

# A SUSTAINABLE FUTURE FOR NAVI MUMBAI THROUGH INFORMAL WASTE MANAGEMENT

— Sustainable Livelihoods for Slum Dwellers and Sustainable Development for the City



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AR3AD105 DWELLING GRADUATION STUDIO: GLOBAL HOUSING (2021/22)











# 01. BACKGROUND

Informal Waste Management as the Pathway to Sustainability

# INFORMAL WASTE MANAGEMENT IN INDIA

## COLLECTION



The collection process involves a network of waste pickers, itinerant buyers, dealers and wholesalers, etc.

## TRANSPORT



Dealers and wholesalers usually use motorised vehicles for transport, while waste pickers and itinerant buyers transport by means of trolleys, tricycles, carts, etc.

## TREATMENT



Some waste with recycling value is transported to micro recycling units in slums for treatment and recycling.

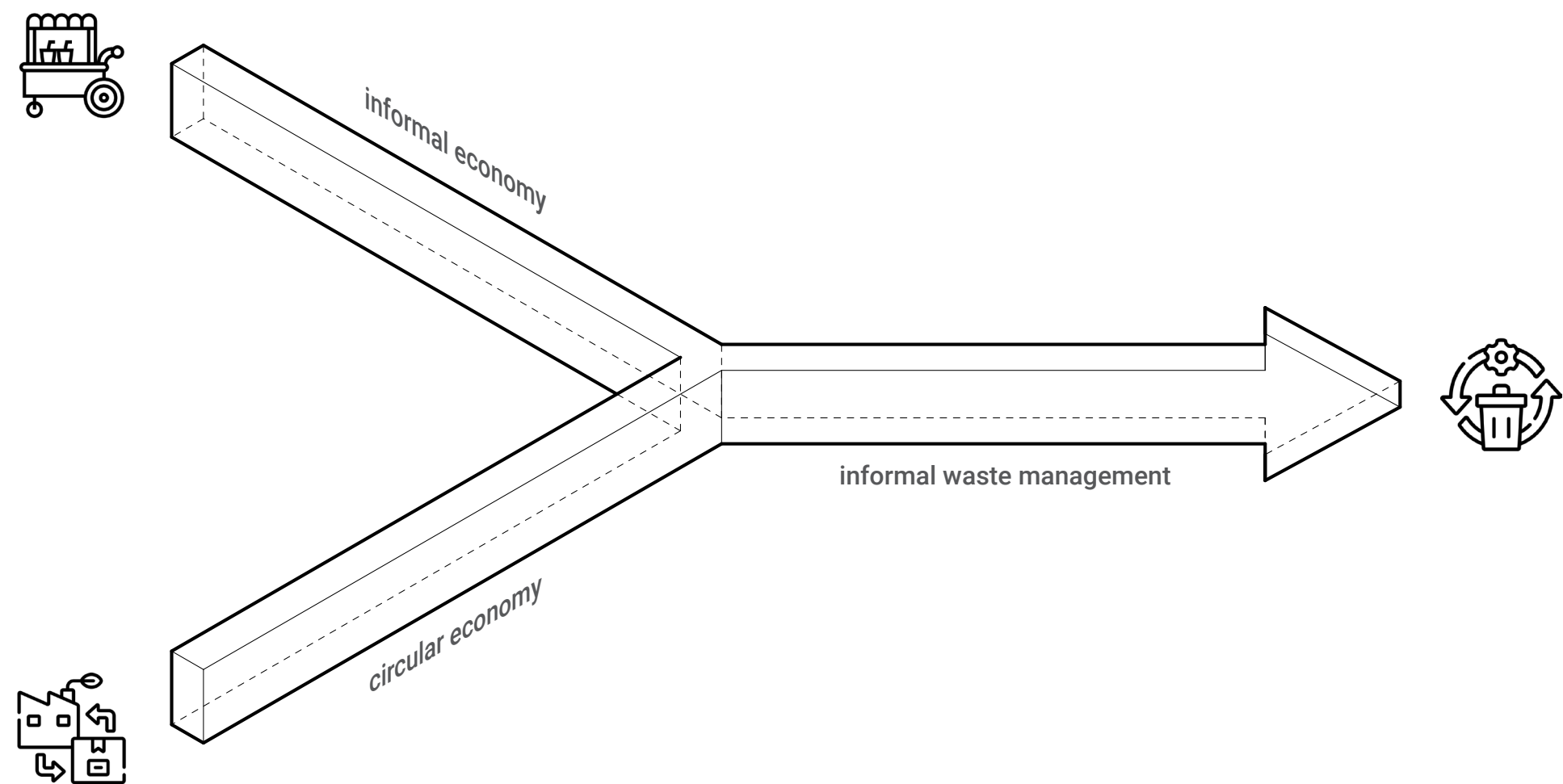
## MANUFACTURE



The treated waste has the potential to be reused or further manufactured to obtain a finished product.



# THE ROLE OF INFORMAL WASTE MANAGEMENT IN INDIA



## INTERSECTION OF INFORMAL ECONOMY AND CIRCULAR ECONOMY

In the context of India, informal waste management (IWM) has the potential to be the pathway to sustainable livelihoods for slum dwellers and sustainable development for cities. Collecting and processing hundreds of tonnes of municipal solid waste per day, IWM supports the millions of people engaged in this business and provides ecological and economic contributions to Indian cities. This industry also promotes the prosperity of other informal businesses, as they are interdependent. Taking IWM as a design starting point, the result is a framework for prosperous, humane and eco-friendly development, which sees slums as part of the growing prosperity of India's cities rather than isolating them as barriers to urban progress.

# INFORMAL WASTE MANAGEMENT AS INFORMAL ECONOMY

## - SUPPORTING THE POOR



### 1. INCOME GENERATION

- Providing income generation for millions of poor people involved in the processes of collecting, transporting, processing, and manufacturing.



### 2. AFFORDABLE EVERYDAY ITEMS

- Providing everyday items that are affordable to the poor and meeting their consumption needs.



### 3. SUPPORTING OTHER BUSINESSES

- Many informal businesses rely on a network of cooperative relationships. For example, recycling units collect paint cans, clean them up and sell to paint shops.

# INFORMAL WASTE MANAGEMENT AS CIRCULAR ECONOMY

## - PROVIDING RECYCLING SERVICE FOR THE CITY



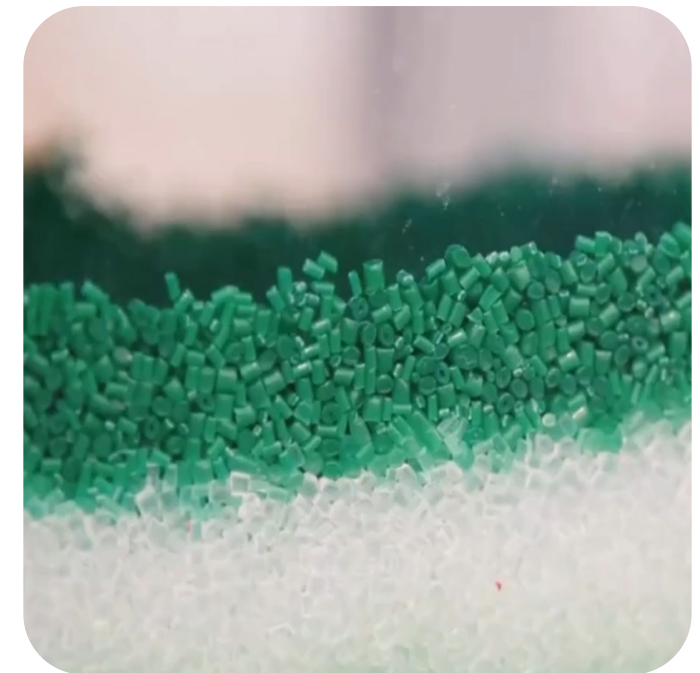
### 1. TACKLING WASTE GROWTH

- Relieving pressure on overburdened municipal waste management systems and prevent cities from being overwhelmed by waste.



### 2. REDUCING RESOURCE CONSUMPTION

- Adding value to materials and reducing gas emissions.



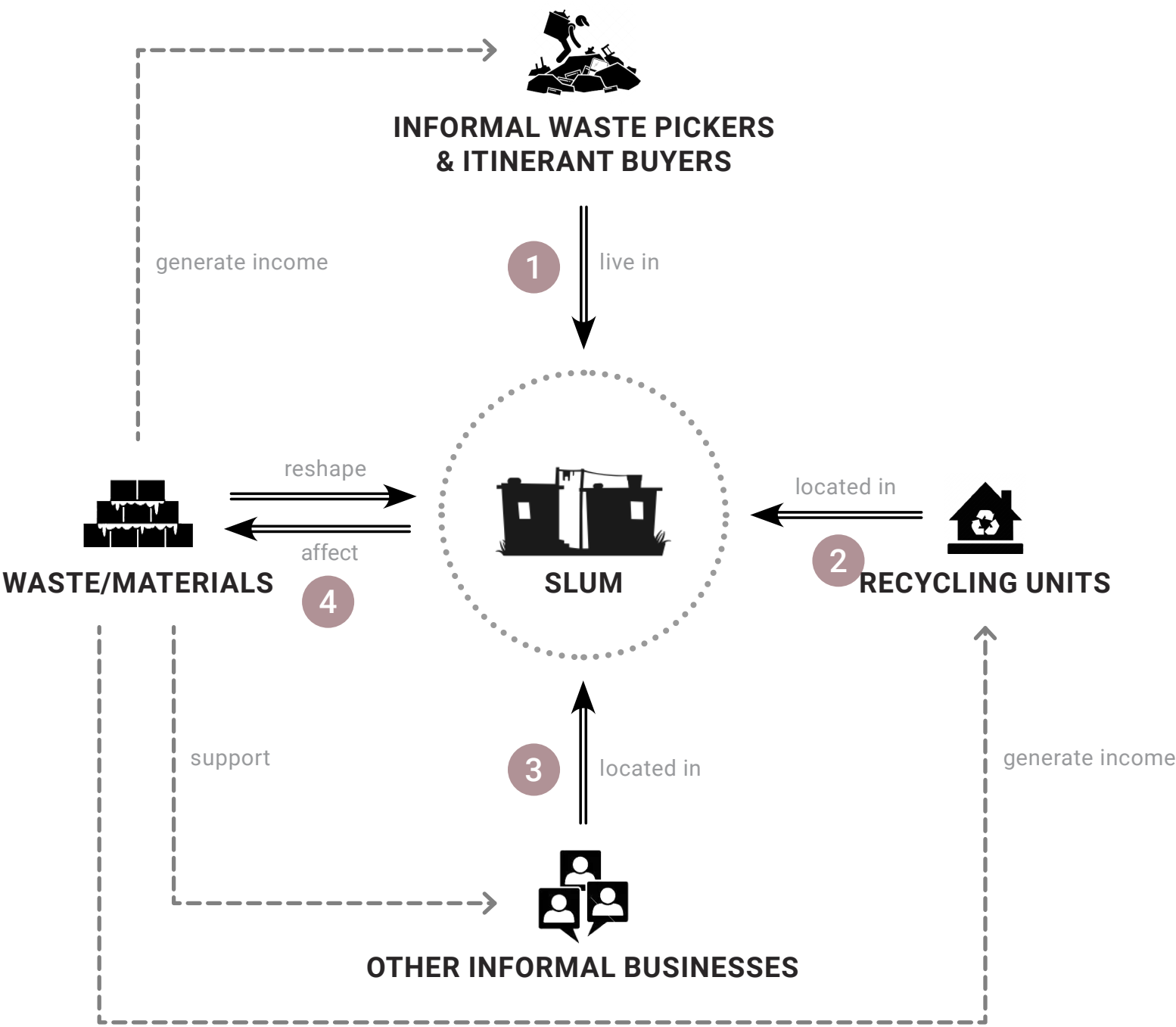
### 3. SECONDARY RAW MATERIALS

- Providing secondary raw materials to the manufacturing industry for the production of products.



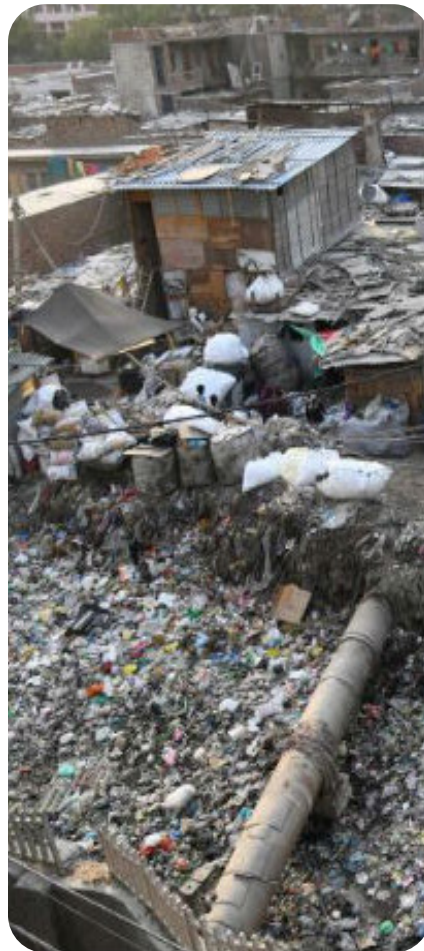
THE INTRINSIC LINK BETWEEN IWM AND SLUM

- 1. Slums are where most **informal waste pickers** and **itinerant buyers** live.
- 2. Slums accommodate many **small recycling units** engaged in IWM.
- 3. Slums are a breeding ground for a wide range of **other informal businesses** that are interdependent and associated with IWM (mainly informal manufacturing production, such as plastics, pottery, textiles and thread).
- 4. The built environment in slums serves as both **input and output** of informal waste recycling, which affects the efficiency of the business and is in turn reshaped by **recycled materials**.





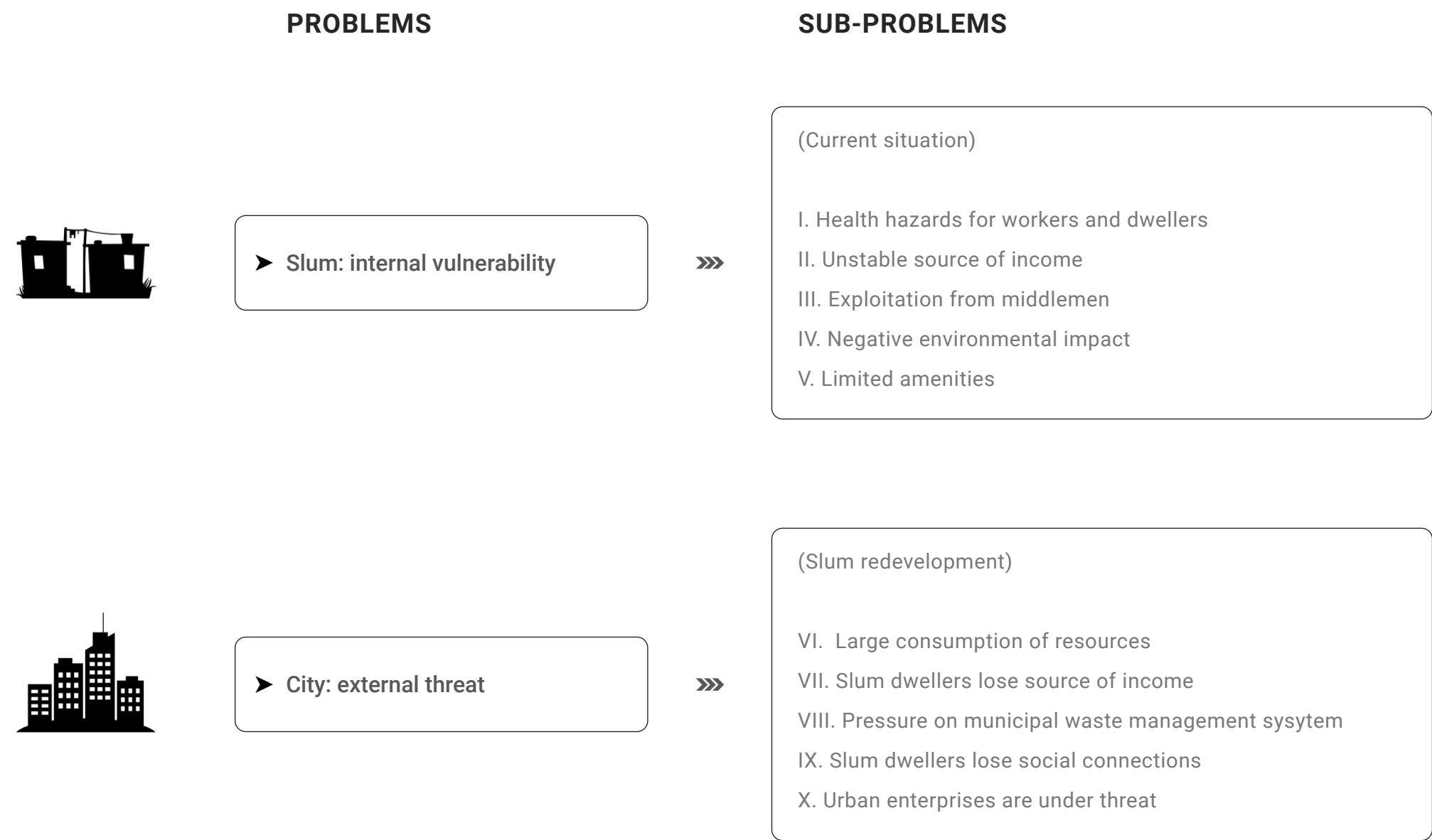
## INDIAN SLUMS DROWNING IN WASTE



### WASTE AS BOTH AN OPPORTUNITY AND A CHALLENGE

Due to a lack of sound management practices and scientific waste treatment technologies, waste accumulates in large quantities in slums, encroaching on private/public spaces and endangering sanitation and health.

# THREATS TO INFORMAL WASTE MANAGEMENT





## SLUM - INTERNAL VULNERABILITY



### I. HEALTH HAZARDS FOR WORKERS AND DWELLERS

- Much of the processing takes place in sweatshop conditions in terms of heat, ventilation, safety and overcrowding.
- Sanitary issues in working and living places, such as unpleasant odours.
- Workers sort and process waste manually and are at risk of health hazards from toxic, allergenic and sharp objects.



### II. UNSTABLE SOURCE OF INCOME

- The livelihoods of waste pickers are highly insecure as they have no rights to the waste on which they depend on and therefore they need to compete with others.
- Sometimes they are harassed by security guards or stray animals.



### III. EXPLOITATION FROM MIDDLEMEN

- The current multi-layered delivery and supply chain is chaotic and complicated, and those at the bottom of the industry are vulnerable to exploitation by dealers and wholesalers.



### IV. NEGATIVE ENVIRONMENTAL IMPACT

- The handling and disposal of waste generates gases, noise, bioaerosols, smoke, dust and particles that pollute the environment of residential areas.



### V. LIMITED AMENITIES

- There is a very limited provision of schools, libraries, community spaces, playgrounds or childcare for workers, dwellers and their kids.

## CITY - EXTERNAL THREAT



### VI. LARGE CONSUMPTION OF RESOURCES

- The demolition of slums and the construction of massive high-rise buildings consumes resources and large quantities of building materials, putting pressure on the environment.



### VII. SLUM DWELLERS LOSE SOURCE OF INCOME

- With no space allocated for informal business, these redevelopment projects cut off the original support networks of the informal economy and the dwellers' source of income. Some past slum redevelopment schemes have turned slums into massive housing and commercial complexes, but there was no space for the poor.



### VIII. PRESSURE ON MUNICIPAL WASTE MANAGEMENT SYSTEM

- With informal waste management in slums under threat, municipal waste management systems have to be overloaded to avoid the city being overwhelmed by waste.



### IX. SLUM DWELLERS LOSE SOCIAL CONNECTIONS

- The form of tower would threaten the community sentiment and the vibrant social structure that underlie the flourishing of informal micro-businesses in the slums.

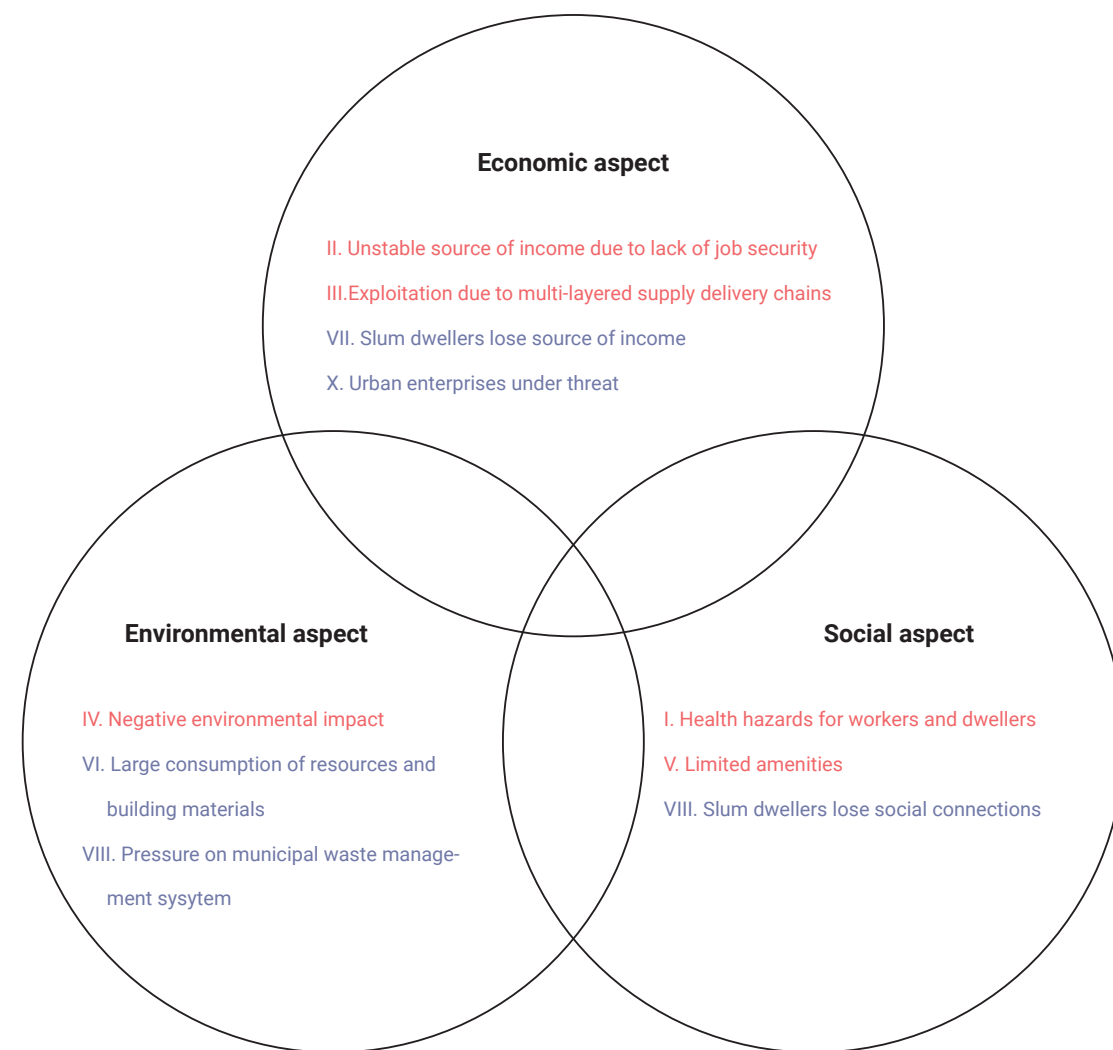


### X. URBAN ENTERPRISES ARE UNDER THREAT

- The disruption of the supply chains threatens thousands of businesses that employ slum dwellers and the downstream industries that depend on raw secondary materials and components from the slums.

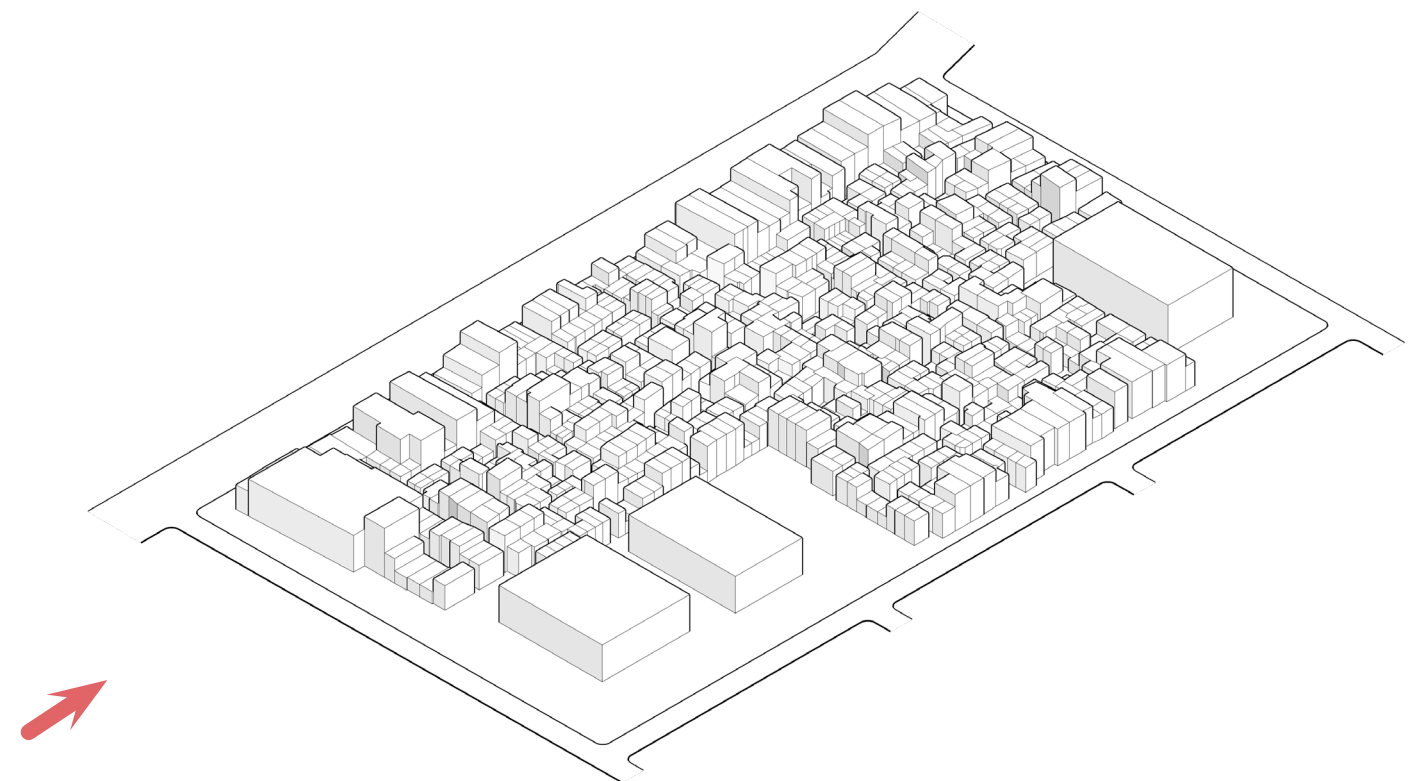


# TWO UNSUSTAINABLE DIRECTIONS FOR SLUM DEVELOPMENT

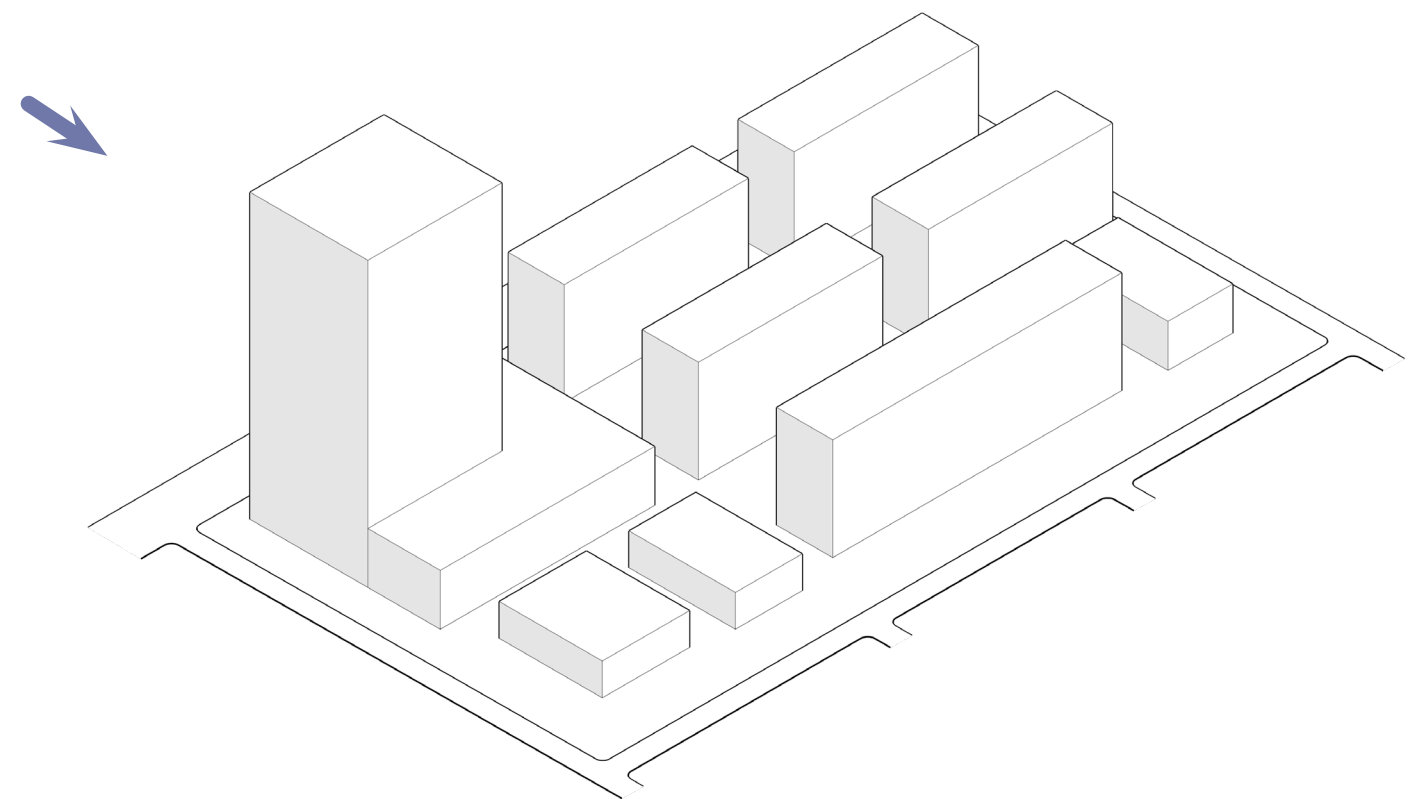


## THREE PILLARS OF SUSTAINABILITY FRAMEWORK

From the perspective of three pillars of sustainability framework, neither the existing situation of slums nor the past interventions to them are sustainable. It is necessary to explore a new direction for future slum development which entails a synthesis of economic, environmental and social sustainability.



Current Situation of slums



Possible interventions by developers

RESEARCH QUESTION

With the approach of slum redevelopment, how does informal waste management operate in synergy with other economic sectors in a spontaneous socio-economic cluster to promote sustainable livelihoods for slum dwellers and sustainable development for Navi Mumbai?

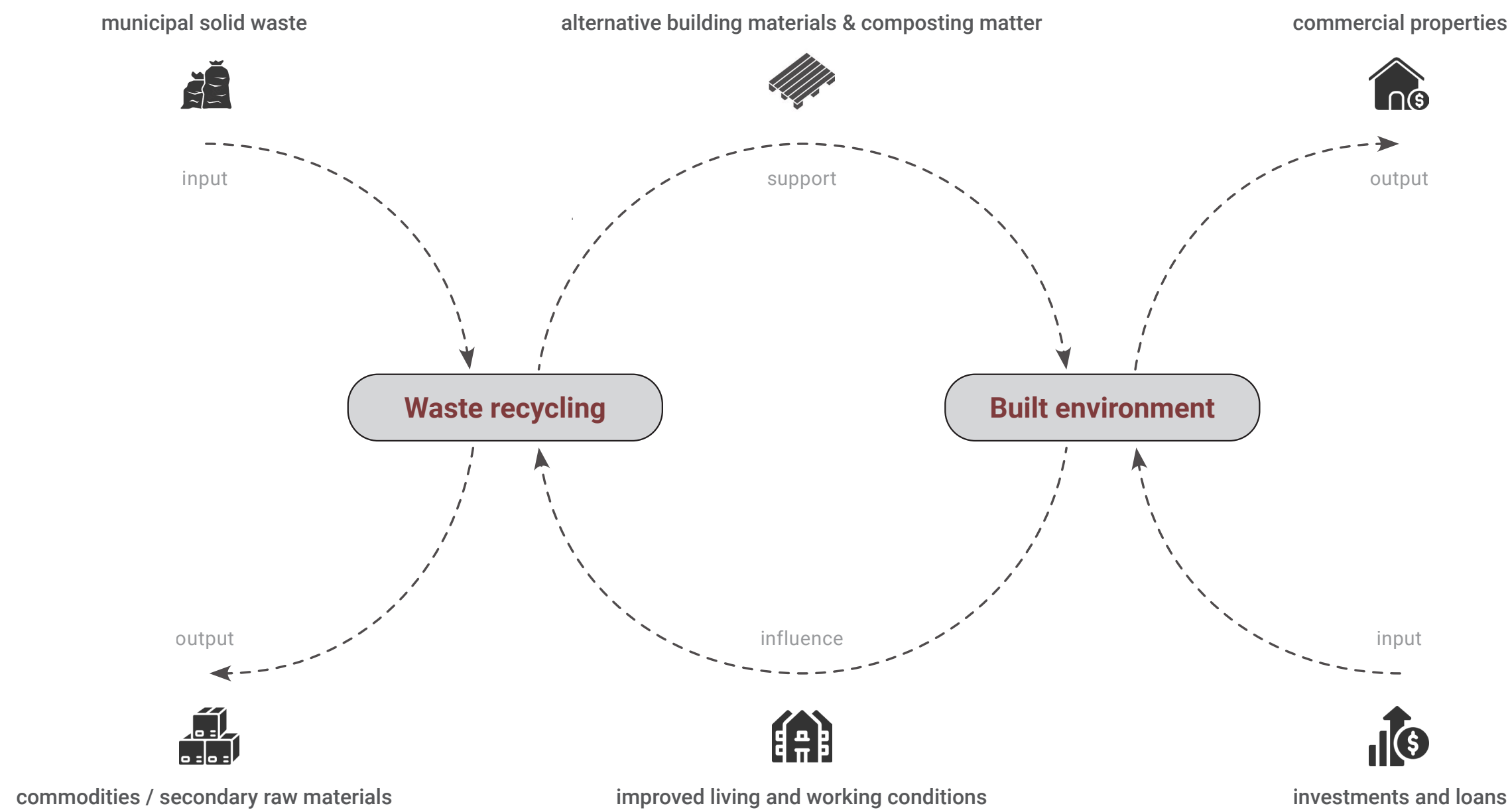
SUB-QUESTIONS

Economic aspect	<div><div>- How to develop a sound operating model for IWM in slums to create healthy working mechanisms, life-work balance, and sustainable financial returns for people engaged in this business?</div><div>- How can IWM positively influence (or be influenced by) other formal/informal businesses, and how do they interact and collectively bring direct and potential economic benefits to the dwellers and the city (generating income or providing inexpensive goods)?</div></div> <div></div>
Environmental aspect	<div><div>- How can IWM promote circularity through recycling resources/materials and saving energy, thereby improving the ecological sustainability and resilience of the slums and the city?</div></div> <div></div>
Social aspect	<div><div>- How can IWM improve the quality of life of citizens and slum dwellers (for example, can recycled waste be used as new building materials or daily necessities)?</div><div>- How to enable a range of vibrant socio-economic activities grounded in a complex network of IWM and other informal industrials? Furthermore, how can an inclusive community be developed on this basis, increasing its dynamism, diversity, cohesion and interconnectedness?</div></div> <div></div>
Housing aspect	<div><div>- How does the built environment (including scales of city, community, neighbourhood, building, and dwelling unit) positively impact the above aspects?</div><div>- How do the output outcomes of the above aspects in turn reshape the built environment, thus creating a positive feedback loop?</div></div> <div></div>

## 02. APPROACH

A New Sustainable Trajectory

# WASTE MANAGEMENT & BUILT ENVIRONMENT



## TWO MUTUALLY PROMOTING SYSTEMS

The approach to the challenge is based on a consideration of the relationship between two mutually promoting systems, waste management and the built environment. The built environment in slums affects the efficiency of the industry and is in turn reshaped by recycled materials, creating a positive feedback loop and bringing economic, environmental and social benefits.



## MAIN AIMS OF THE PROJECT



### 1. ENVIRONMENTAL SUSTAINABILITY

Improving the model of IWM and treating wet and dry waste scientifically to increase the efficiency of recycling industry and bring positive environmental impacts.



### 2. SOCIAL SUSTAINABILITY

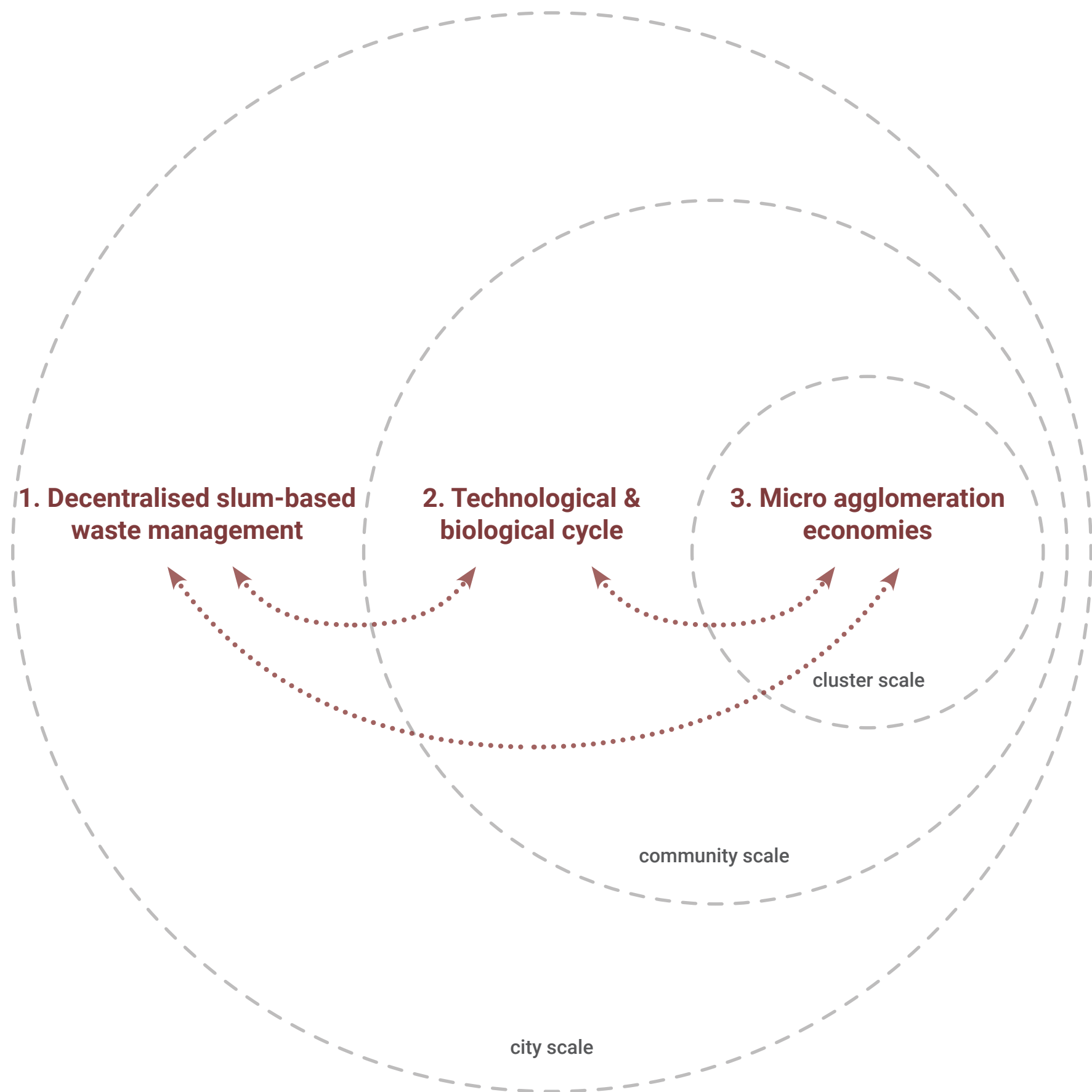
Upgrading the built environment to improve working and living conditions in current slums and promote community participation and cohesion.



### 3. ECONOMIC SUSTAINABILITY

Enhancing linkages between IWM and other formal/informal businesses in slums to bring the benefits of agglomeration economies and create diversified income generation.

# HYPOTHESIS MODEL



## PRINCIPLES AT THREE SCALES

Three design strategies at the city, community, and cluster scales are proposed respectively, namely decentralised slum-based waste management, technological and biological cycle, and micro agglomeration economies. These strategies are mutually supportive, contributing to and influencing each other at different scales. They together set the principles for replicating the model in other slums in the city, and indeed throughout India.

REINTERPRETING RELATIONSHIPS

1. DECENTRALISED SLUM-BASED WASTE MANAGEMENT

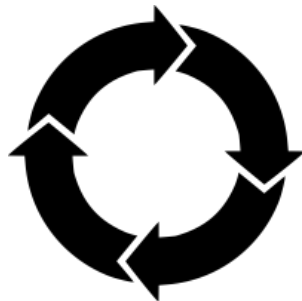
city - slum



Slums are scattered throughout the city as semi-formalised recycling sites

2. TECHNOLOGICAL & BIOLOGICAL CYCLE

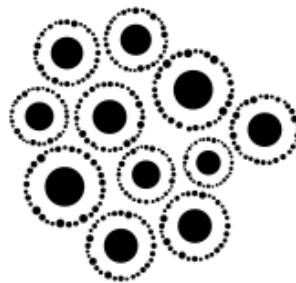
factory - recycling uint



Factories and recycling uints work together to process dry and wet waste with different means

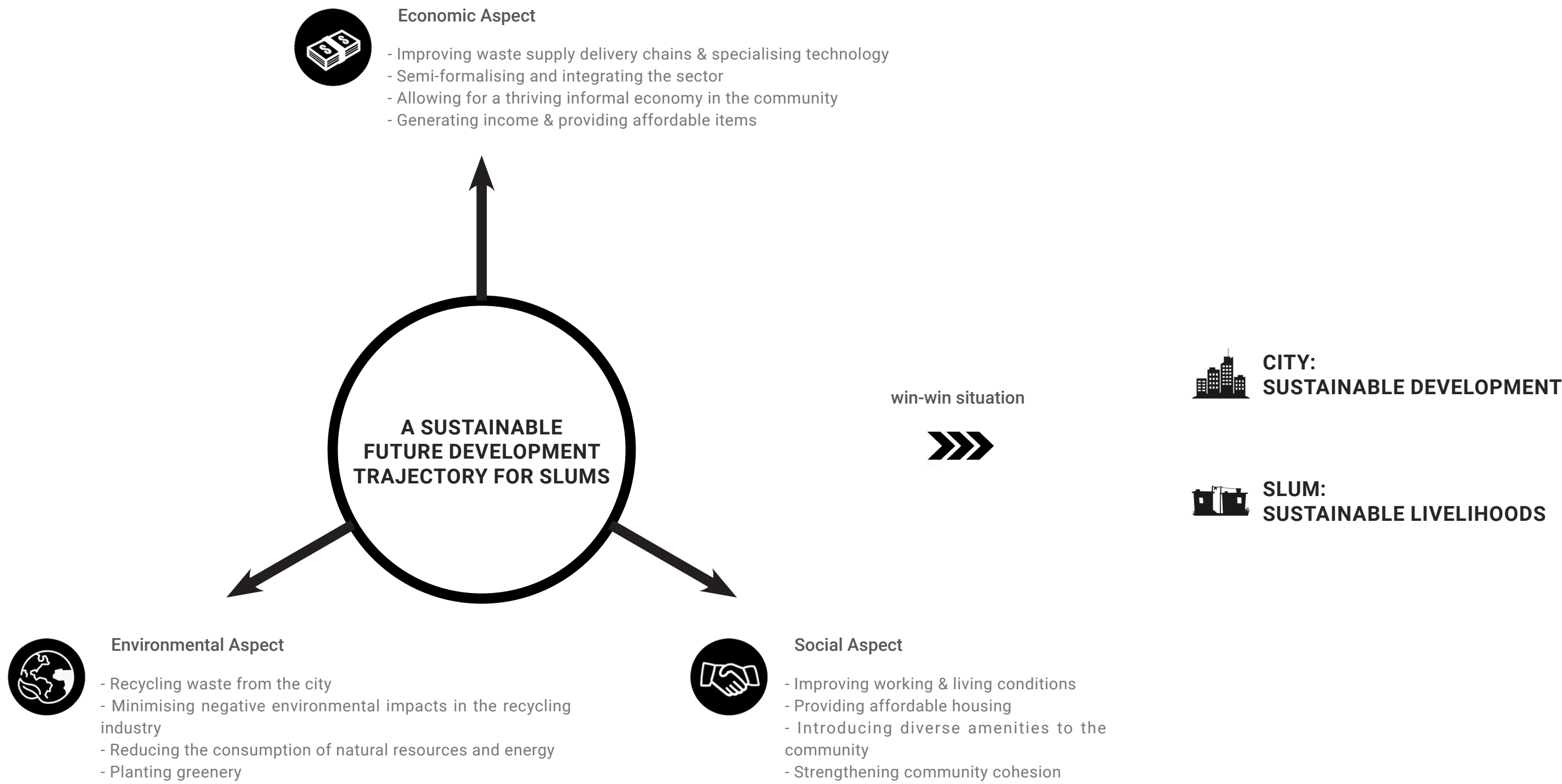
3. MICRO AGGLOMERATION ECONOMIES

home - workplace



Workplaces and commercial units are clustered together and stay in close connection with the living space

A WIN-WIN SITUATION THROUGH A NEW SUSTAINABLE TRAJECTORY





## 03. URBAN SCALE

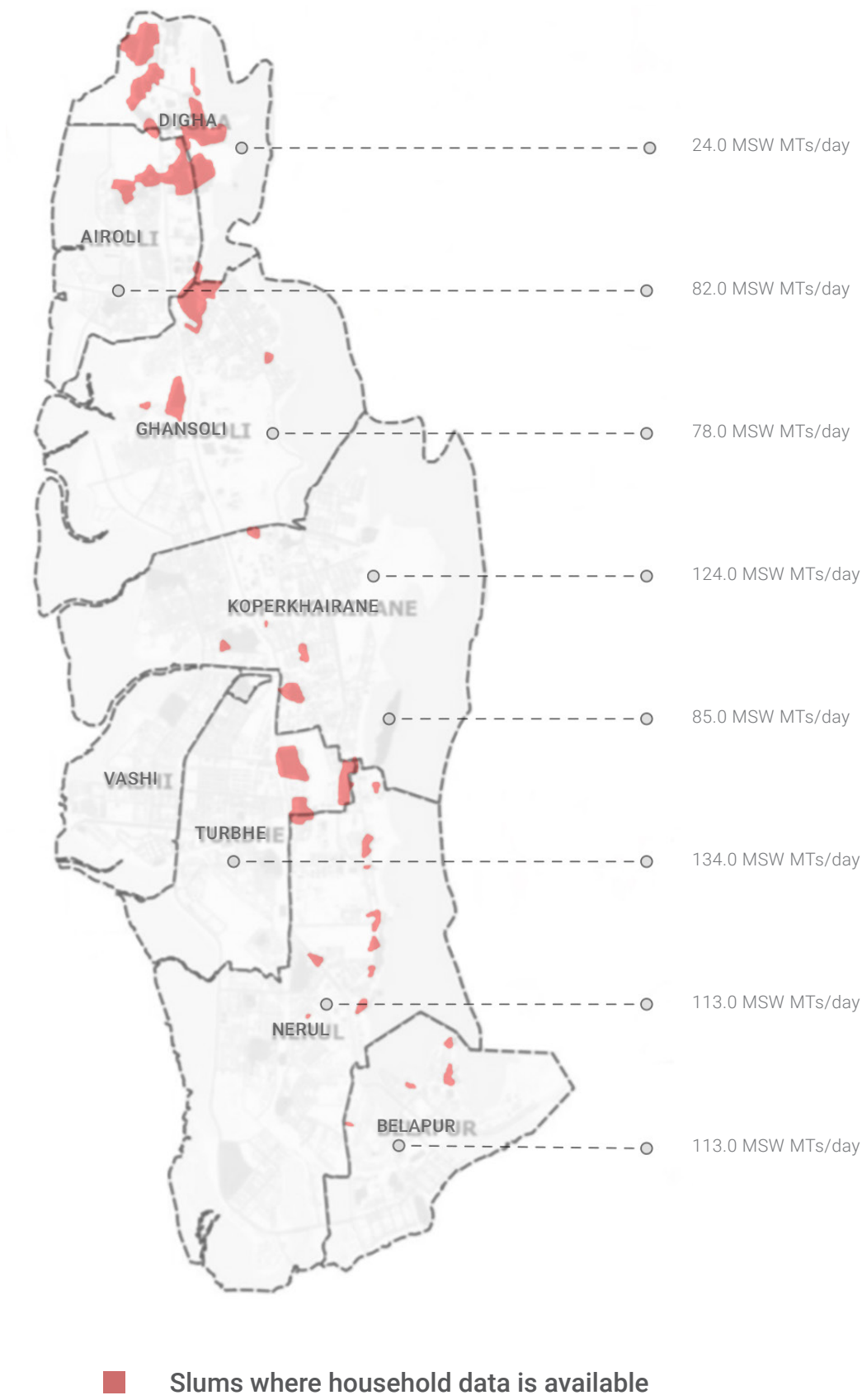
Decentralised Slum-based Waste Management

# SLUM & WASTE IN NAVI MUMBAI

## THE AMOUNT OF WASTE AND SLUMS BY REGION

According to the 2011 Census of India, Navi Mumbai has 48,577 dwellings in slums, which house approximately 1/5 of the city's total population. The informal sector in slums acts as a driving force for recycling management.

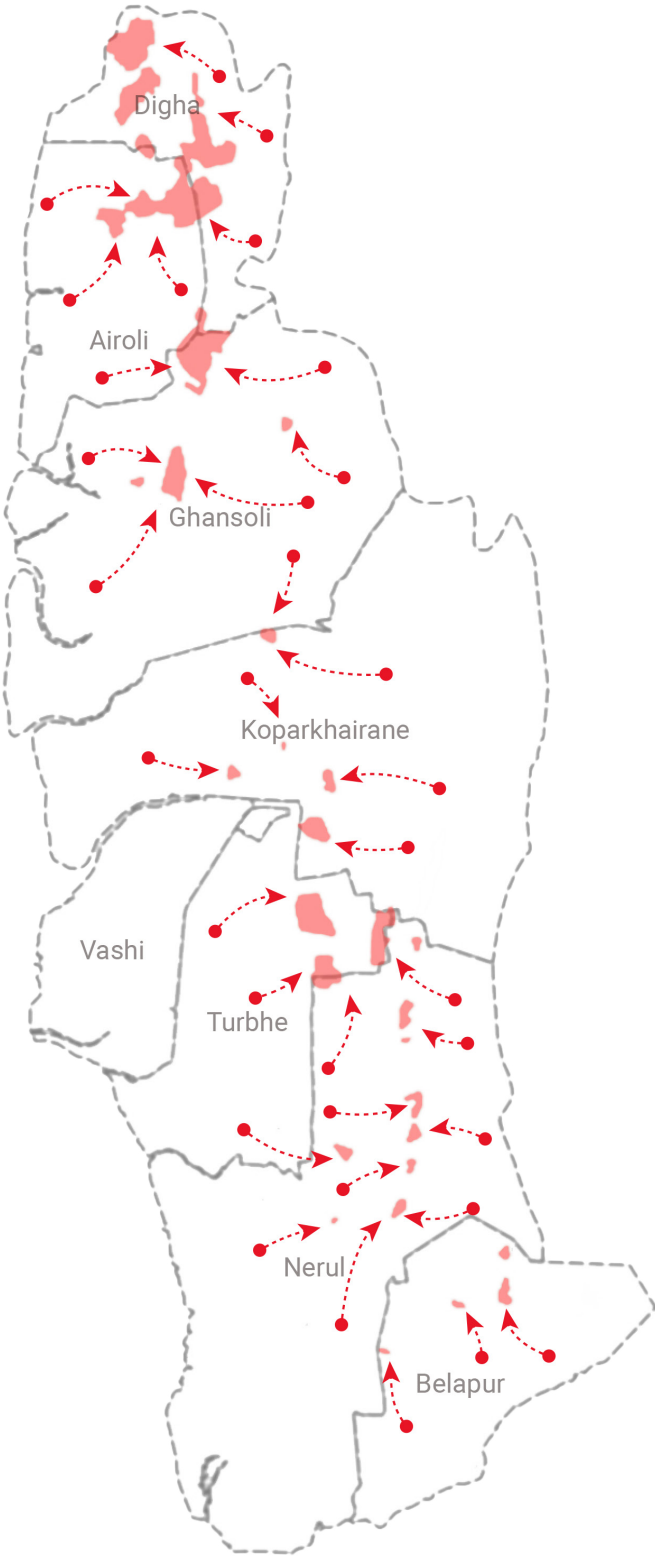
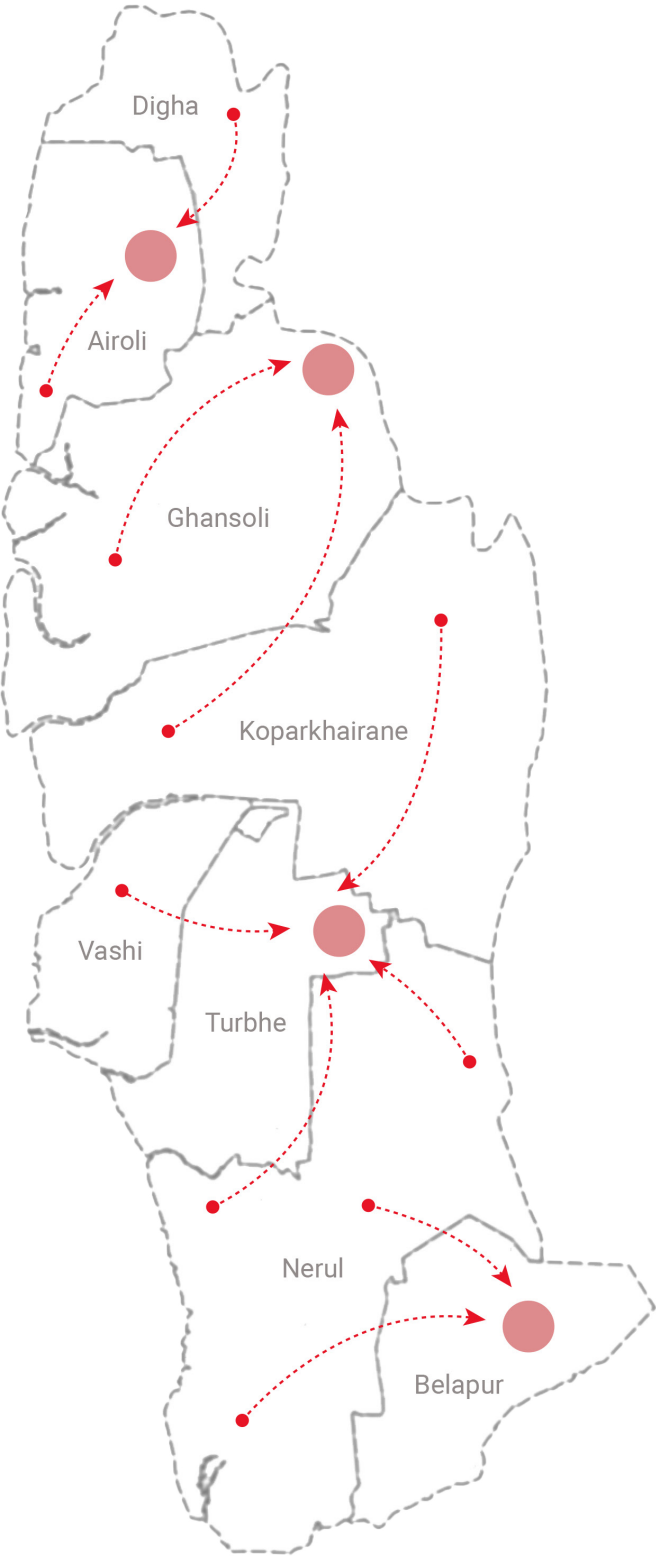
In 2018-19, the daily average solid waste generated in Navi Mumbai was 753 Metric Tons. Among all nodes, Turbhe generates the highest daily average waste (134.0 MTs/day).



