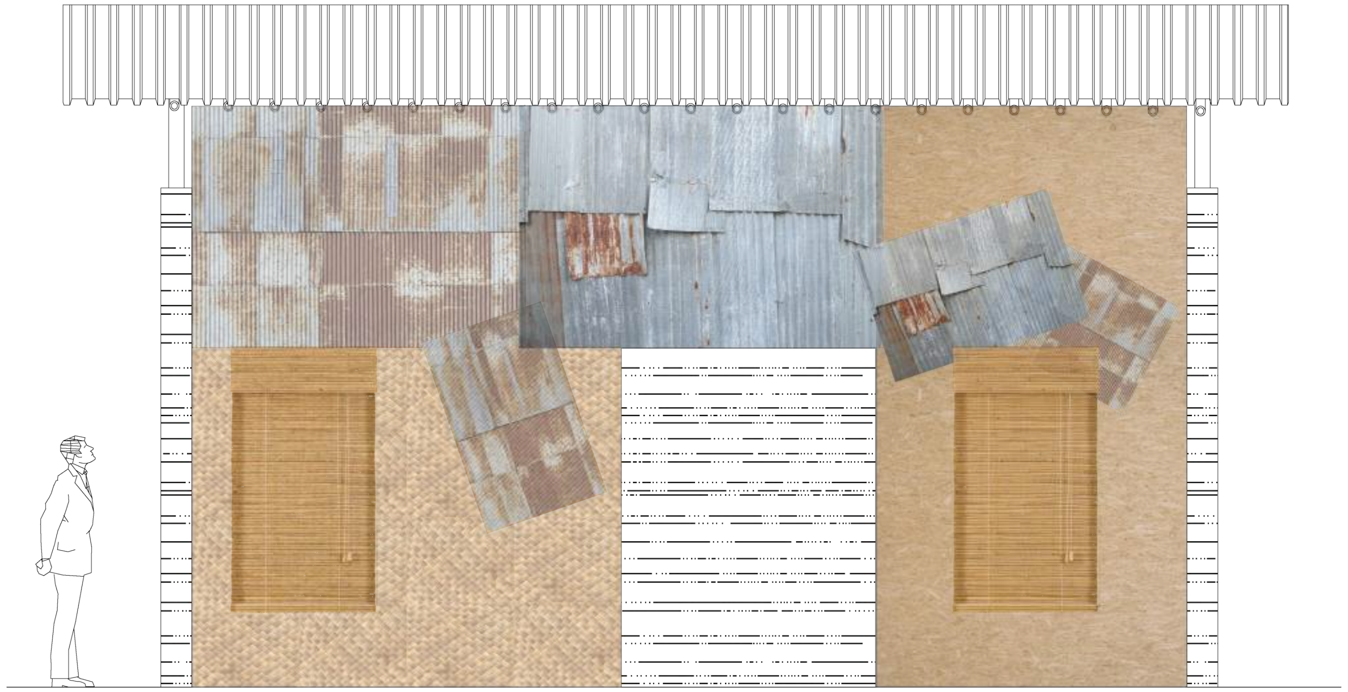


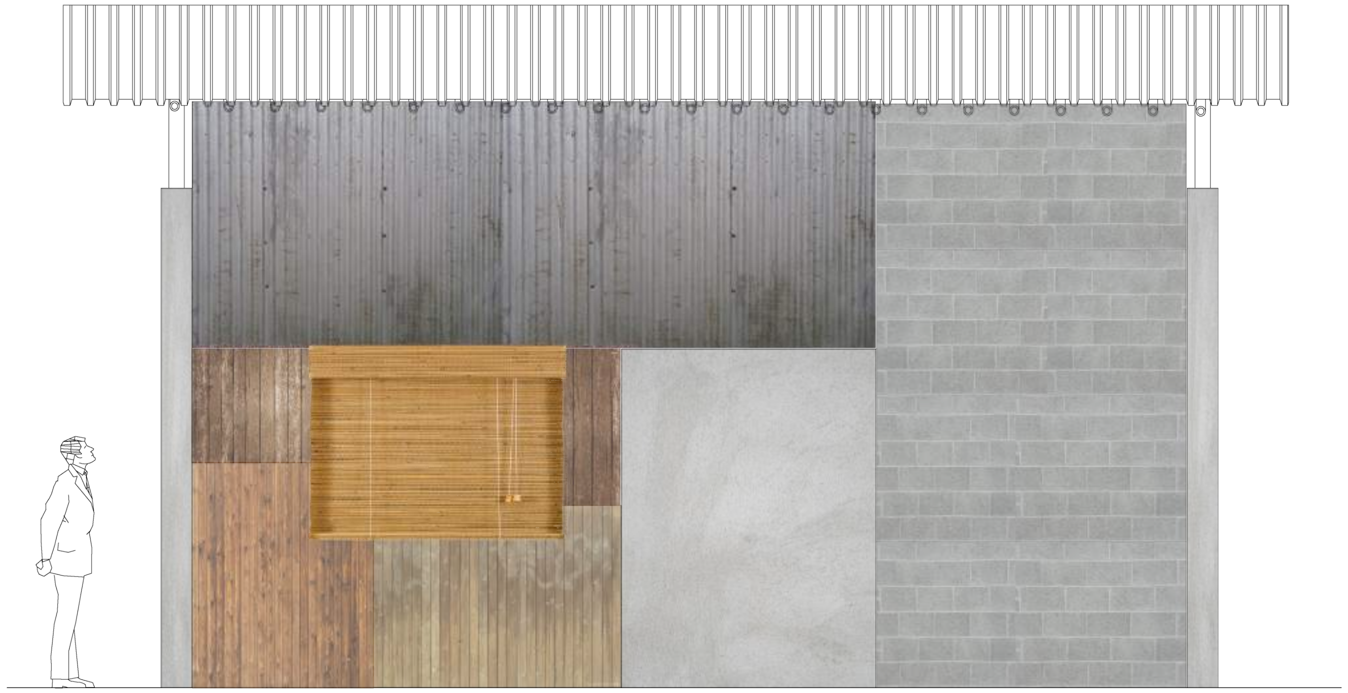
Section A-A



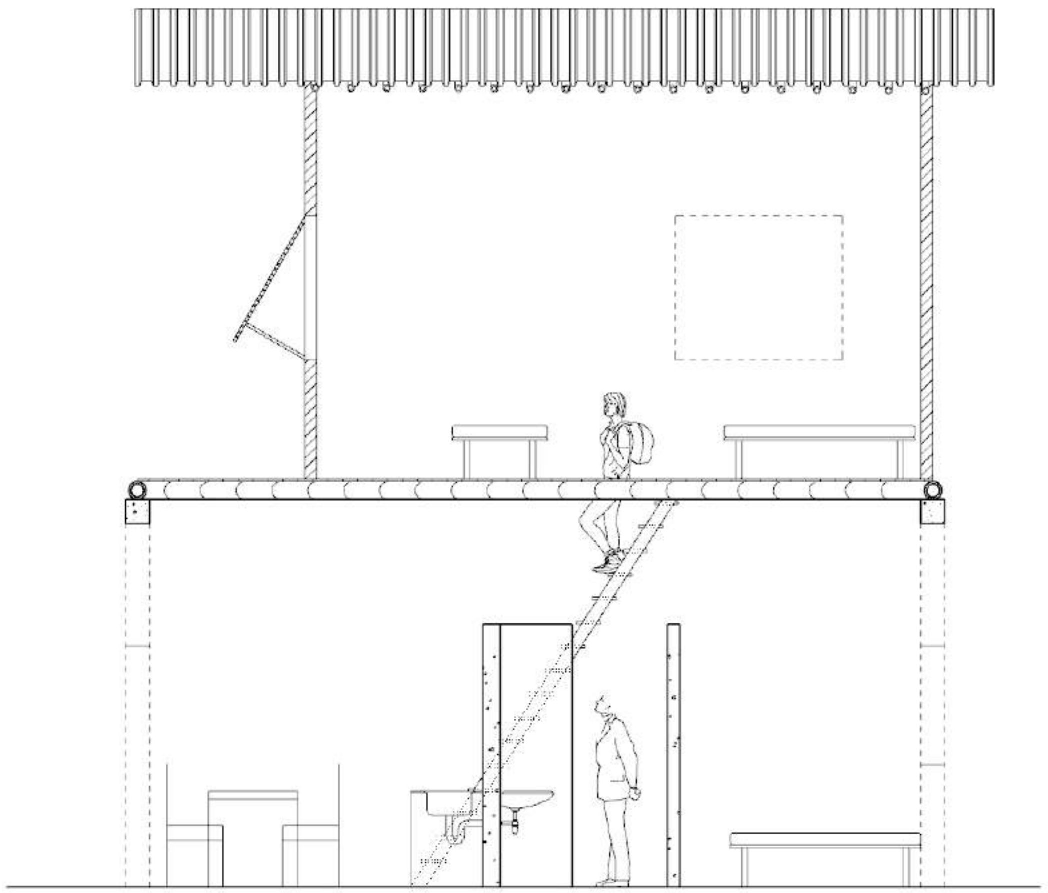
Section B-B

INFILL



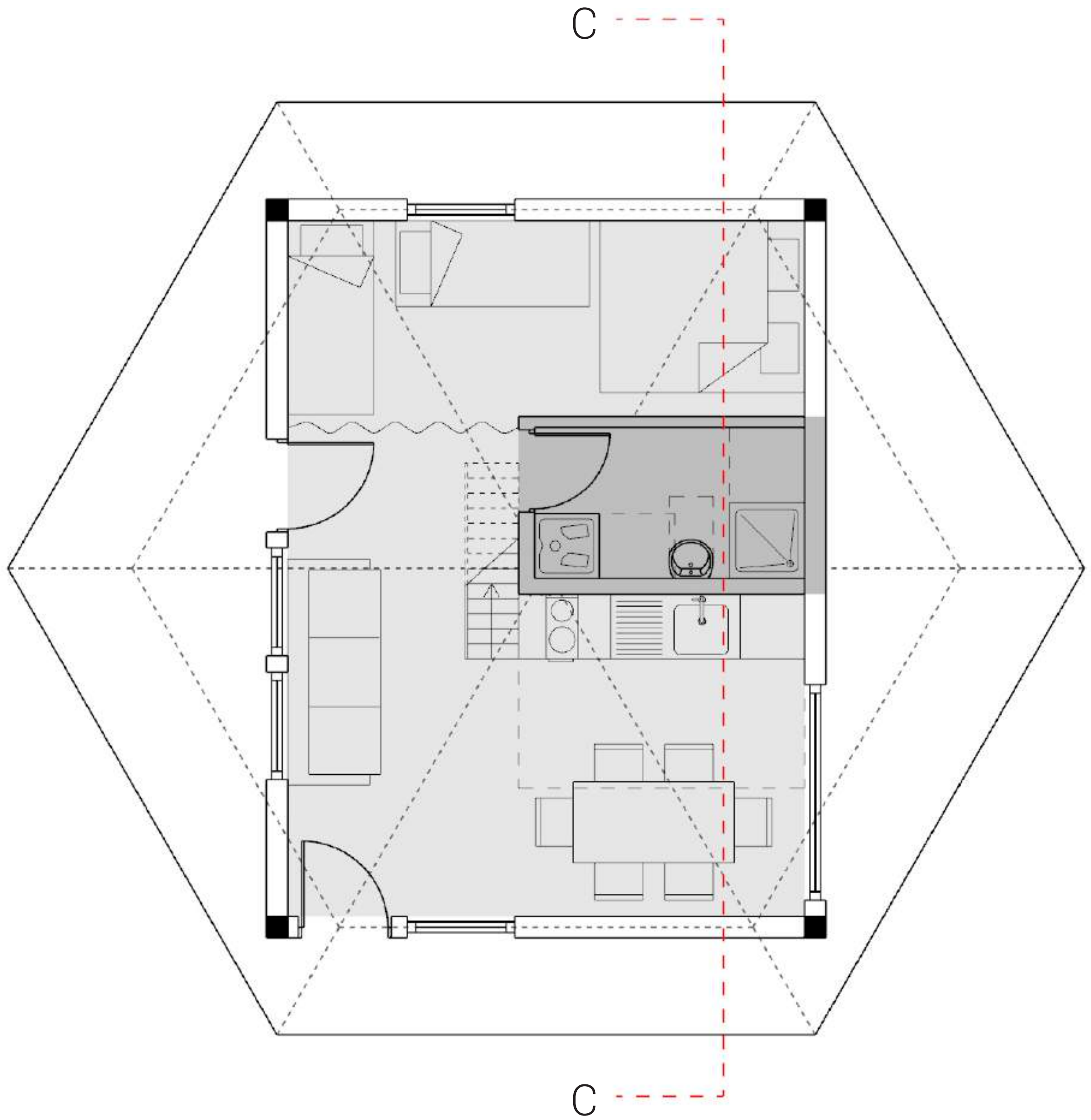


DIY extension



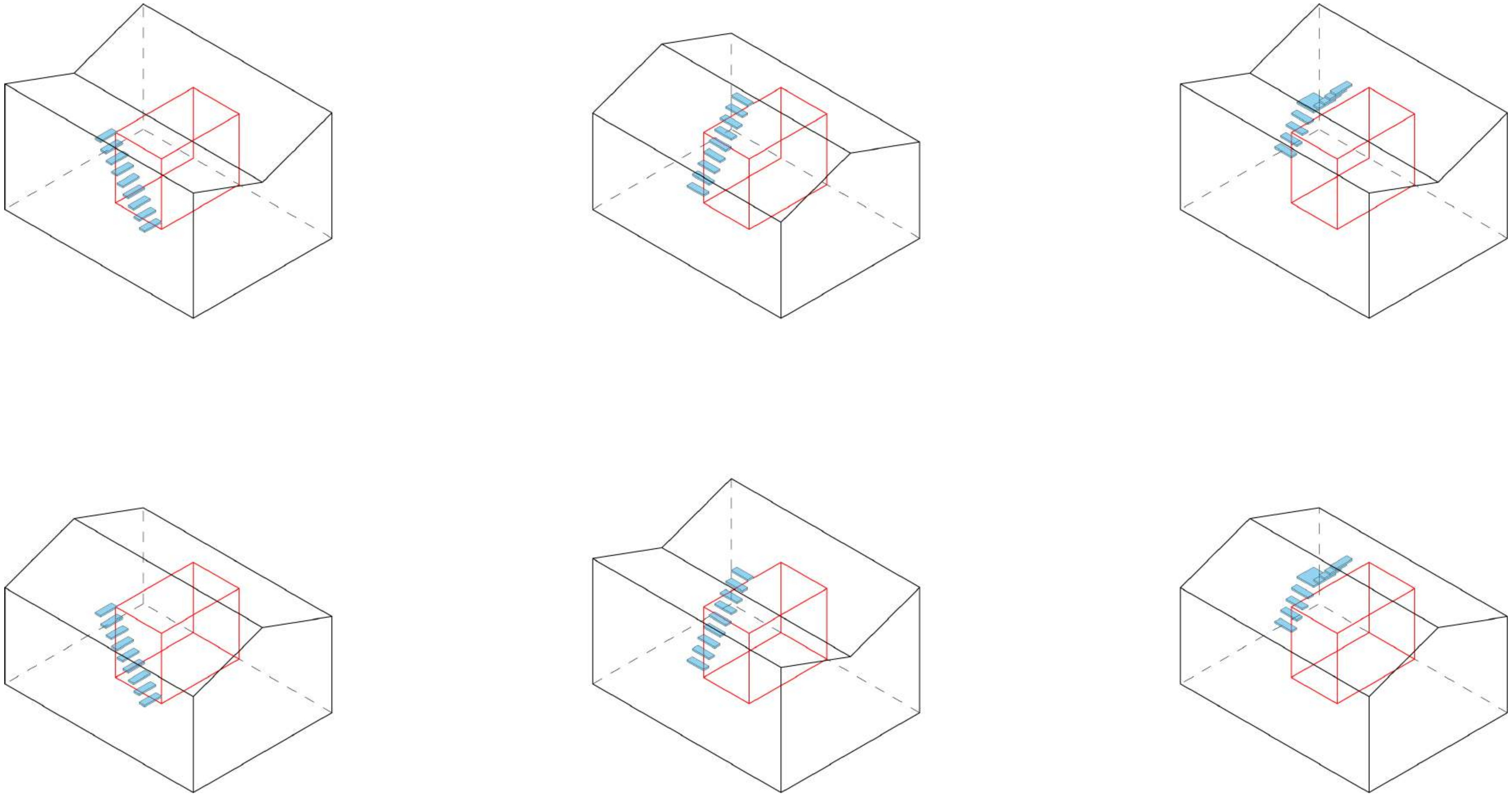
Section C-C

0 1 5m

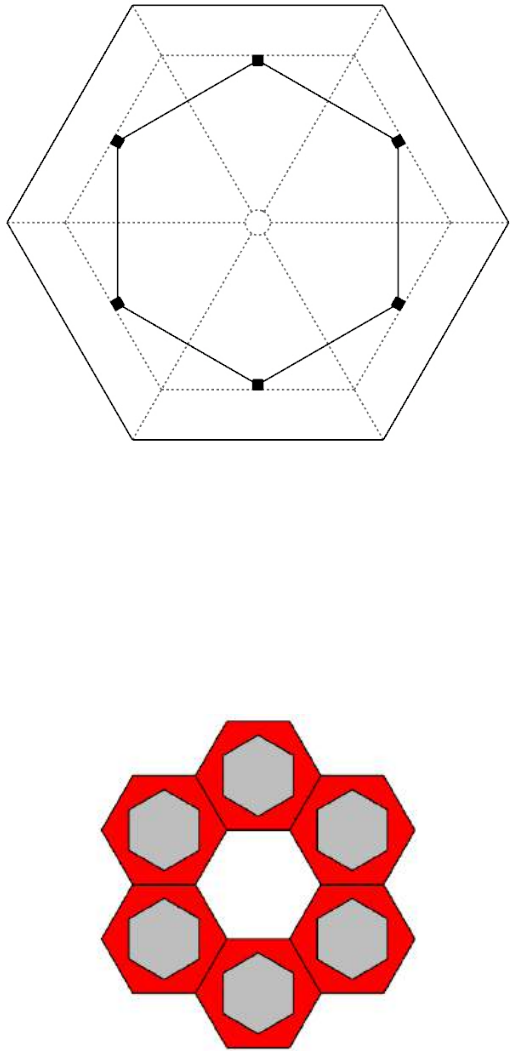


Appropriation and Improvement

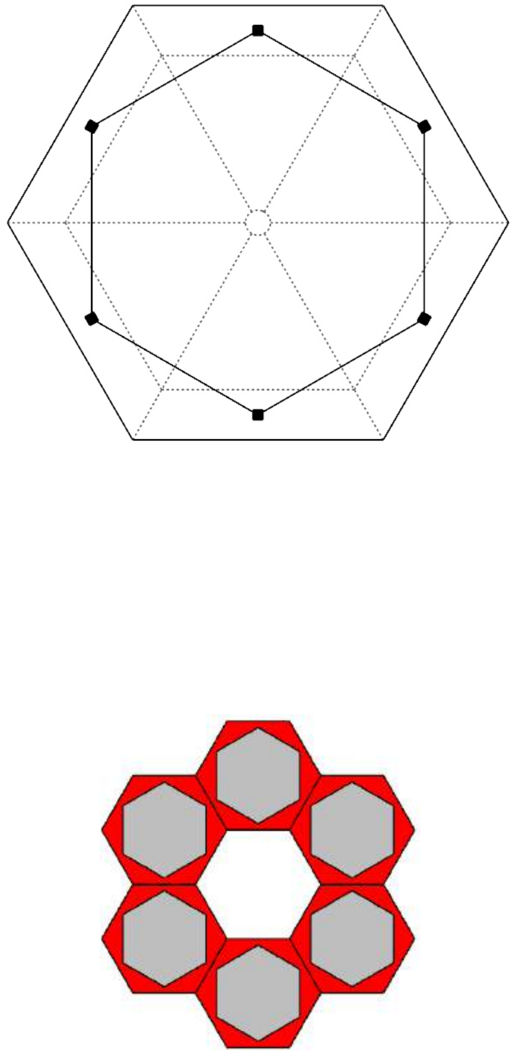
Exploring other house typologies



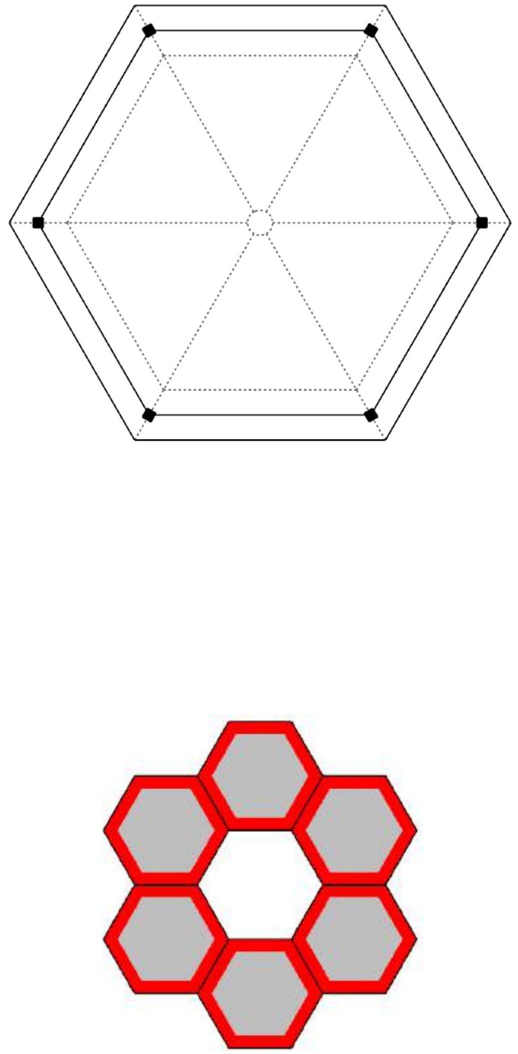
Hexagonal options



