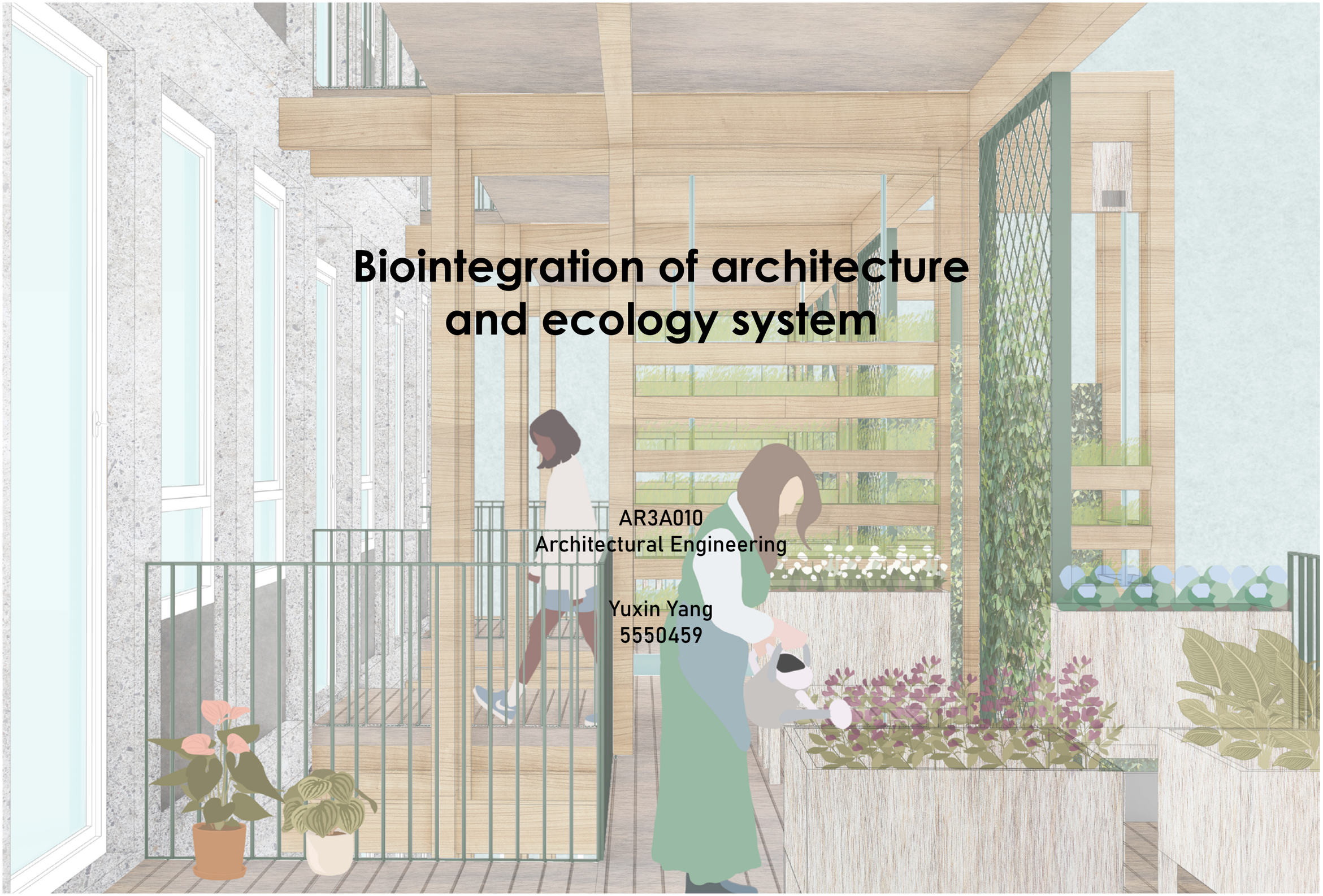


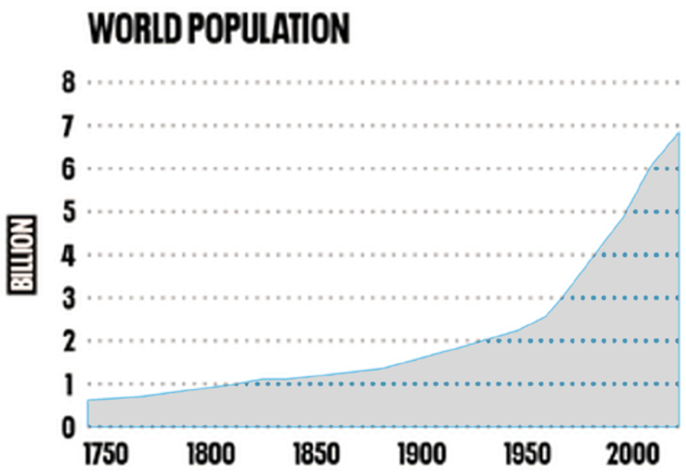
Biointegration of architecture and ecology system

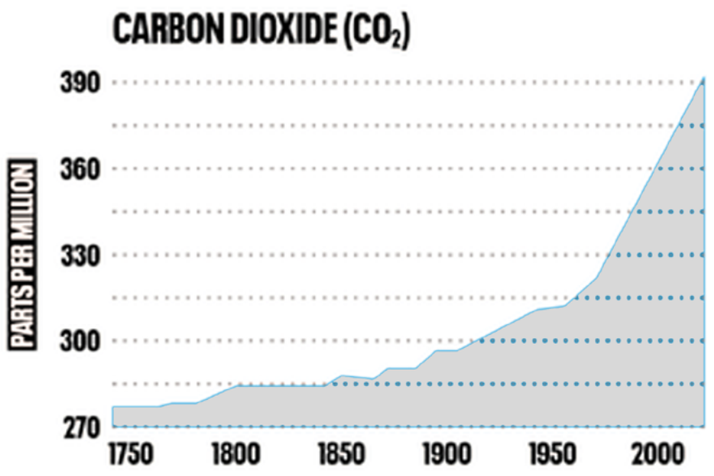
AR3A010
Architectural Engineering

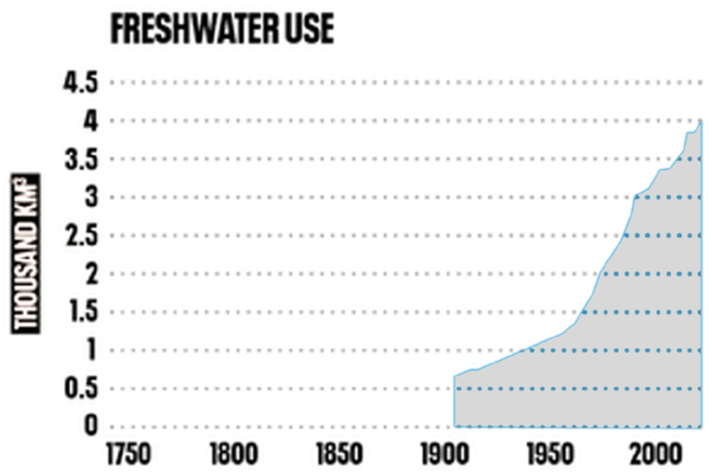
Yuxin Yang
5550459

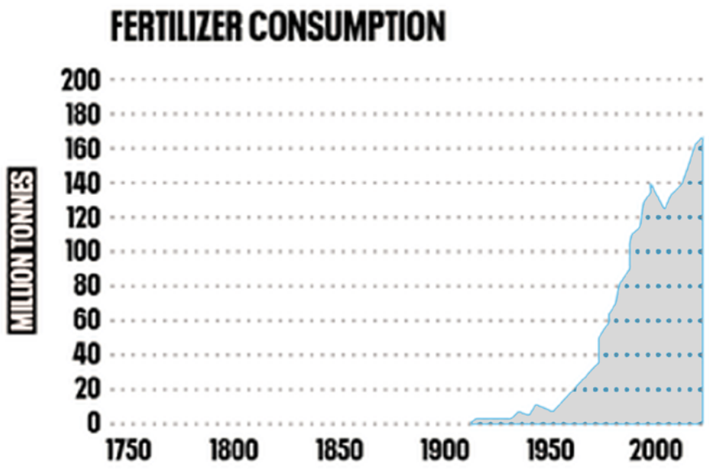
Problem statement

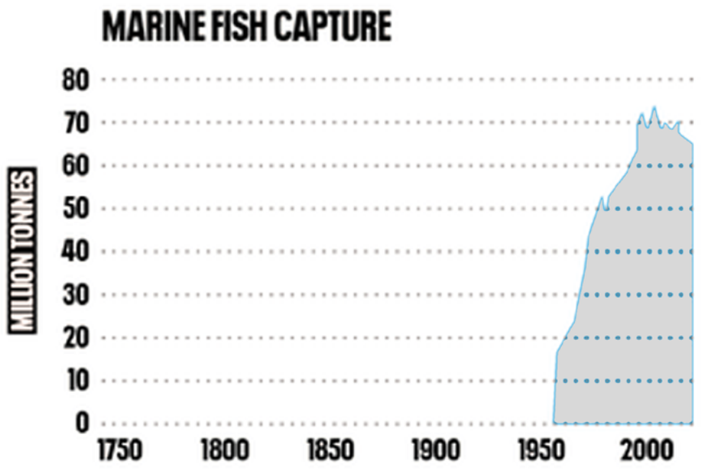
Ecological consequences of human activities on the natural environment

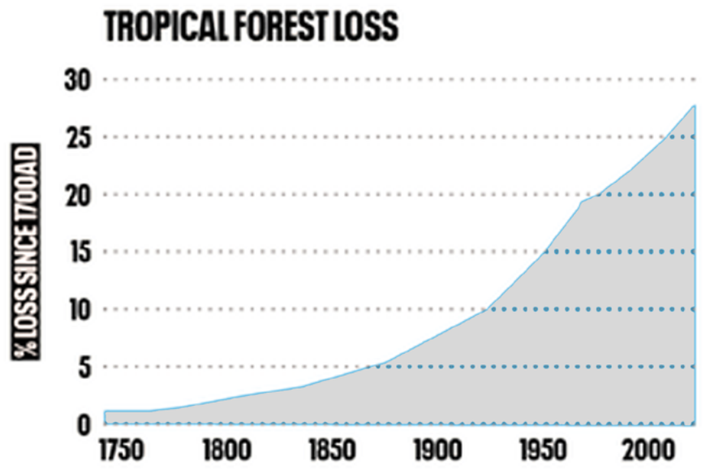










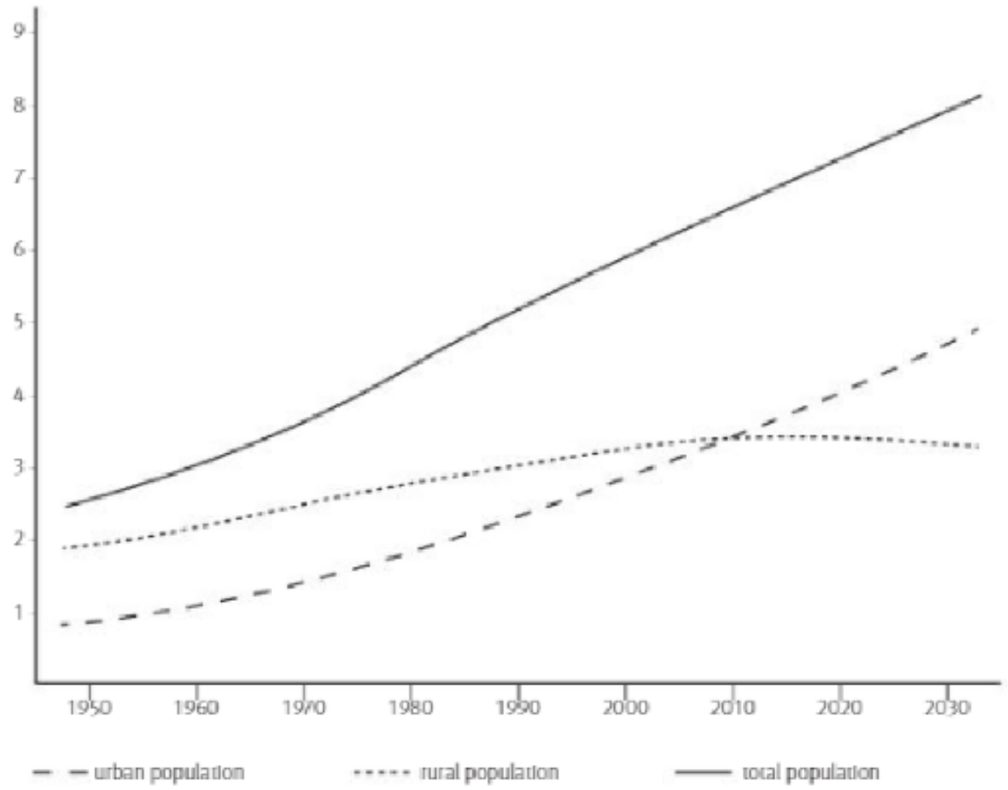


Source: WWF

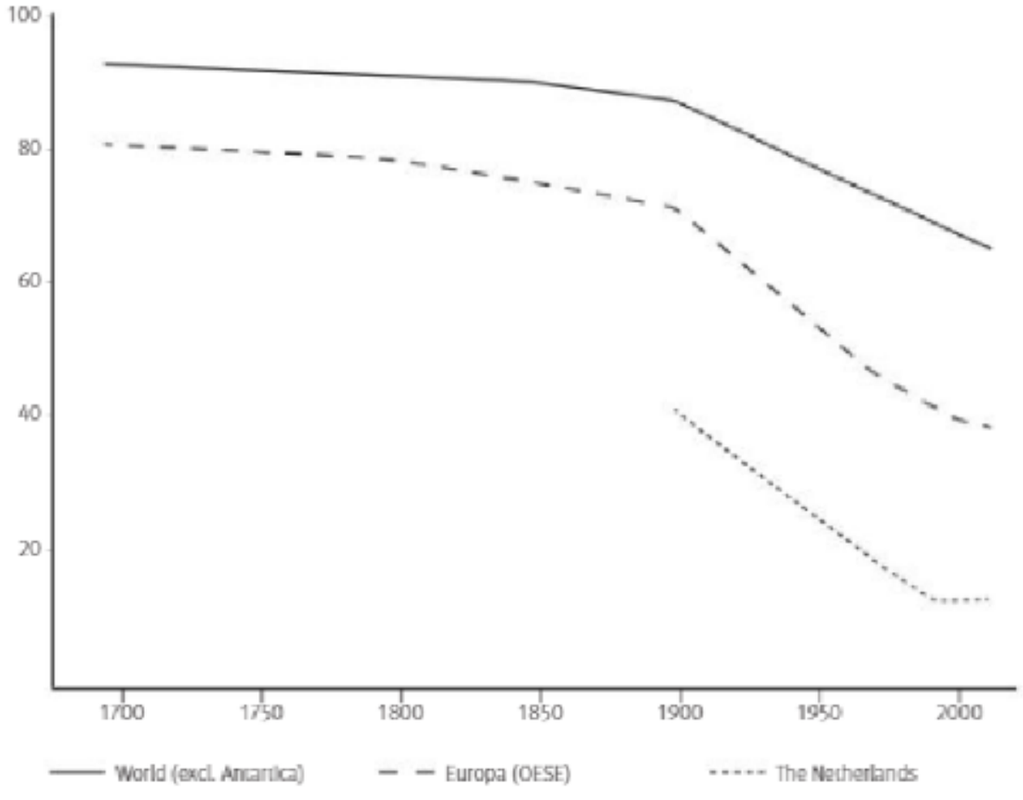
Problem statement

Biodiversity

The Growth of the world population



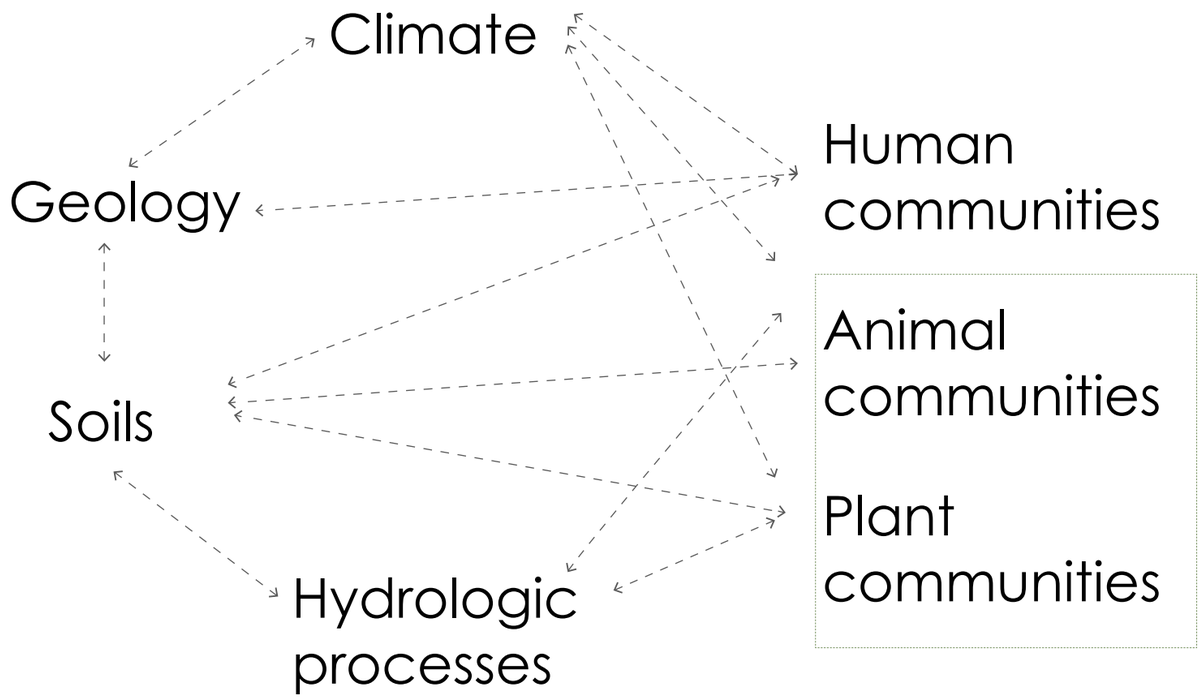
Main species abundance



Problem statement

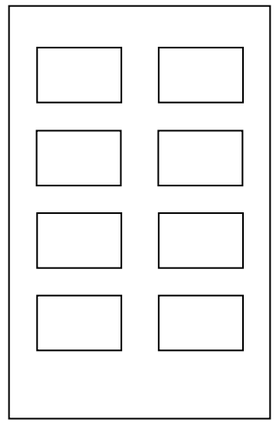
Difference between ecological and artifical environment

Ecological environment



Ecosystems

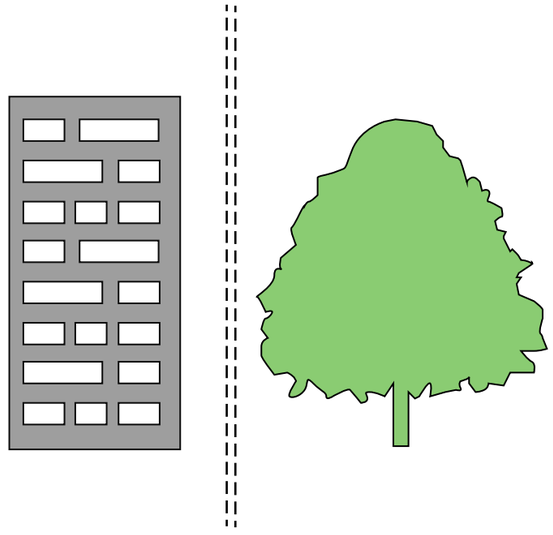
Artifical environment



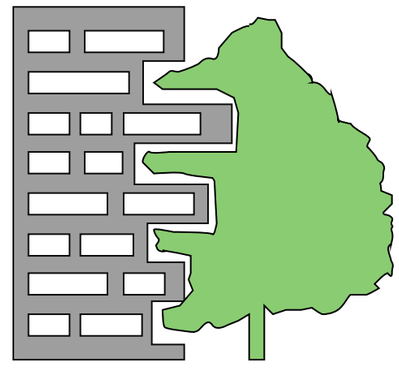
Architecture

Problem statement

Design for the ecosystem



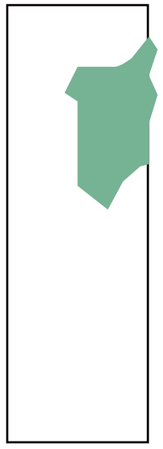
Architectural denaturalisation



Symbiotic bio-integration

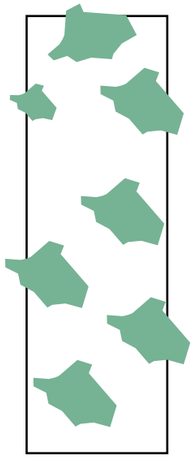
Problem statement

Three ways of designing plants and non-human biomass into built systems



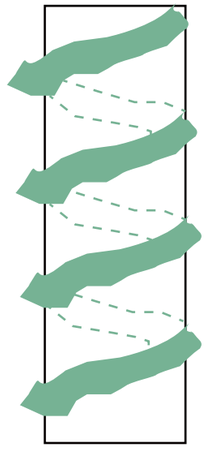
Juxtapositioning

Juxtapositioning is the concentrated placement of greening meterial at one or a few locations in the built form



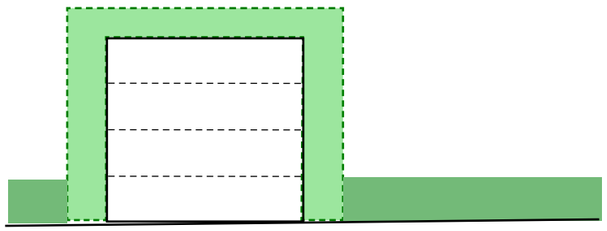
Intermixing

Intermixing is the distributed and patchy placement of green material



Integrating

Integrating consists of a woven blending of the greening material with tha built form

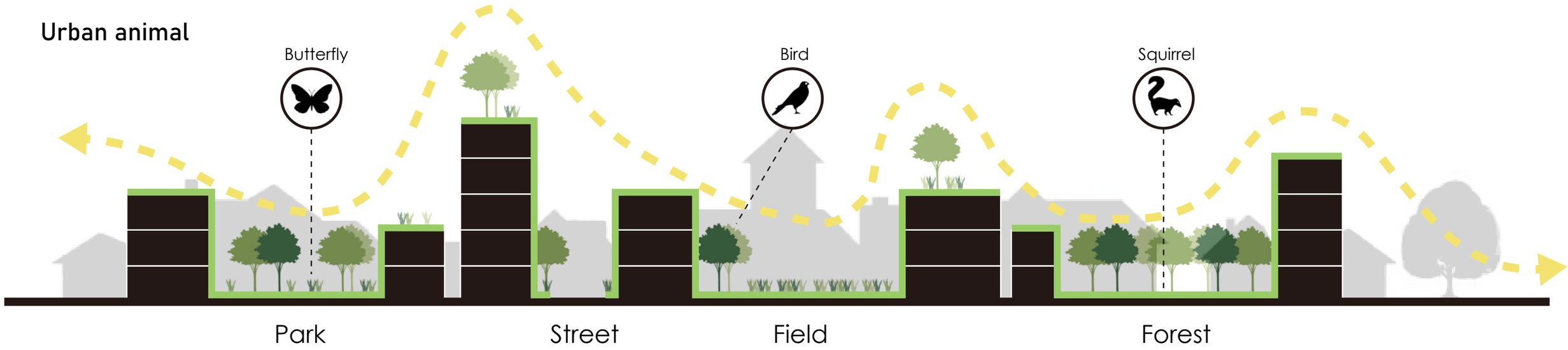


The greening material is linked to the existent vegetation at the ground plane and enables species interaction and migration , thereby engendering a more diverse and stable ecosystem

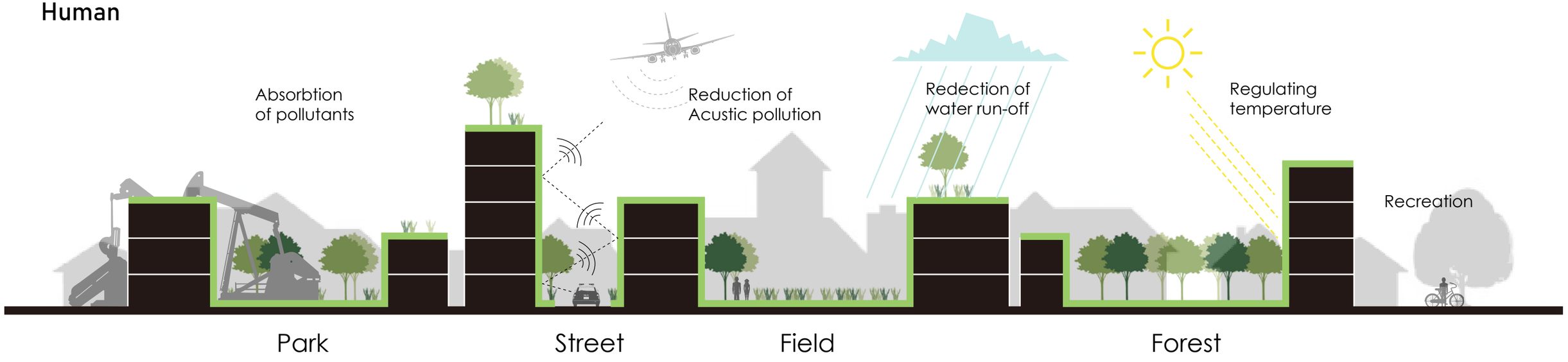
Problem statement

Ecological connection

Urban animal



Human

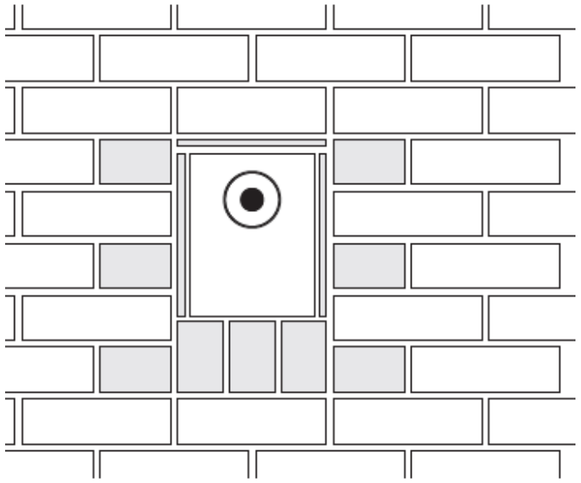


Problem statement

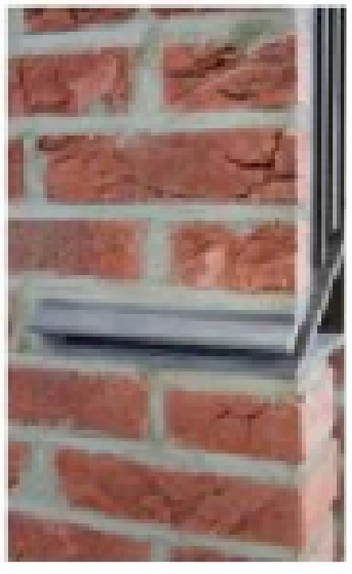
Building-reliant species

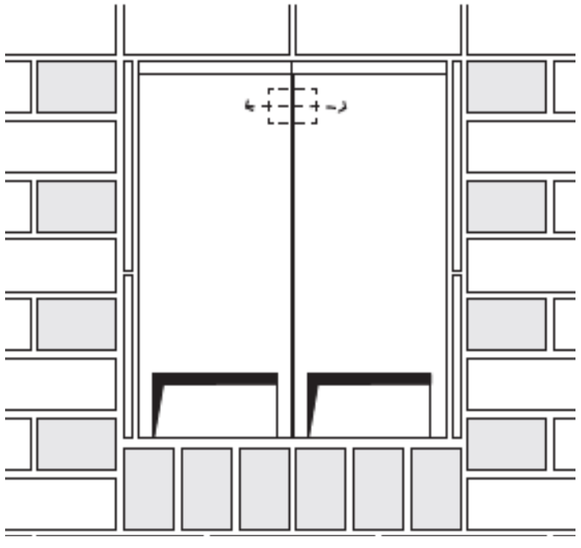
As our buildings and developments have crept over the landscape, some animal species have adapted to share our built structures with us in order to survive, and have done so for a very long time. Some of these animals have come to depend on buildings for their survival. We term them ‘building-reliant species’.