# CHANGING THE WAY WASTE IS COLLECTED AND TRANSPORTED

## SEMIFORMALISING THE SYSTEM

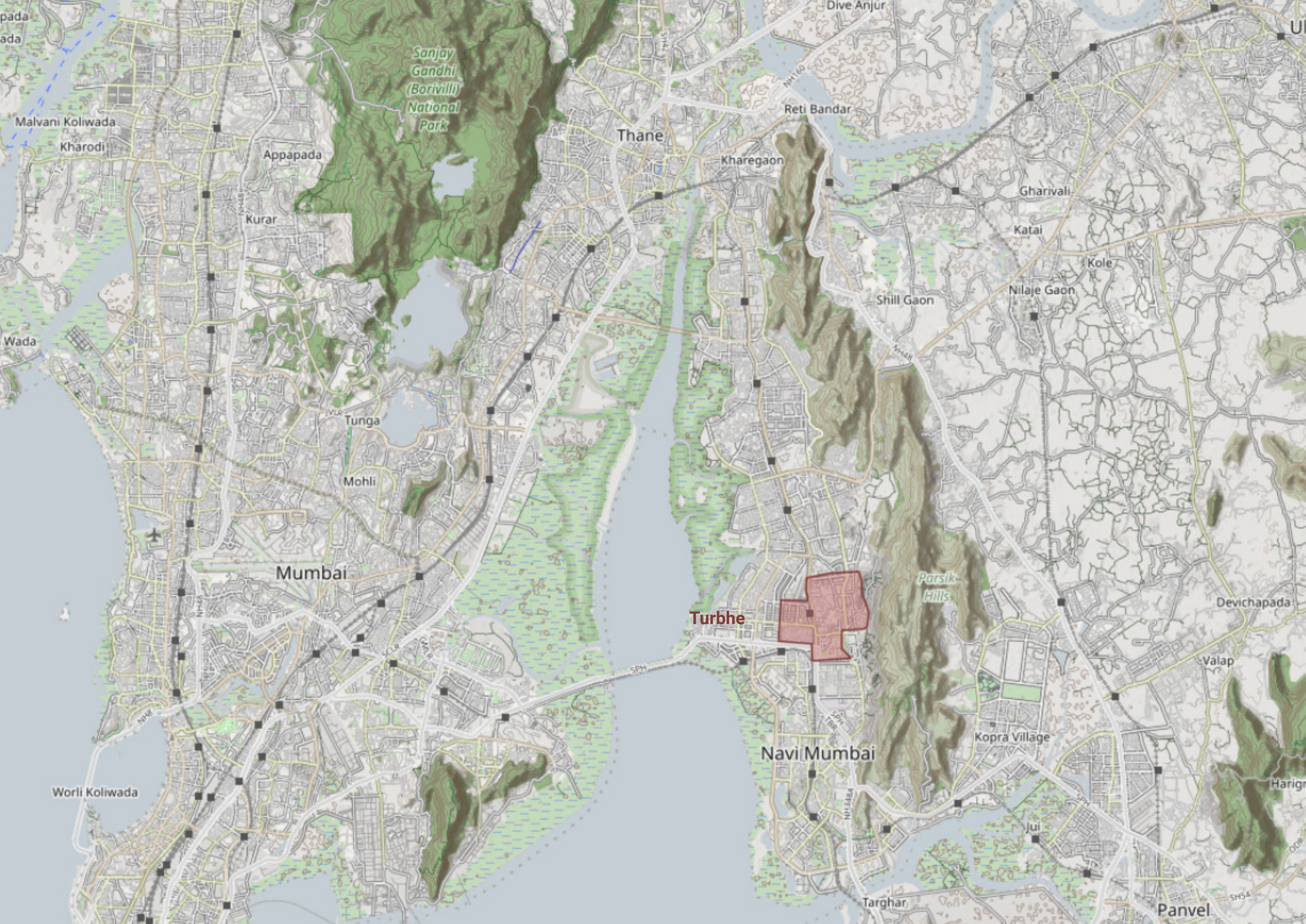
Currently, most of the waste ends up in the city's centralised landfills, leading to **significant collection and transport costs**. However, the existing slums can potentially be integrated with the municipal system and developed into **a decentralised waste management network, expanding the range of recycling services and generating income for slum dwellers**. This decentralised waste management model has the potential to be applied in other Indian cities, as waste and slums are common problems in India.



From centralised landfill-based waste management...

...to decentralised slum-based waste management





Sanjay  
Gandhi  
(Borivili)  
National  
Park

Thane

Turbhe

Navi Mumbai

Parsik  
Hills

Panvel



EXISTING CENTRALISED MODE





FUTURE DECENTRALISED MODE



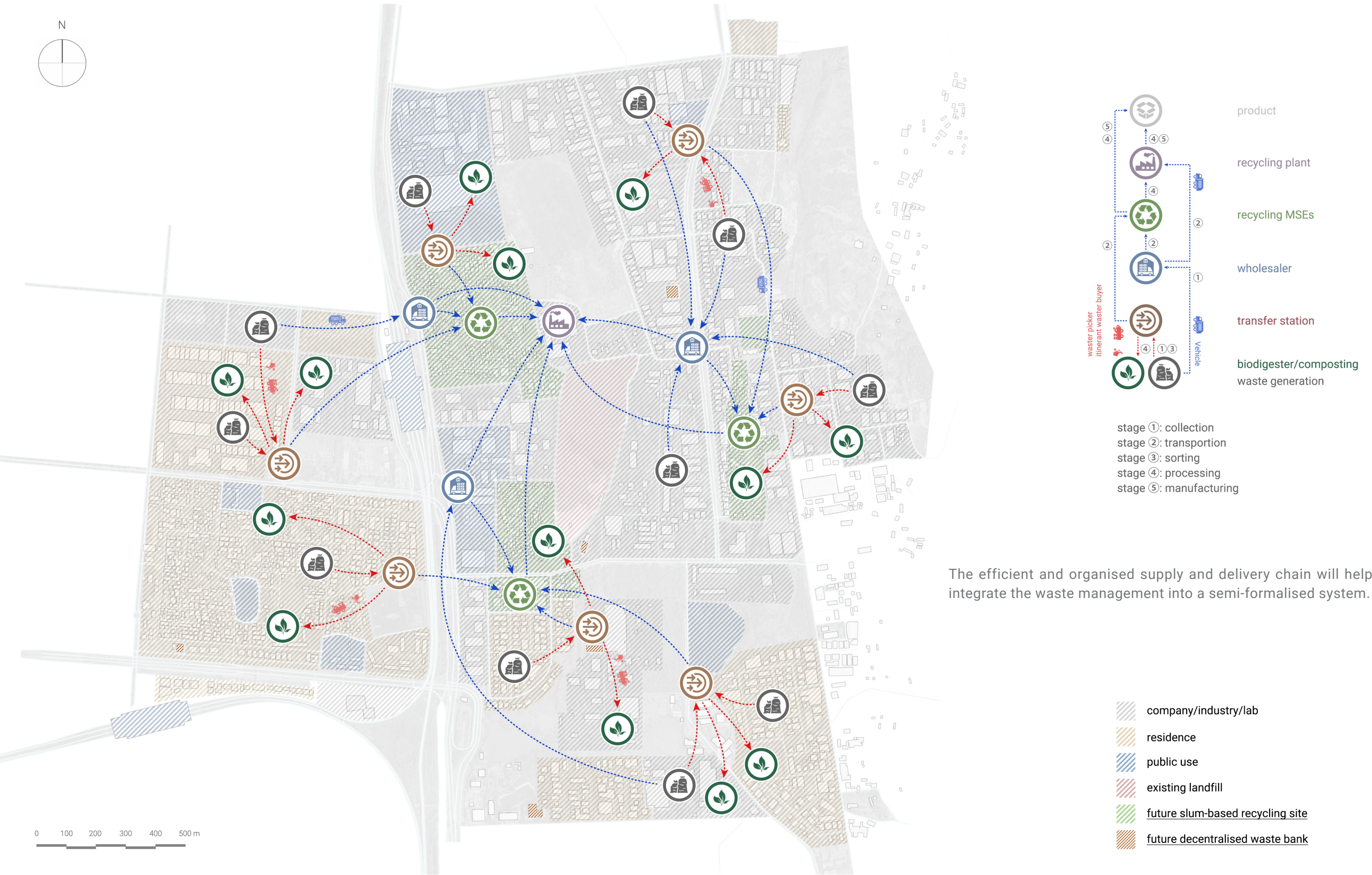


# SEMI-FORMALISATION OF THE INDUSTRY





# NEW SUPPLY AND DELIVERY CHAIN

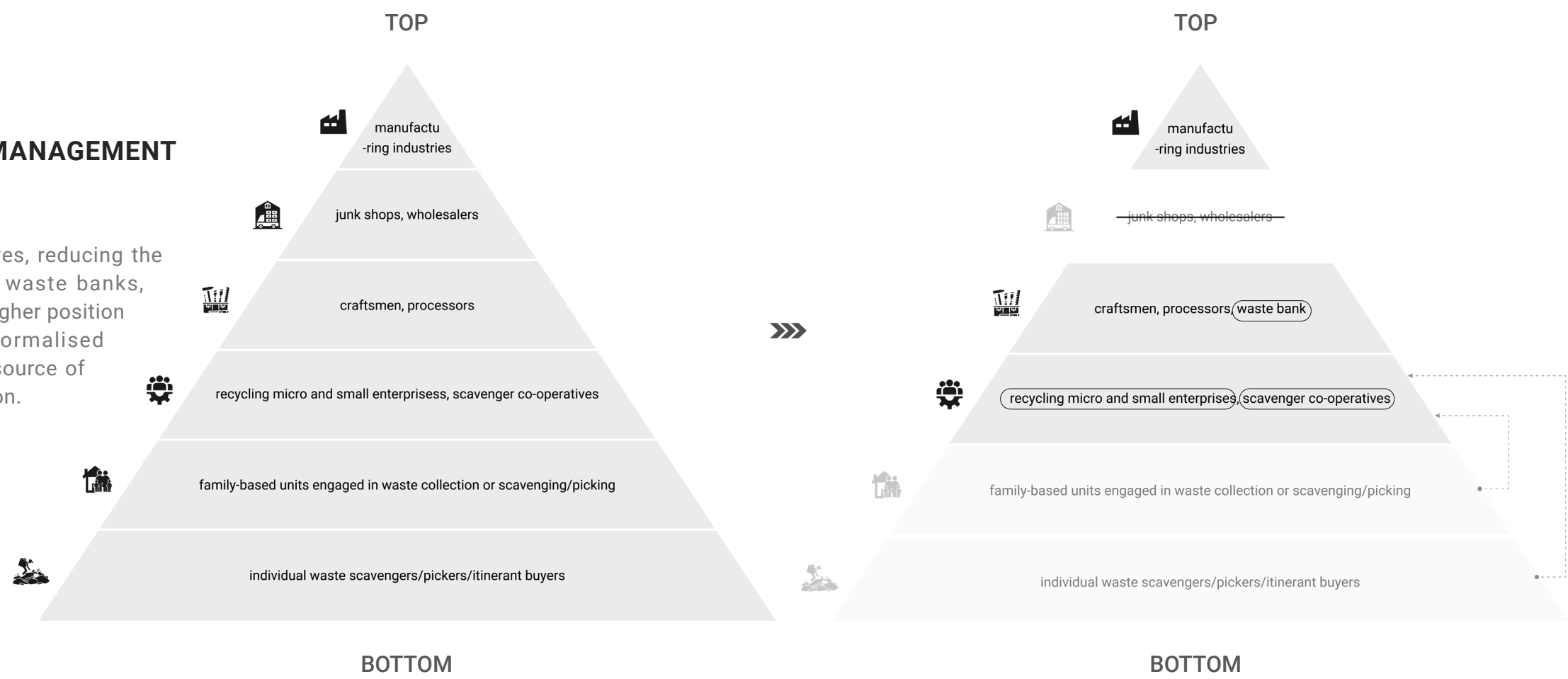




# REDESIGNING HIERARCHY OF THE INDUSTRY

## HIERARCHY OF INFORMAL WASTE MANAGEMENT

By promoting the establishment of cooperatives, reducing the involvement of middlemen and introducing waste banks, waste pickers and itinerant buyers will have a higher position in the hierarchy of the industry. The semi-formalised IWM system will provide workers with stable source of income, job security and a good social reputation.







1. itinerant waste buyer



2. waste collector from community bins or storage units



3. street waste picker



4. landfill waste picker





# SITE & SCOPE OF WASTE MANAGEMENT SERVICE



## SLUM INFORMATION

Area: 3.9 ha  
Dwellers: 3200  
Occupied dwellings: 740  
Dwellings ownership rate: 62%  
Site density: 215 dw/ha

The selected site for the project is one of the slums in Turbhe, which will provide waste management services to the surrounding area in the future.

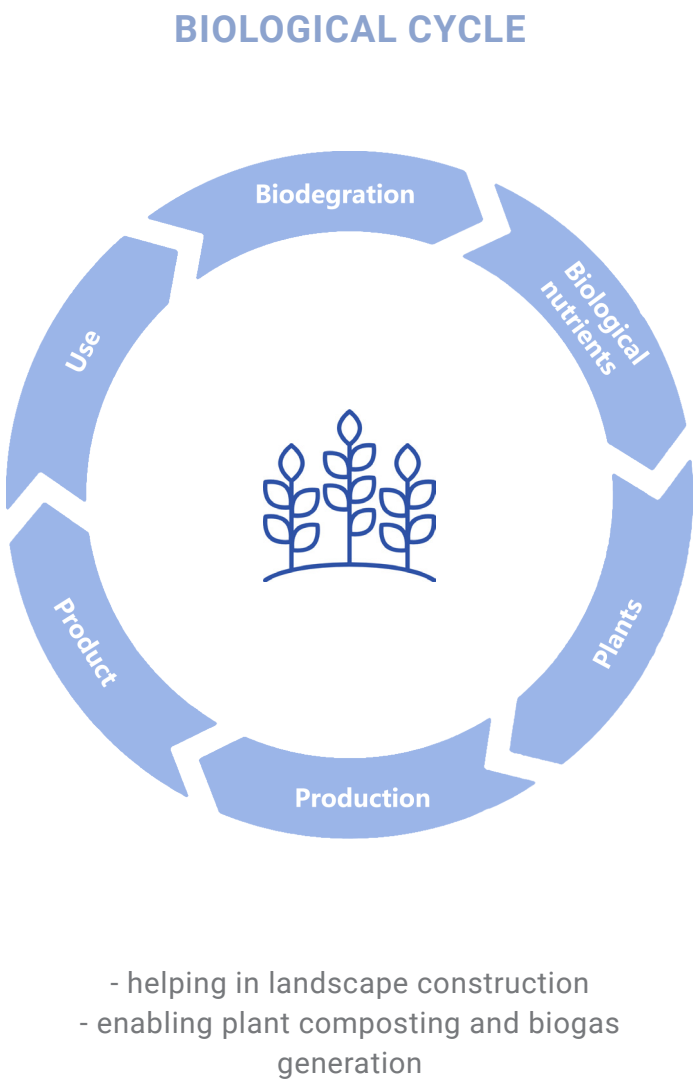
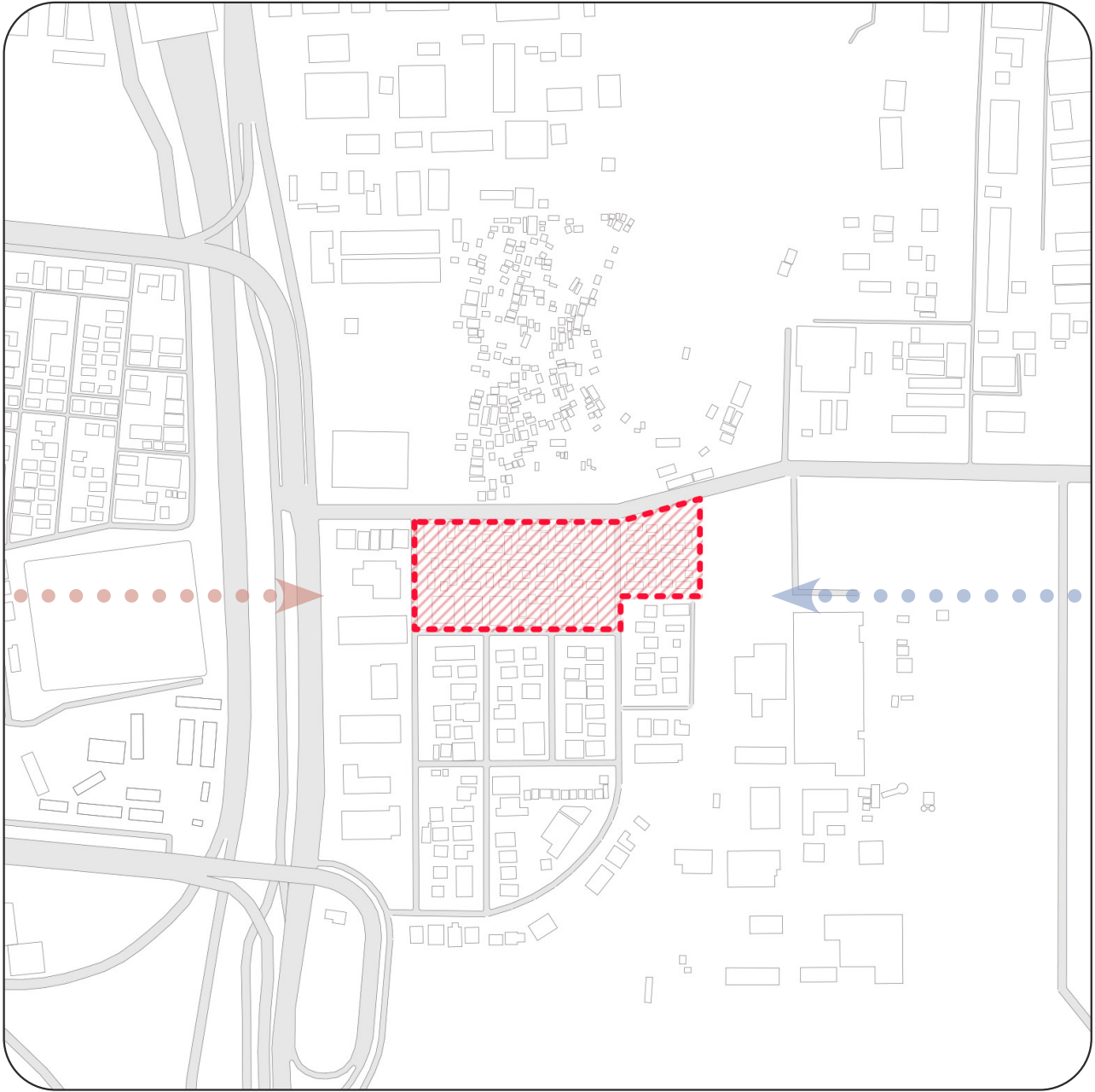
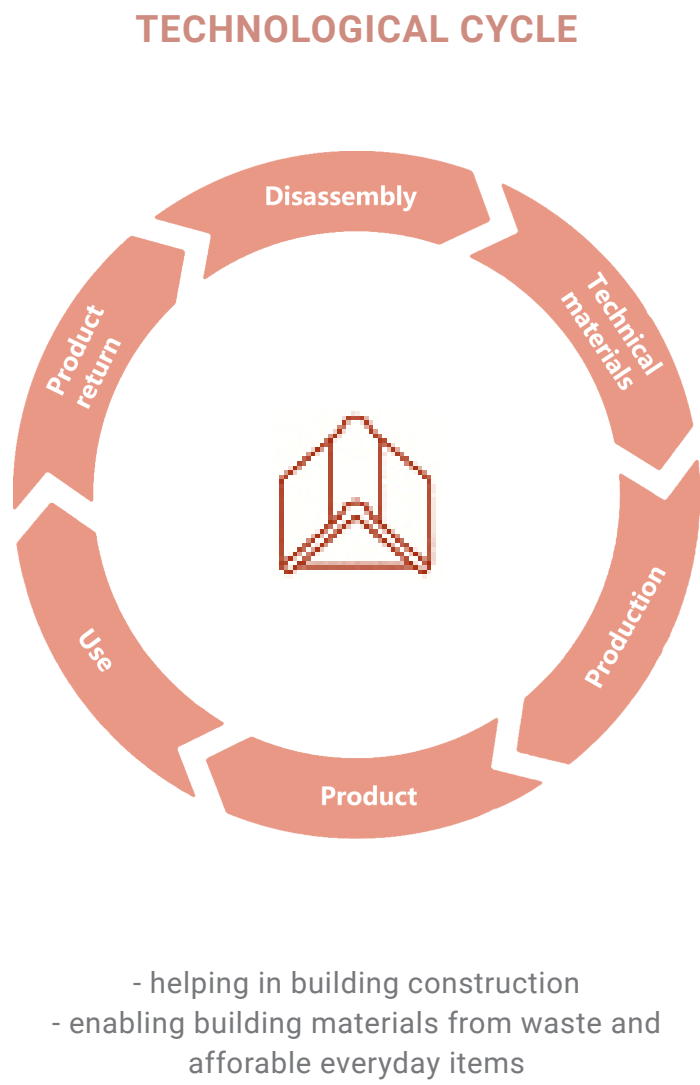
-  site boundary
-  scope of services

## 04. COMMUNITY (SLUM) SCALE

Technological & Biological Cycle

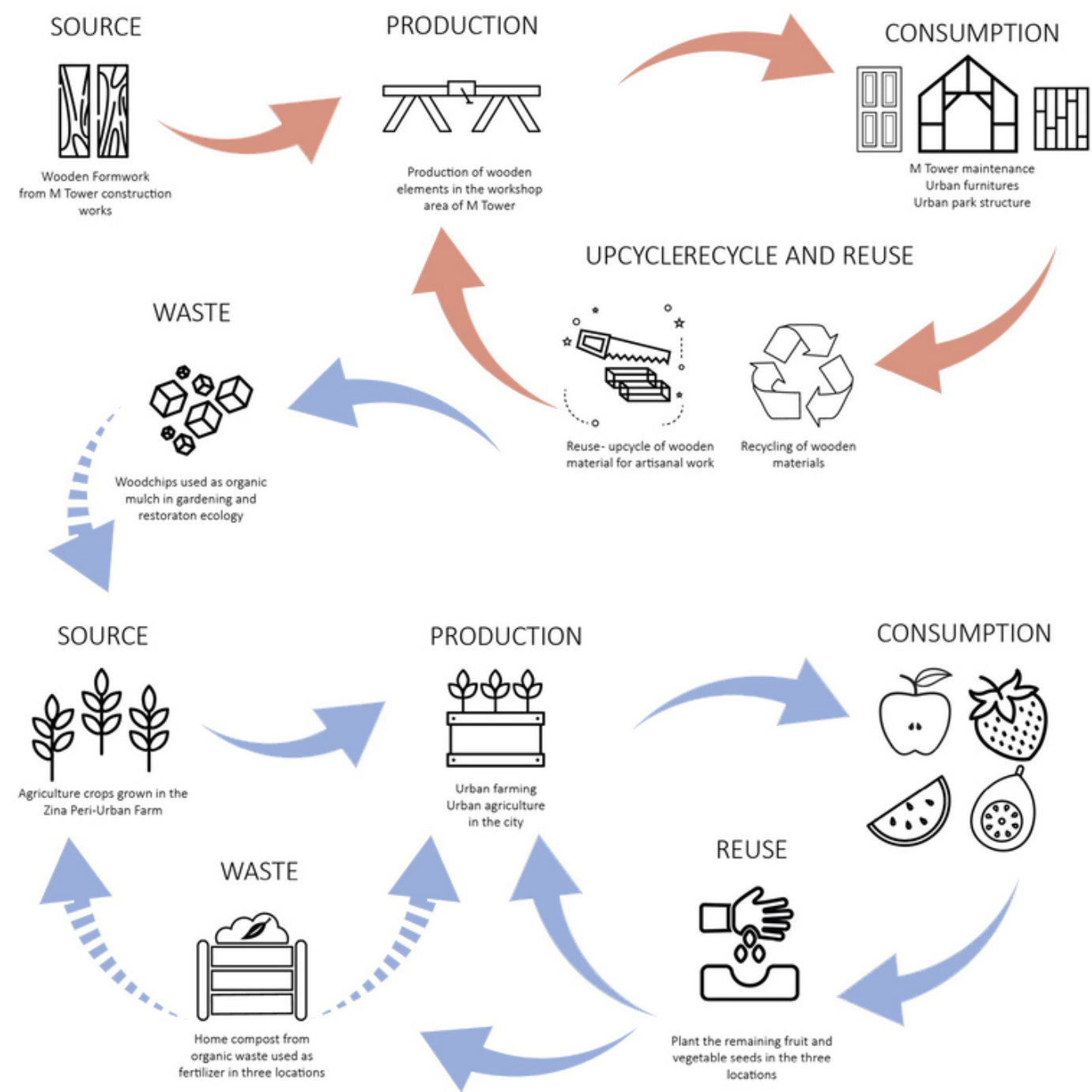


# TECHNOLOGICAL CYCLE & BIOLOGICAL CYCLE



# TECHNOLOGICAL & BIOLOGICAL CYCLE PROCESS

## TECHNOLOGICAL CYCLE



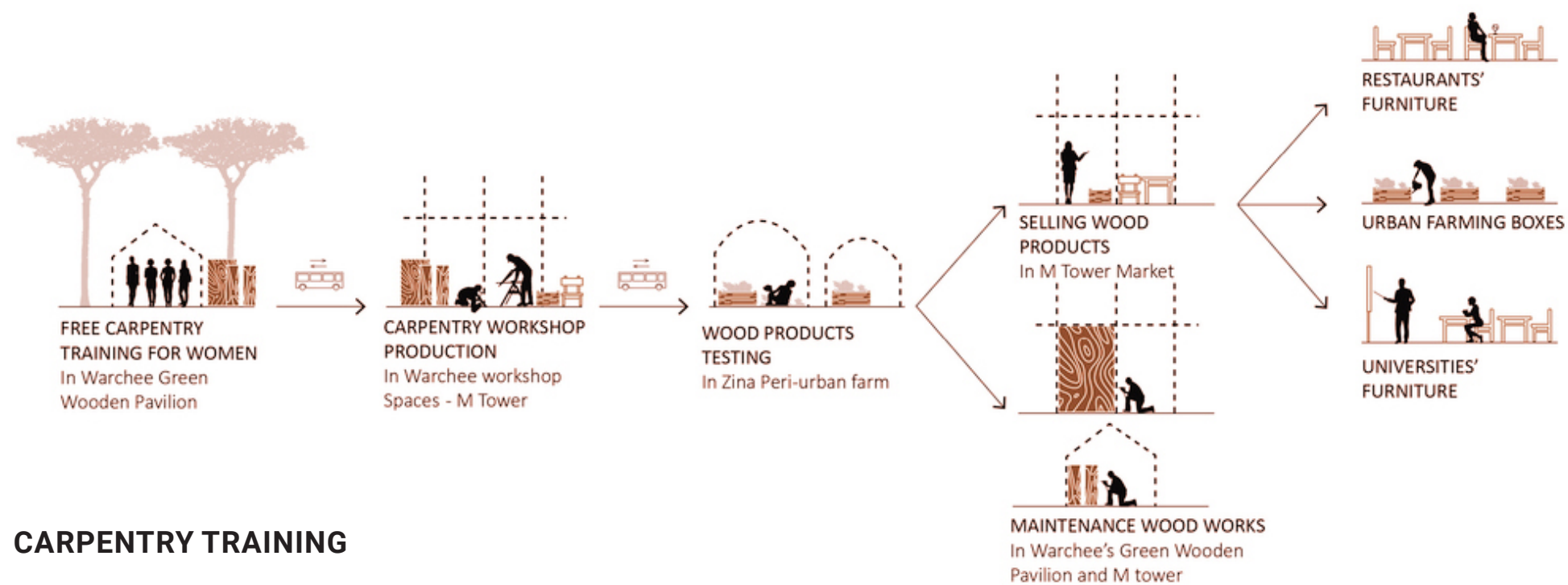
## BIOLOGICAL CYCLE

The technological cycle is achieved through **dry waste recycling**, bringing about **alternative building materials for building construction**. While the biological cycle is achieved through **wet waste recycling**, bringing about **renewable energy** and **landscape construction through plant composting**.

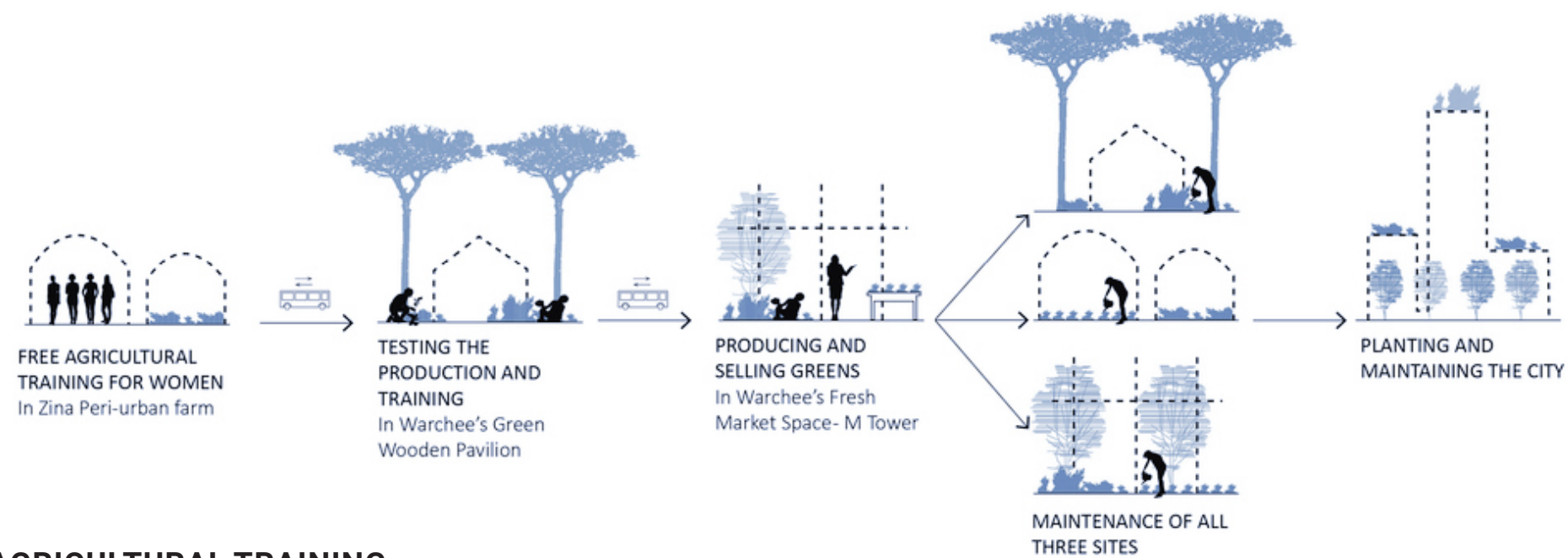
Source: <https://www.archdaily.com/942255/anastasia-elrouss-designs-a-vertical-eco-village-in-beirut-a-new-way-to-inhabit-the-built-environment>



# NEW JOBS EMERGING FROM TECHNOLOGICAL & BIOLOGICAL CYCLE



## CARPENTRY TRAINING



## AGRICULTURAL TRAINING



## INTEGRATION OF EXISTING WAREHOUSES

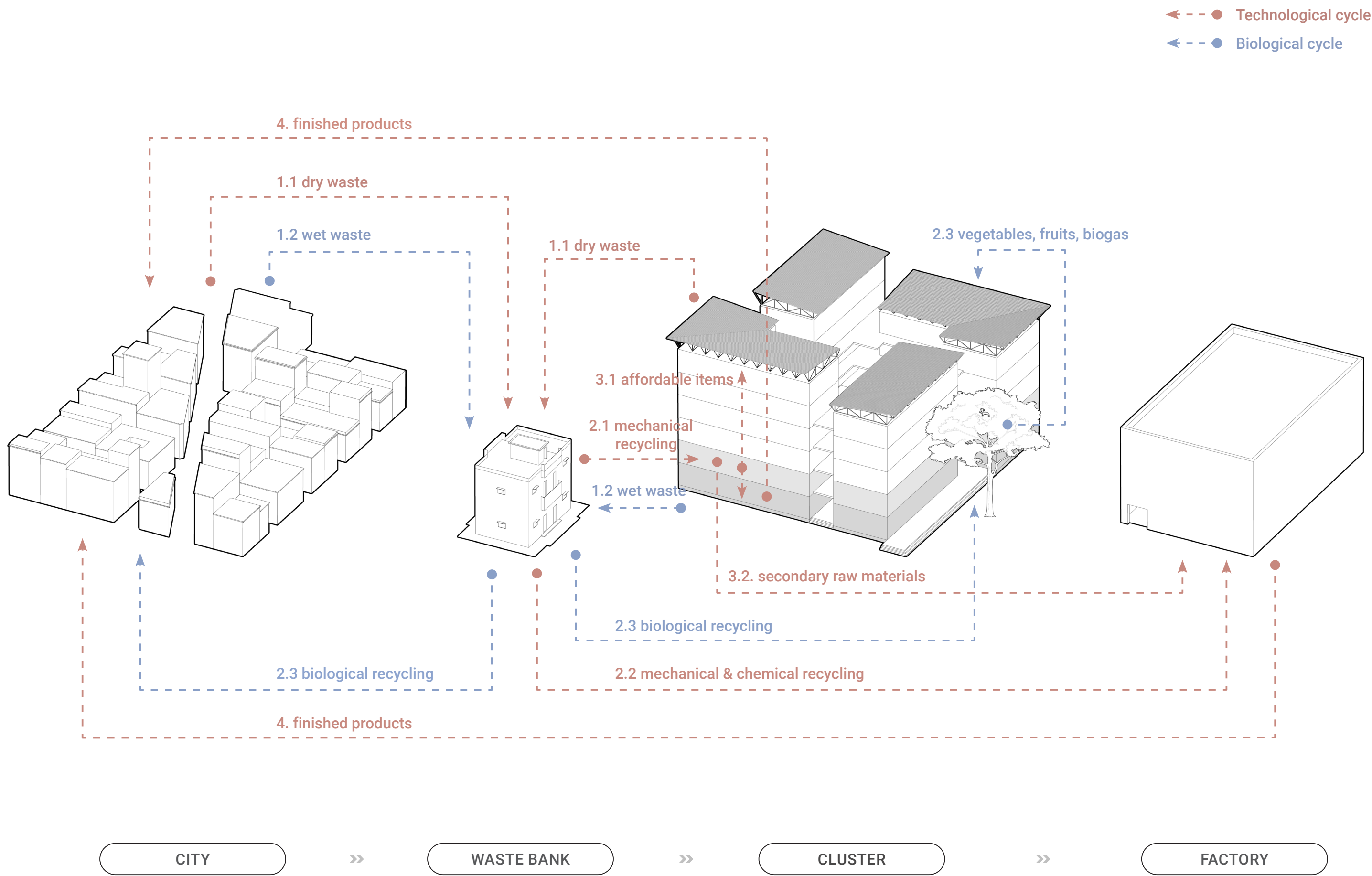
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Area: 3.9 ha  
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WASTE MANAGEMENT WORKFLOW







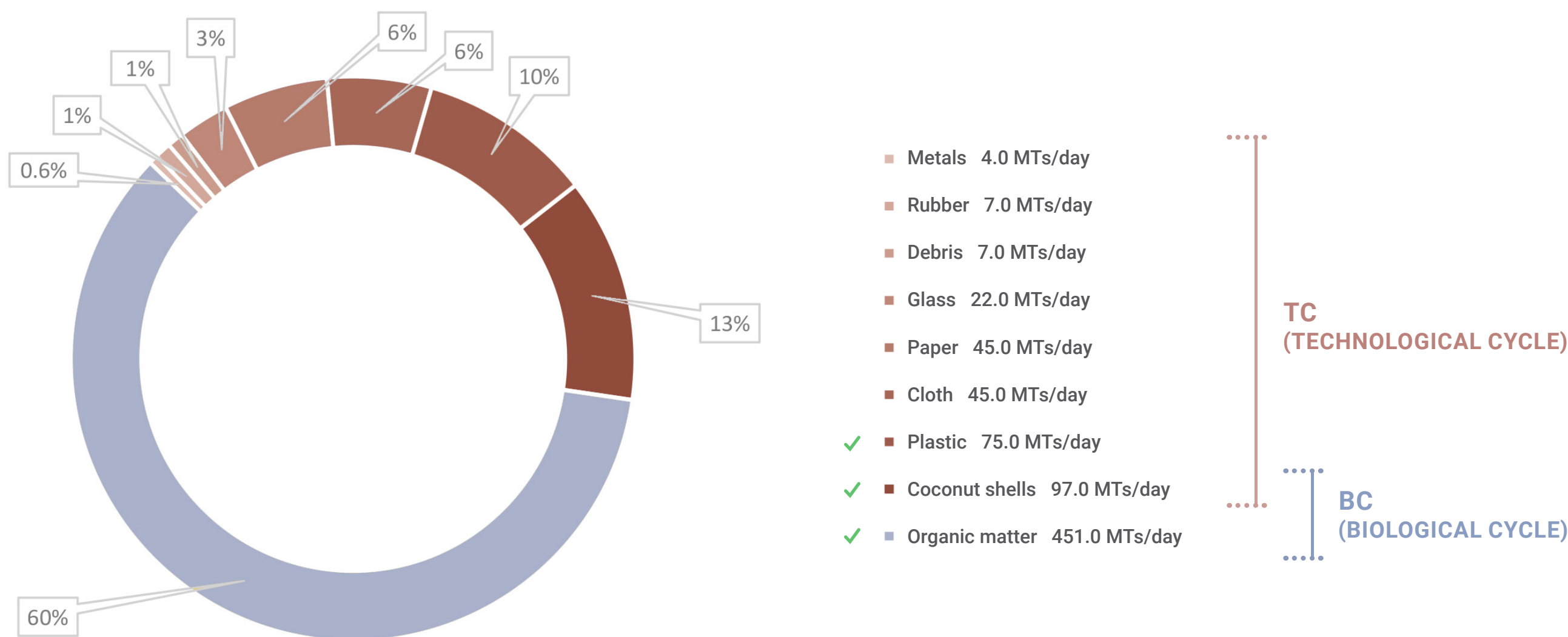
PRODUCTS OF BIOLOGICAL CYCLE

PRODUCTS OF  
BIOLOGICAL CYCLE



SOURCES OF WASTE

COMPOSITION OF MUNICIPAL SOLID WASTE IN NAVI MUMBAI IN 2018-19



The most waste generated by Navi Mumbai is **organic matter, coconut shells and plastic**. The organic matter will enter the biological cycle to produce **biogas or plants**, while other materials have the opportunity to enter the technical cycle to produce various **alternative building materials**.

TC — WASTE / RAW MATERIALS FOR CONSTRUCTION

1. PLASTIC

.....



1.1 THERMOPLASTICS

drinking bottles, grocery bags, food storage containers, etc.



1.2 THERMOSET PLASTIC

gas & water pipelines, electrical plugs, kitchen appliances, etc.

2. COCONUT

.....



2.1 COIR

seed-hair fibres obtained from the shell or husk of coconuts



2.2 COCONUT HUSK

rough exterior shells of coconuts

3. OTHERS

.....



3.1 PAPER

office paper, newspapers, magazines, cardboard, etc.



3.2 TETRA PAK

packaging of dairy, beverages, ice cream and prepared foods



3.3 STRAW

stalks of cereal grasses as wheat, oats, rye, barley, etc.



3.4 GLASS

beer and soft drink bottles, food bottles and jars, etc.

4. RAW MATERIALS

.....



4.1 RESIN

thermosetting polymers as epoxy, polyester resin, vinyl ester resin, etc.



4.2 CEMENT

limestone, shells, clay, marl, shale, silica sand, etc.



TC – BUILDING MATERIALS FROM WASTE

1. PLASTIC

PLASTIC LUMBER

wall frame, cladding, tile



- low-cost
- modular & demountable
- 100% recyclable

GLASS FIBRE-REINFORCED PLASTIC

column, beam, floor slab, roof



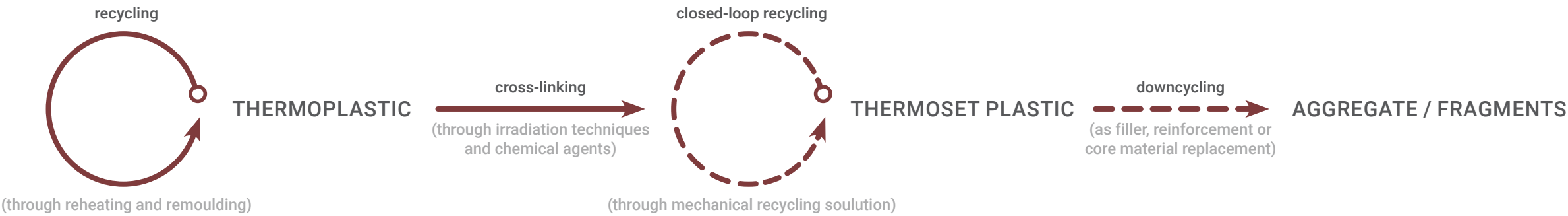
- cost efficient
- strong and lightweight
- modular & demountable

CONCRETE / ASPHALT CONCRETE (WASTE PLASTIC AS AGGREGATE)

foundation, platform, pavement



- low-cost
- durability & longevity
- energy savings



TC — BUILDING MATERIALS FROM WASTE

2. COCONUT

COCONUT FIBRE MAT

insulation



- low-cost
- local production
- thermal and acoustic performance

COCONUT HUSK BOARD

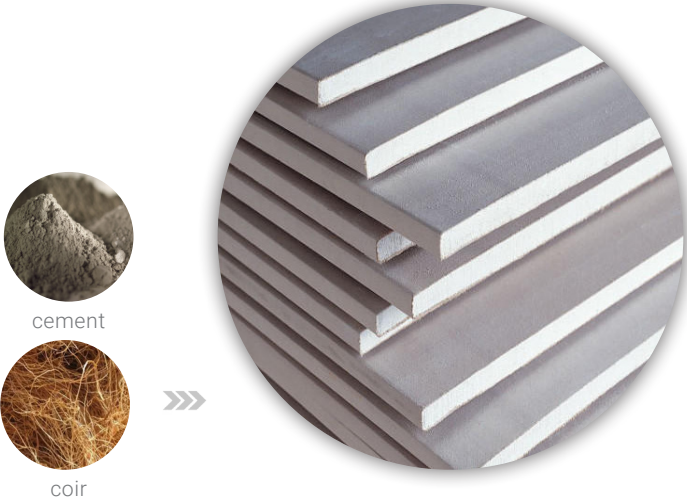
wall lining, cladding



- low-cost
- local production
- quick and easy installation

CEMENT FIBRE BOARD

sandwich wall, lining, cladding, flooring



- cost efficient
- long life span
- quick and easy installation



TC — BUILDING MATERIALS FROM WASTE

3. OTHERS

PAPER TILE

wall / floor tile



- low-cost
- local production
- thermal and acoustic performance

TETRA PAK BOARD

wall lining, cladding, roof



- low-cost
- local production
- quick and easy installation

STRAW PANEL

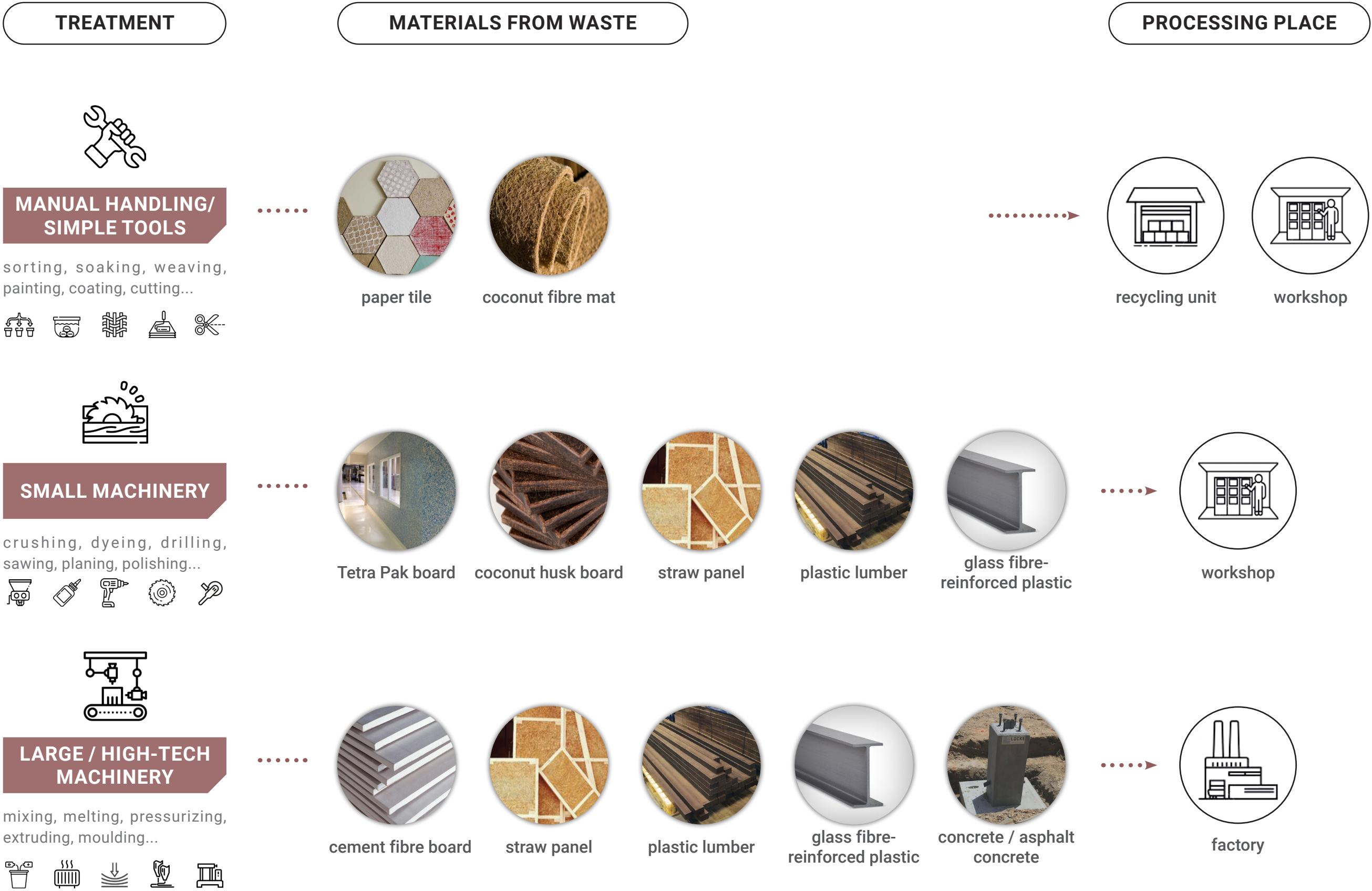
wall, insulation



- cost efficient
- thermal and acoustic performance
- quick and easy installation

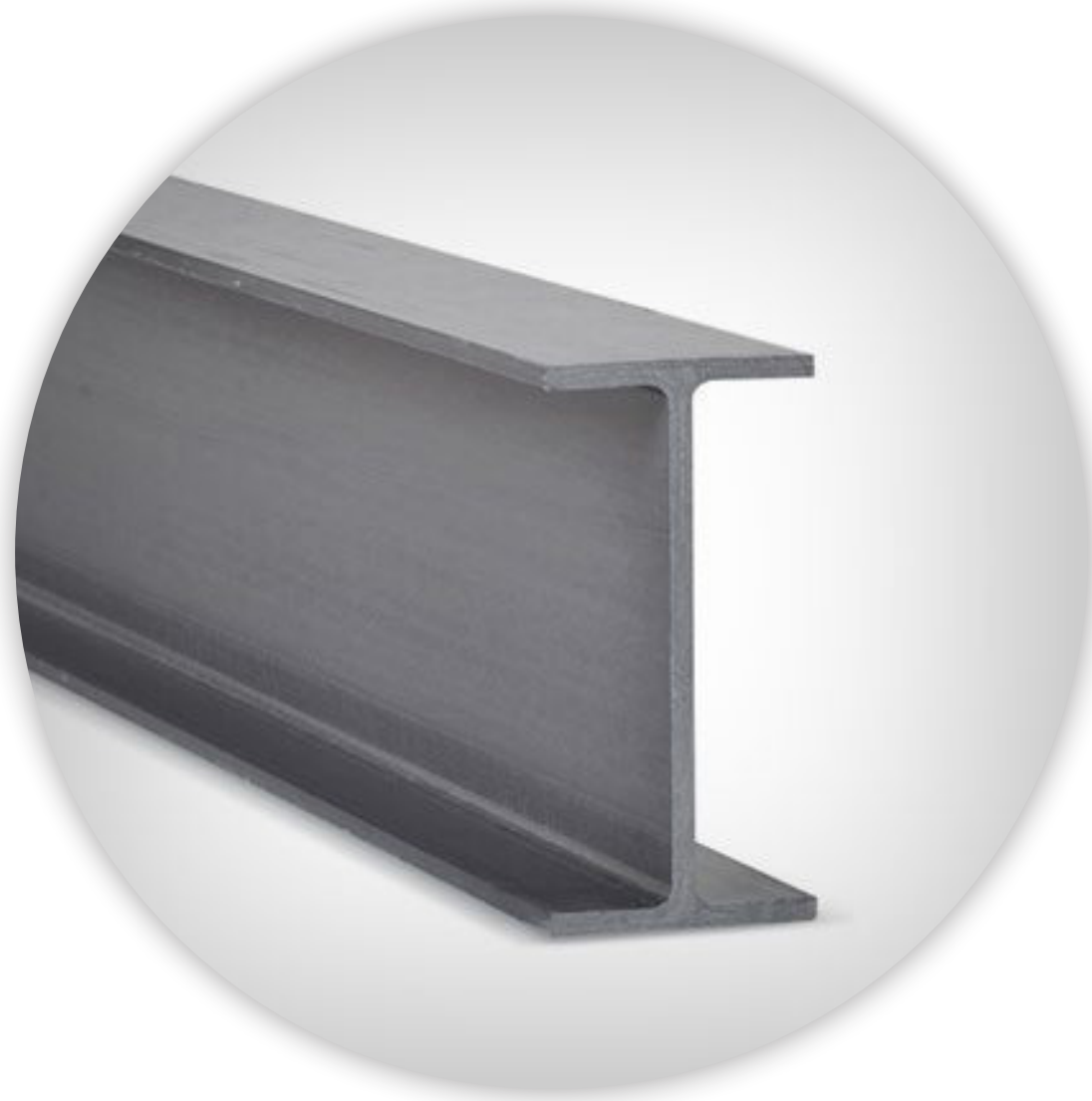
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TC – HIERARCHY OF MATERIAL TREATMENT PROCESSES





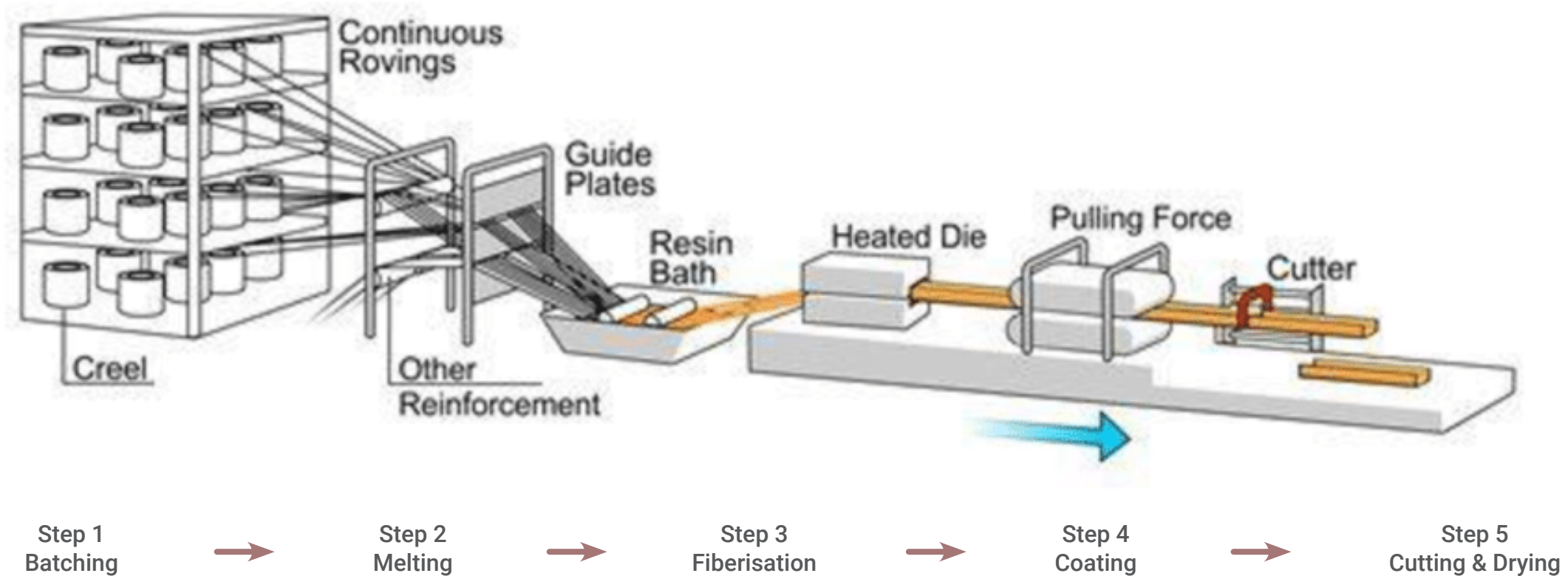
## TC — GFRP AS MAIN STRUCTURE



### GLASS FIBRE-REINFORCED PLASTIC

- stronger, lighter, cheaper
- modular, demountable, durable, environmentally friendly

## TC – MANUFACTURING PROCESS OF GFRP



### GLASS FIBER-REINFORCED PLASTIC

Glass fiber-reinforced plastic is a synthetic amalgamated material made up of plastic and fine fibers of glass. The formation process of GFRP involves a combination of extrusion and attenuation. The material is in demand for its **high strength, light weight, corrosion resistance quality** from last few decade.

Source: [https://www.researchgate.net/figure/A-pultrusion-line-or-a-pultrusion-machine-is-used-to-produce-the-pultruded-GFRP-profile\\_fig10\\_303921353](https://www.researchgate.net/figure/A-pultrusion-line-or-a-pultrusion-machine-is-used-to-produce-the-pultruded-GFRP-profile_fig10_303921353)  
<https://www.pfh-university.com/blog/gfrp-manufacturing-process-properties-and-application.html>



TC – COMPARISON OF STRENGTH

➤

	Density (g/cm <sup>3</sup> )	Tensile Strength (MPa)	Compressive Strength (MPa)	Elasticity Modulus (GPa)
Glass FRP	1.25-2.50	483-4580	103-206	35-86
Steel	7.85	483-690	250	200
Glulam	0.4-0.6	29-63	24-31	9-14.5
Concrete	2.24-2.40	2-5	20-40	14-41
Brick	1.6-1.92	0.35-2.1	7-14	3.5-34

STRUCTURAL FEASIBILITY

Pound for pound, GFRP has excellent structural properties comparable to steel in the lengthwise direction and weigh up to 75% less. The fibres provide the main load-bearing capacity of the material, making its far stronger than traditional building materials such as glulam, concrete and bricks.