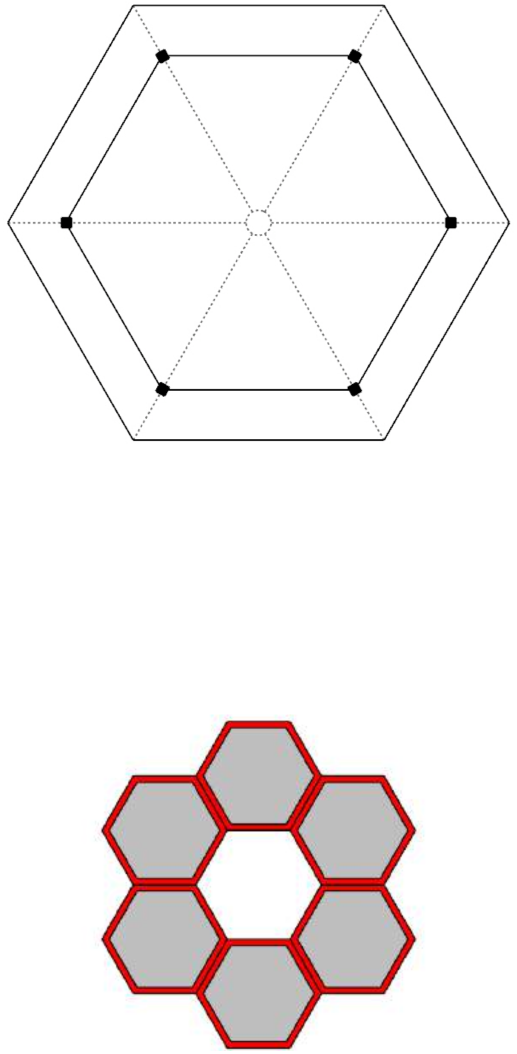
27 m^2
2m between houses



38 m^2
0.8m between houses

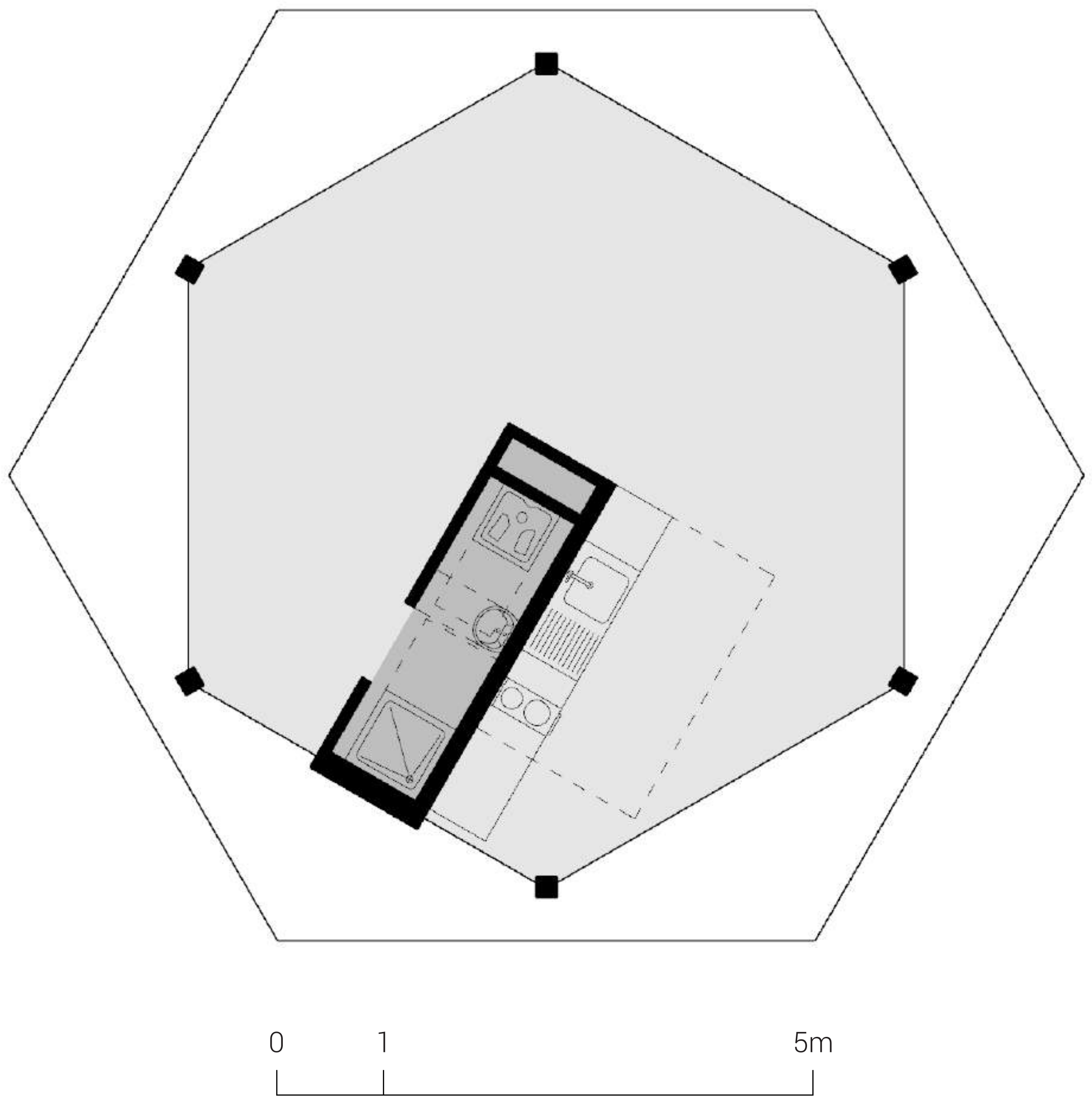


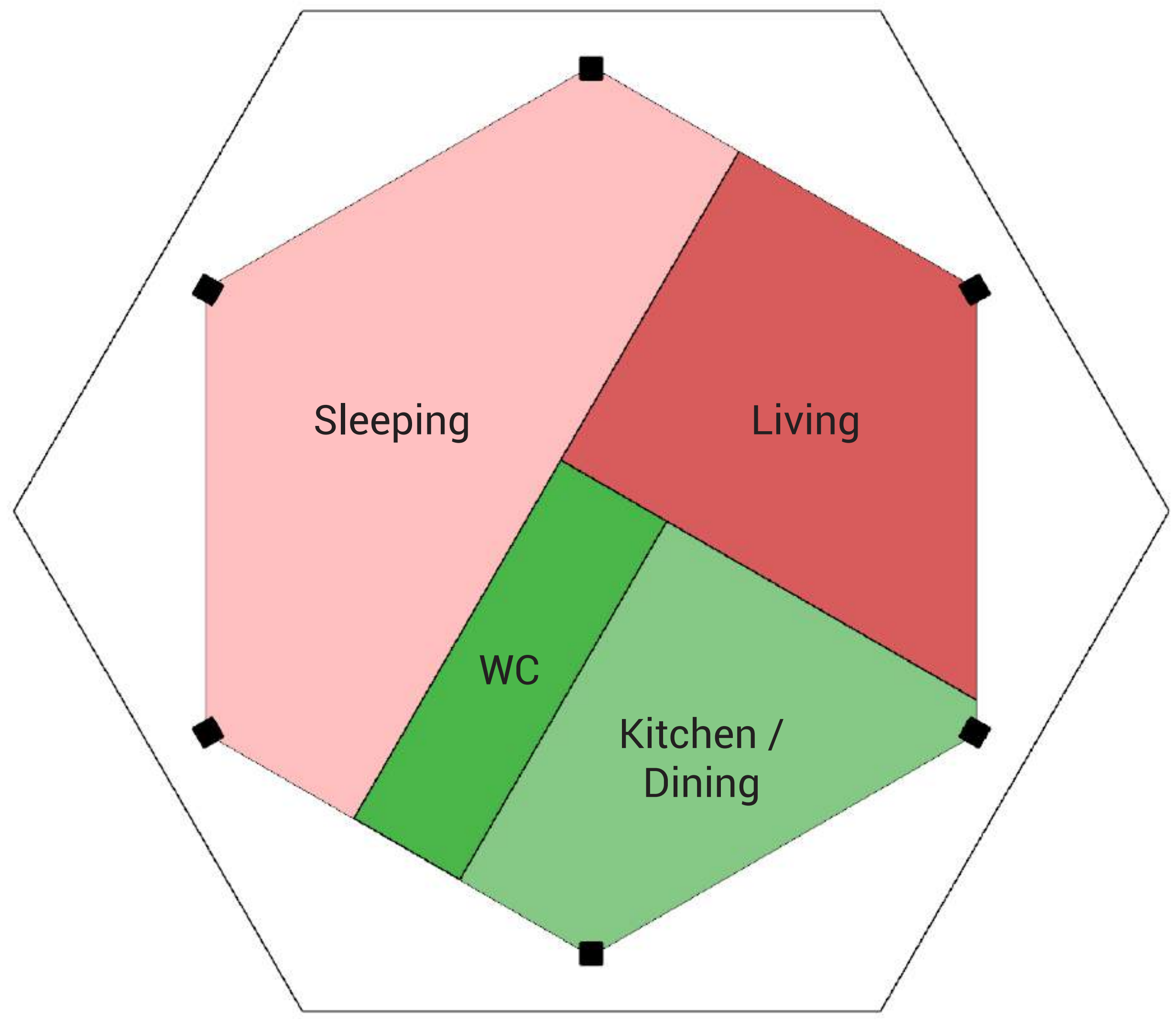
38 m^2
1.7m between houses



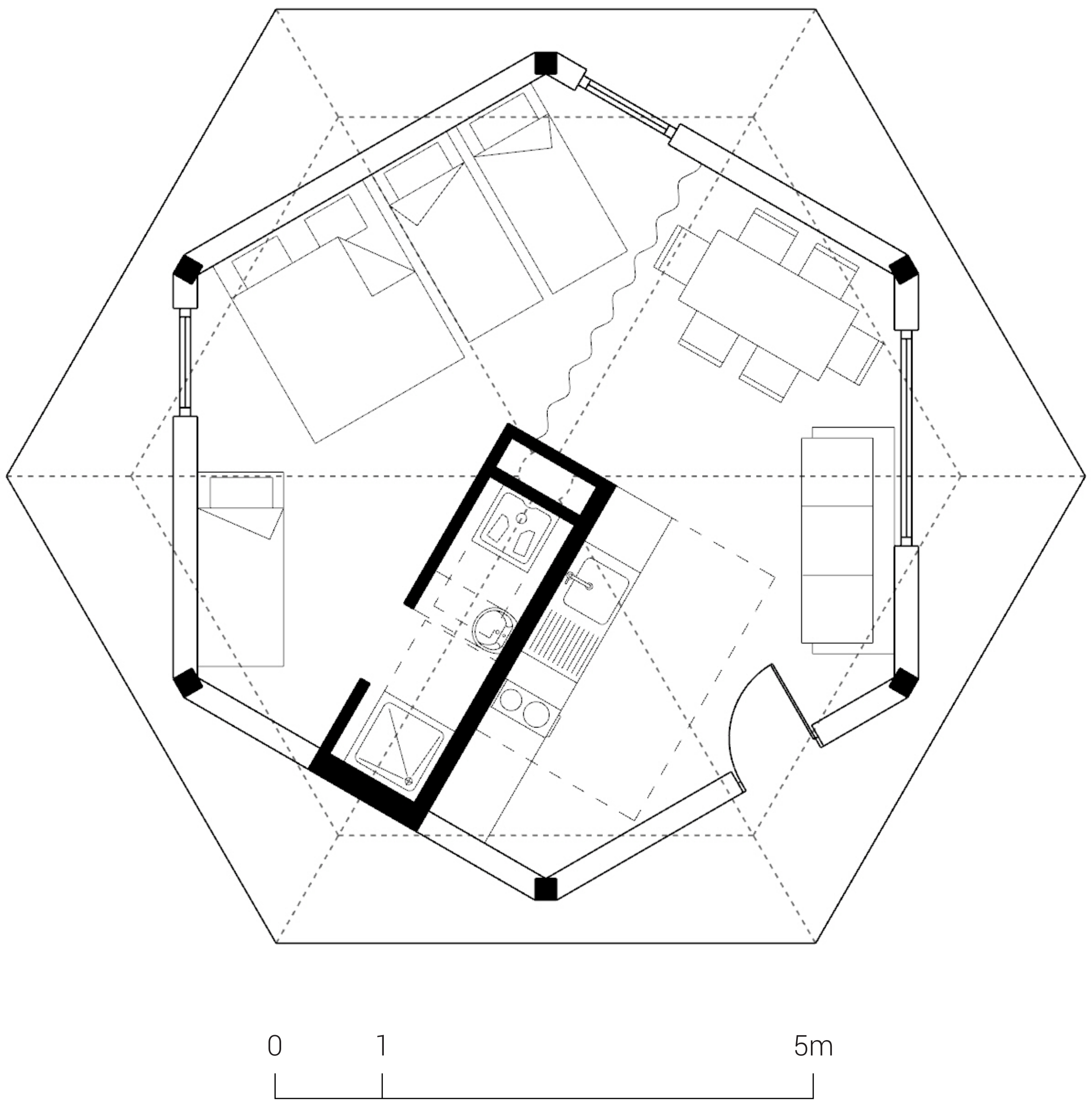
38 m^2
0.7m between houses

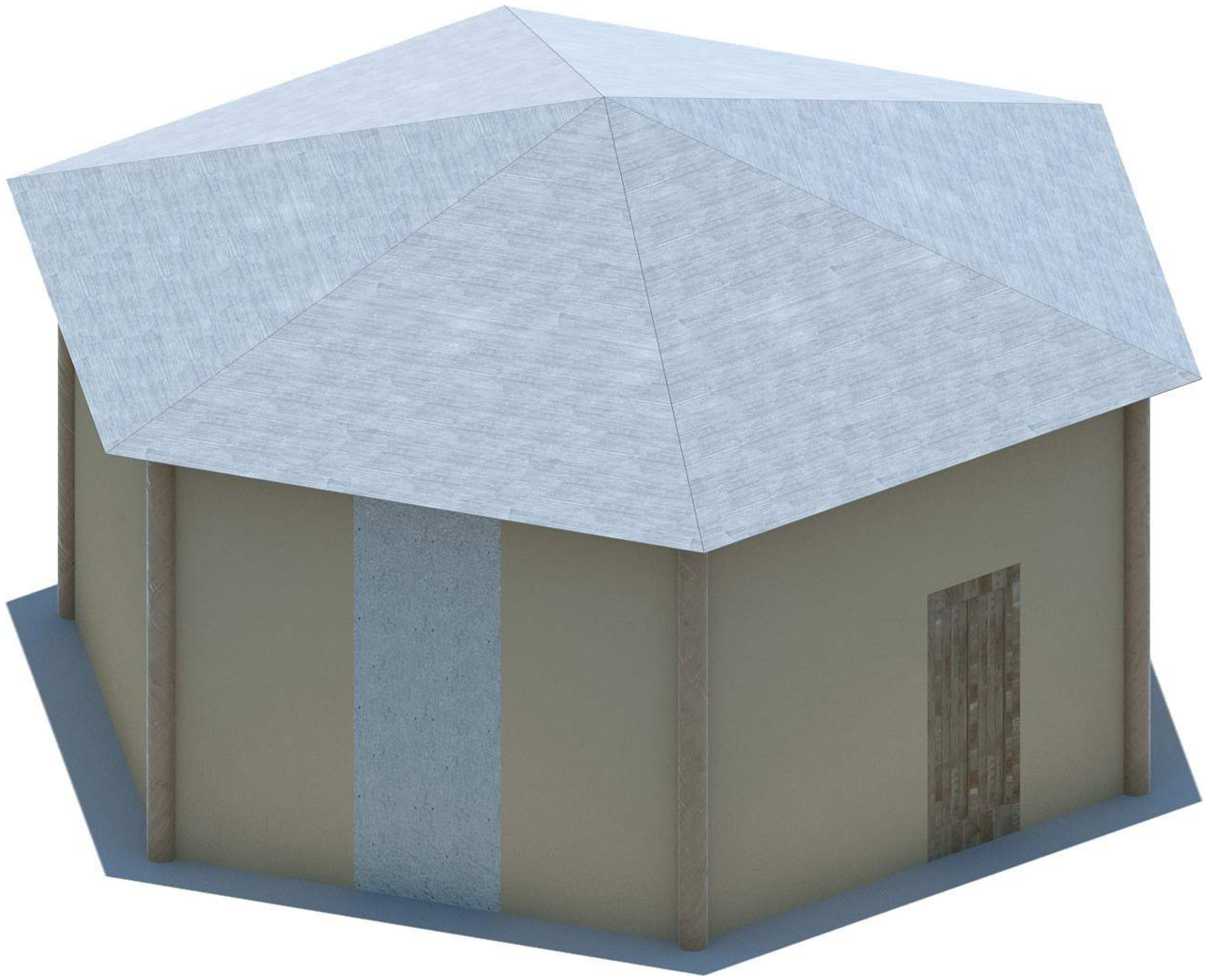
Hexagonal floorplan





Hexagonal volume

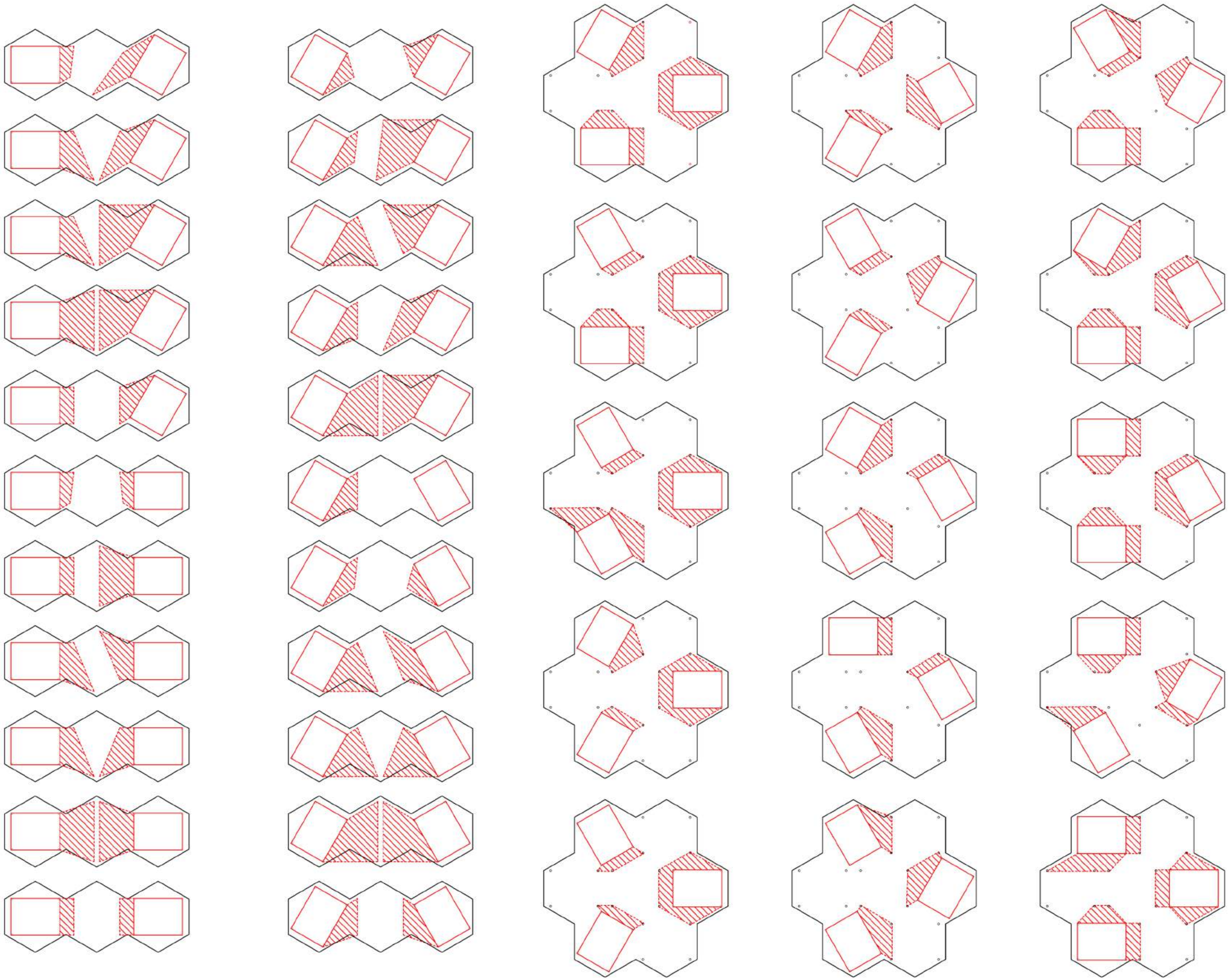




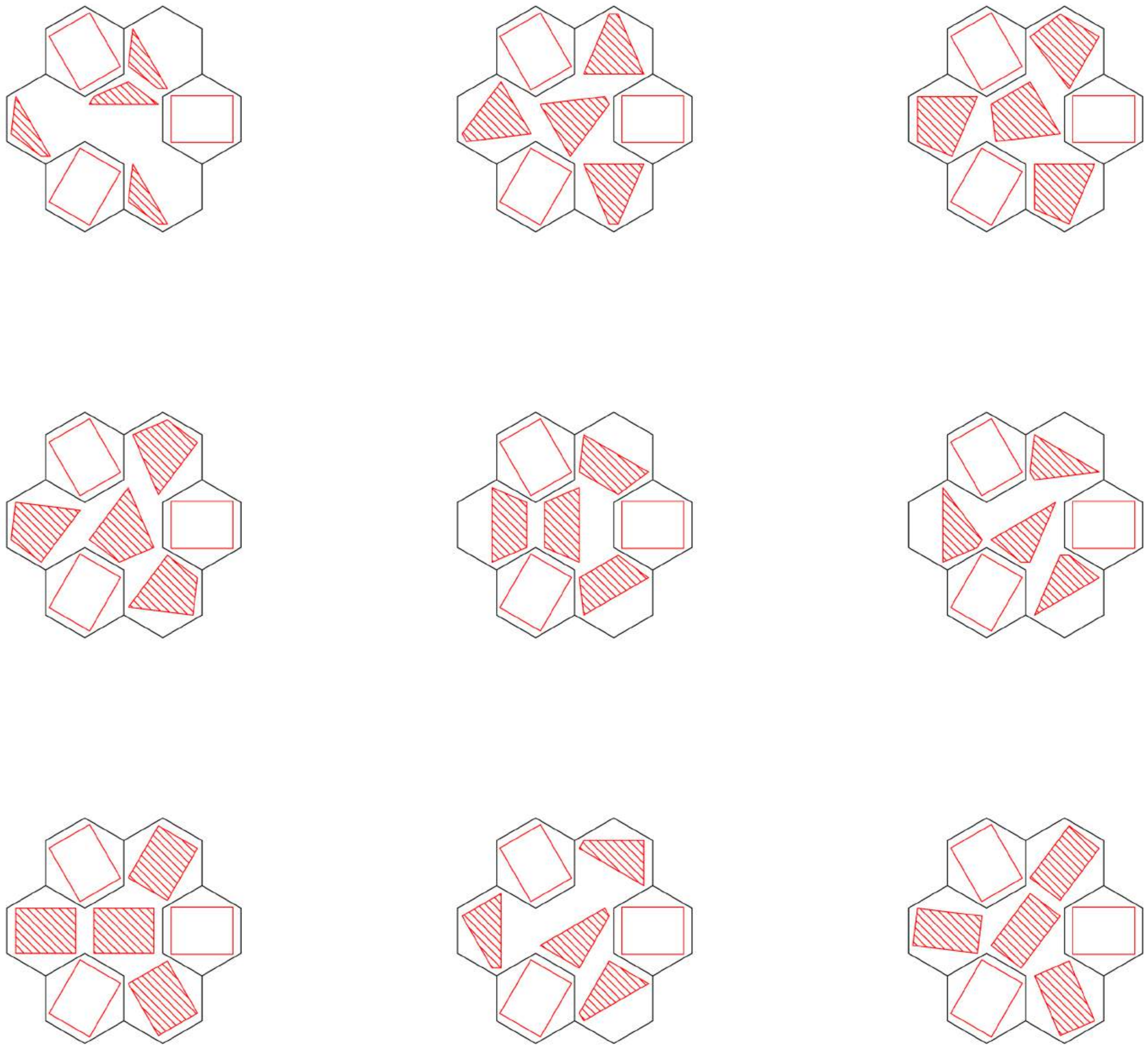
Comparison of hexagonal and rectangular houses