Nesting bricks for birds



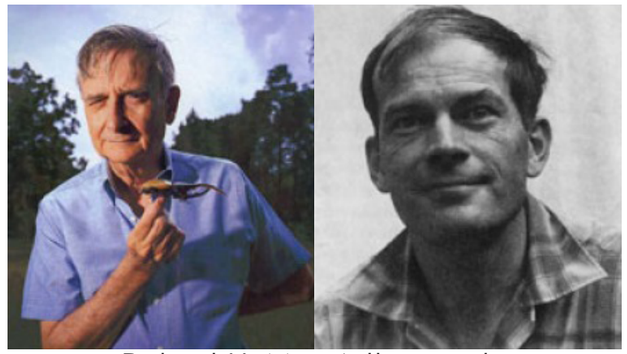
Bat boxes



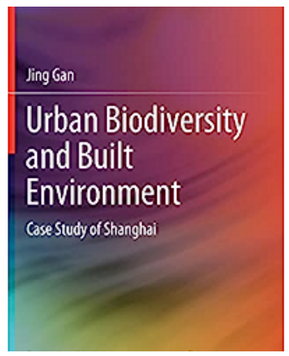


Problem statement

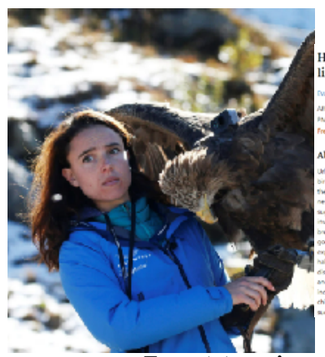
Home range



Robert H. MacArthur and
Edward O. Wilson



Jing gan

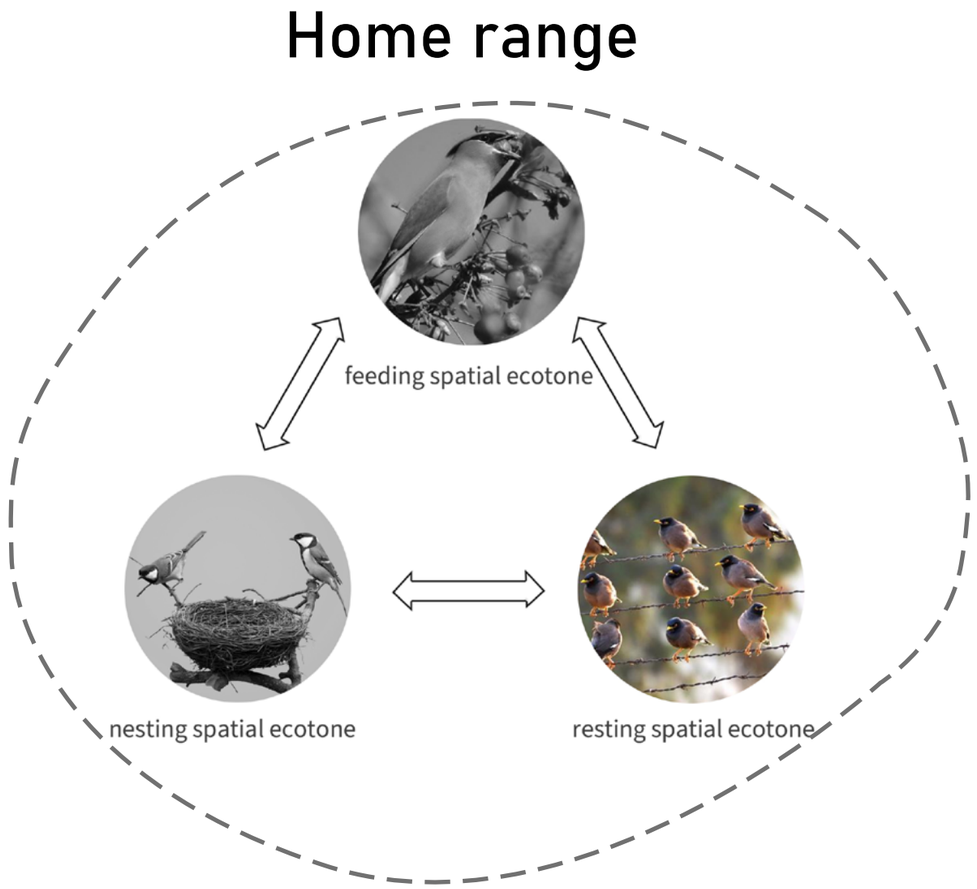


Eva Meyrier and Lukas
Jenni et al.

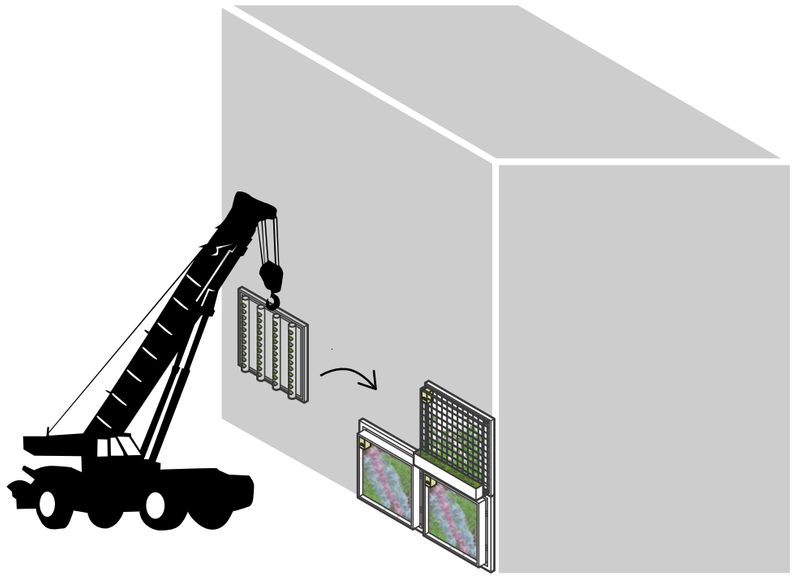
The Theory of Island Biogeography

Convergent demands of nesting, feeding and resting space ecotopes

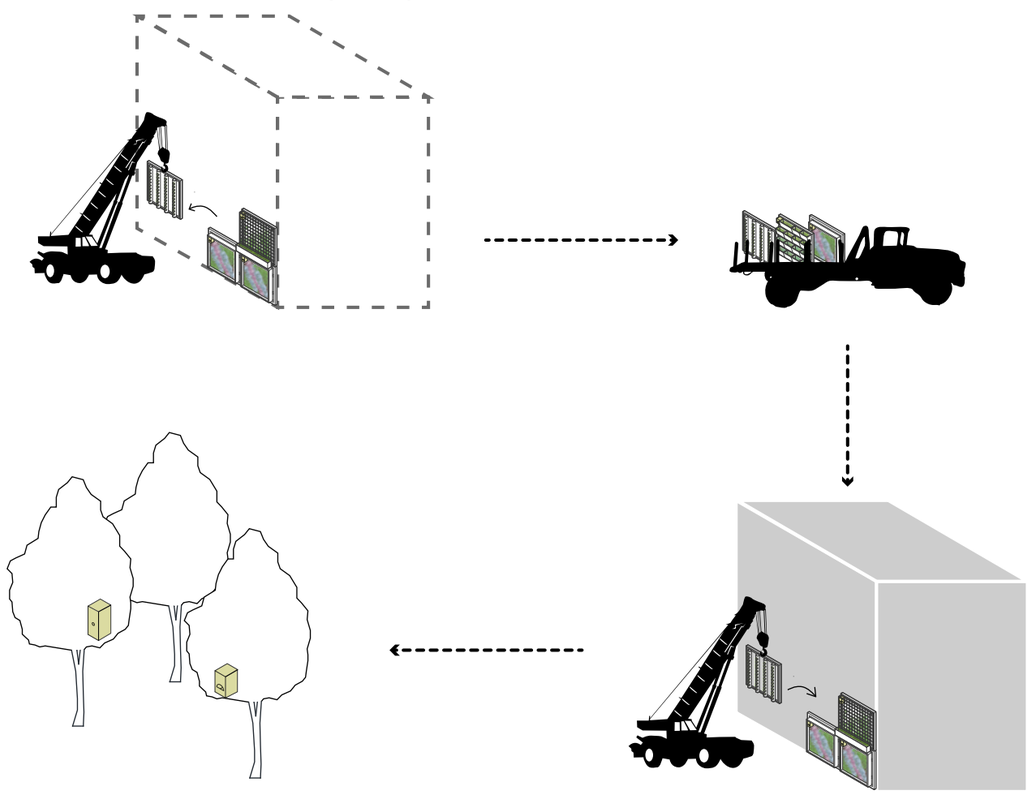
Nest sites should be provided in or close to adequate food resources



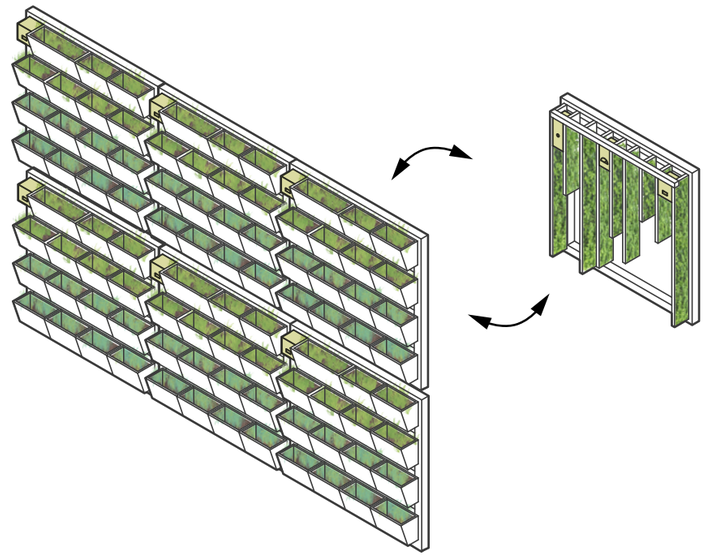
Why Modularity



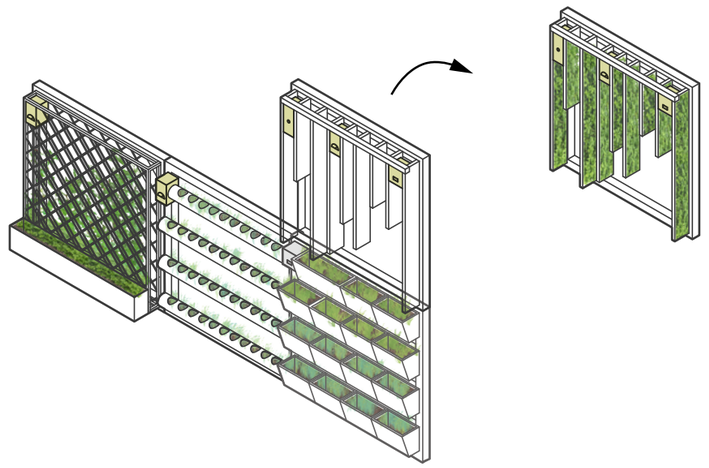
Quick installation without disturbing surrounding people and animals



Recoverable and recyclable



Flexbility(to respond to changes in animal needs)

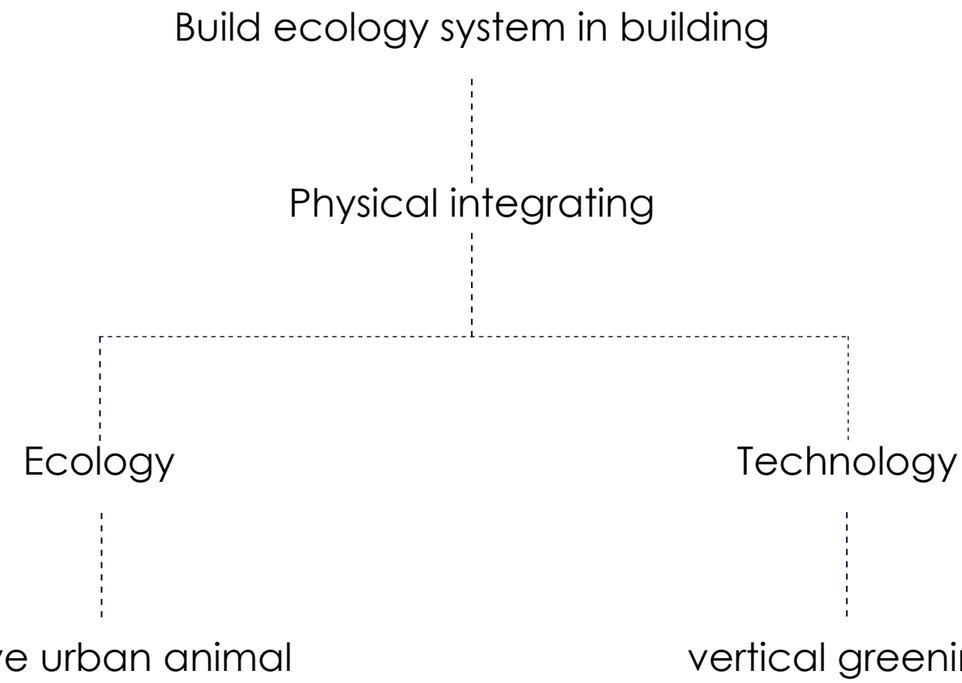


Easy to maintain

Research

Research question: How to use flexible modular vertical greening system to enhance the biodiversity of the city and build an ecological system on the building scale?

Sub question:
1.What is local biodiversity?
2.What is modular vertical greening?
3.How to combine the needs of urban animals with modular vertical greening system?



Research

Target species

Birds:

House sparrow

Black redstarts

Common swift

Oystercatcher

Bats:

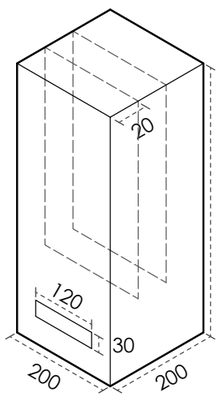
Common pipistrelle

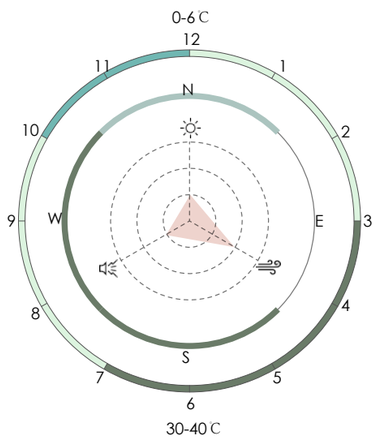
Insects: Wild bees

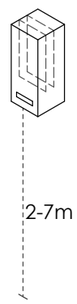
Plants: Native plant species

Result1: Native urban animal

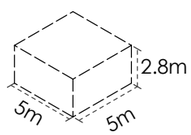
Needs for nesting and breeding space







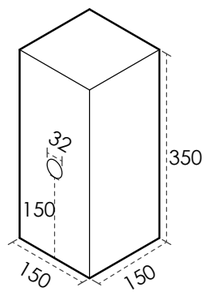
Flying area

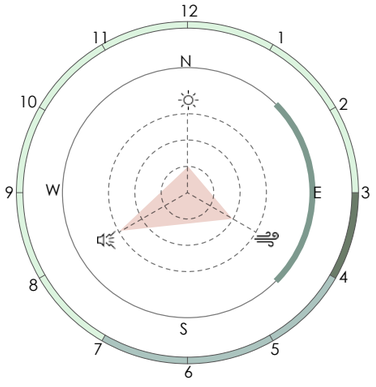


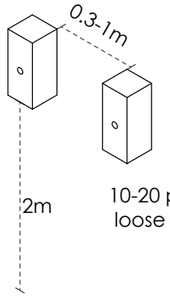
Material:
Rough (for grip)

- Breeding
- Nursing
- Active
- Hibernate
- Migrate

HS

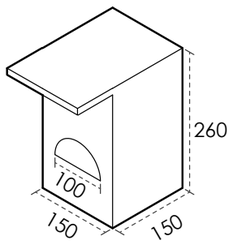


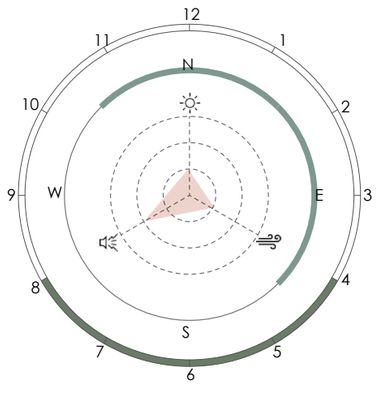


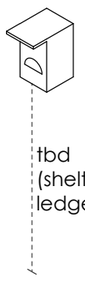


10-20 pairs
loose colony

BR



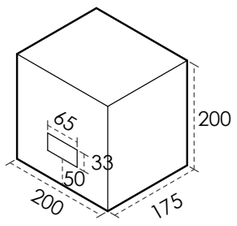


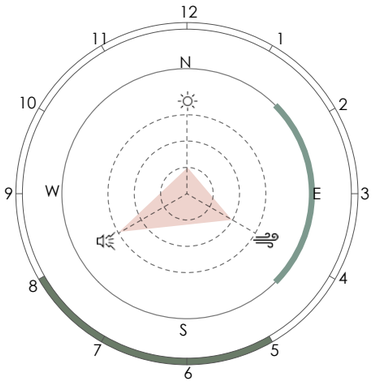


Attracted to
brown roofs or
ecoroofs

tbd
(sheltered
ledges)

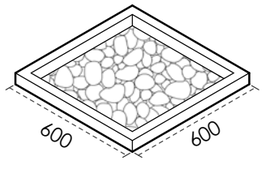
CS

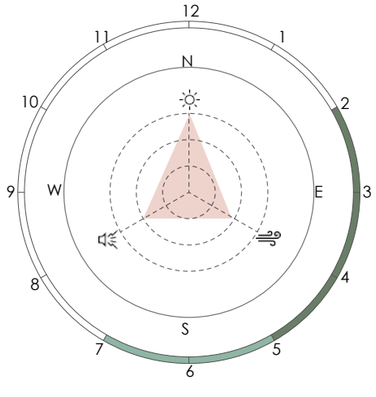




several
potential
nests

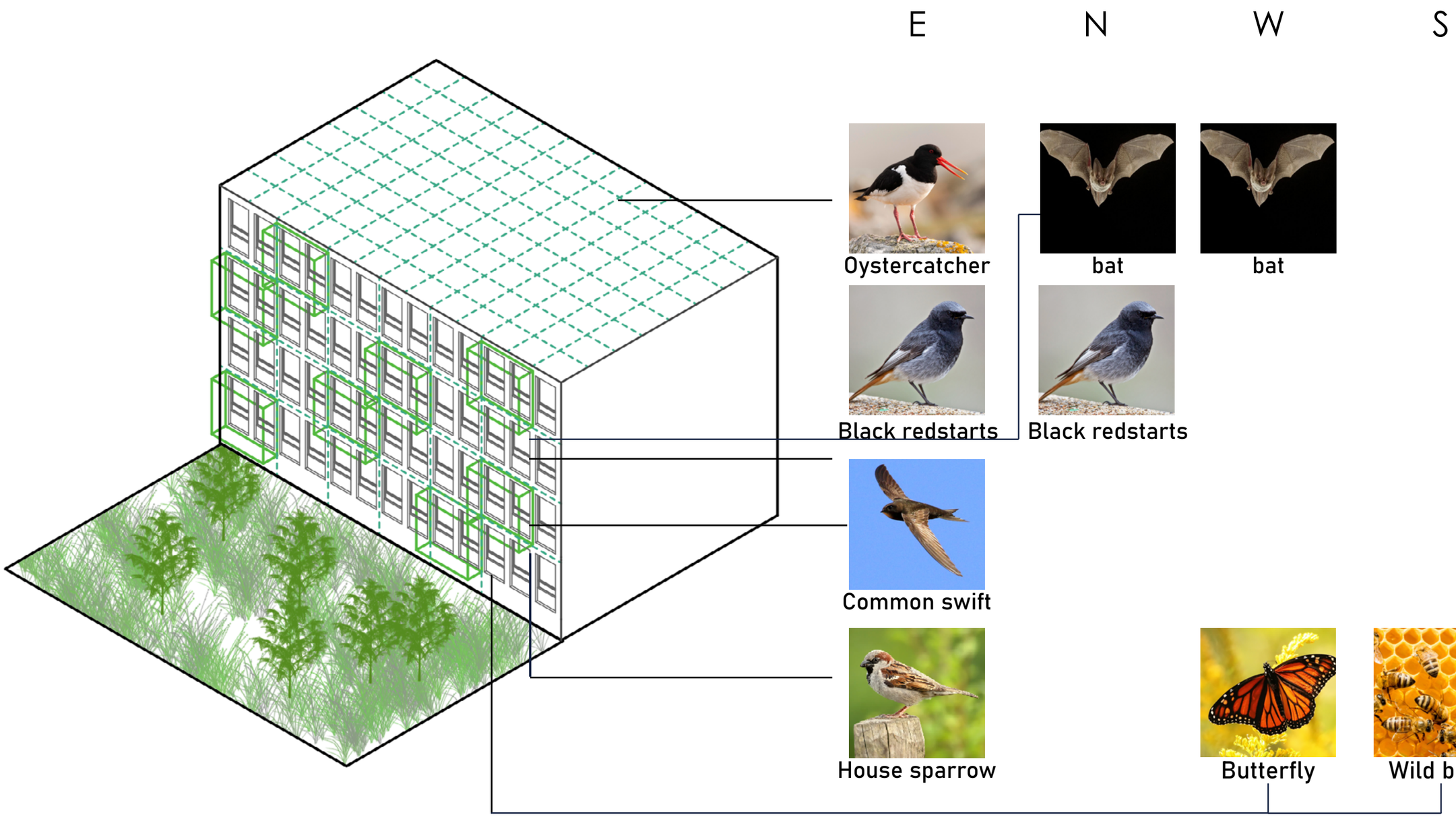
OC





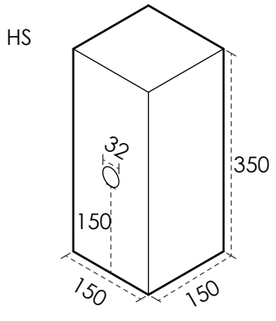
Result1: Native urban animal

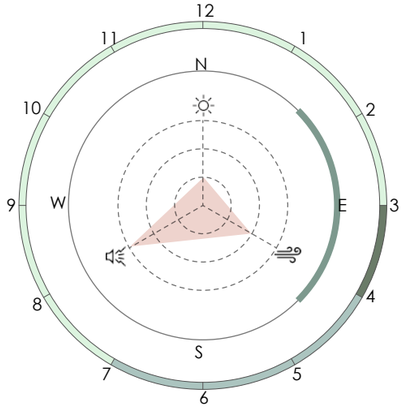
Different nesting positions in the building



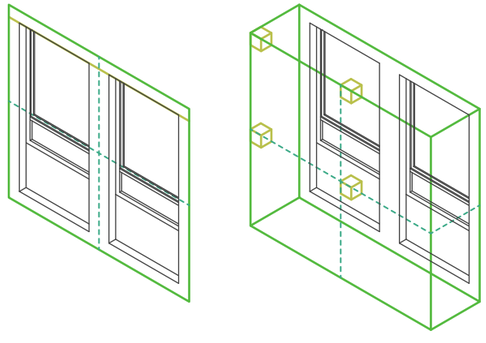
Result1: Native urban animal

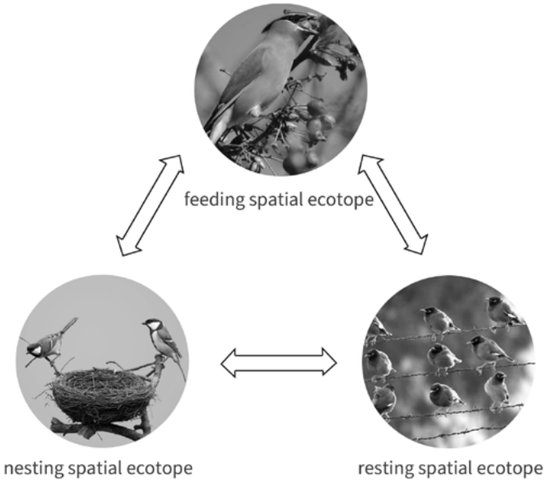
Ecotopes in different scales





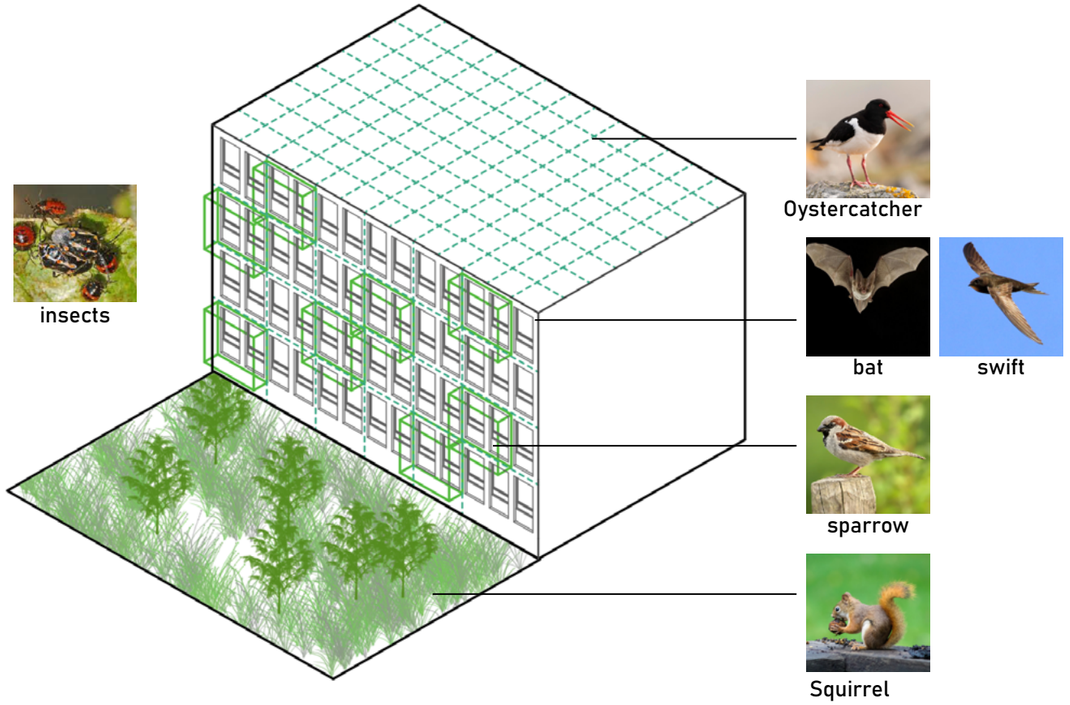
nesting spatial ecotope





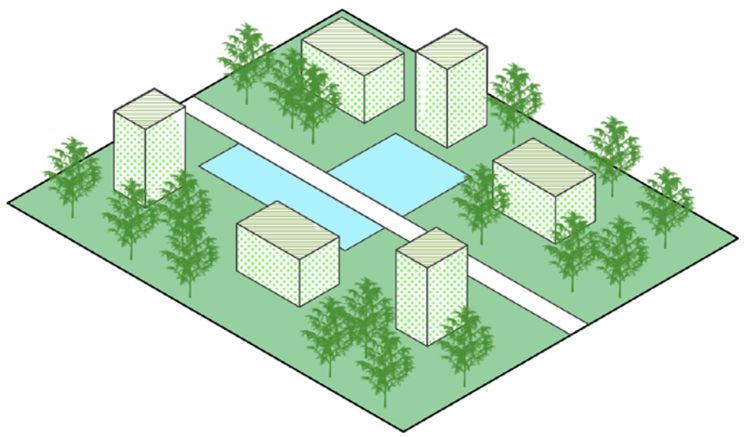
Element

Unit



Building

Creating better habitats for building-dependent species

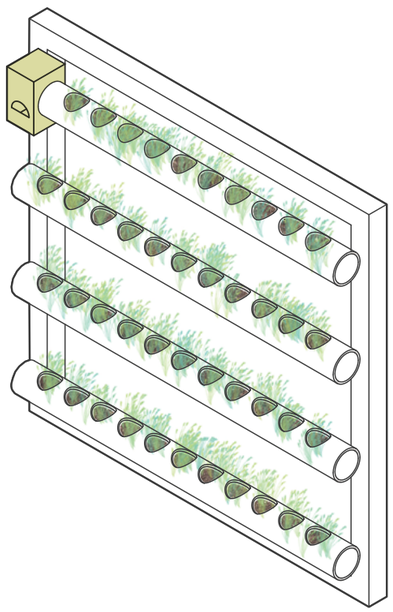


Neighbourhood

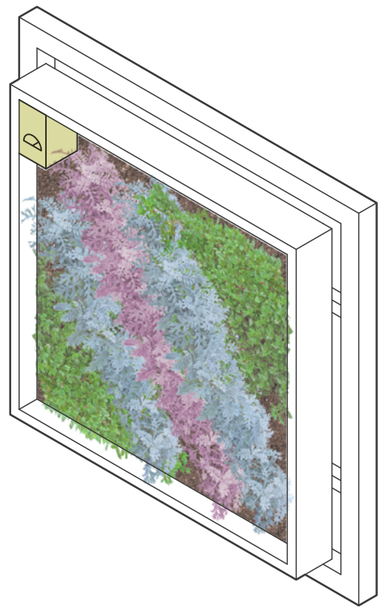
Result2:Vertical greening

Different types of green walls

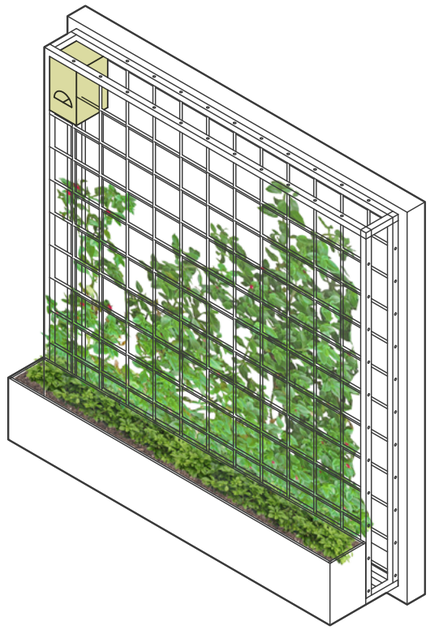
Pipe living wall



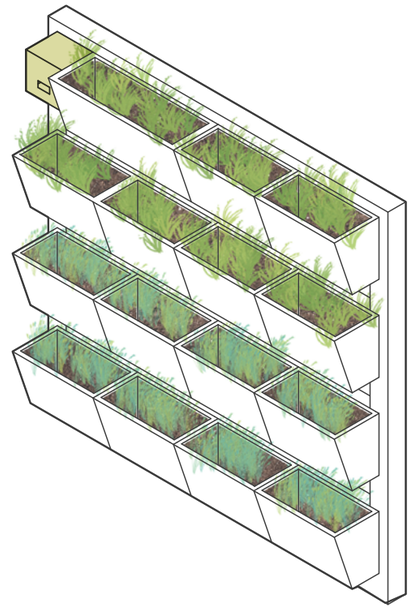
Panel living wal



Indirect green wall mesh support



Planter living wall

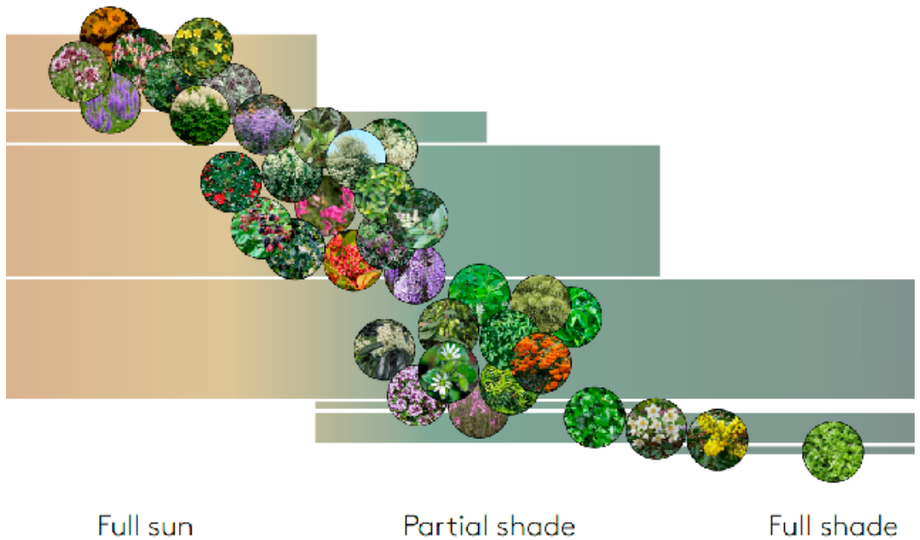


Result2: Vertical greening

Requirements for plant species and green wall structures

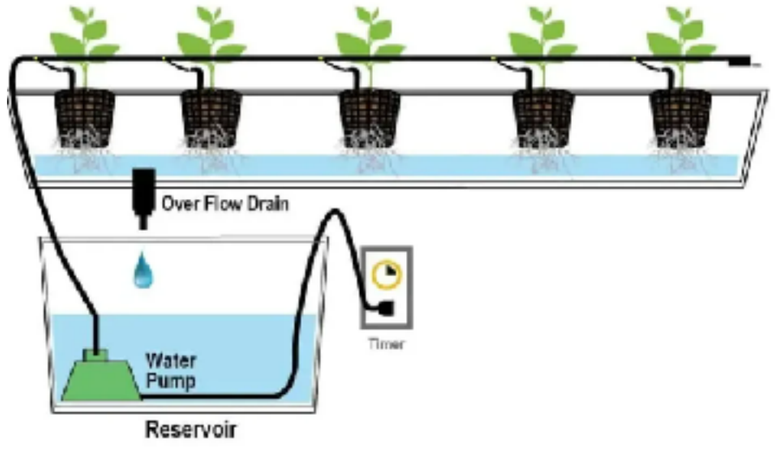
Species:

Evergreen species

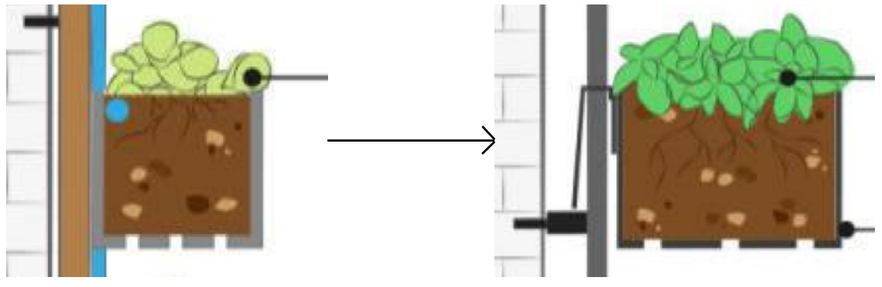


Native species

Structure:



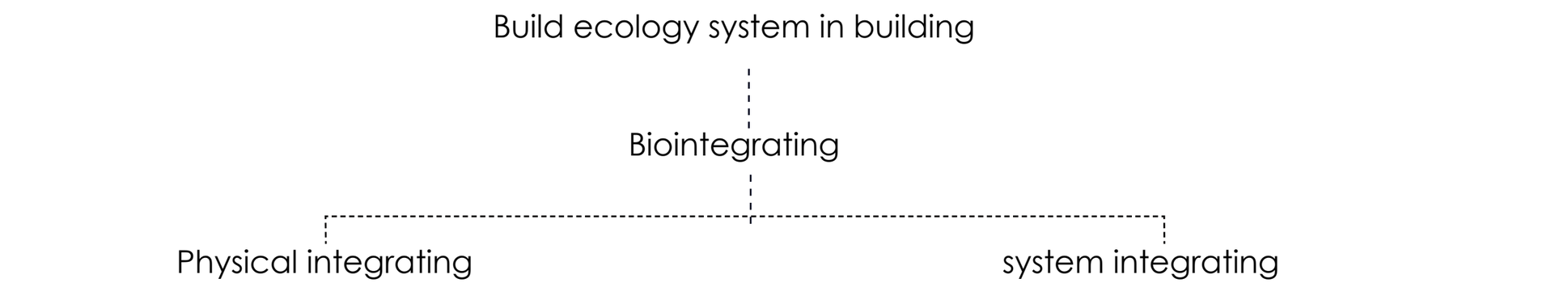
Drip irrigation

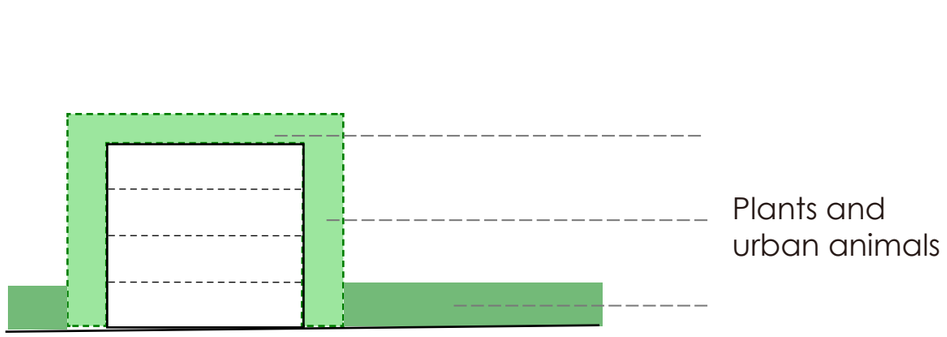


Enlarge rooting area
(new containers)

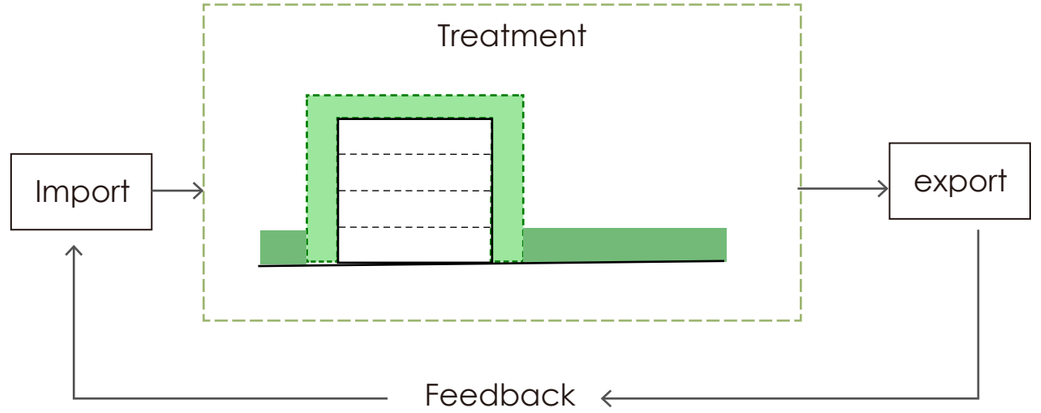
Result3: System integration

Modelling natural ecosystem





Modelling biological structures in ecosystems

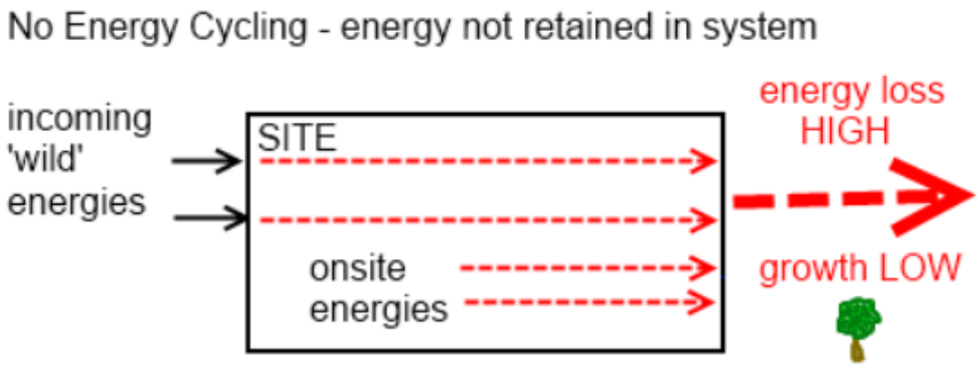


Modelling energy cycles in ecosystems

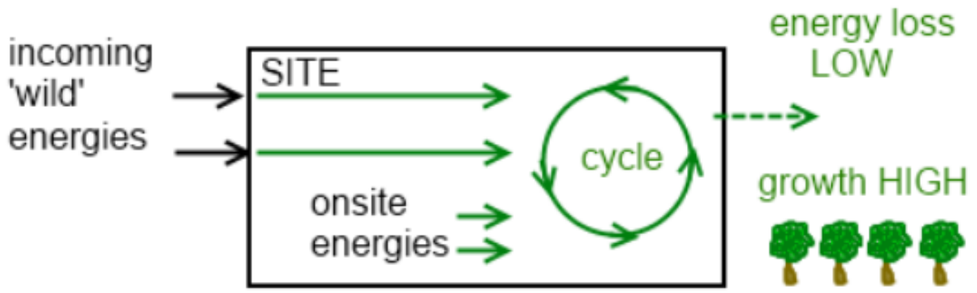
Result3: System integration

Create energy cycle

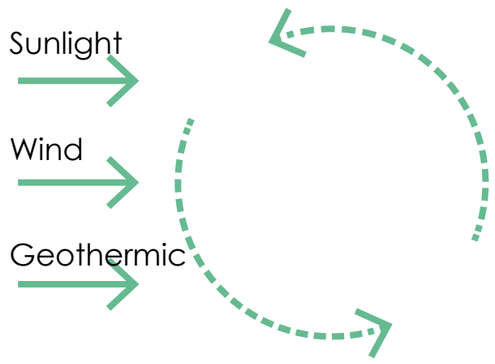
Existing



New



Bioclimatic design

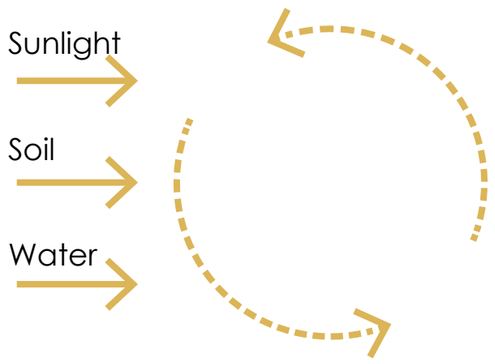


Shade/Heat storage

Natural ventilation

Geothermal heating systems

Energy cycle

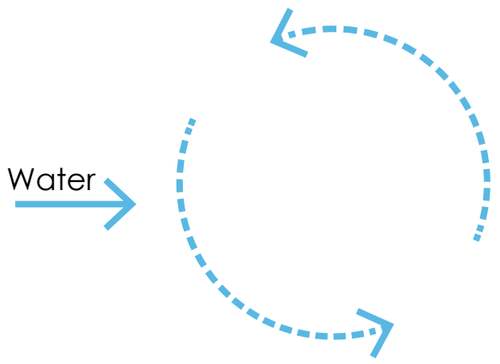


Permaculture

Compost piles

Scolar panel

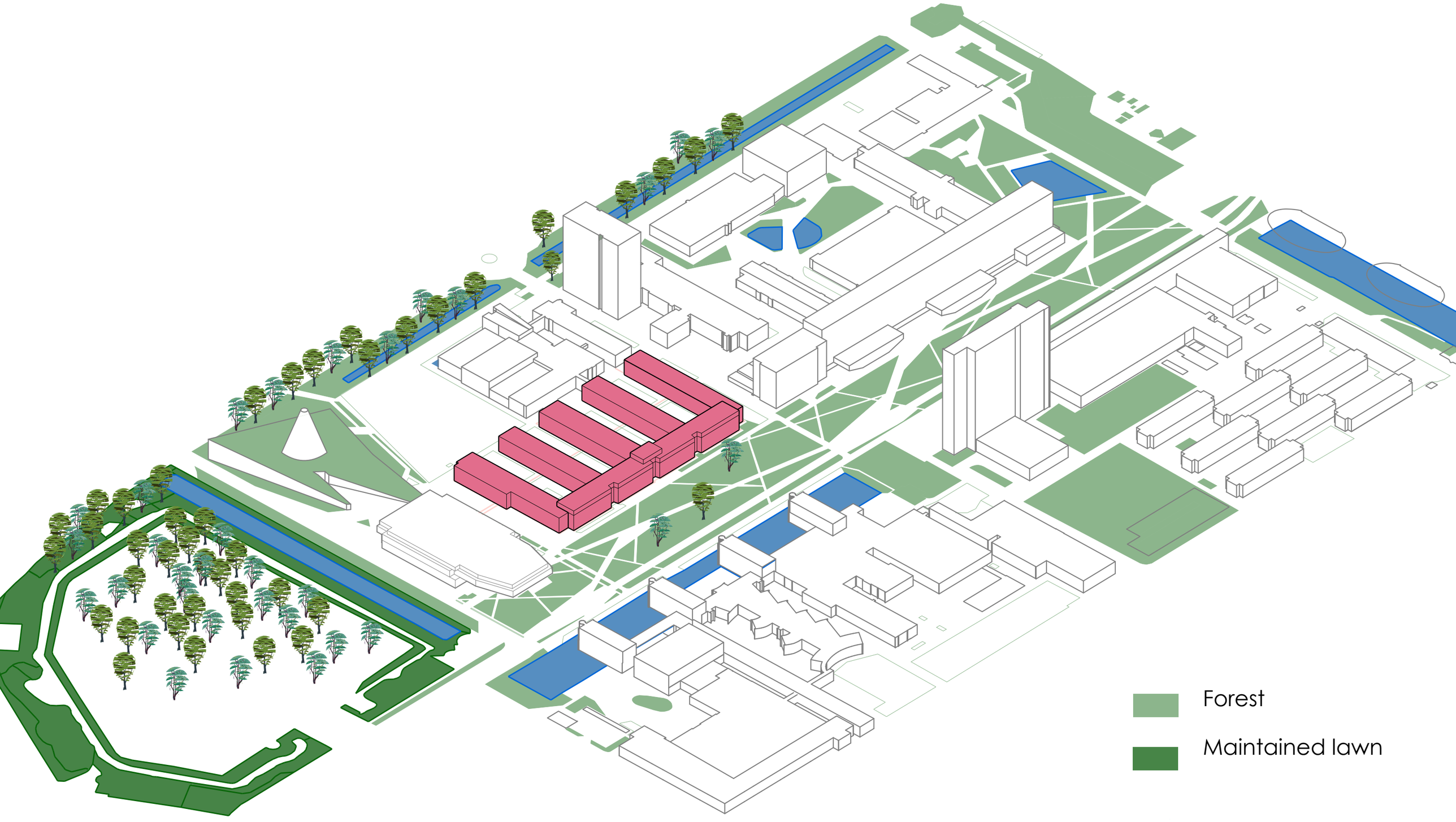
Water cycle



Green wall for greywater treatment

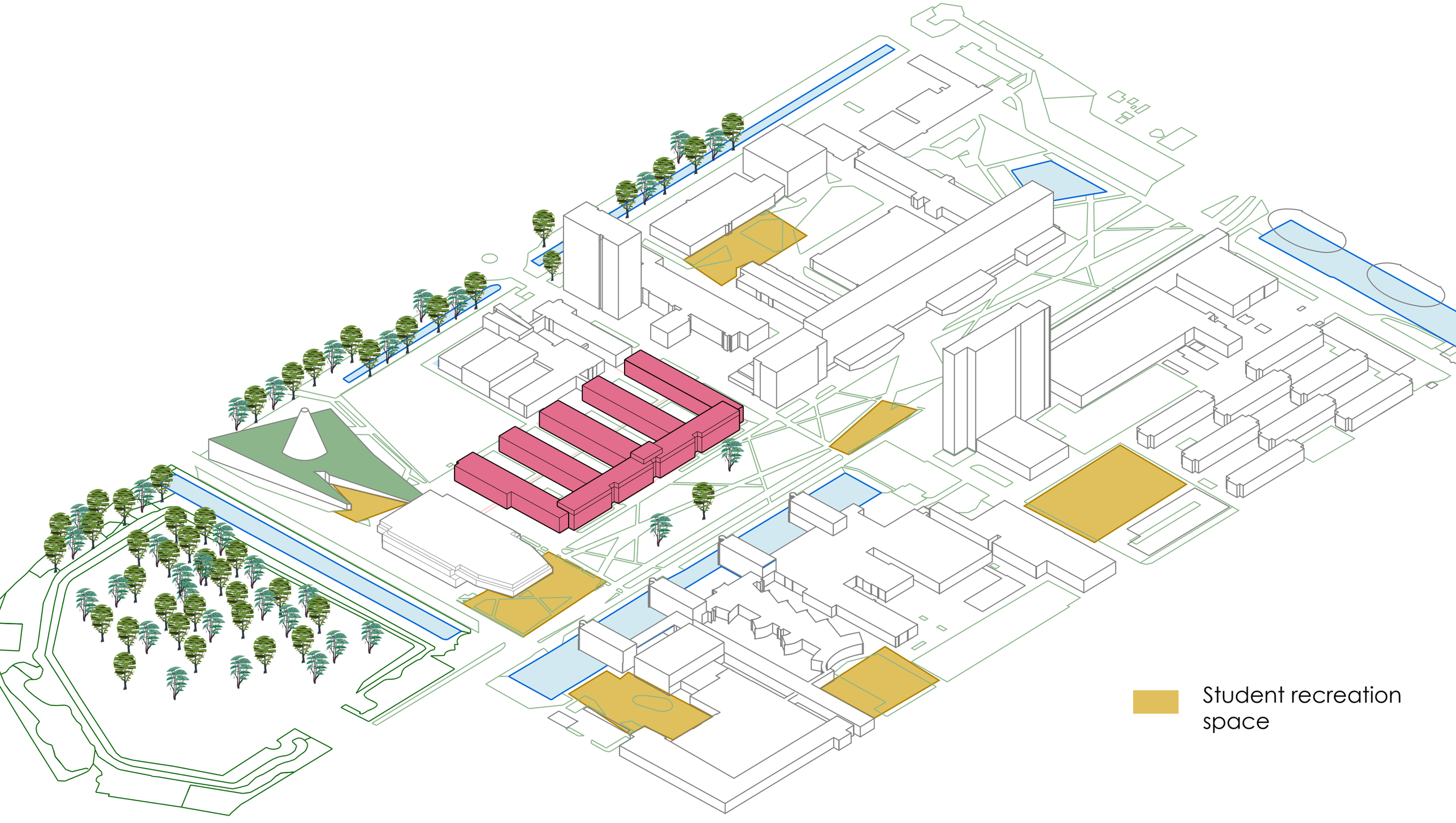
Context

Site analysis-Greenary and water



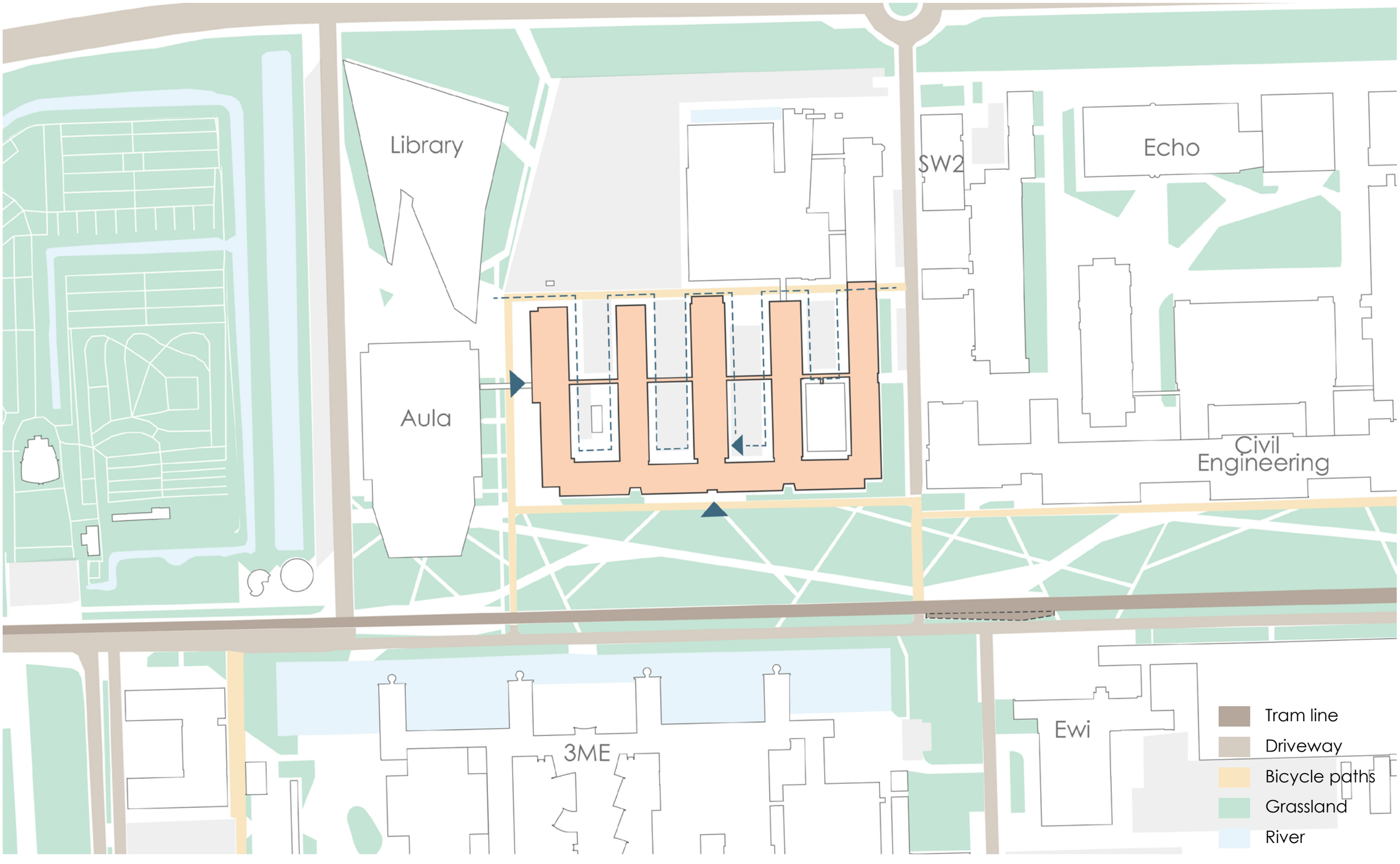
Context

Delft campus-Area vision



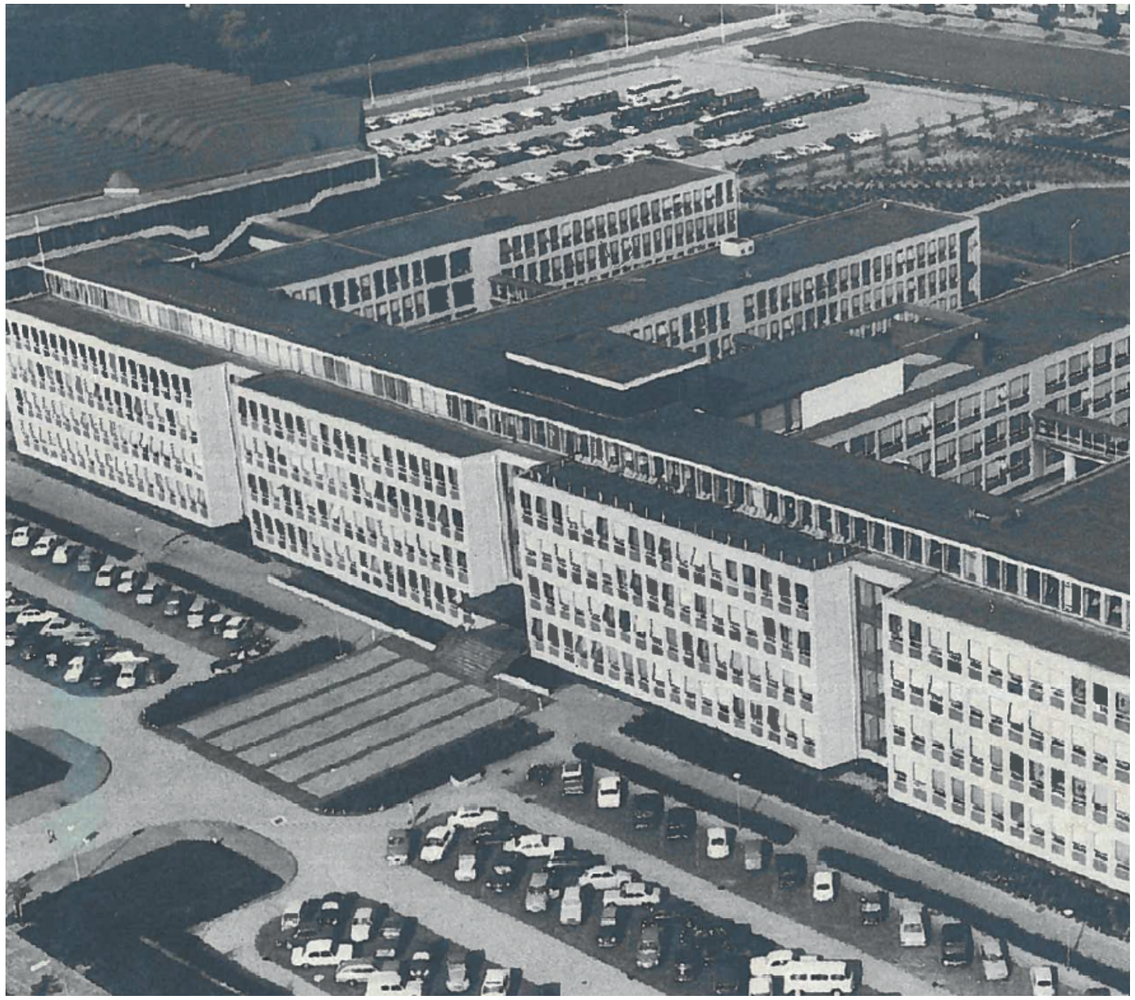
Context

Site analysis-Transportation



Context

TNW



Context

TNW-Courtyard

1.Courtyard space used for parking, lack of landscaping
2.Lack of funtion within
3.Lack of places to stay within

The courtyards are not connected to each other and there are many dead end spaces

Context

TNW-Surrounding Green Space

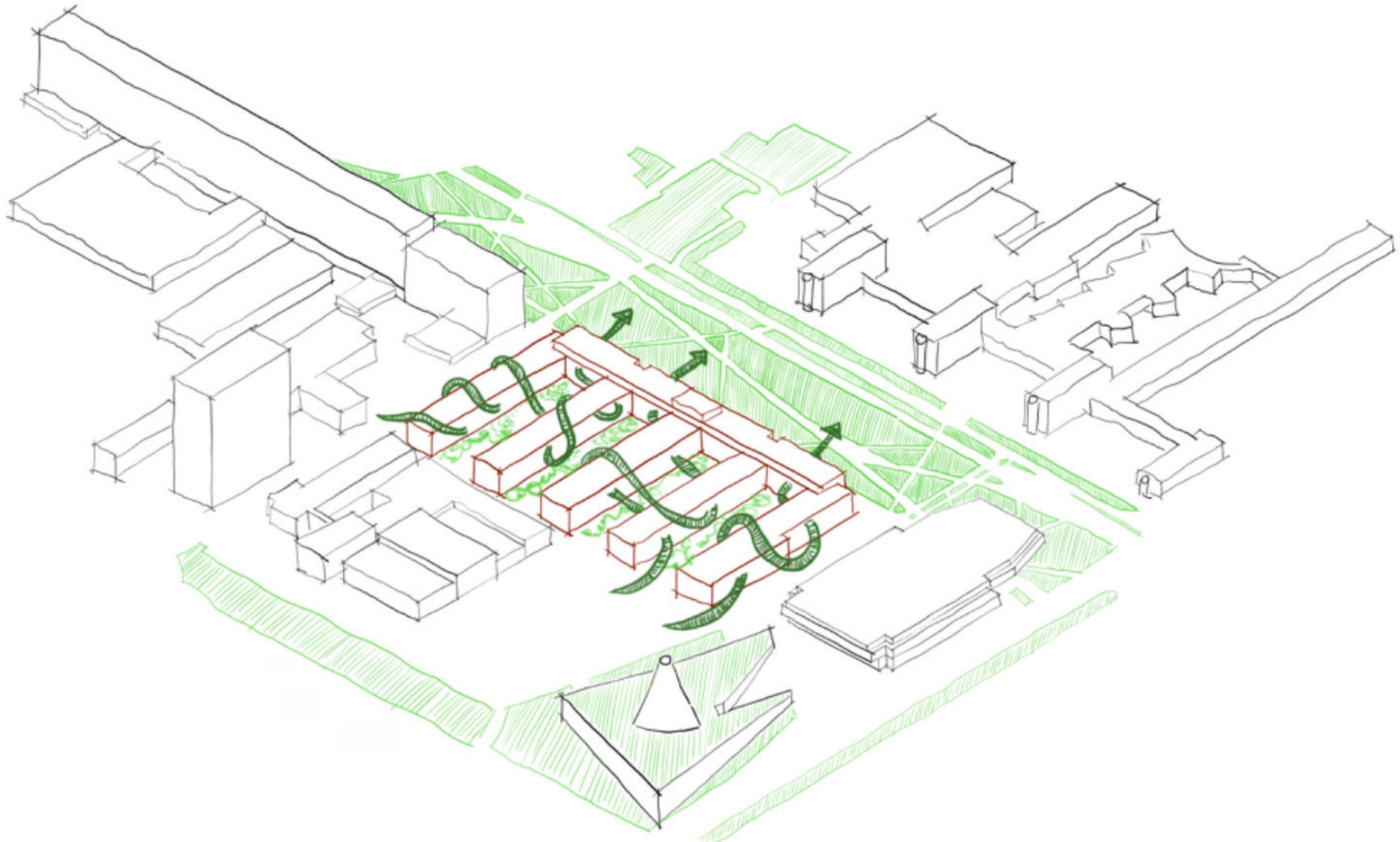
The plants are homogenous and over-maintained artificially--
lack of biodiversity