Data Source:  
<https://www.sciencedirect.com/science/article/pii/S2214785320357618>  
[https://www.engineeringtoolbox.com/concrete-properties-d\\_1223.html](https://www.engineeringtoolbox.com/concrete-properties-d_1223.html)  
[https://www.engineeringtoolbox.com/timber-mechanical-properties-d\\_1789.html](https://www.engineeringtoolbox.com/timber-mechanical-properties-d_1789.html)  
[https://www.engineeringtoolbox.com/compression-tension-strength-d\\_1352.html](https://www.engineeringtoolbox.com/compression-tension-strength-d_1352.html)

GFRP I-BEAM CACULATION

CACULATION			
Dimensions			
H:	240	mm	
B:	150	mm	
s:	12	mm	
t:	6	mm	
Conditions			
Distributed load:	12000	N/m	
Density:	1.8	g/cm <sup>3</sup>	
E-modulus:	80000	MPa	
Length:	4000	mm	
Results			
Bending:	9.64	mm	
Flex. moment:	24000	Nm	
Tesion:	55.526	MPa	
Elongation	0.069	%	

Profiles

☐ Rod

☐ Tube

☐ Flat Profile

☐ rect. Tube

☒ I-Profile

☐ H-Profile

☐ U-Profile

☐ U-Profile head

☐ U-Profile side

☐ Angle

☐ T-Profile

☐ T-Profile head

Dimensions

H (mm)

240

h (mm)

40

B (mm)

150

b (mm)

40

s (mm)

12

t (mm)

6

D (mm)

10

d (mm)

5

Conditions

Dist.Load q (N/m)

12000

Uni.Load F (N)

100

Density (g/cm<sup>3</sup>)

1.8

E-Modulus (MPa)

80000

Length (mm)

4000

Precision

3

Results

Bending (mm)

9.64

Flex.Moment (Nm)

24000

Tension (MPa)

55.526

Elongation (%)

0.069

W (mm<sup>3</sup>)

432230.4

I (mm<sup>4</sup>)

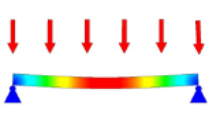
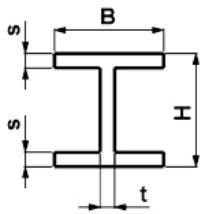
51867648

Mass (kg)

35.251

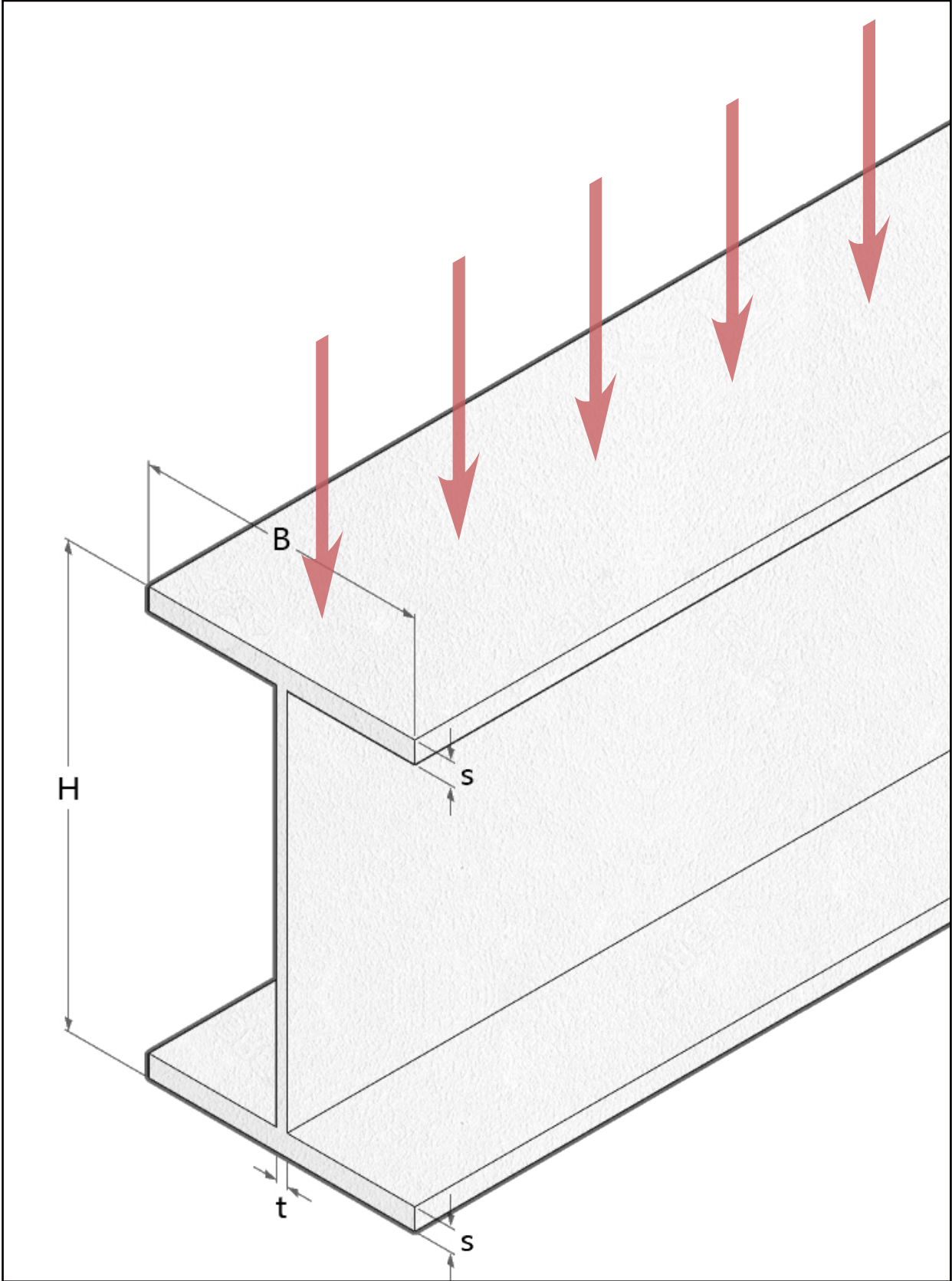
Area (mm<sup>2</sup>)

4896



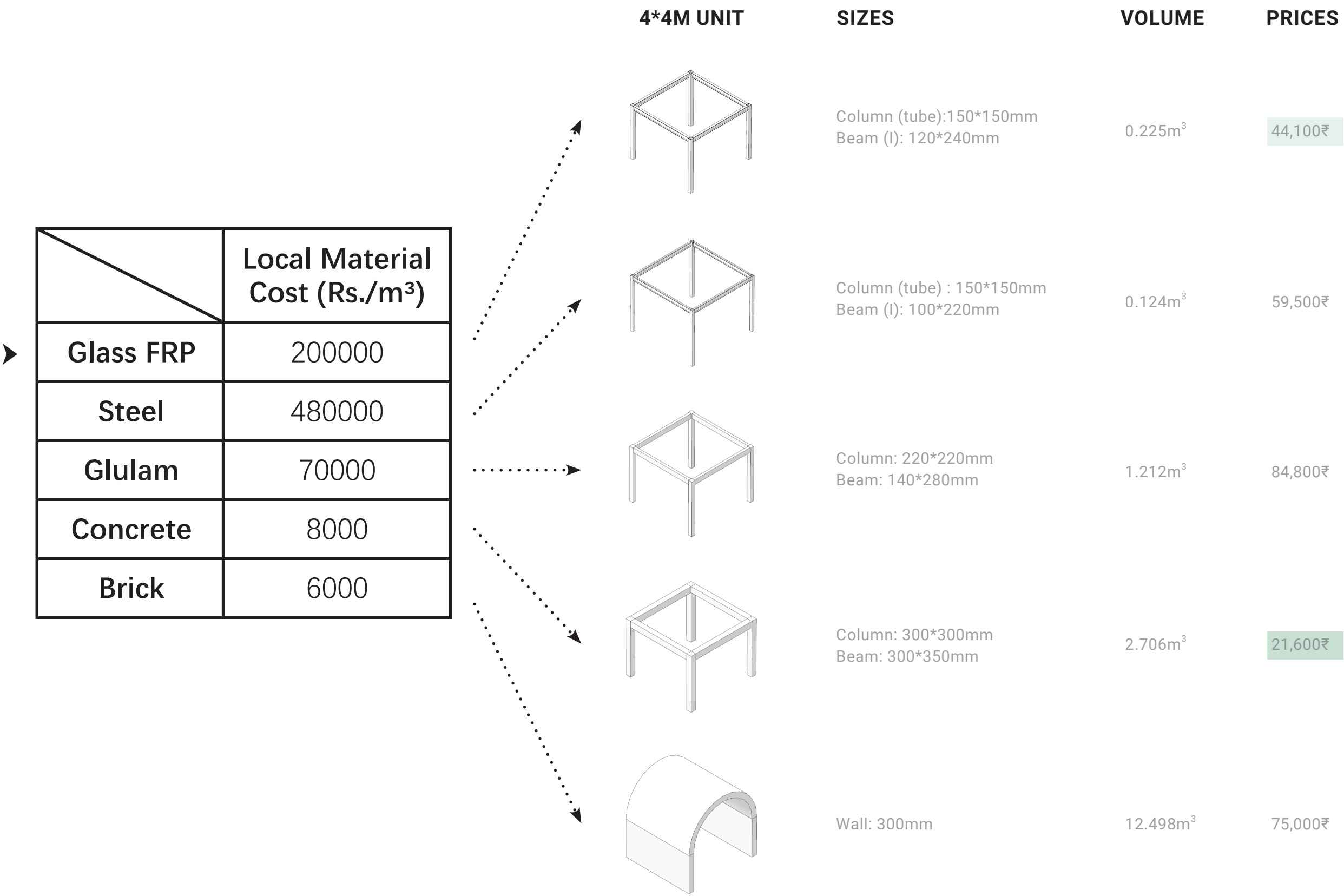
Loading Case 2

Data source: <https://fibrolux.com/grp/knowledge/static-calculation/>



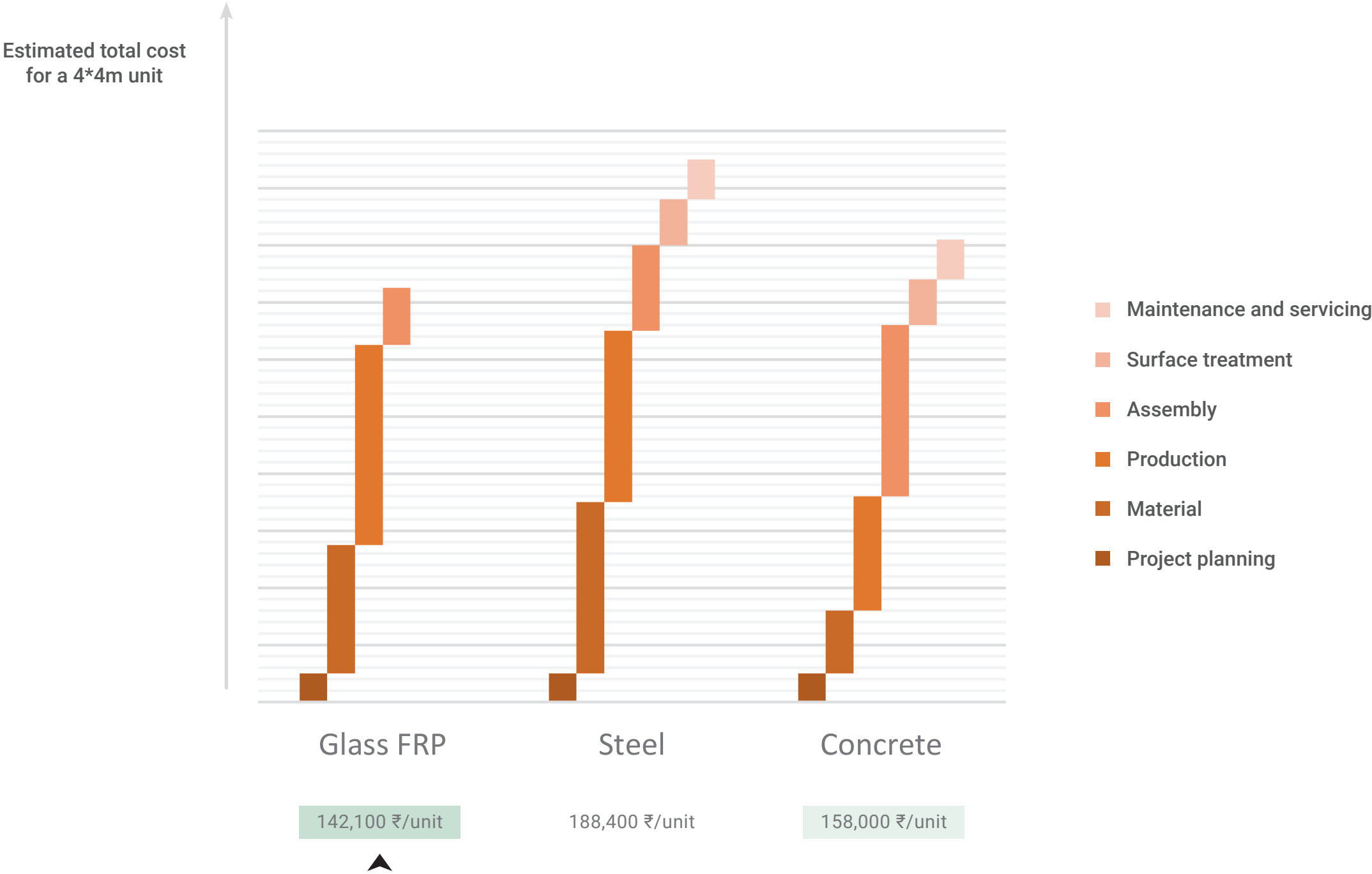


TC – COMPARISON OF INITIAL MATERIAL COST



Data Source:  
<https://www.globalwoodmarketsinfo.com/latest-timber-prices-in-india/>  
<https://civiconcepts.com/blog/construction-and-building-materials-market-price>  
<https://www.indiamart.com/proddetail/fiber-reinforced-plastic-sheets-7749244755.html>  
<https://civilsir.com/what-is-the-rcc-column-cost-per-sq-ft-in-india/#:~:text=For%20calculating%20rcc%20column%20cost,rcc%20column%20per%20square%20feet>

TC – COMPARISON OF TOTAL COST IN LIFETIME






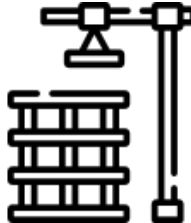


COST EFFICIENCY OF GFRP

Compared to concrete, GFRP requires a higher initial investment to manufacture the material. However, this investment is worthwhile in view of the whole life span of the building, as GFRP requires less maintenance, assembly and transport costs.

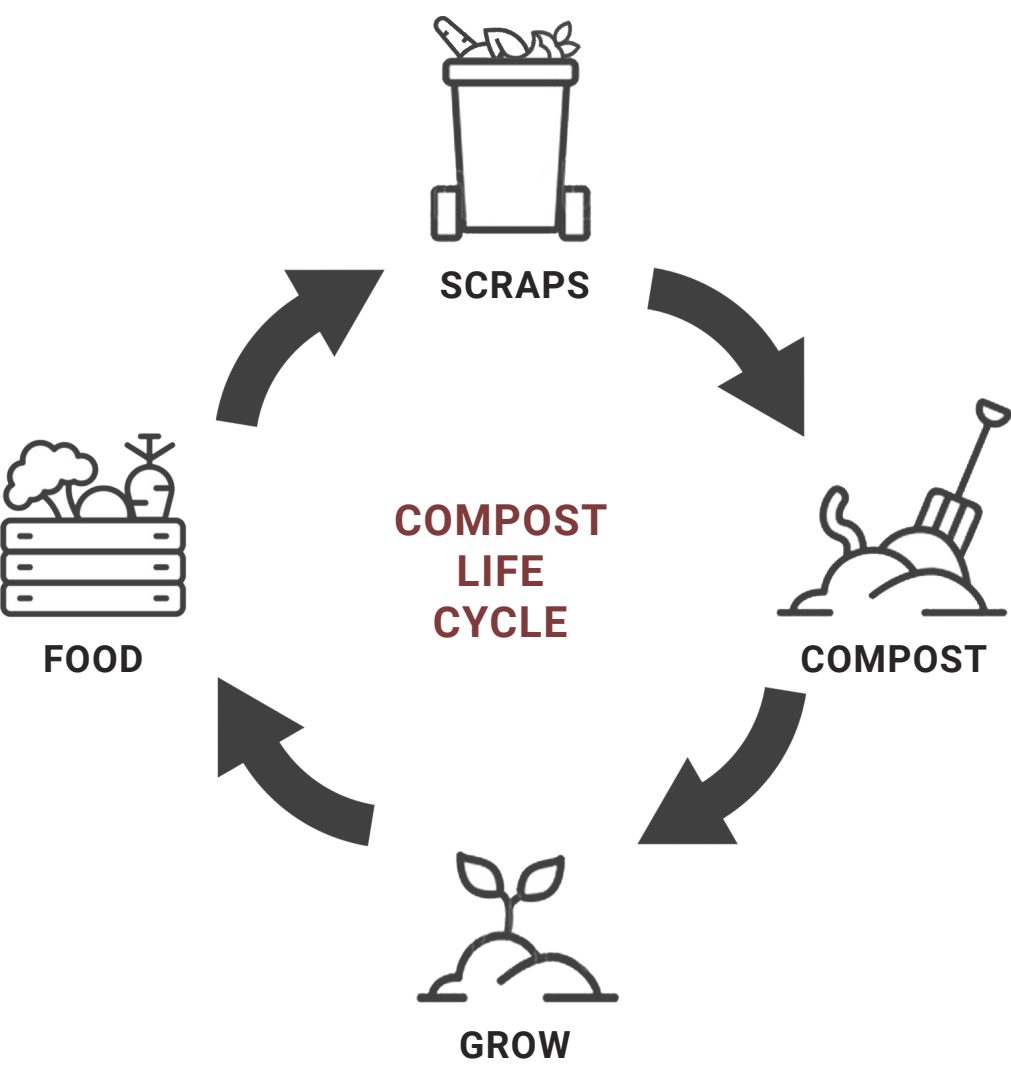
Data Source:  
<https://fibrolux.com/grp/knowledge/advantages-cost/>  
<https://civilsir.com/rate-analysis-for-concrete-calculate-quantity-and-cost/>  
<https://www.rhinobldg.com/should-you-build-with-steel-or-concrete/>  
[https://www.steelconstruction.info/Cost\\_of\\_structural\\_steelwork](https://www.steelconstruction.info/Cost_of_structural_steelwork)



TC – FEASIBILITY OF APPLYING GFRP IN SLUMS OF NAVI MUMBAI

<div>1. RAW MATERIALS</div> <div>sufficient amount of waste</div> <div></div> <div><ul style="list-style-type: none"><li>- Large amount of plastic and glass waste resources;</li><li>- The collection and pre-treatment processes can be integrated into the IWM system.</li></ul></div>	<div>2. MANUFACTURE</div> <div>local production</div> <div></div> <div><ul style="list-style-type: none"><li>- Local manufacturers already have the technology and machinery and do not need to import;</li><li>- The existing warehouses can be used as factories for local production;</li><li>- The manufacturing process is energy saving.</li></ul></div>	<div>3. COST</div> <div>high cost efficiency</div> <div></div> <div><ul style="list-style-type: none"><li>- Affordable initial cost;</li><li>- Low total cost in its useful life.</li></ul></div>	<div>4. CONSTRUCTION</div> <div>quick construction by local labour</div> <div></div> <div><ul style="list-style-type: none"><li>- The strength is comparable to that of steel;</li><li>- Lightweight and modular design allows for quick self-built construction, promoting the participation of users and reducing construction costs.</li></ul></div>	<div>5. MAINTENANCE</div> <div>low-maintenance</div> <div></div> <div><ul style="list-style-type: none"><li>- Long life span due to the superior durability;</li><li>- Low-maintenance as it is highly resistant to water, salt and chemical corrosion.</li></ul></div>	<div>6. END OF LIFE</div> <div>reusable and recyclable</div> <div></div> <div><ul style="list-style-type: none"><li>- The components can be deconstructed and reused thanks to the reversible design;</li><li>- GFRP can be incorporated as filler or reinforcement replacement into new composite materials or as a closed-loop recycling for the same source-material.</li></ul></div>
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BC – PLANT COMPOSTING



THE PROCESS OF COMPOST

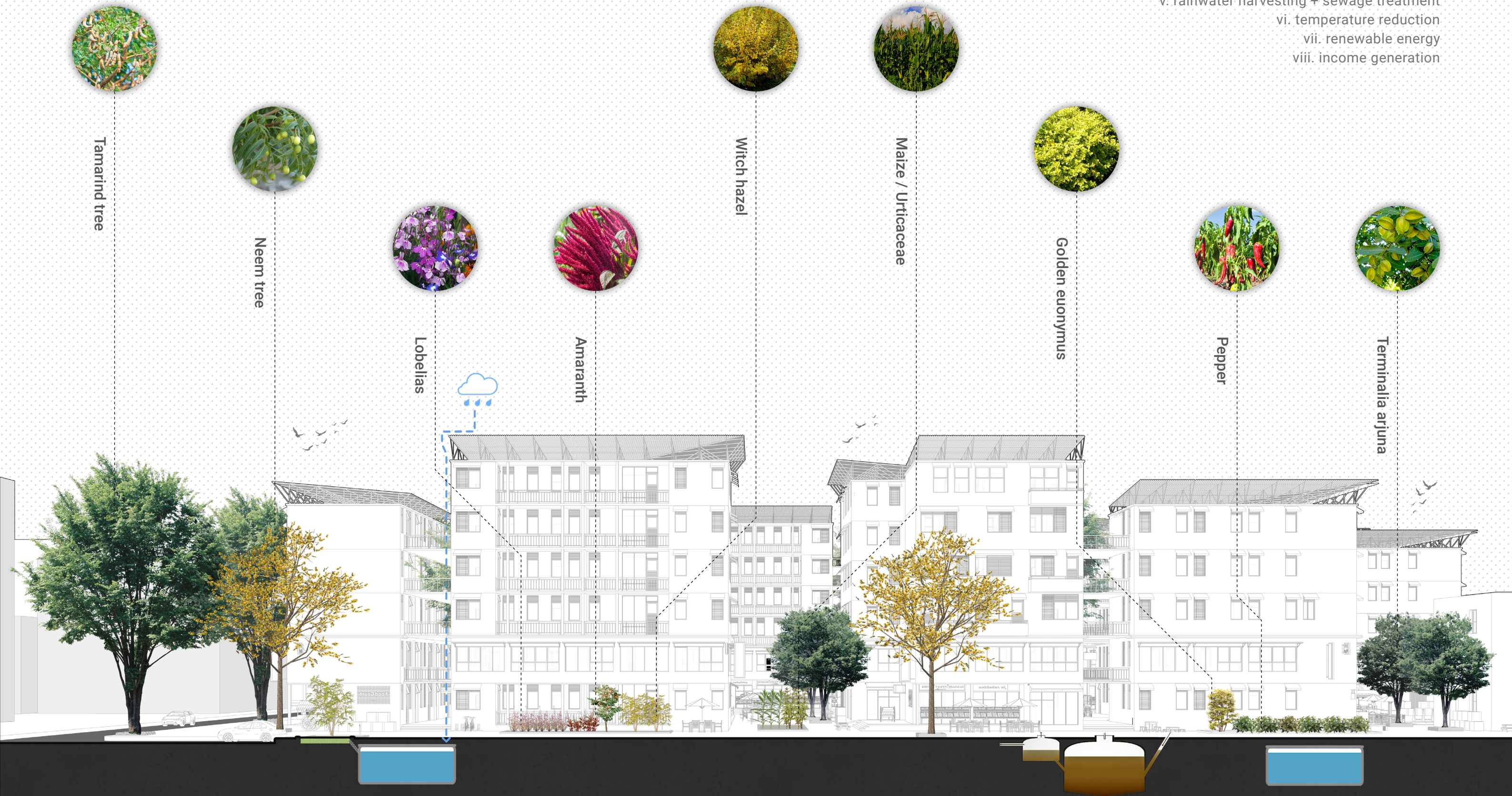
Compost is a mixture of ingredients used to fertilise and improve the soil in a process that involves breaking down organic materials, such as leaves and food scraps, into a humus-like material. It is an aerobic method of breaking down organic solid waste and the resulting mixture is rich in plant nutrients and beneficial organisms.





BC — PLANT DIVERSITY

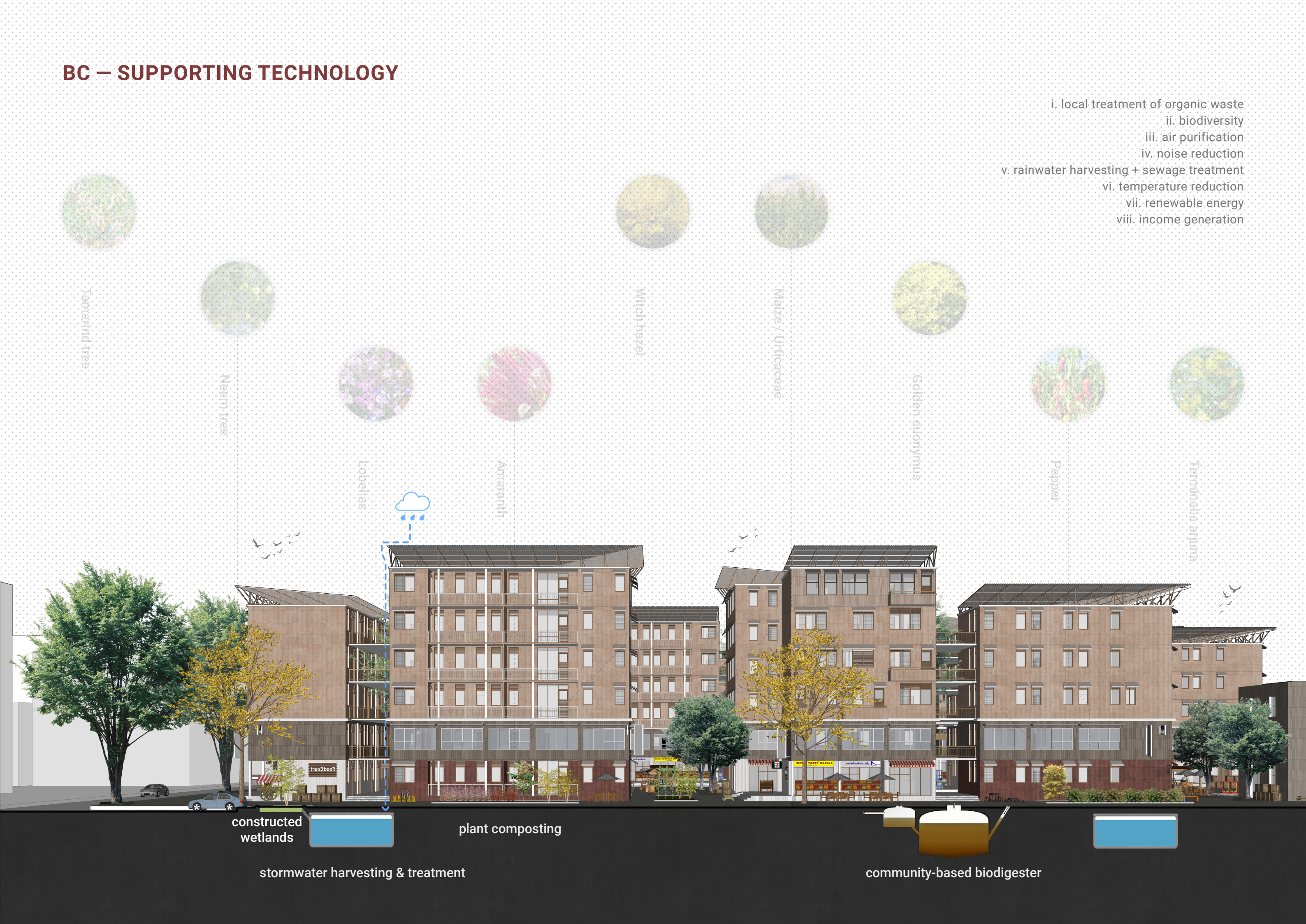
- i. local treatment of organic waste
- ii. biodiversity
- iii. air purification
- iv. noise reduction
- v. rainwater harvesting + sewage treatment
- vi. temperature reduction
- vii. renewable energy
- viii. income generation





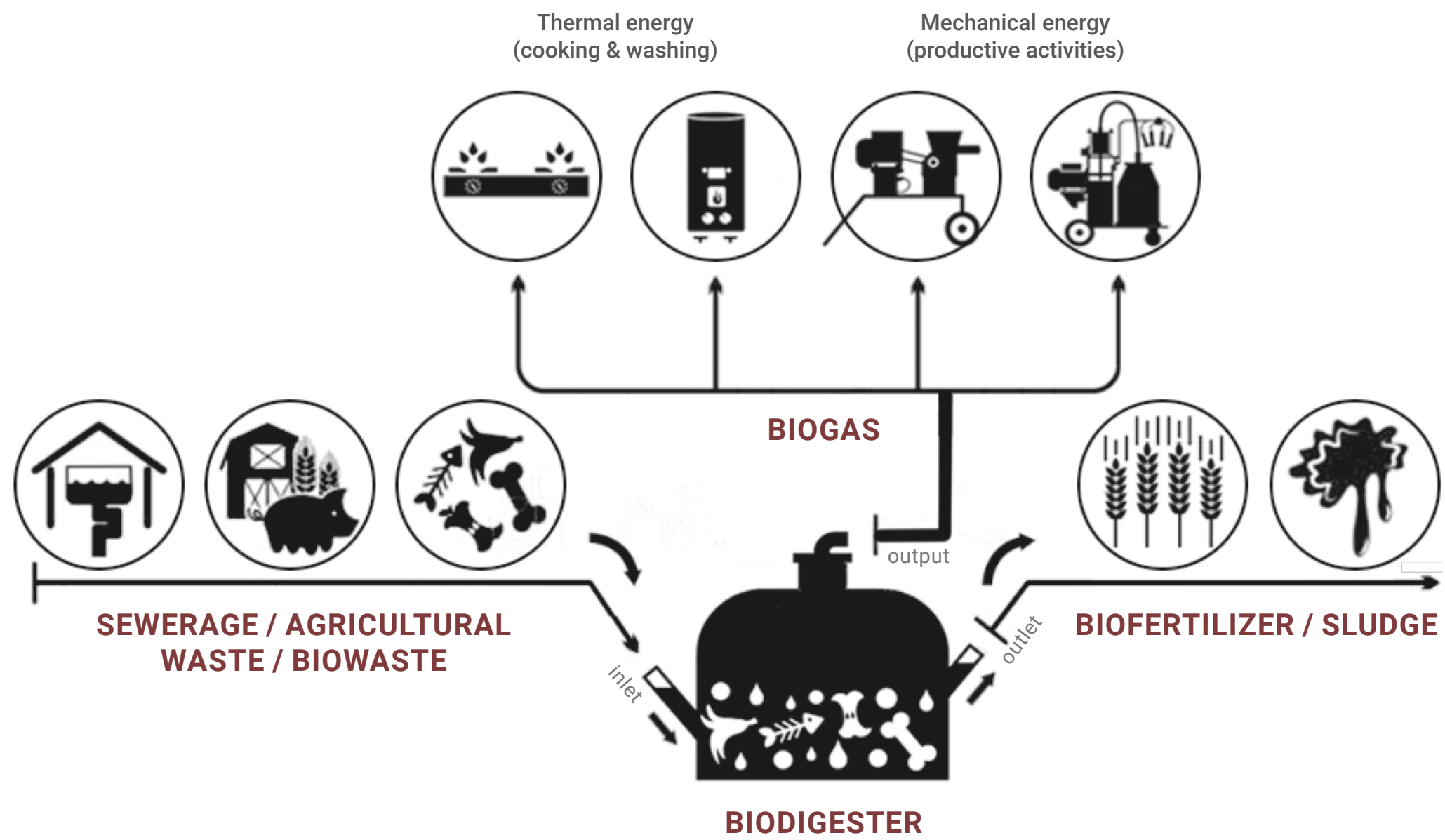
BC — SUPPORTING TECHNOLOGY

- i. local treatment of organic waste
- ii. biodiversity
- iii. air purification
- iv. noise reduction
- v. rainwater harvesting + sewage treatment
- vi. temperature reduction
- vii. renewable energy
- viii. income generation





BC – COMMUNITY-BASED BIODIGESTER



**BIODIGESTER**

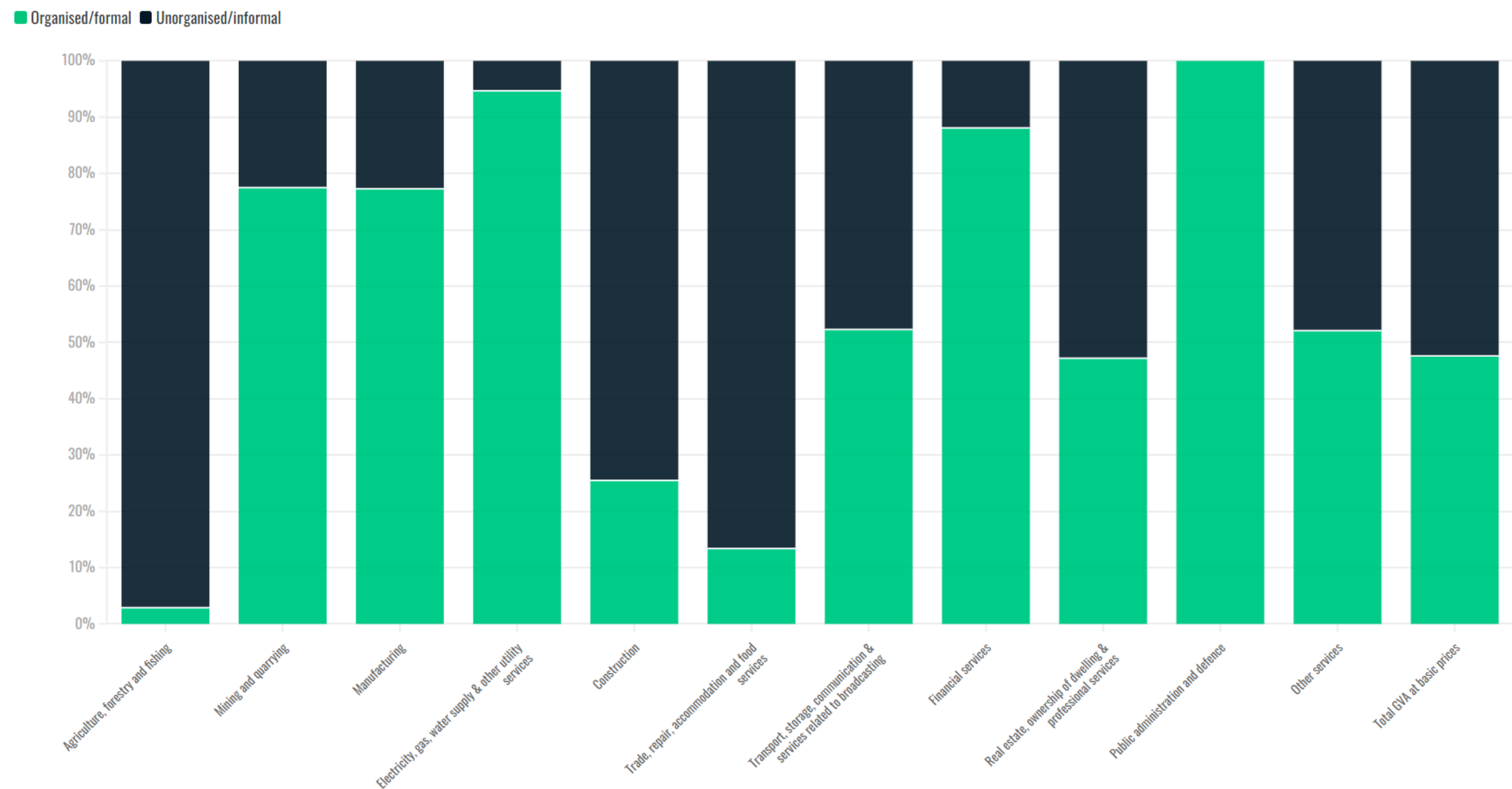
A biodigester is a system that biologically digests organic matter and transform it into biogas for thermal or productive purposes and fertilizer for plant growth. It is a scientifically effective means of dealing with wet waste, improving community sanitation and providing a sustainable source of energy. As a community-based infrastructure system, the biodigester in this project relies on the existing warehouse on the site.

## 05. CLUSTER SCALE

Micro Agglomeration Economies



# DIVERSITY OF BUSINESSES IN SLUMS



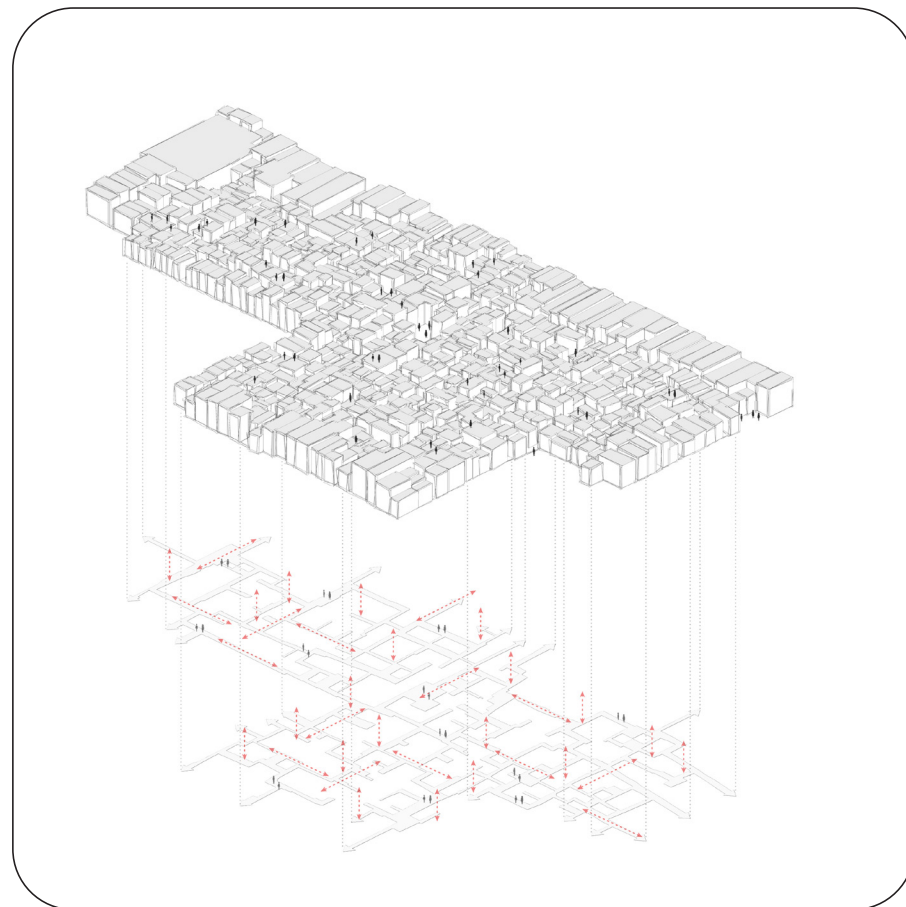
## THE VARIETY OF ECONOMIC ACTIVITIES IN THE SLUMS

It is important to note that there are many **other informal businesses coexisting in slums** in addition to waste recycling. They together contribute to the thriving informal economy ecosystem in slums. There is a need to **maintain their interconnections to sustain the socio-economic viability within slums**. In fact, informal waste management is also linked with many other industries, such as composting workshop, urban farming, manufacturing, etc.

<https://ww3.rics.org/uk/en/modus/built-environment/construction/slumdog-billionaire--turning-rubbish-into-rupees.html>

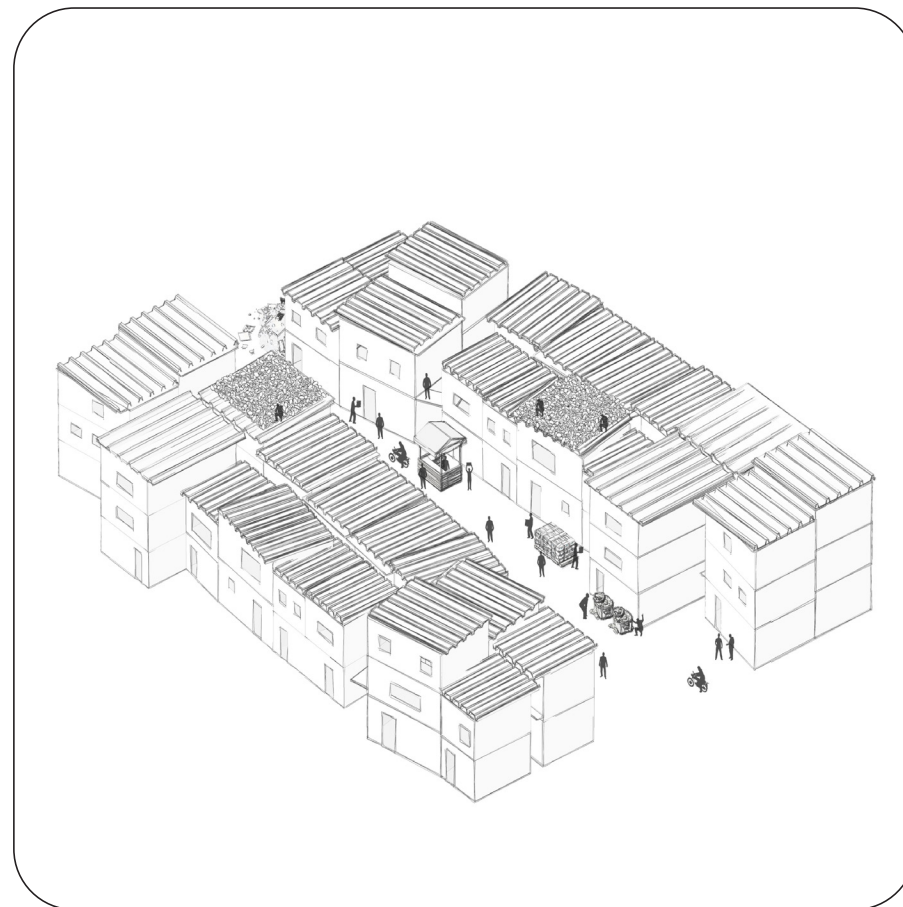
# HOW TO INTEGRATE PRODUCTION ACTIVITIES IN SLUMS

## CLUSTERING OF BUSINESSES



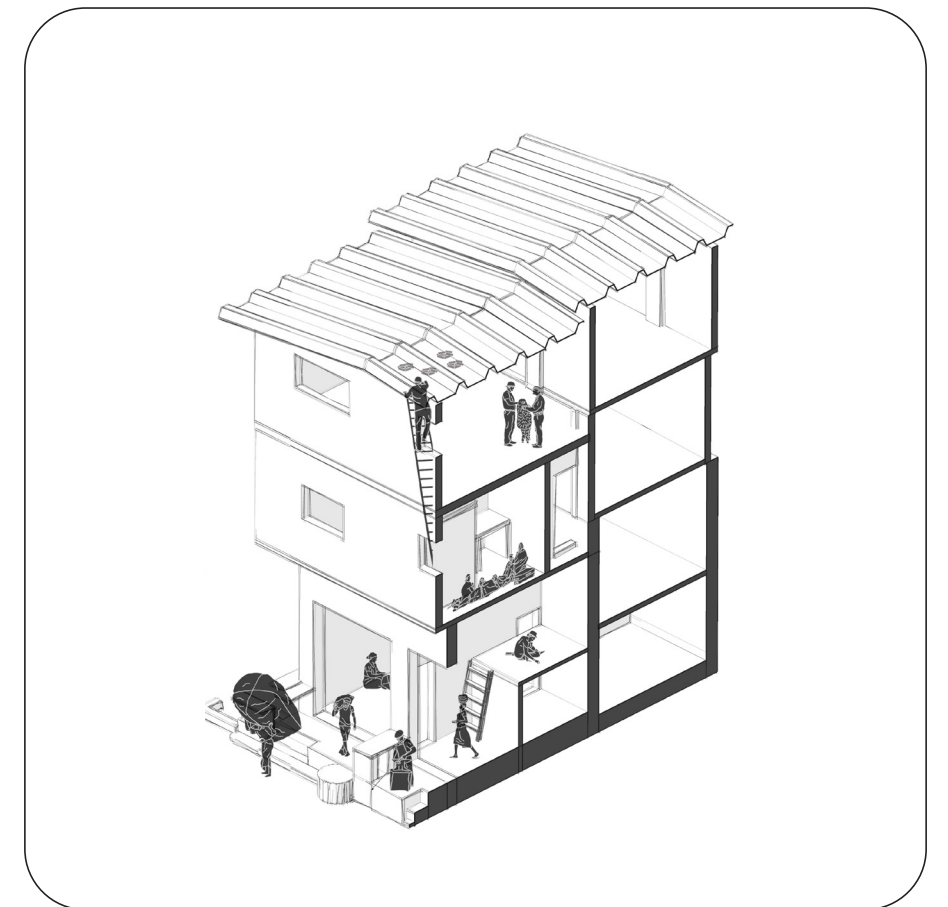
The clustering of economic activities within slums **reduces production costs and provides supply networks and well-trained workers**. The vertical and horizontal traversability (street, lane, ladder, stairs, platform,, etc.) further **strengthens interconnections** between related informal businesses.

## OPEN SPACE CONTACTING THE GROUND



The open spaces provide **a rich social life and informal spaces that can be freely occupied** for living, production or commercial use.

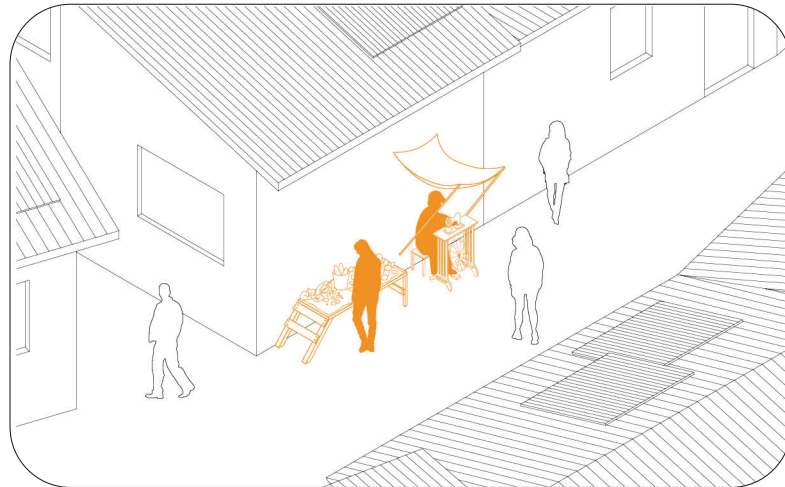
## LIVE-WORK LIFESTYLE



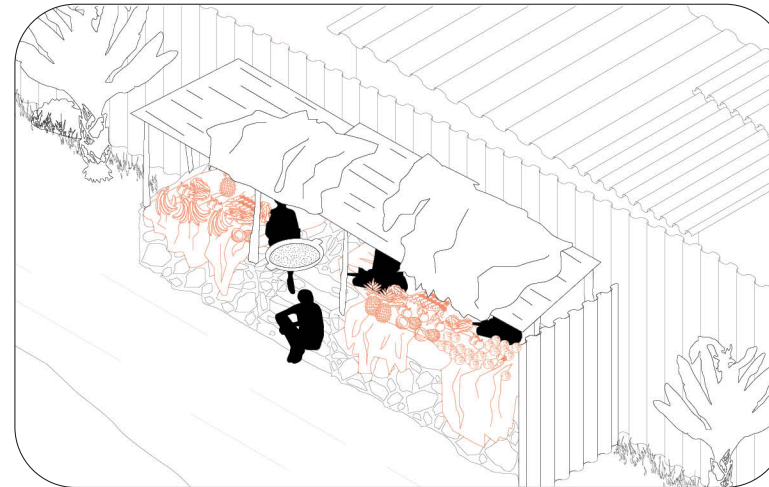
There is an **intricate relationship between the home and the workplace in slums**. Houses or public spaces directly connected to them are often used as workplaces.



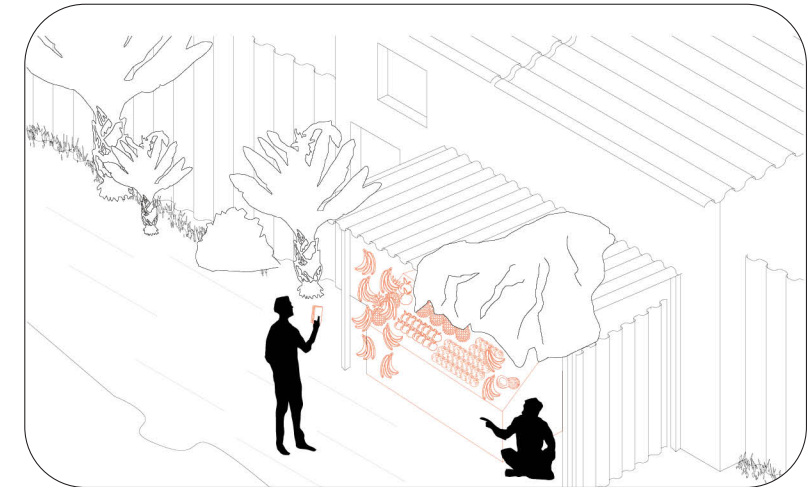
## HOW TO INTEGRATE PRODUCTION ACTIVITIES IN SLUMS



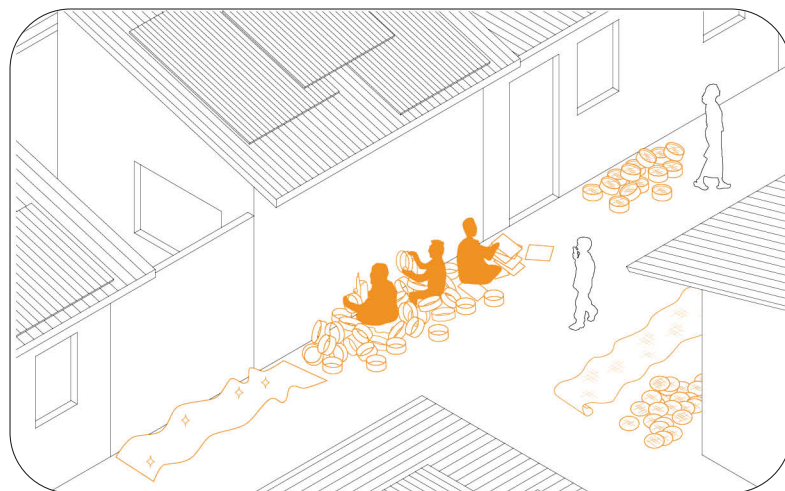
Pop-up vendor



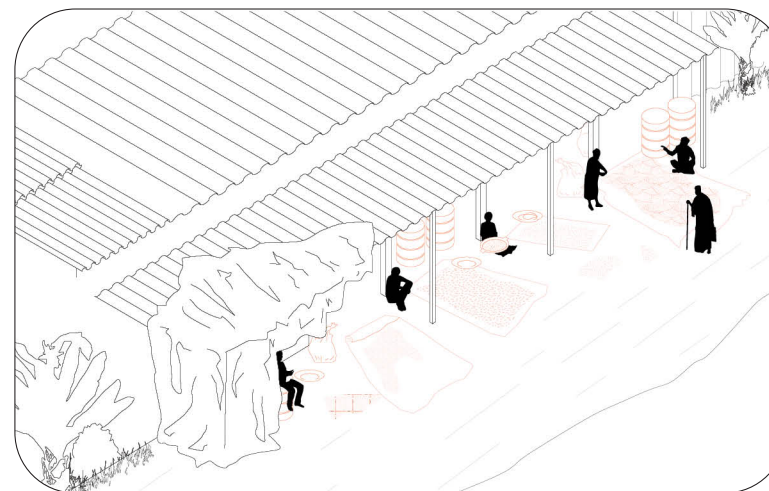
Market stall on the side



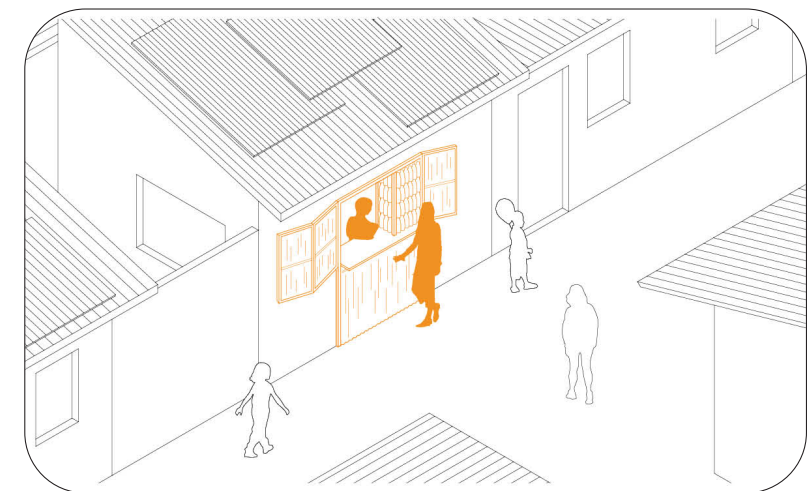
Vegetable stall on the side



Working area



Shop extending on the street



Window shop

In slums, people use **all possible public or semi-public spaces**, such as street corners, sheds, verandahs, terraces and steps, **for various productive activities** like buying, selling, drying, or stacking goods. These spaces are occupied informally or temporarily to carry out these economic activities or daily activities, which gives vitality to the public space.

Source: Bartosz Kobylakiewicz; Development Induced Empowerment: The Roof Villages of Addis Ababa



## THE MULTIPLE ROLES OF THE CORRIDOR / PLATFORM



1. Circulation



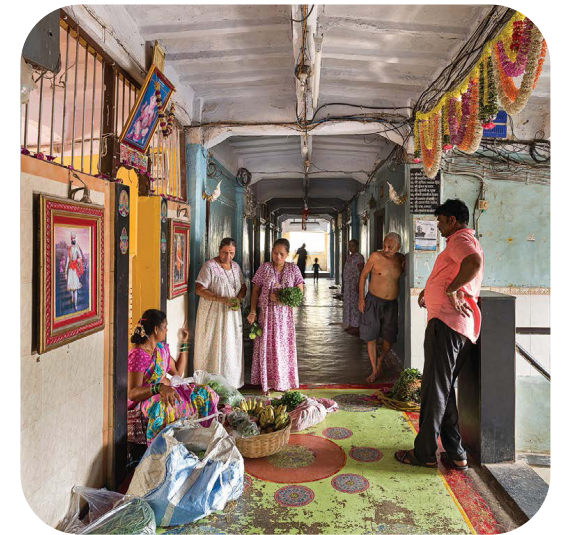
2. Daily life use



3. Socialisation & leisure



4. Stacking & production



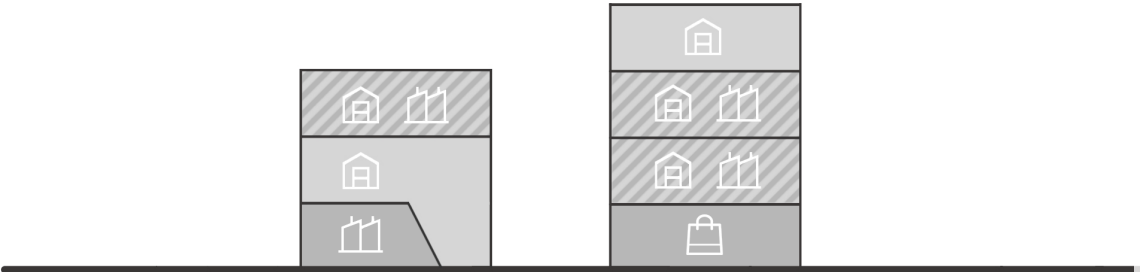
5. Buying & selling

### CORRIDOR IMMEDIATELY ADJACENT TO THE LIVING SPACE

The corridor immediately adjacent to the living space takes on a variety of roles, with functions such as circulation, daily life use, socialisation, stacking & production, buying & selling, etc. These activities make the corridor **an overlap of living and working**.