Collective informal

House extensions

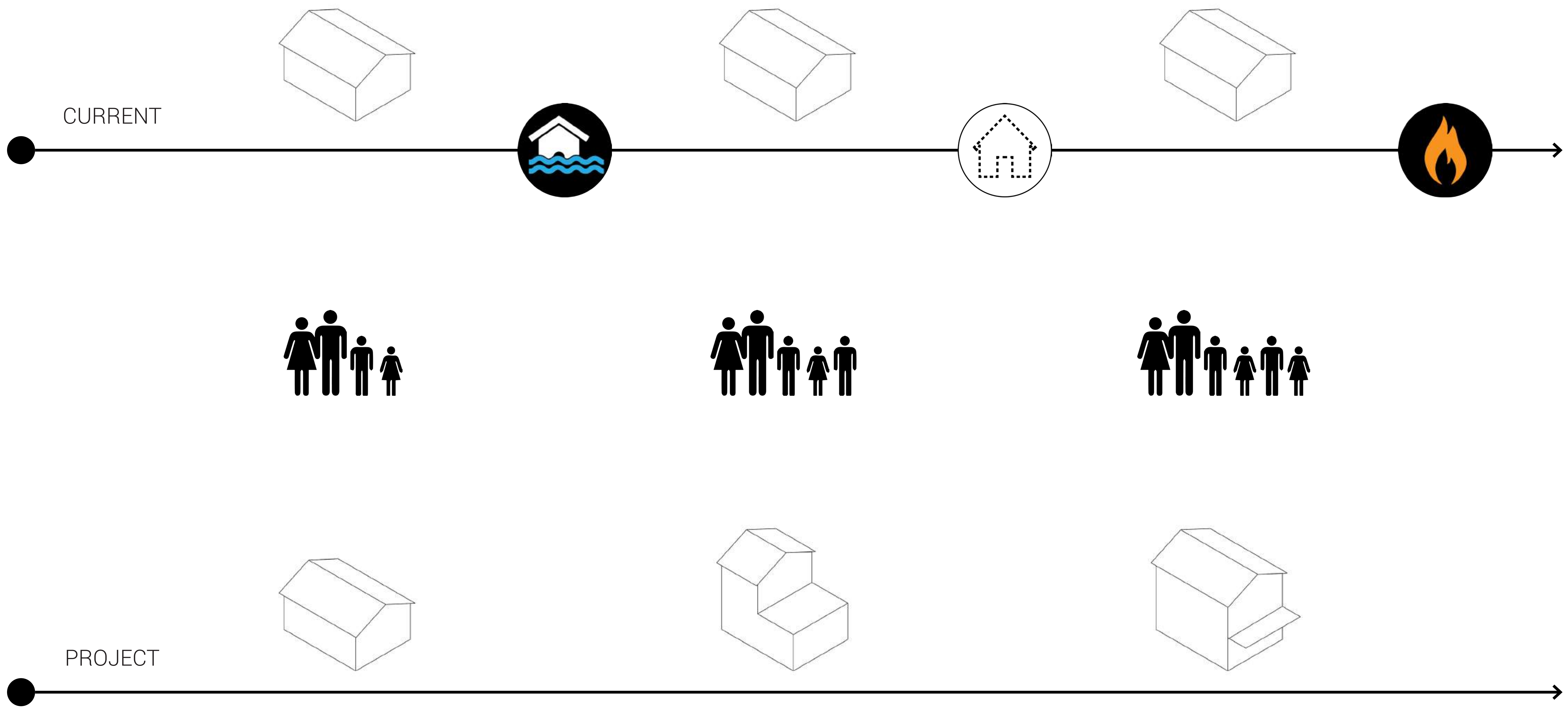


Collective extensions

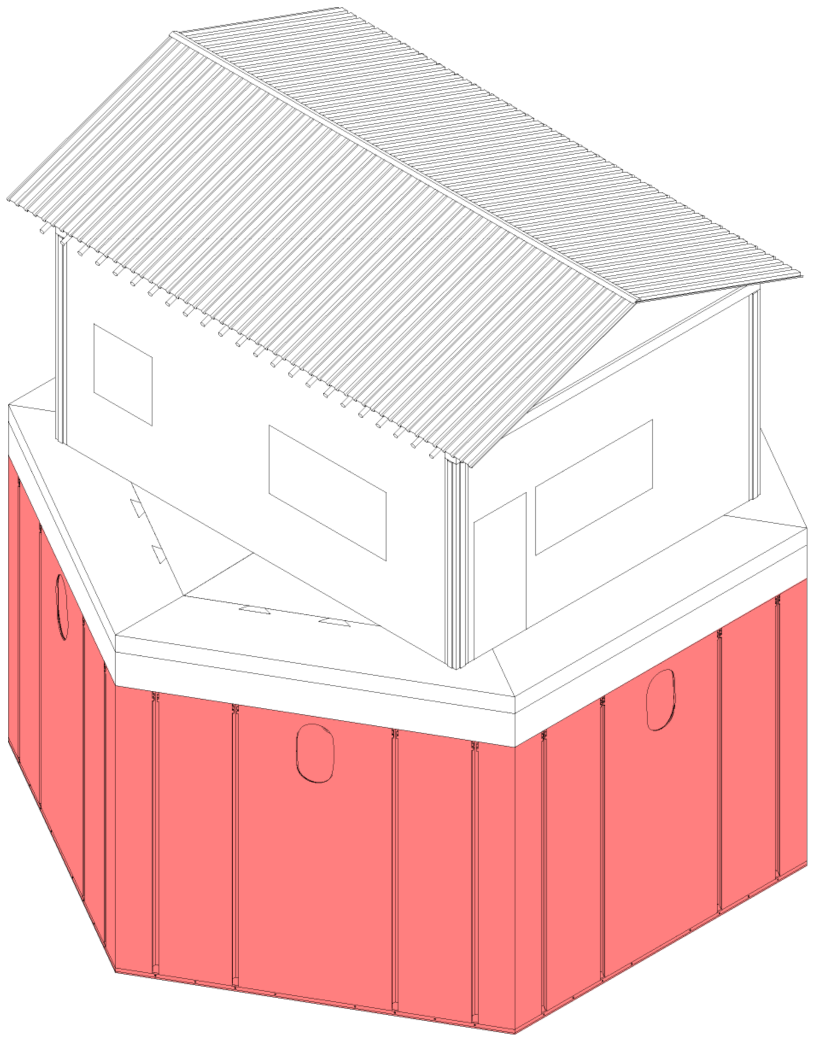


Street life

Housing in Time

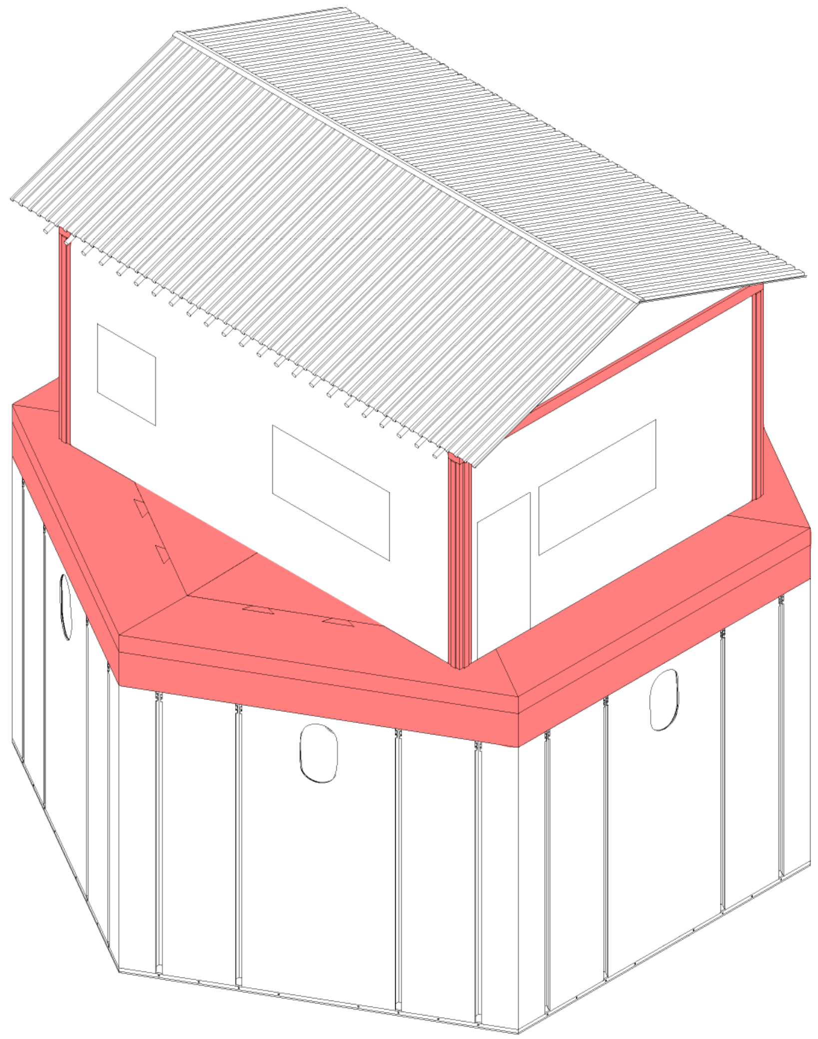


Components in Time



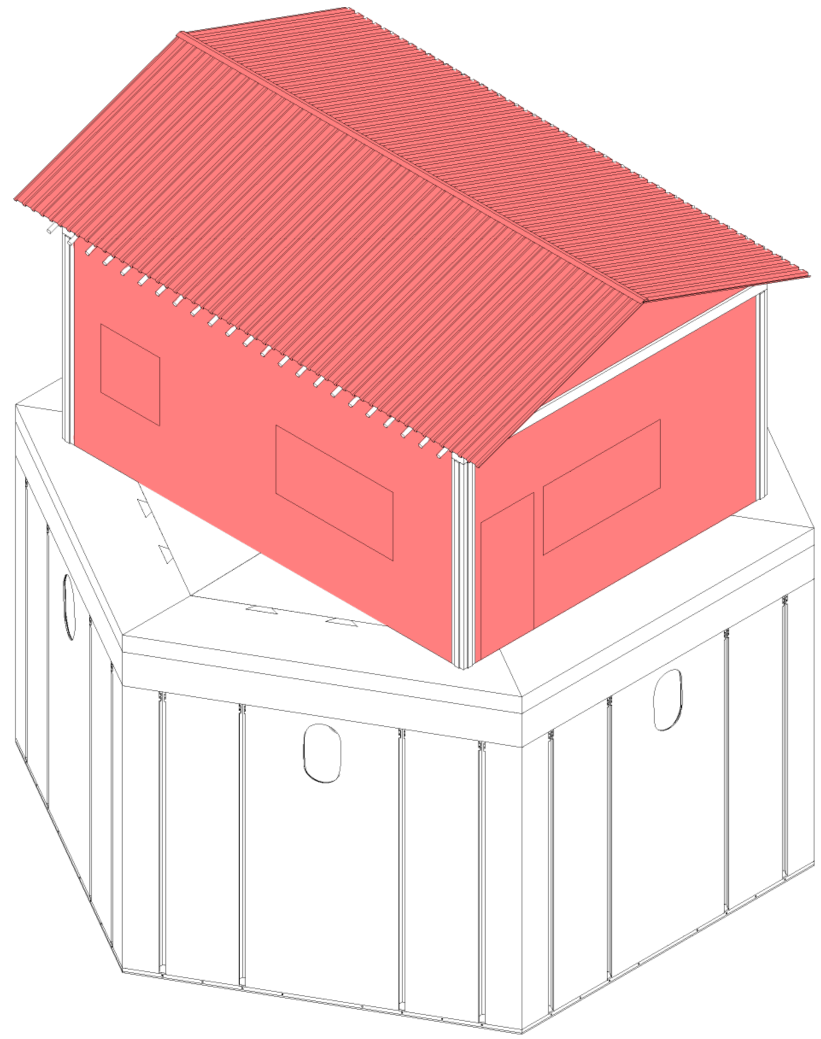
Base pod

30 years



Modular elements

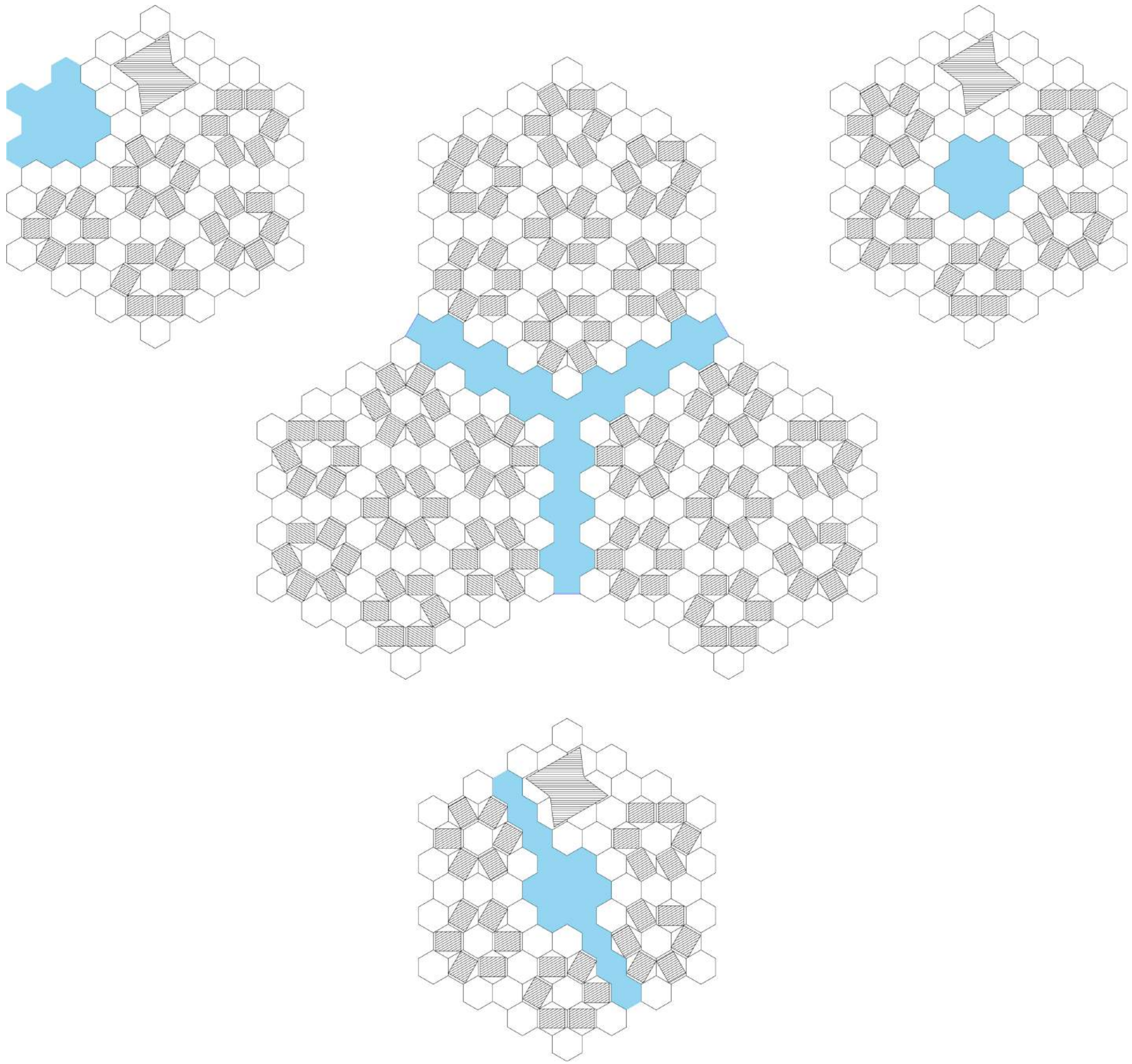
10 years



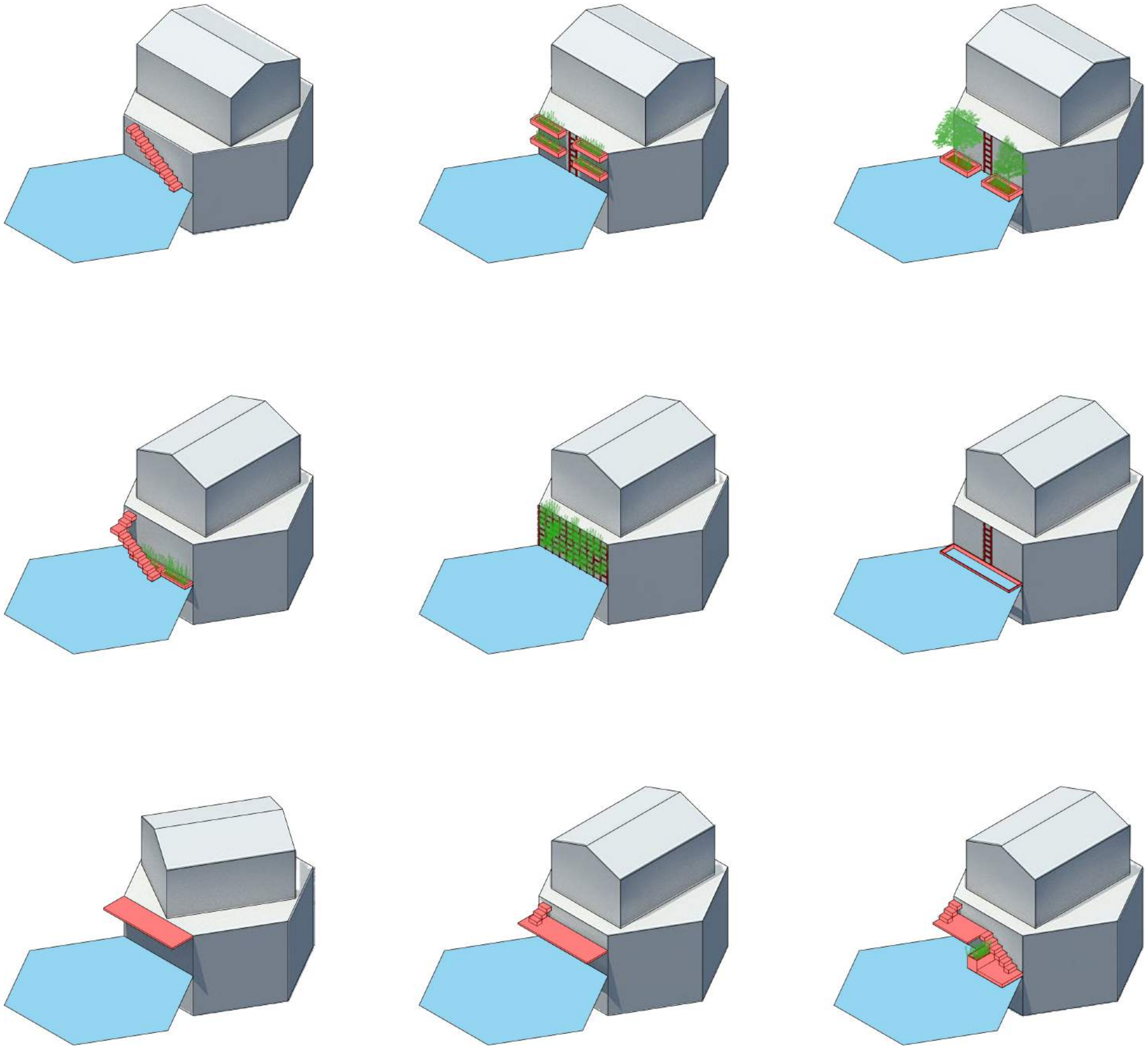
Daily life

3 years

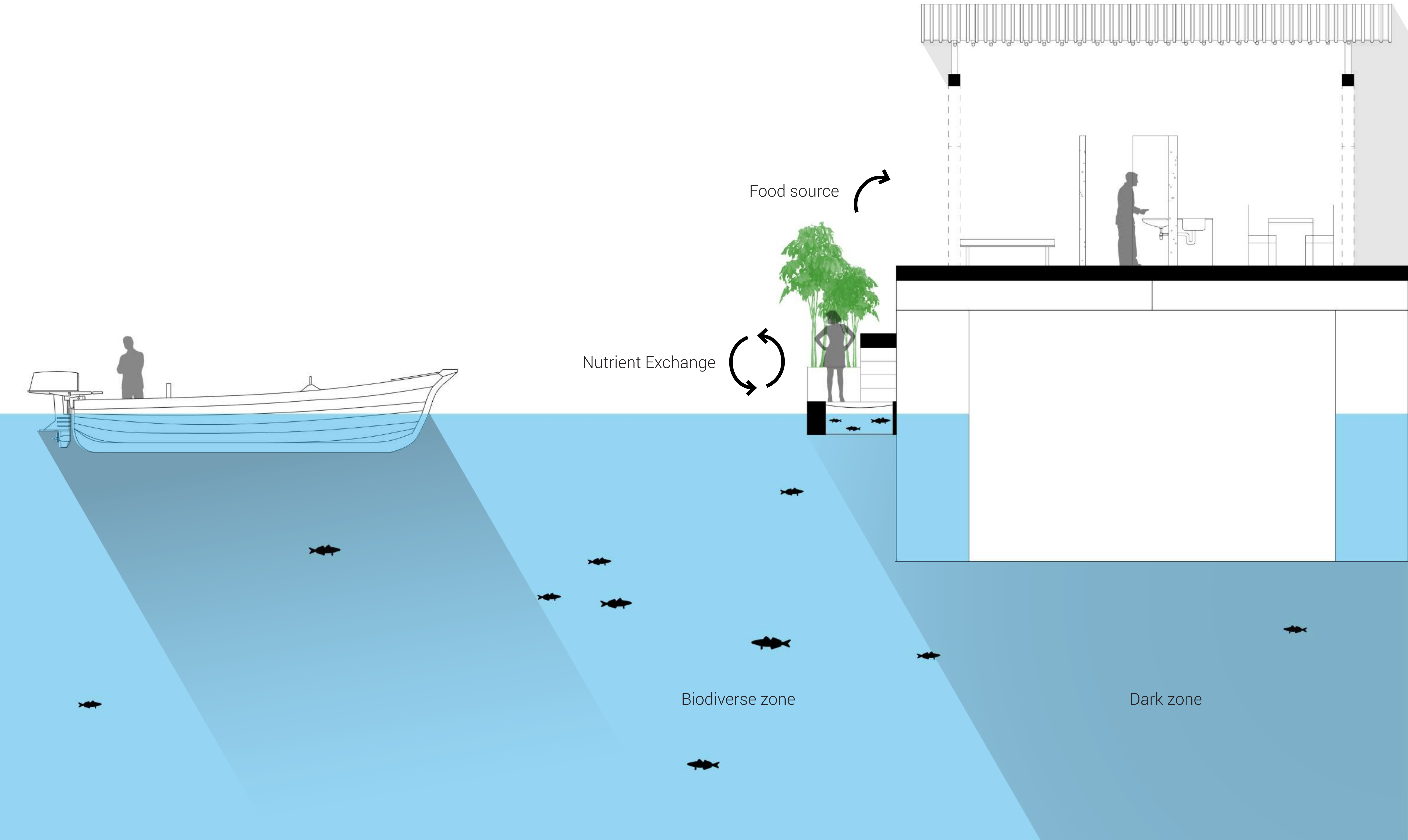
Life on the water



Relation with water



Biodiversity



Private Semi-private Public Semi-public

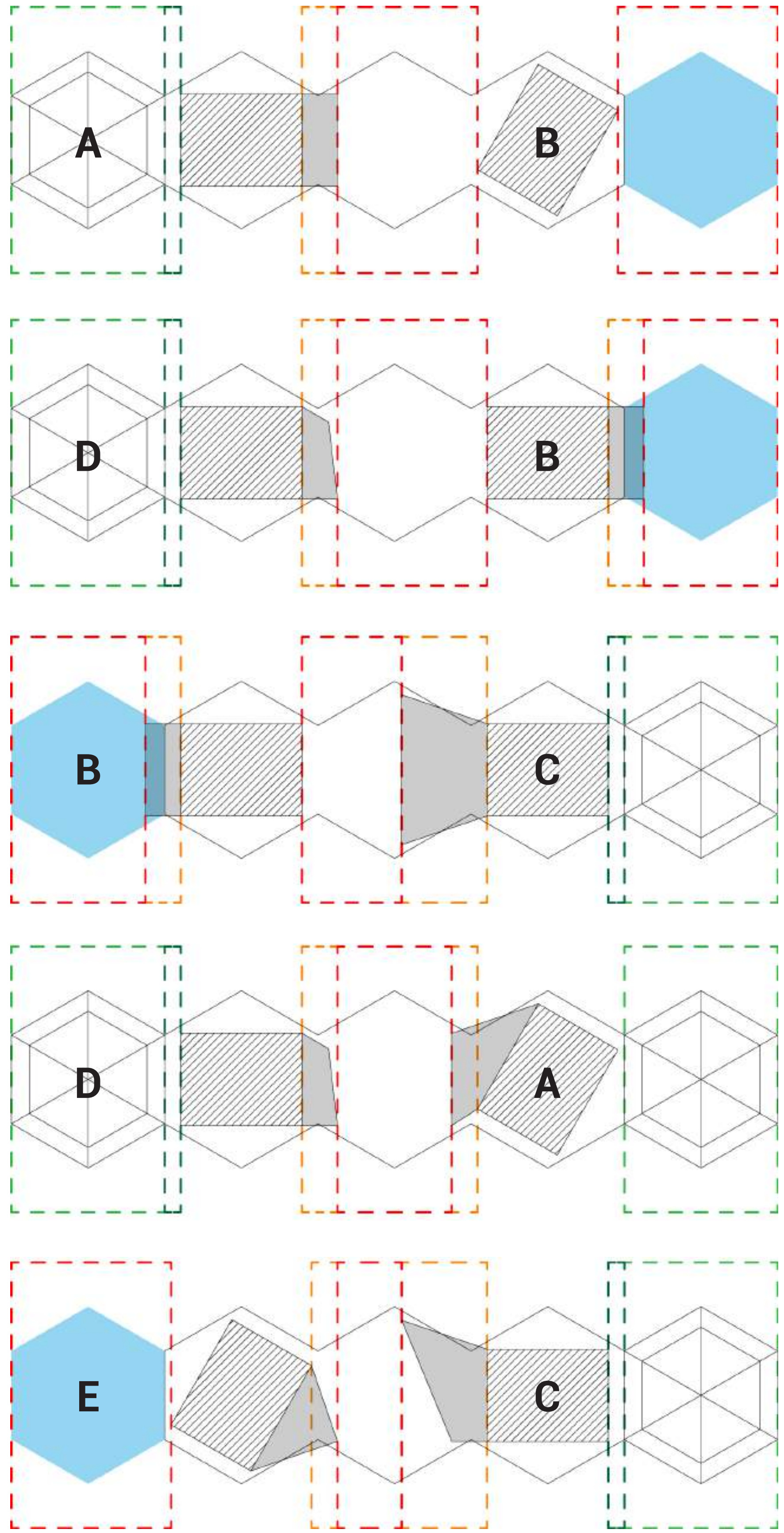
A Couple with 4 children
Home shop

B 3 generation home
Fishermen

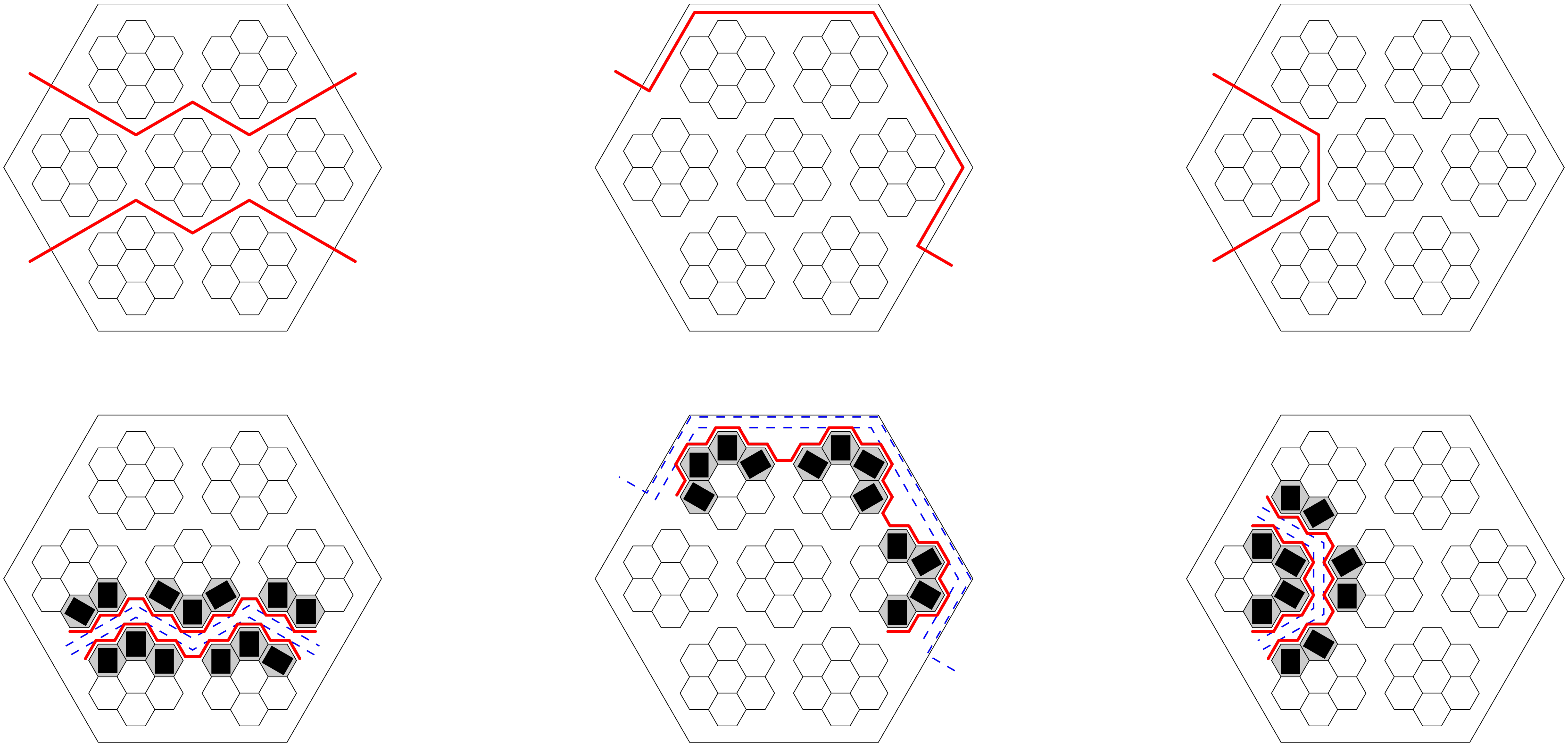
C Young couple with relatives
Street vendors