Bike lanes isolate the building from the green space

Design

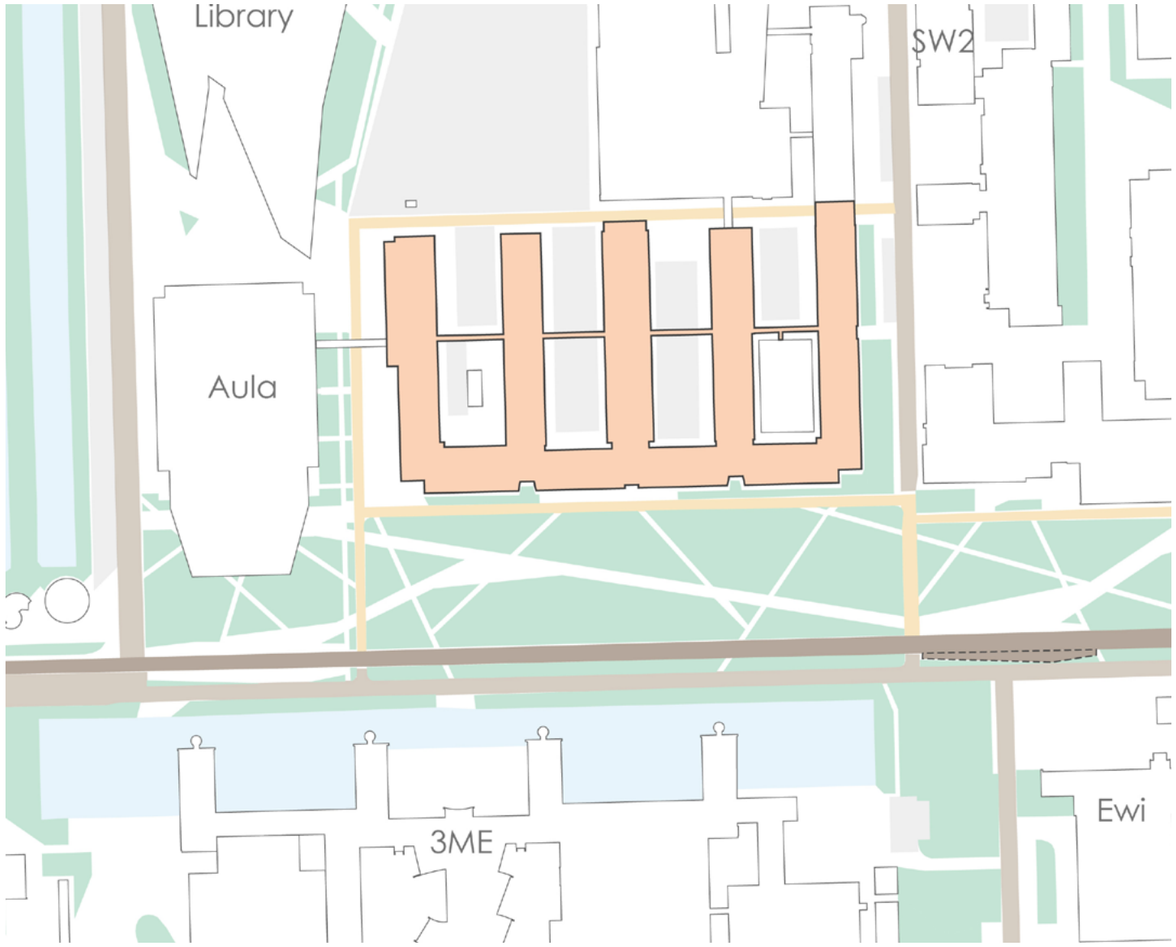
Concept

Make TNW building integrating with ecology system



Design

Horizontal ecological connection

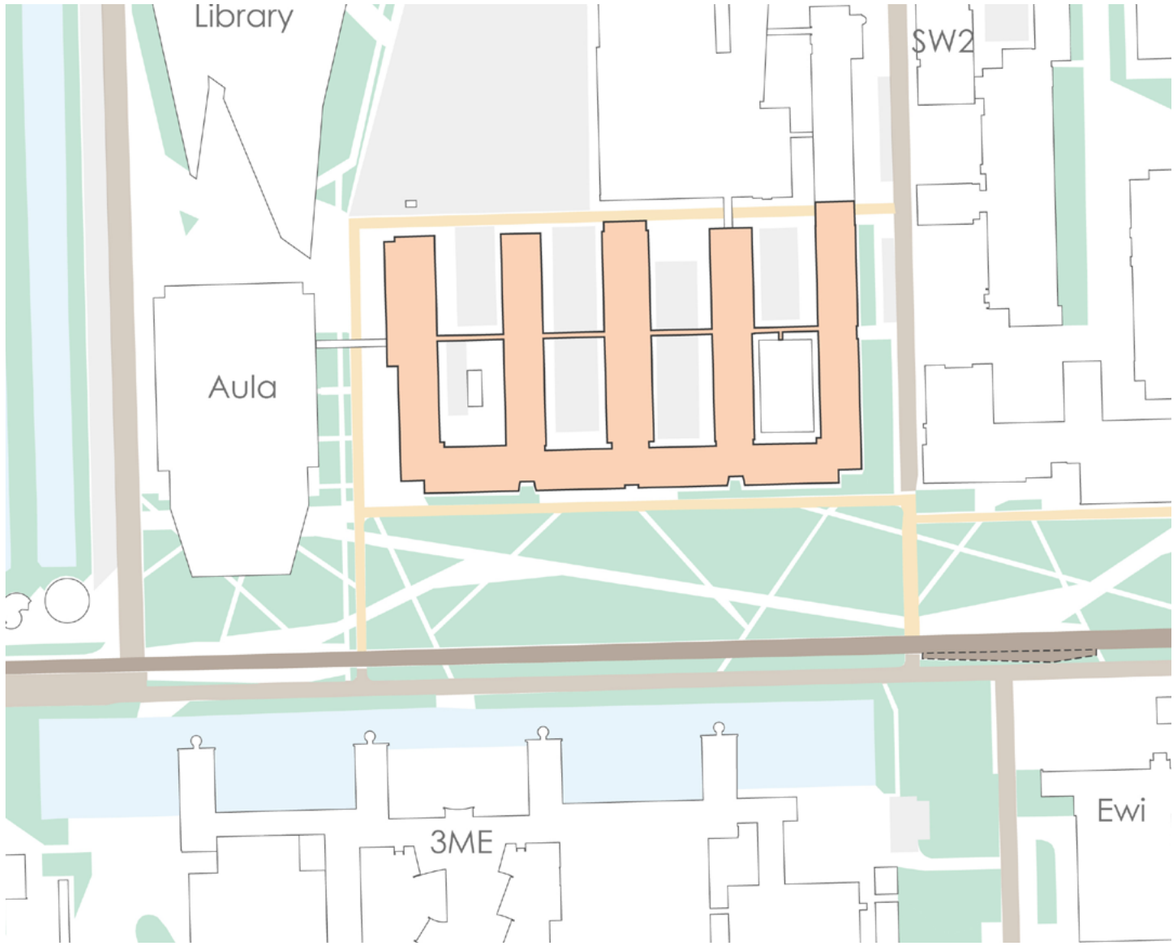


Tram line
Driveway
Bicycle paths
Grassland
River

Greenfield
Courtyard garden
Student housing
Public function
Green atrium

Design

Vertical ecological connection

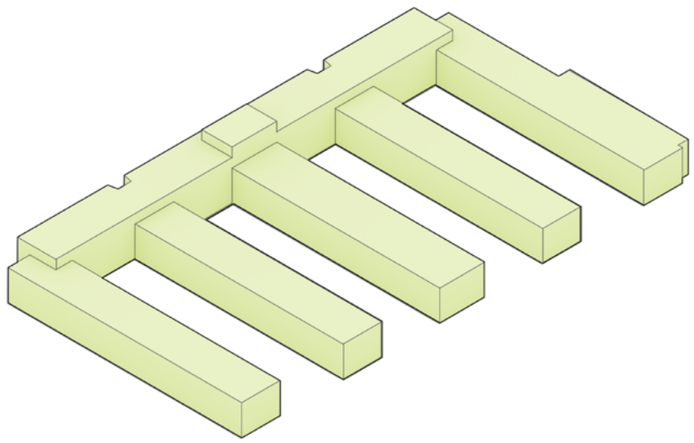


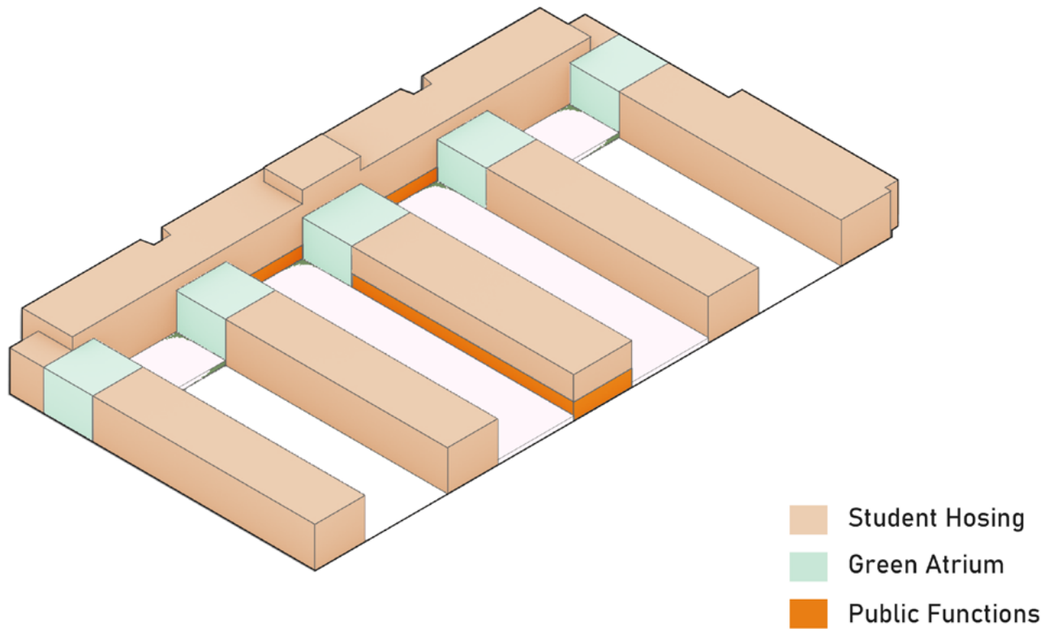
Tram line
Driveway
Bicycle paths
Grassland
River

Green roof
Green balcony
Green atrium

Design

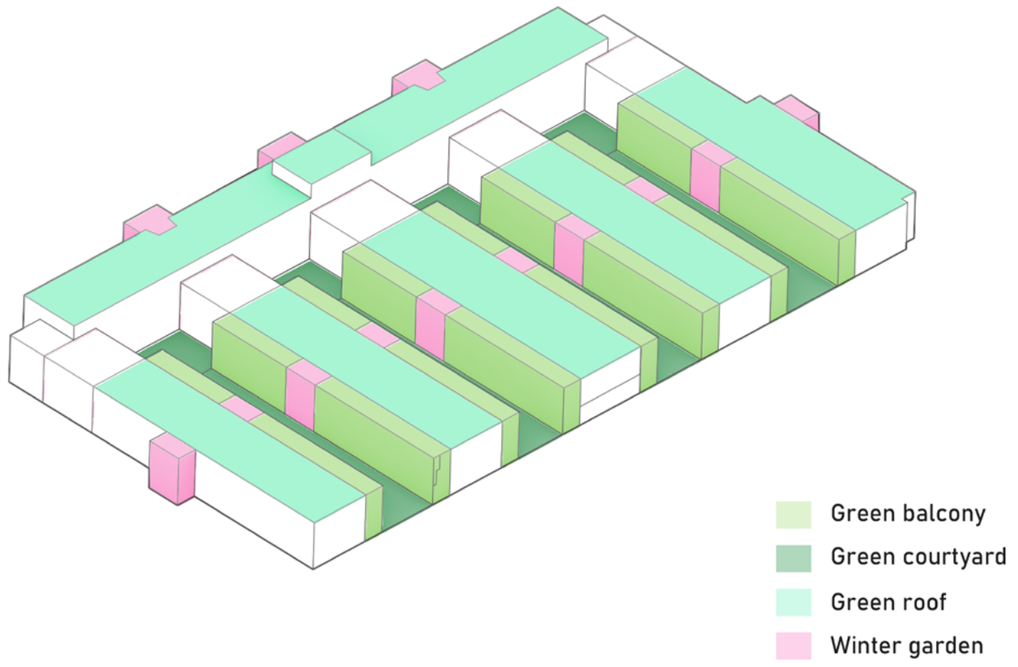
Program





Educational

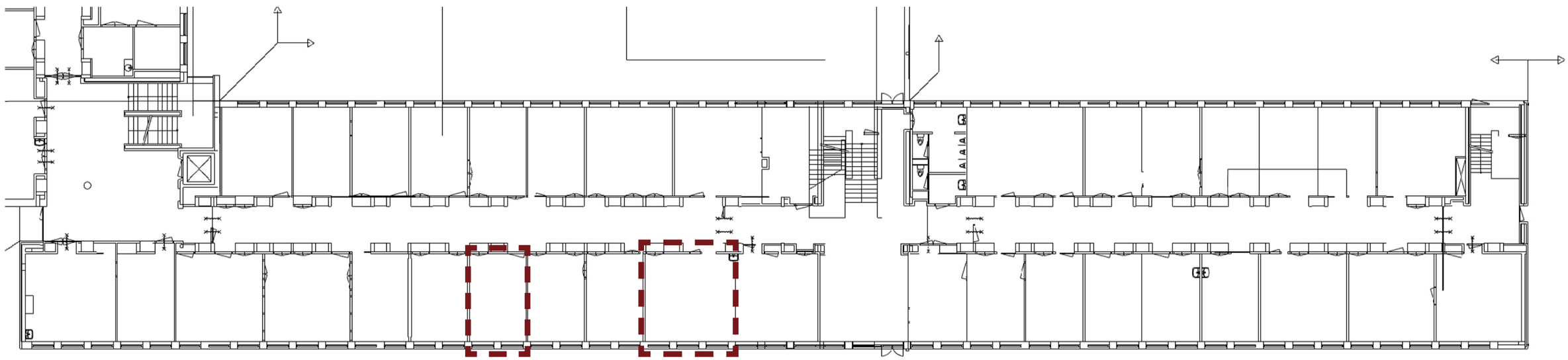
Collective housing+Urban gardening



Design

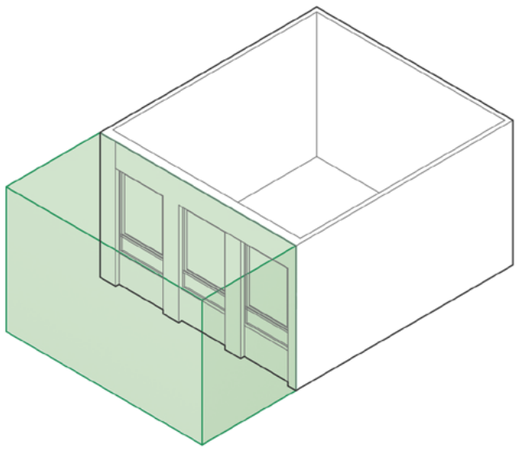
Modular green balcony

Principle: Reuse internal walls of old buildings where possible

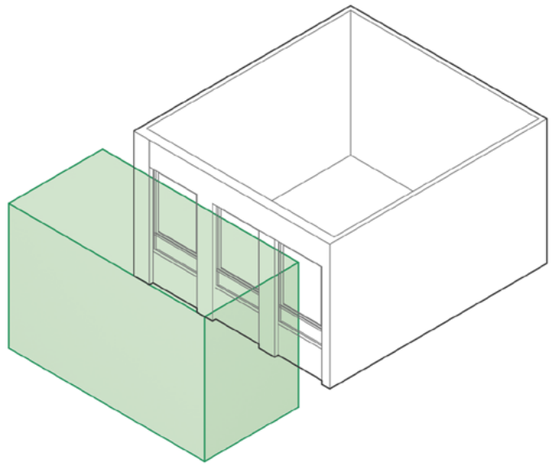


Design

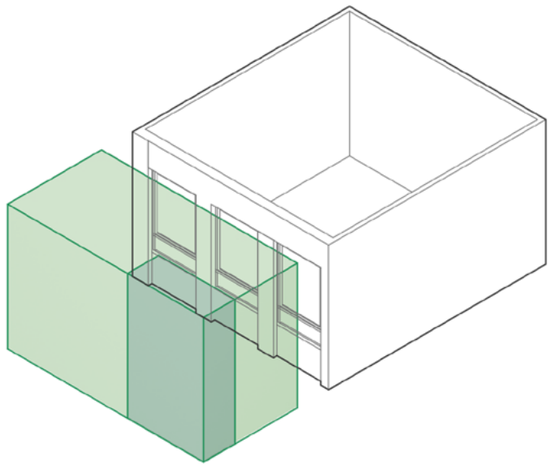
Modular green balcony-mass study development



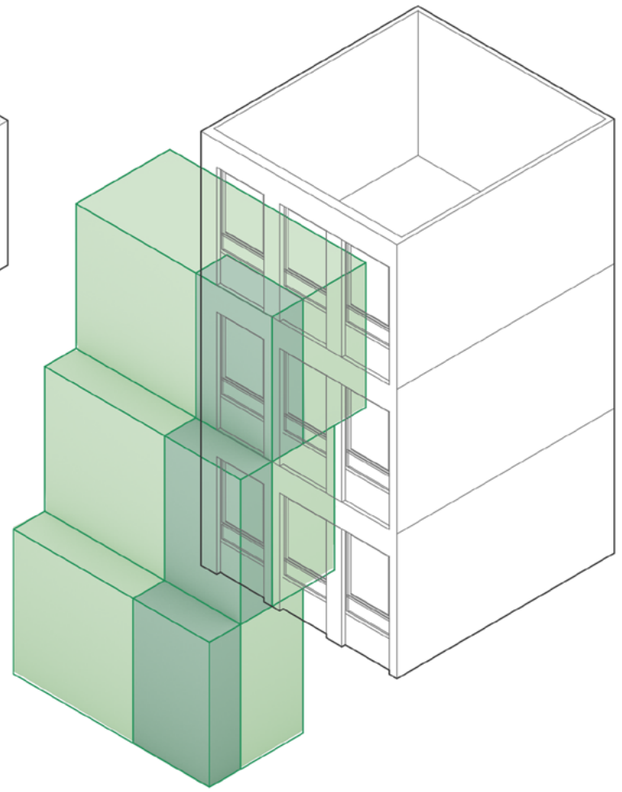
Extend a balcony space outside the existing building to give residents enough space for their activities.



Add gaps between the new addition and the existing building. To increase light and create a contrast between the old and new structures.



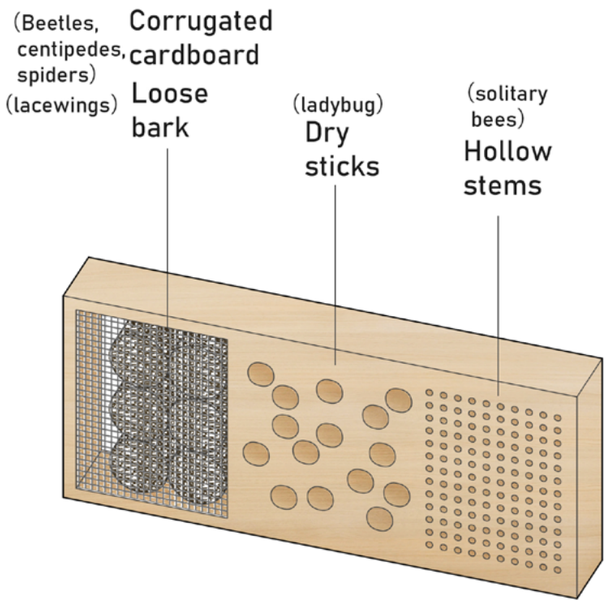
Divide a part of the balcony to be used for animals so that people cannot enter. At the same time this space is used as part of a continuous landscape.

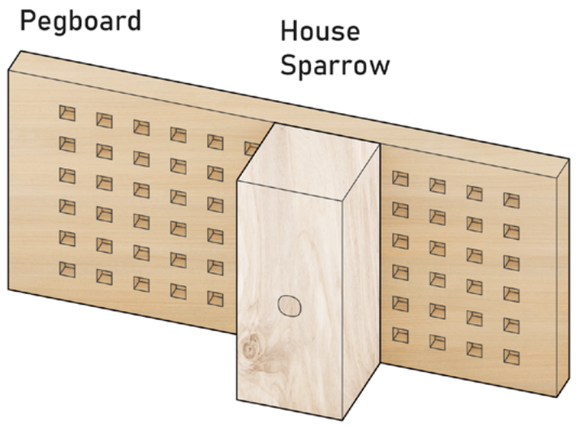


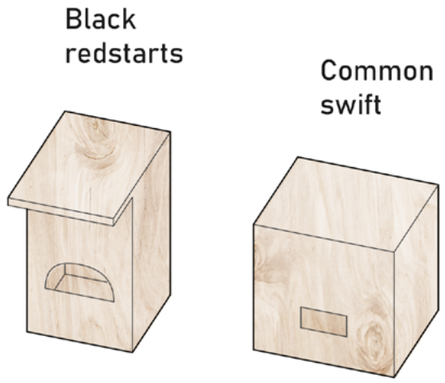
To simulate a mountain in nature, also for collect more rainwater and have visual communication. The balcony was built in the shape of a terrace.