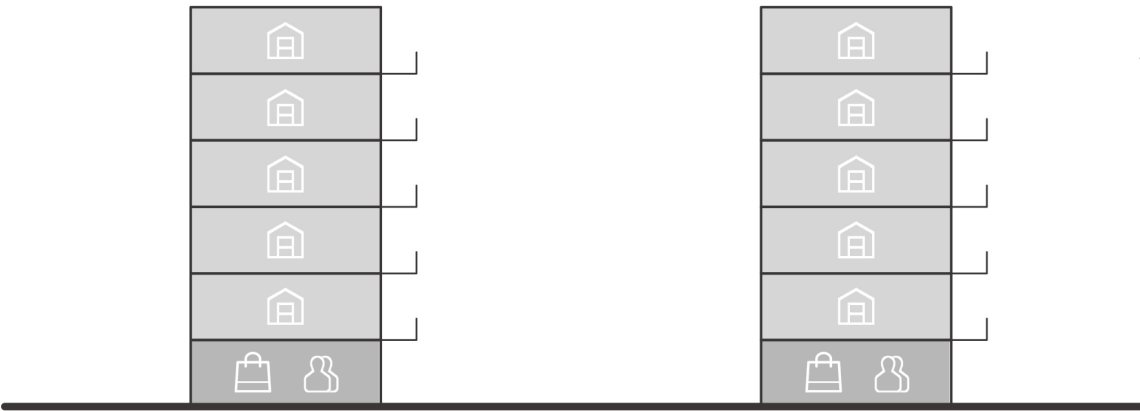


AN ALTERNATIVE COMBINATION OF LIVING & WORKING



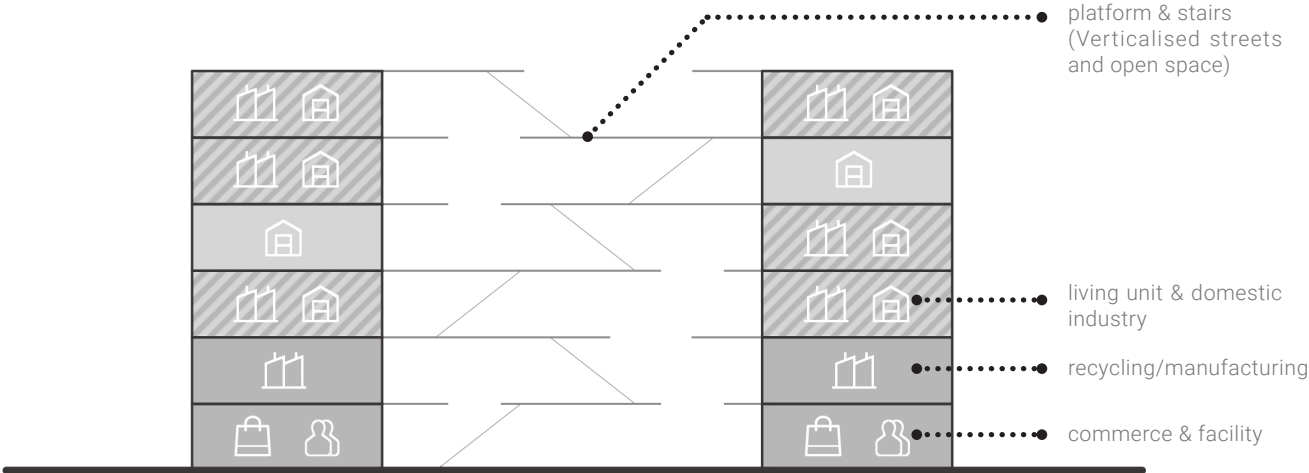
TRADITIONAL SLUM

S: diverse productive and commercial activities;  
the living space is highly interlinked with the working space;  
W: ambiguous boundaries lead to mutual interference;  
lack of communal facilities and amenities



TRADITIONAL CONDOMINIUM

S: improved living conditions (ventilation, etc.);  
larger residential population and greater economic benefits  
W: no space allocated for informal business;  
lack of diverse open spaces



MICRO AGGLOMERATION ECONOMIES

The cluster is an alternative combination of living and working. The ground floor is for commerce and facility, the first floor is for light industry, and the upper floors are for living and domestic industries. The platforms and stairs in between are considered as verticalised streets, taking activities from the ground level to upper levels.

- private

communal use
- living unit

home-based industry / office

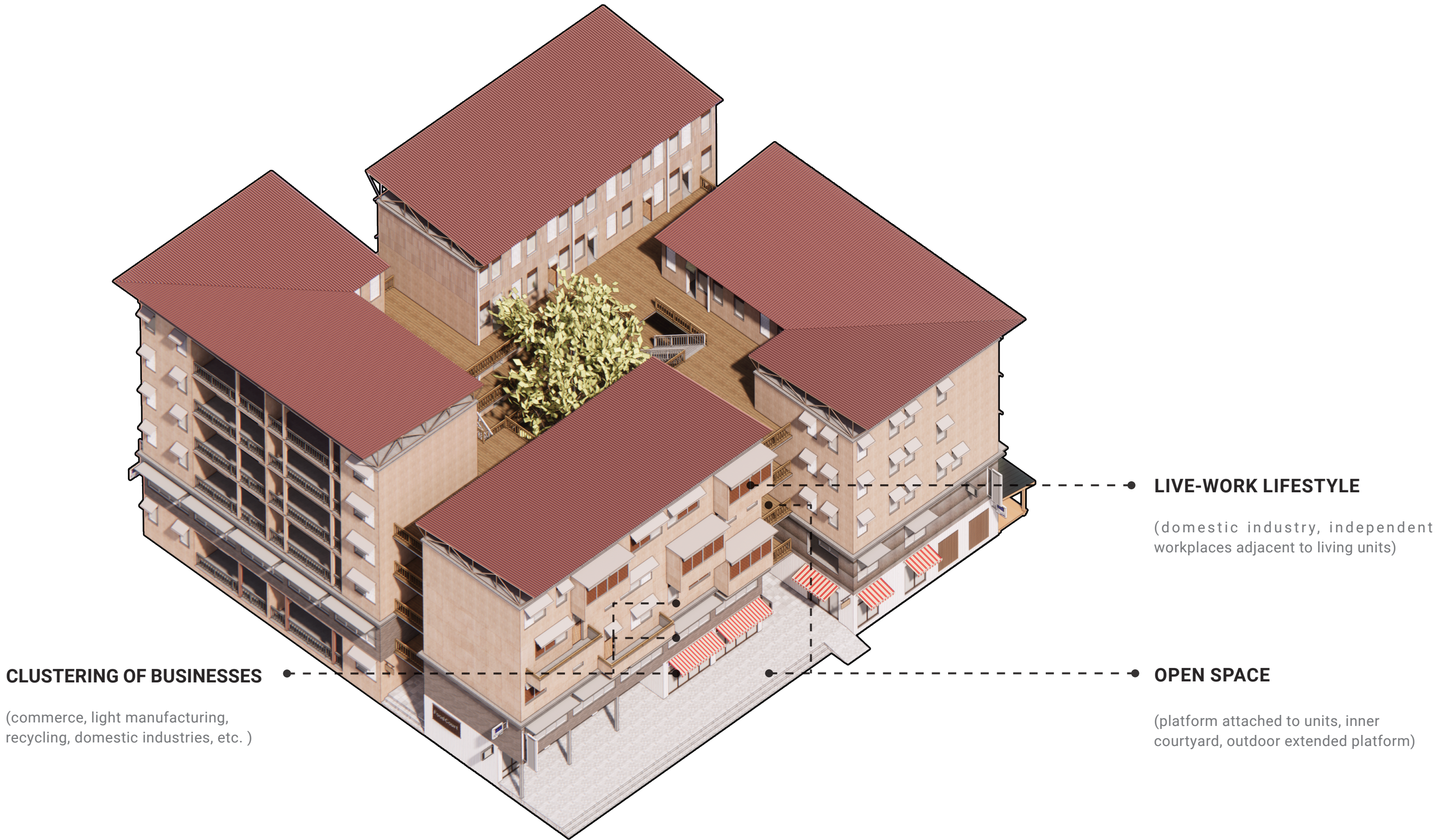
light industry / manufacture

communal amenity

commercial shop

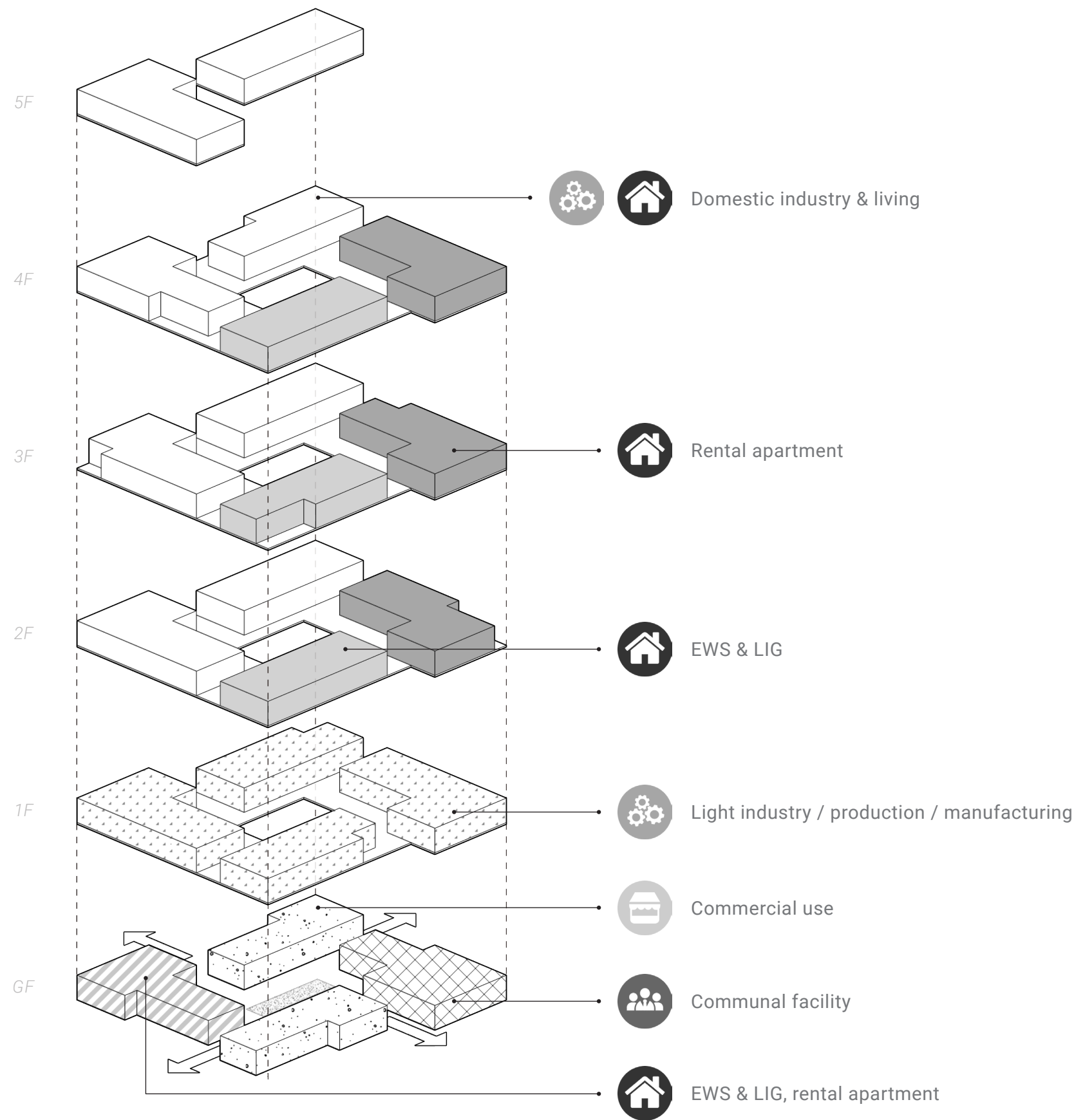


HOW TO INTEGRATE ECONOMIC ACTIVITIES INTO THE LIVING SPACE





SOCIO-SPATIAL MIX



EWS & LIG CLUSTER



RESIDENTIAL  
60%



FACILITY  
5%

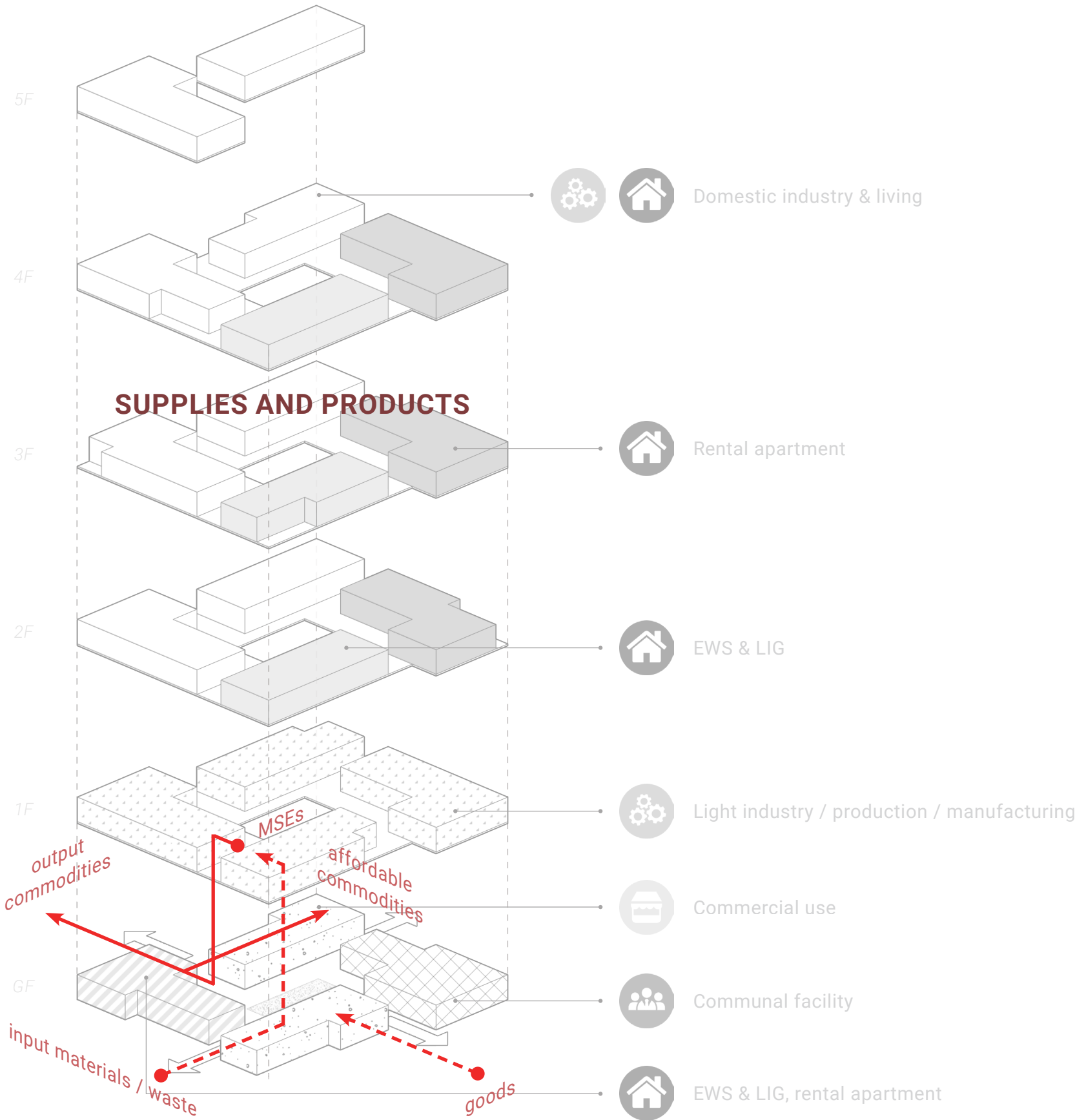


INDUSTRIAL  
25%



COMMERCIAL  
10%

CIRCULATION



EWS & LIG CLUSTER



Residential

60%



Facility

5%



Industrial

25%

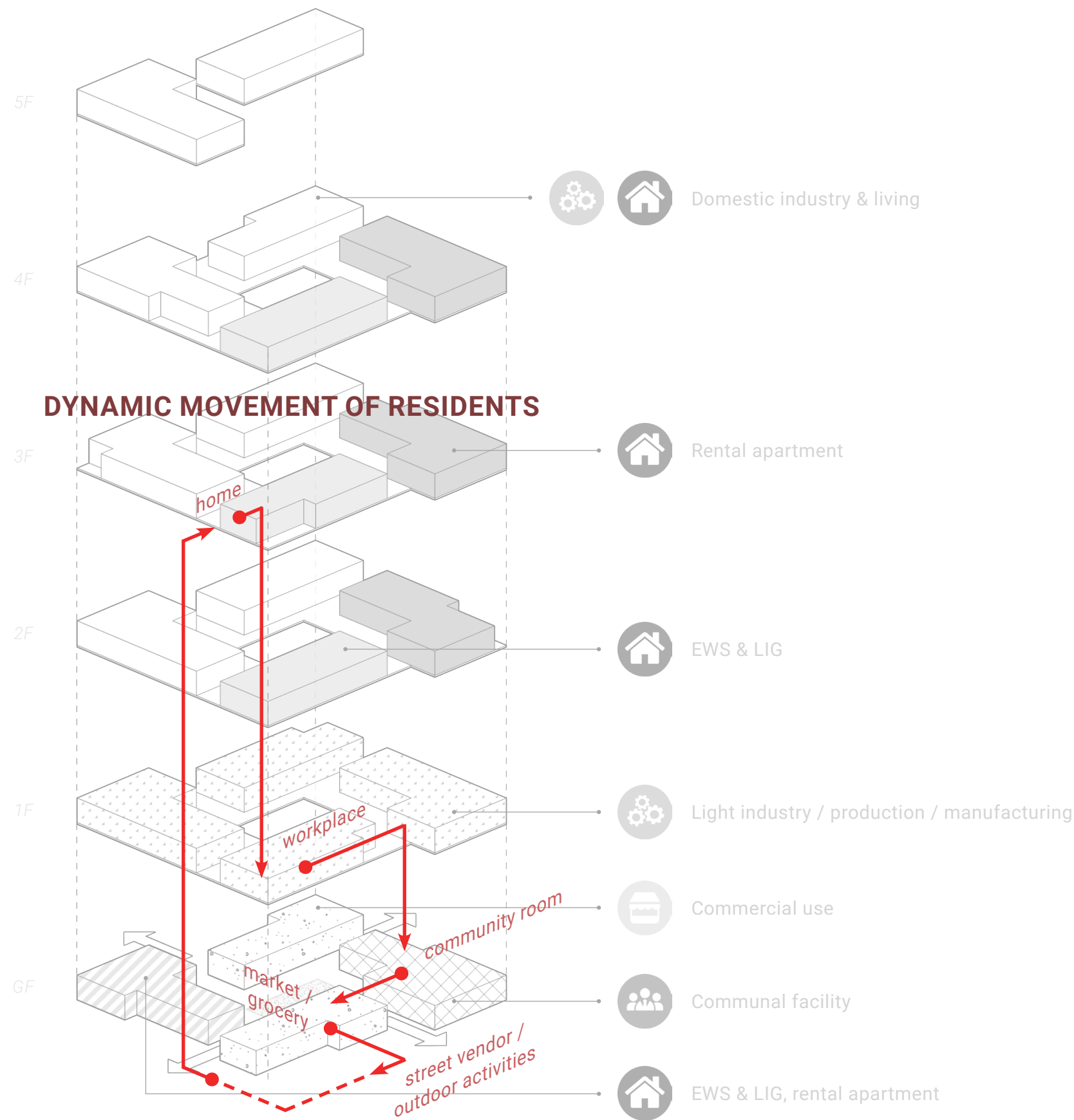


Commercial

10%



CIRCULATION

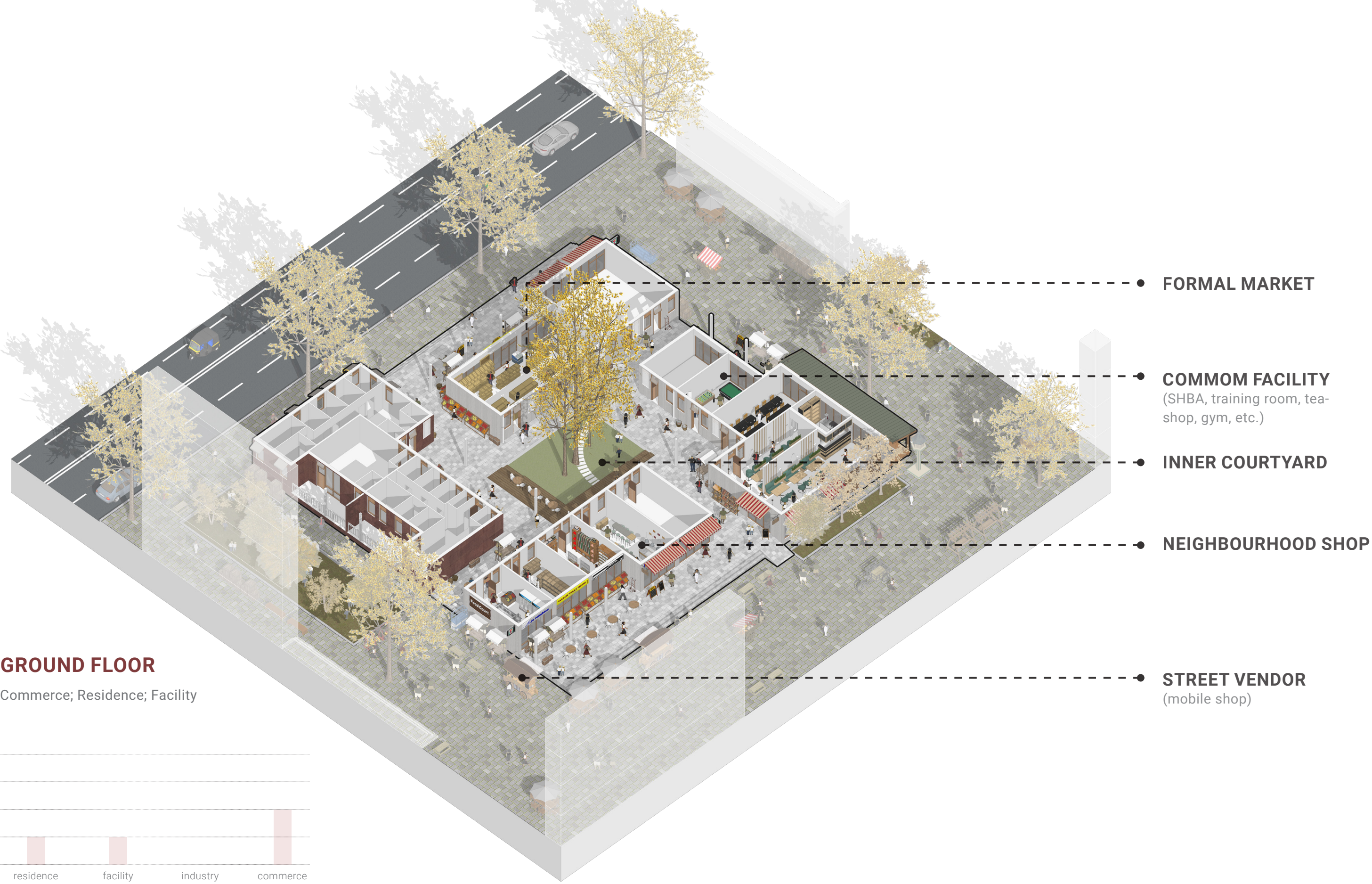


**EWS & LIG CLUSTER**



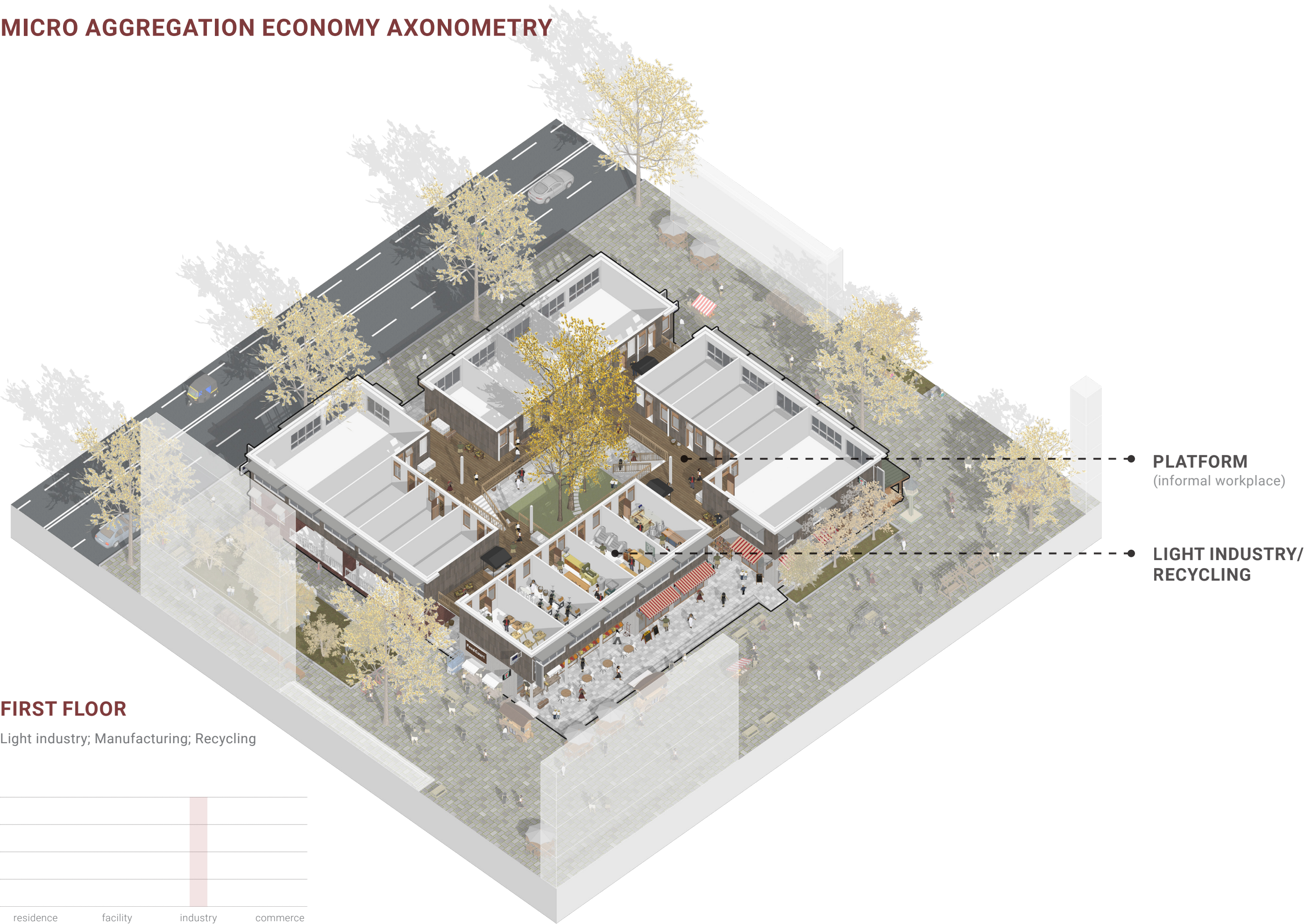


# MICRO AGGREGATION ECONOMY AXONOMETRY



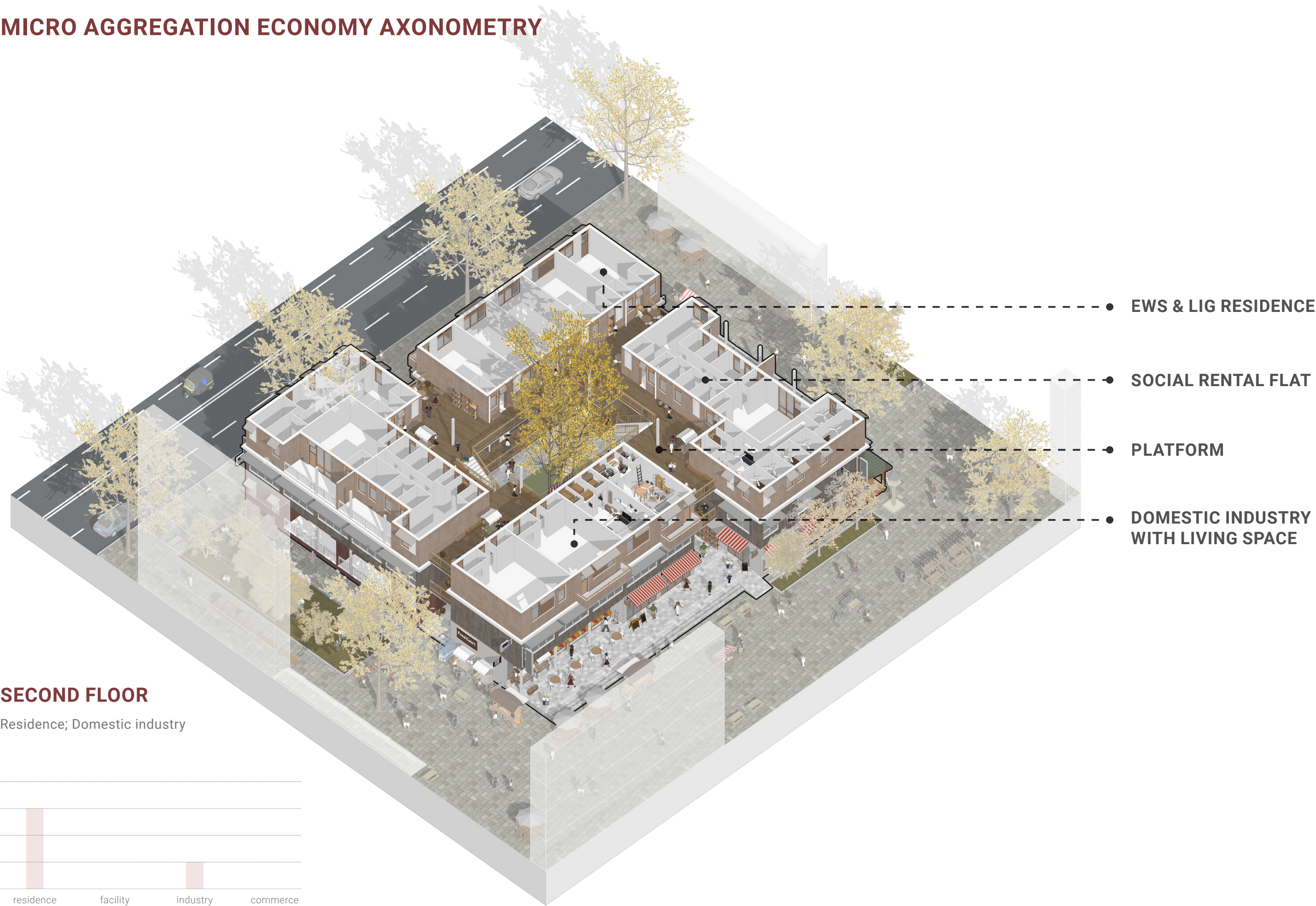


MICRO AGGREGATION ECONOMY AXONOMETRY





MICRO AGGREGATION ECONOMY AXONOMETRY



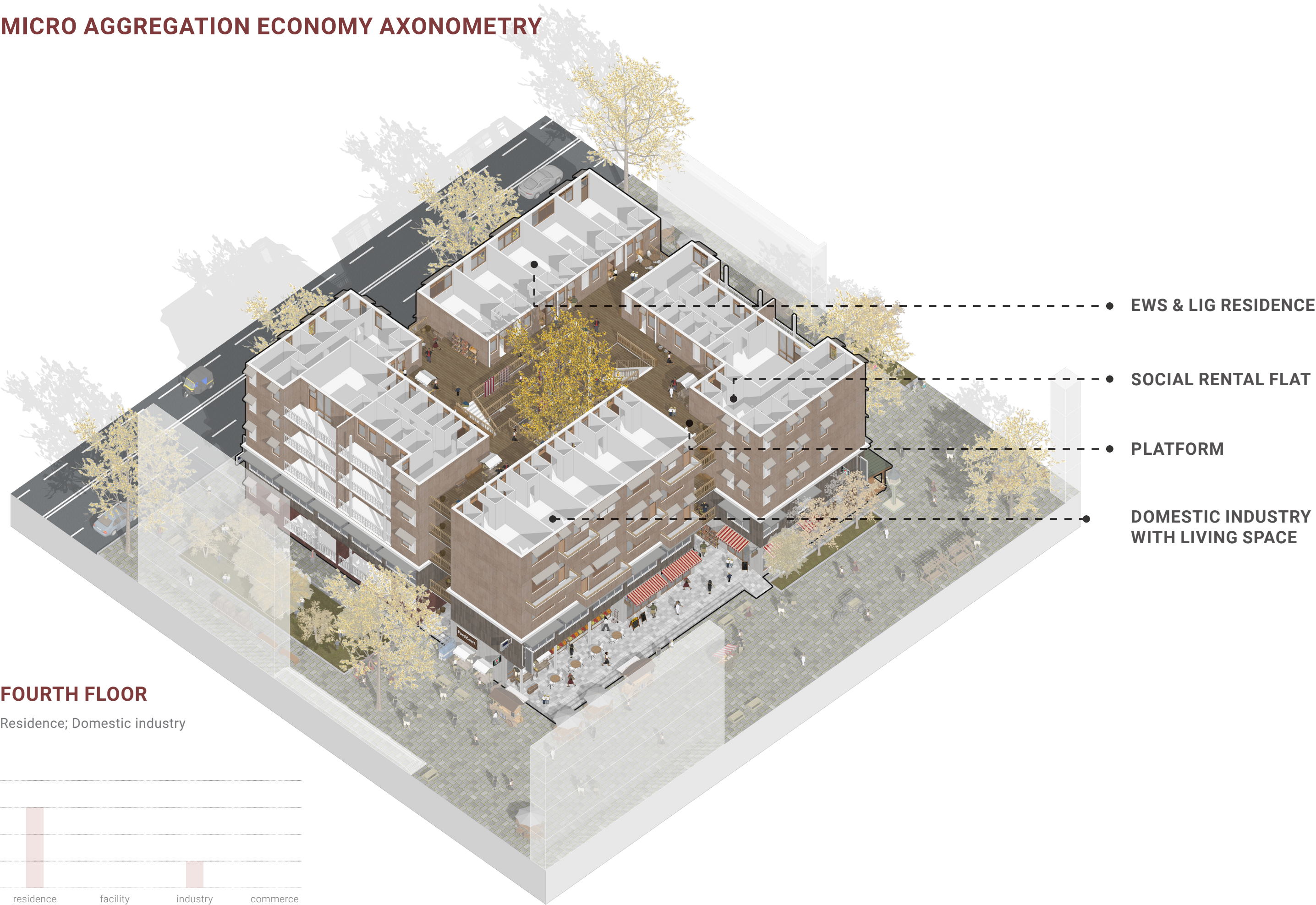


MICRO AGGREGATION ECONOMY AXONOMETRY



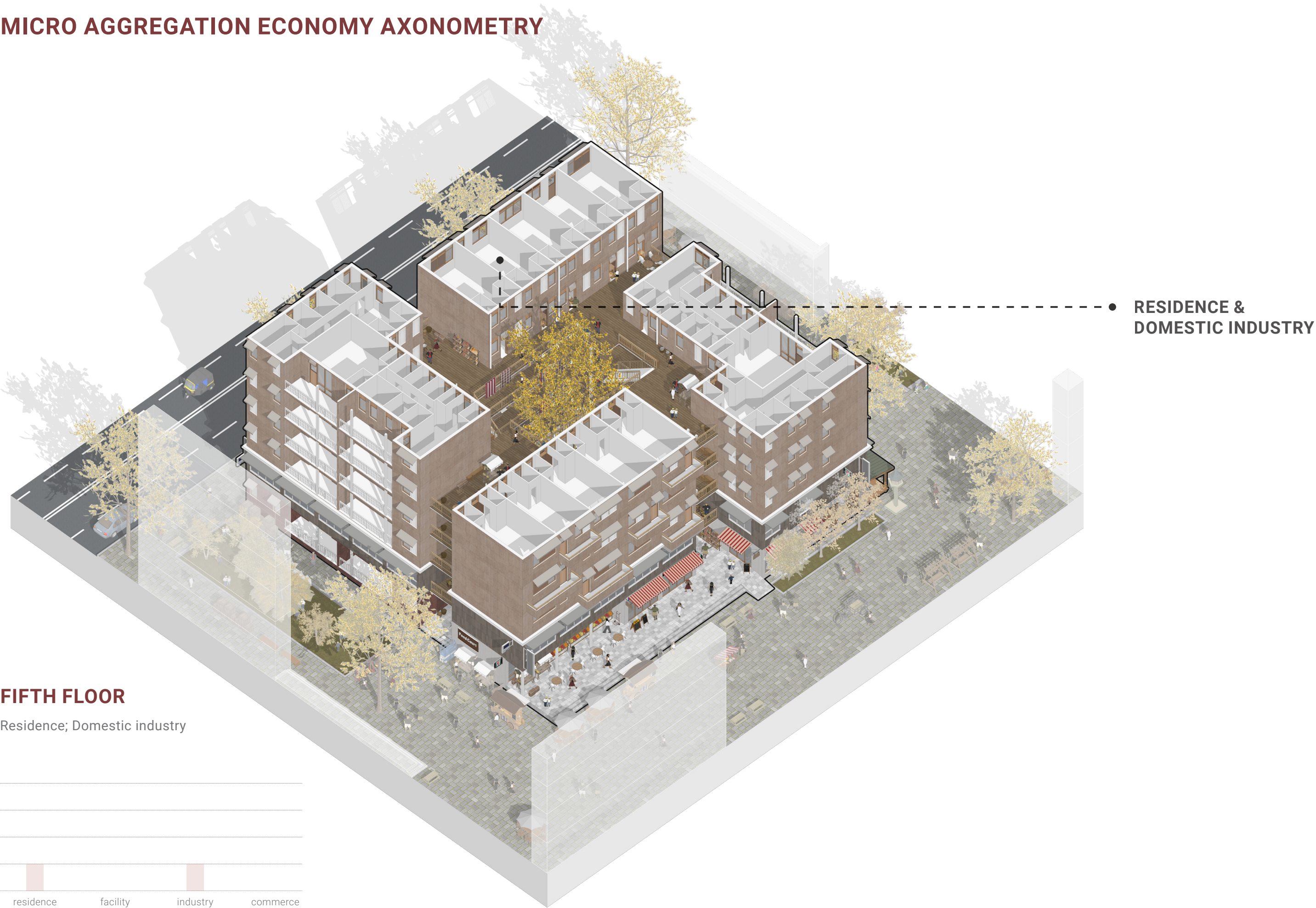


MICRO AGGREGATION ECONOMY AXONOMETRY



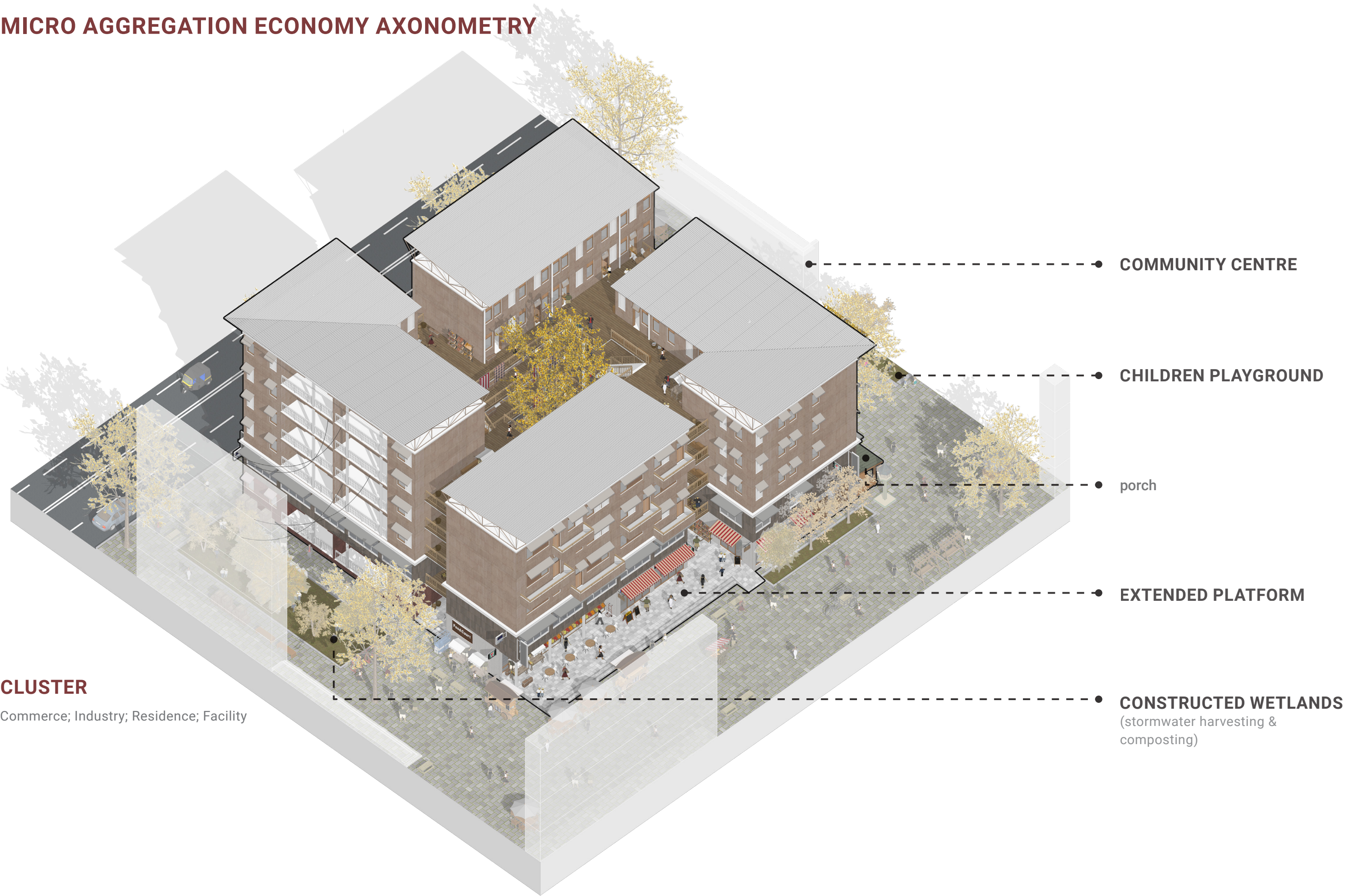


MICRO AGGREGATION ECONOMY AXONOMETRY



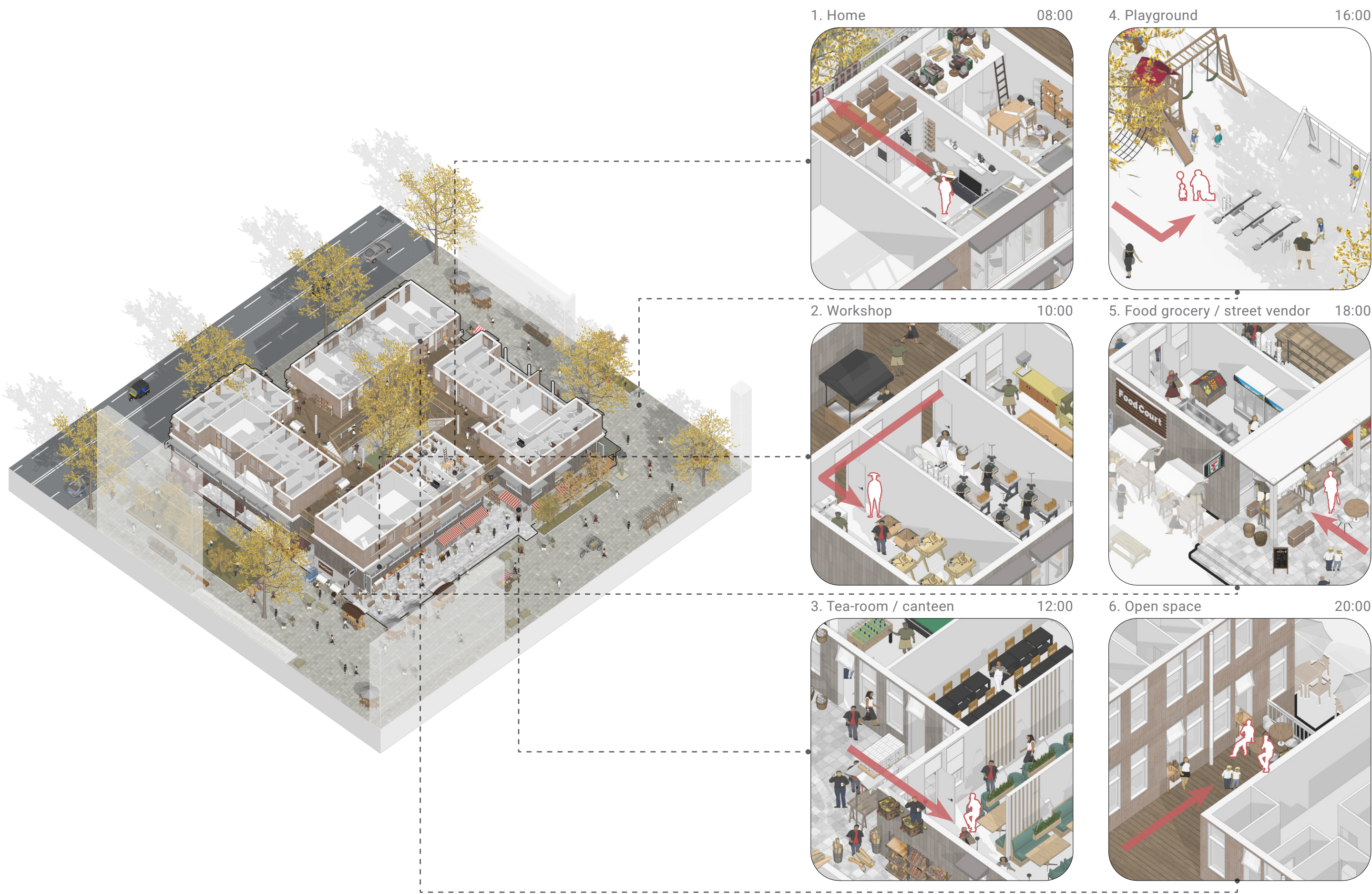


MICRO AGGREGATION ECONOMY AXONOMETRY





24H ACTIVITY CYCLE





DIVERSITY OF ACTIVITIES IN THE CLUSTER

1. social rent flat

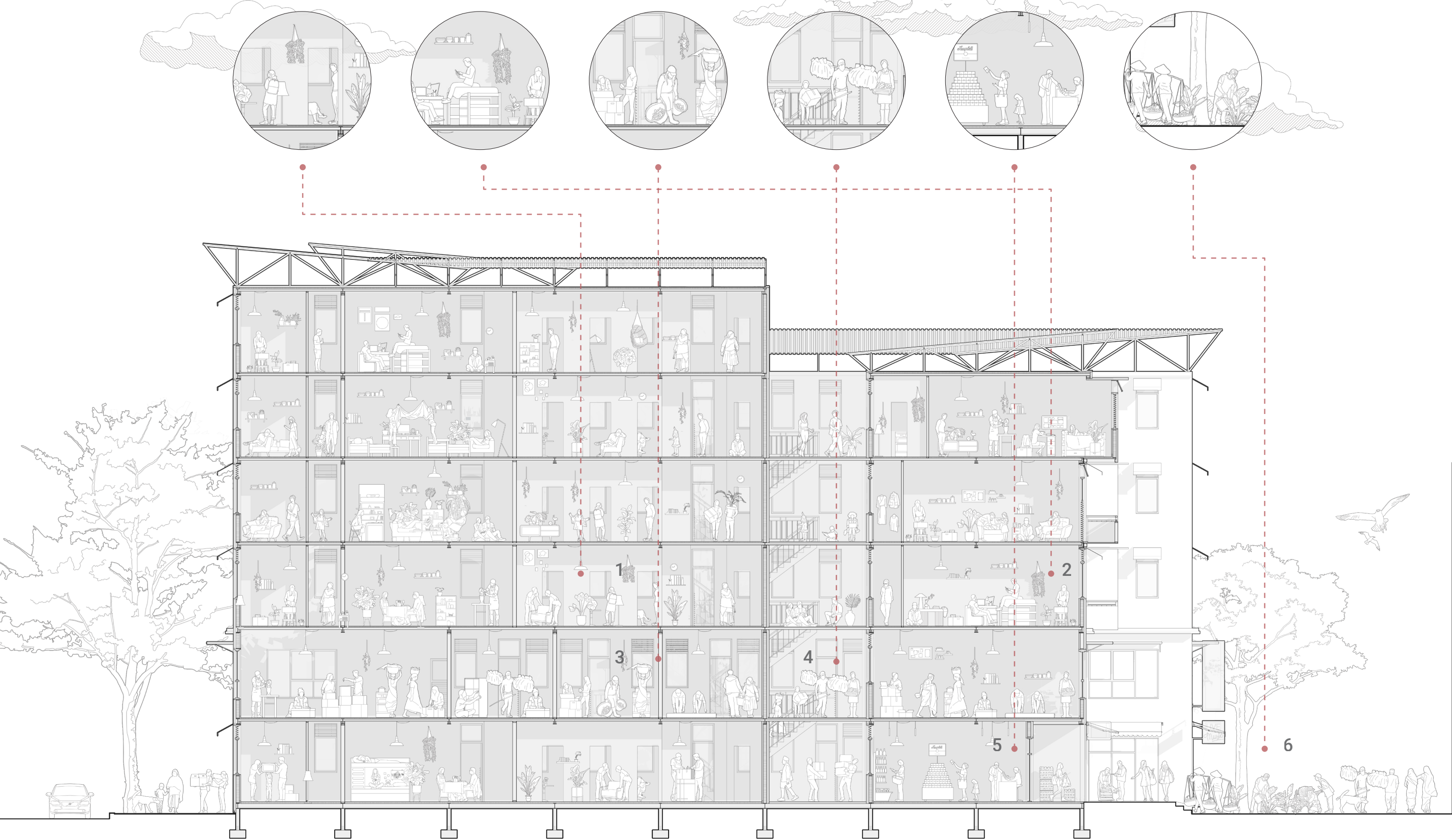
2. EWS & LIG residence / domestic industry

3. light industry / recycling

4. outdoor platform

5. formal / informal shop

6. walkway / constructed wetlands





FACADE - SECTION



The function of each unit is in part reflected in the façade. Spectators can recognise the rich diversity of the cluster by the type of materials and openings.



STREET VIEW





INNER COURTYARD





CORRIDOR





PLATFORM



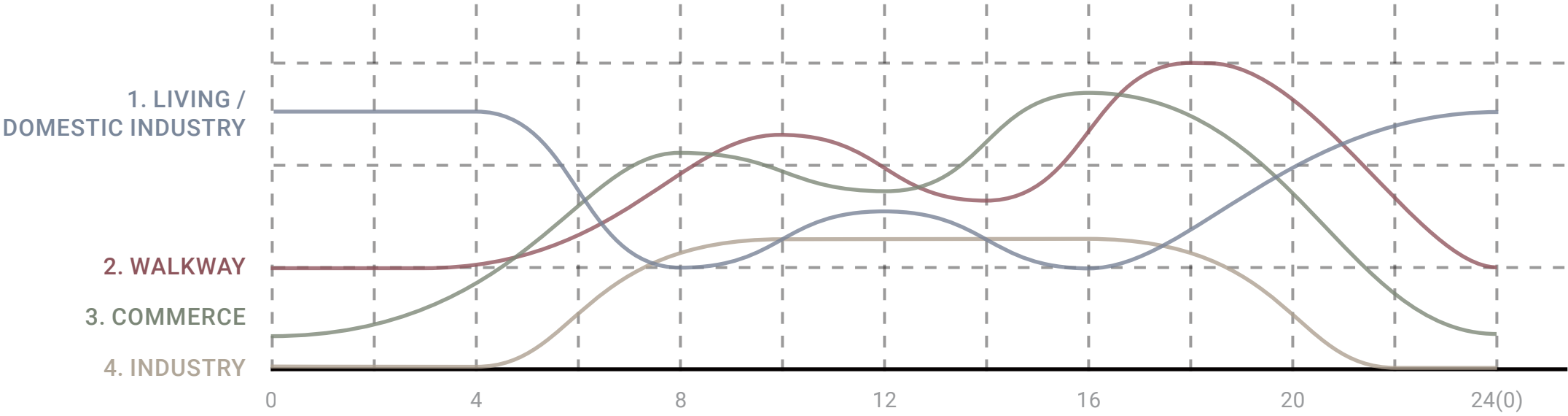


INTERIOR





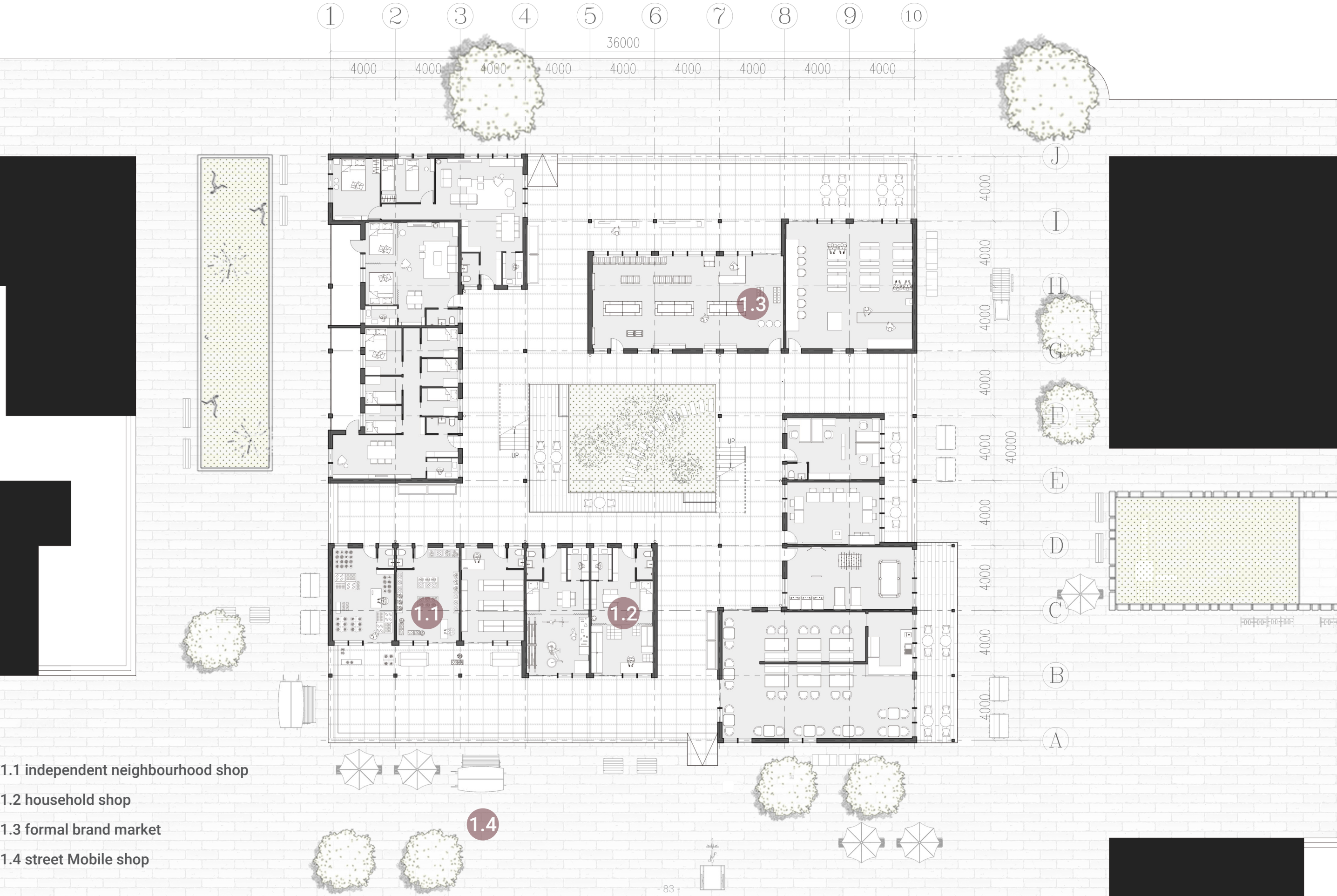
FOOT TRAFFIC IN A DAY



The foot flow of people on different levels of the cluster changes throughout the day. The streets and commercial spaces are crowded during the daytime, promoting various economic activities; while in the evening the upper living spaces become more crowded, and the platform becomes a place for relaxation and socialising.