D Young couple with children
Scavenging trash

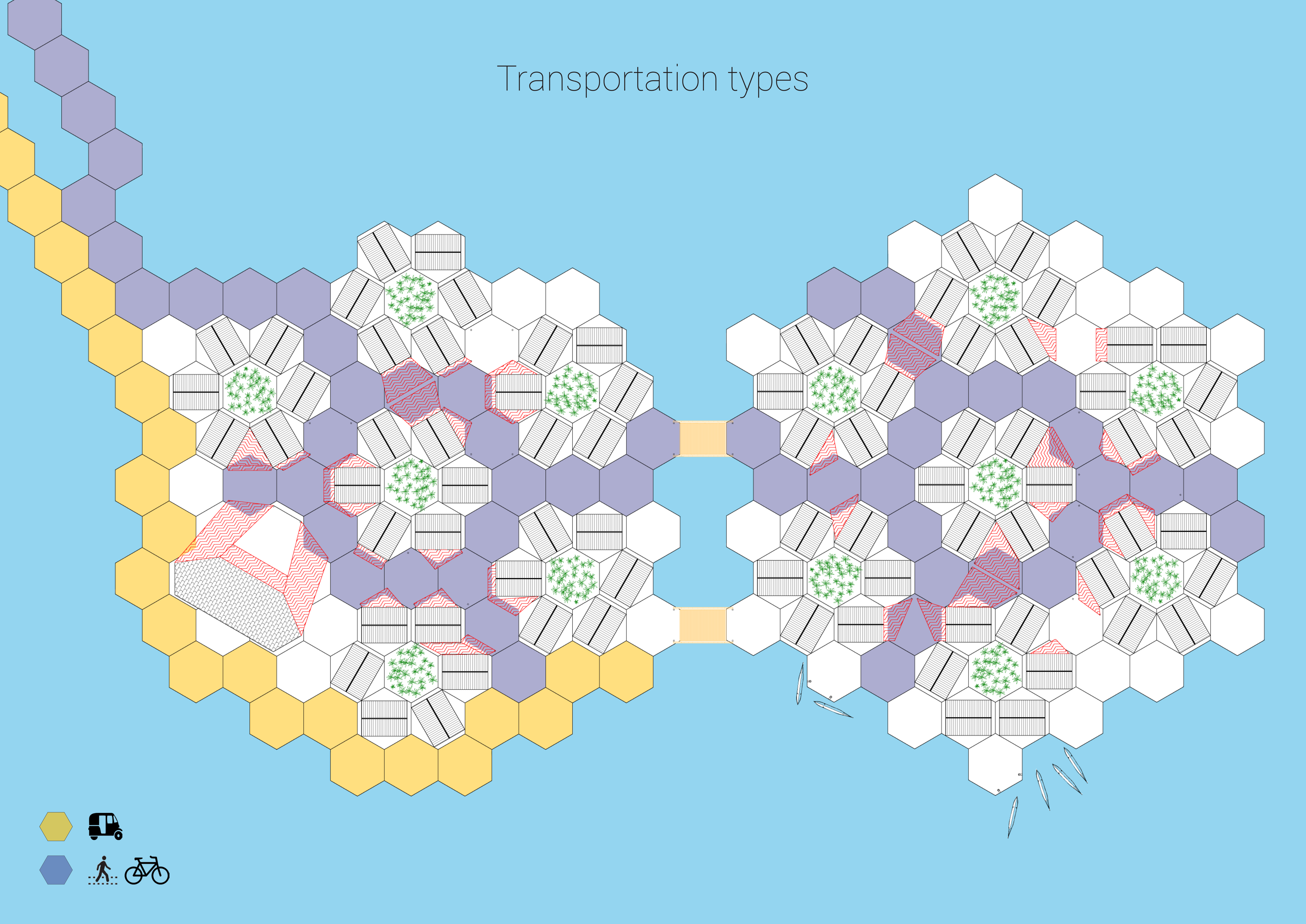
E Young couple with children
Construction worker