Design

Modular green balcony-ecological meeting point



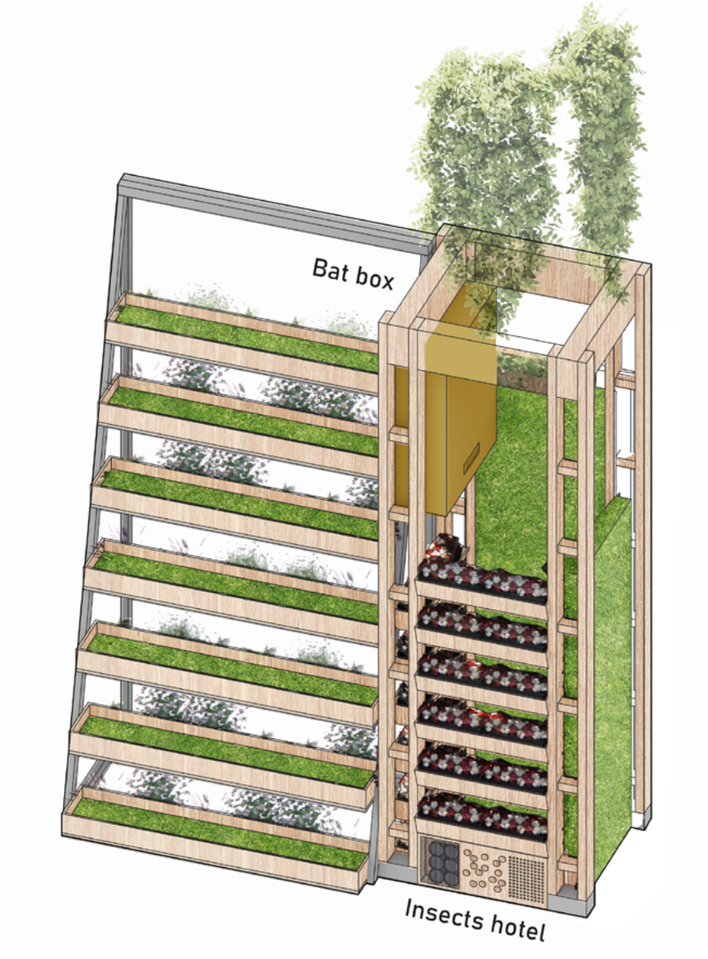


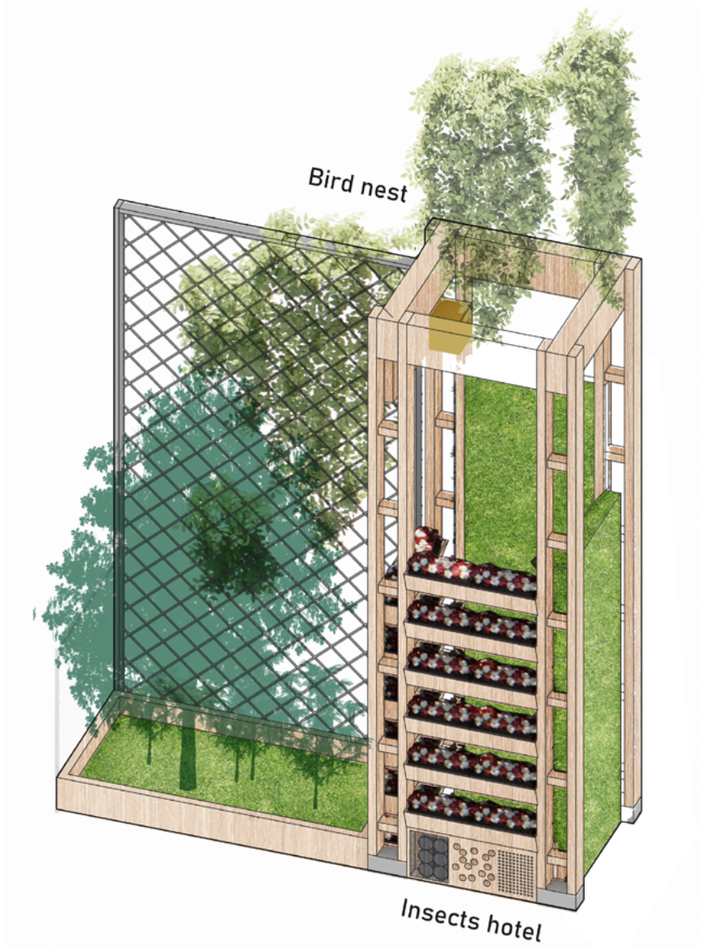


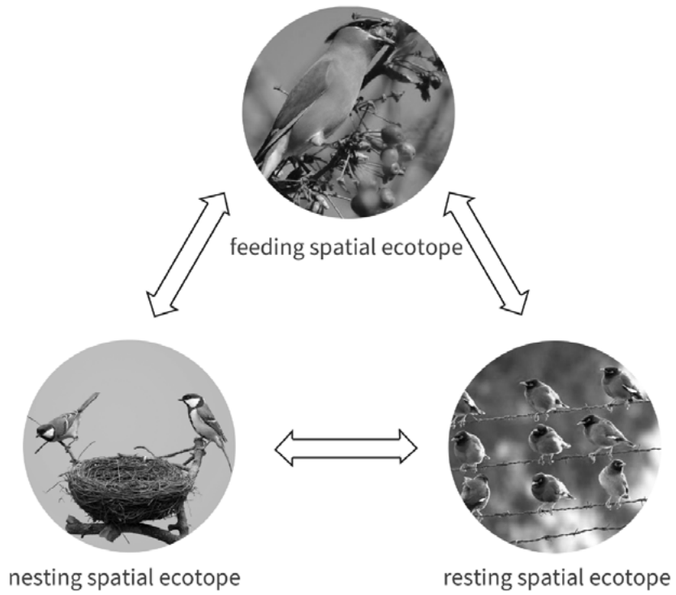
nesting spatial ecotope

Design

Modular green balcony-ecological meeting point

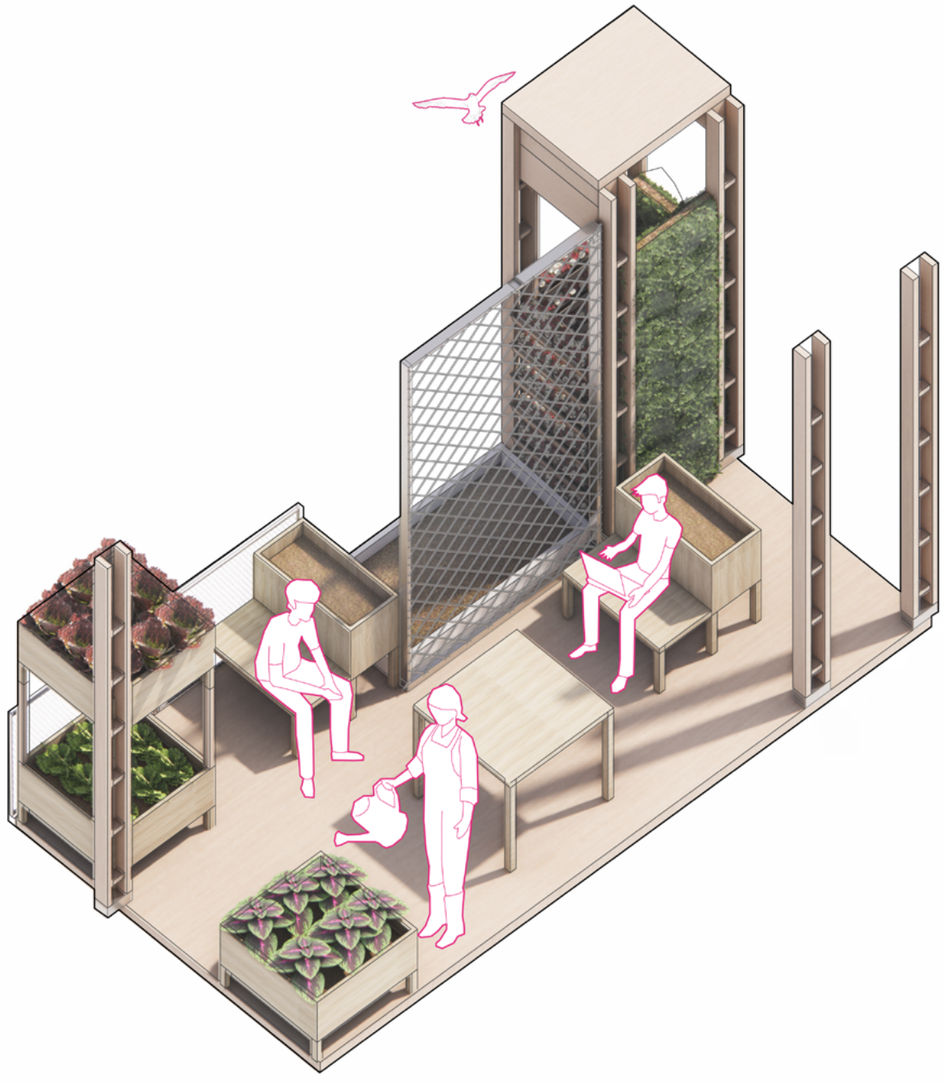


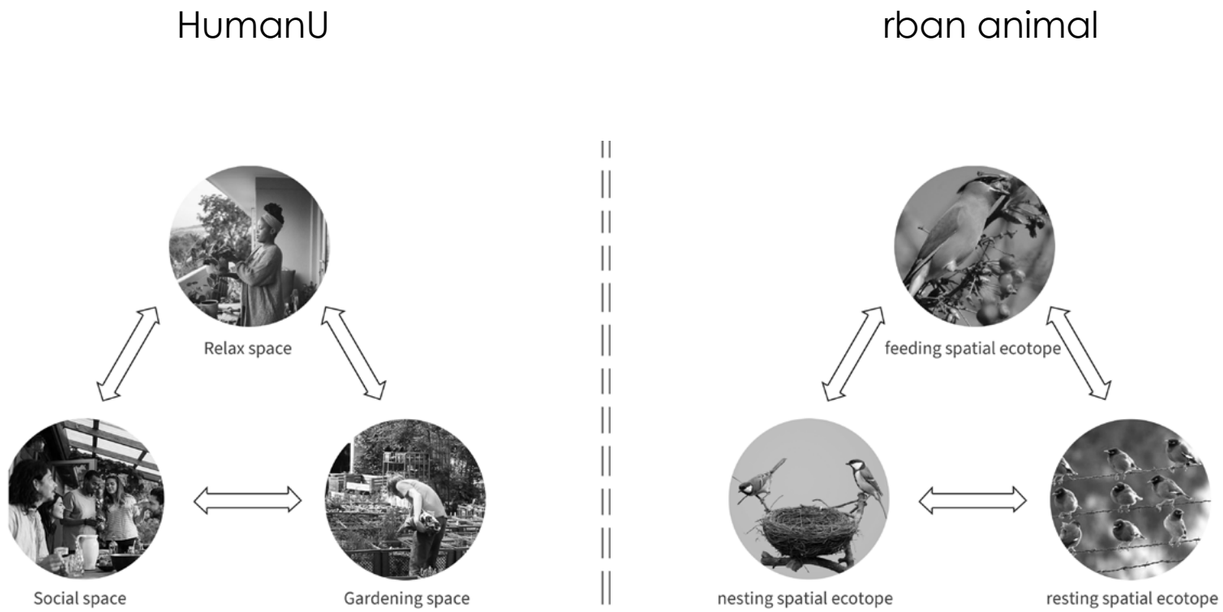




Design

Modular green balcony-ecological meeting point



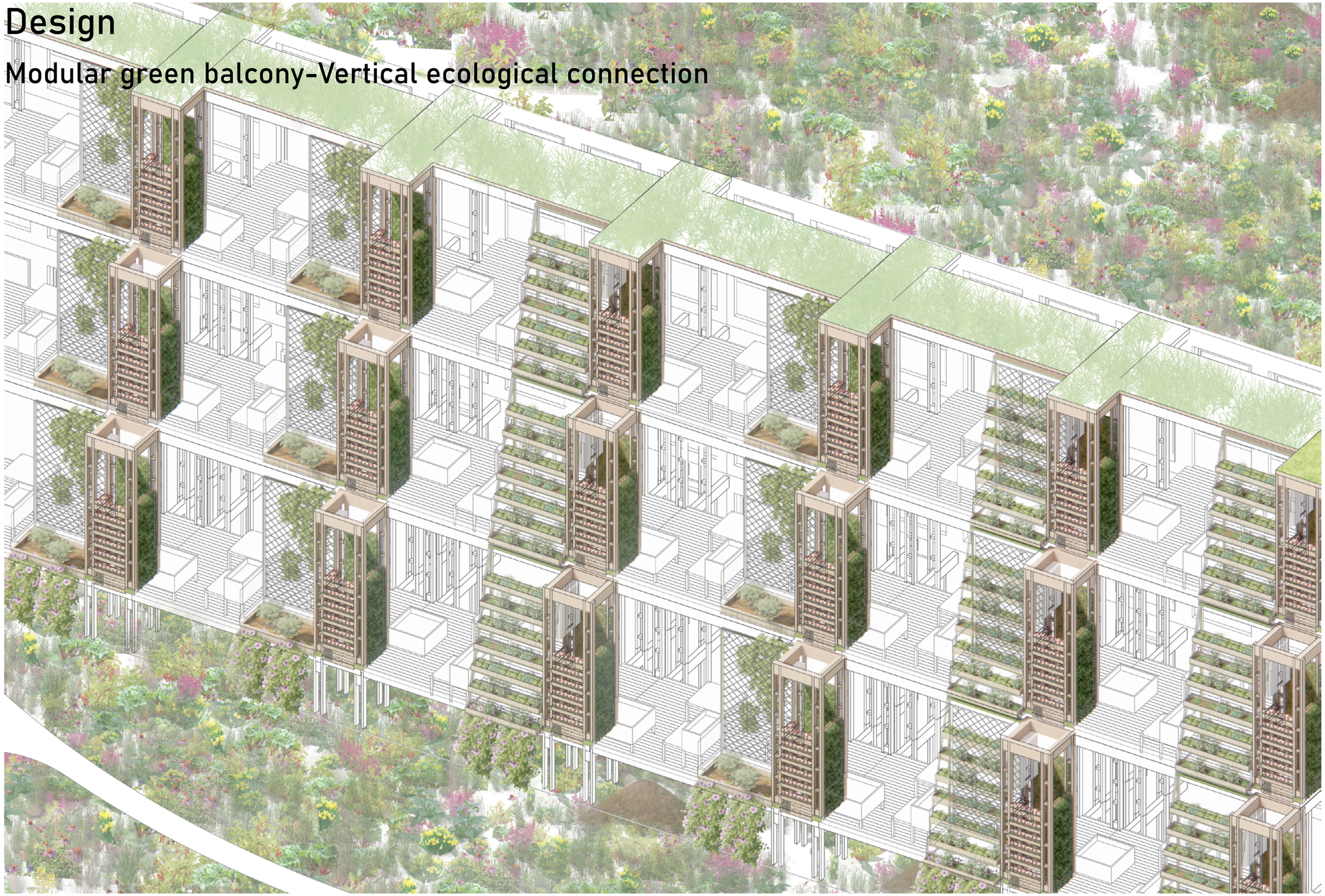


Design

Modular green balcony-Terrace shape

Design

Modular green balcony-Vertical ecological connection



Design

Modular green balcony-Vertical ecological connection

Oystercatcher

Black redstarts

Bat

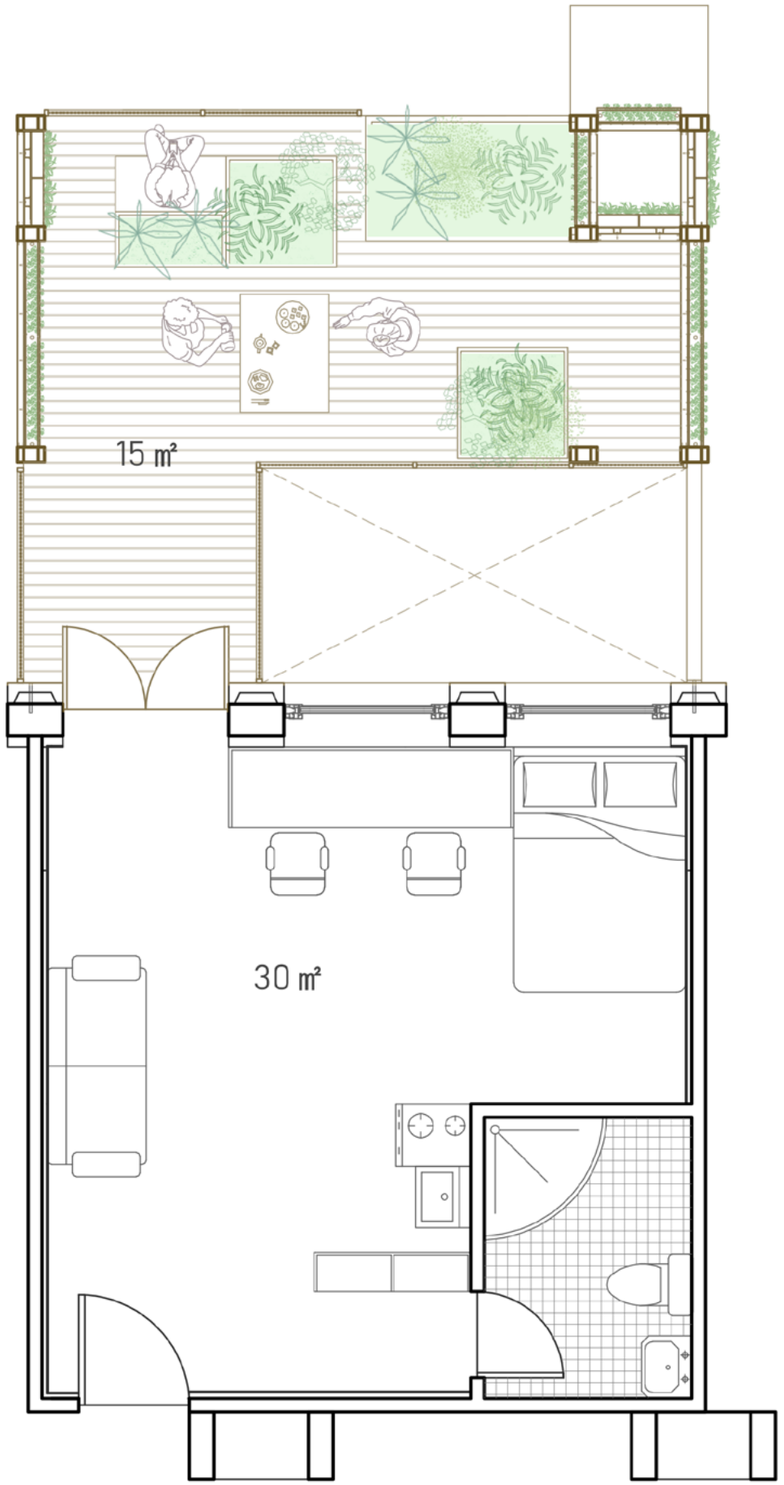
Common swift

House sparrow

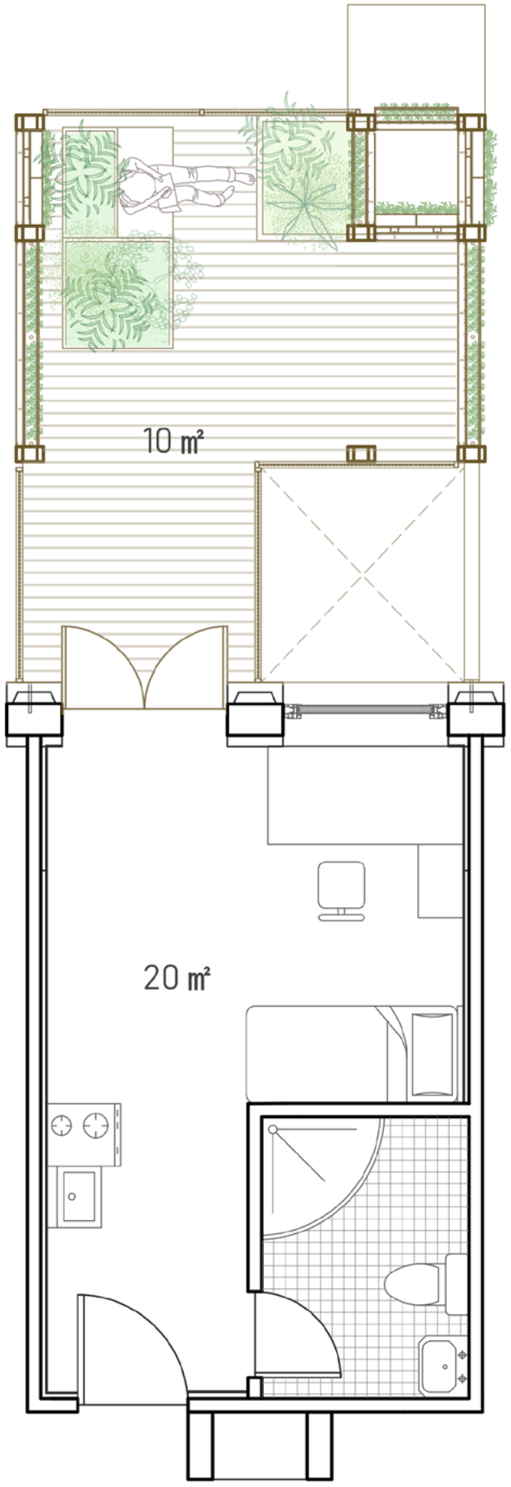
Butterfly

Wild bees

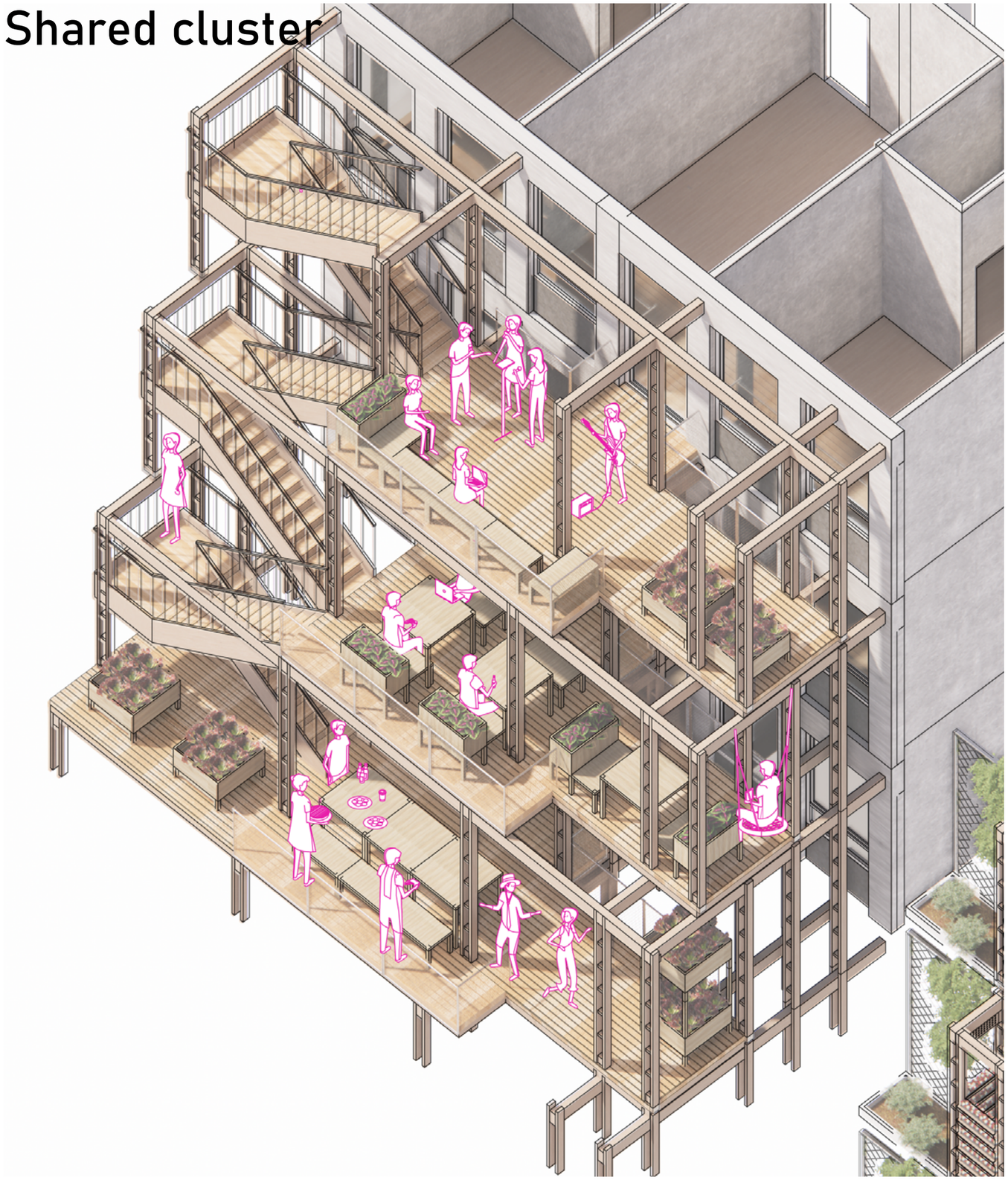
Studio A

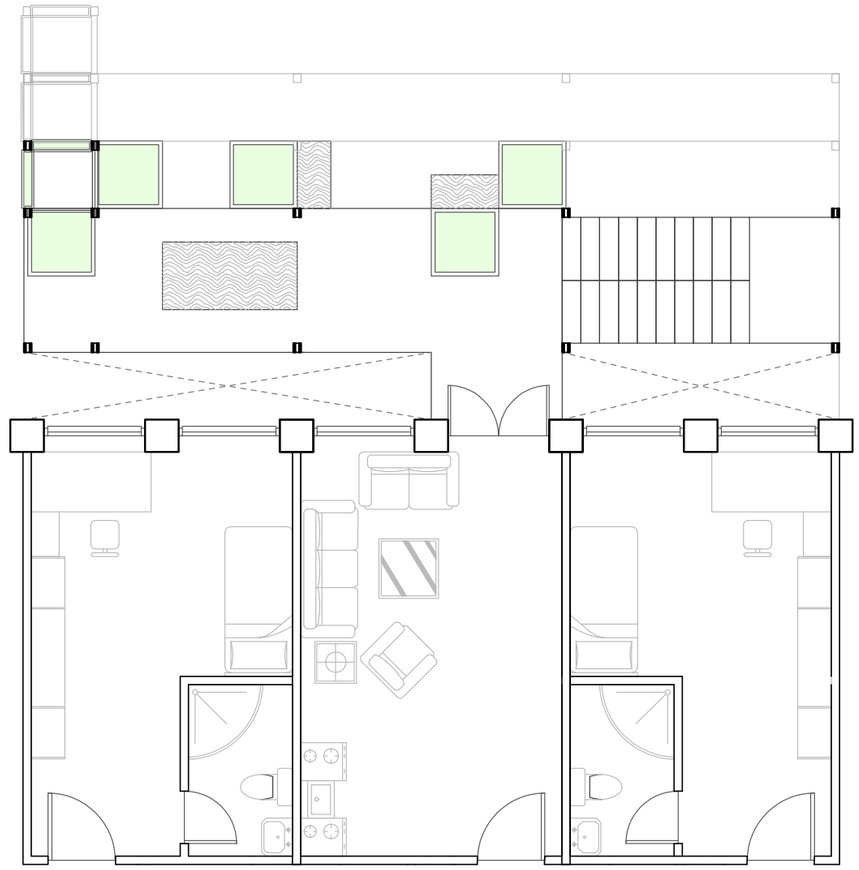


Studio B



Shared cluster

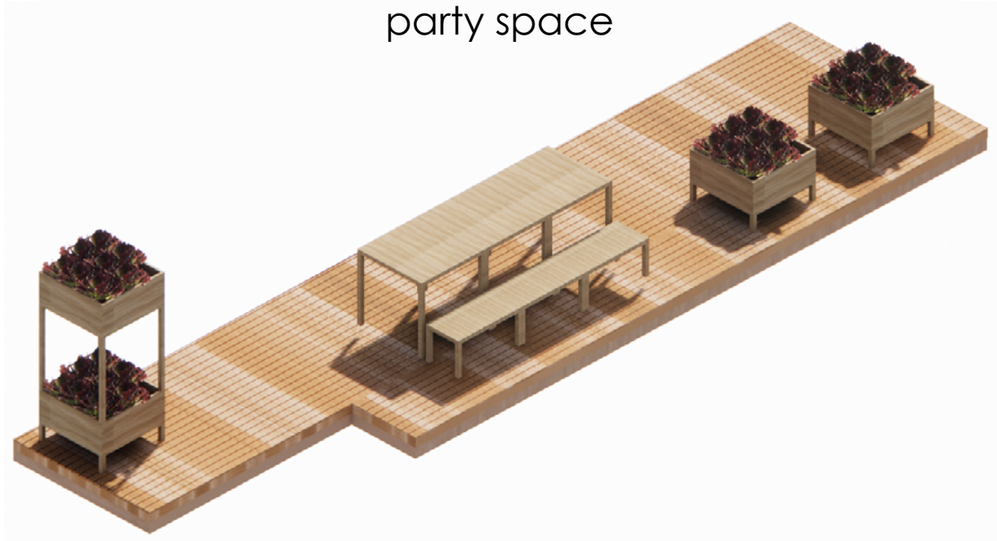




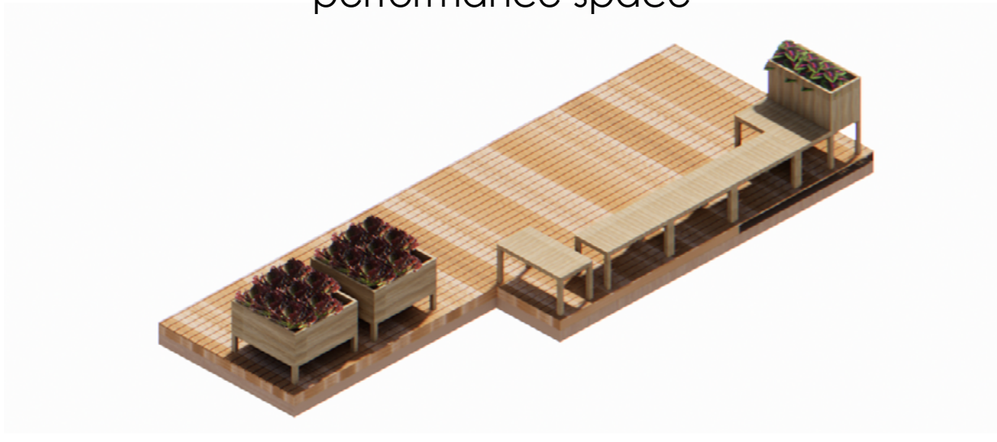
Modular unit for different space

lunch space

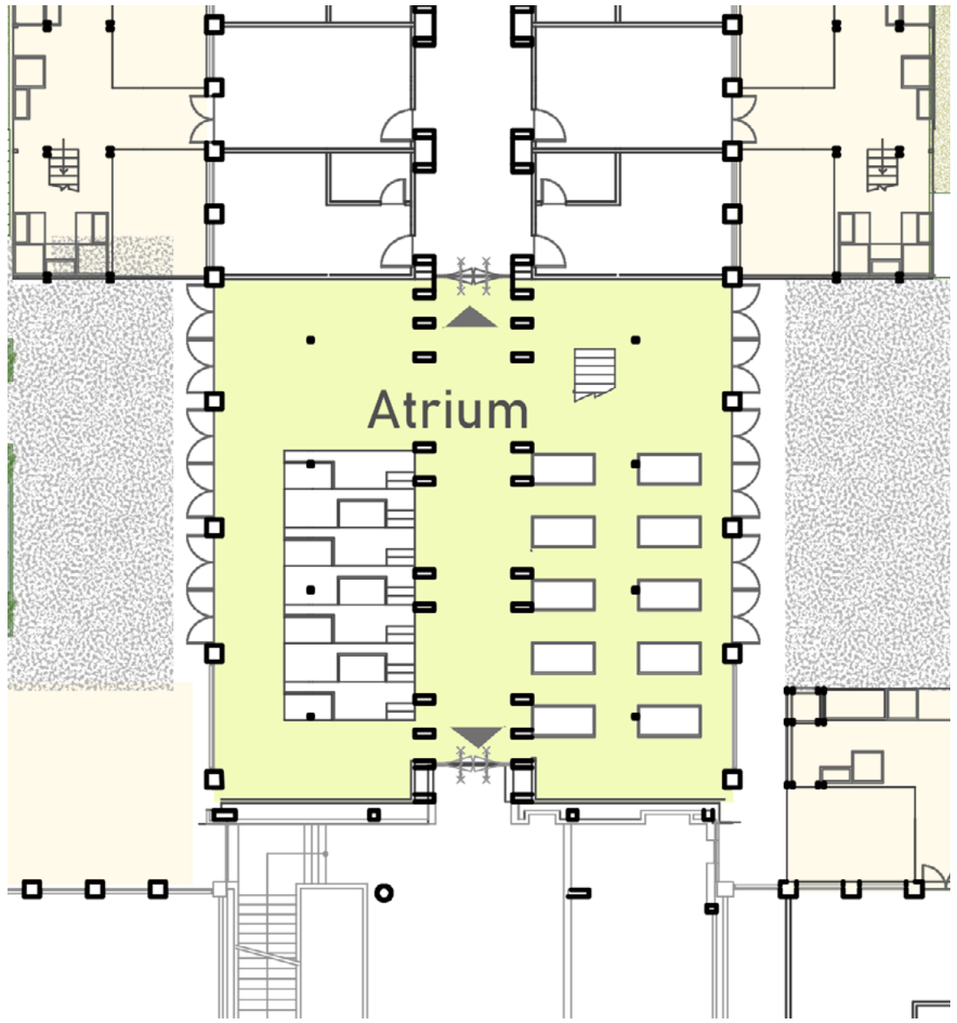
party space

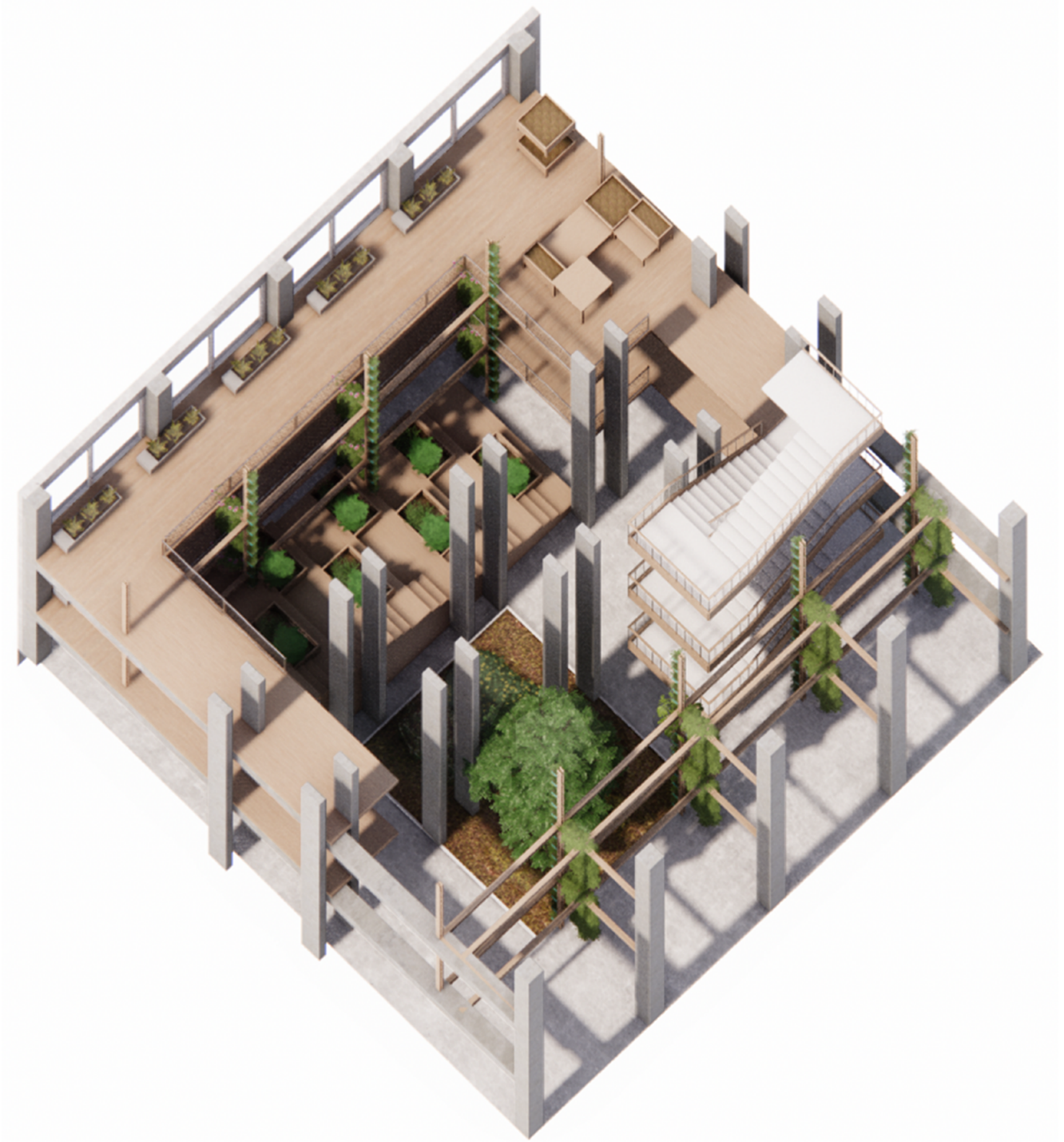


performance space

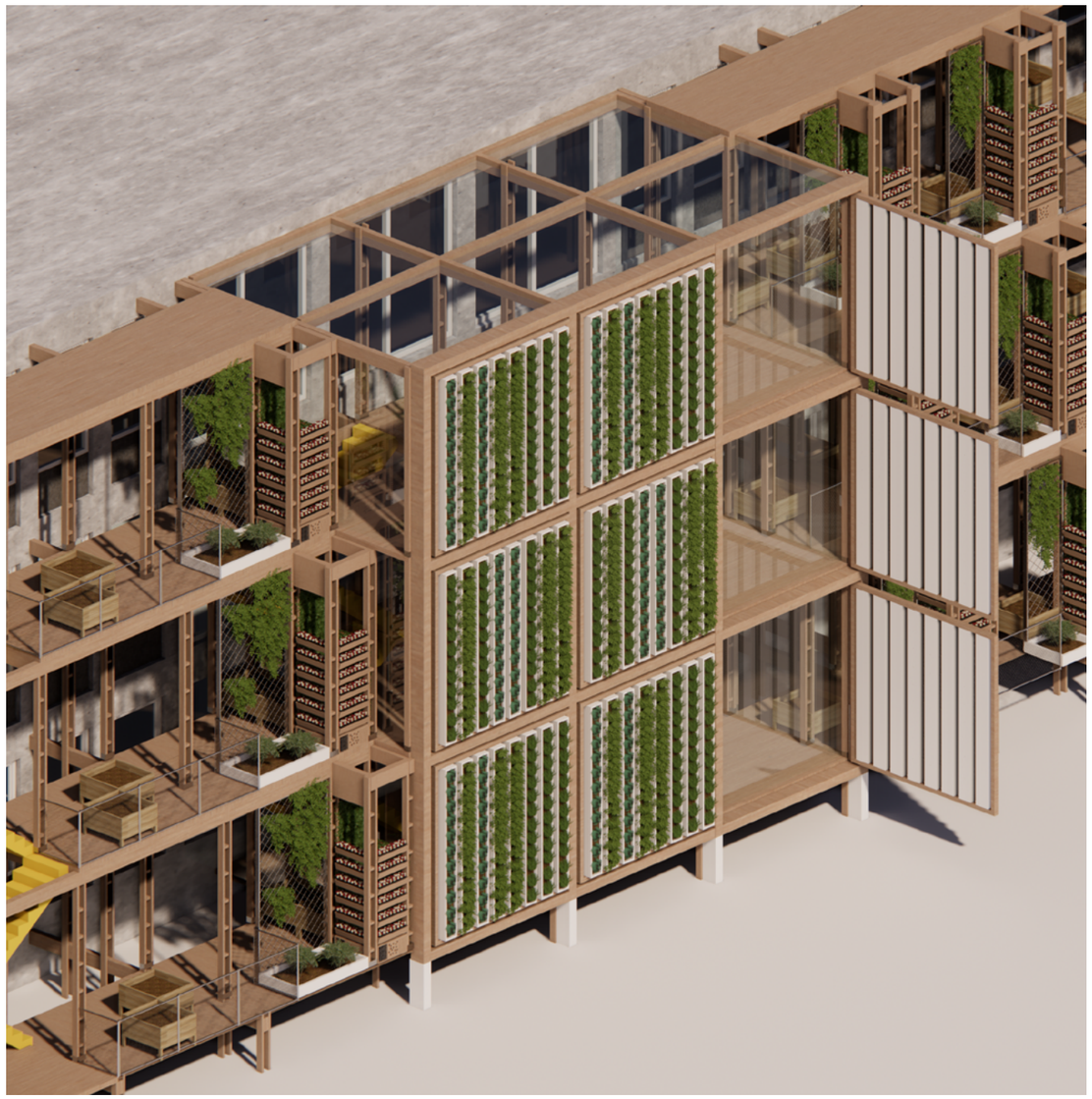


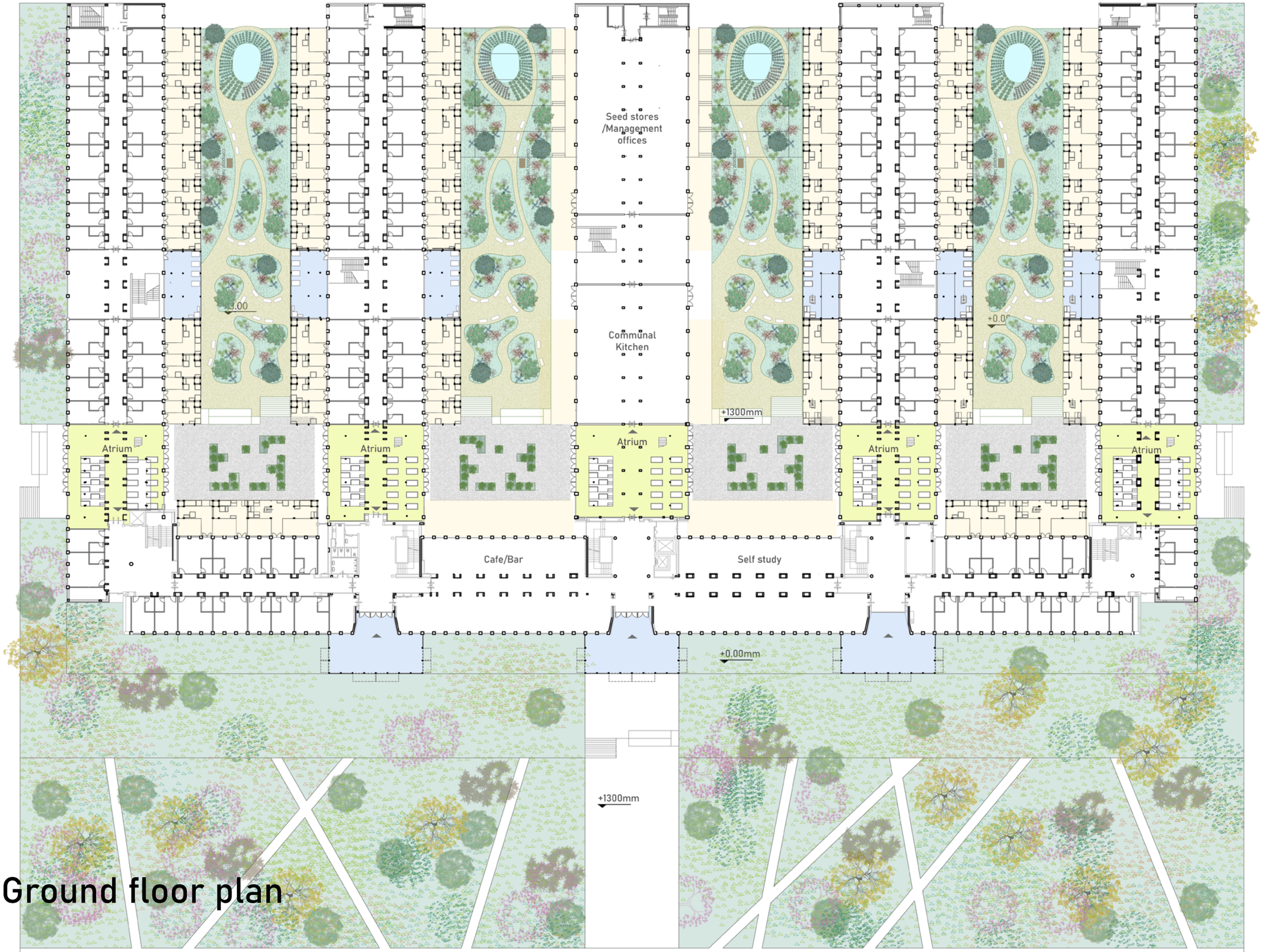
Green atrium





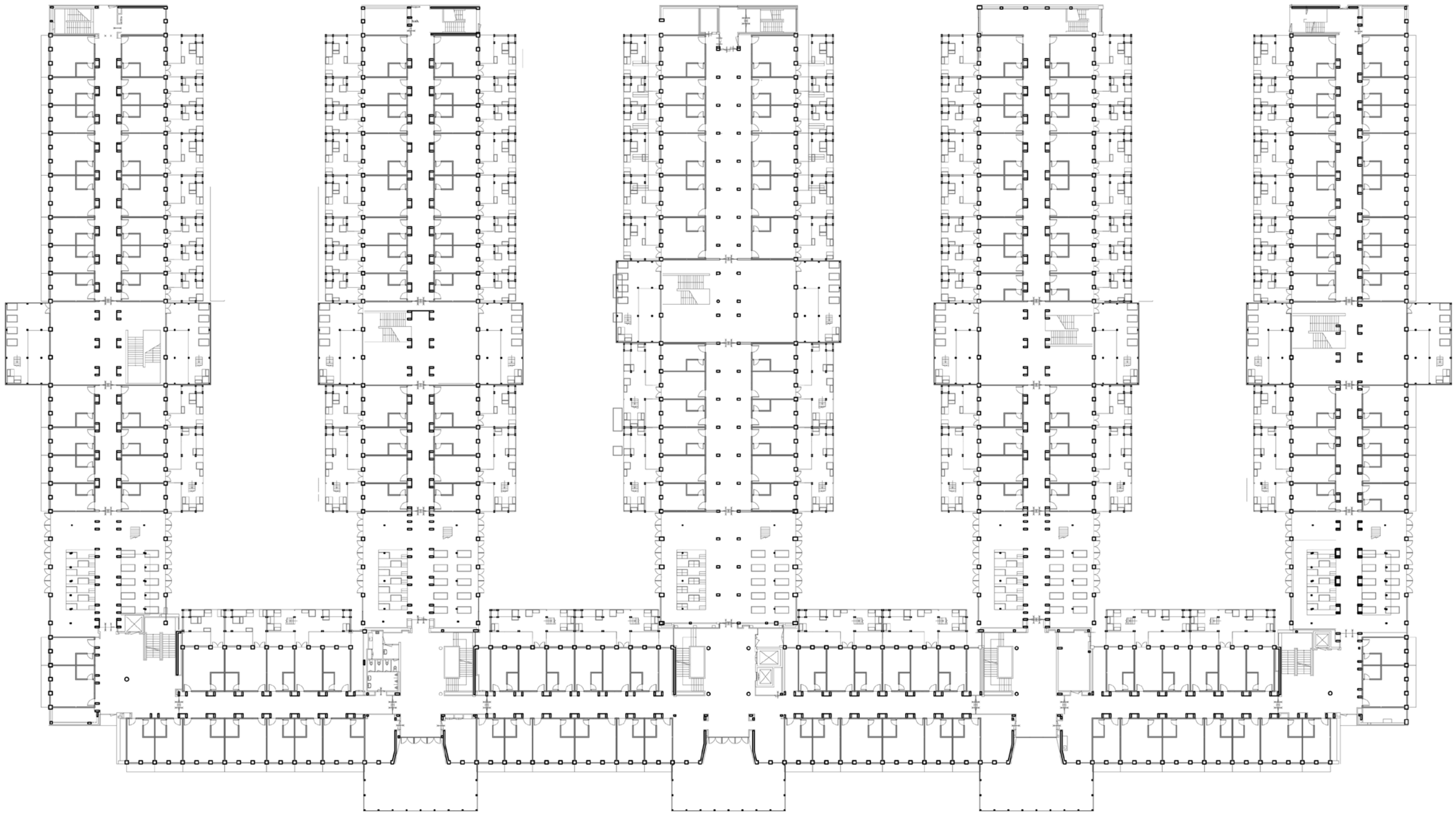