COMMERCIAL USE - GROUND FLOOR PLAN





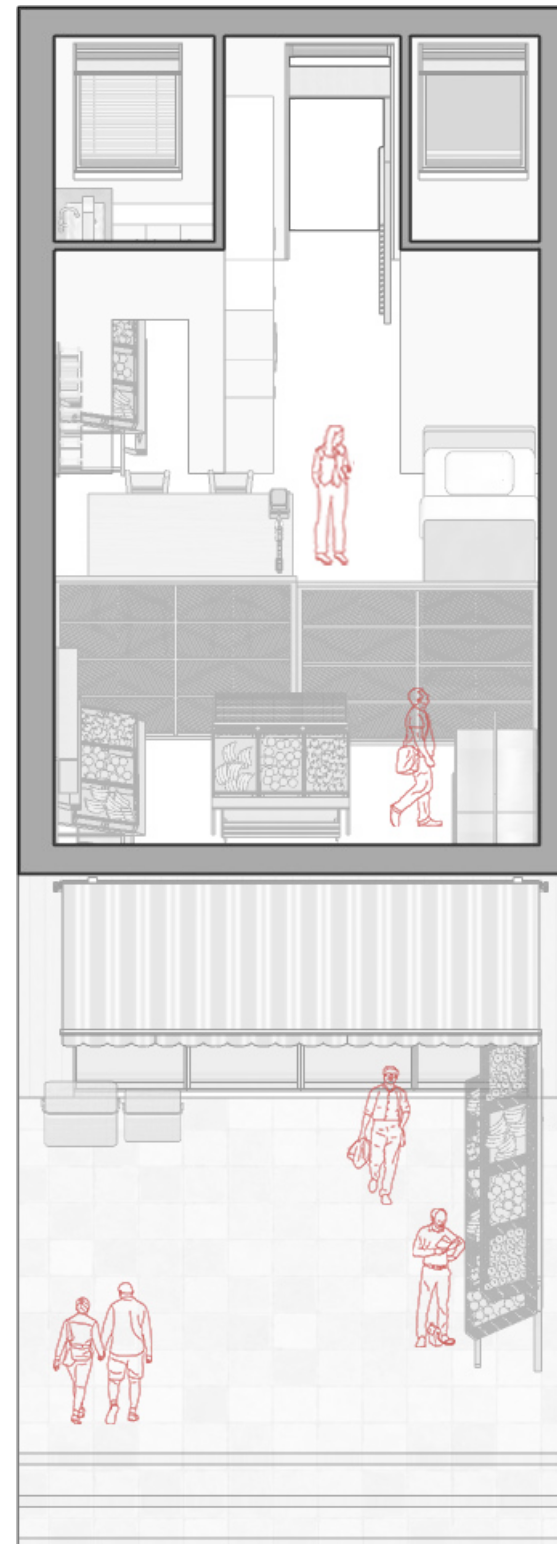
COMMERCIAL SPACE TYPE



1.1 INDEPENDENT NEIGHBOURHOOD SHOP



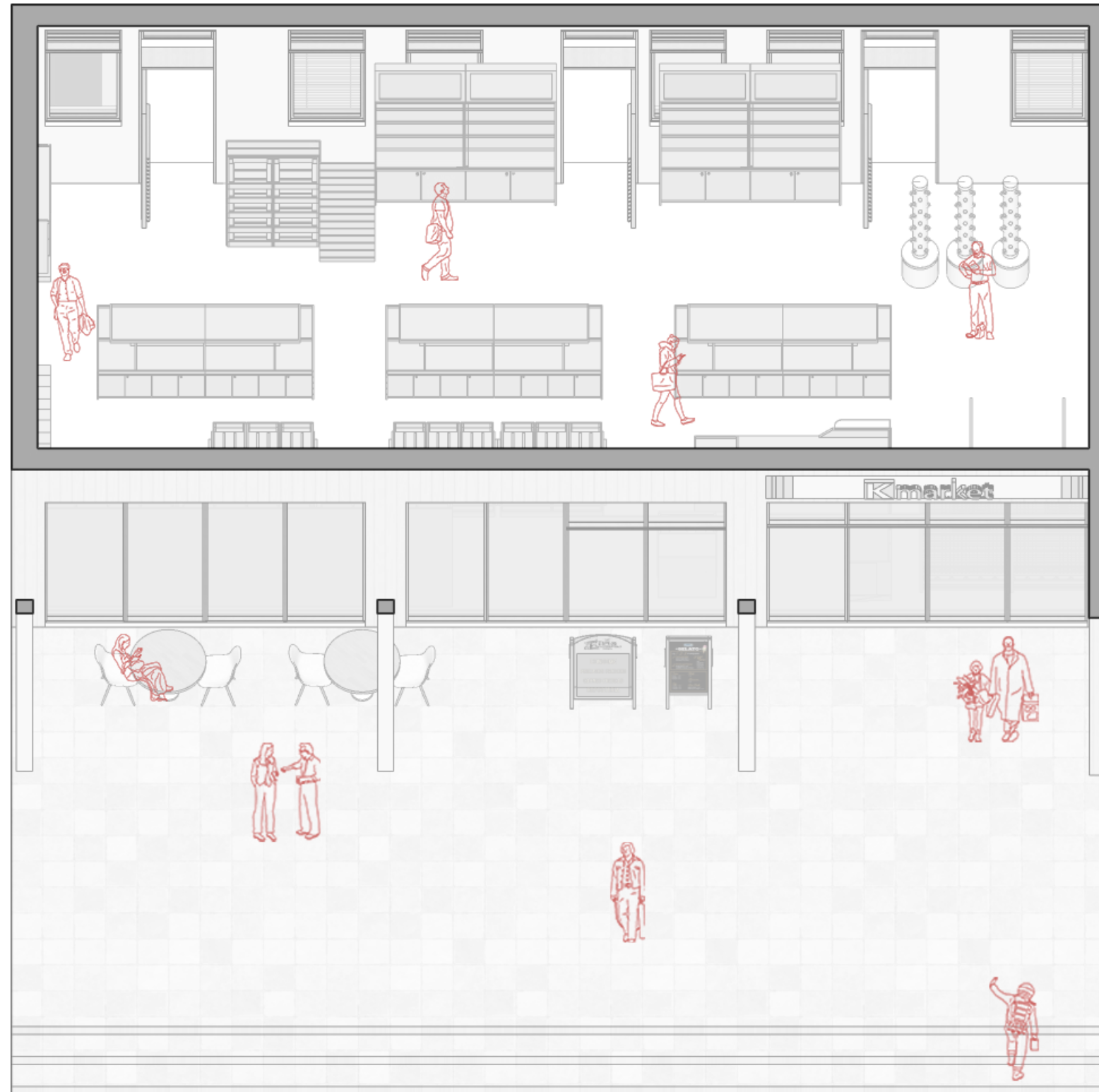
## COMMERCIAL SPACE TYPE



1.2 HOUSEHOLD SHOP



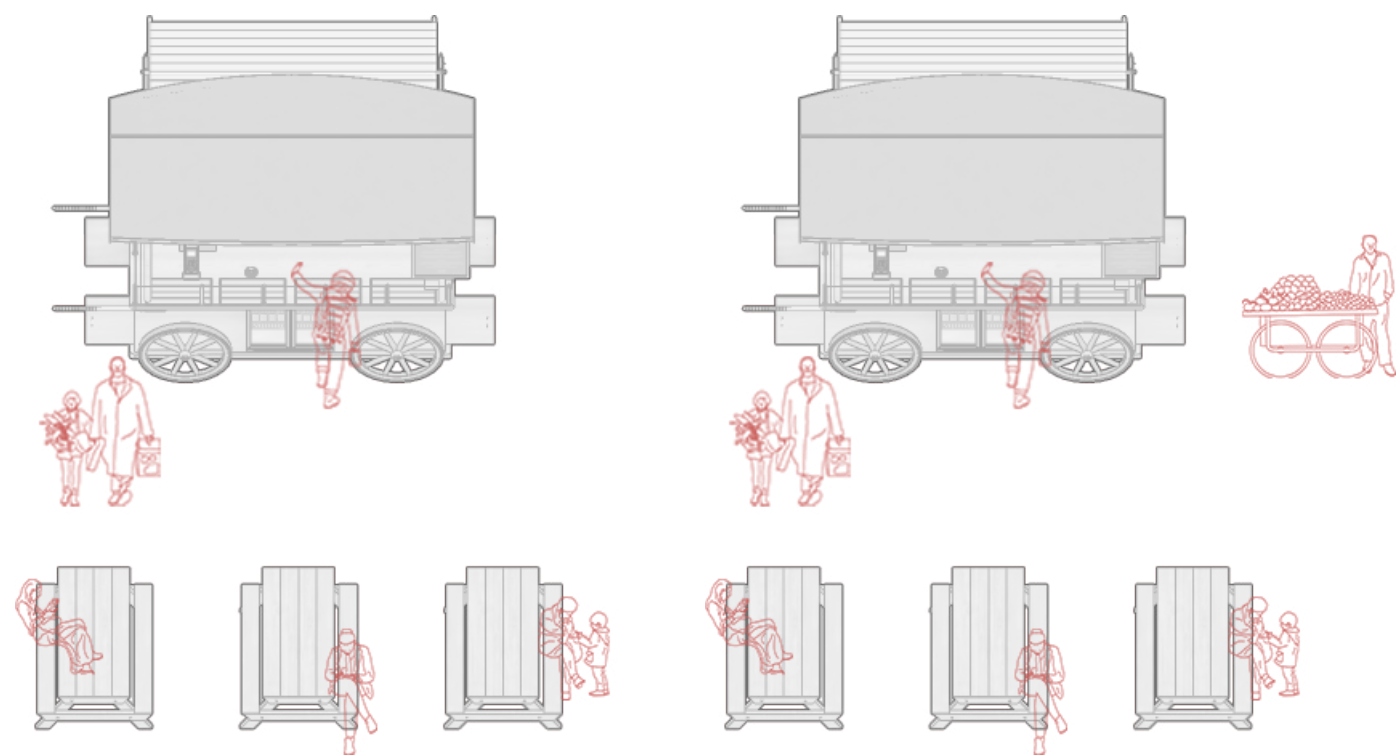
## COMMERCIAL SPACE TYPE



### 1.3 FORMAL BRAND MARKET



COMMERCIAL SPACE TYPE



1.4 STREET MOBILE SHOP



INDUSTRIAL USE - FIRST FLOOR PLAN



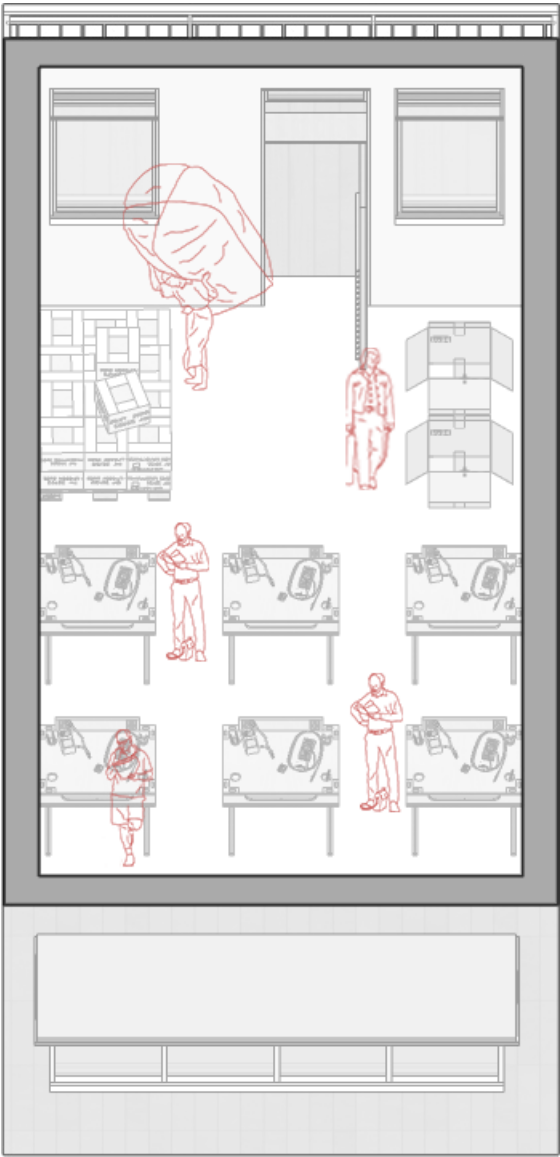
INDUSTRIAL USE:

Size a	32m <sup>2</sup>
Size b	32m <sup>2</sup>
Size c	64m <sup>2</sup>
Size d	96m <sup>2</sup>

- 2.1 Service industry
- 2.2 recycling industry
- 2.3 Manufacturing



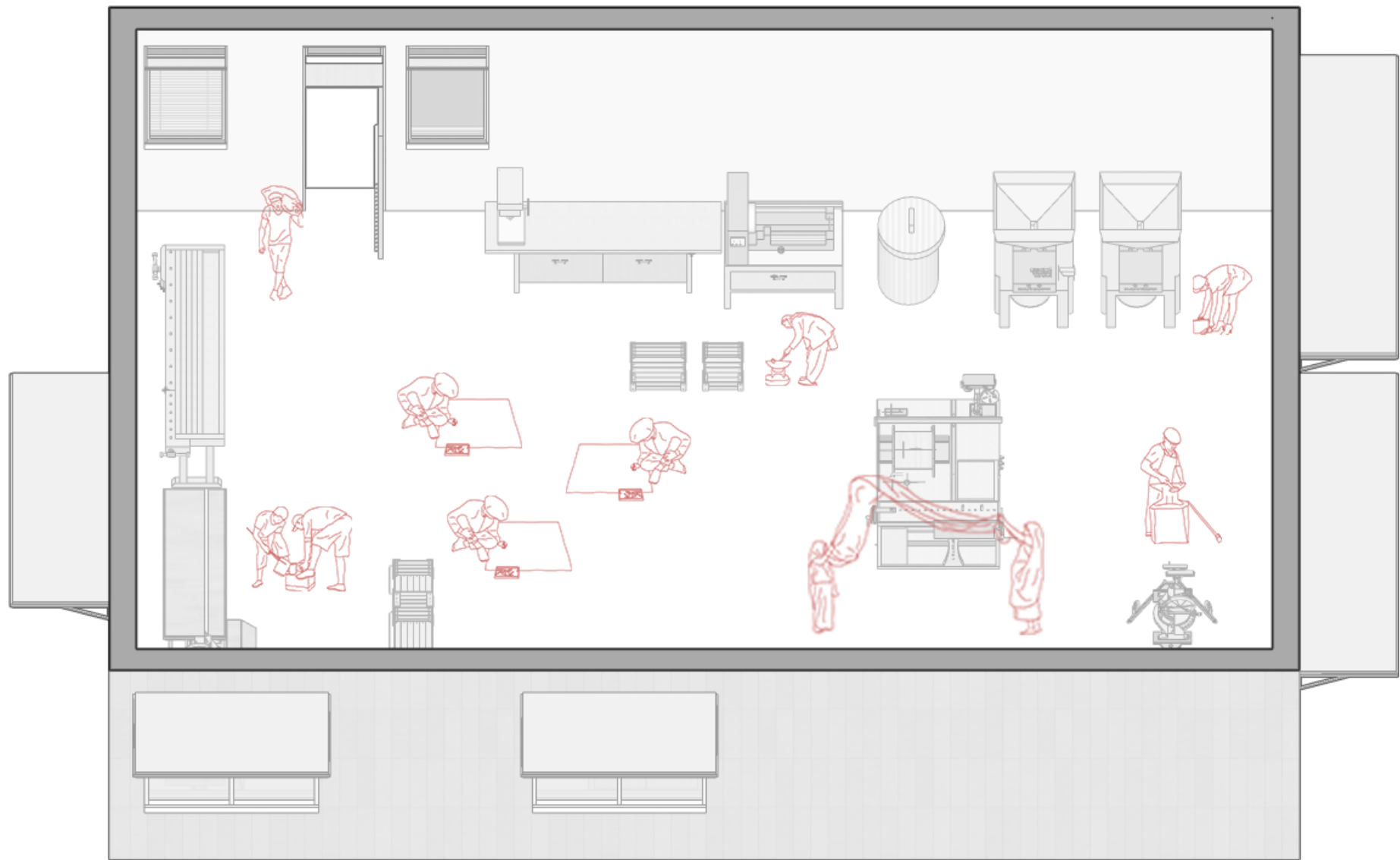
INDUSTRIAL SPACE TYPE



2.1 SERVICE INDUSTRY



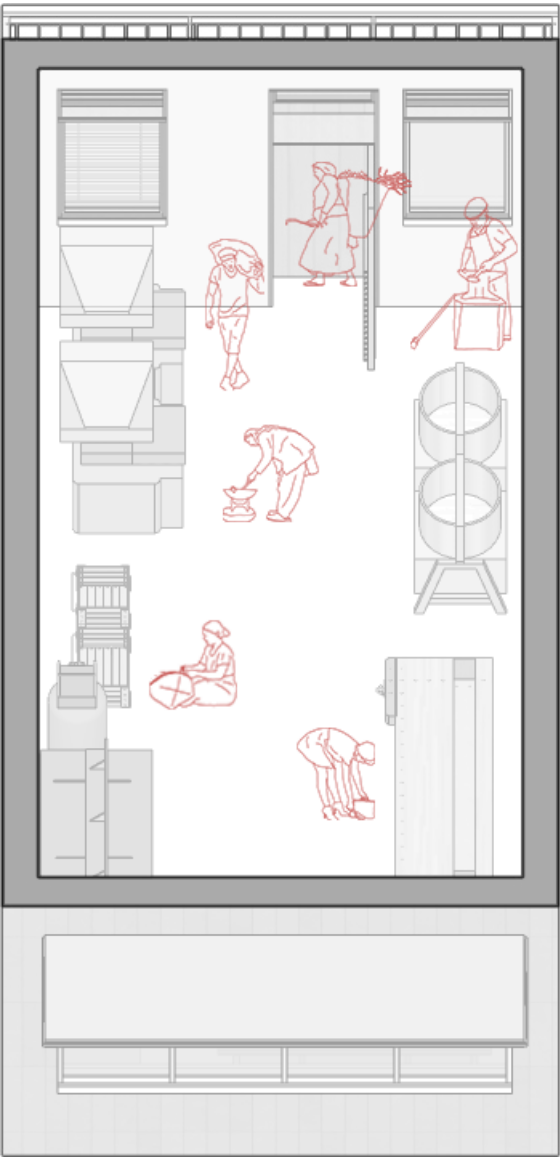
INDUSTRIAL SPACE TYPE



2.2 MANUFACTURING



INDUSTRIAL SPACE TYPE



2.3 RECYCLING INDUSTRY



RESIDENTIAL USE - THIRD FLOOR PLAN



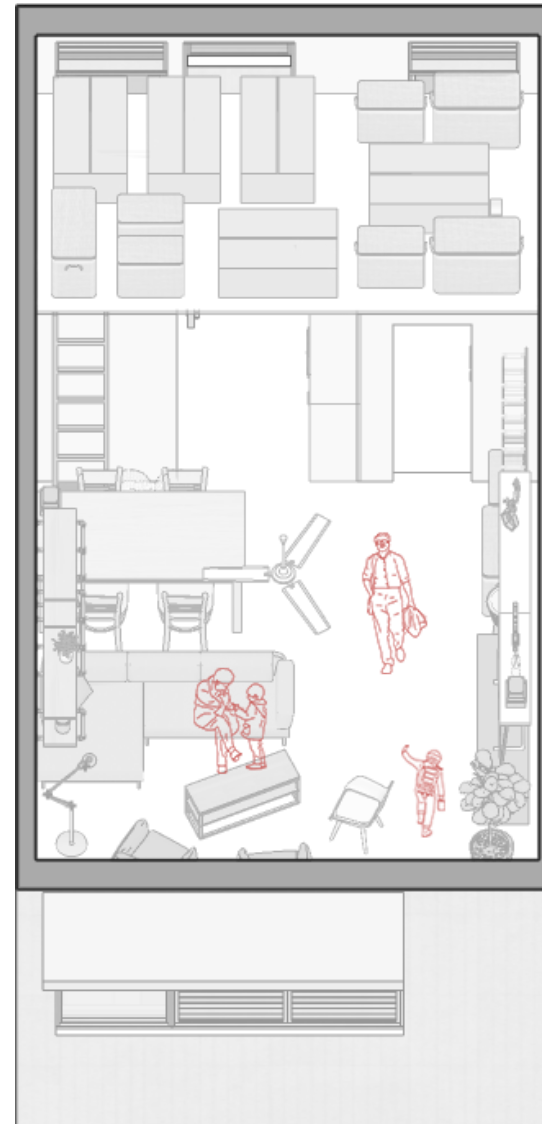
EWS & LIG LIVING:

Size a	32m <sup>2</sup>	2-4ppl.
Size b	48m <sup>2</sup>	3-5ppl.
Size c	56m <sup>2</sup>	3-5ppl.
Size d	64m <sup>2</sup>	6-8ppl. (social rental)
Size e	72m <sup>2</sup>	6-8ppl. (social rental)

- 3.1 EWS & LIG living unit
- 3.2 domestic industry with living space
- 3.3 Social rent apartment



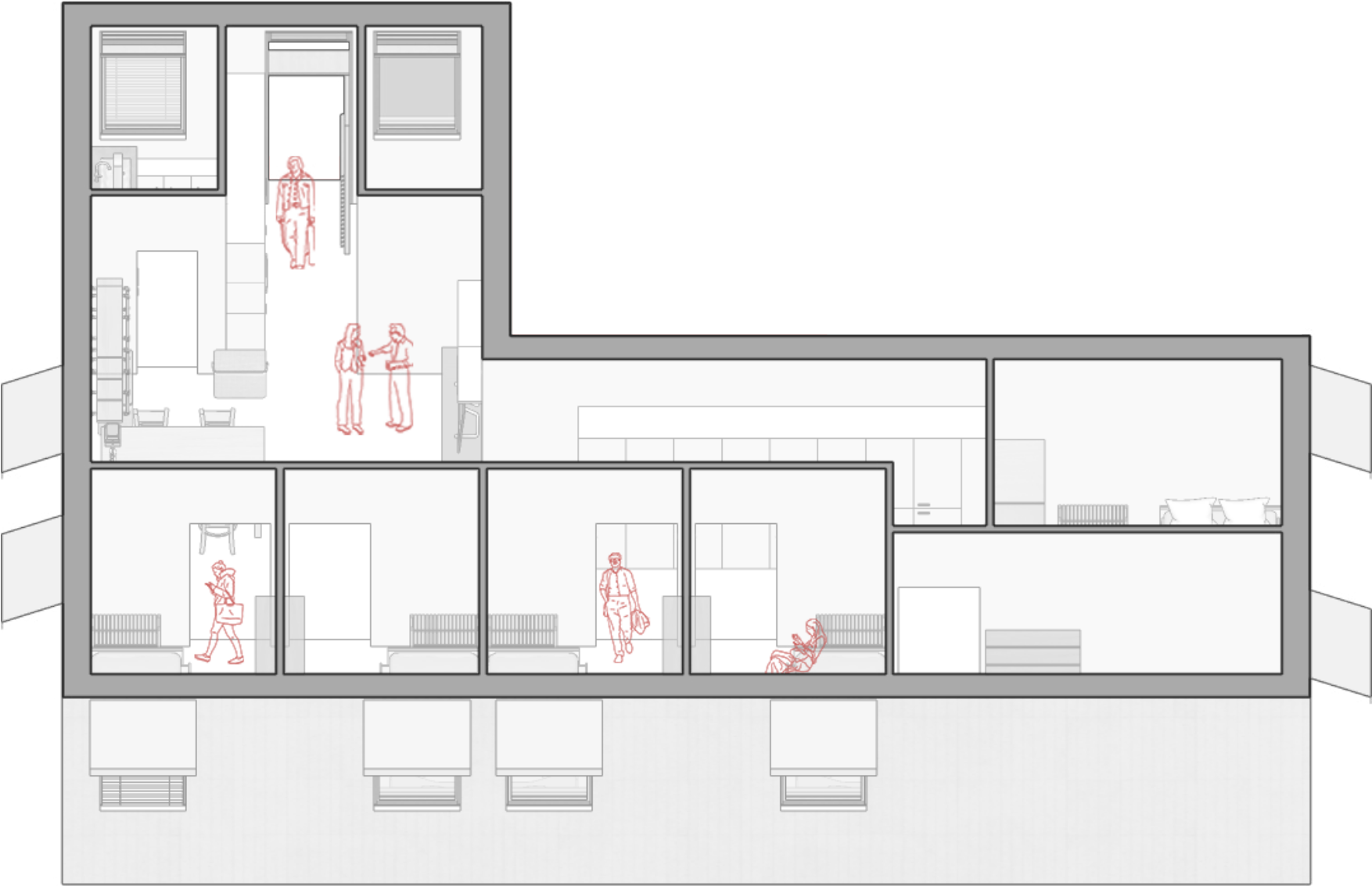
## RESIDENTIAL USE



### 3.1 EWS & LIG LIVING UNIT



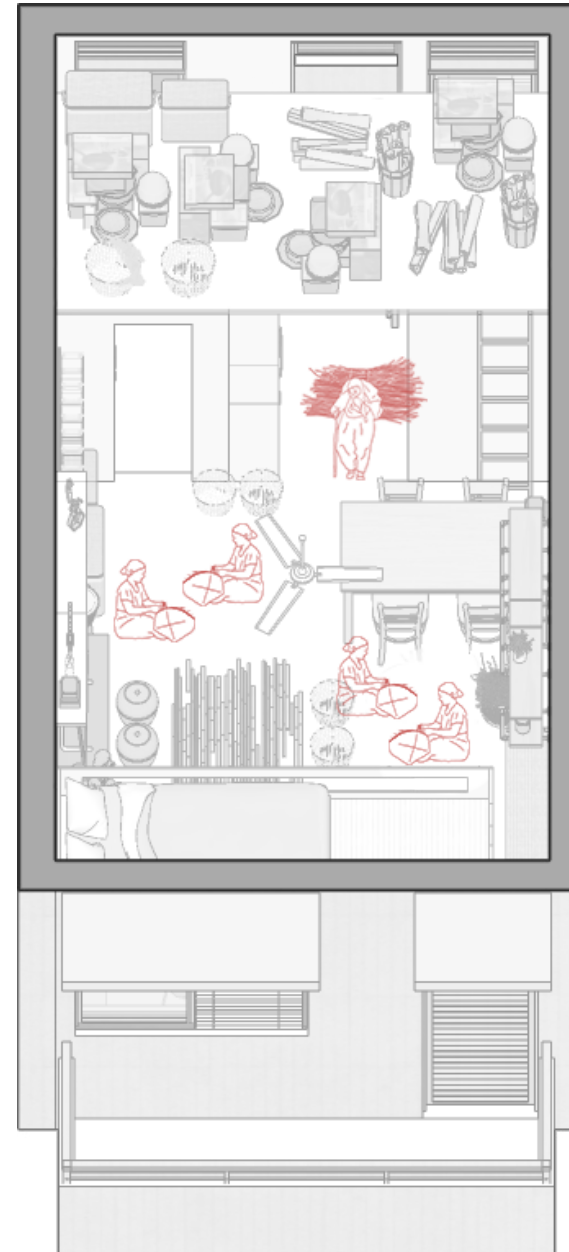
RESIDENTIAL USE



3.2 SOCIAL RENT APARTMENT



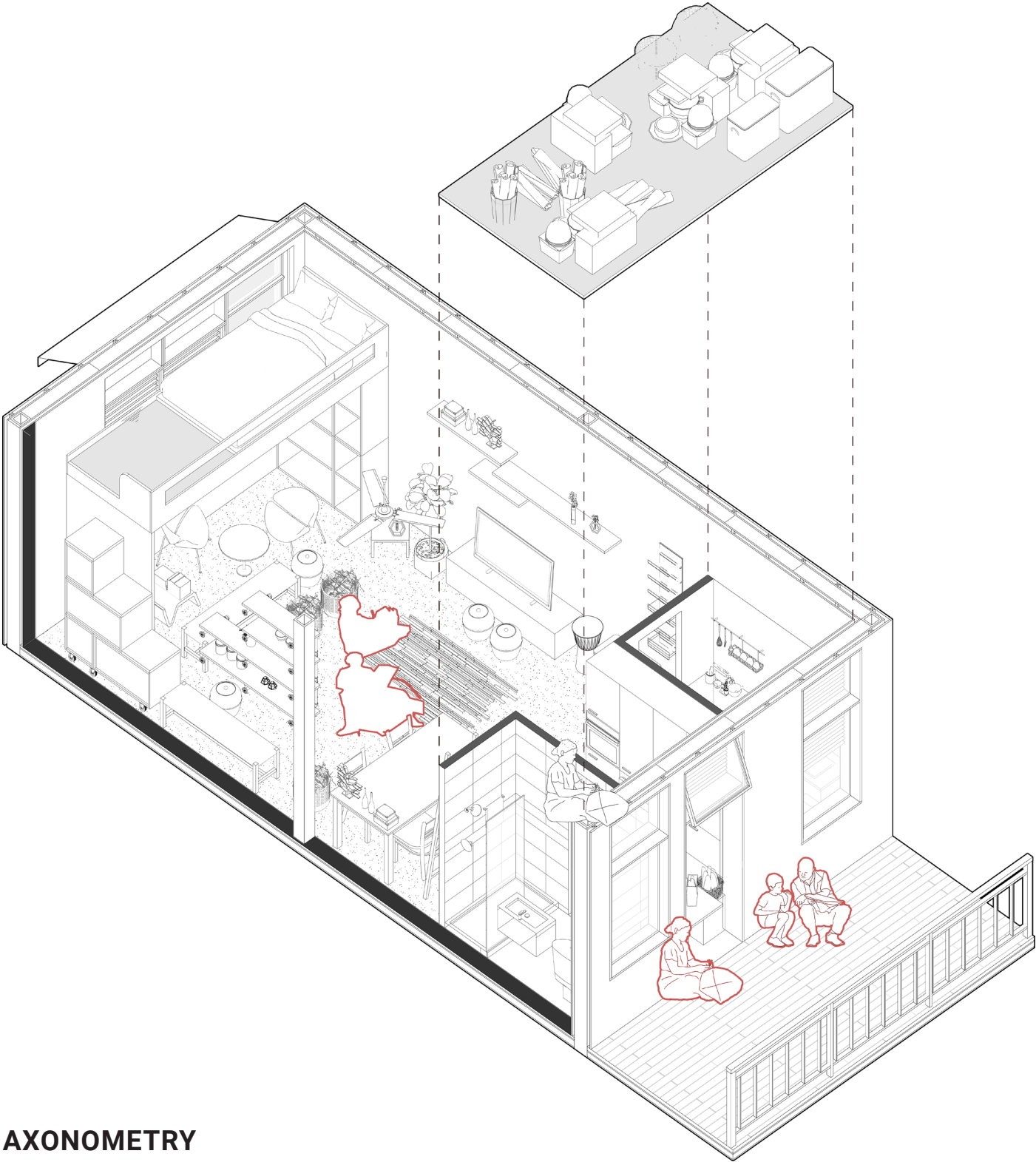
## RESIDENTIAL USE



### 3.3 DOMESTIC INDUSTRY WITH LIVING SPACE

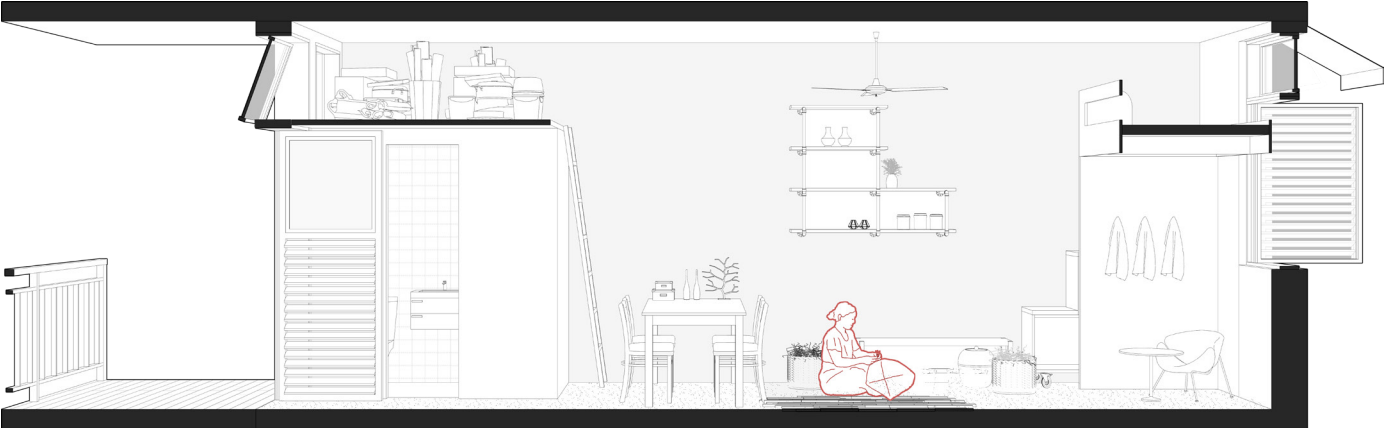


DOMESTIC INDUSTRY LIVING UNIT

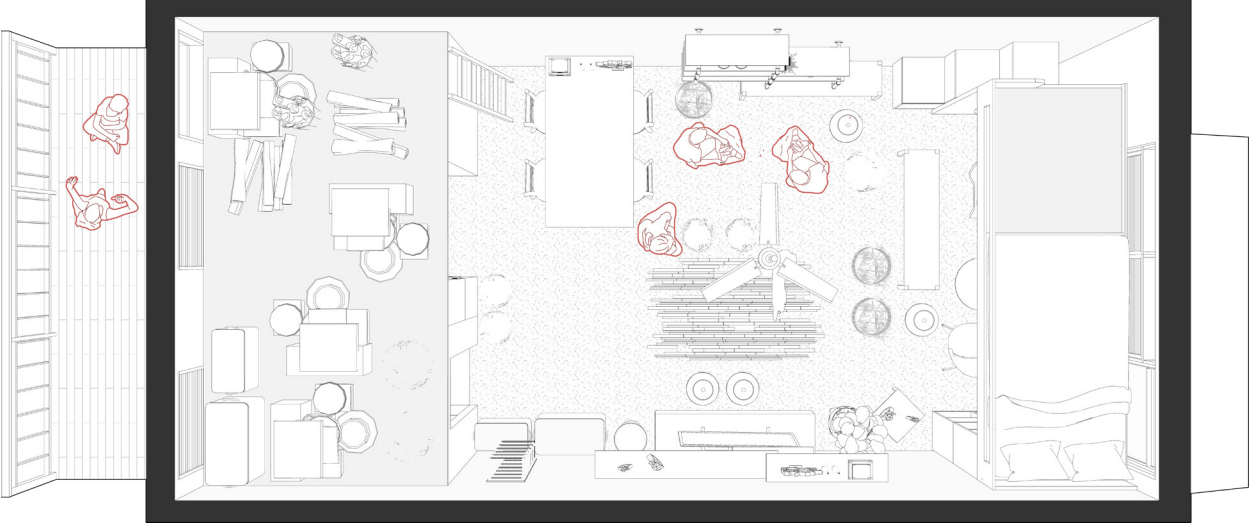


AXONOMETRY

SECTION



PLAN



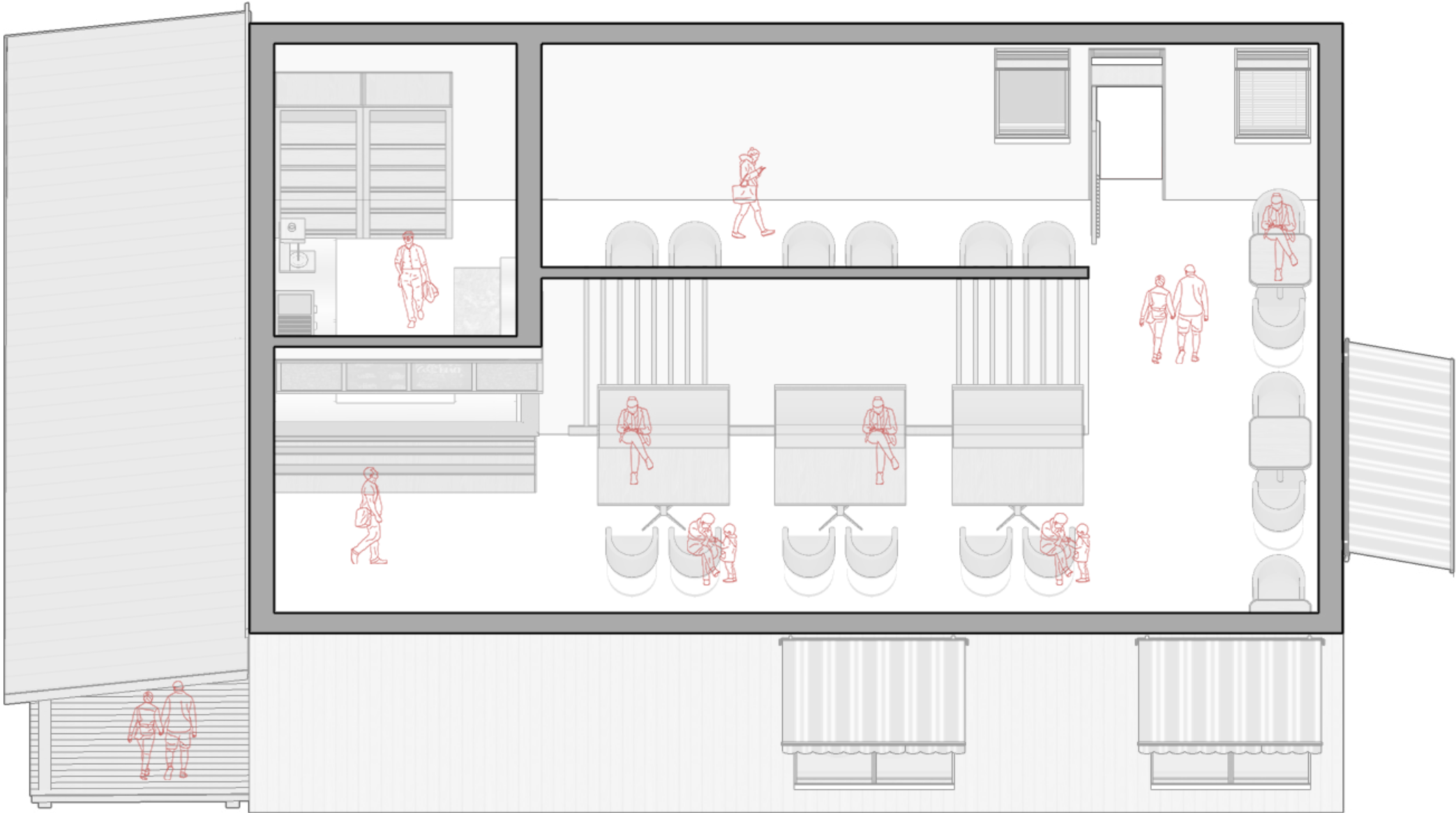


COMMUNITY PLAN





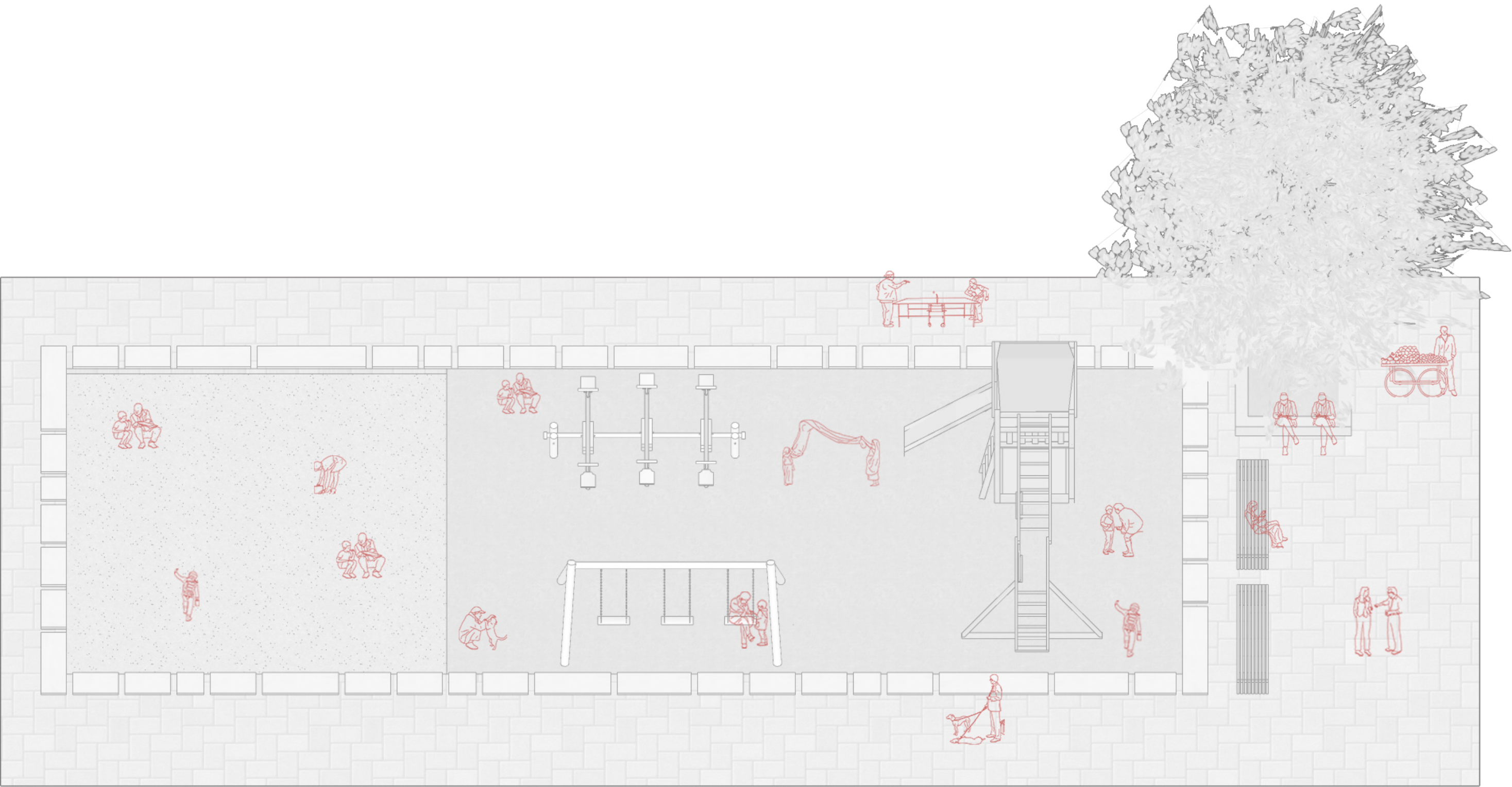
COMMUNAL FACILITY / PUBLIC STRUCTURE



4.1 CLUSTER FACILITY



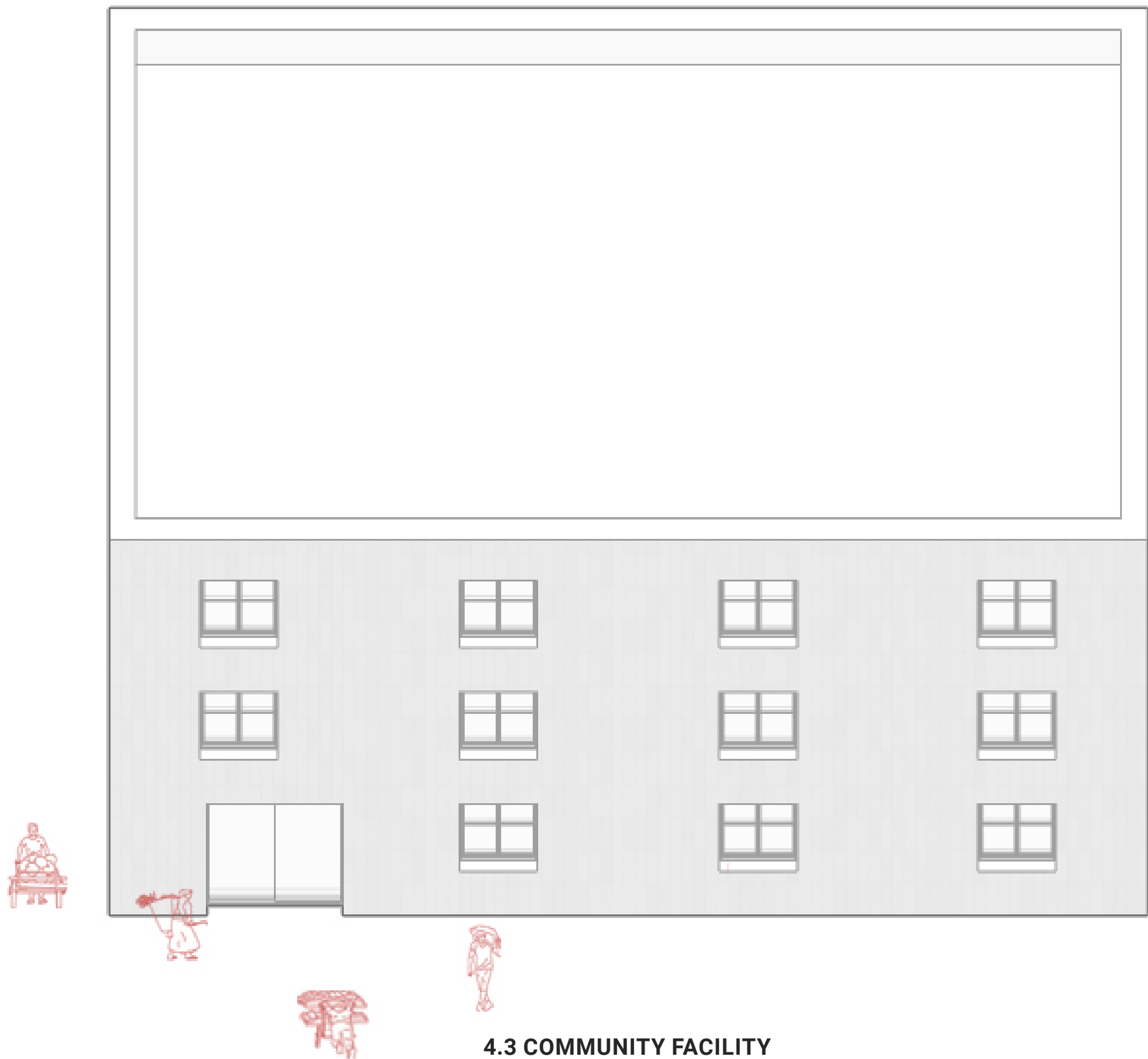
COMMUNAL FACILITY / PUBLIC STRUCTURE



4.2 STREET FACILITY



COMMUNAL FACILITY / PUBLIC STRUCTURE



4.3 COMMUNITY FACILITY



COMMUNAL FACILITY / PUBLIC STRUCTURE

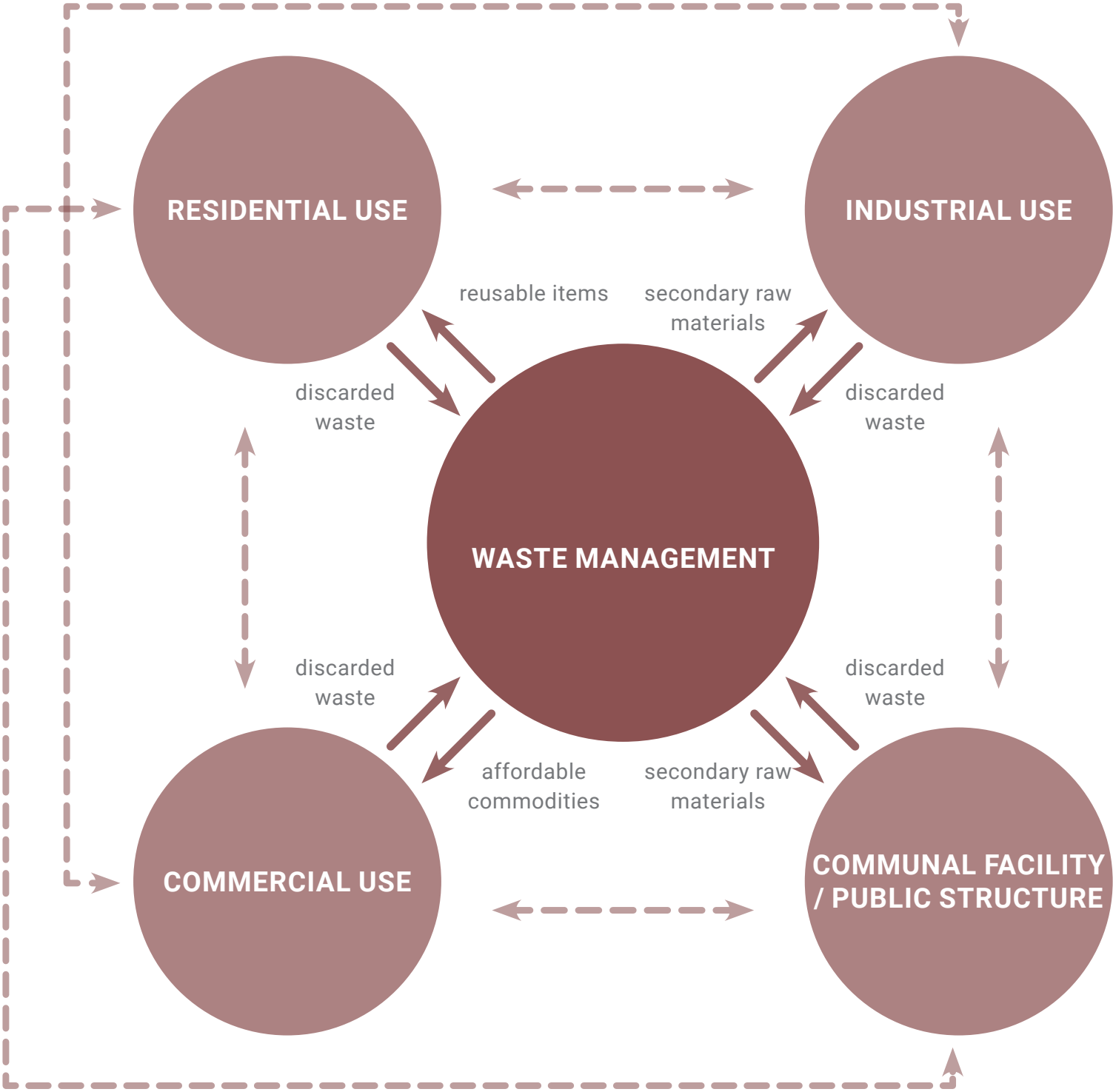


4.4 FACTORY

# THE ROLE OF WASTE MANAGEMENT

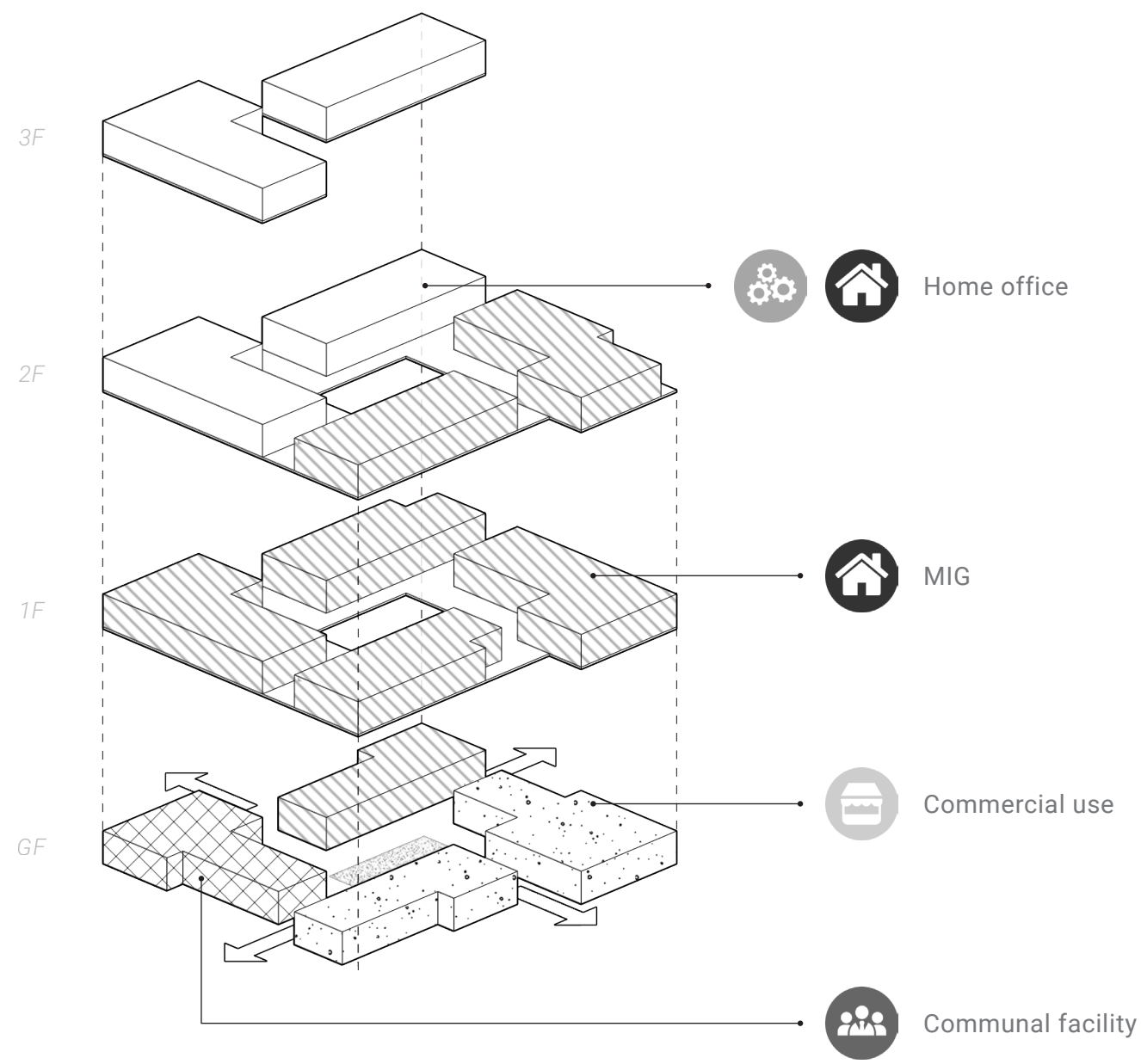
## INTERDEPENDENT WITH OTHER FUNCTIONS

Among these functions, waste management occupies the core position, complementing other functions and helping form a vibrant social-economic structure. Waste management provides material or economic support for other activities to take place, and also receives the waste generated from daily activities. The materials produced from waste management also reshape the built environment in the slum.