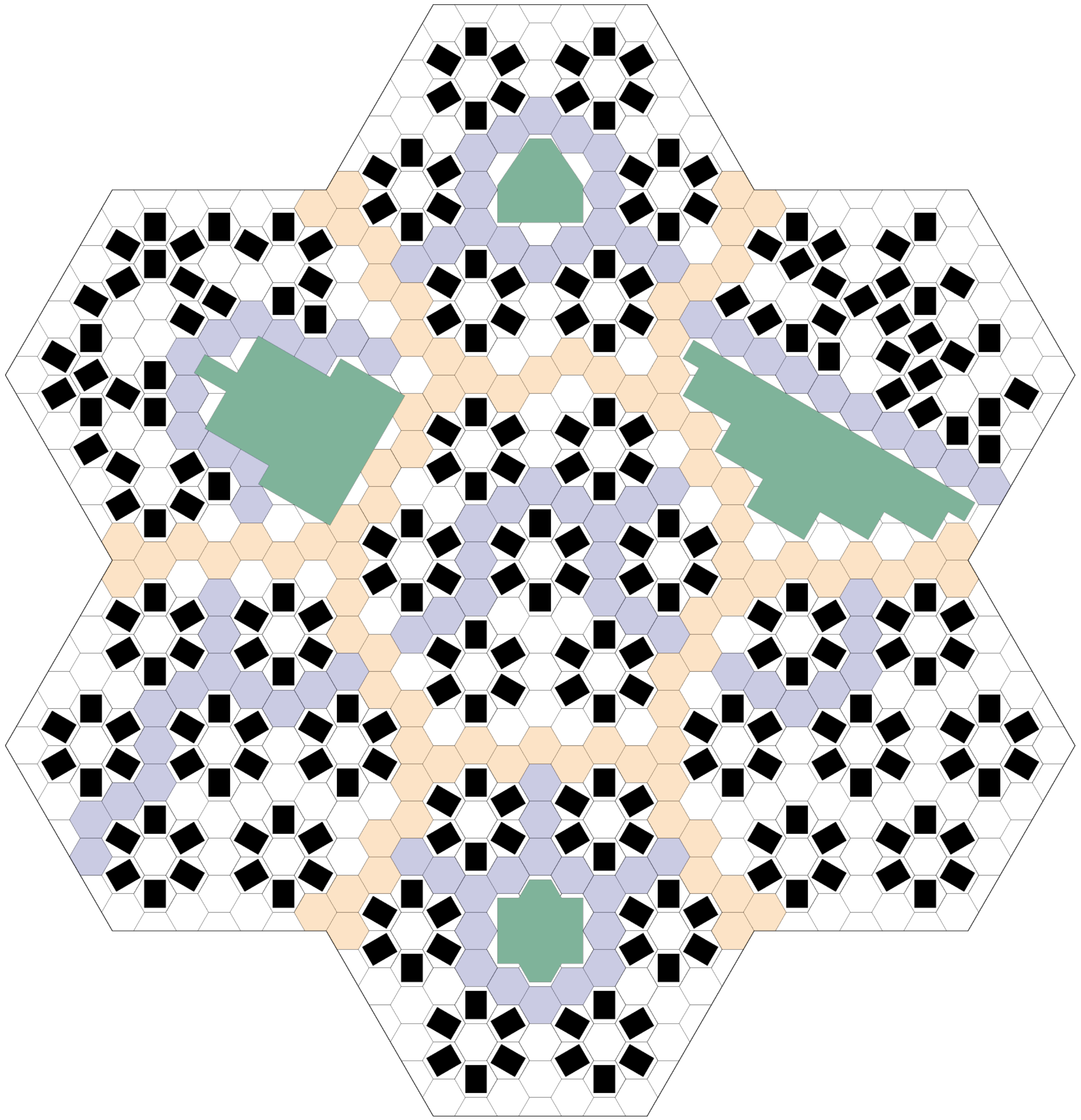
Types of movement

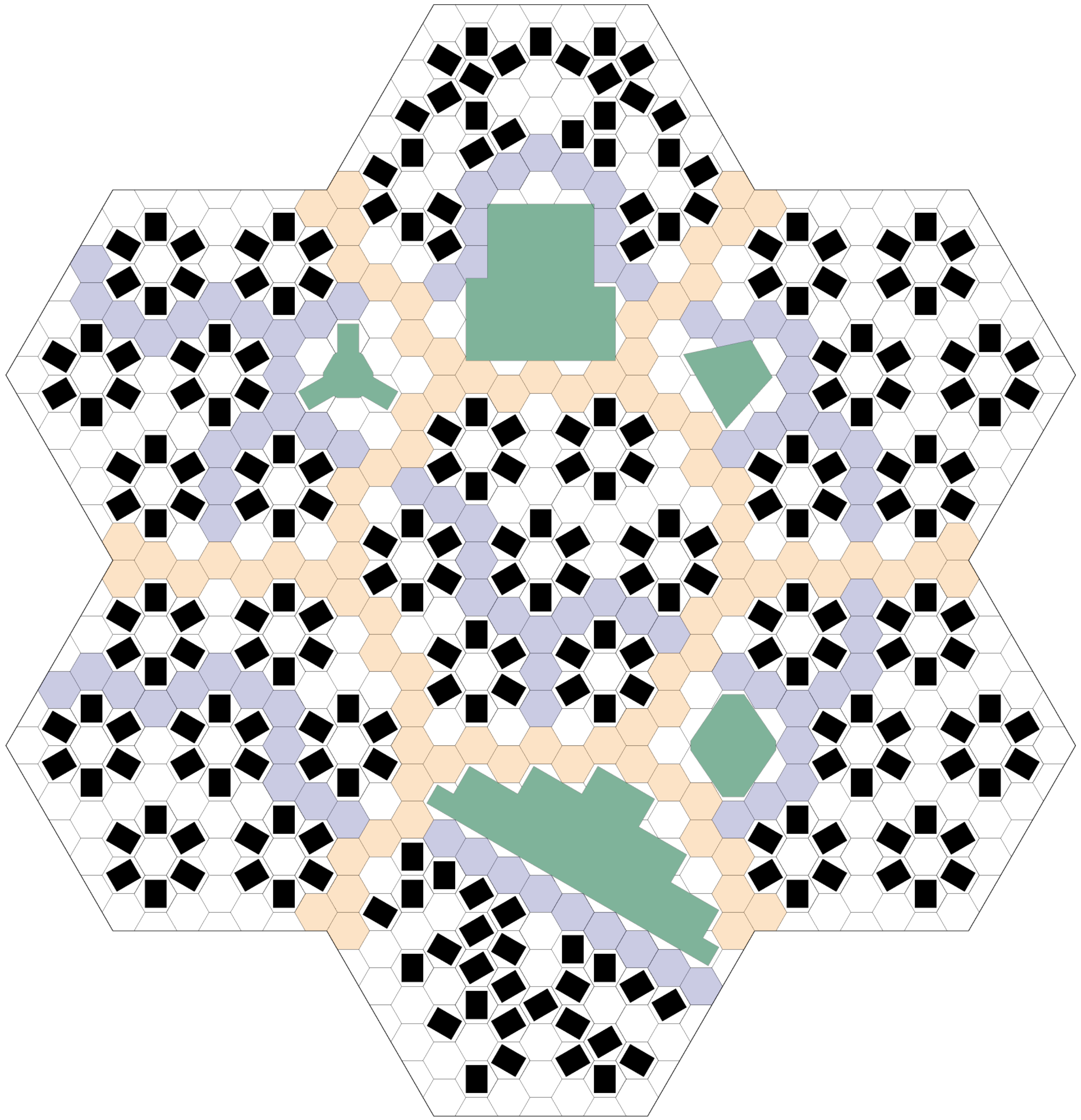


Transportation types

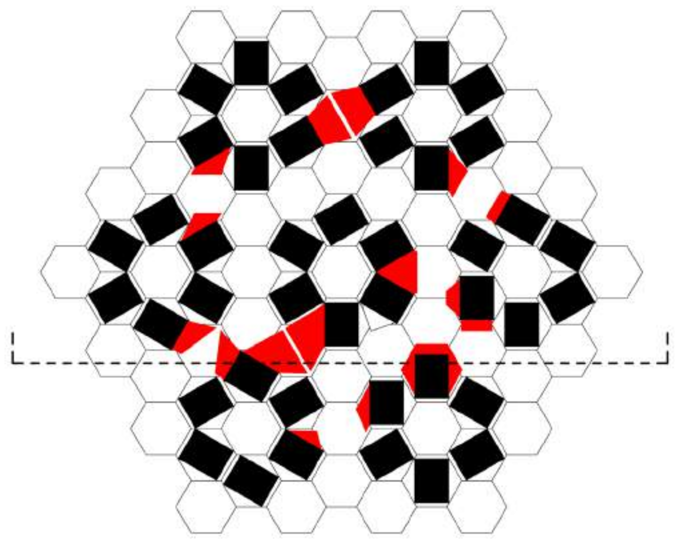


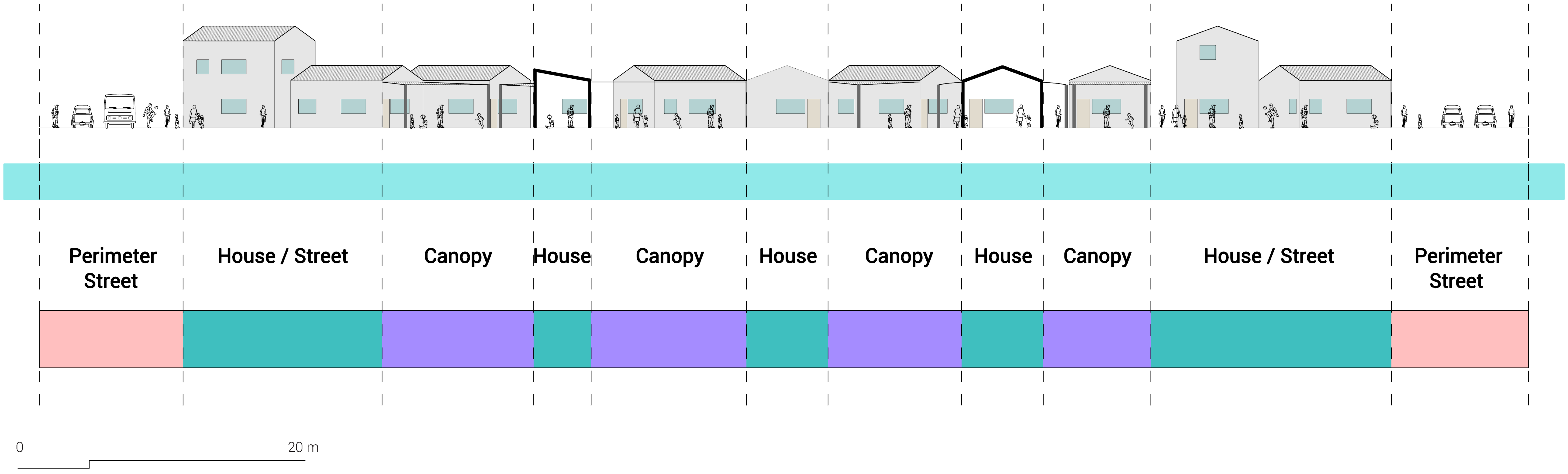
Street hierarchy



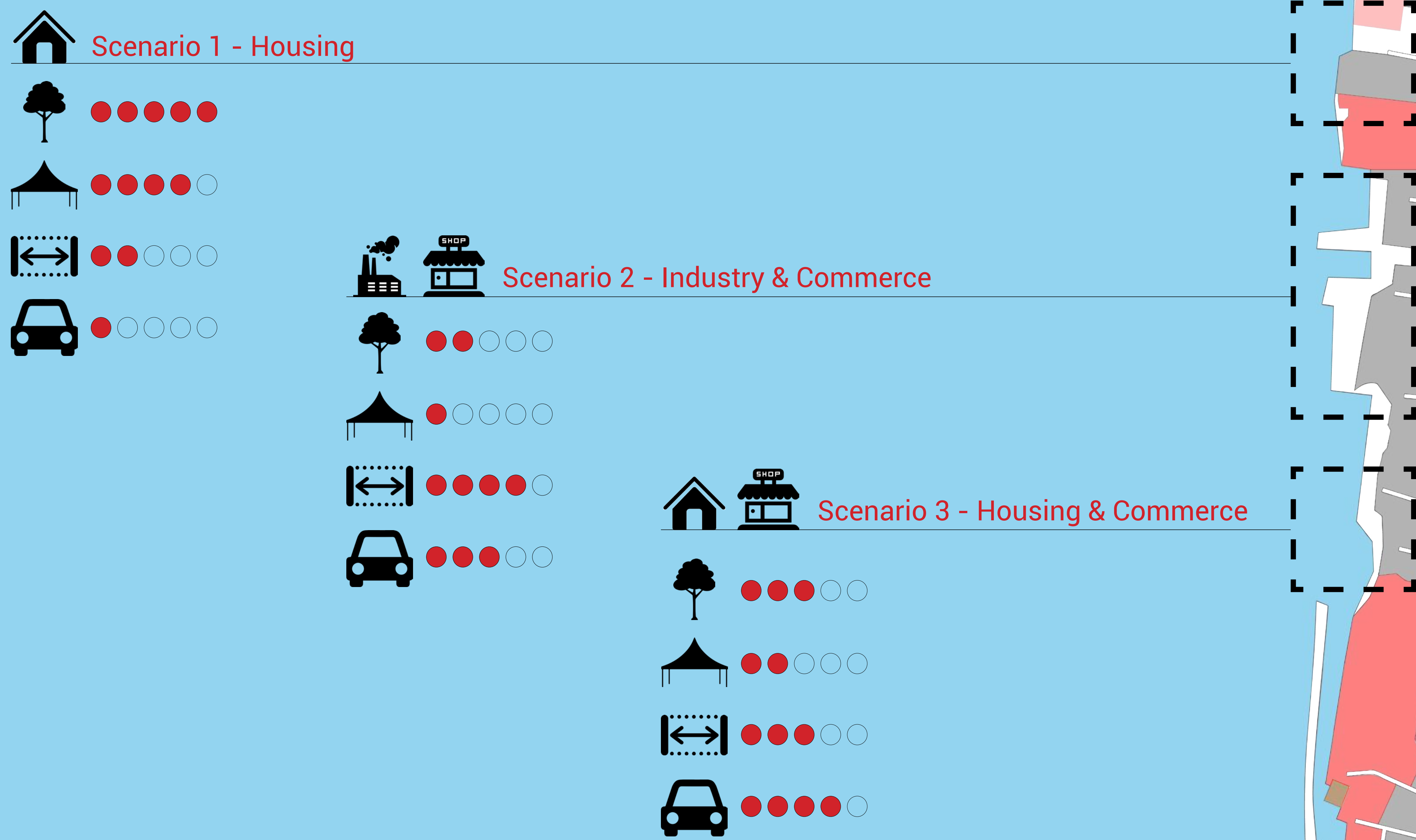


Urban section





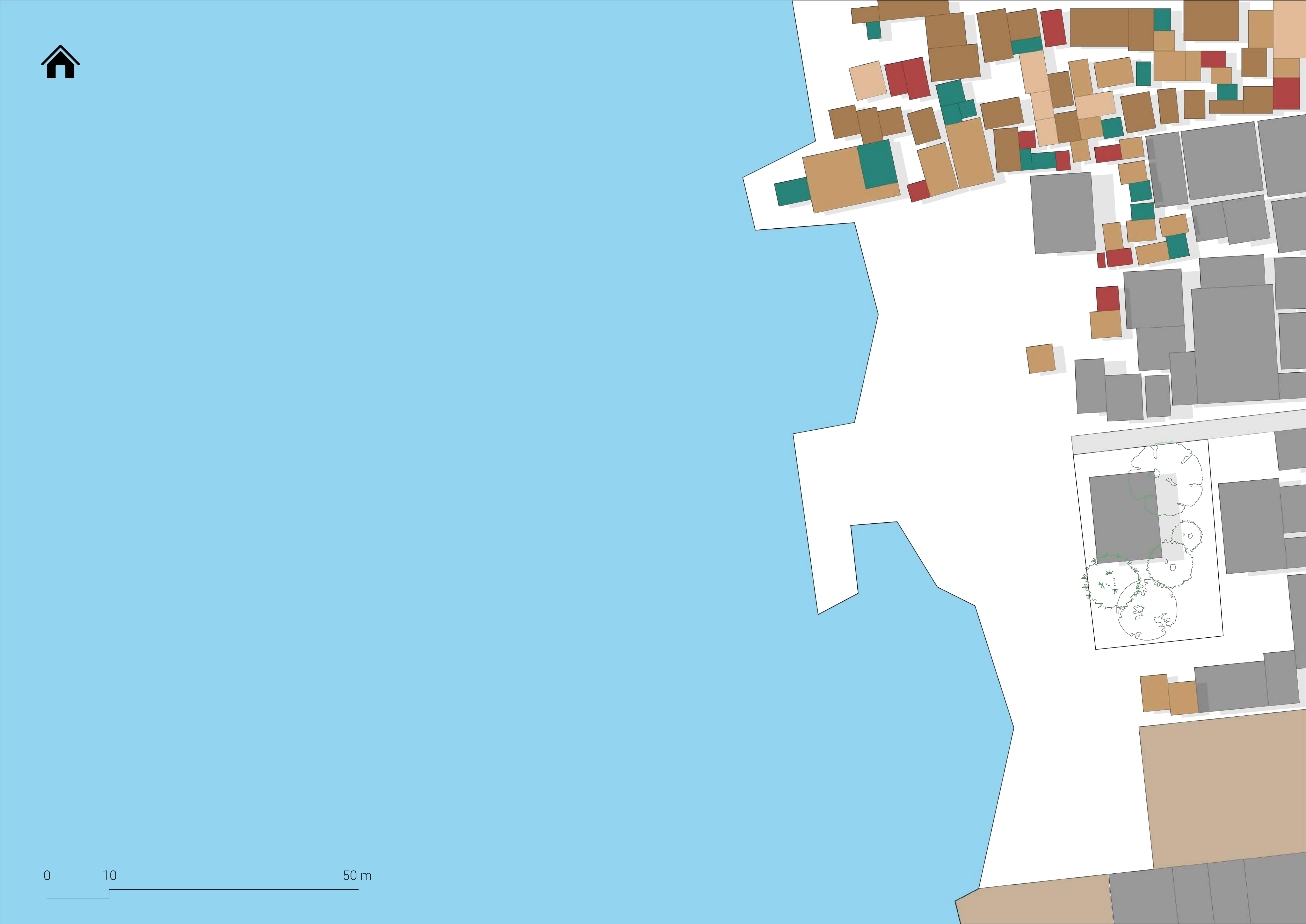
Urban Scenarios



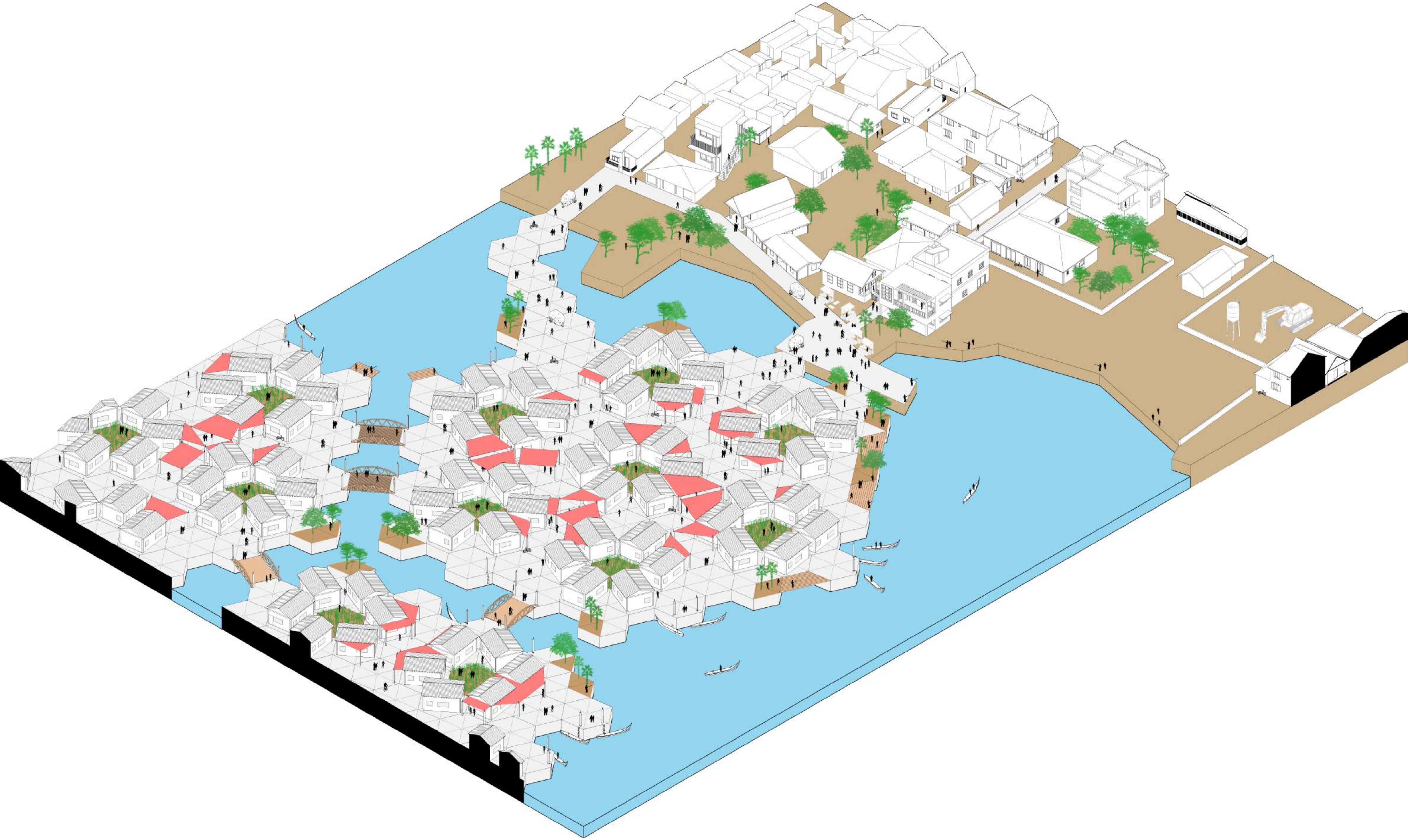
Placement of the developement in **proximity** to current habitation and economic activities creates an **extension of the city fabric**.

Slums

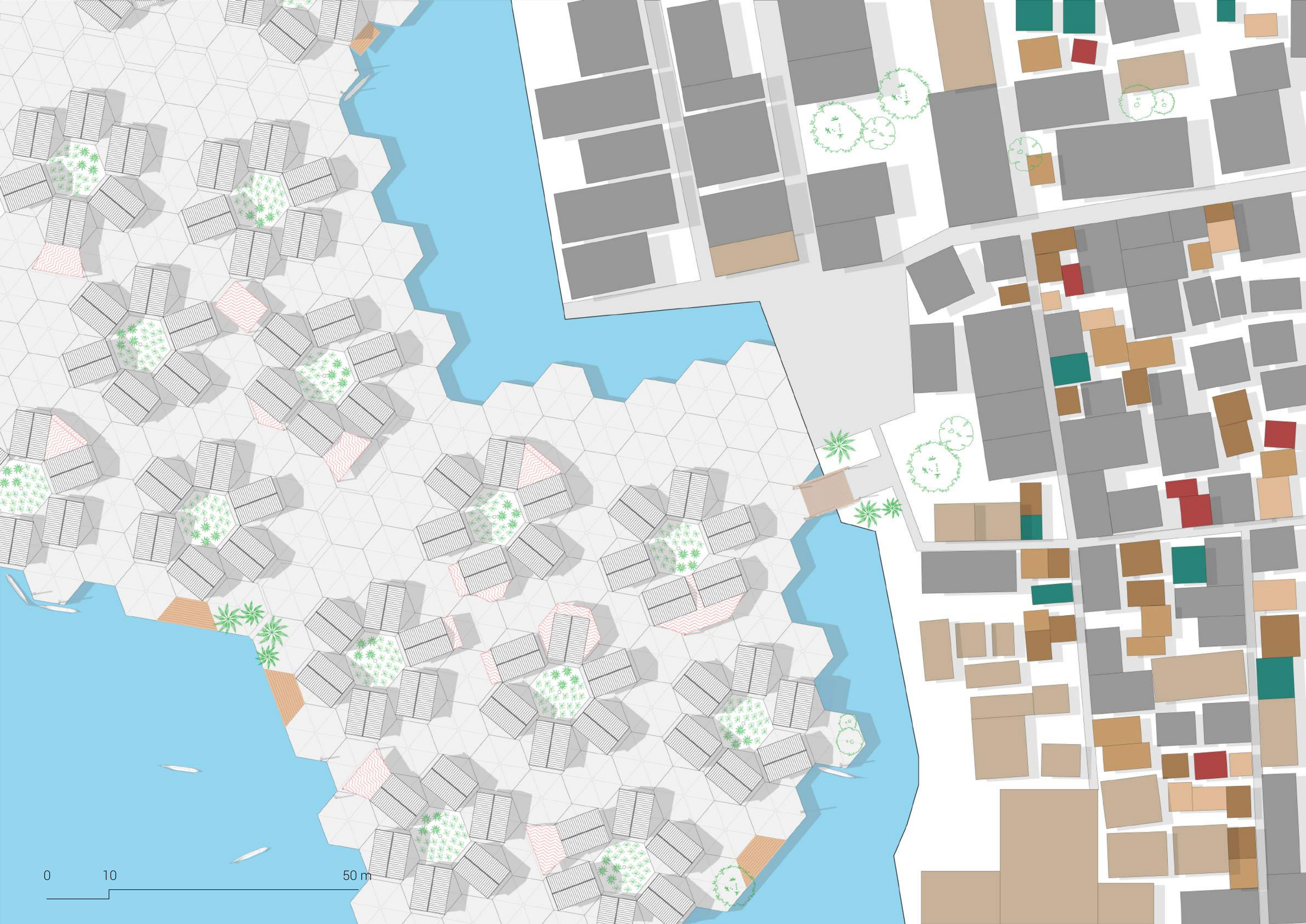
Housing

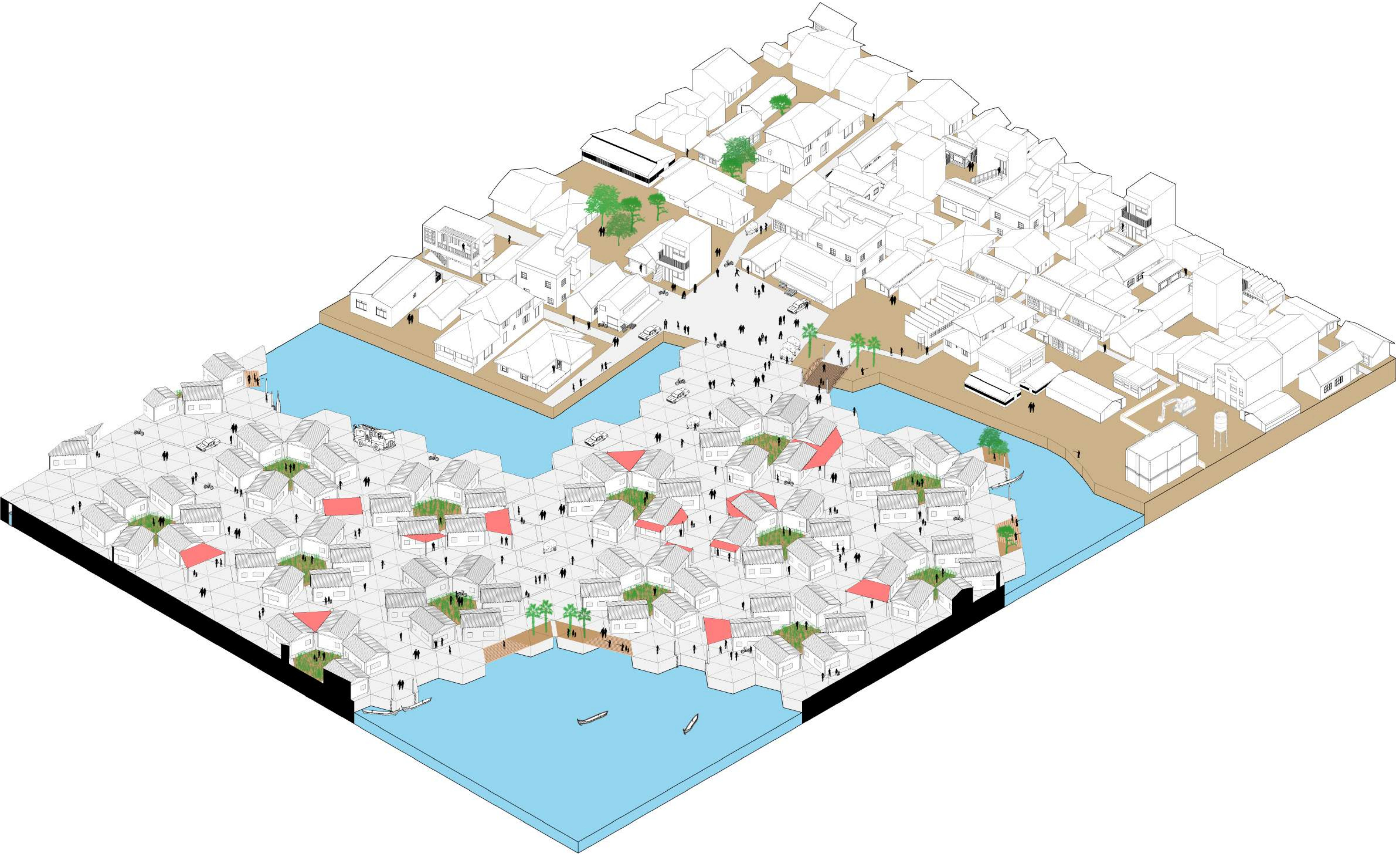

0
10
50 m

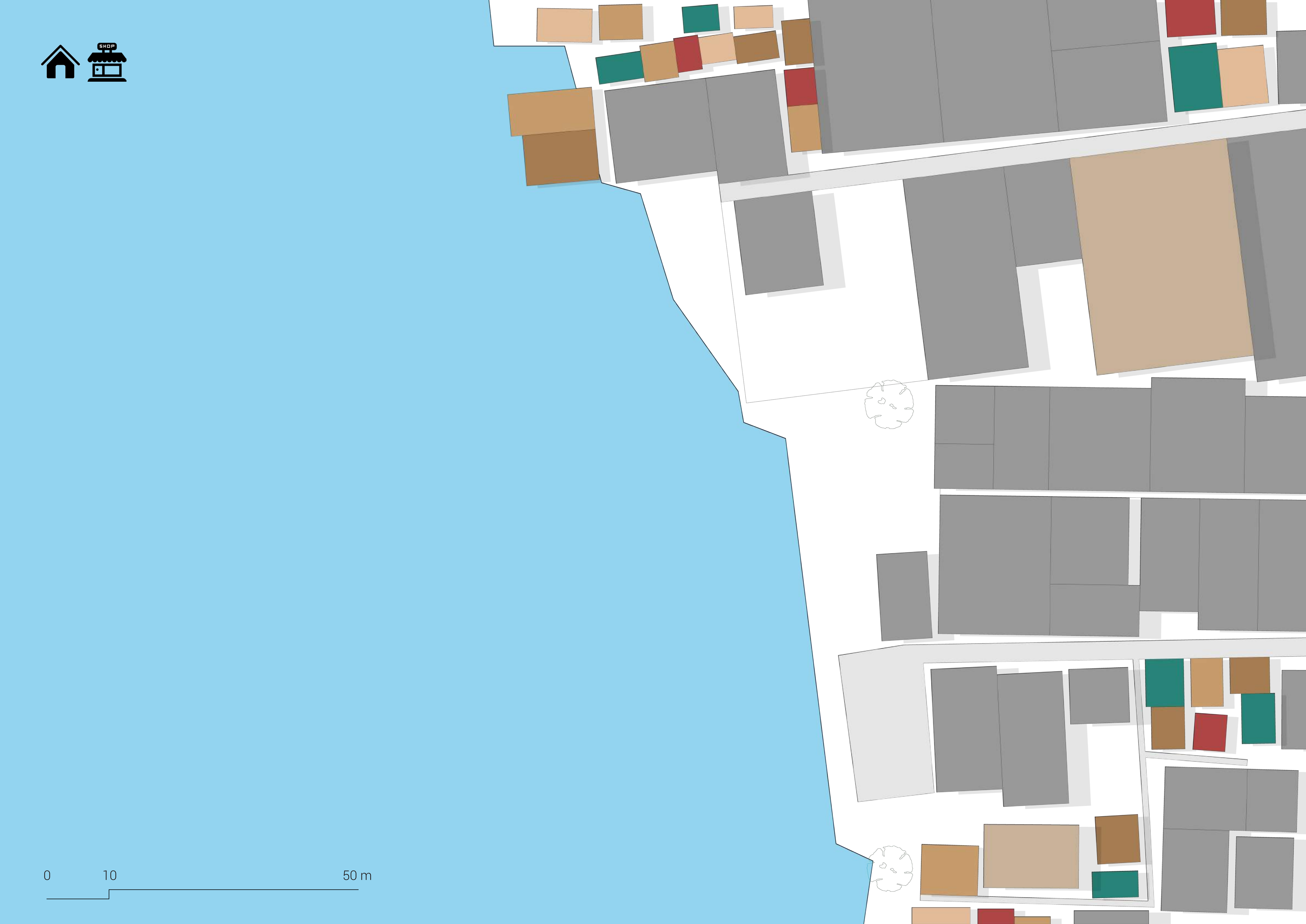

0
10
50 m



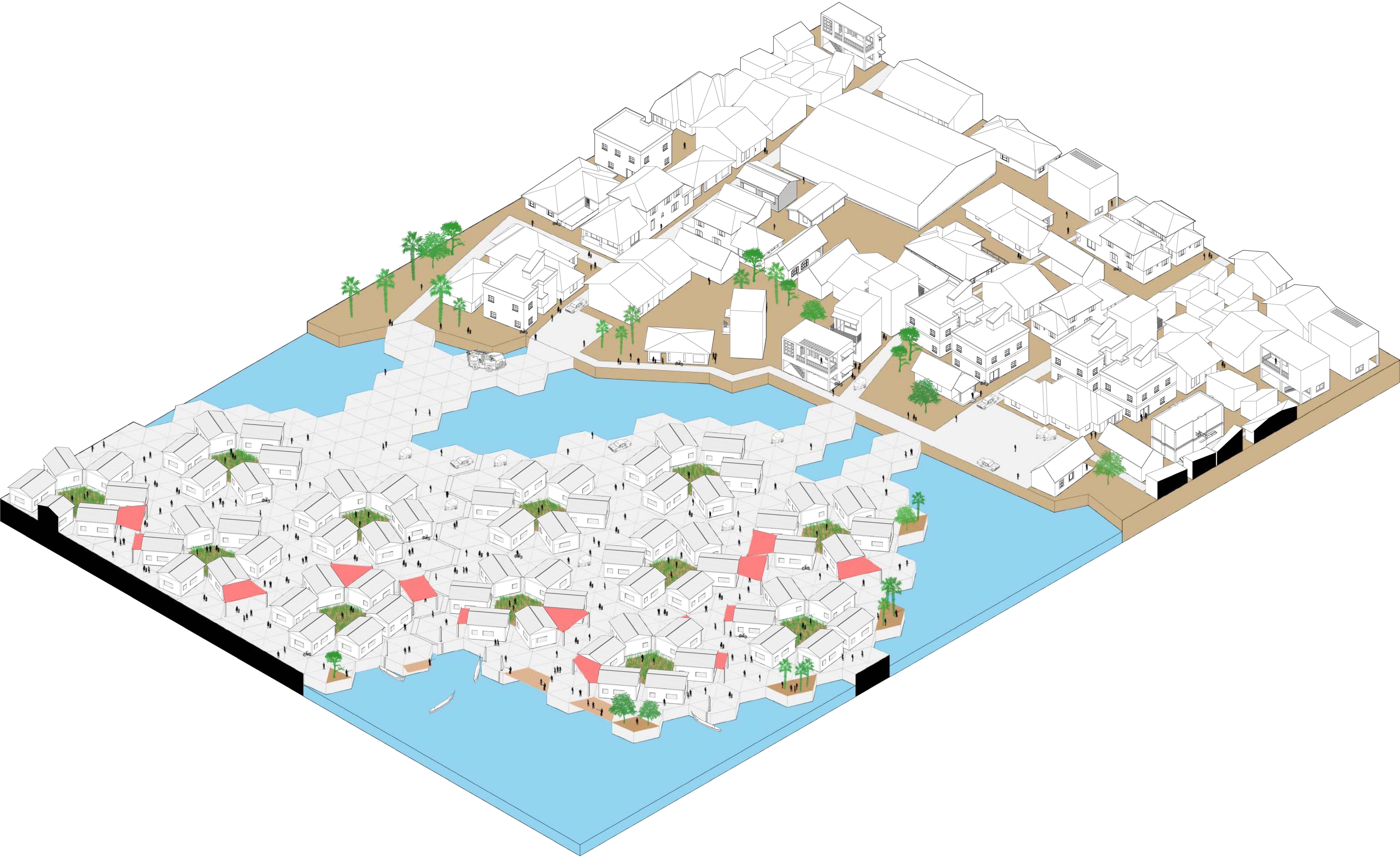

SHOP
0
10
50 m

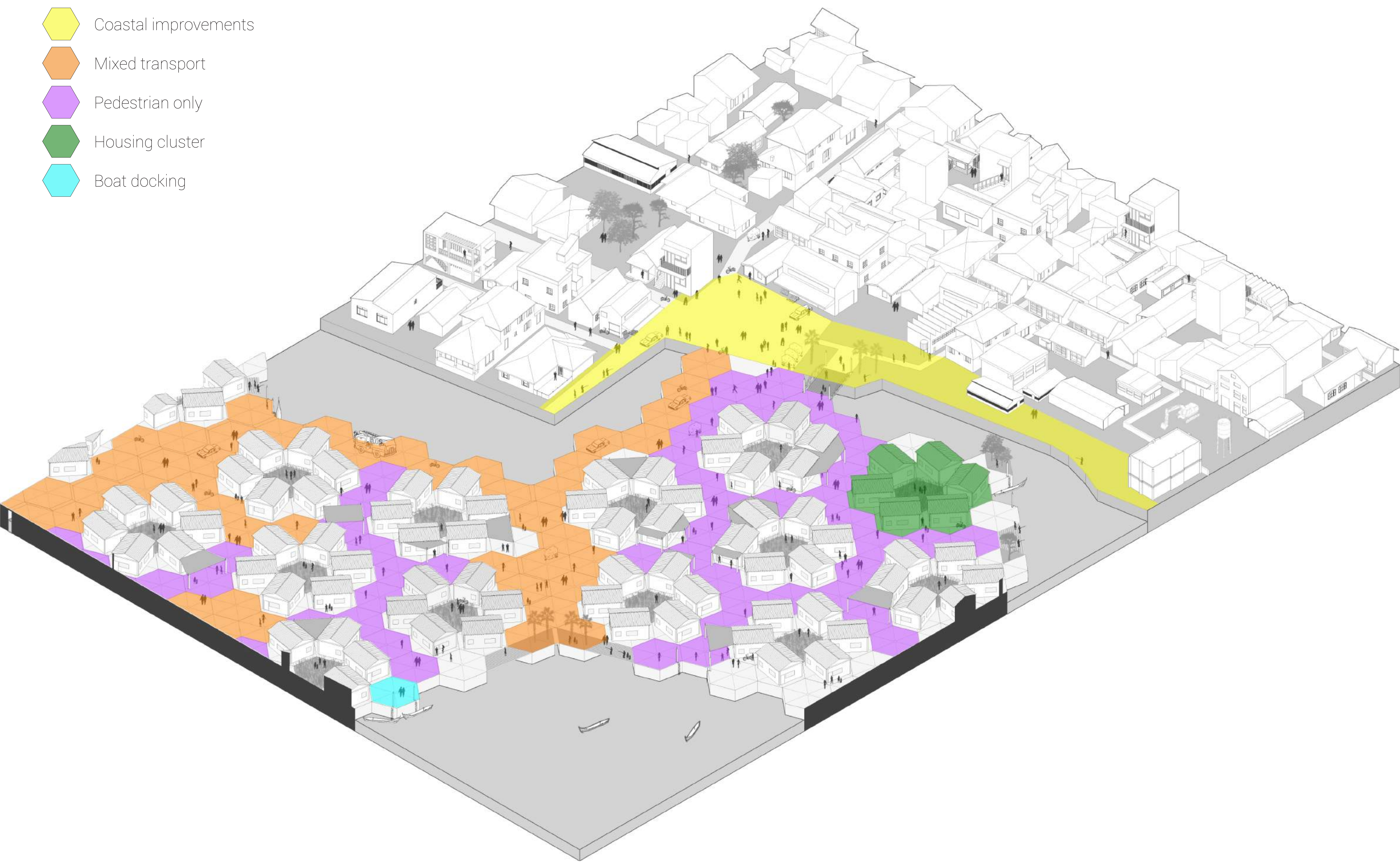

0
10
50 m




SHOP
0
10
50 m


0
10
50 m




Coastal improvements
Mixed transport
Pedestrian only
Housing cluster
Boat docking