Winter garden

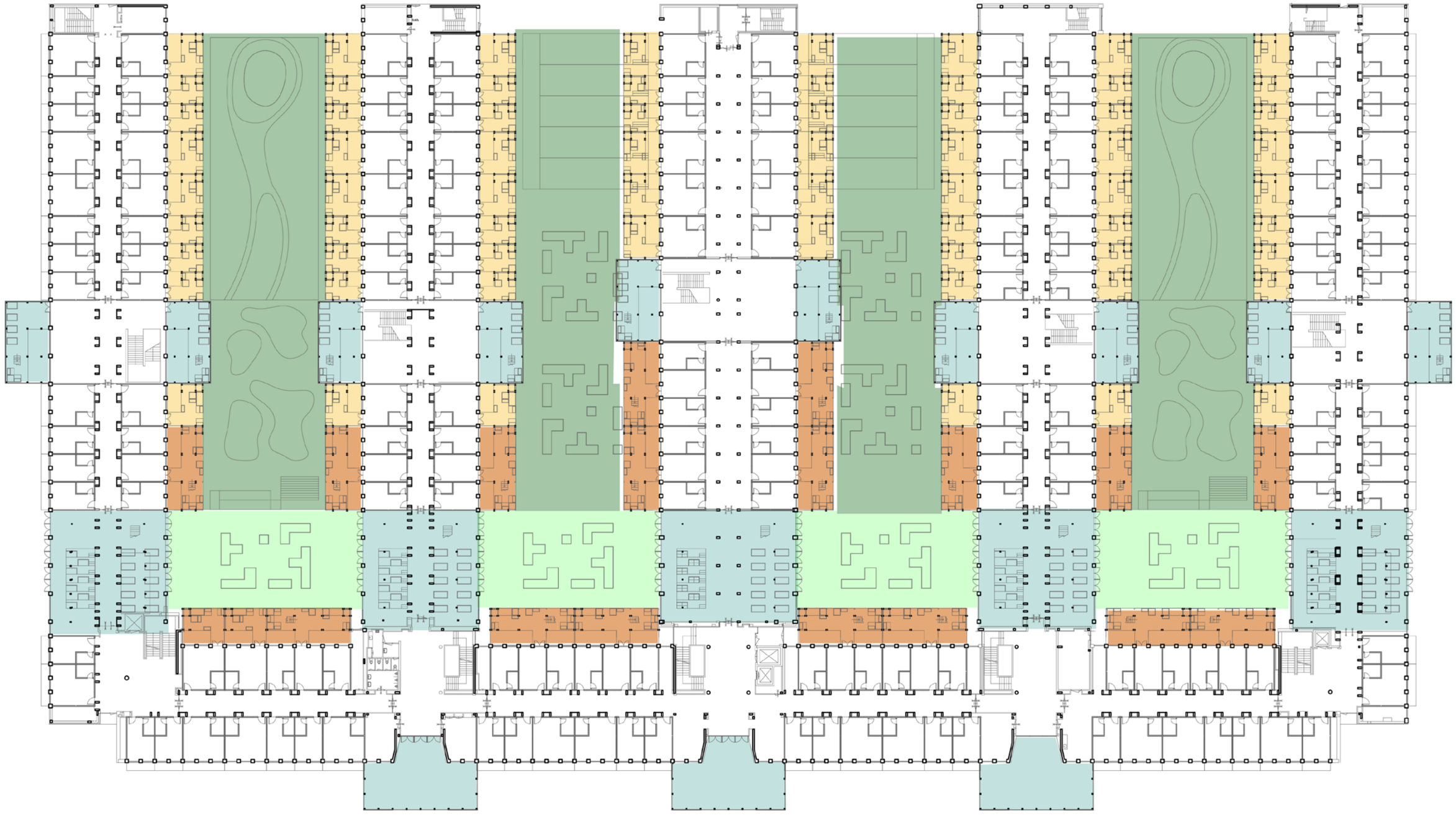




Ground floor plan

First floor plan



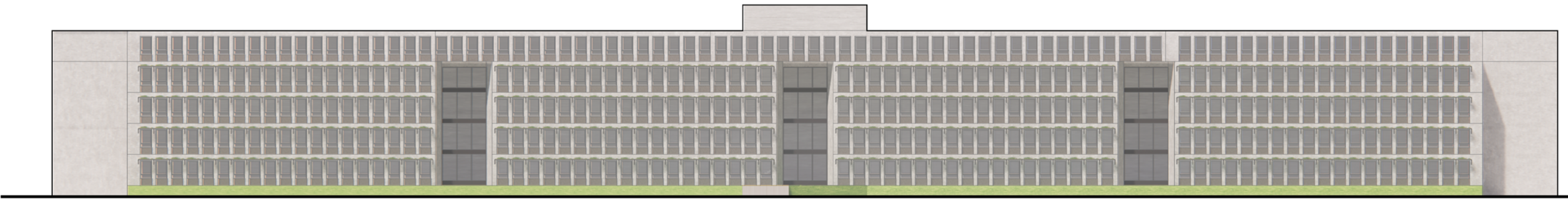


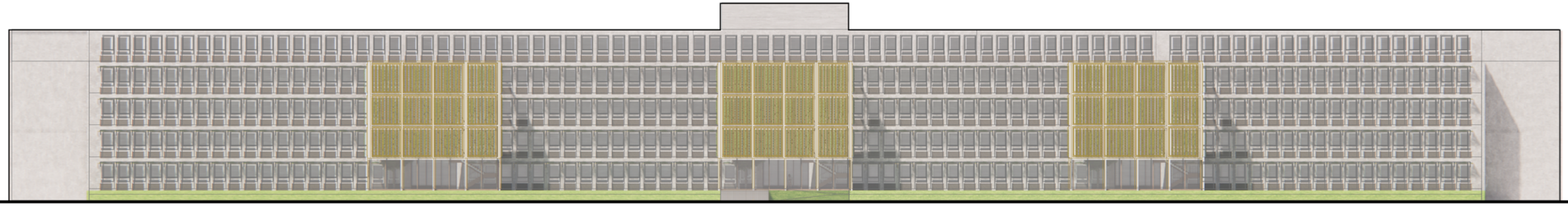

Building Unit
Main Entrance
Entrance
Existing staircases
New staircases

Section

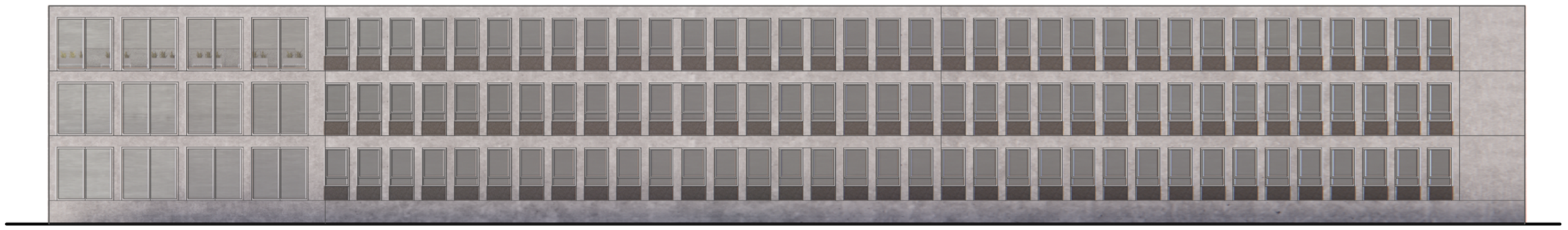

18.000
14.400
10.800
7.200
3.600
±0.000
−1.300
−3.900
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q

Elevation west





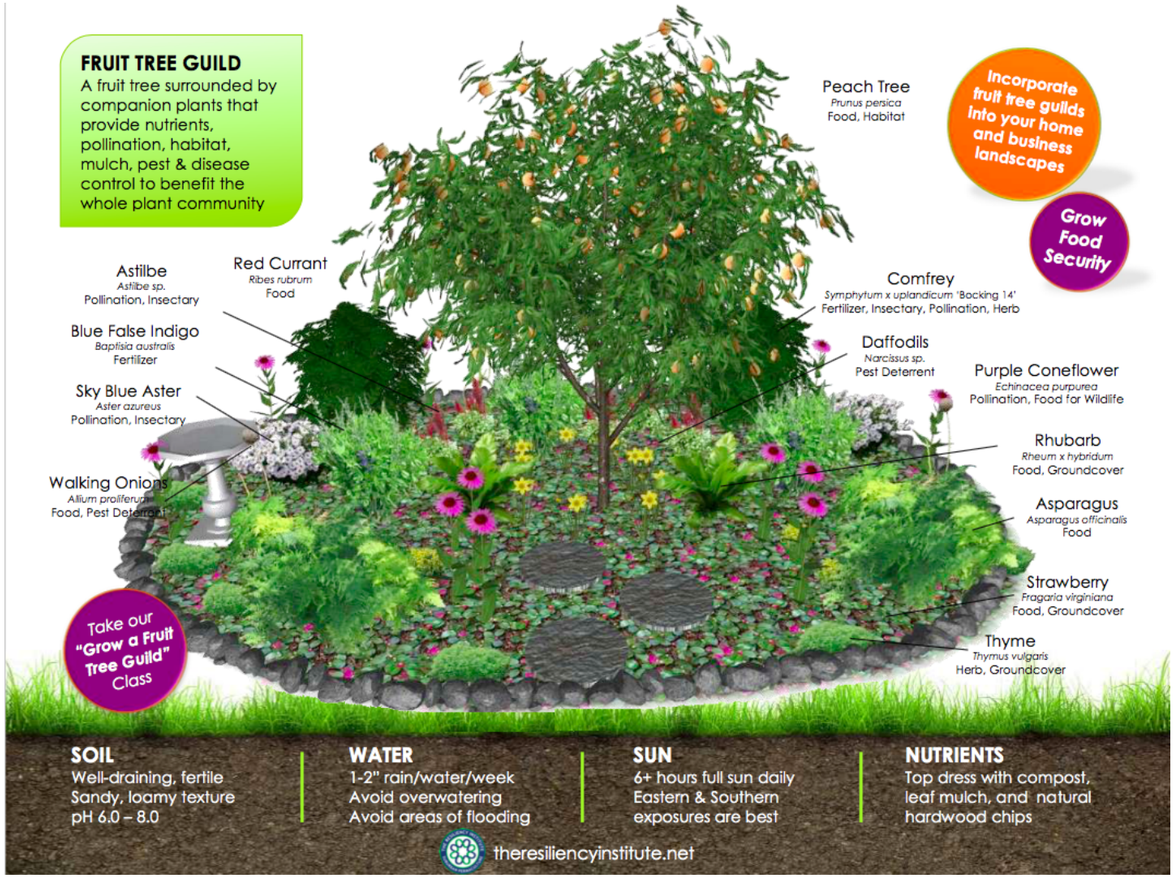
Elevation south



Green courtyard

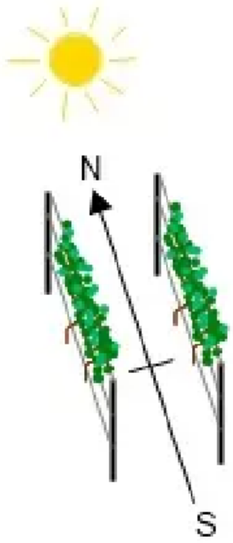
Design principles of permaculture

Fruit Tree Guild



Fertilizing plants, mulching plants, pest confusing plants, pollinator attracting plants, and - most importantly - food plants for you.One simple fruit tree guild can produce up to 200 pounds of food

Site climate

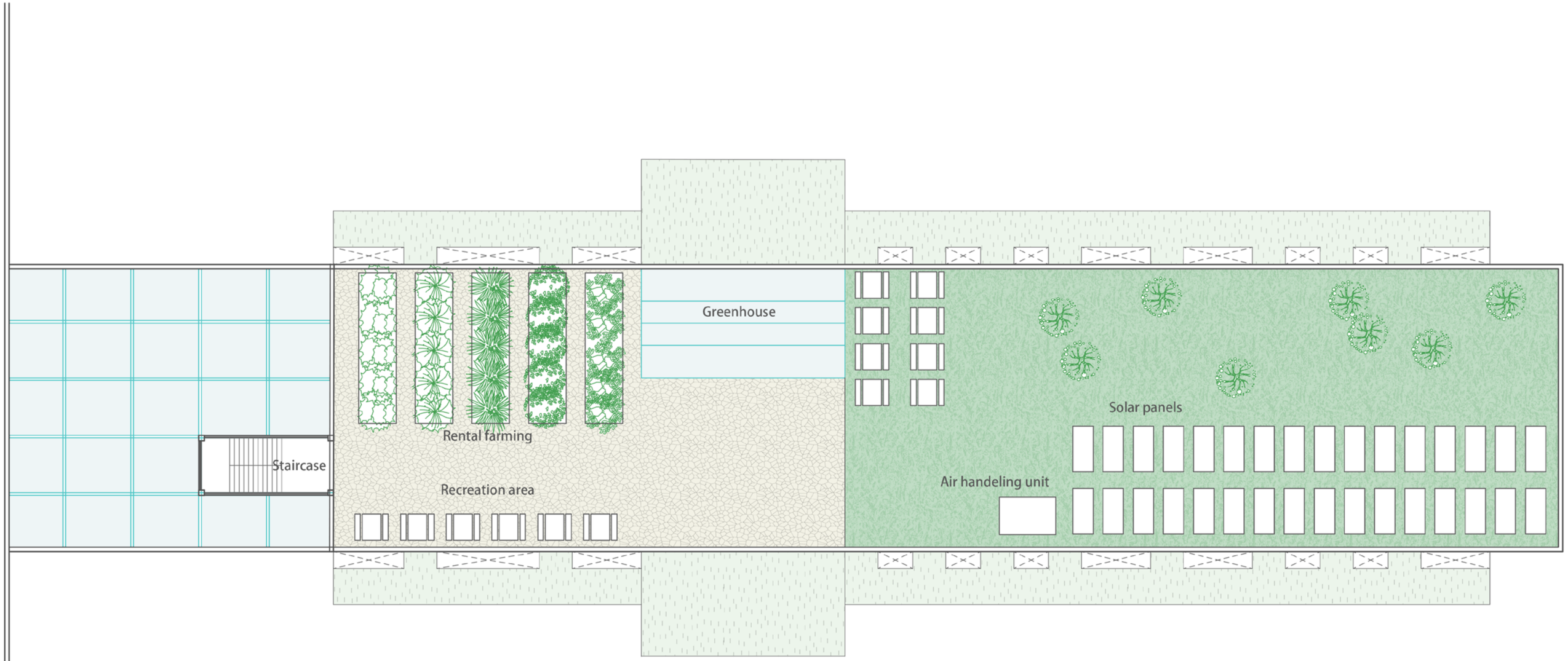


North-South orientation of trellises so plants do not shade each other and sun shiles along full length of trellised plant

Scent of wormwood carried by wind over garden bed, masking scent from pests

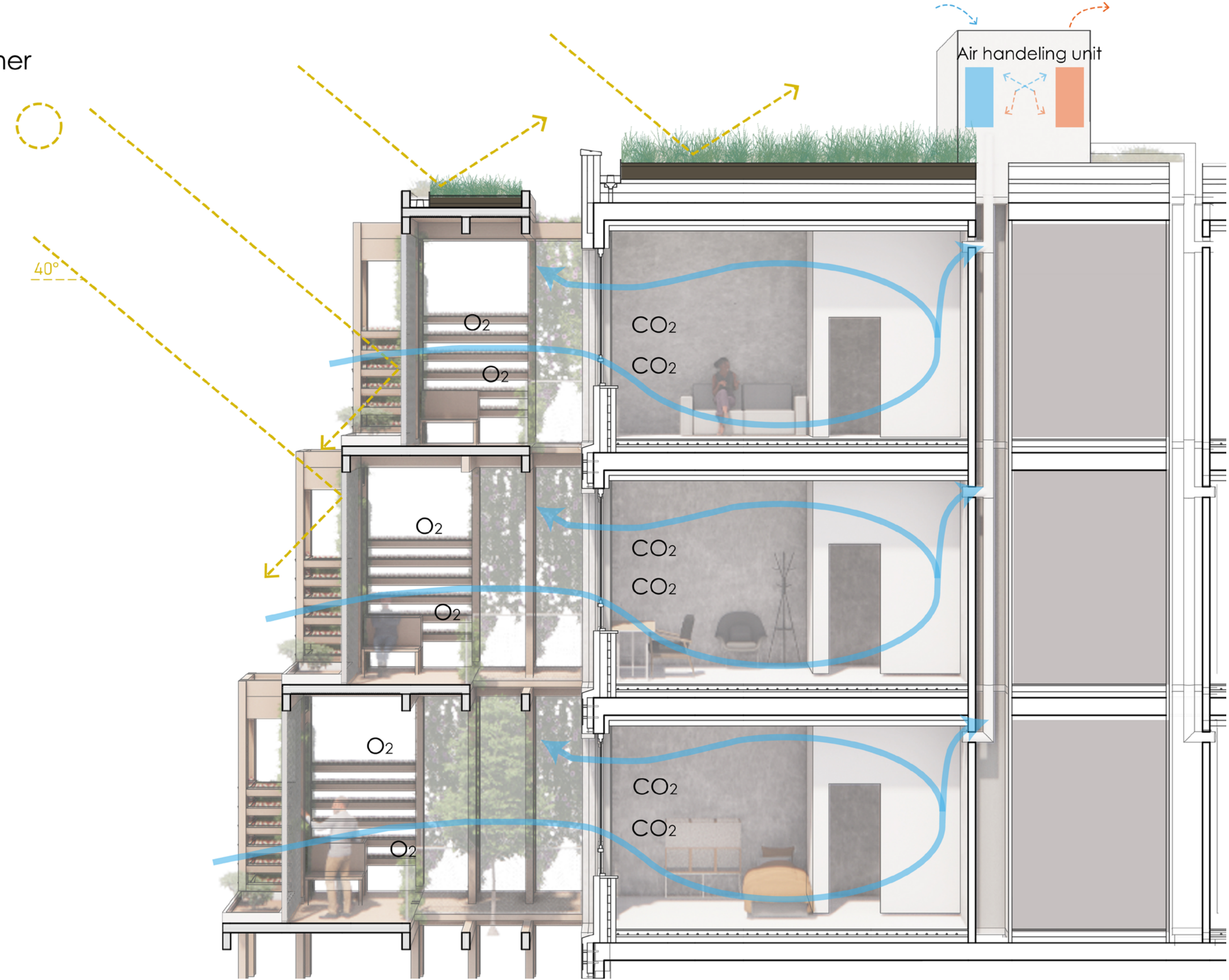

Food forest
Fruit tree guild
compost heap
Organic farming
Path made from treesurgeons'waste-cordwood edging&surfaced with woodchip
Path surfced with slads made from reconstituted building waste