SOCIO-SPATIAL MIX



MIG CLUSTER



RESIDENTIAL  
65%



FACILITY  
8%



INDUSTRIAL  
12%



COMMERCIAL  
15%

TYPICAL FLOOR PLAN





PLATFORM





STREET VIEW





SITE PLAN



Area: 3.9 ha      GSI: 0.35      FSI: 1.76      Density: 246 dw/ha      Dwellers: 3800





STREET VIEW OF THE BOUNDARY



MIG CLUSTER

EWS & LIG CLUSTER



COMMUNITY AXONOMETRY

- MIG CLUSTER
- FACTORIES
- EWS & LIG CLUSTER
- GATHERING PLAZA
- COMMUNAL FACILITY
- CONSTRUCTED WETLANDS

Area: 3.9 ha    GSI: 0.35    FSI: 1.76    Density: 246 dw/ha    Dwellers: 3800

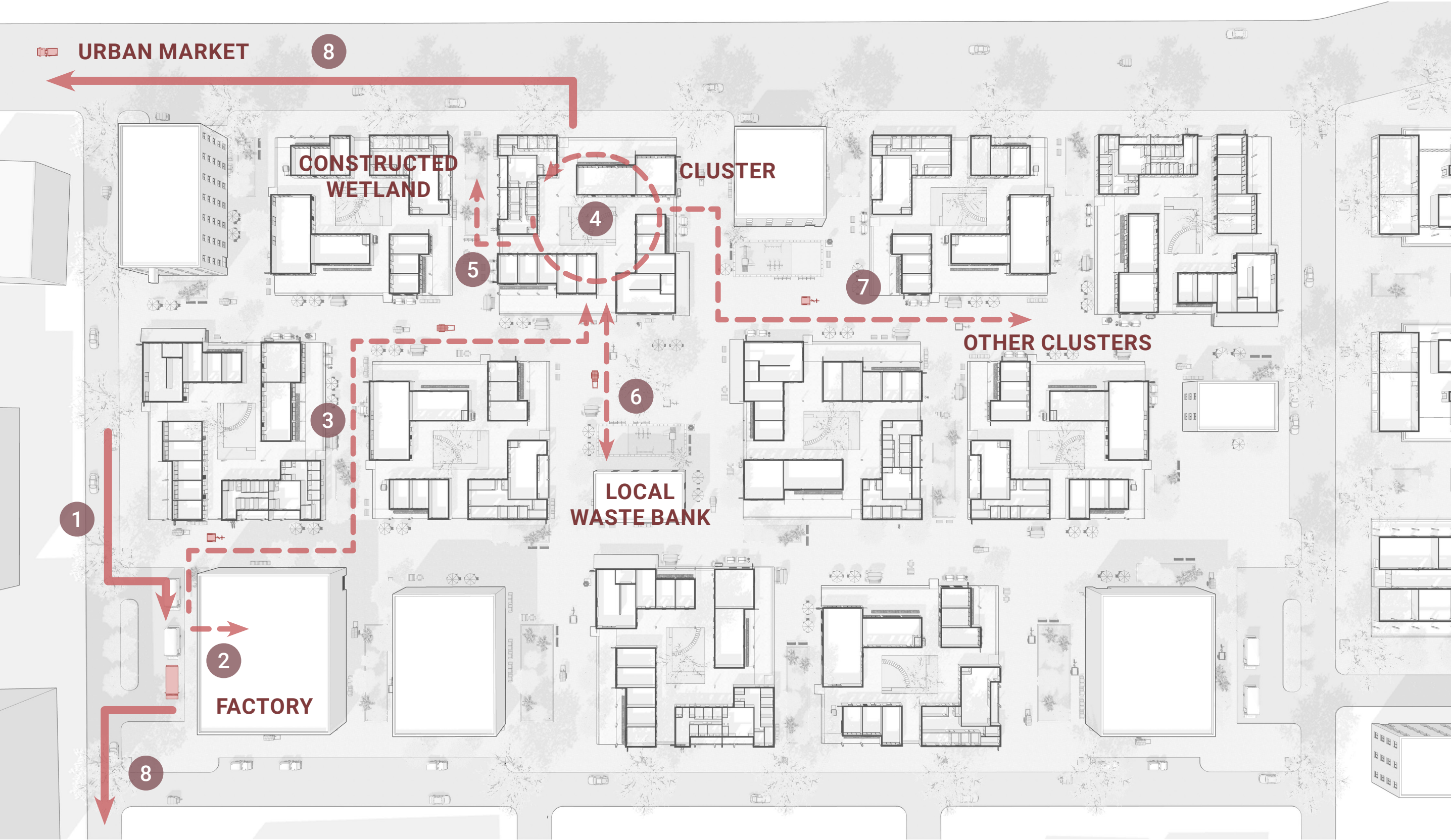


PARKING LOT



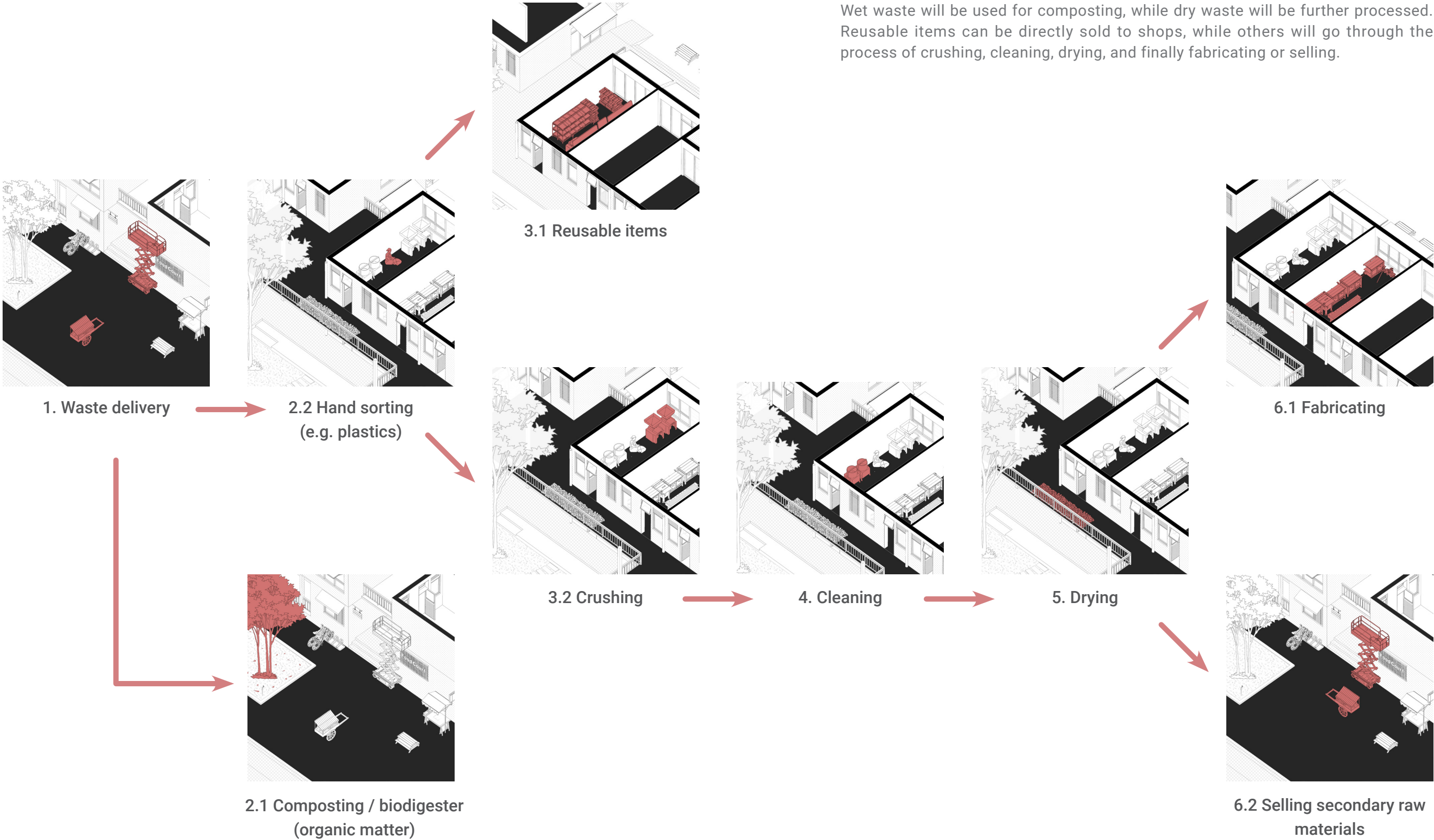


WASTE LOGISTICS IN THE COMMUNITY





RECYCLING WORKFLOW IN THE CLUSTER

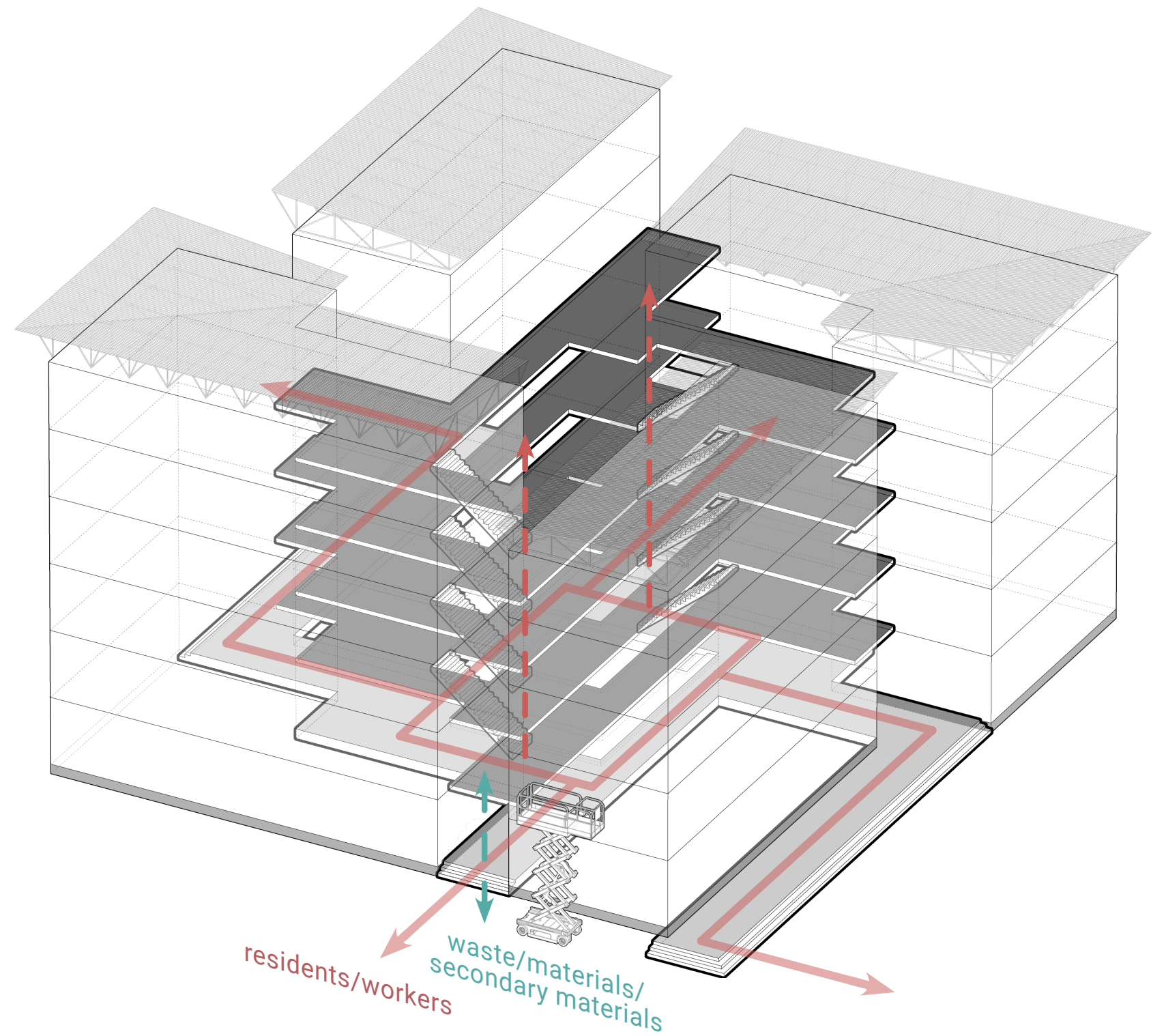




## VERTICAL & HORIZONTAL CIRCULATION IN THE CLUSTER

### PLATFORMS, STAIRCASES, LIFTING PLATFORM

Staircases and platforms are the main spaces for pedestrians to move around in the cluster and meet their daily circulation needs. As the link between the various units, they are also important social nodes and informal workplaces for a range of socio-economic activities. Large bundles or heavy materials or waste destined for the first floor workshops can be transported vertically via the lifting platform.





SMALL LANE





LARGER LANEWAY





MAIN STREET





# KIDS PLAYING AREA





GATHERING PLAZA





## 06. CLIMATE STRATEGY

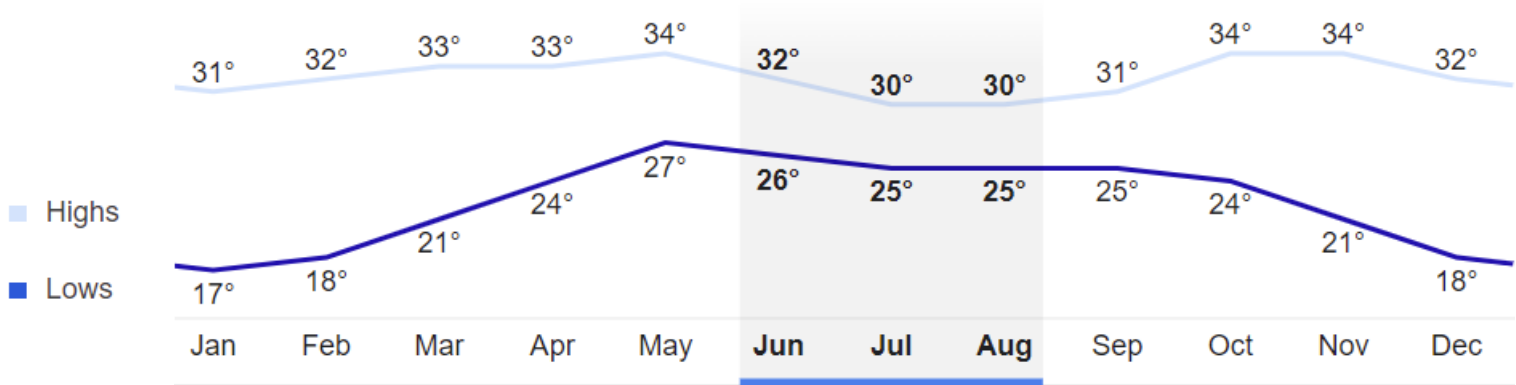
Passive Design



# TROPICAL CLIMATE IN NAVI MUMBAI

## HOT AND HUMID CLIMATE IN NAVI MUMBAI

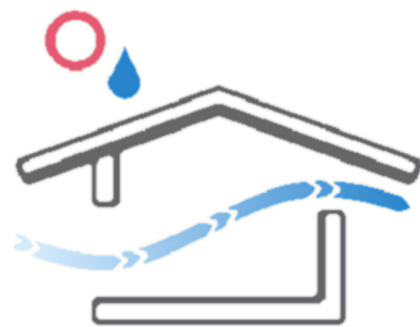
- in summer the temperature difference between day and night is only five to six degrees
- thermal mass prevents heat loss at night
- insulation reduces heat gain by preventing heat flow from the outdoor surfaces to the indoor ones





COOL BUILDING DESIGN STRATEGIES

HOT & HUMID



Open without AC

Lightweight building, encouraging constant air circulation



Closed with AC

Mid-weight building, cooling down mechanically in the most efficient way



Open without AC

Massive building, blocking heat and encouraging air circulation



Closed with AC

Massive building, blocking heat and cooling down mechanically

HOT & DRY



# CLIMATE STRATEGY

## 1. Double roof

Sunlight protection & ventilation to remove heat

## 2. Shutter

Diffused sunlight & permanent cross-ventilation even on rainy days

## 3. Envelope cavity cooling

Cooling through ventilation in the skin cavity

## 4. Rainwater and stormwater harvesting

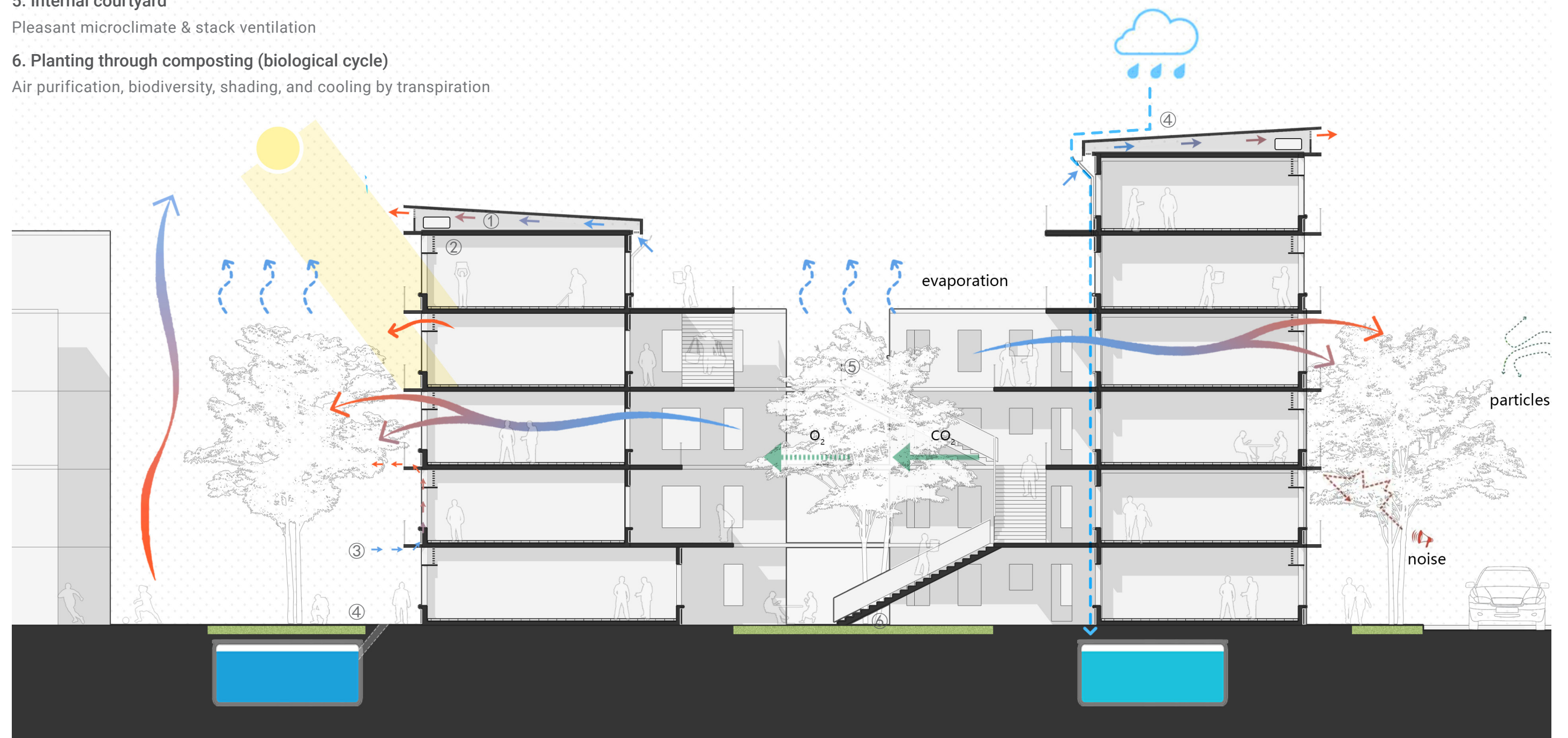
Water collection tanks & water treatment system

## 5. Internal courtyard

Pleasant microclimate & stack ventilation

## 6. Planting through composting (biological cycle)

Air purification, biodiversity, shading, and cooling by transpiration





STACK VENTILATION CACULATION

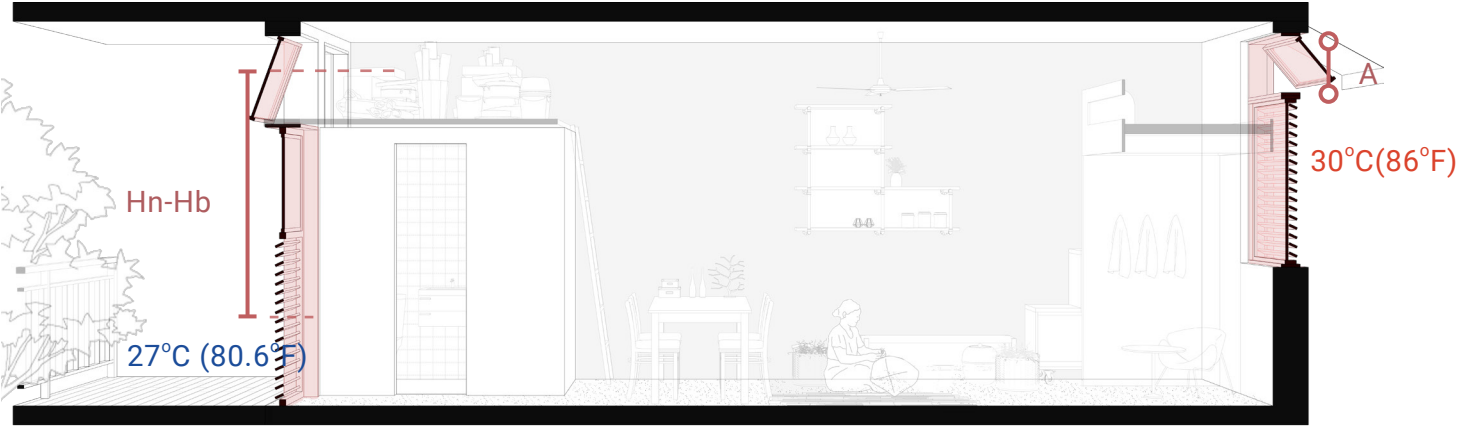
The 1997 ASHRAE Fundamentals handbook gives the following relationship:  
 $Q = 60 * Cd * A * \text{sqrt}(2 * g * (Hn - Hb) * ((Ti - To) / Ti))$

where  
Q = flow rate in cfm,  
Cd = 0.65 (for unobstructed openings),  
A = opening area, square feet,  
Ti = indoor temp (Rankine),  
To = outdoor temp (Rankine),  
Hn = height of "neutral pressure point" (for simple systems, assume 1/2 way between top and bottom openings).  
Hb = height of bottom opening  
g = gravity.

OPEN DOOR & WINDOW



CLOSED DOOR & WINDOW



CACULATION

Dimensions

A:	25.07	sq.ft
Hn-Hb:	2.22	ft
Ti:	80.6	F
To:	86	F

Results

Q:	1159	CFM
Heat transfer rate:	6625	BTUH

CACULATION

Dimensions

A:	4.84	sq.ft
Hn-Hb:	6.63	ft
Ti:	80.6	F
To:	86	F

Results

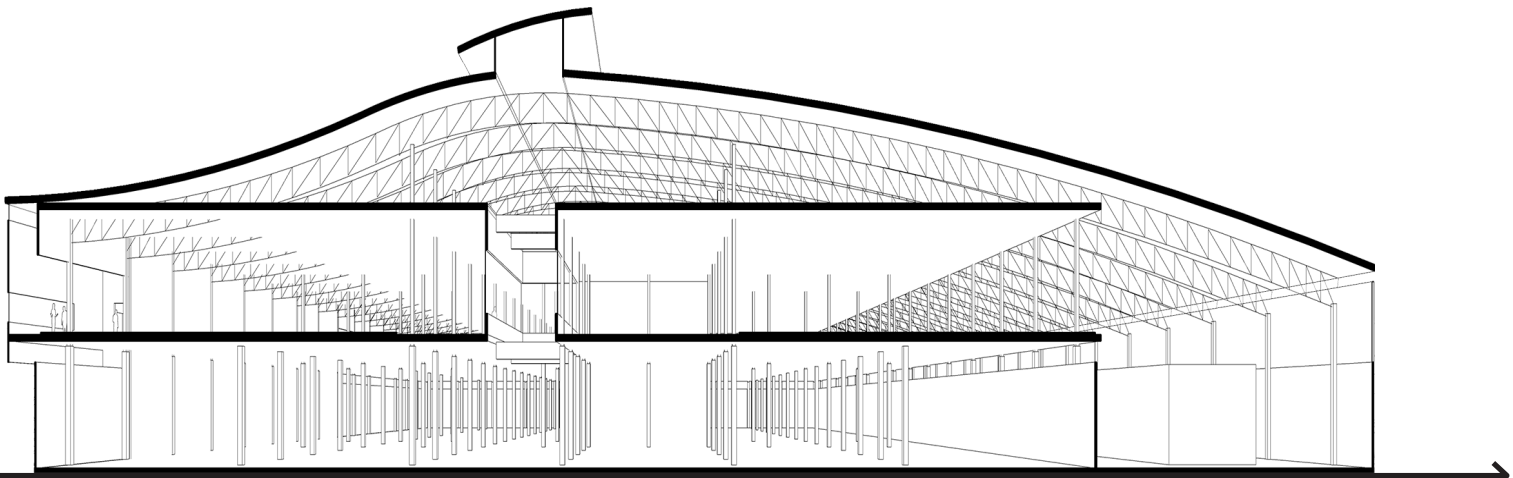
Q:	386.7	CFM
Heat transfer rate:	2210	BTUH



# HYBRID WASTEWATER SYSTEM

On-site wastewater management

Municipal wastewater management



## DECENTRALIZED WASTEWATER SYSTEM

- grey water
- rainwater & stormwater harvesting



toilet flushing, constructed wetlands, irrigation, washing or other non-potable uses



## CENTRALIZED WASTEWATER SYSTEM

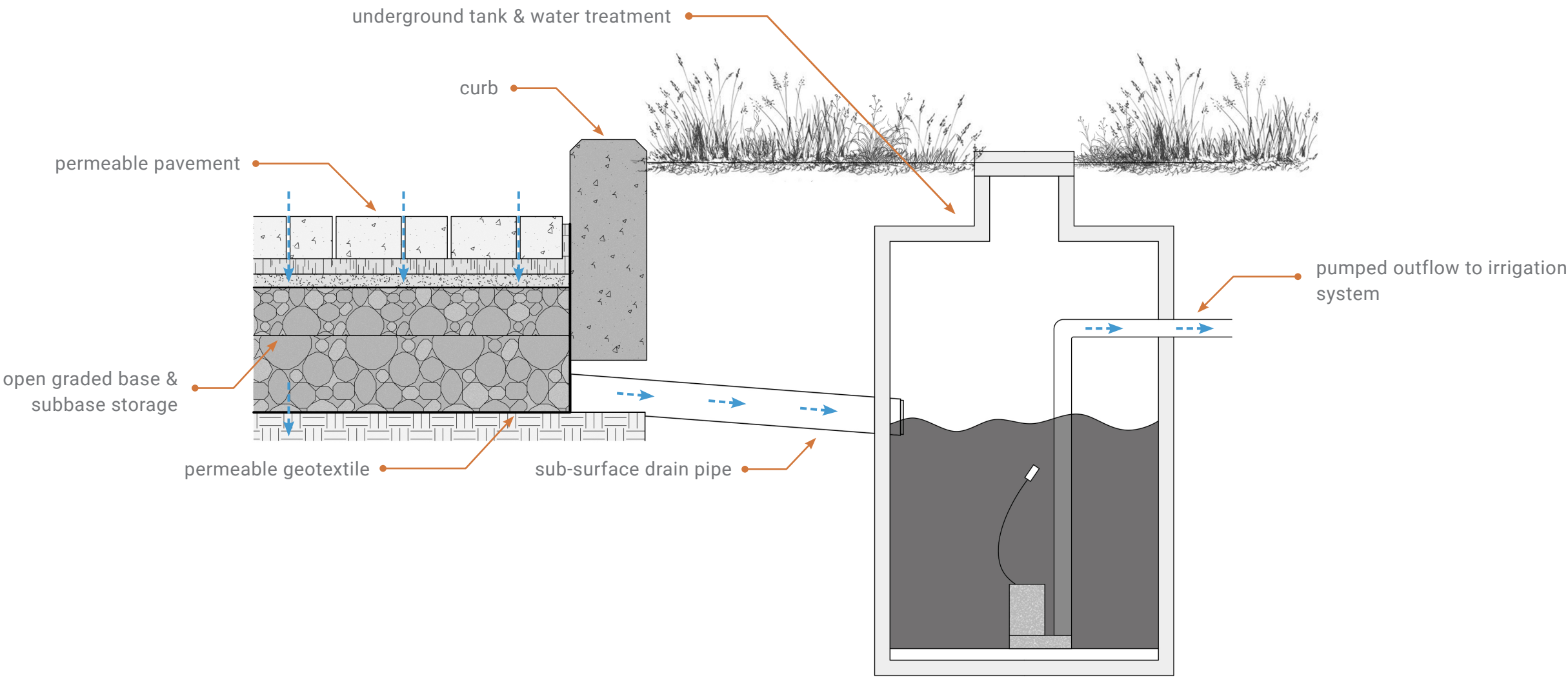
- black water
- flooding



treating water in a central location and then distributing the treated water via dedicated distribution networks



# STORMWATER HARVESTING

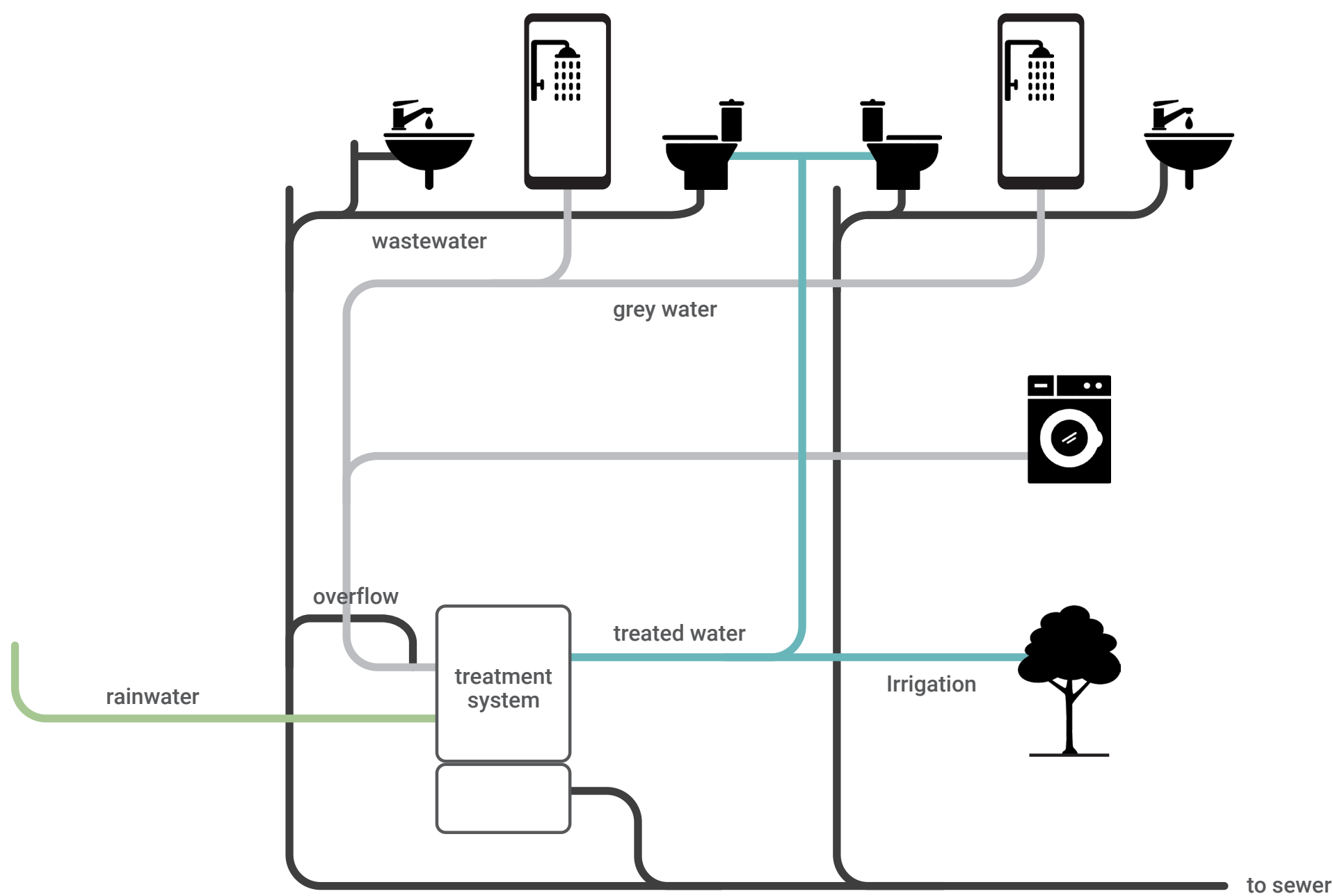


## STORMWATER HARVESTING

Black water will go to the sewer and treated centrally in a factory, while grey water and rainwater are treated on site. Stormwater flows through the permeable pavement into the drain pipe and is stored and treated in the underground tank and treatment system.



WATER REUSE SYSTEM



GREY WATER & RAINWATER TREATMENT

Grey water and rainwater are collected and treated locally and then can be used for toilet flushing, constructed wetlands irrigation, washing or other non-potable uses.



## 07. HEALTH

Workflow, Lifestyle, Technology



# EXISTING HEALTH HAZARD & IMPROVED WORKFLOW

## EXISTING HEALTH HAZARDS IN SLUMS



**1. Proximity of waste accumulations to living space**  
gases, dust, leachate



**- Storing the majority of waste in the factories**  
The collected waste is stored away from living areas, thus avoiding contamination of living them.



**2. Manual sorting of mixed waste within living space**  
toxic, allergenic and infectious components, sharps



**- separating waste at source under regulated guidance**  
Toxic and hazardous waste is sorted out and disposed of separately.



**3. Hazards arising from waste processing**  
odour, noise, vibration, accidents, air and water emissions, residuals, explosions, fires



**- Carrying out hazardous or polluting processes at the factories**  
Recycling MSEs in living areas only carry out processes that have a minimal impact on the environment. The landscape design will also reduce the impact of noise, odours and particles, which are dependent on the biological cycle.



**4. Open burning of organic waste**  
gaseous emissions, bioaerosols, dust, and particles



**- Integrating wet waste into the biological cycle**  
Wet waste contributes to community landscape and urban farming through composting, or produces biogas through biodigester. The greenery will bring a high level of biodiversity, which will be beneficial to health.



IMPROVED LIVING AND WORKING CONDITIONS



1. Semi-formalised workflow

Toxic or hazardous waste is transported directly to the factory for disposal, staying away from the living areas of the residents.



2. Separation of workplaces from home

Workshops are separated from the living space but remain in close proximity, adapting to the lifestyle of slum dwellers while keeping the living spaces free from noise and stale air.



3. Landscape & greenery

The composting process promotes plant growth and wetland construction, cooling buildings and bringing biodiversity.



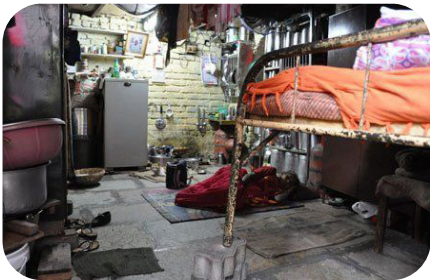
4. Facility & outdoor space

Outdoor spaces and communal facilities enable residents to enjoy socialisation and public spaces, leading to physical and mental well-being.



3. Sanitation, water and energy

The biodigester and water reuse system scientifically and efficiently treats the wet waste and grey water generated by the residents and brings clean energy.



6. Ventilation & sound insulation

Shutters provide continuous ventilation even on rainy days; coconut fibres act as an infill between the frames to block out noise.



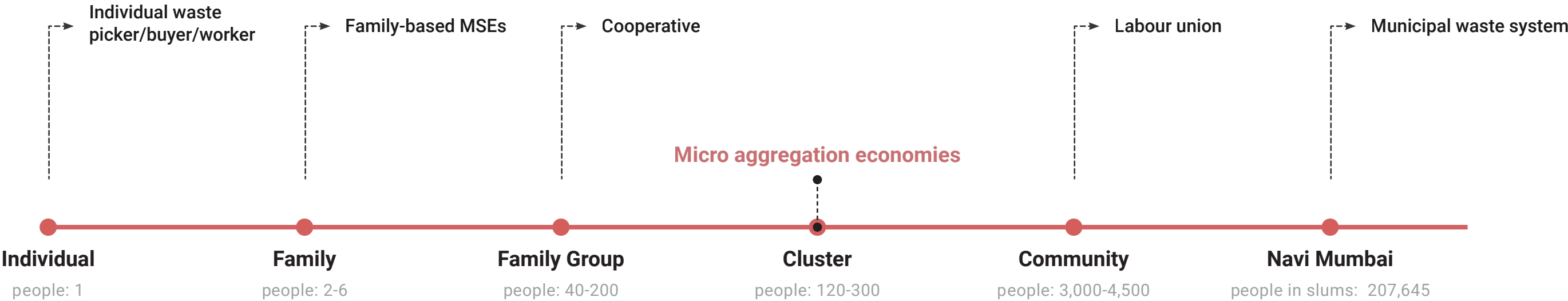
## 08. MANAGEMENT

Waste Recycling & Housing Construction

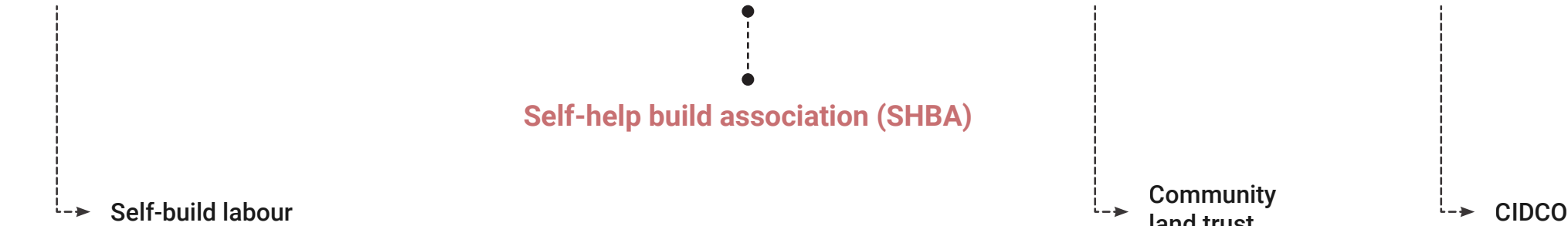


MANAGEMENT IN DIFFERENT SCALES

WASTE RECYCLING

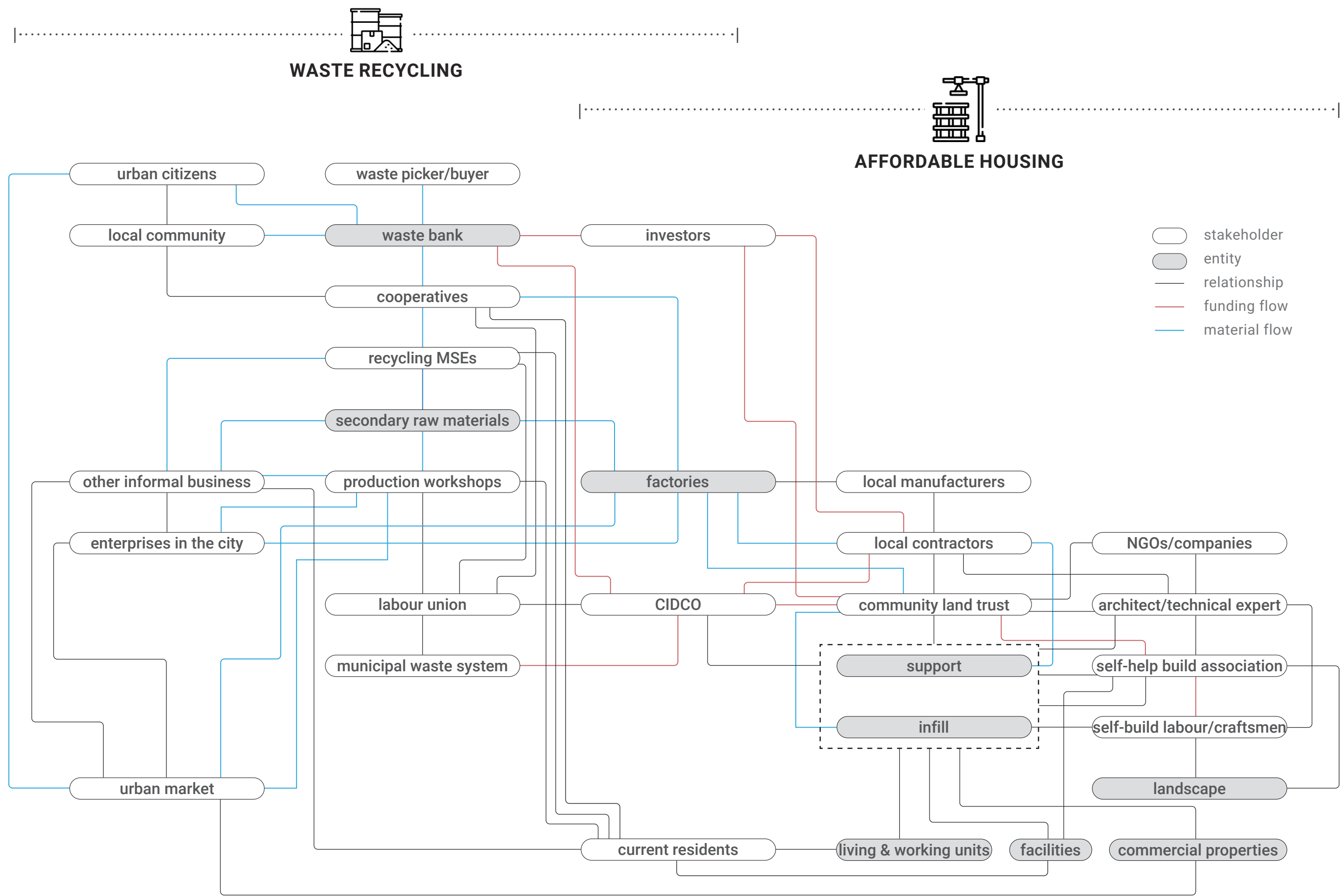


AFFORDABLE HOUSING





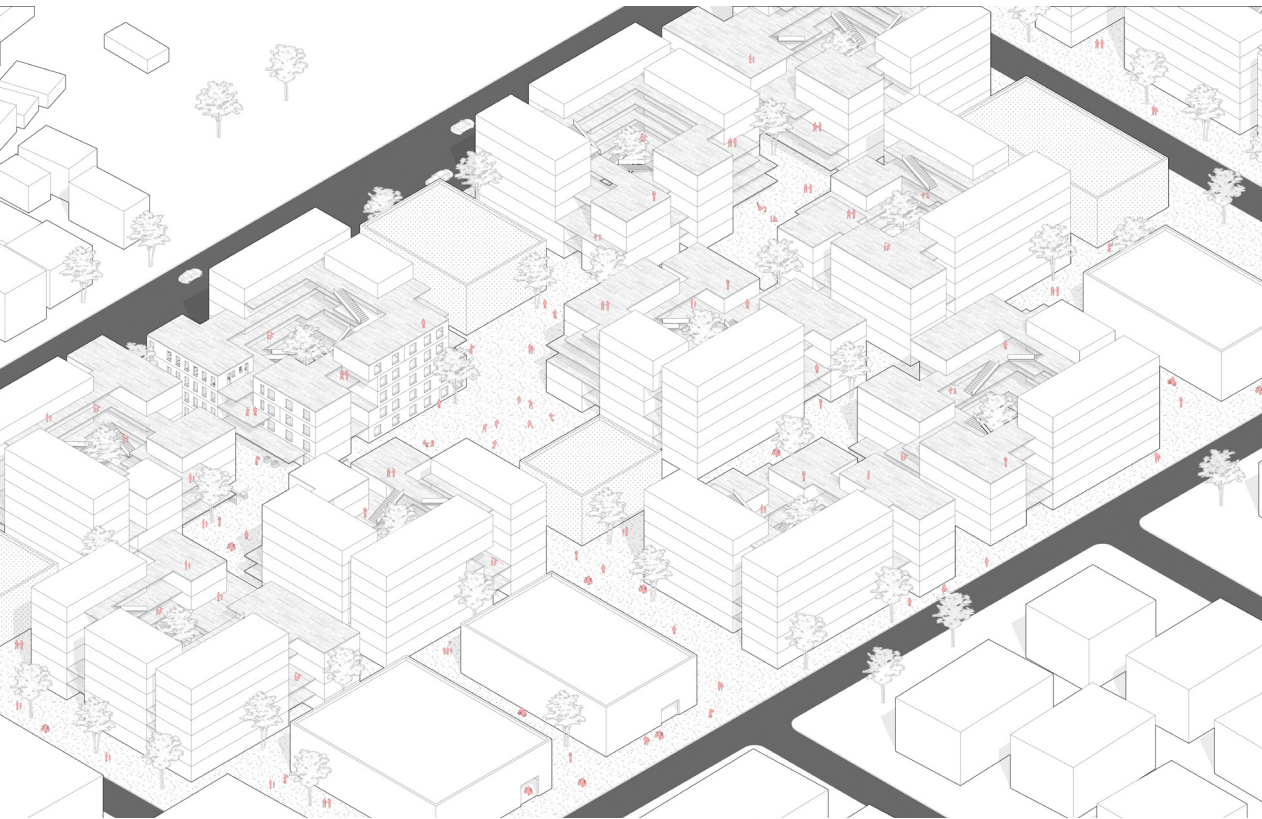
STAKEHOLDER RELATIONSHIP





# COMMUNITY LAND TRUST

## Functions:

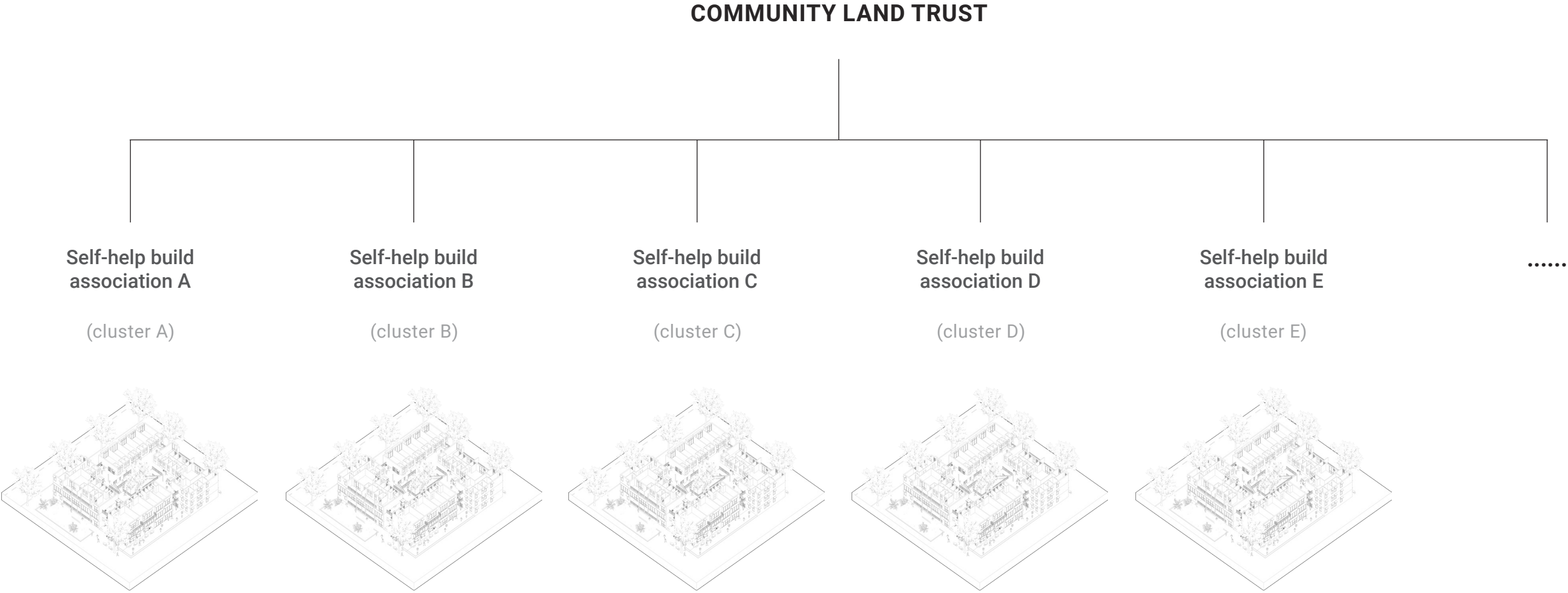


<b>BANKING</b>	<ul style="list-style-type: none"><li>- funding management</li><li>- cost control</li></ul>	before
<b>PLANNING &amp; MANAGEMENT</b>	<ul style="list-style-type: none"><li>- preliminary planning</li><li>- self-help build association management</li></ul>	
<b>CONSTRUCTION</b>	<ul style="list-style-type: none"><li>- materials storage and sale</li><li>- on-site supervision</li></ul>	during
<b>FACILITIES &amp; LANDSCAPE</b>	<ul style="list-style-type: none"><li>- operation and maintenance of community facilities</li><li>- infrastructure</li></ul>	
<b>EDUCATION &amp; HEALTHCARE</b>	<ul style="list-style-type: none"><li>- playground, school and library</li><li>- sanitation maintenance</li><li>- community clinic</li></ul>	after
<b>DEVELOPMENT</b>	<ul style="list-style-type: none"><li>- cross-subsidisation and social rent</li><li>- sale or lease of properties</li><li>- daily community stewardship</li></ul>	



# COMMUNITY LAND TRUST AND SELF-HELP BUILD ASSOCIATION

Members:





# CLUSTER-BASED SELF-HELP BUILD ASSOCIATION

## Functions:

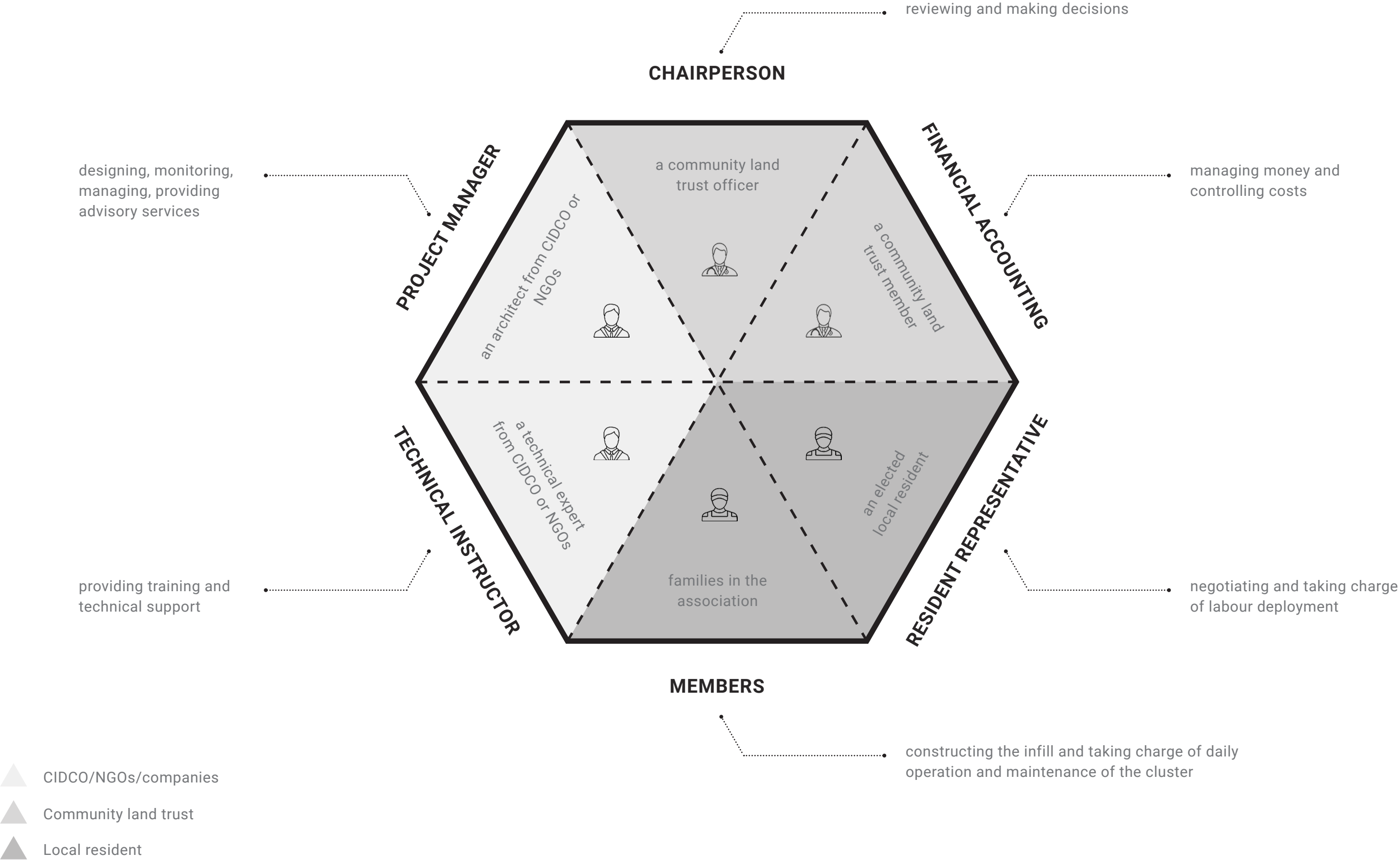


<b>BANKING</b>	<ul style="list-style-type: none"><li>- funding management and cost control</li><li>- rotating savings and credit association (ROSCA)</li></ul>	before
<b>PLANNING &amp; MANAGEMENT</b>	<ul style="list-style-type: none"><li>- local law and policy</li><li>- self-help build labour management</li></ul>	
<b>CONSTRUCTION</b>	<ul style="list-style-type: none"><li>- training</li><li>- design advice and technical support</li><li>- road construction</li></ul>	during
<b>FACILITIES &amp; LANDSCAPE</b>	<ul style="list-style-type: none"><li>- communal facilities operation</li><li>- inner courtyard</li><li>- tree planting and composting</li></ul>	
<b>EDUCATION &amp; HEALTHCARE</b>	<ul style="list-style-type: none"><li>- training course and community classroom</li><li>- sanitation maintenance</li><li>- care centre</li></ul>	after
<b>DEVELOPMENT</b>	<ul style="list-style-type: none"><li>- housing upgrade</li><li>- unit function transformation</li><li>- collective activities and events</li></ul>	



# CLUSTER-BASED SELF-HELP BUILD ASSOCIATION

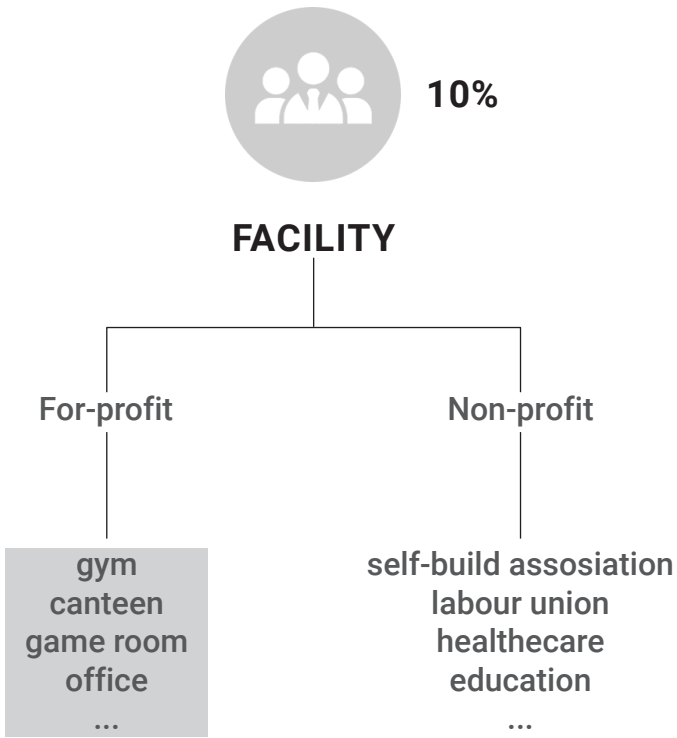
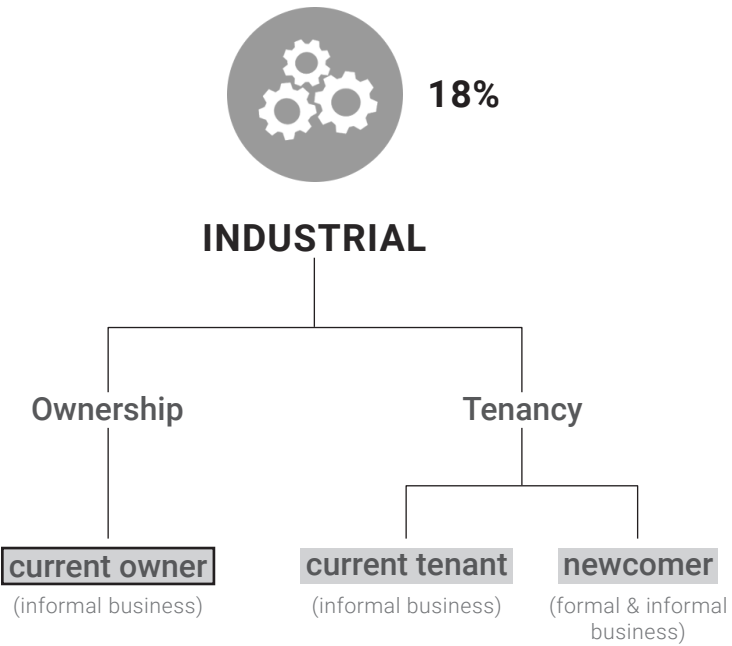
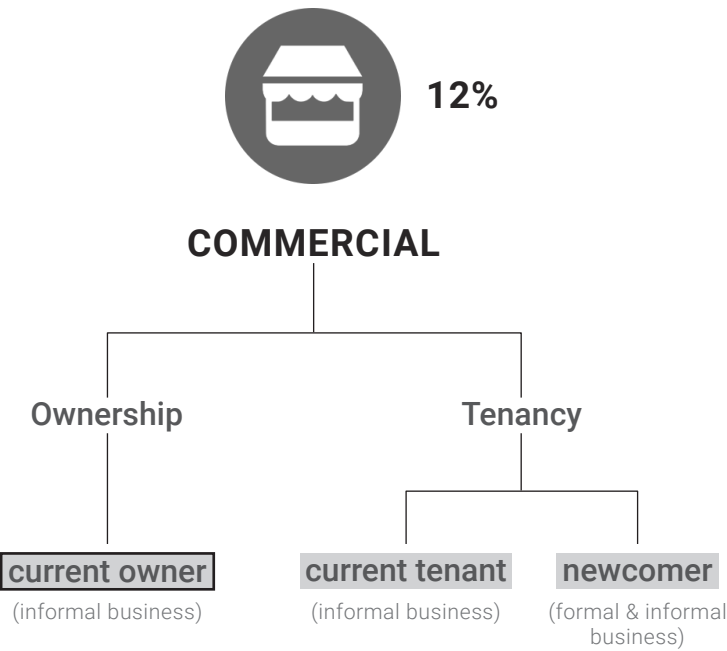
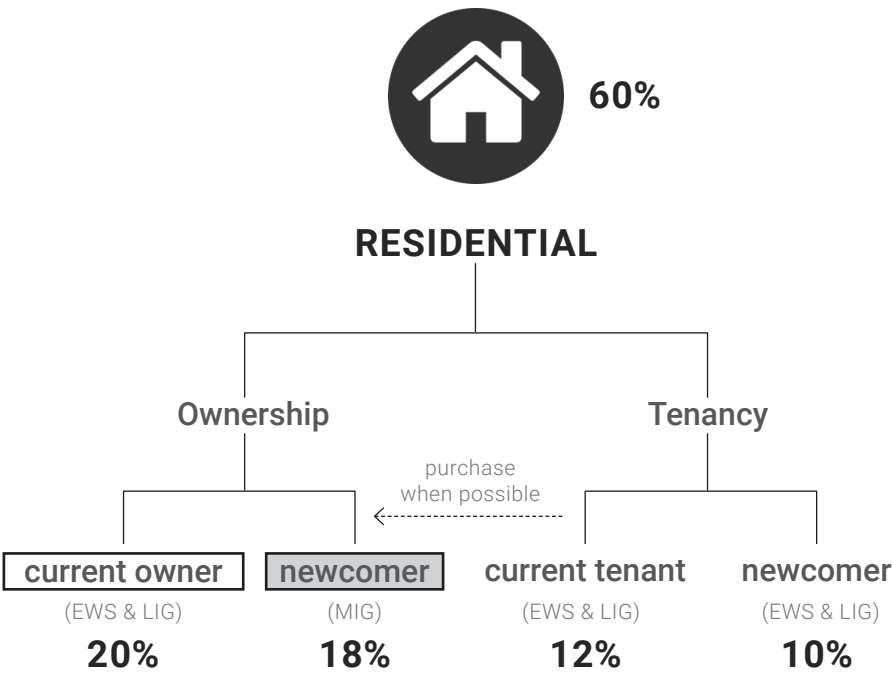
## Members:







USERS

- Rather than a lottery system, the current residents have priority;
- Families who originally owned a house received a certain amount of free area based on the size of their house.
- For EWS and LIG, social rent is offered to lower the threshold;
- If residents wish to have a unit for commercial or industrial use, they will need to purchase a leasehold or buy a unit at a higher price than social housing;
- The government finances or loans the initial construction, and social renting and ownership properties for EWS and LIG are cross-subsidised by properties for middle-income households and commercial and industrial use units.