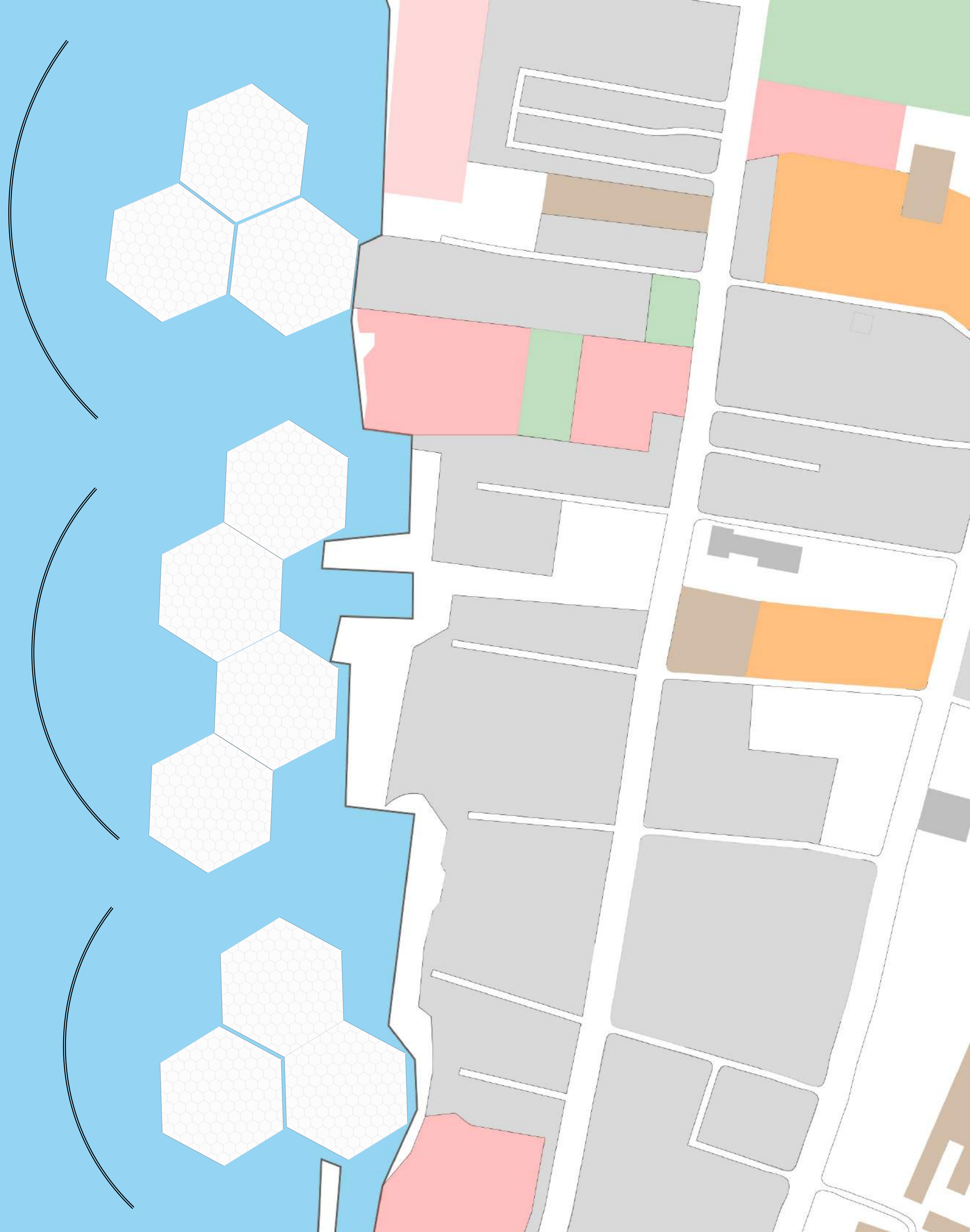
Urban Scenario
Year 3

10 communities
1000 pods

400 housing units
3000 inhabitants

65,000 m2

3 wavebreakers
45 IMTA units

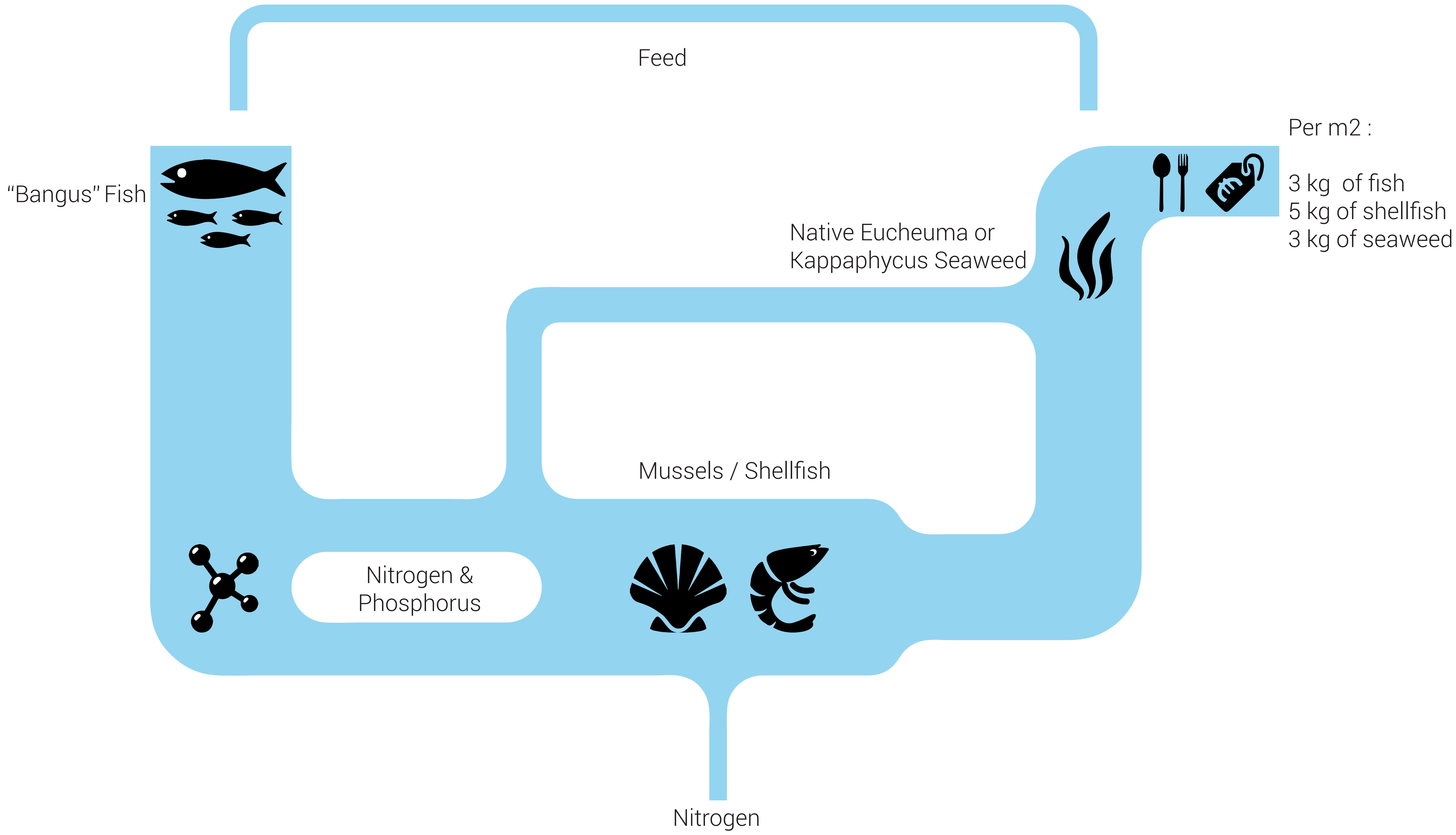


0 100m

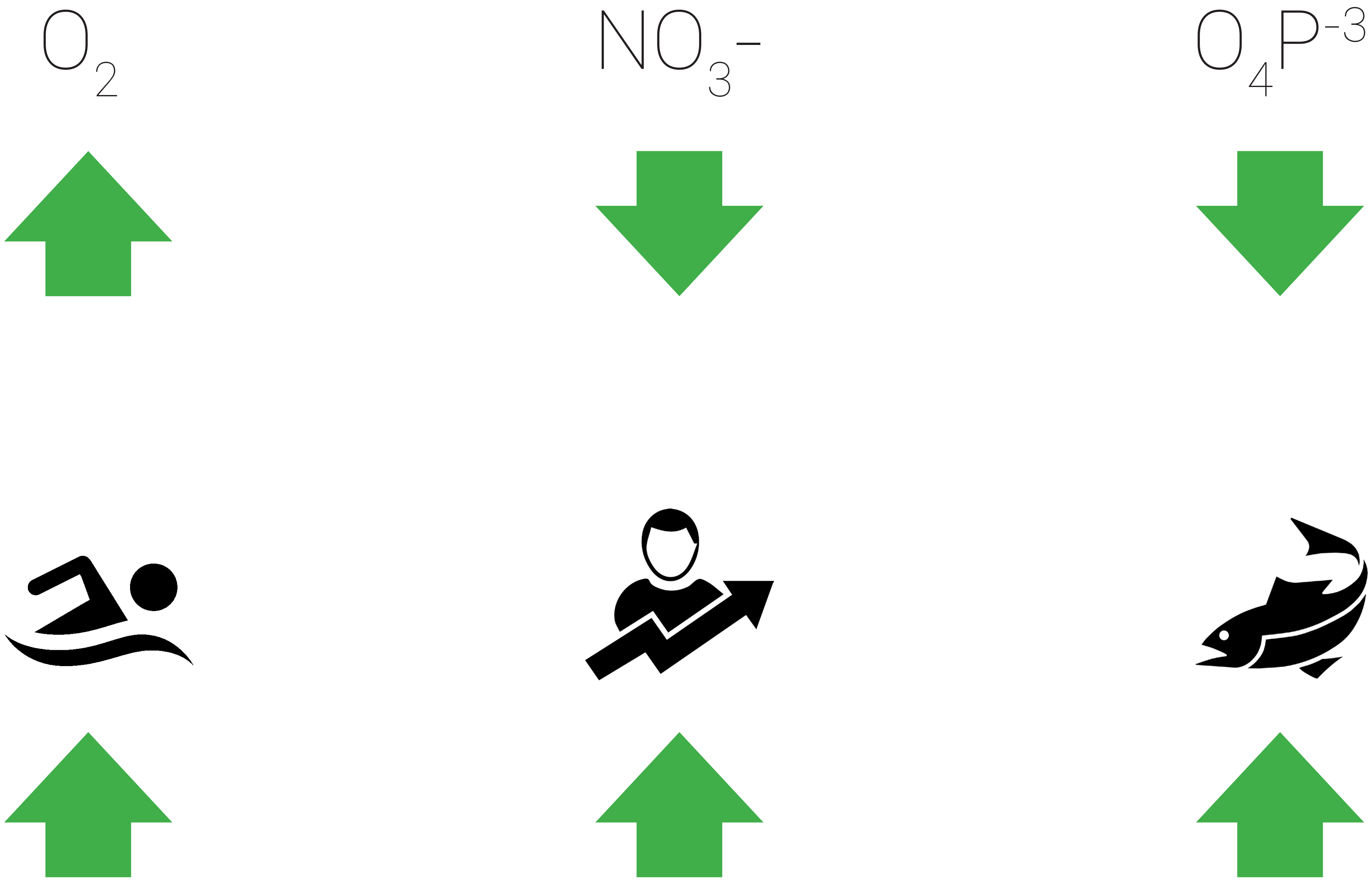
Wave Breaker

A **floating wave breaker** which integrates **nutrient remediation** with **economic opportunity** could prove resilient on many scales.

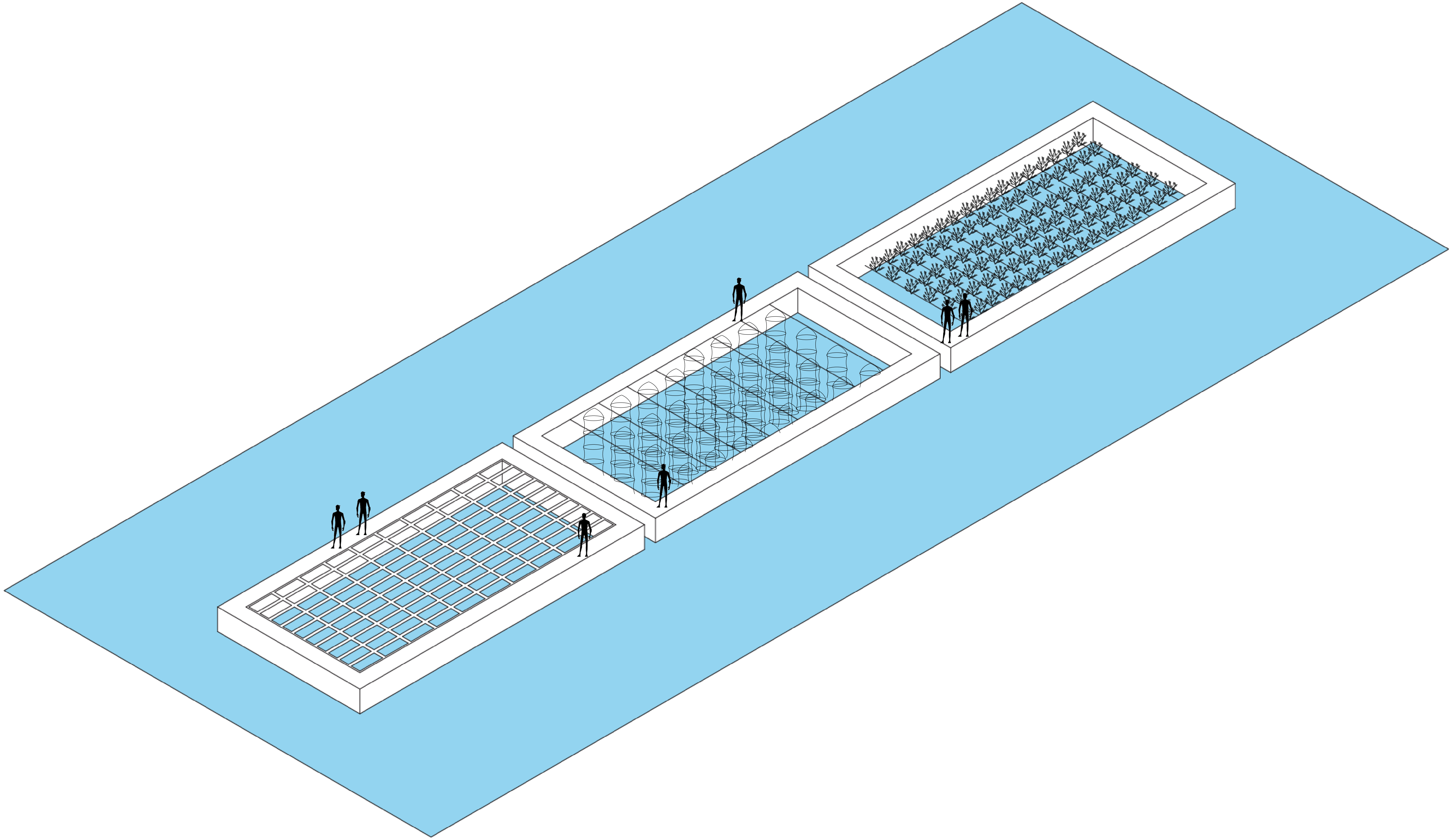
Integrated multi-trophic aquaculture [IMTA]