Green roof

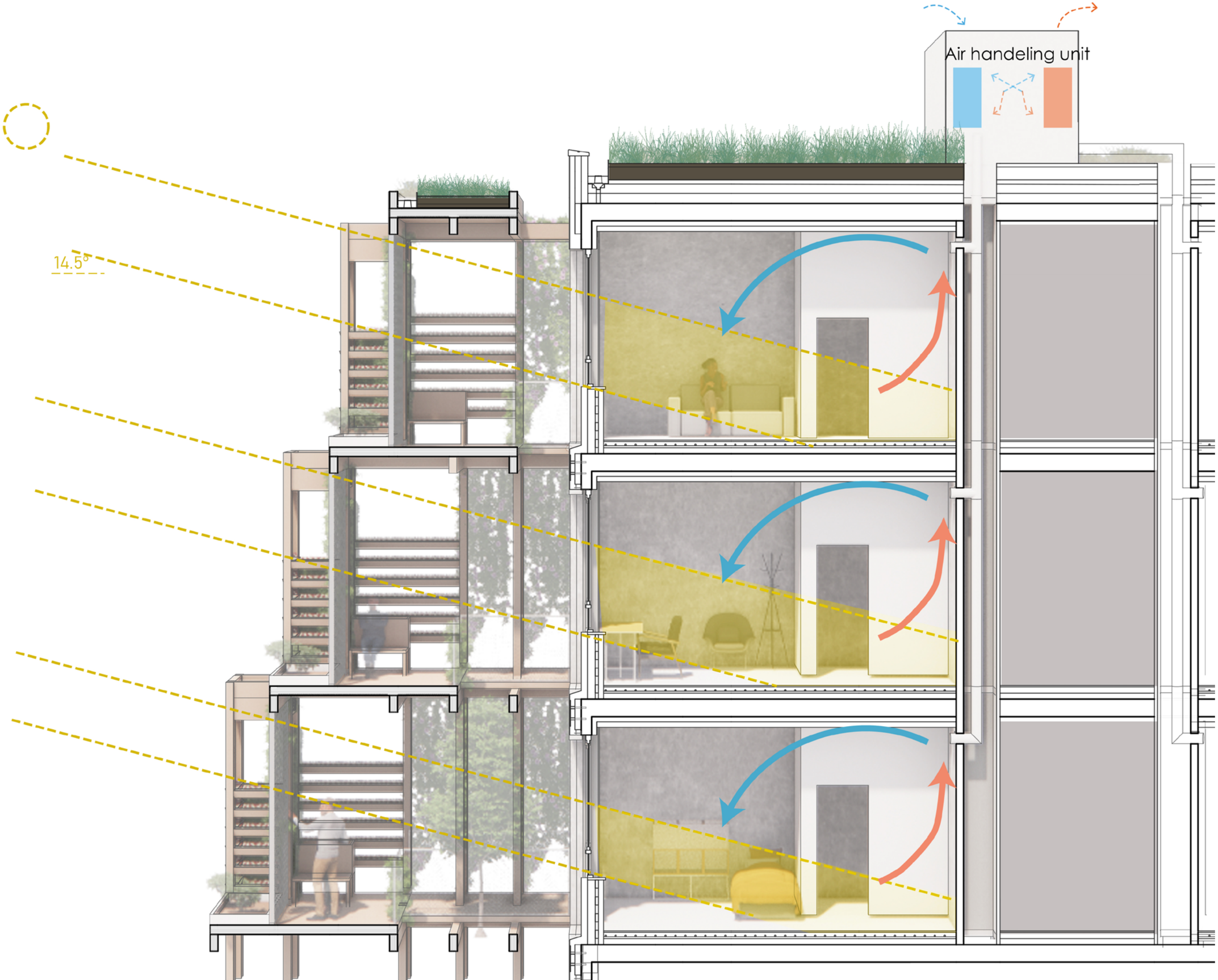

Greenhouse
Rental farming
Staircase
Recreation area
Solar panels
Air handeling unit

Climate

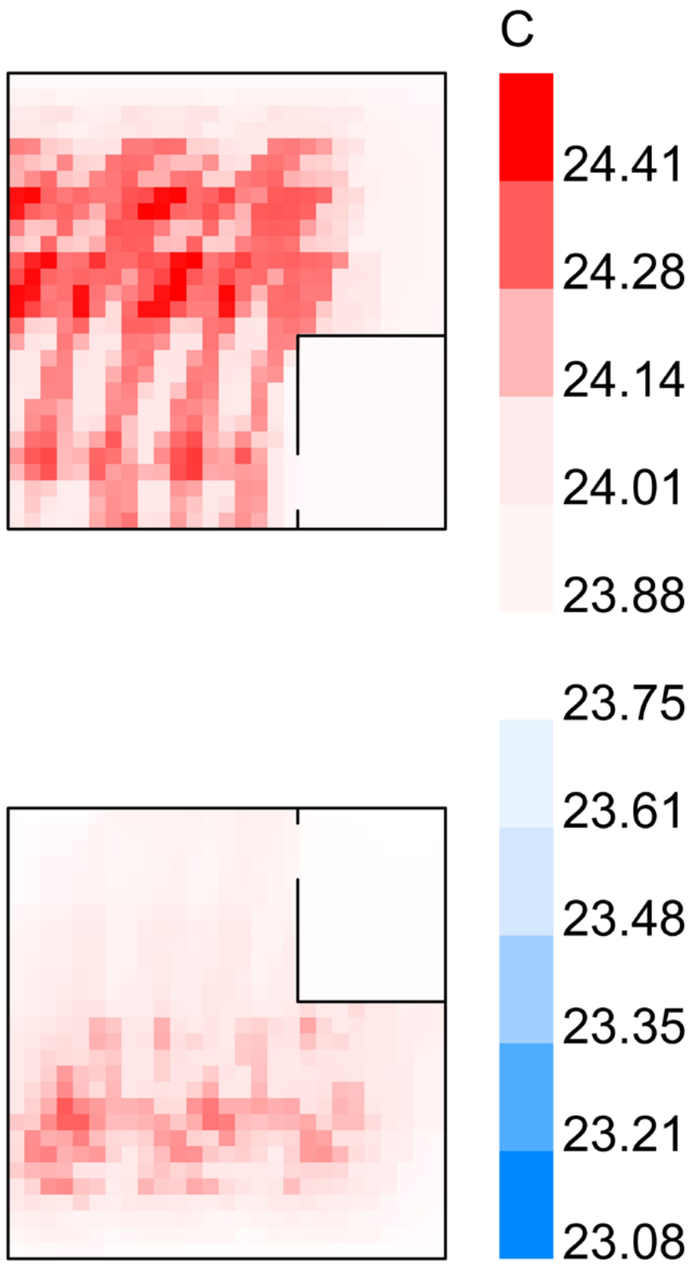
Summer



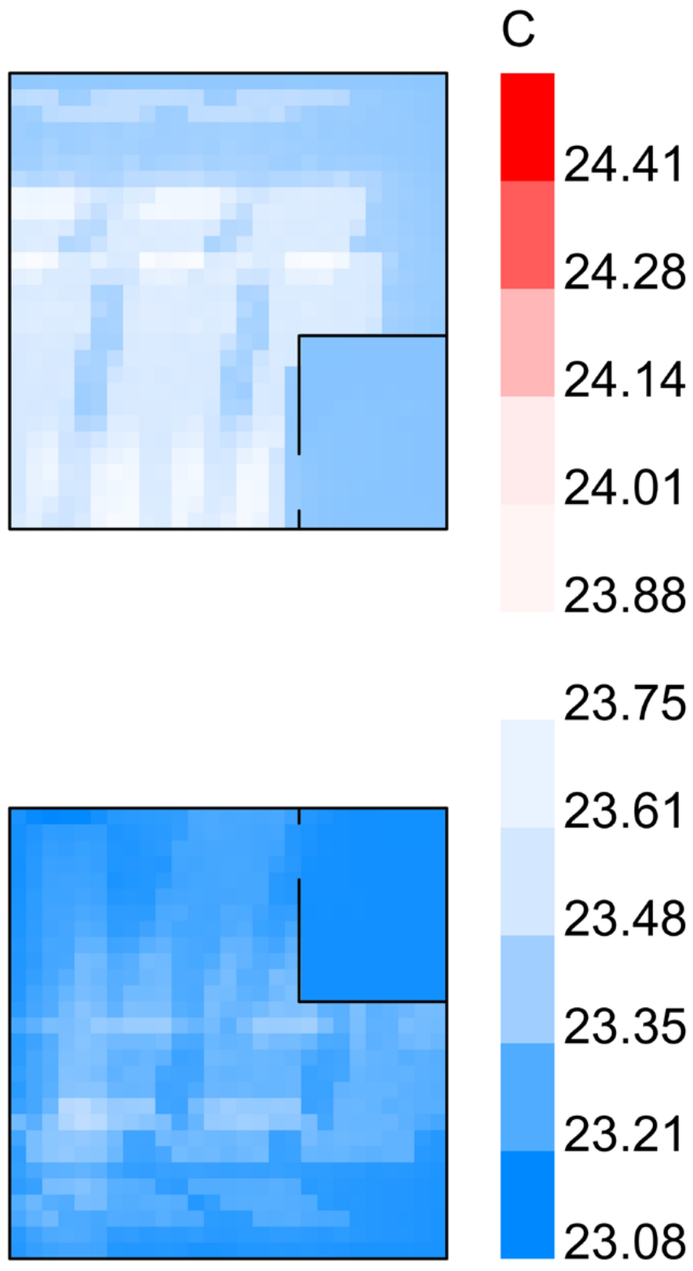
winter



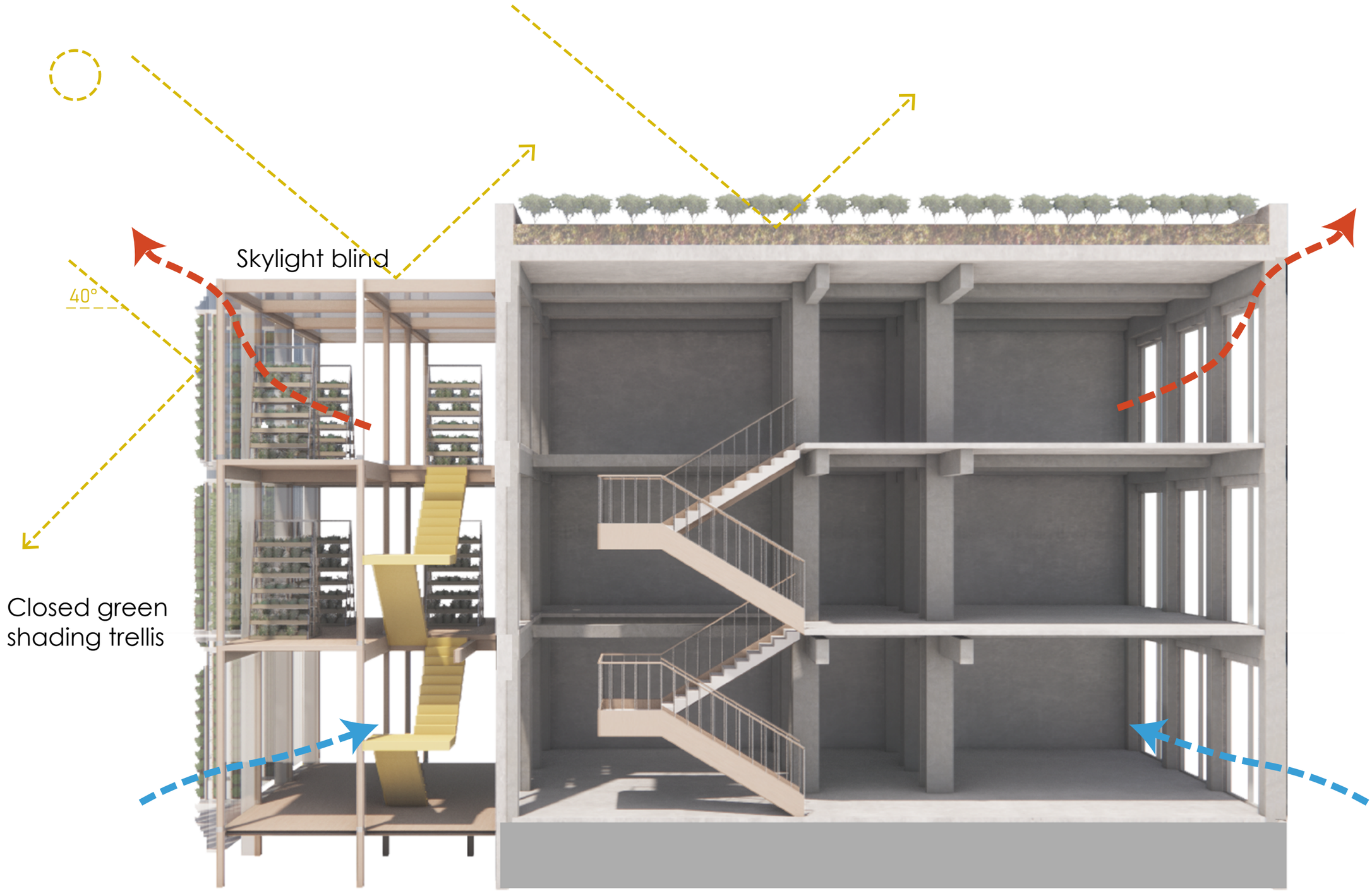
Indoor thermal comfort (UTCI) during extremely hot weeks
Before renovation



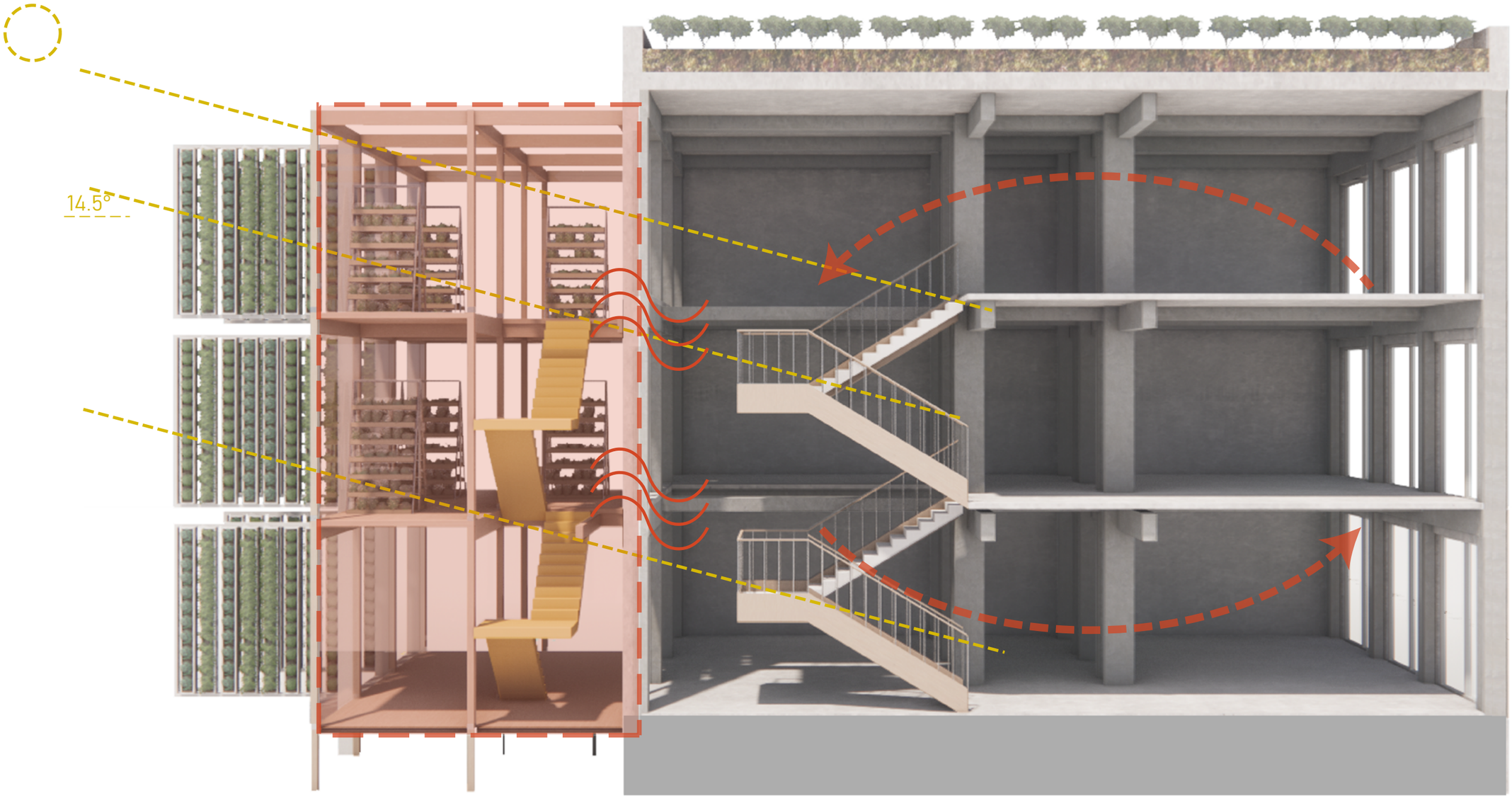
Indoor thermal comfort (UTCI) during extremely hot weeks
After renovation



Summer



winter



Indoor environment quality (IEQ)

	Green balcony	Winter garden
Thermal comfort	**Overhang effect**—provides solar shading **Airflow pattern transformation**—increases the natural ventilation **Acoustic shielding effect**—reduces background noise with doors open, enabling an increase of natural ventilation	**Greenhouseeffect**—increase in solar gains with a positive effect in heating season conditions(Green shading in summer)
Air quality	**Airflow pattern transformation**—increases the air flow rate **Acoustic shielding effect**—reduces background noise with doors open, enabling an increase of natural ventilation	**Greenhouseeffect**—improves the thermal insulation and facilitate the evaporation of moisture
Visual comfort	**Overhang effect**—blocks the undesirable penetration of sunlight, reducing uncomfortable glare	
Acoustic comfort	**acoustic shielding effect**—acts as a protection device against outdoor noise	**Acoustic protection**—acts as an acoustic barrier against outdoor noise

Winter garden

Circulation space
around winter garden

Collective heat
control system
source management
system

Soil heat
buffer

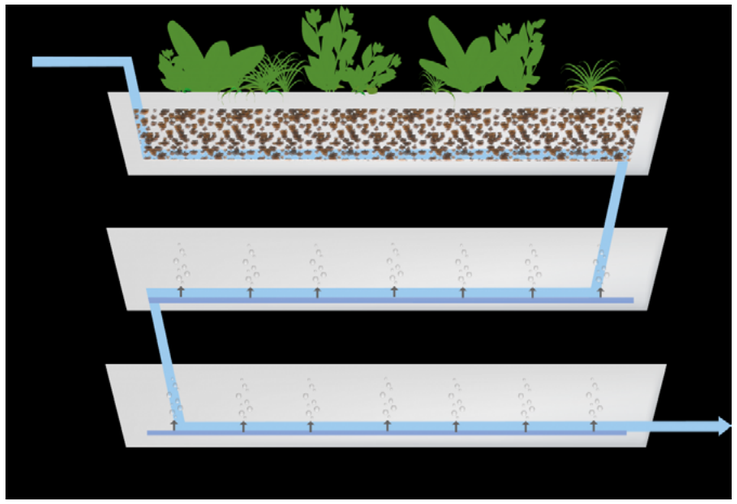
25℃

18℃ Aquifer

8℃

Watertreatment

VertECO technology treats waste/greywater within a vertically constructed plant-based wetland. The underlying principle is the employment of specific plant species in a special sequence to encourage the cleansing of polluted water through microbiological activity occurring in the root-zone.