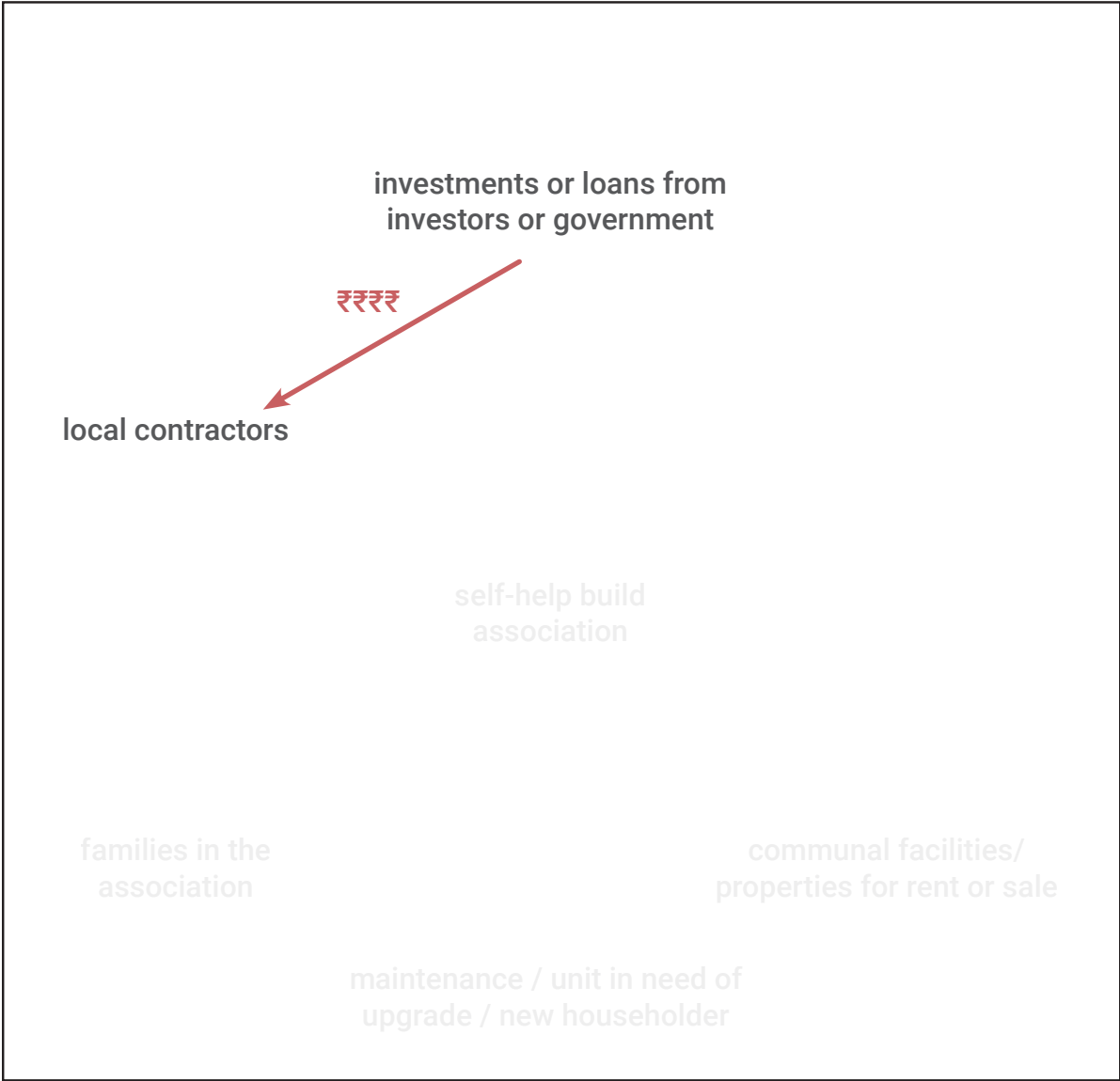


 SHBA member

 properties for cross subsidization

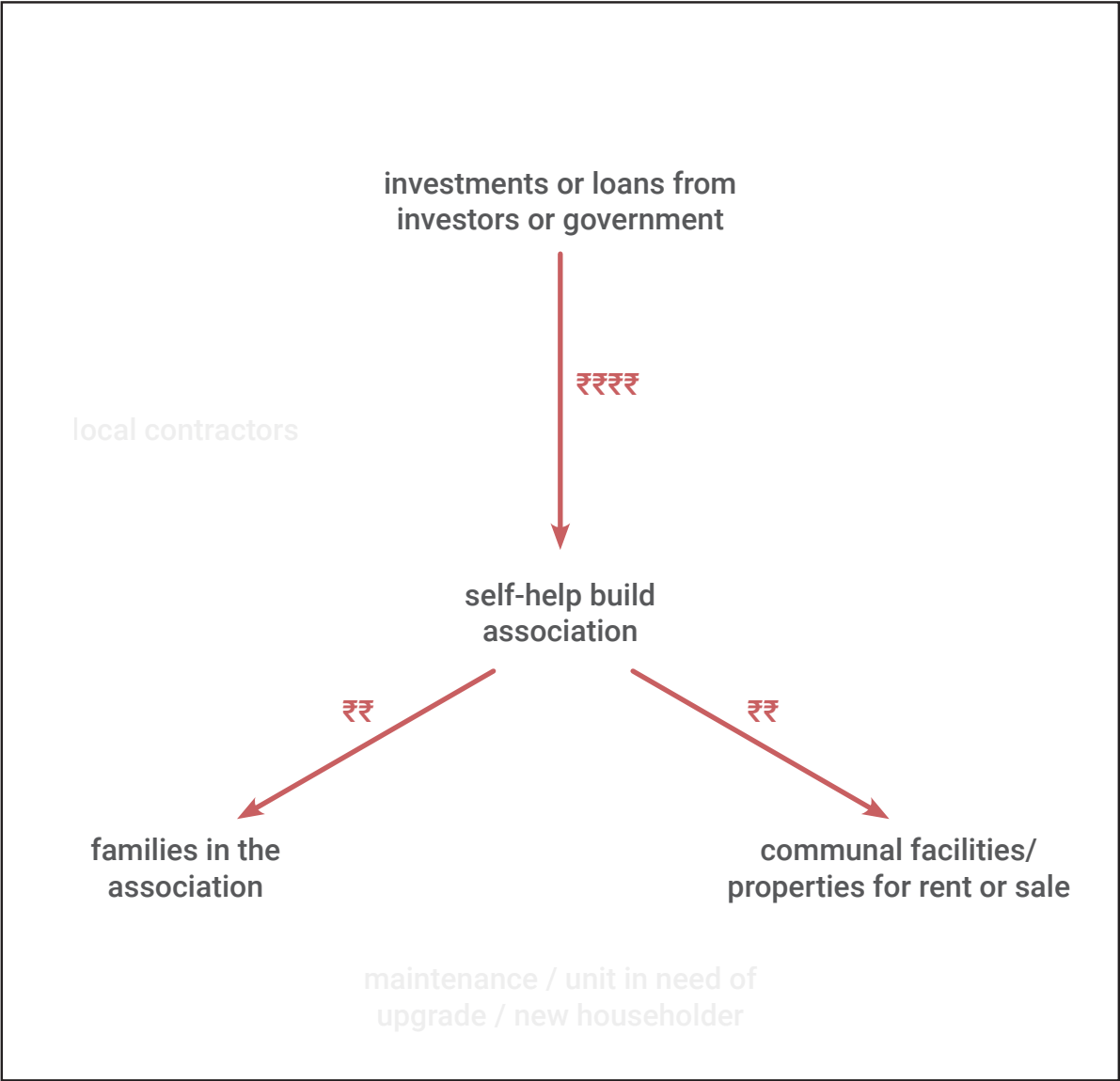


ECONOMIC MODEL



STAGE 1

The government or investors provide initial funds to help with the construction of the support.

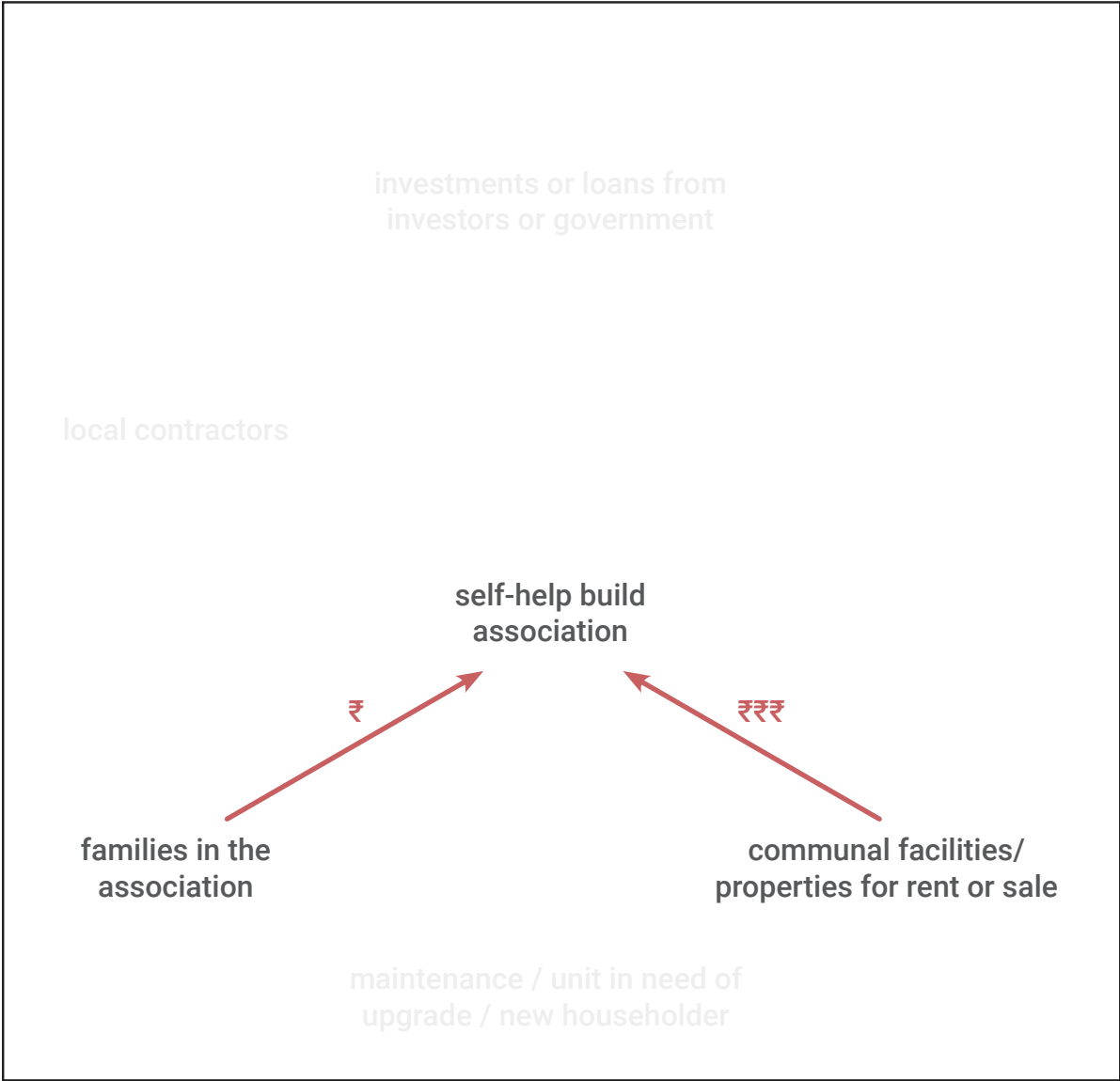


STAGE 2

The government or investors provide initial funds to help with the construction of the infill.

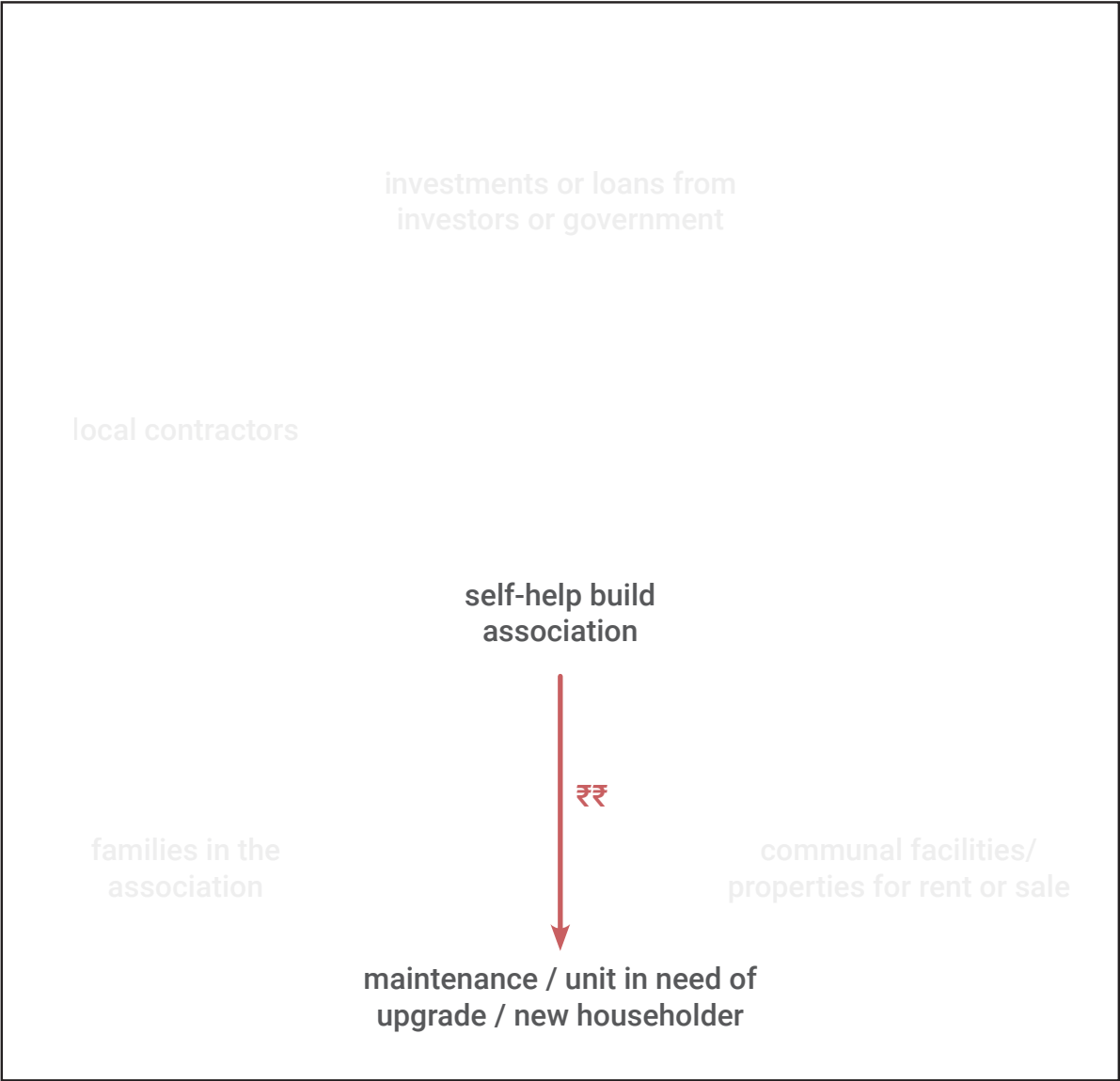


ECONOMIC MODEL



STAGE 3

Association members make a regular payment; communal facilities and commercial properties generate profits to realise cross subsidization.

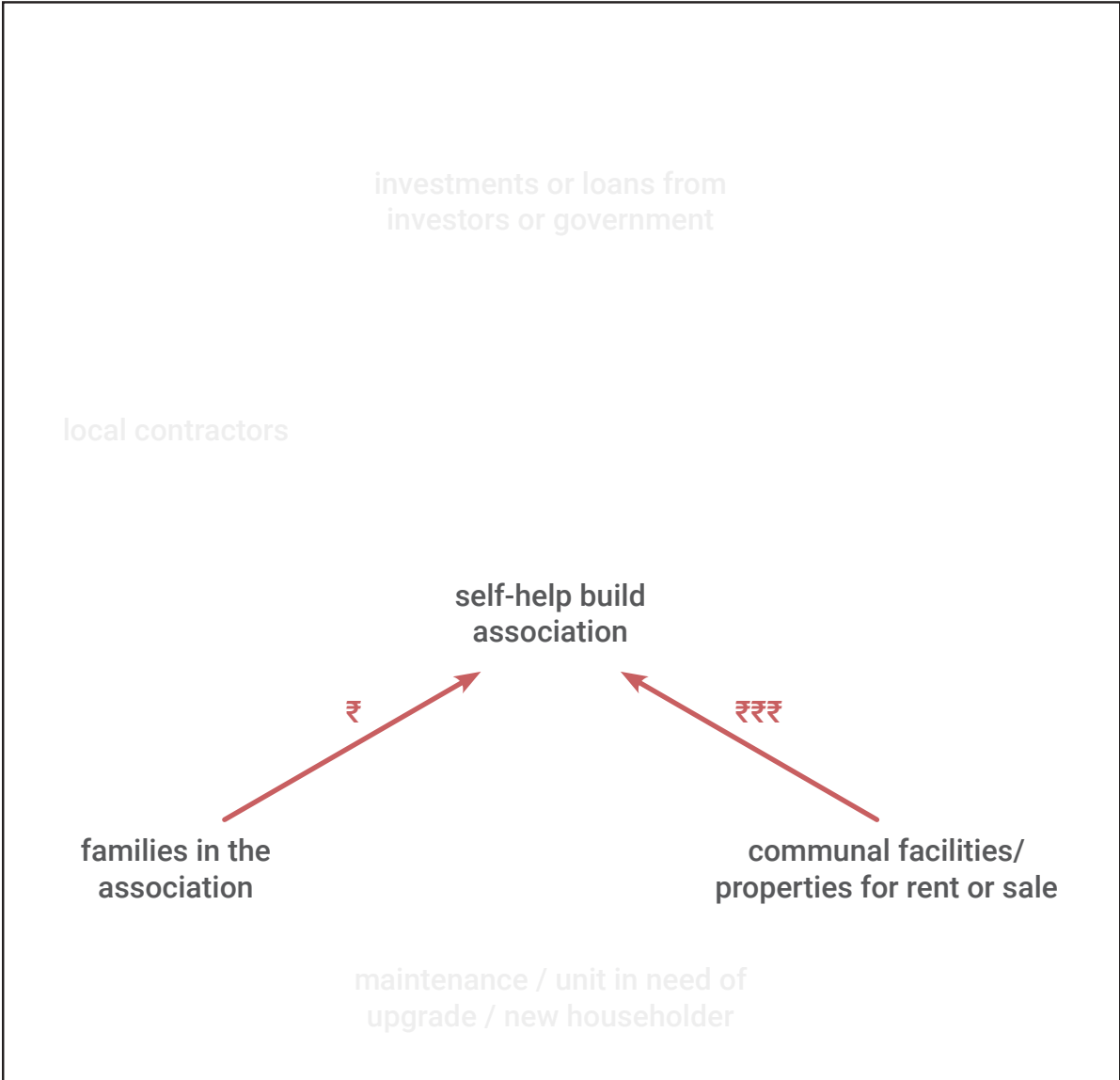


STAGE 4

The association funds the maintenance of the external spaces and supports new householders or families in need of upgrad. This funding can also be used to upgrade their workplace.

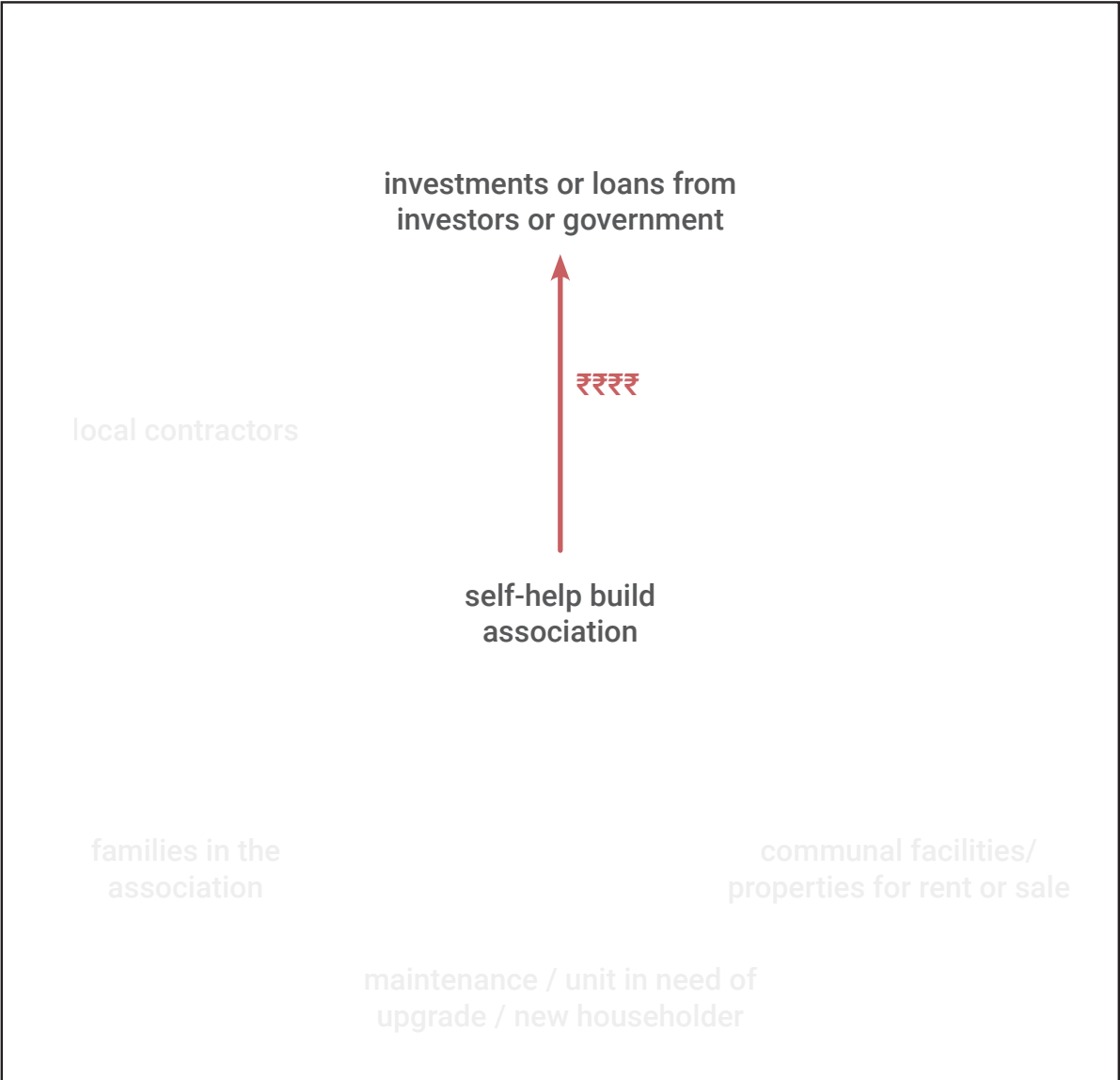


ECONOMIC MODEL



STAGE 5

The association continues to collect financial contributions from the members and facilities/properties over time.



STAGE 6

The association pays back the loans or pay dividends to investors.

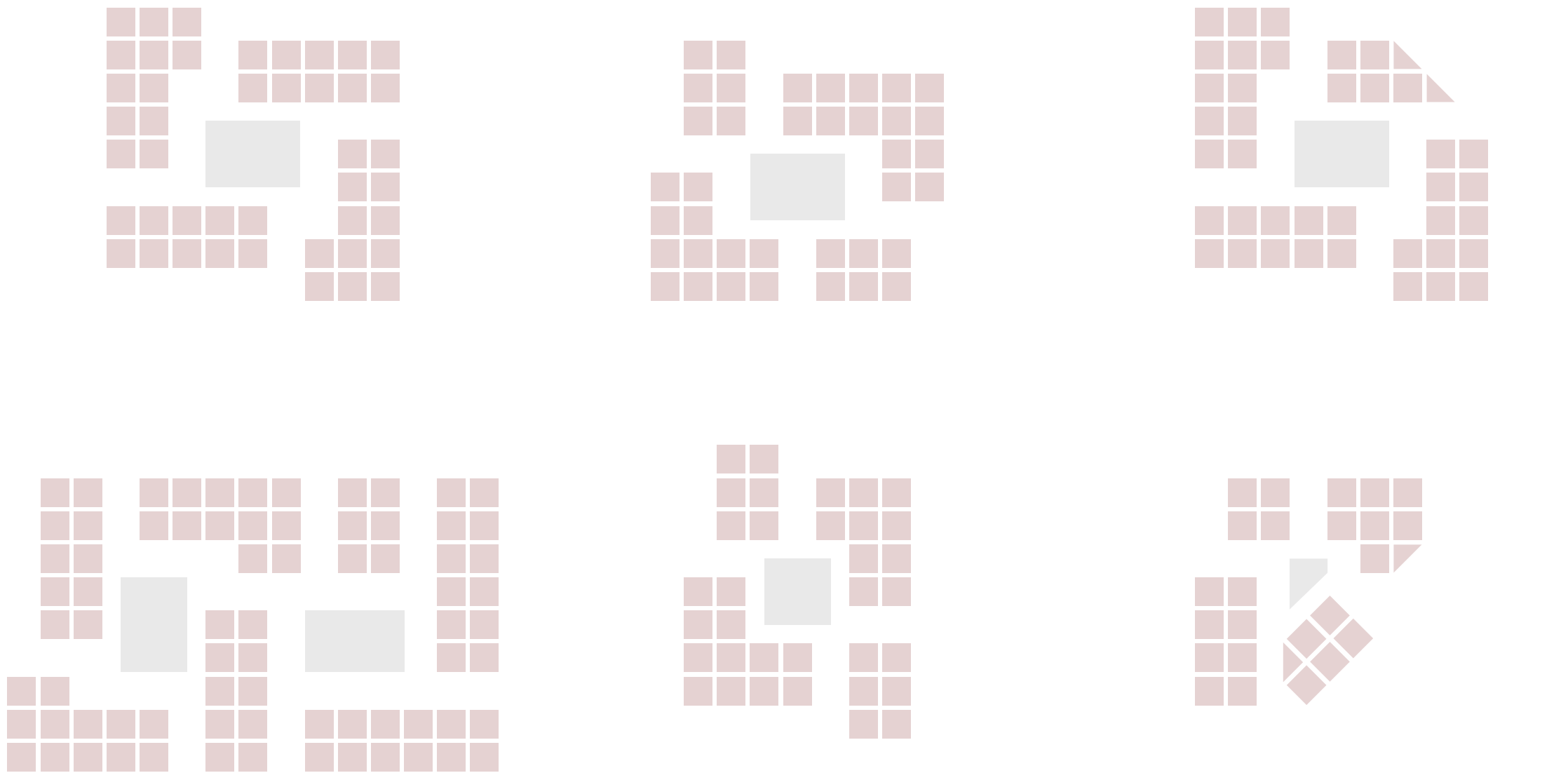


# 09. FLEXIBILITY

Constants & Variations



# REPRODUCIBILITY OF THE SCHEME IN DIFFERENT LOCATIONS



## REPLICATION OF THE SCHEME TO OTHER SLUMS

This design was made in a way that allows for its implementation in other slums in Navi Mumbai. The size of the **units** used in the project is very flexible and can be adapted to suit the conditions of the site. The **platforms** connect the units of various functions and act as informal places which are an extension of both the working and living spaces. The **courtyard** in the middle of the cluster improves the quality of life, providing greenery and contributing to the ventilation and cooling of the living and working spaces.



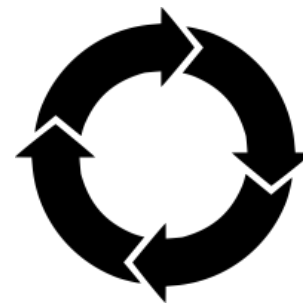
# PRINCIPLES

## 1. POLICY



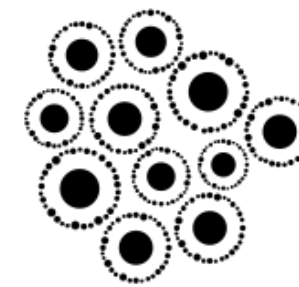
Decentralised slum-based waste management

## 2. TECHNOLOGY



Technological & biological cycle

## 3. LIFESTYLE



Micro agglomeration economies

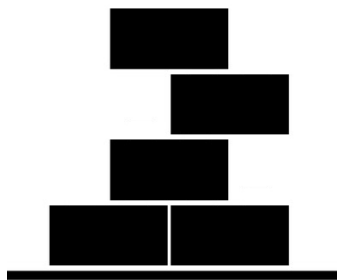
## CONSTANTS AND VARIATIONS

Within **the framework of the three principles of policy, technology and lifestyle** (namely decentralised slum-based waste management, technological & biological cycle, micro agglomeration economies), residents are empowered with decision making **regarding form, materials, function, unit size and layout**. However, residents' customisation needs to be **limited** to a certain extent and under the guidance of architects in order to avoid property disputes or chaos.



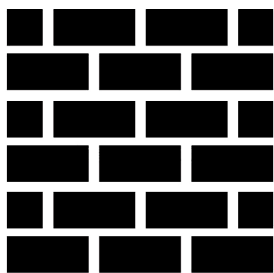
FLEXIBILITY

1. FORM



Cluster size and scale

2. MATERIALS



Diverse building materials from waste

3. FUNCTION



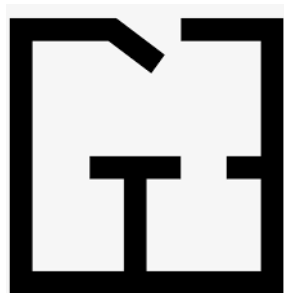
Living / Working / Amenities

4. UNIT SIZE



Different unit types available depending on income and family size

5. LAYOUT



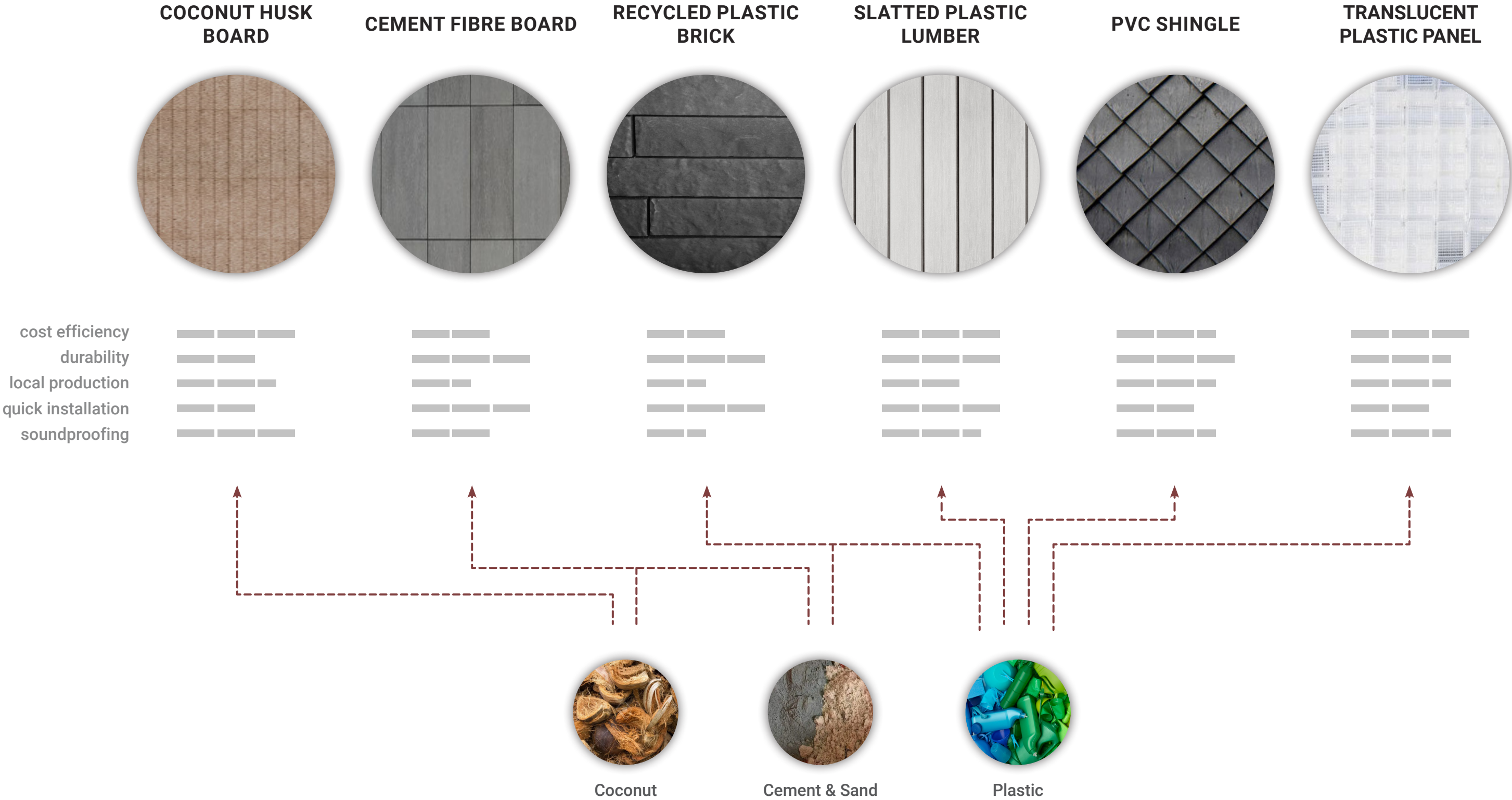
Personalised space layout according to family needs

CONSTANTS AND VARIATIONS

Within the framework of the three principles of policy, technology and lifestyle (namely decentralised slum-based waste management, technological & biological cycle, micro agglomeration economies), residents are empowered with decision making regarding form, materials, function, unit size and layout. However, residents' customisation needs to be limited to a certain extent and under the guidance of architects in order to avoid property disputes or chaos.



MULTI-STYLE FACADE SYSTEM





# 10. CONSTRUCTION

Support & Infill



COMMUNITY TEMPORALITY



STAGE 0

The relocated households would temporarily be housed in vacant houses on the site.



STAGE 1

The first cluster will be built by occupying vacant land and demolishing unoccupied houses.



STAGE 2

Recycling units in clusters would work in synergy with the factories to produce alternative building materials to contribute to community construction.



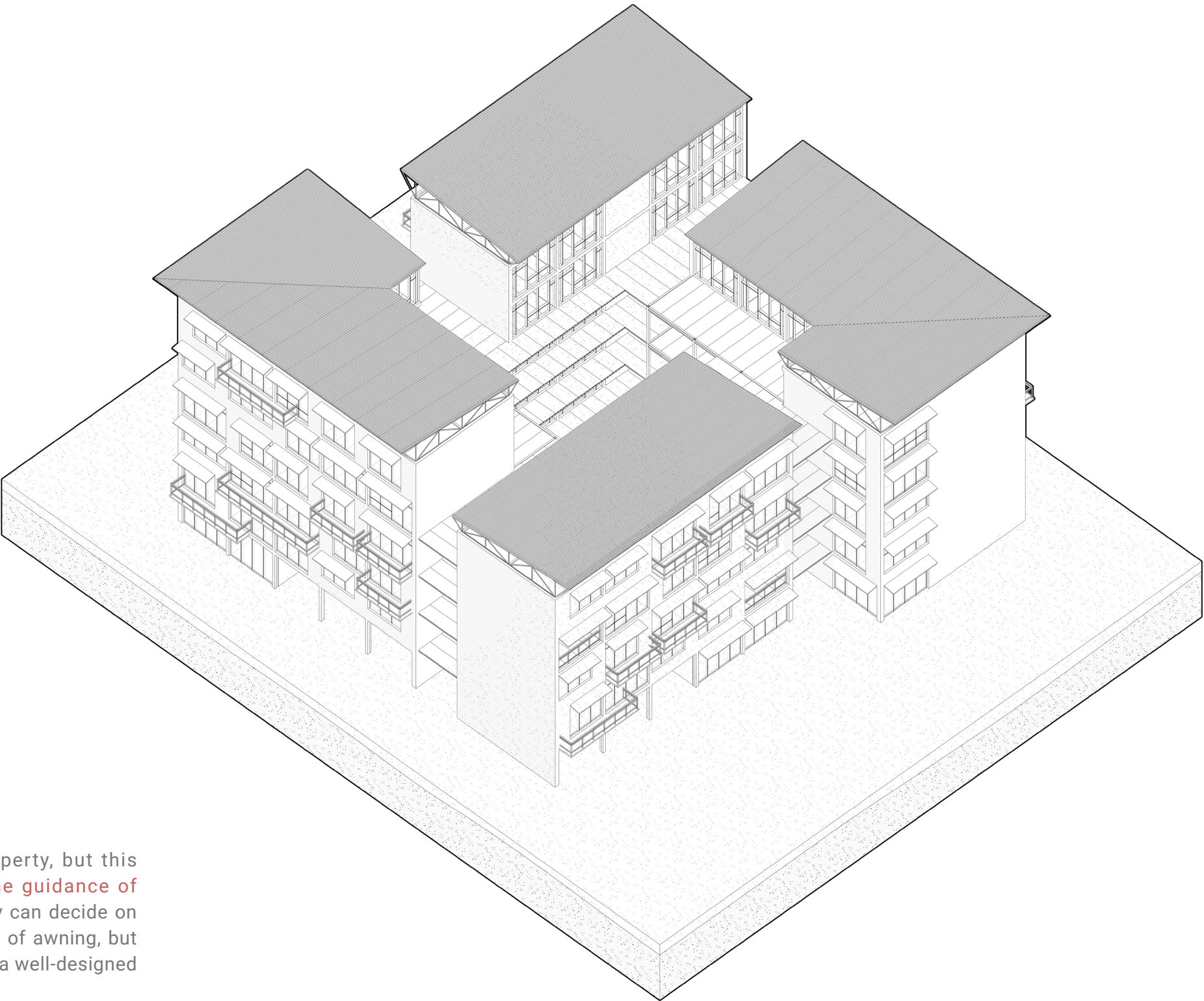
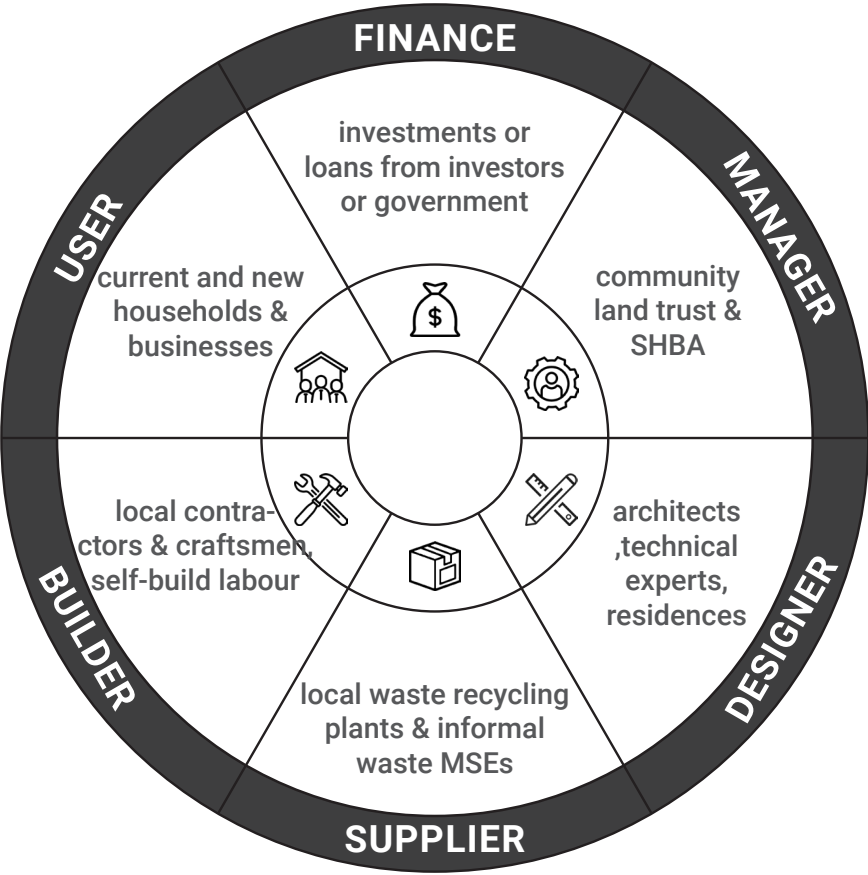
STAGE 4

Composting helps with landscape construction in the community. Finally MIG clusters will be built, which are close to the forest to the east of the site.



# STAGES OF CONSTRUCTION

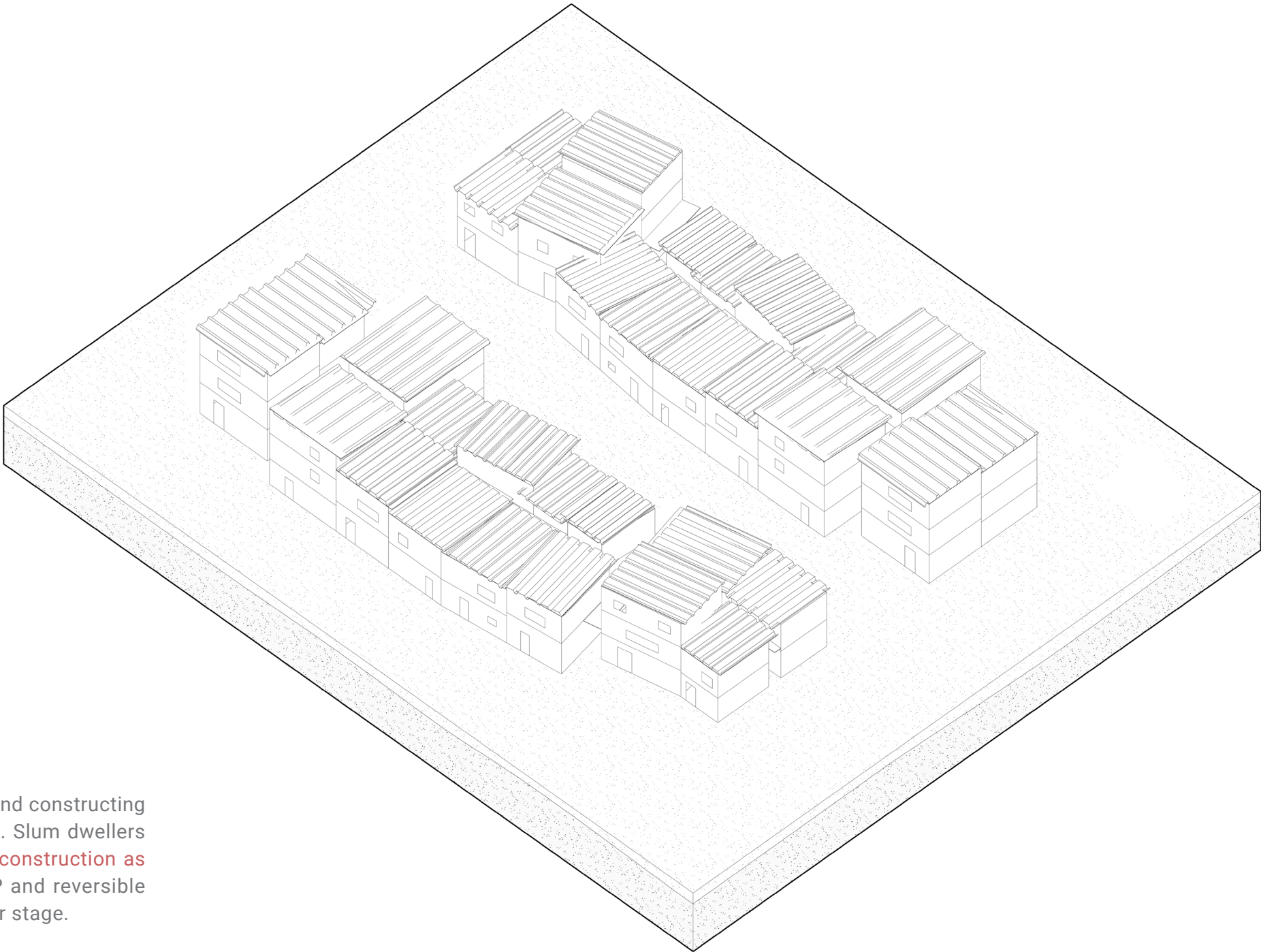
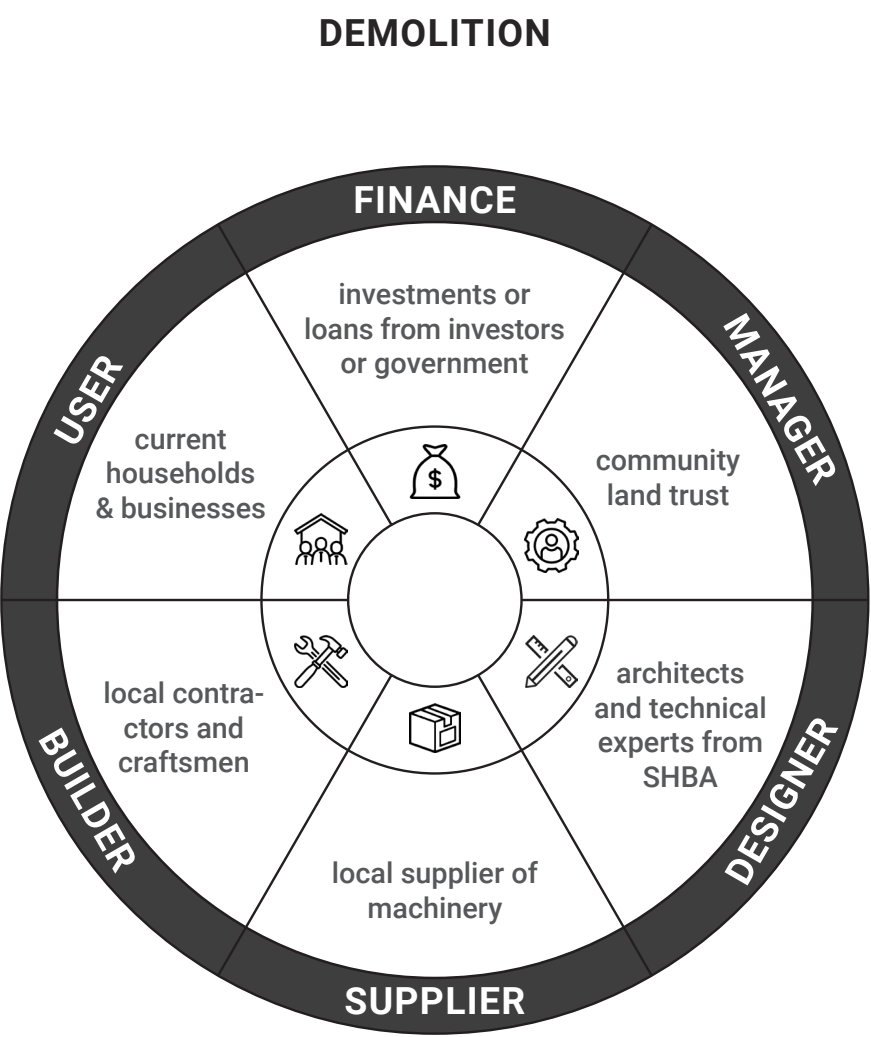
## SUPPORT & INFILL



Residents have the right to make decisions or changes to their property, but this customisation needs to be limited within a framework and under the guidance of architects in order to avoid property disputes or chaos. For example, they can decide on the form and size of the windows, the material of the façade, or the type of awning, but these variations are limited to a certain extent. Residents can also choose a well-designed scheme from the options provided by architects.



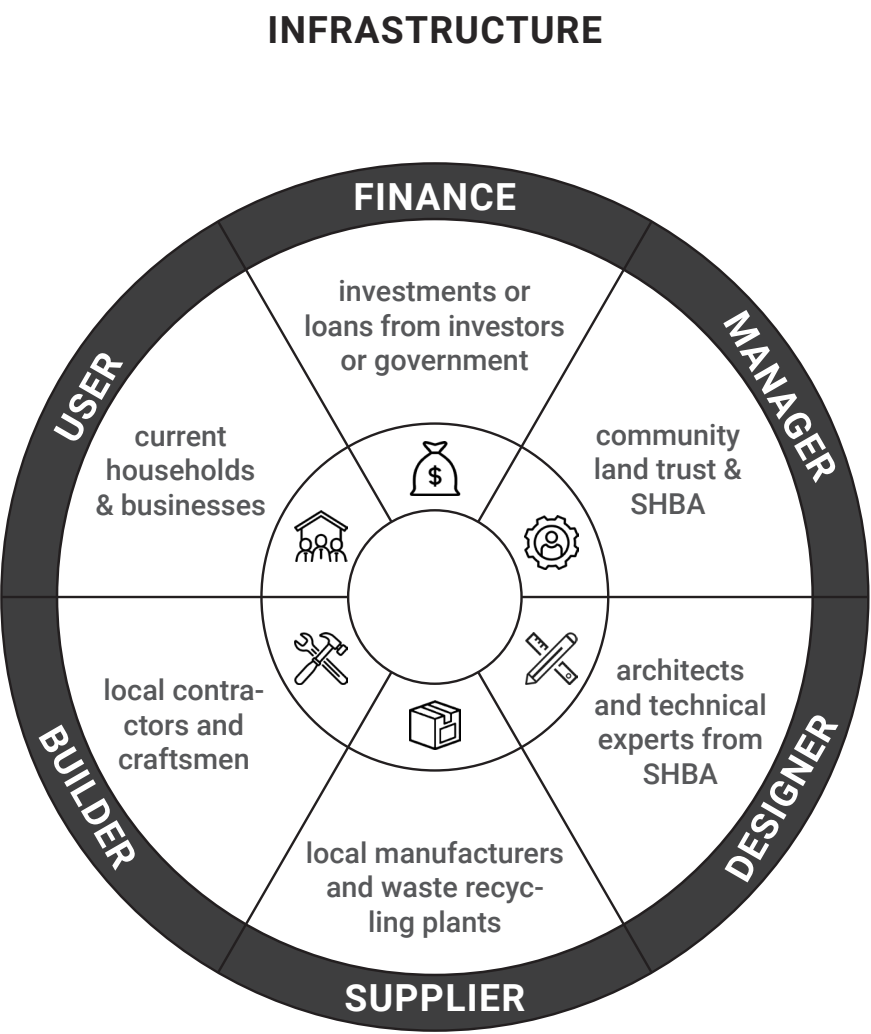
# STAGES OF CONSTRUCTION



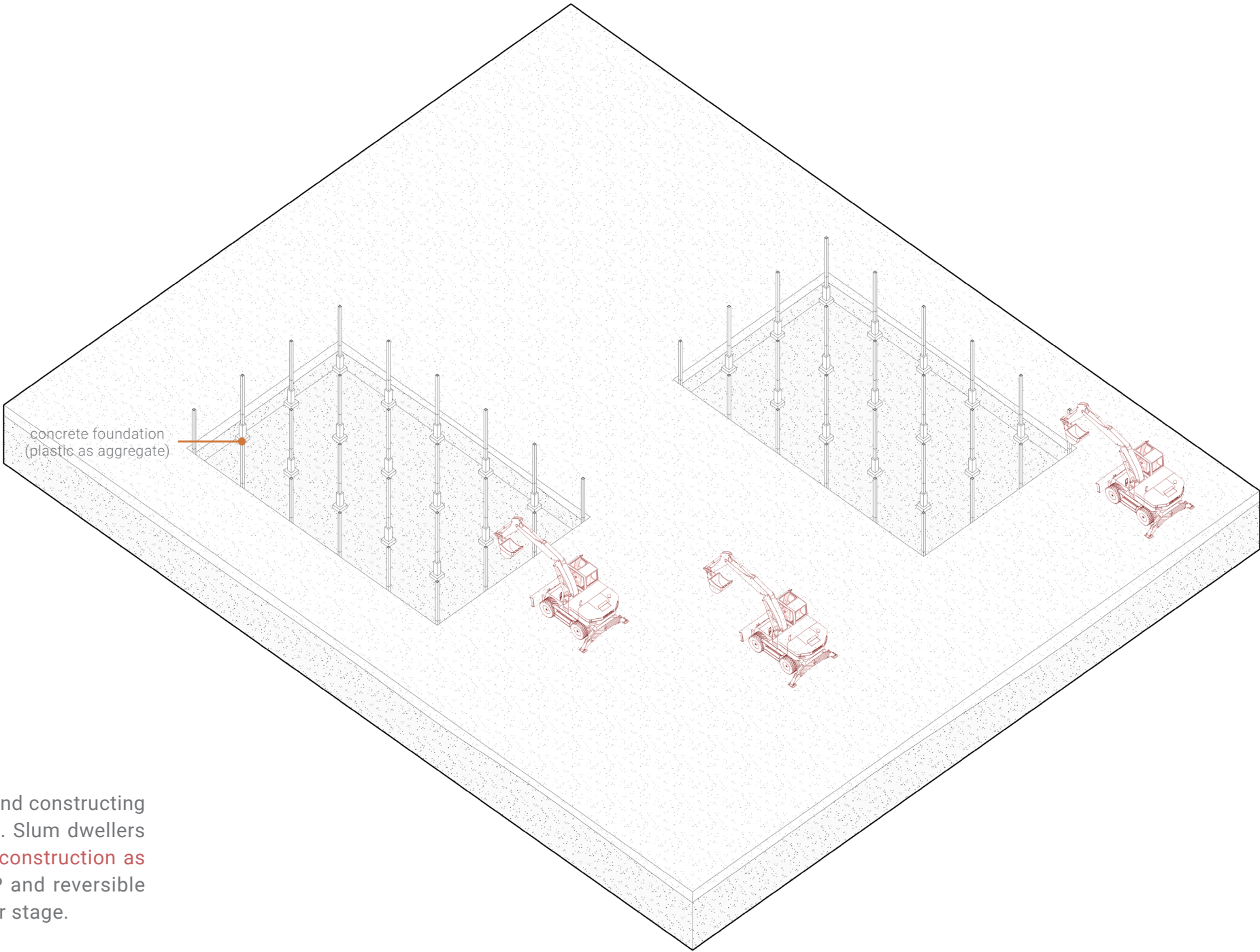
The initial construction work, including demolition, building infrastructure and constructing the main structure, will be carried out by local contractors and craftsmen. Slum dwellers will have the option to **receive training from SHBA and participate in the construction as a self-build workforce** (which is possible due to the lightweight of GFRP and reversible design), generating extra income and enabling customised design at a later stage.