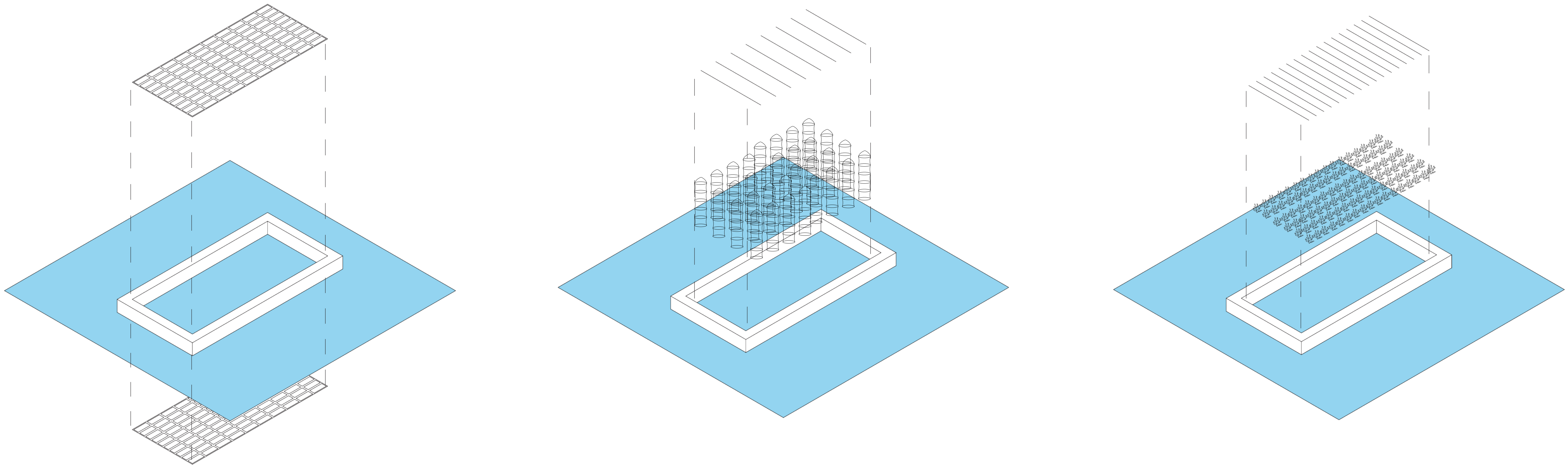



O_2
NO_3-
O_4P^{-3}

Working at sea

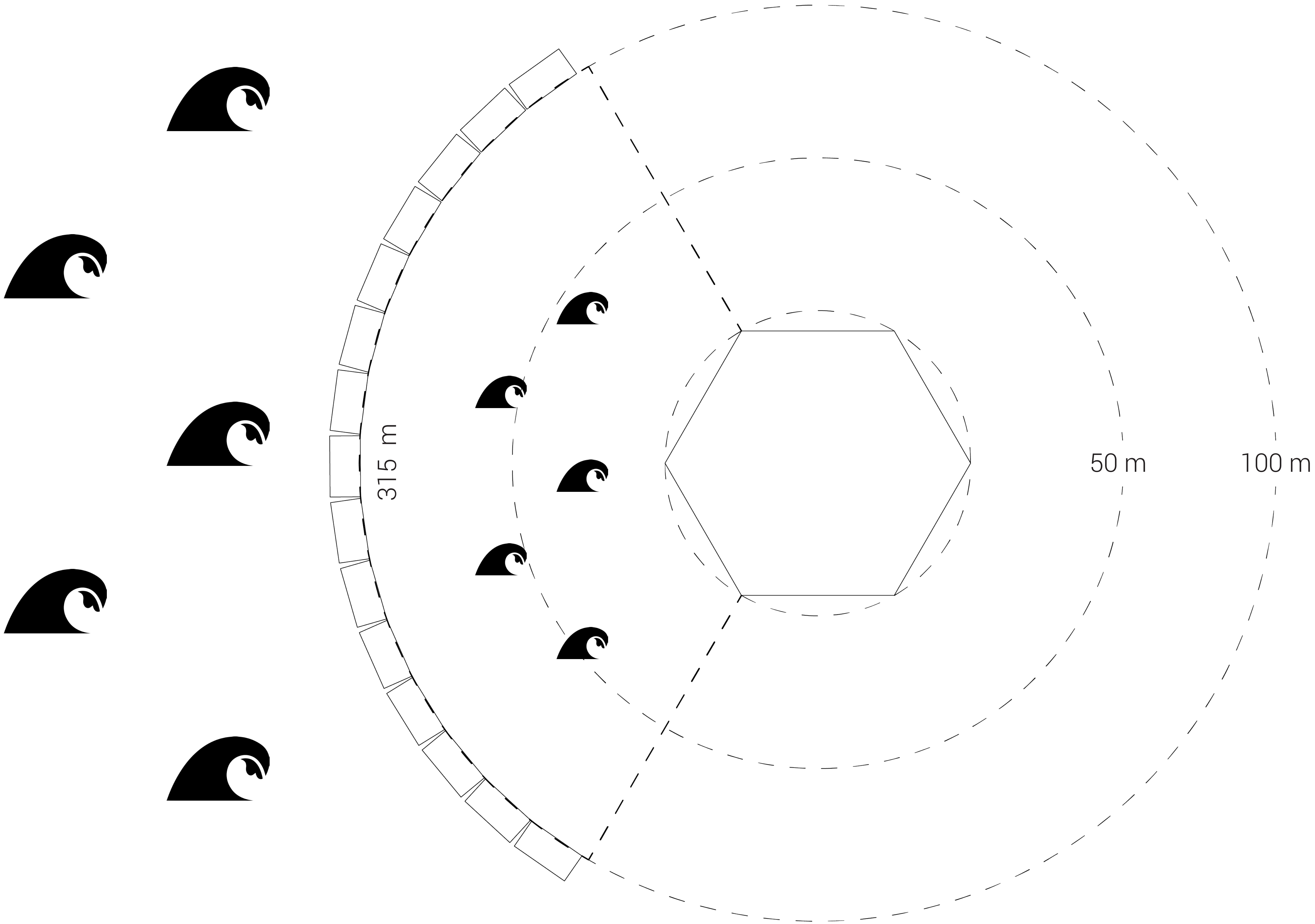


IMTA

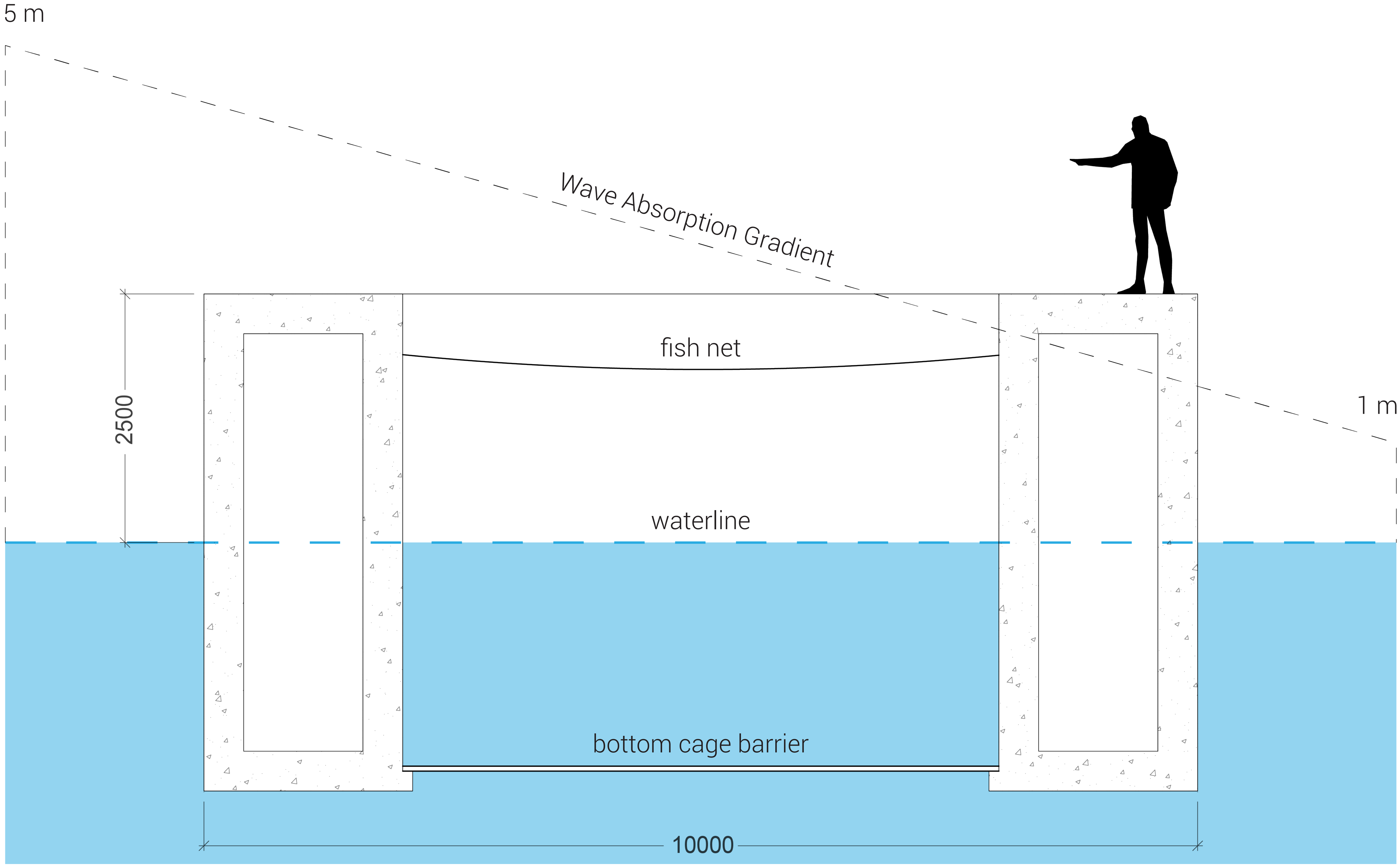


Milkfish Cages | Shellfish Nets | Seaweed Lines

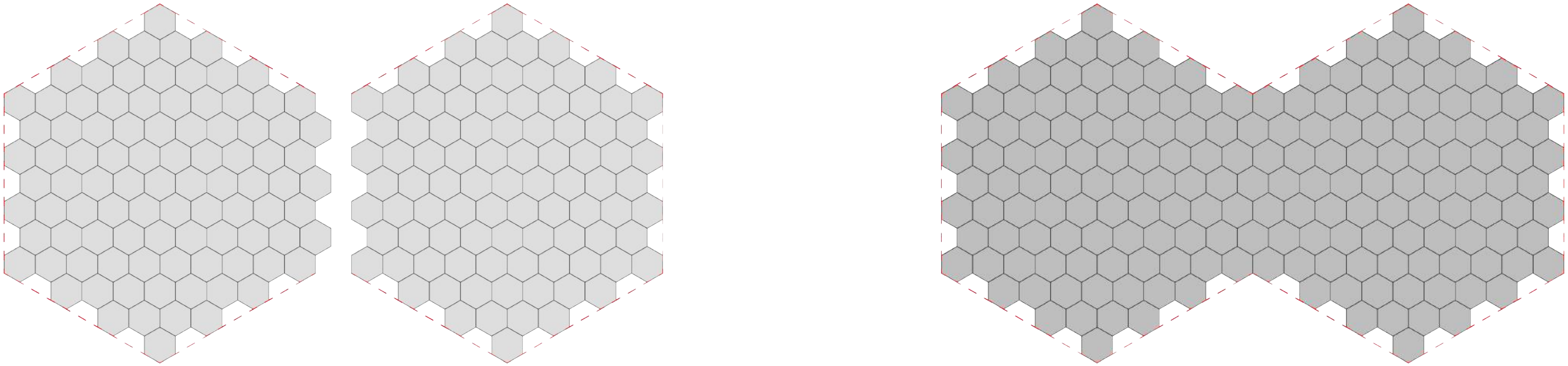
Large scale defensive strategy



IMTA unit section

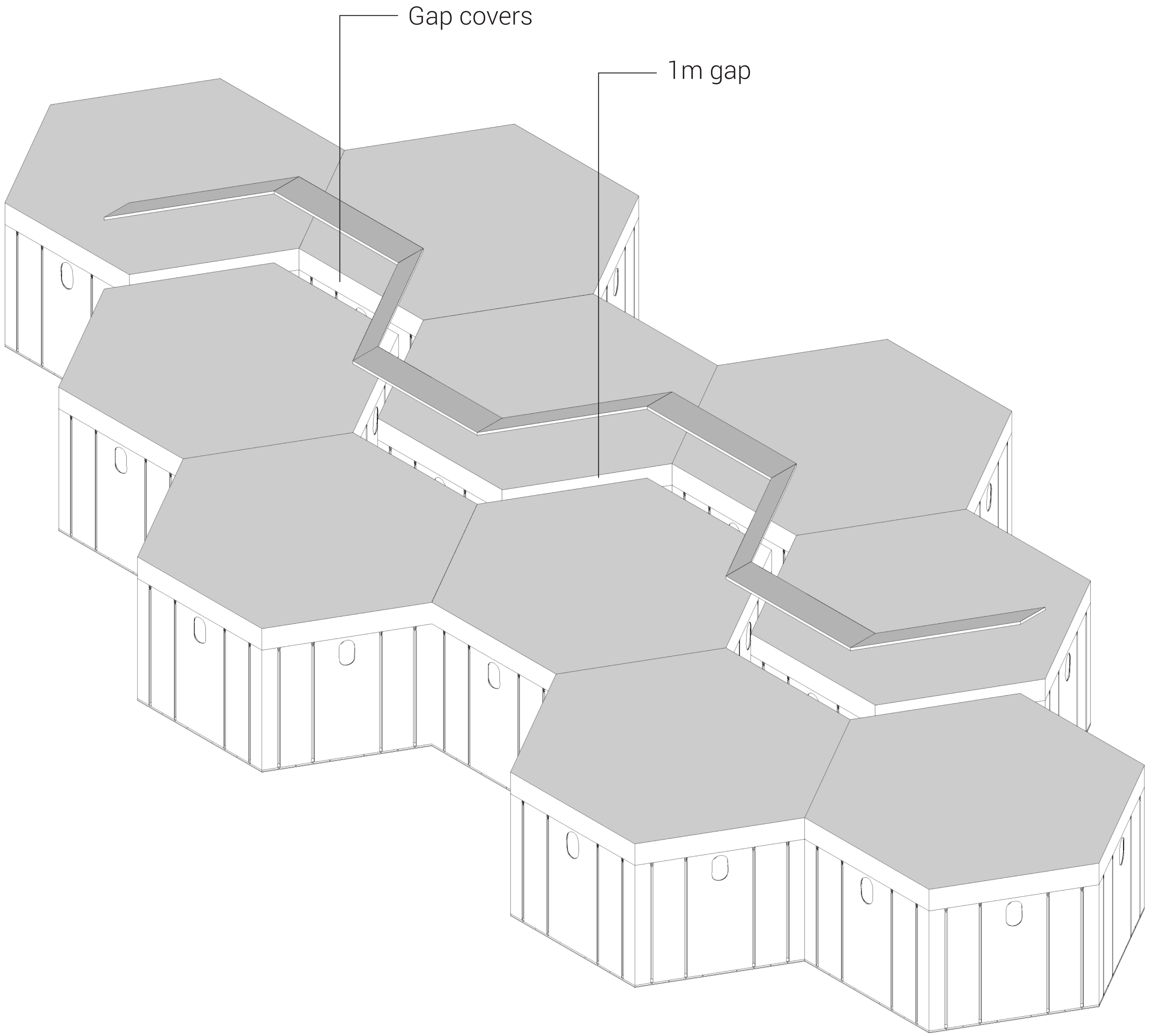


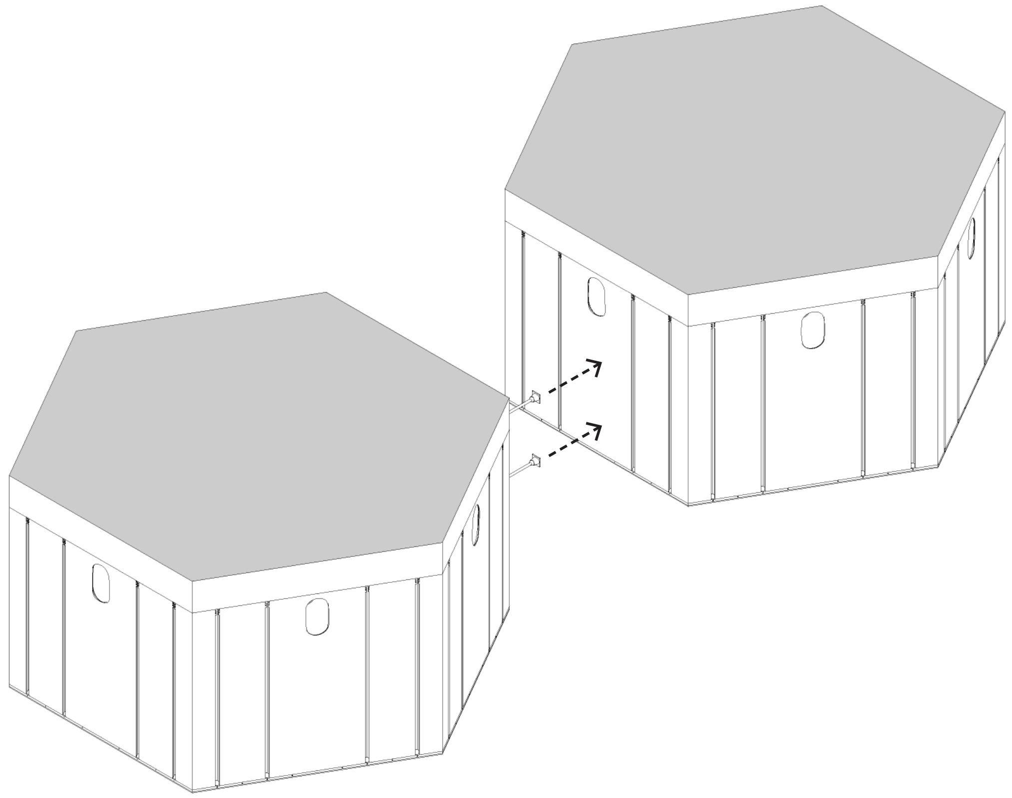
Connecting modules

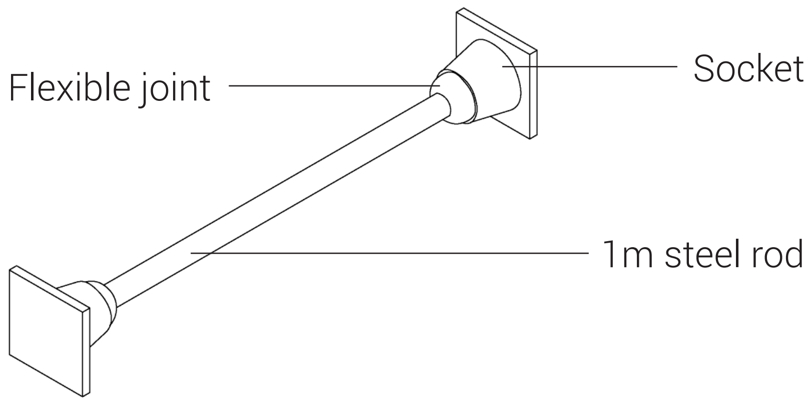


A B A-B

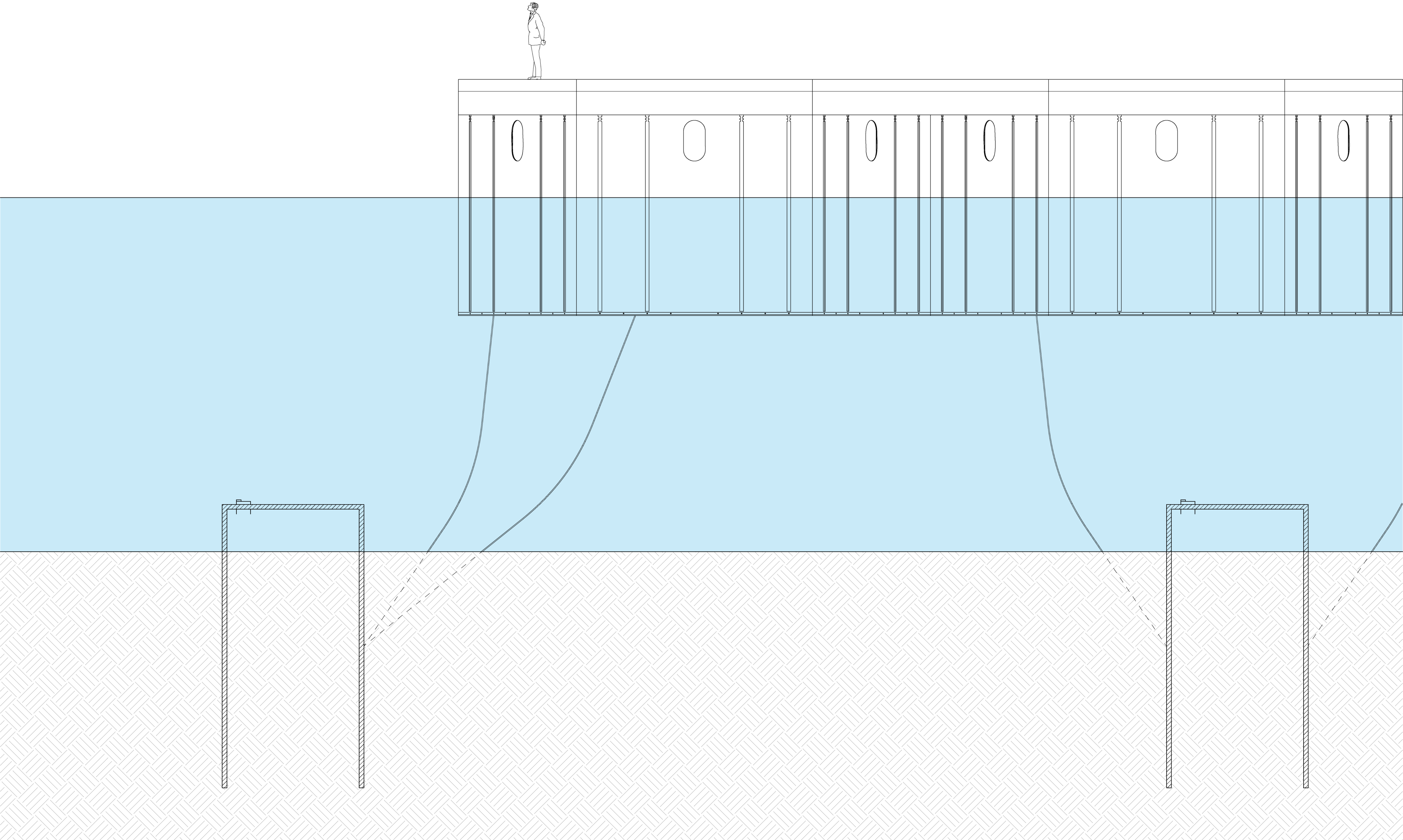
Connecting modules





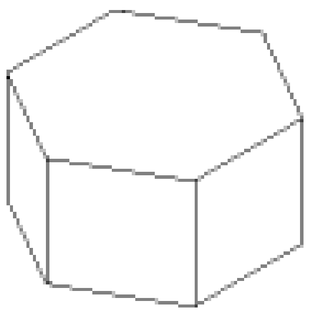


Seabed anchoring - suction caissons



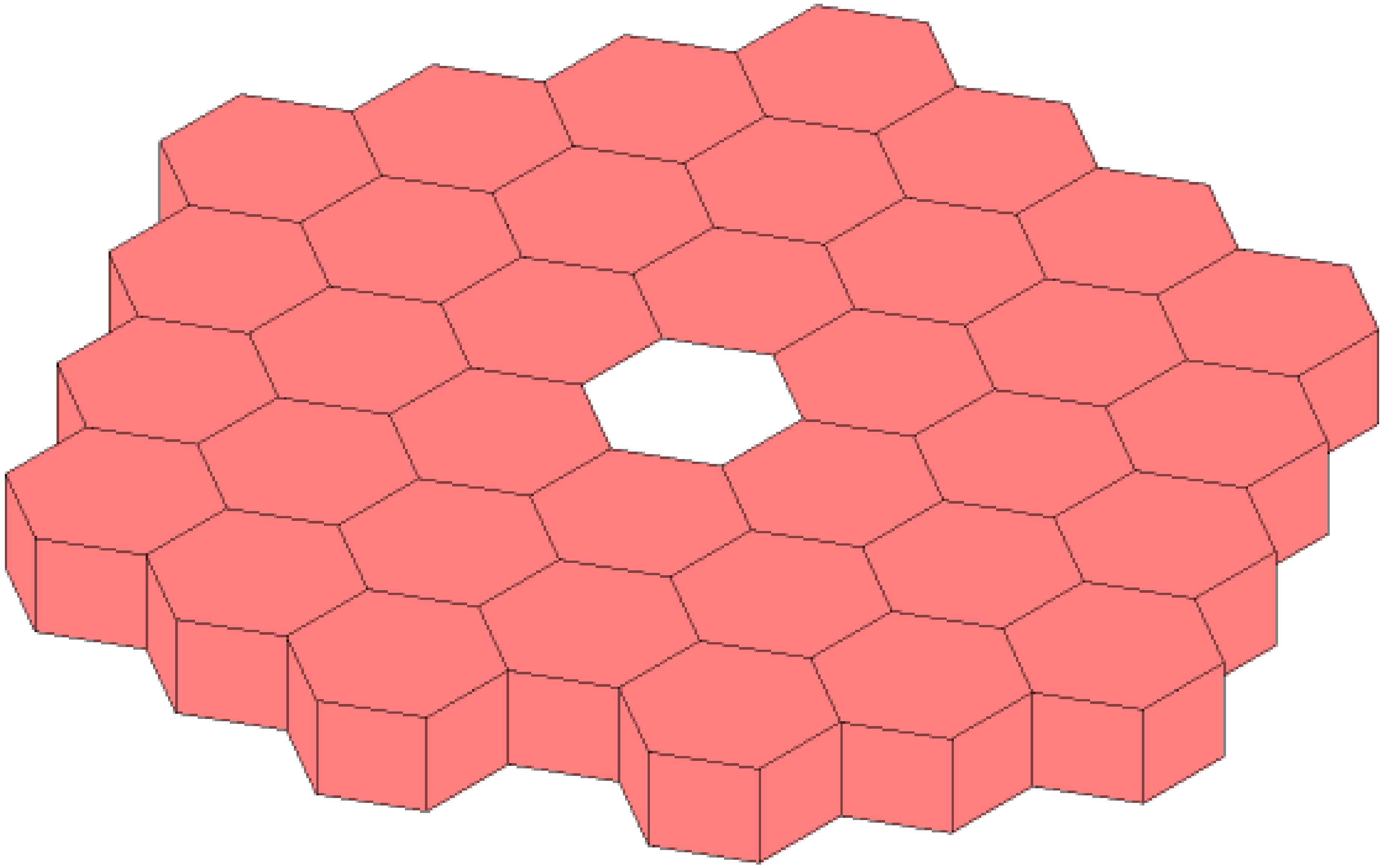
Development Sequence

1st Pod



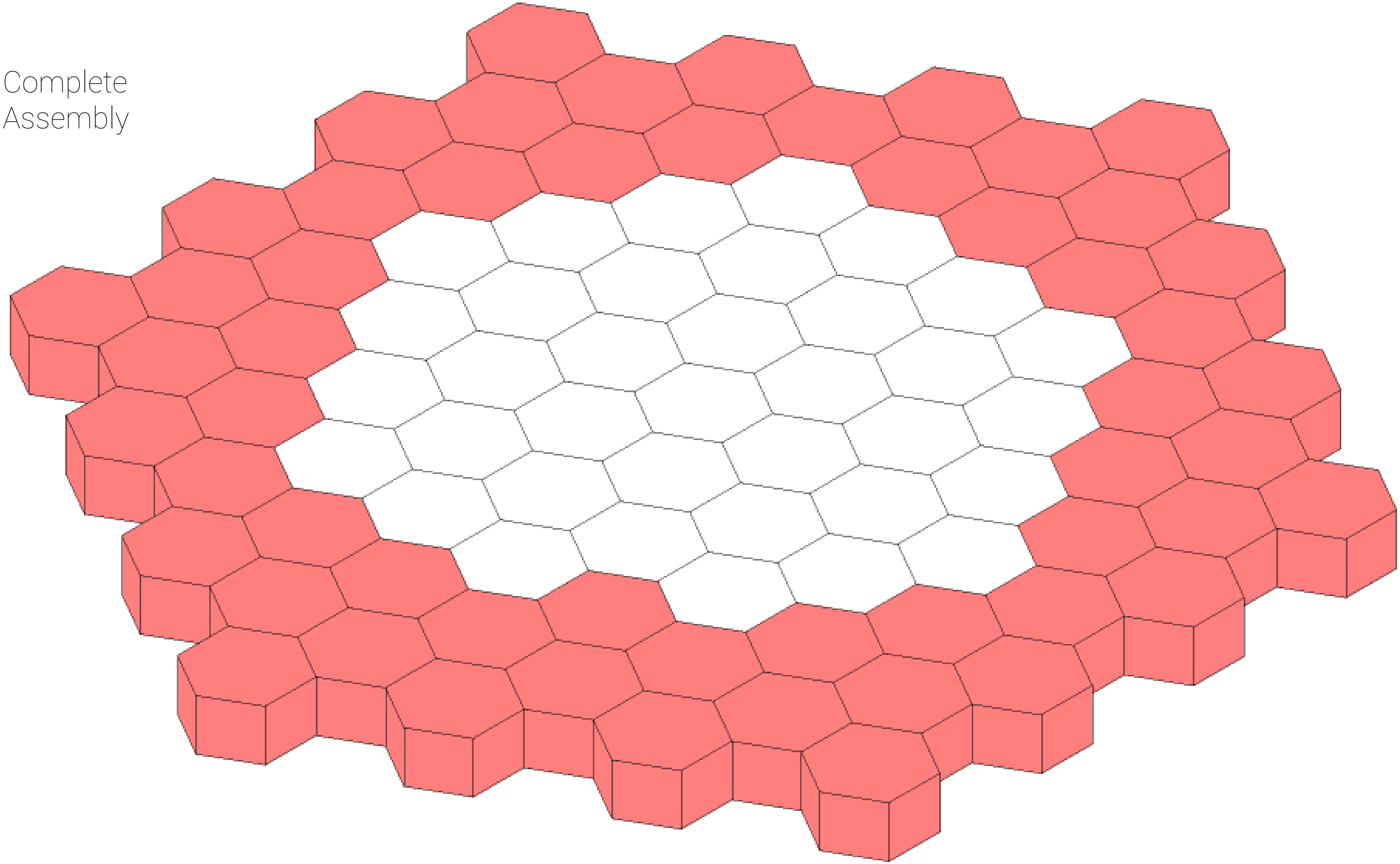
Development Sequence

Attached Pods



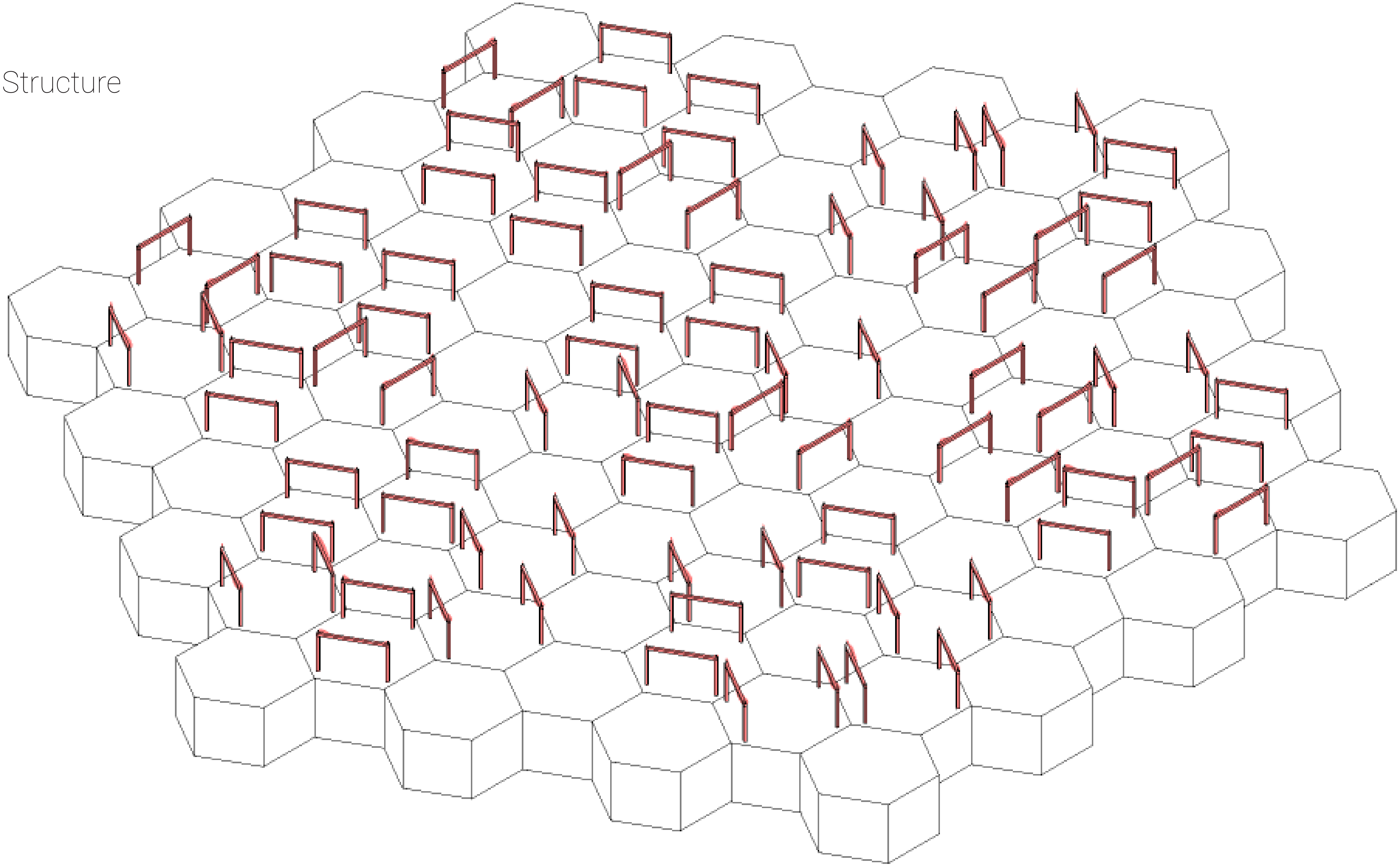
Development Sequence

Complete Assembly



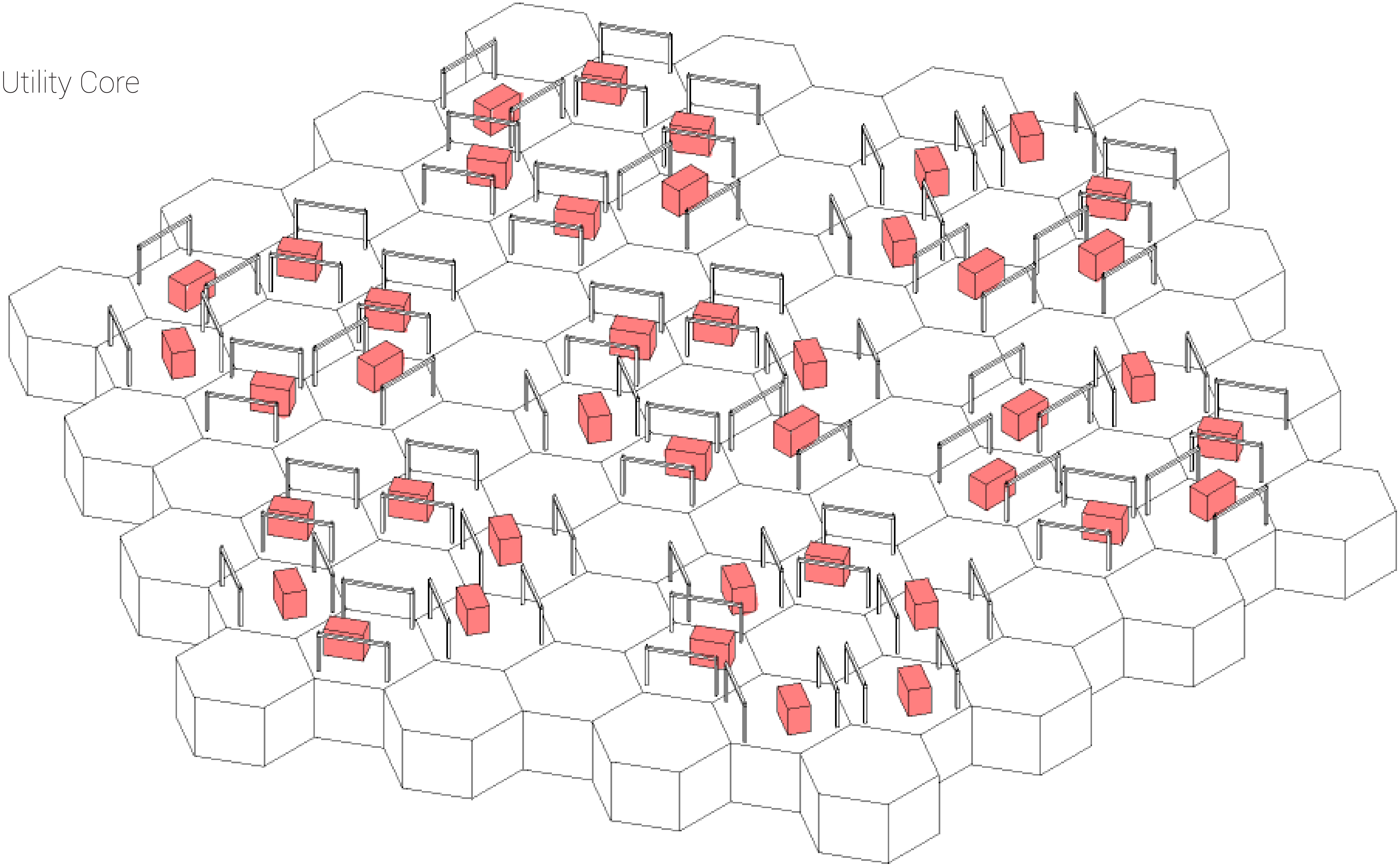
Development Sequence

Structure



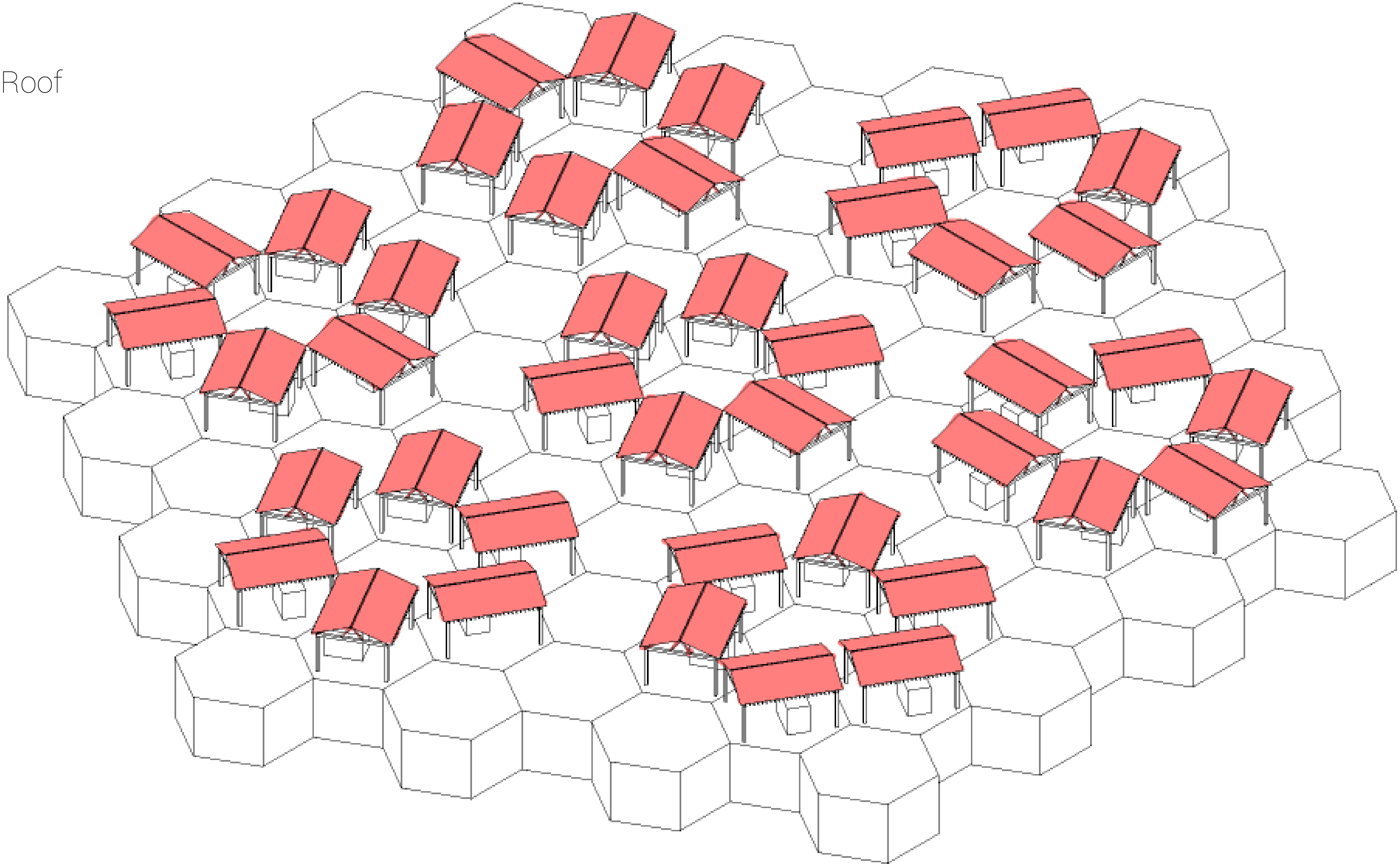
Development Sequence

Utility Core



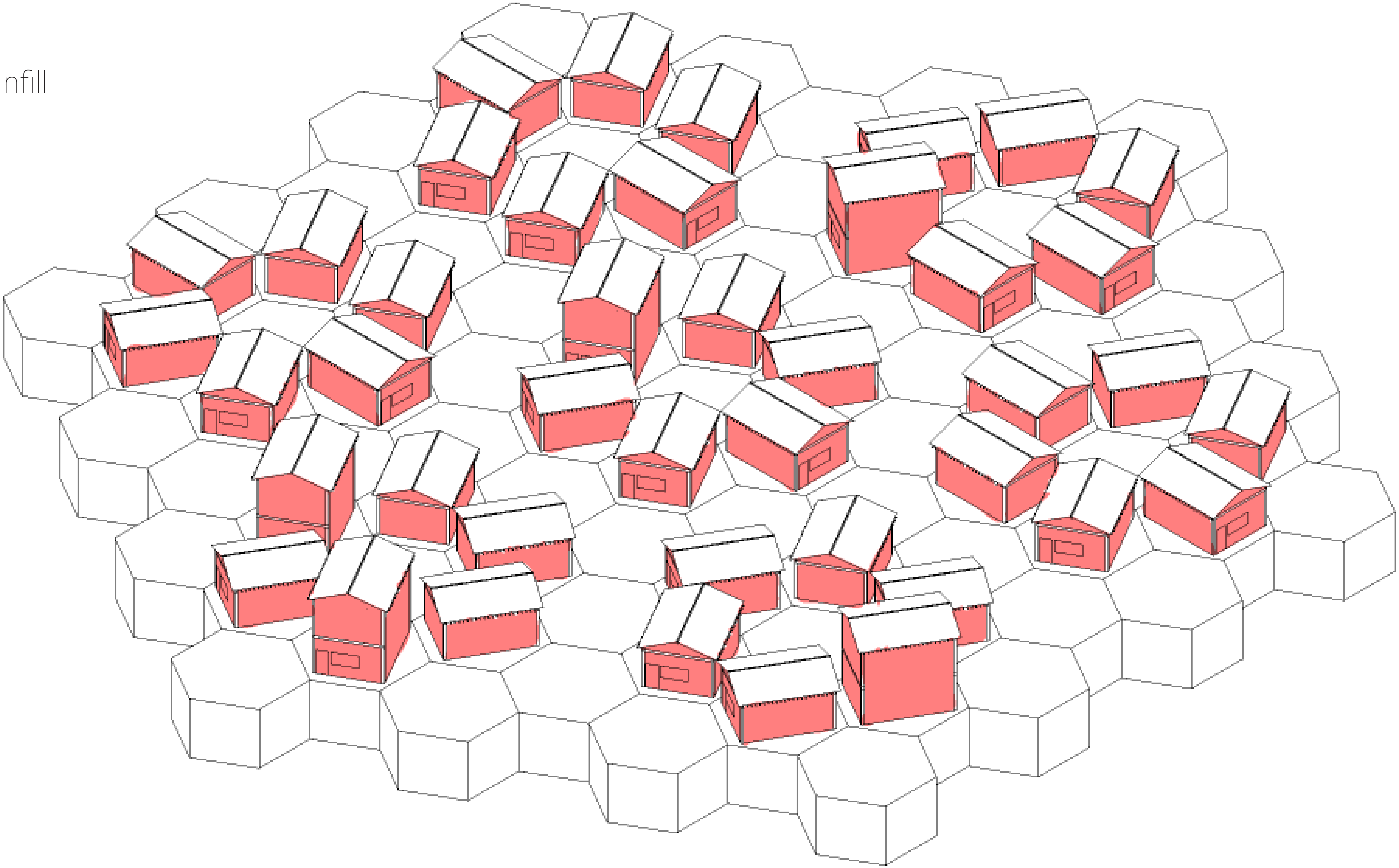
Development Sequence

Roof



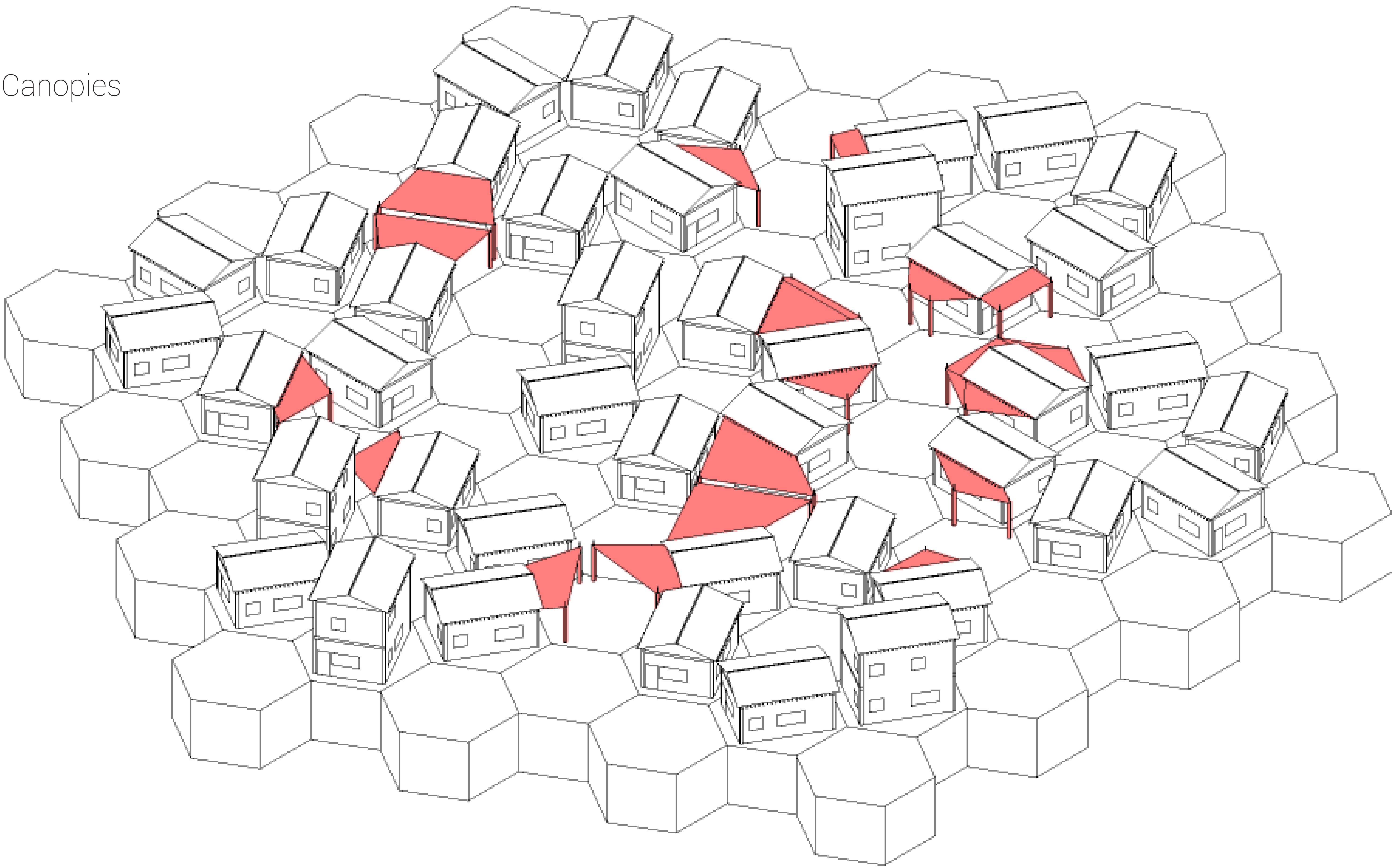
Development Sequence

Infill



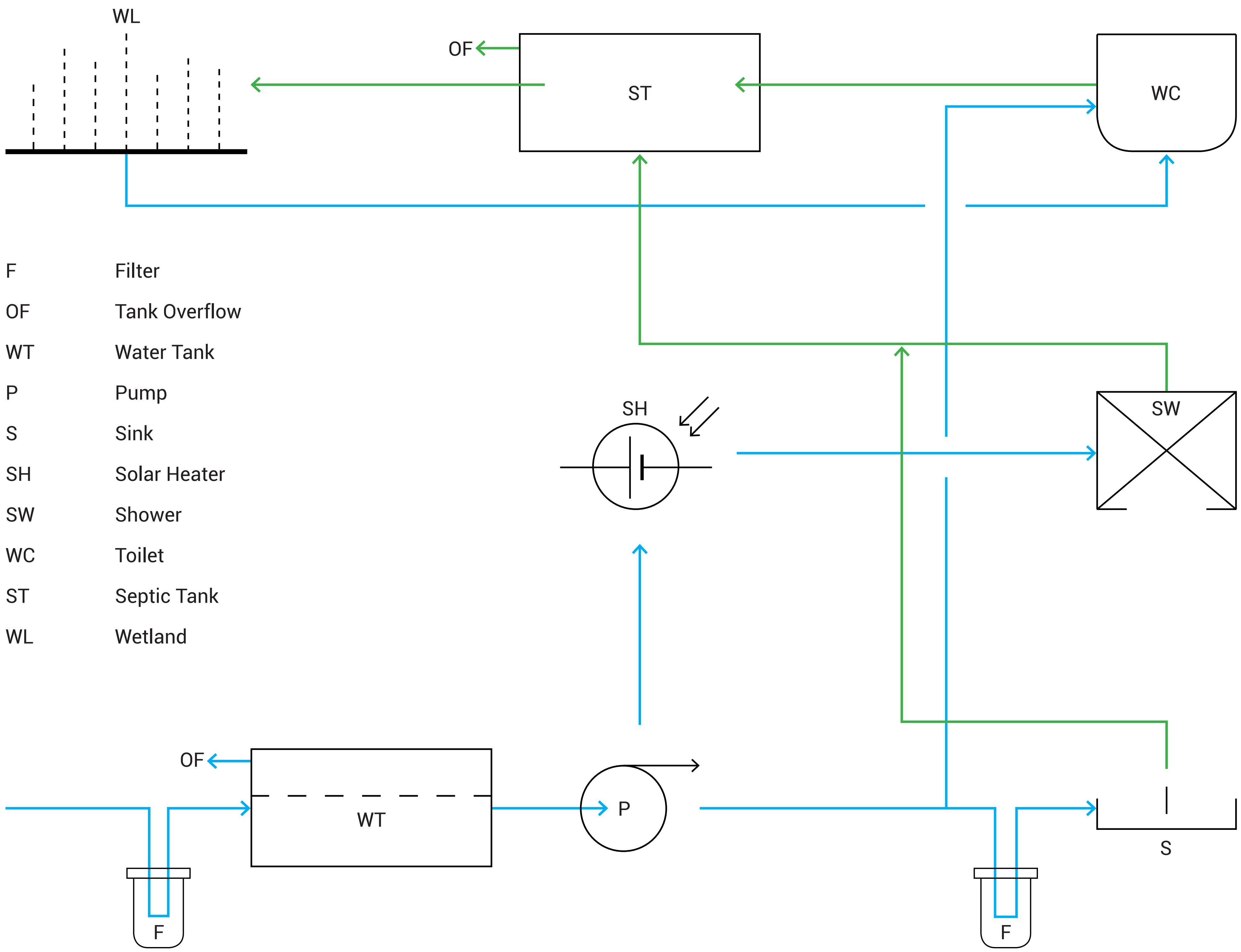
Development Sequence

Canopies



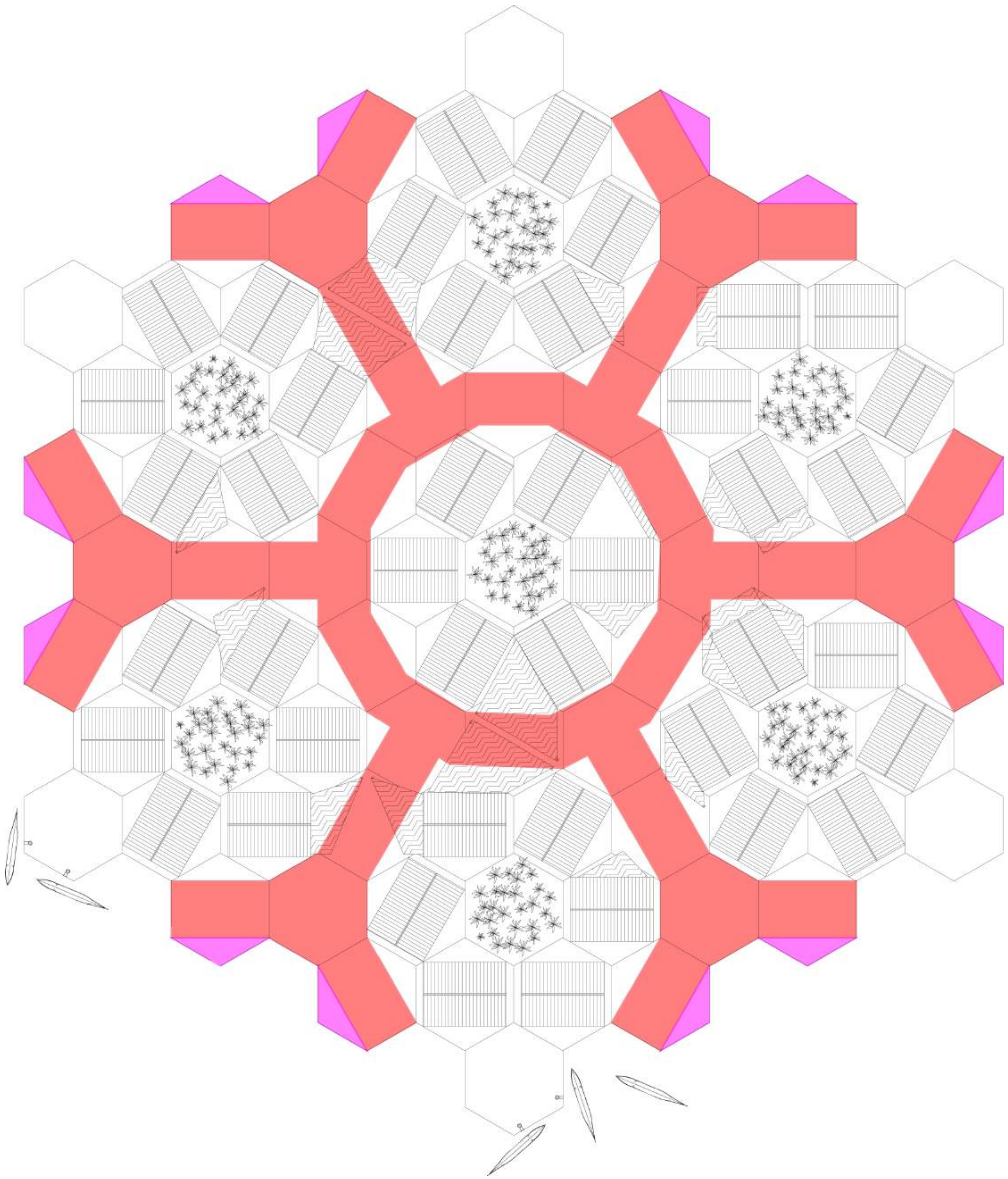
APPENDIX

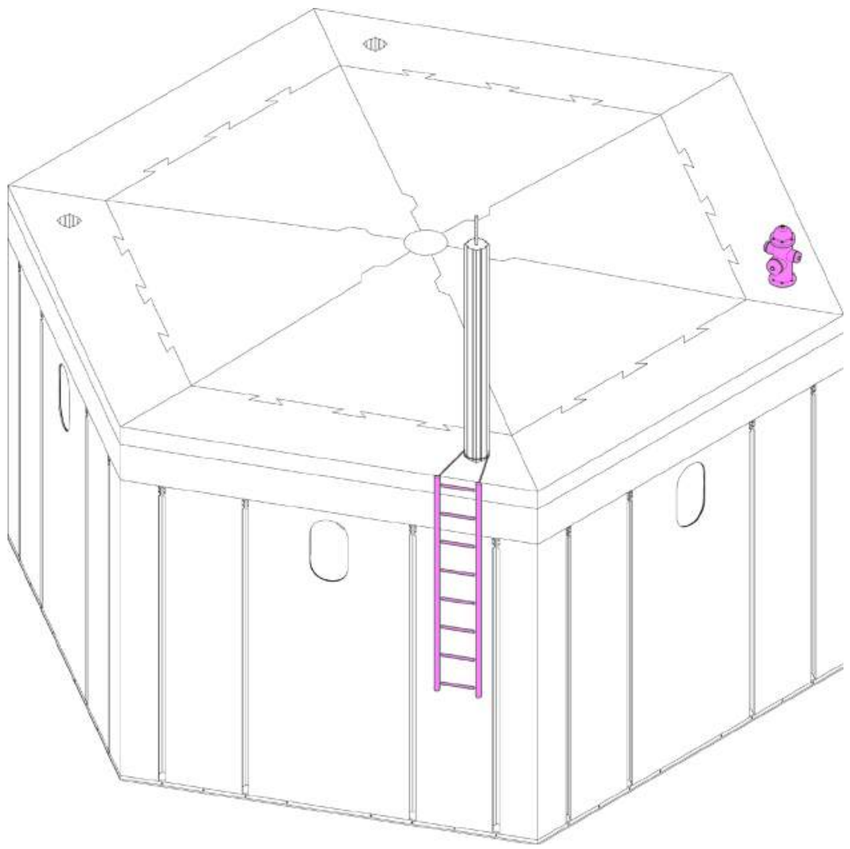
Utility schematic for House and Courtyard

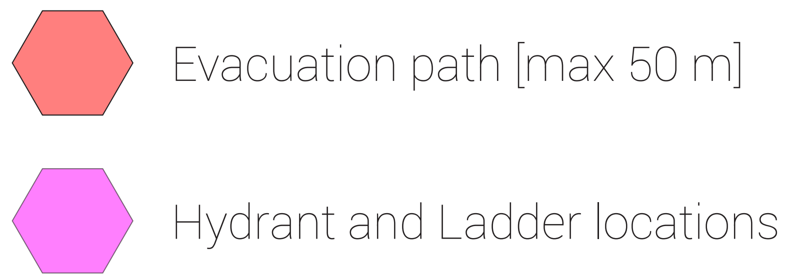


F	Filter
OF	Tank Overflow
WT	Water Tank
P	Pump
S	Sink
SH	Solar Heater
SW	Shower
WC	Toilet
ST	Septic Tank
WL	Wetland

Safety measures







Pod weight calculations

Material	m^3	$m^3 * (Kg/m^3)$	$Kg / 325\ m^3$	% submerged
HDPE plastic	6.5	6240	19.20	1.92
Concrete	17	40800	125.54	12.55
Seawater	111	111000	341.54	34.15
Bamboo	0.25	125	0.38	0.04
Other	x	~5000	15.38	1.54
		163165		50