# STAGES OF CONSTRUCTION

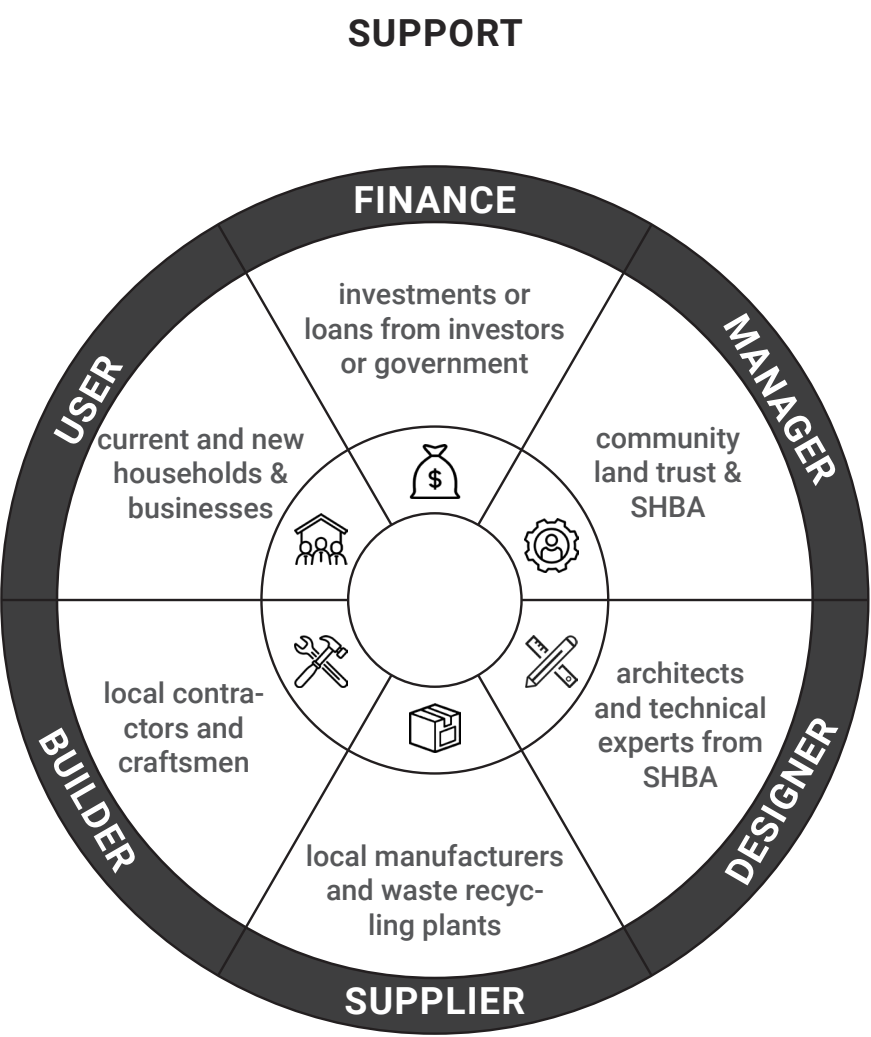


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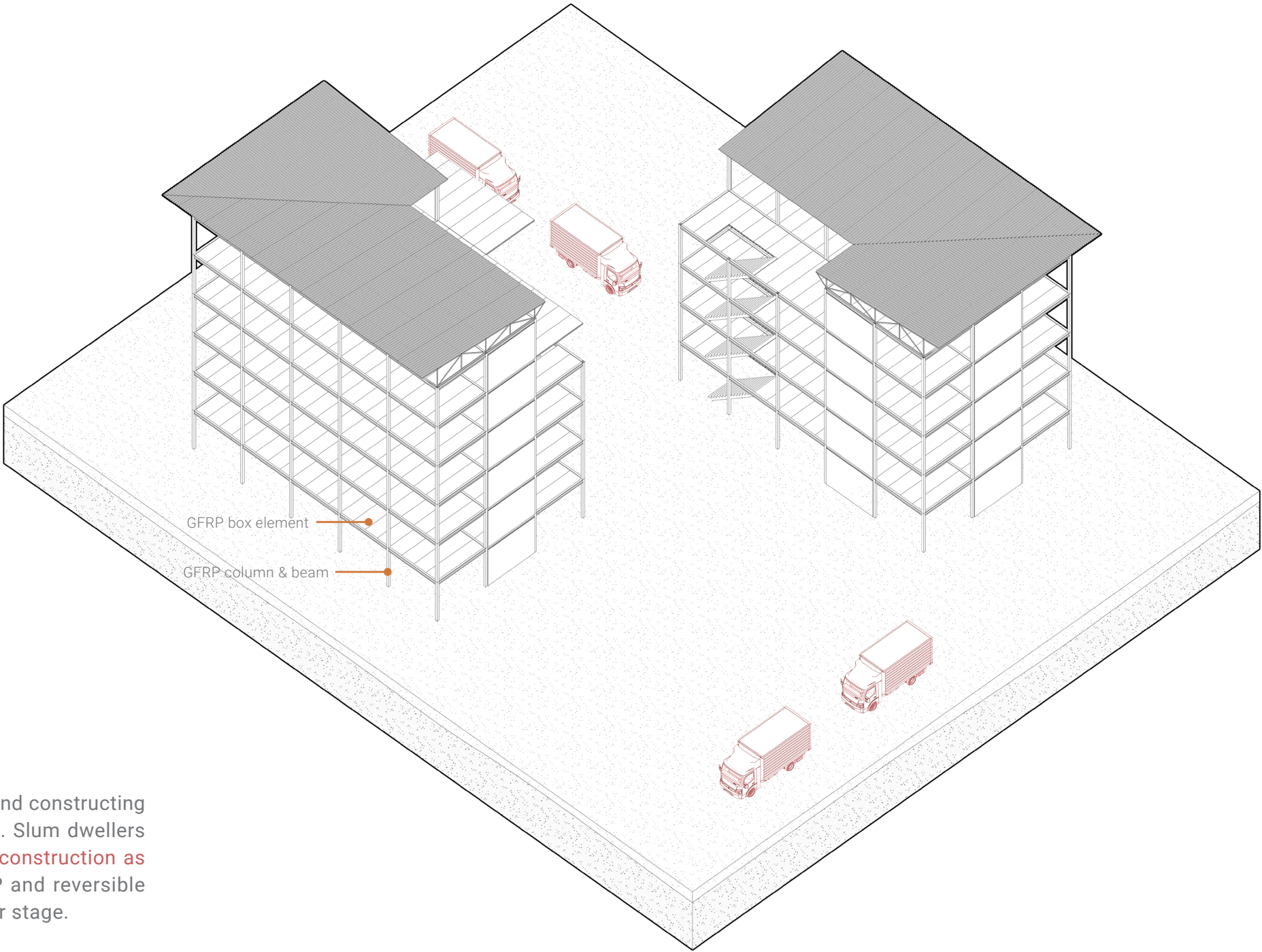




# STAGES OF CONSTRUCTION



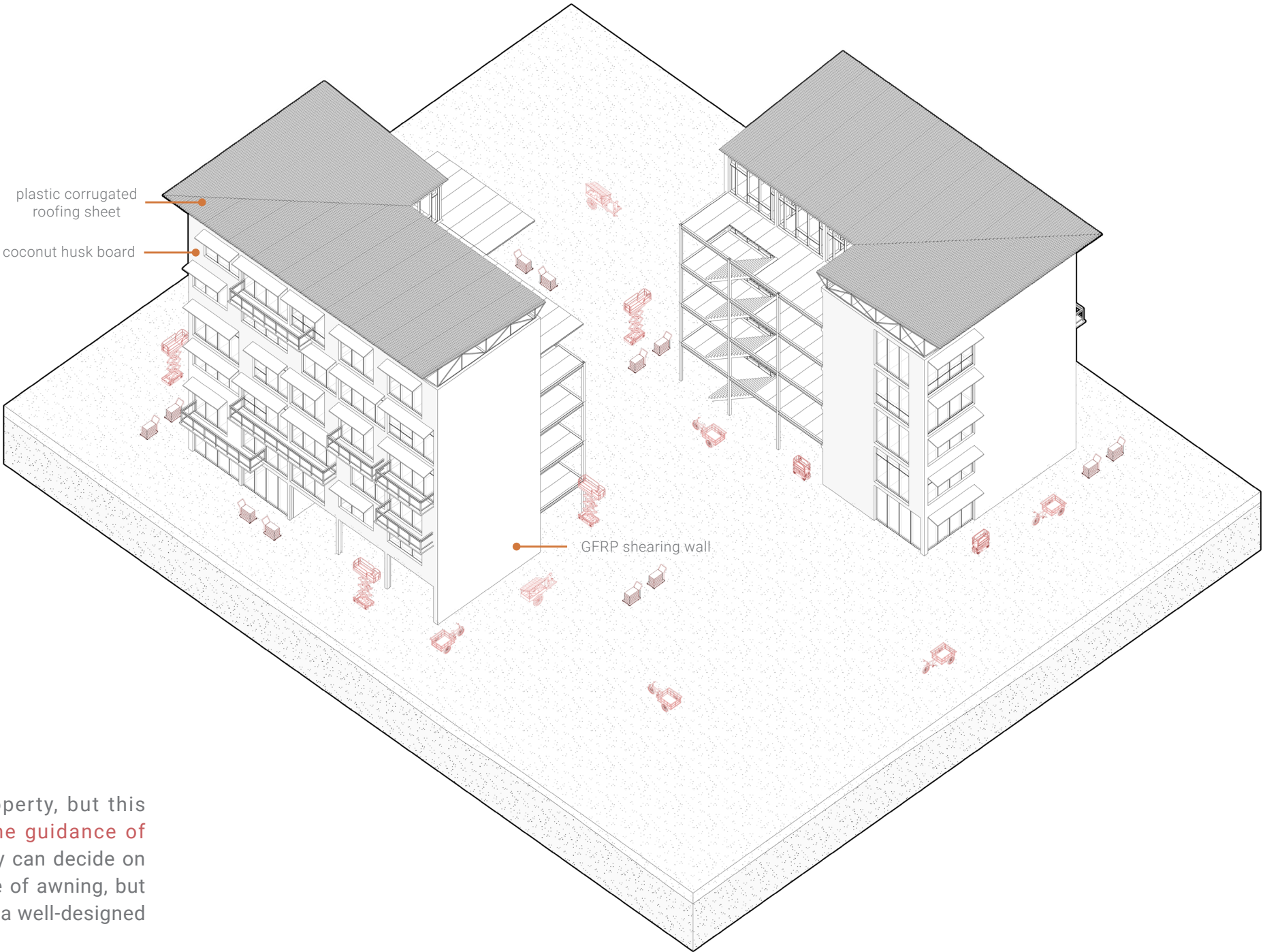
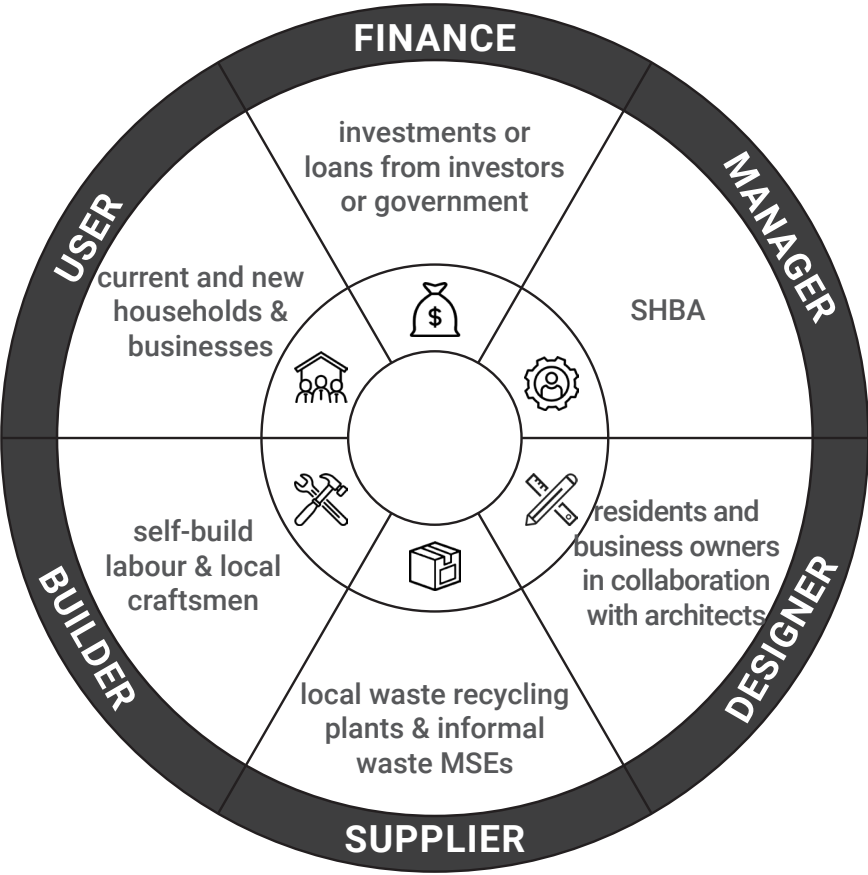
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# STAGES OF CONSTRUCTION

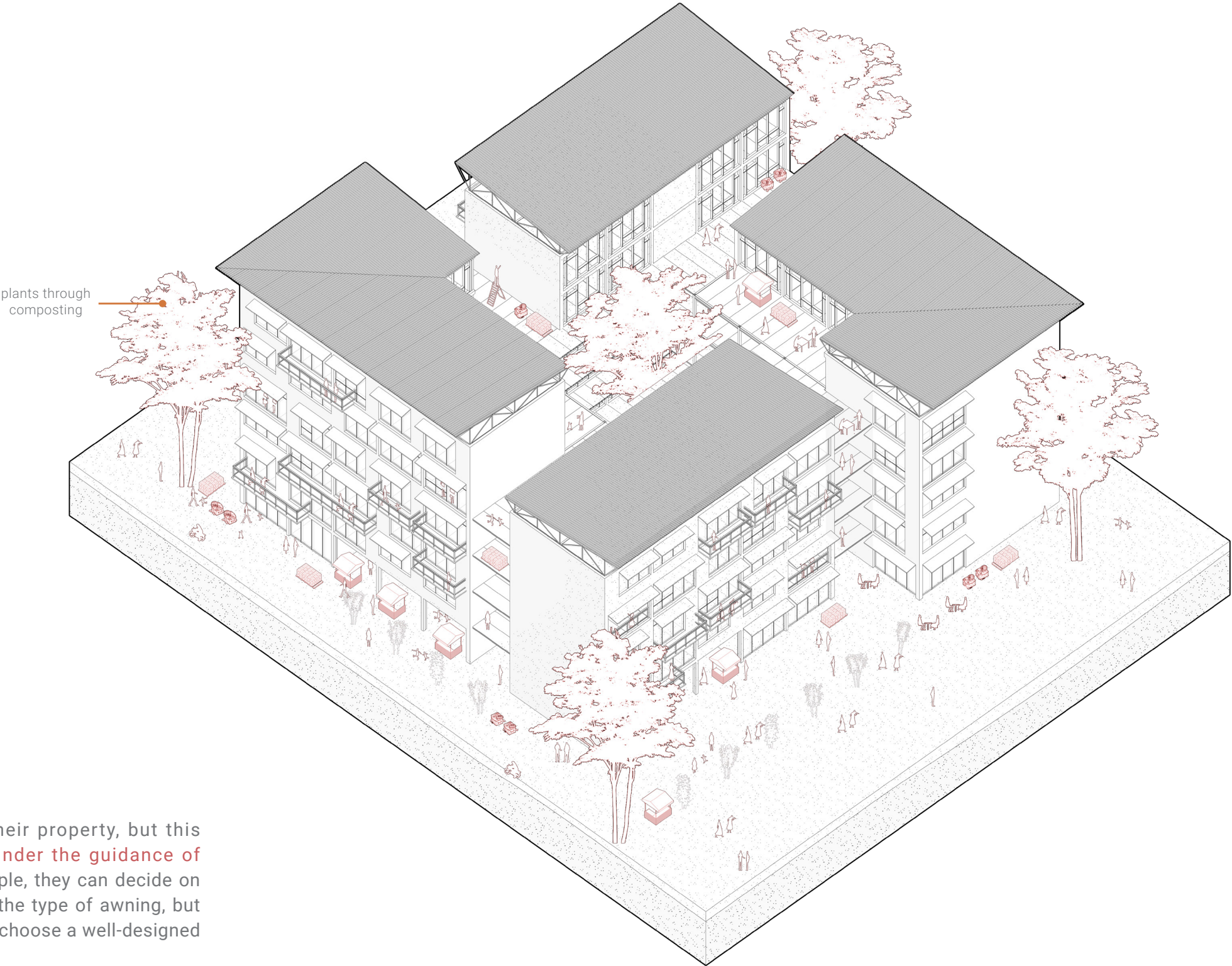
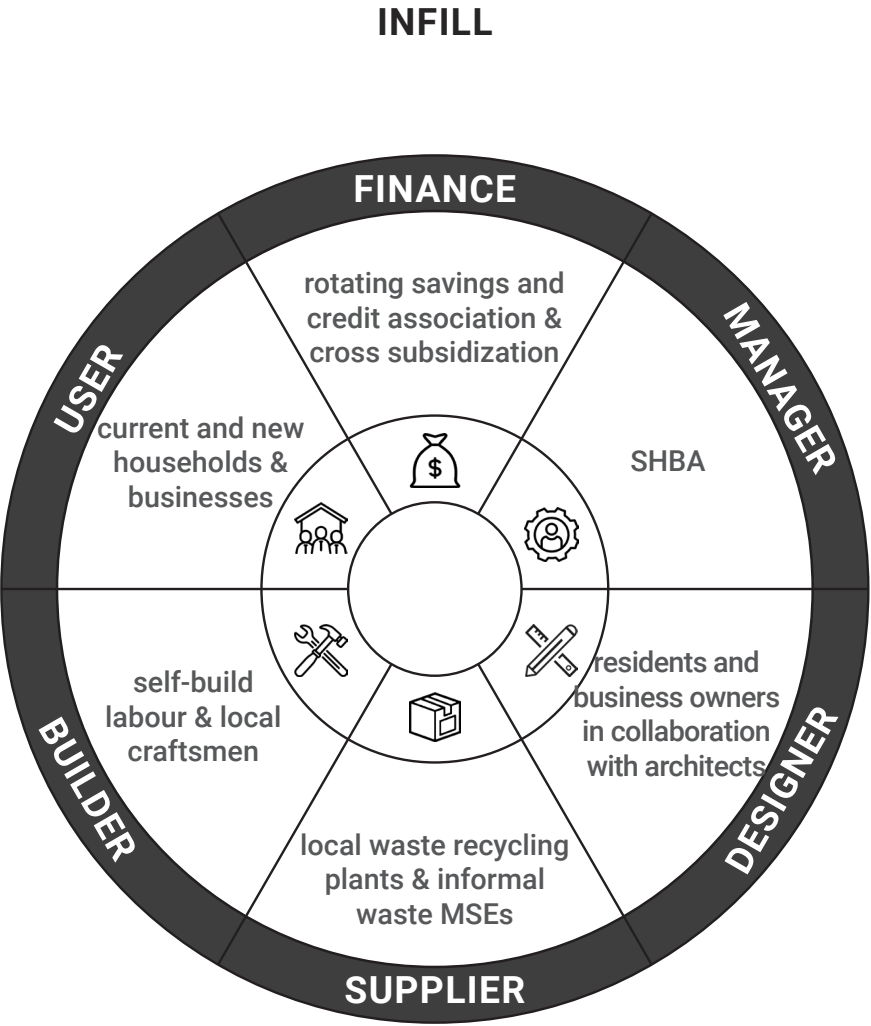
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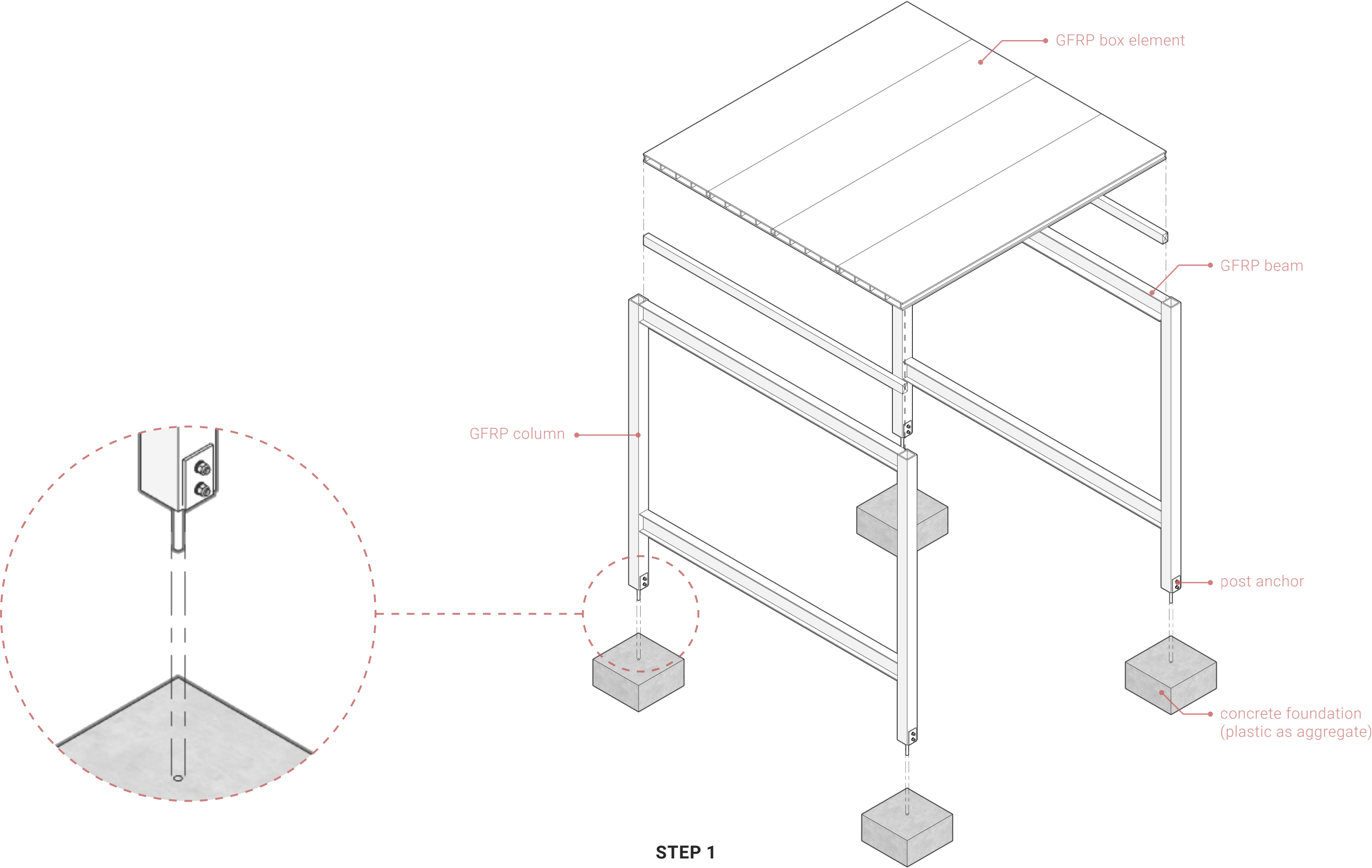
# STAGES OF CONSTRUCTION



Residents have the right to make decisions or changes to their property, but this customisation needs to be limited within a framework and under the guidance of architects in order to avoid property disputes or chaos. For example, they can decide on the form and size of the windows, the material of the façade, or the type of awning, but these variations are limited to a certain extent. Residents can also choose a well-designed scheme from the options provided by architects.

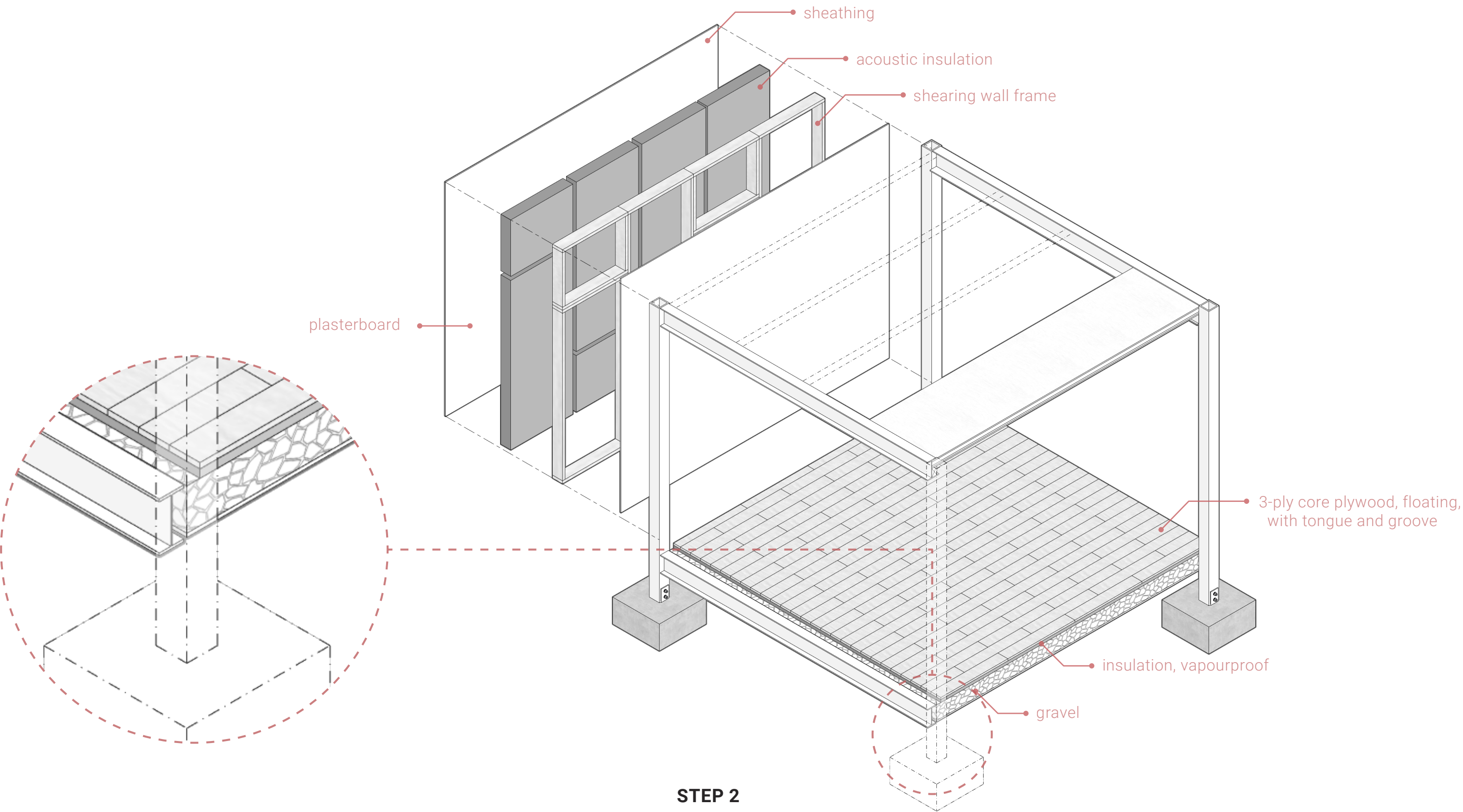


STRUCTURE & CONSTRUCTION PROCESS



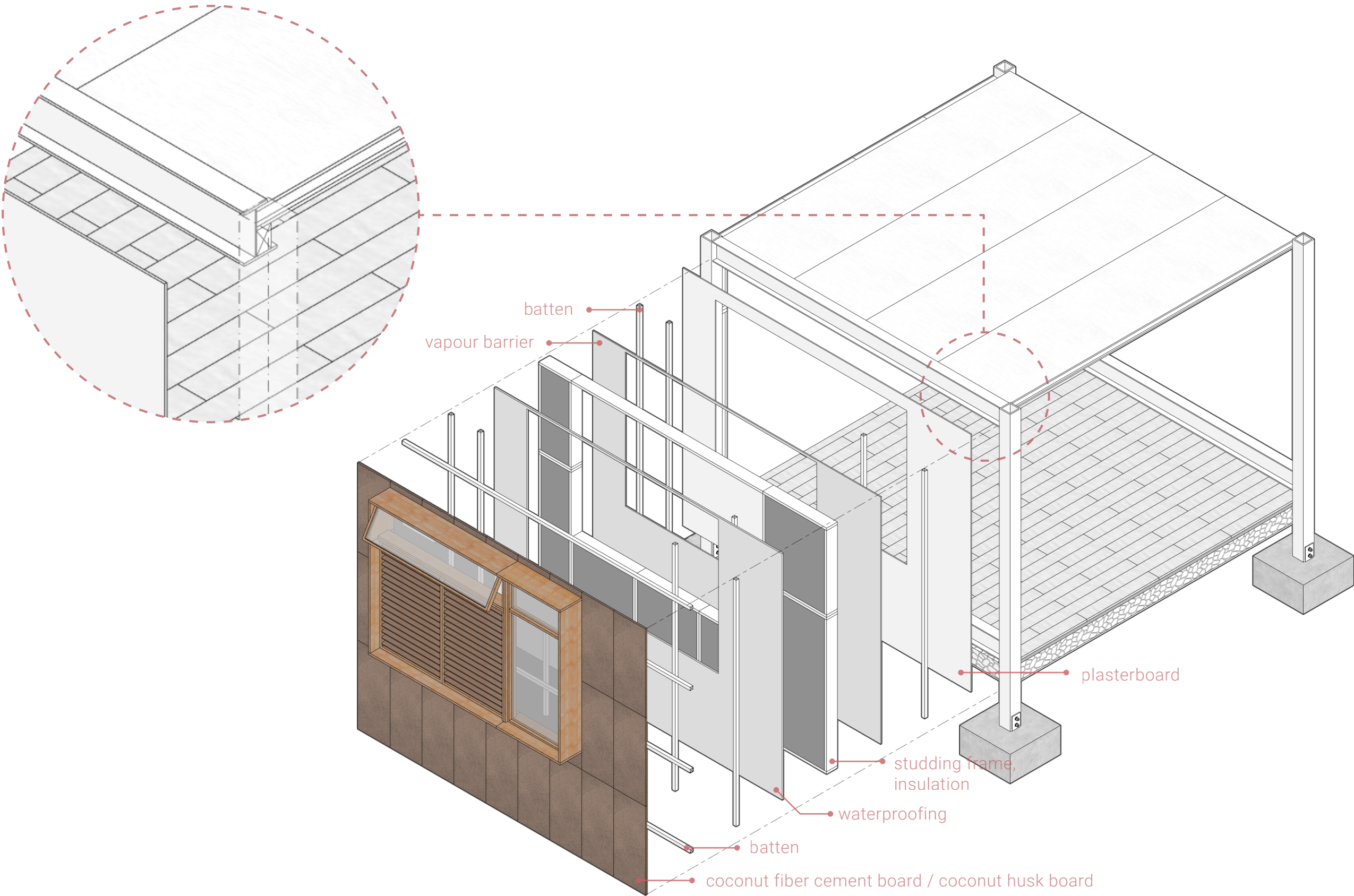


STRUCTURE & CONSTRUCTION PROCESS





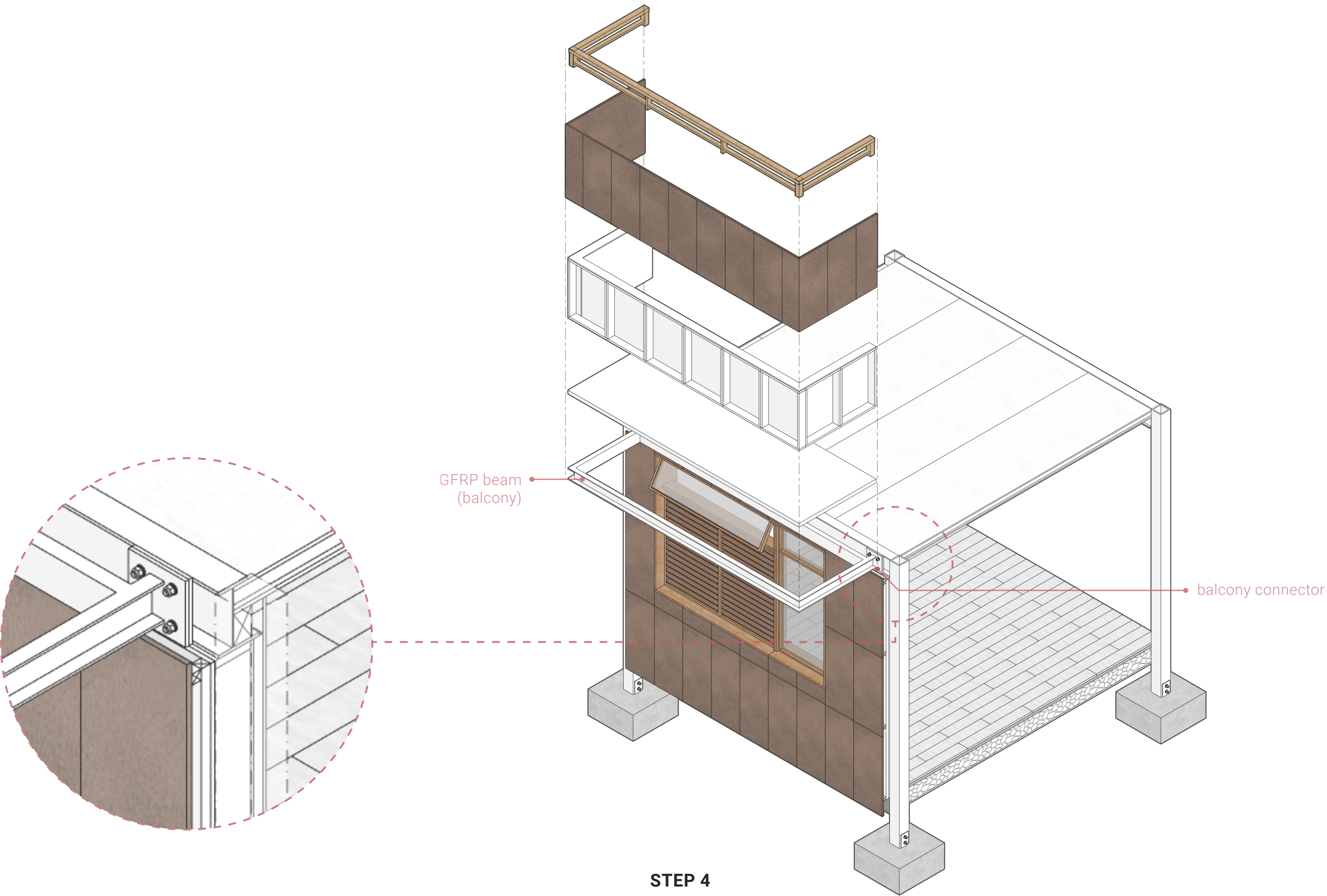
STRUCTURE & CONSTRUCTION PROCESS



STEP 3

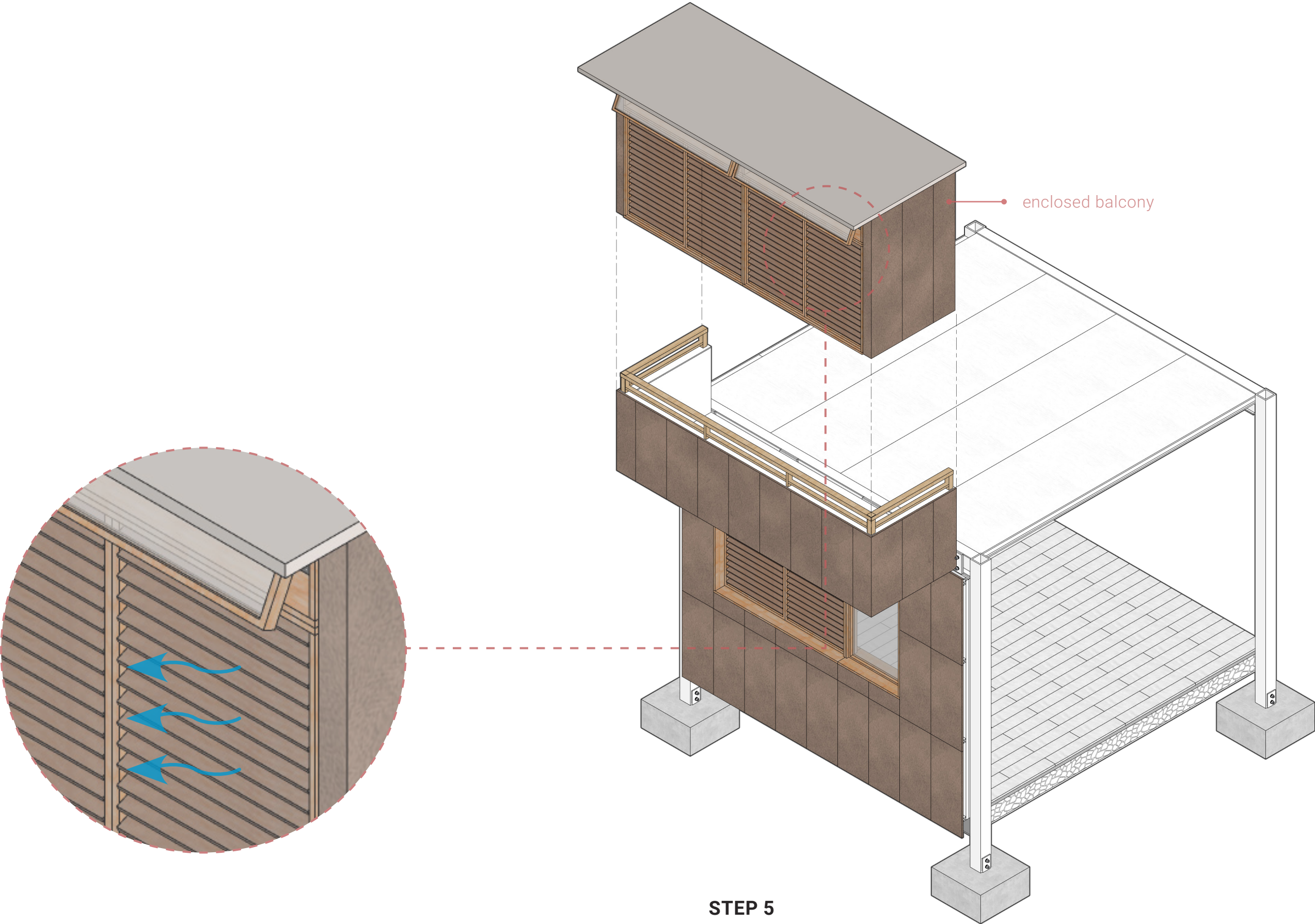


STRUCTURE & CONSTRUCTION PROCESS



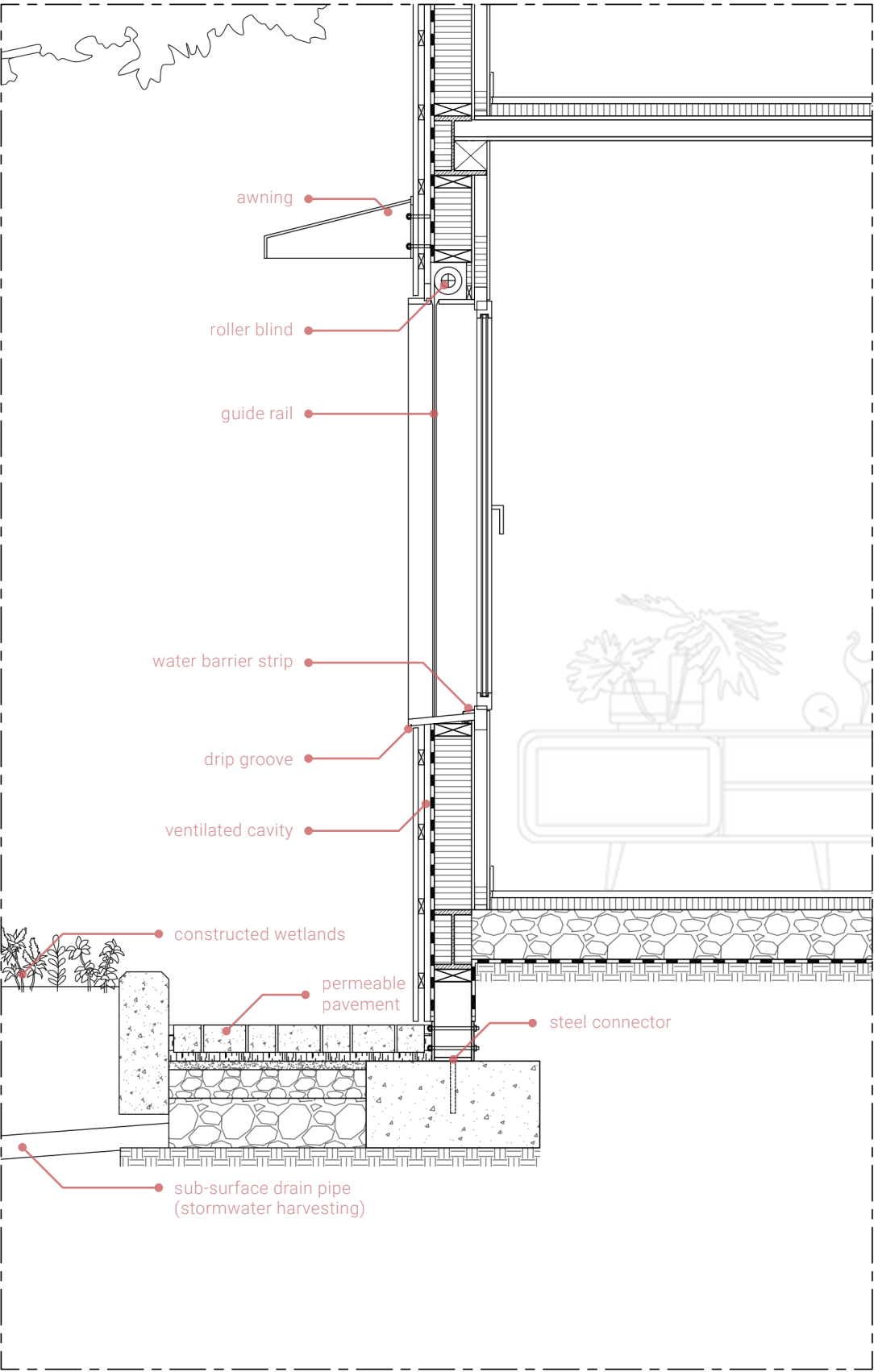


STRUCTURE & CONSTRUCTION PROCESS





DETAIL



FLOOR CONSTRUCTION

- 3-ply core plywood, floating, with tongue and groove	27 mm
- Acoustic insulation (gypsum / coconut cellulose fibre)	50 mm
- GFR plastic box element	100 mm
Total	177 mm

WALL CONSTRUCTION

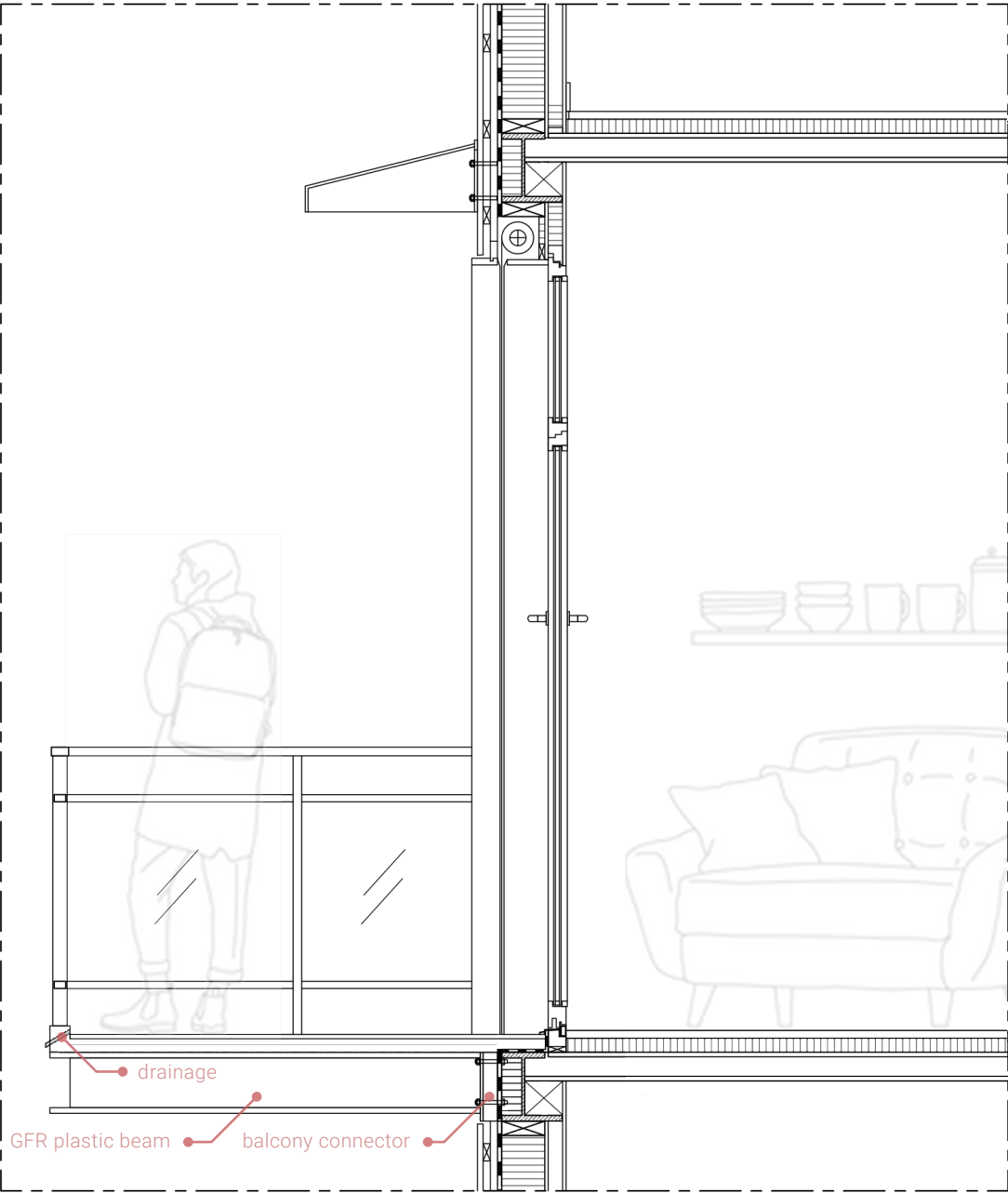
- Coconut fiber cement board/ Coconut husk board	20 mm
- Horizontal battens	40 mm
- Vertical battens (ventilated cavity)	40 mm
- Waterproofing	18 mm
- Timber studding, cellulose insulation (coconut cellulose fibre)	150 mm
- Plywood (vapour barrier)	12 mm
- Vertical battens (space for services)	50 mm
- Particleboard / plasterboard	12 mm
Total	342 mm

FLOOR CONSTRUCTION

- 3-ply core plywood, floating, with tongue and groove	27 mm
- Insulation, vapourproof	50 mm
- Gravel	200 mm
- Waterproofing	18 mm
- Soil	
Total	295 mm



DETAIL



WALL CONSTRUCTION

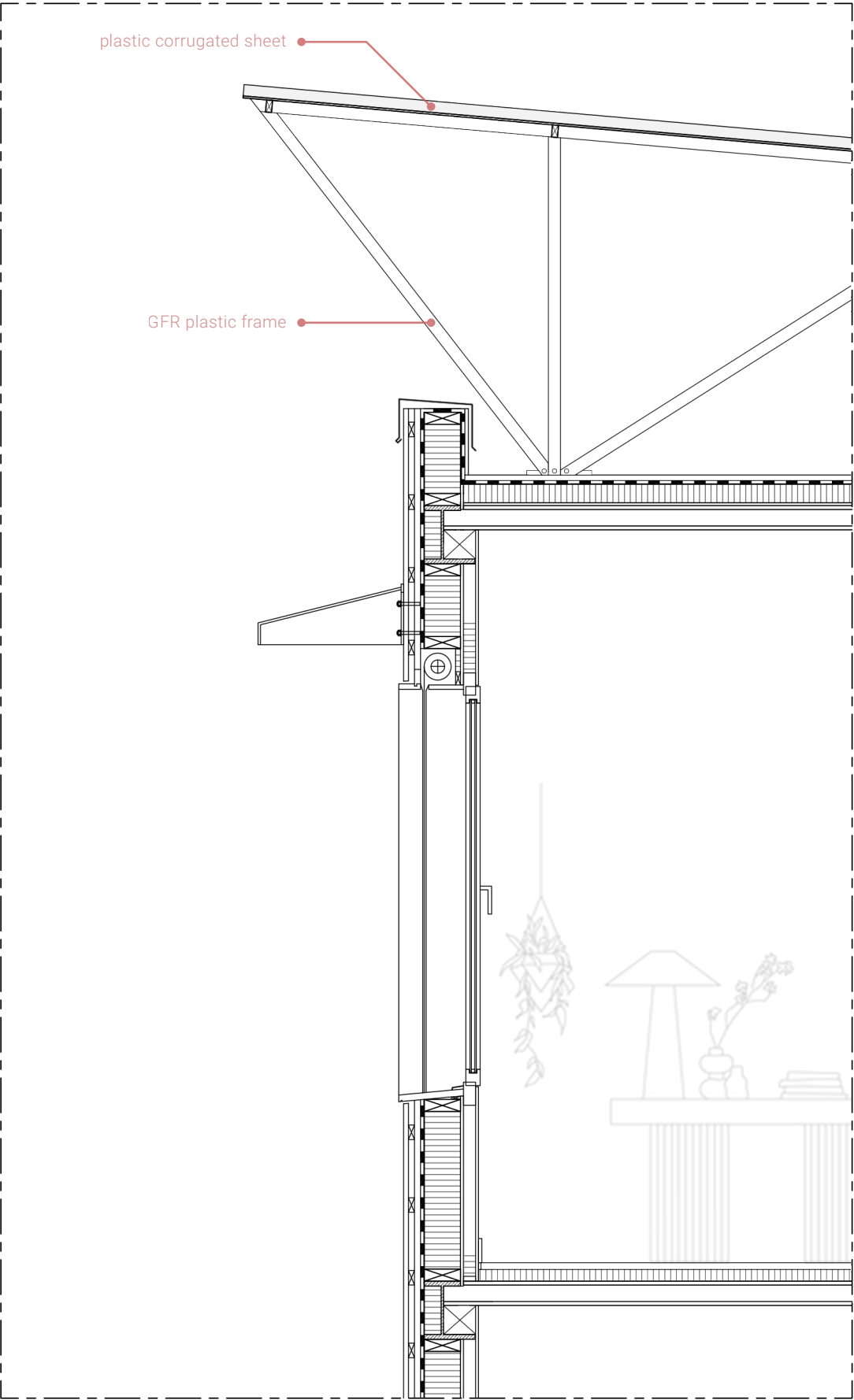
- Coconut fiber cement board/ Coconut husk board	20 mm
- Horizontal battens	40 mm
- Vertical battens (ventilated cavity)	40 mm
- Waterproofing	18 mm
- Timber studding, insulation (coconut cellulose fibre)	150 mm
- Plywood (vapour barrier)	12 mm
- Vertical battens (space for services)	50 mm
- Particleboard / plasterboard	12 mm
<i>Total</i>	342 mm

FLOOR CONSTRUCTION

- 3-ply core plywood, floating, with tongue and groove	27 mm
- Acoustic insulation (gypsum / coconut cellulose fibre)	50 mm
- GFR plastic box element	100 mm
<i>Total</i>	177 mm



DETAIL



ROOF CONSTRUCTION

- Plastic corrugated roofing sheet	
- Shed roof GFR plastic frame	
- Protective mat	20 mm
- Waterproofing	18 mm
- Insulation (coconut cellulose fibre)	80 mm
- Plywood (vapour barrier)	12 mm
- GFR plastic box element	100 mm
<i>Total</i>	225 mm

WALL CONSTRUCTION

- Coconut fiber cement board/ Coconut husk board	20 mm
- Horizontal battens	40 mm
- Vertical battens (ventilated cavity)	40 mm
- Waterproofing	18 mm
- Timber studding, insulation (coconut cellulose fibre)	150 mm
- Plywood (vapour barrier)	12 mm
- Vertical battens (space for services)	50 mm
- Particleboard / plasterboard	12 mm
<i>Total</i>	342 mm

FLOOR CONSTRUCTION

- 3-ply core plywood, floating, with tongue and groove	27 mm
- Acoustic insulation (gypsum / coconut cellulose fibre)	50 mm
- GFR plastic box element	100 mm
<i>Total</i>	177 mm



DETAIL



WALL CONSTRUCTION

- Coconut fiber cement board/ Coconut husk board	20 mm
- Horizontal battens	40 mm
- Vertical battens (ventilated cavity)	40 mm
- Waterproofing	18 mm
- Timber studding, insulation (coconut cellulose fibre)	150 mm
- Plywood (vapour barrier)	12 mm
- Vertical battens (space for services)	50 mm
- Particleboard / plasterboard	12 mm
<i>Total</i>	342 mm



# 11. REFLECTION

Economic Sustainability, Environmental Sustainability, Social Sustainability



# SUSTAINABILITY

## **Environmental Sustainability**

- i. Decentralised slum-based waste recycling sites in the city
- ii. Alternative building materials
- iv. Plant composting / constructed wetlands / biodigester
- v. Passive climate strategy

## **Social Sustainability**

- i. Improved living and working conditions / communal facilities
- ii. Community participation
- iv. Neighbourhood contact / community inclusiveness and diversity
- v. Semi-formalisation of IWM / social recognition / career security / identity

## **Economic Sustainability**

- i. Strengthened links between businesses / agglomeration economy benefits
- ii. Diverse source of income / new jobs
- iv. Cheap building materials for affordable housing
- v. Self-help group and cross subsidization





THANK YOU!