Eleocharis Palustris

Juncus Effusus

Carex Pendula

Lysimachia Vulgaris

Lythrum Salicaria

Caltha Palustris

Water cycle

Grey water
&Collected rainwater

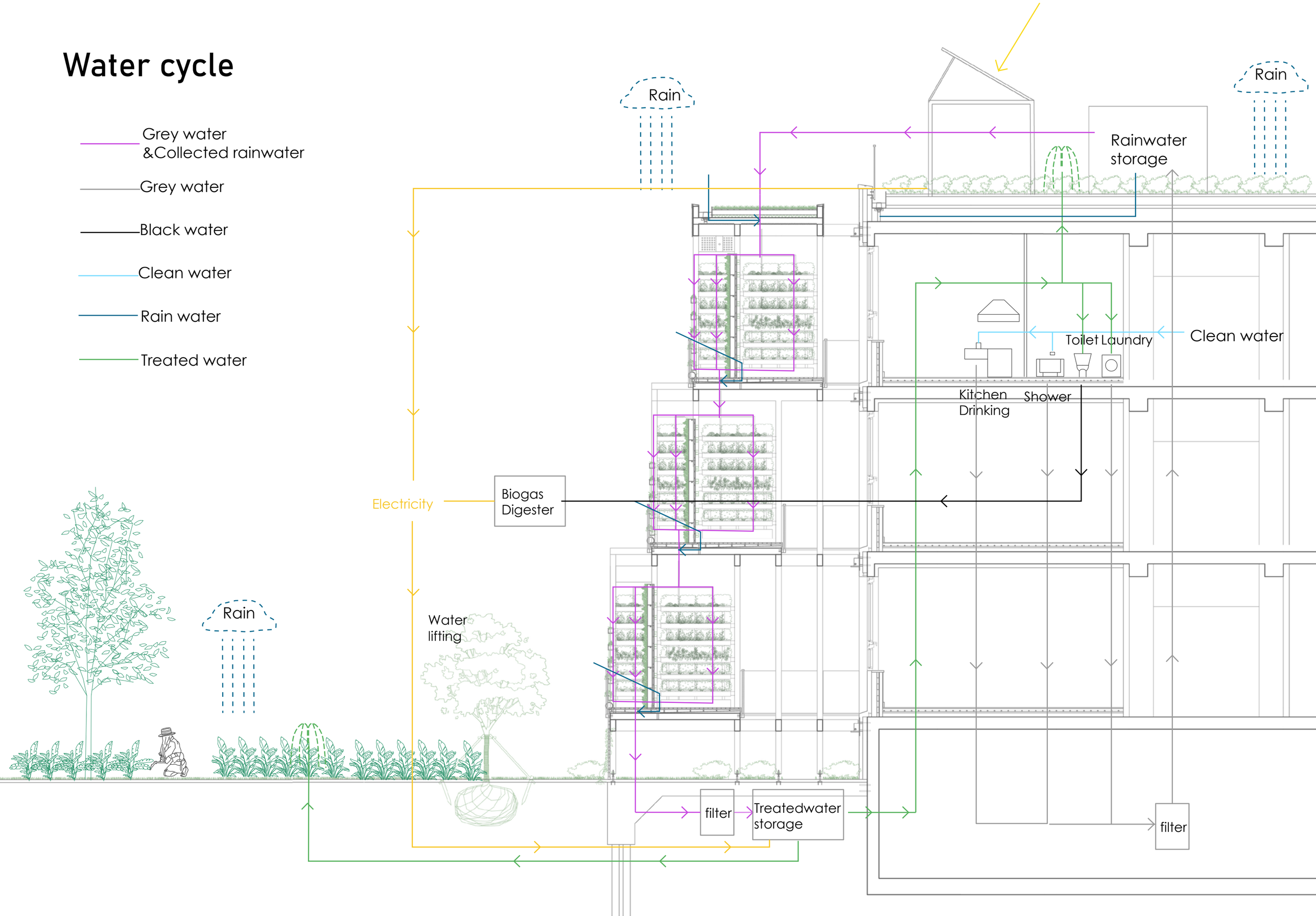
Grey water

Black water

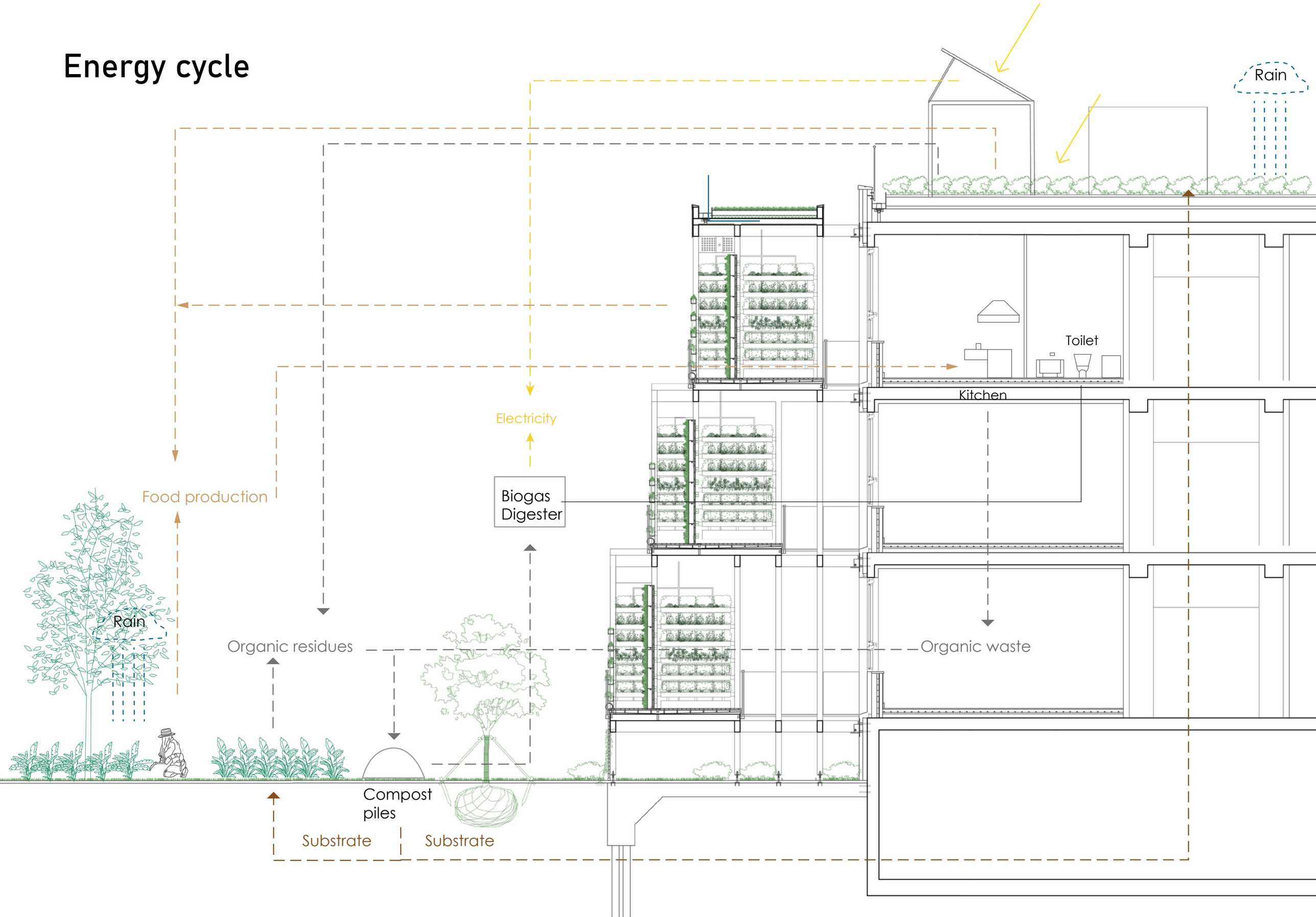
Clean water

Rain water

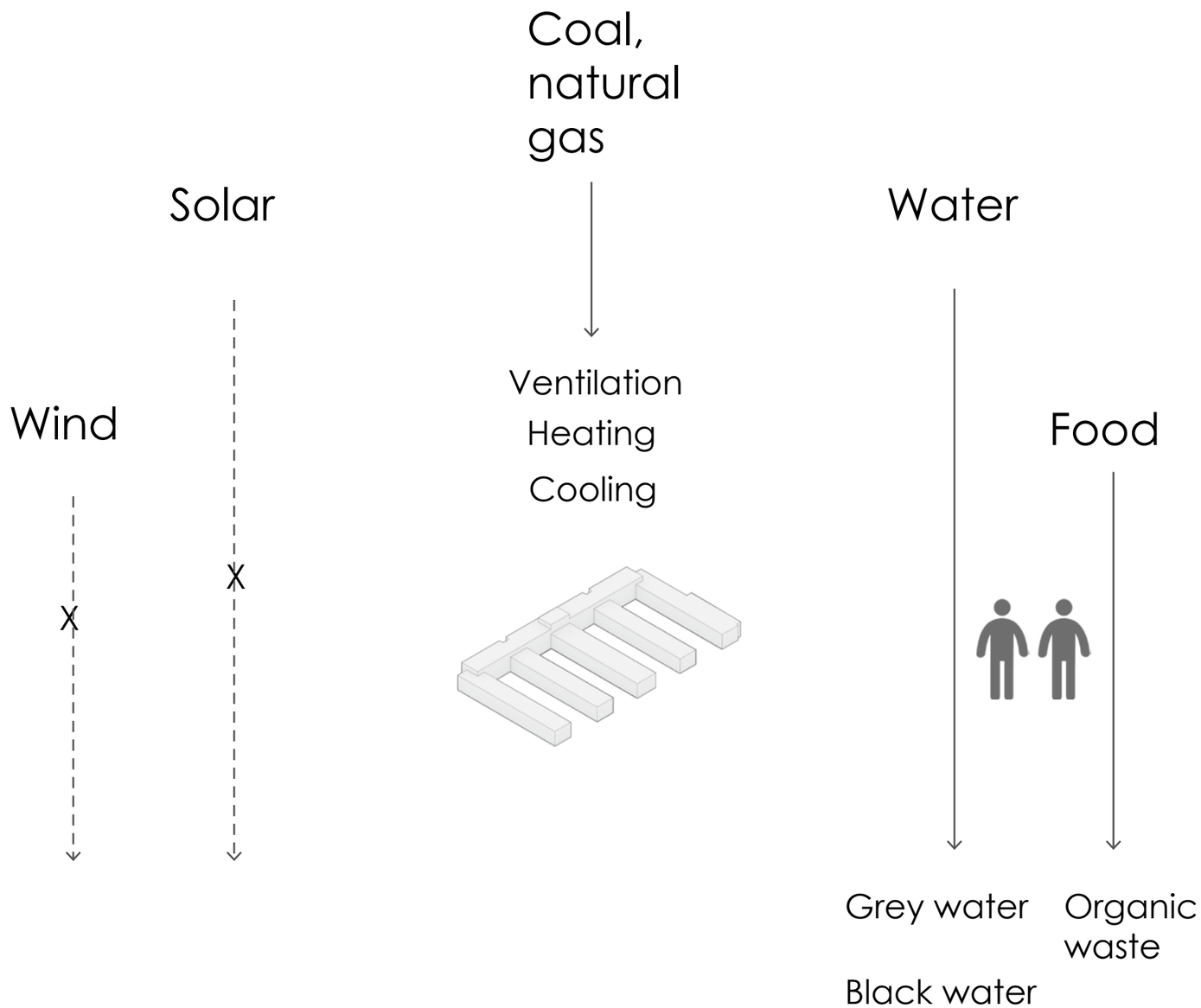
Treated water

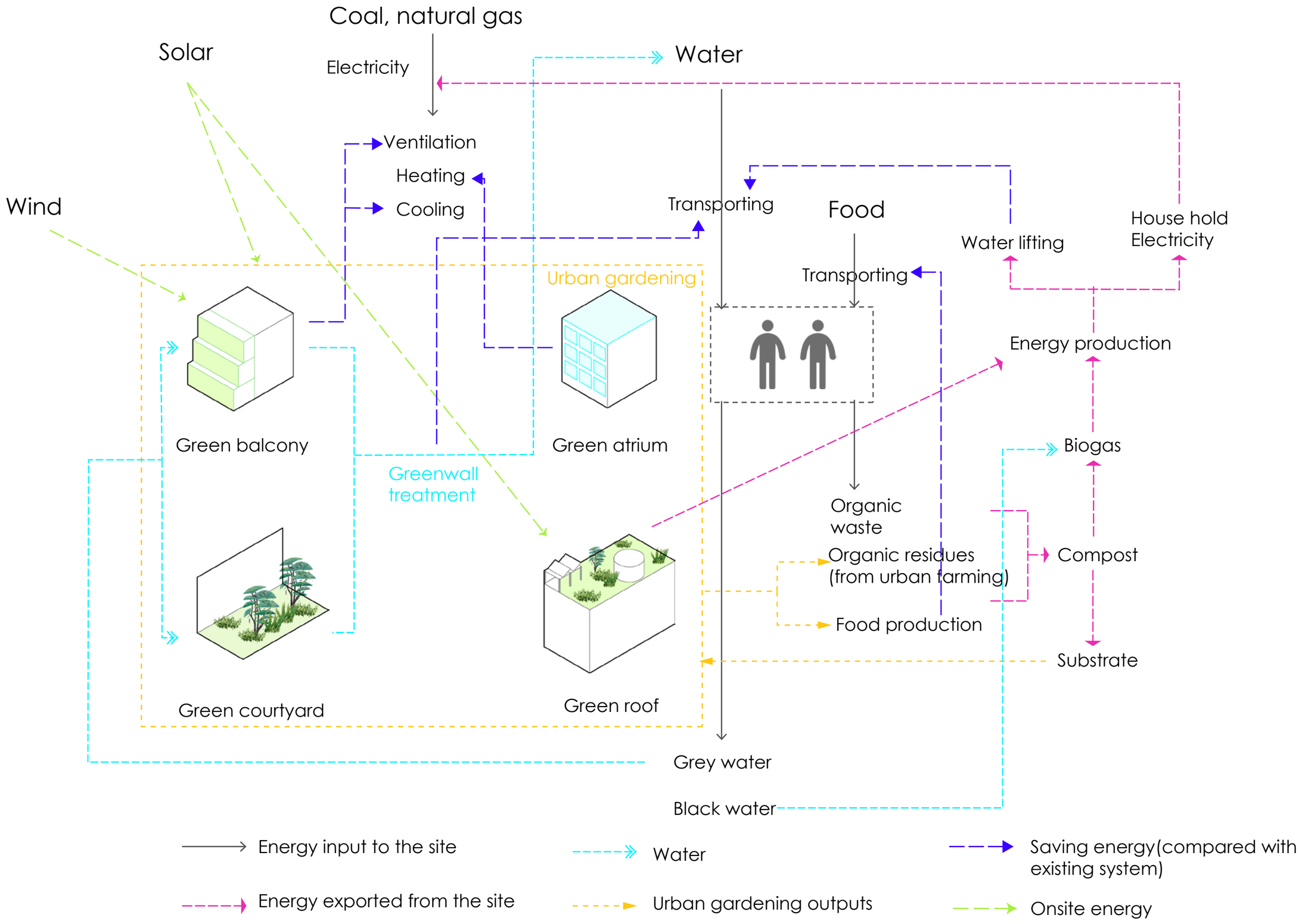


Energy cycle



System integration




Coal, natural gas
Solar
Electricity
Water
Ventilation
Heating
Cooling
Wind
Transporting
Food
Water lifting
House hold
Electricity
Urban gardening
Transporting
Energy production
Green balcony
Green atrium
Biogas
Greenwall
treatment
Organic
waste
Organic residues
(from urban farming)
Compost
Food production
Substrate
Green courtyard
Green roof
Grey water
Black water
Energy input to the site
Water
Saving energy(compared with
existing system)
Energy exported from the site
Urban gardening outputs
Onsite energy

I just moved into a dorm room and
used modular units to plan the space.
I still need to purchase seeds to plant.

Spring


Summer is here but the plants are not growing well and I need some professional help. And I would like to grow grow more vegetables, maybe I can go and rent more green space.
Summer


Indeed. Perhaps you could go to the Atrium for more information, there is information about gardening classes and rental planter.
Great music! How about your balcony garden? Do you know where to learn more about gardening activities?

Look! That's TNW eco-committe organising an event, maybe I should attend too. It's a great opportunity to gain knowledge about farming, and at the same time I get to meet new people and get organic vegetables.

Thank you! I am very interested. I would like to know the prices of gardening courses and the rental of planters!

Hi, what do you need to know? We offer gardening classes, plant seed shopping, and rental of flowerbeds. Also we have monthly parties at atrium, you are welcome to join us

We are the TNW ECO-Committee, pick up a flyer to find out more about the event!


It's good to see you. My vegetables are ripe. I grow peppers and tomatoes, maybe we can swap some veggies? That way everyone can taste a lot of variety.
It's been a long time! All the veg I've grown is ripe and I'm picking some back for dinner. How's your harvest?
Autumn


Thank goodness for WINTER GARDEN, my plants don't freeze to death. And there is a place to hold gardening events.

Winter

Material

Existing material

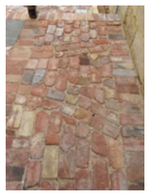
Poriso stone

Black glazed bricks

Natural stone

Polished concrete

Path surfced with slads made from reconstituted building waste



New material

CLT panel

Wood decking

Reclaimed wood planter

Principles

Local materials

Carbon storage

Nature material

Recyclable

Aesthetic value

Reduce reverberation

Plants

Roles of Plants **Dominant trees, shrubs and groundcovers**	Ecological control							Production			Wildlife	
	Oxygen/carbon dioxide	Filters air	Controls water flow	Filters water	Cools water	Forms still air pockets	Holds soil	Food	Fibre	Energy	Food	Cover
Pinus pinea	●	●	○	○	○		○			○	○	○
Sophora	○	○	○	○	●	●	○			○		○
Ginkgo biloba	●	●	●	○	○	○	○					○
Acacia			○	○	○							○
Avocado *(Persea)*	●	●	●	○	○	○	○	●			●	○
Citrus spp.	○	○	○	○	○		○	●			●	○
Arbutus unedo	○	○	○	○	○	○	○				○	○
Cassia artemisioides							○					
Cistus spp.			○	○			○					○
Carissa grandiflora		○	○	○			○	○			●	○
Heteromeles arbutifolia	○	○	○	○			○					
Rhus integrifolia	○	○	○	○			○				○	●
Yucca whipplei									○			○
Romneya coulteri				○								○
Baccharis pilularis				○			●					
Rosmarinus officinalis			○				○	●				
Gazania spp.				○			○					○
Strawberries			○				○	●			○	
Vegetables								●			●	
Herbs								●				

● **Major**

○ **Significant**

Ecological Unit

1.Provide food for birds and insects
2.Provide cover for birds and insects
3. Native plants

Winter Garden

1.Produce oxygen
2.Filters air
3.Profuce food
4.Able to grow in winter

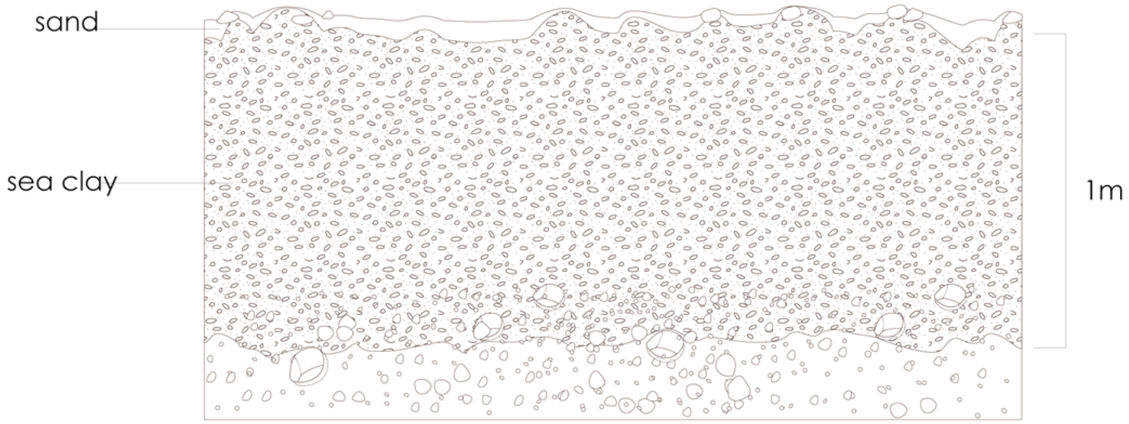
Green courtyard and green roof

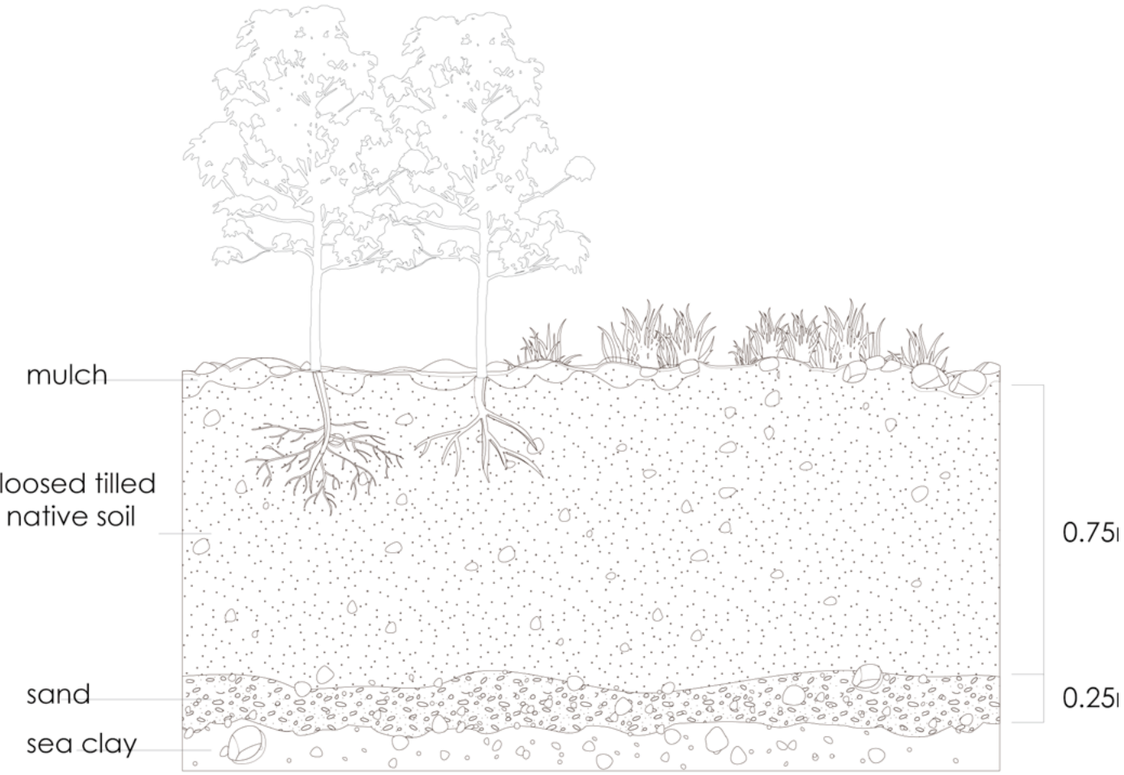
1.Holds soil
2.Controls water flow
3.Produce oxygen
4.Filters air
5.Food forrest

Watertreatment

1.Filters water
2.Produce oxygen

Soil


sand
sea clay
1m


mulch
loosed tilled
native soil
sand
sea clay
0.75
0.25

Ecologica unit


Common Sage


Sheep Grass


Hyssop


Chives


Lavender


Flowering Rush


Hornwort


Willow


Bulrush


Yellow Loosestrife


Avocado(Persea)


Citrus app


Carissa grandiflora

Green roof and green courtyard


Red Currant


Astilbe


Blue False Indigo


Sky Blue Aster


Walking Onions


Daffodils


Purple Coneflower


Rhubarb


Asparagus


Thyme


Strawberry

Peach Tree

Winter garden

Pinus pinea

Arbutus unedo

Gazania spp

Avocado(Persea)

Cassia Artemisioides

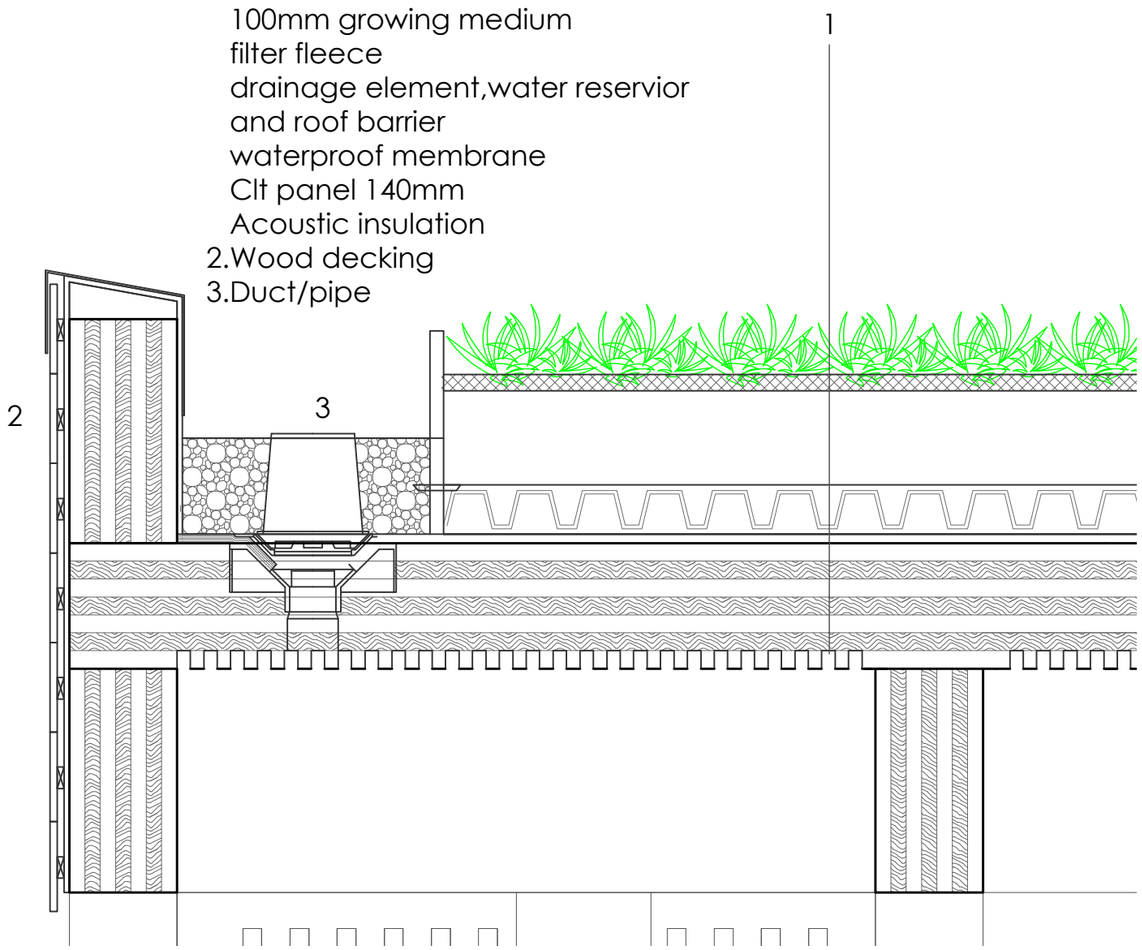
Cistus Spp

Carissa Grandiflora

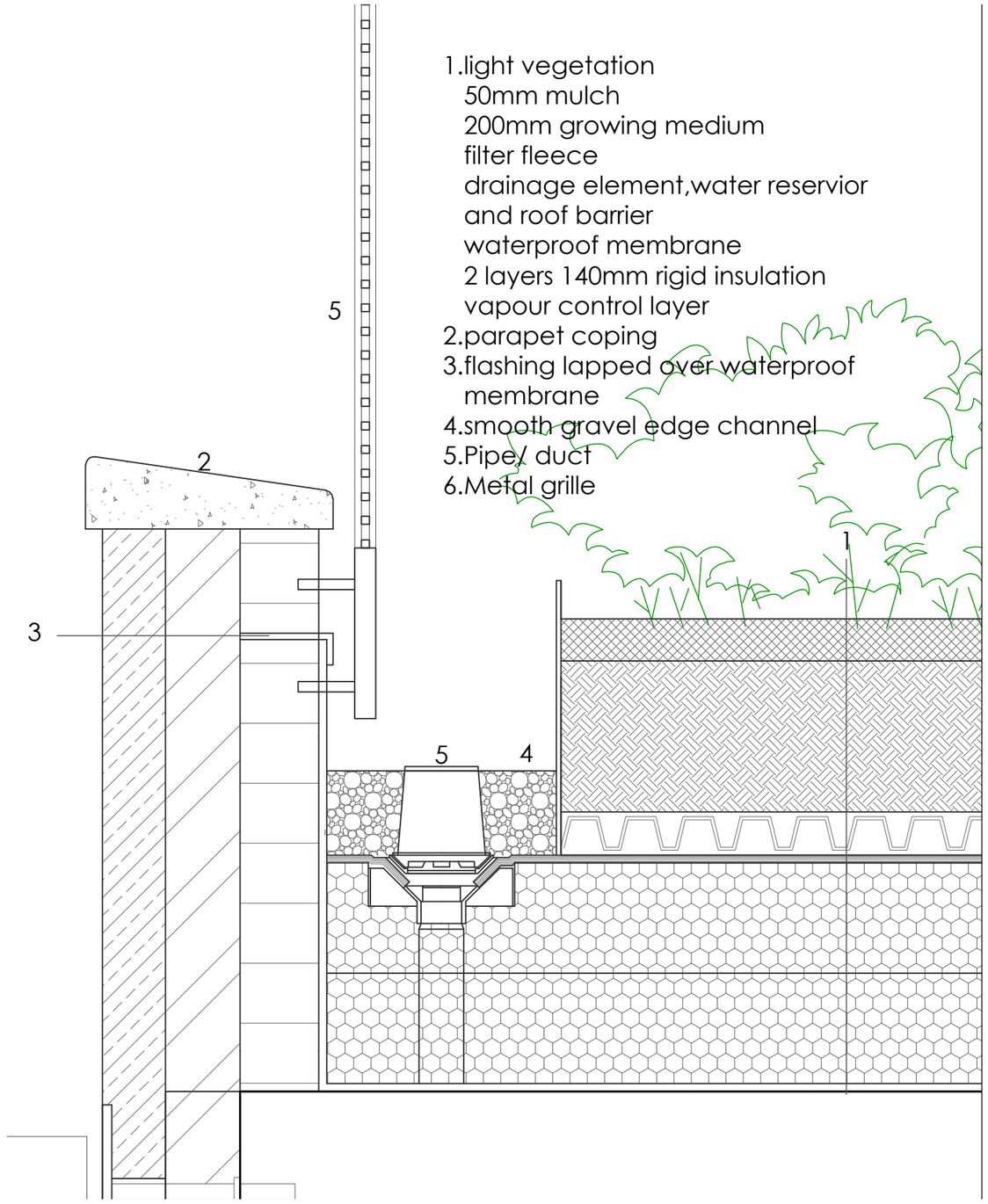
Romneya Coutten

Details

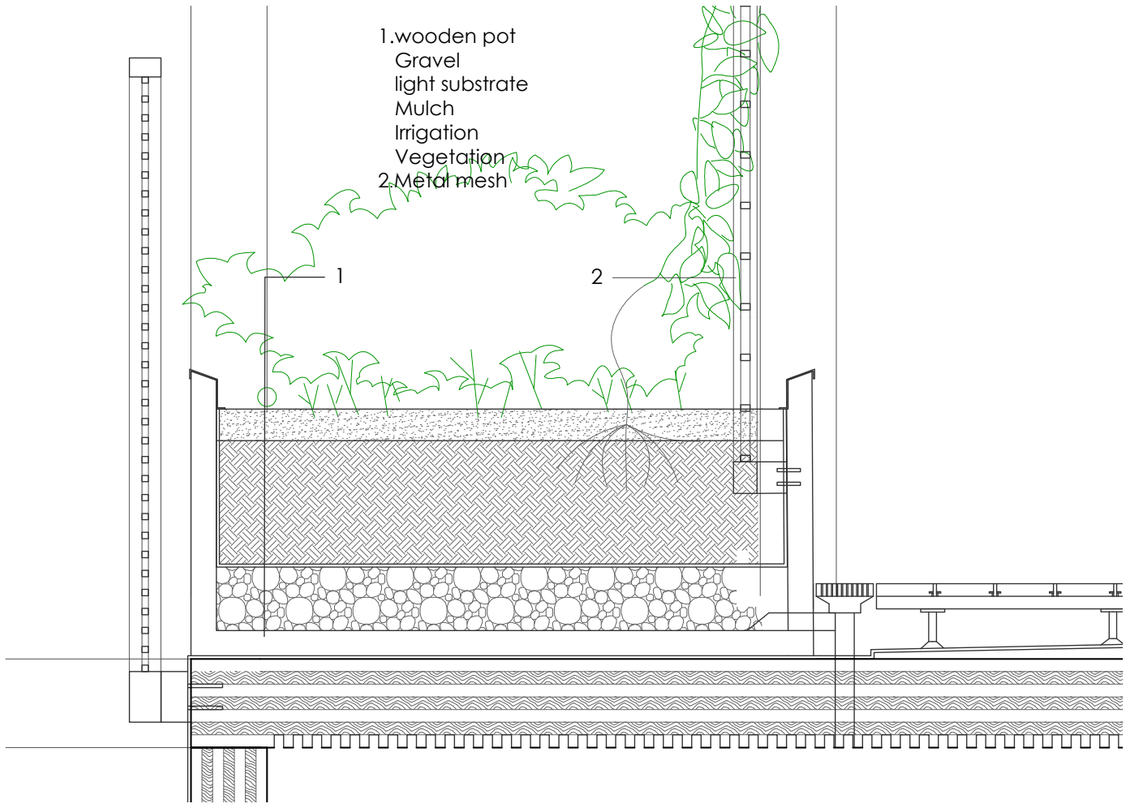
1.light vegetation
20mm mulch
100mm growing medium
filter fleece
drainage element,water reservior
and roof barrier
waterproof membrane
Clt panel 140mm
Acoustic insulation
2.Wood decking
3.Duct/pipe

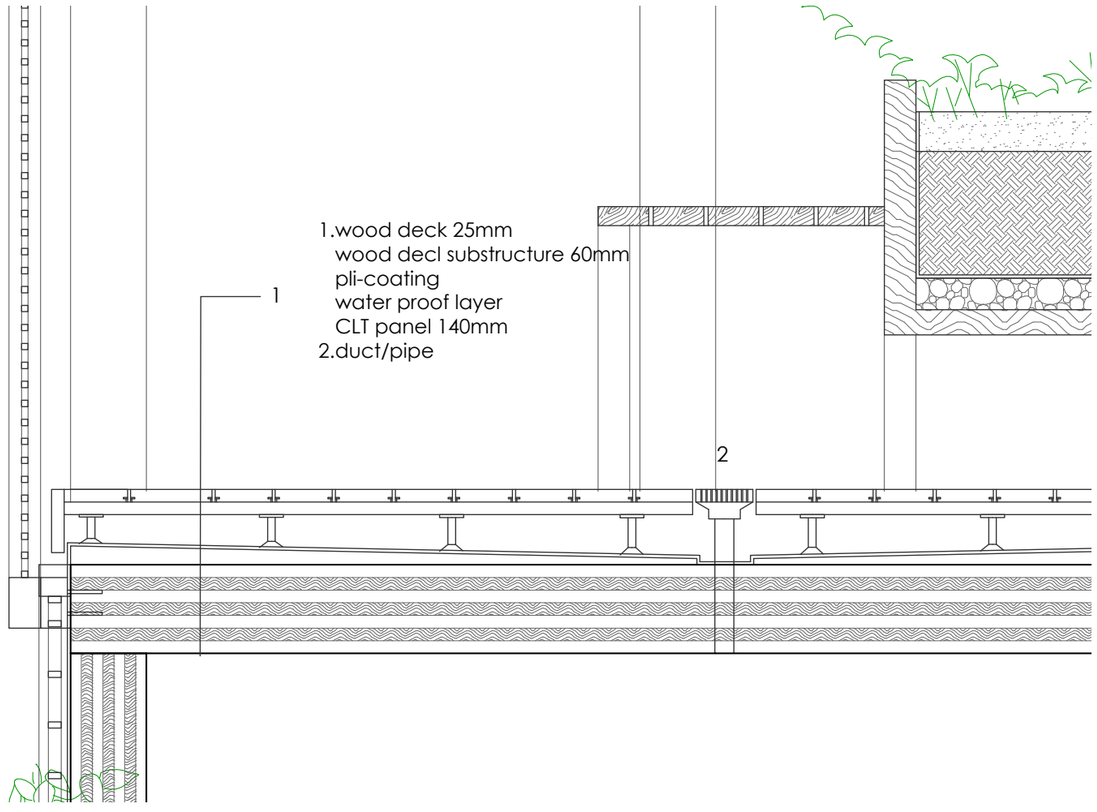


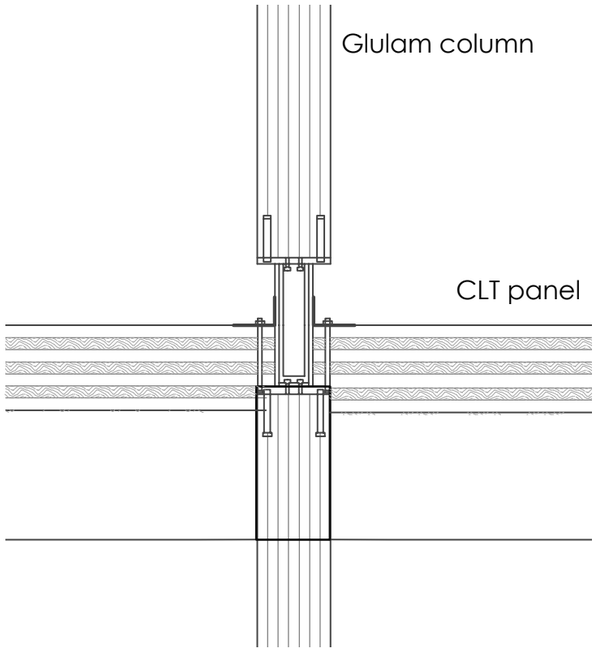
1.light vegetation
50mm mulch
200mm growing medium
filter fleece
drainage element,water reservior
and roof barrier
waterproof membrane
2 layers 140mm rigid insulation
vapour control layer
2.parapet coping
3.flashing lapped over waterproof
membrane
4.smooth gravel edge channel
5.Pipe/ duct
6.Metal grille

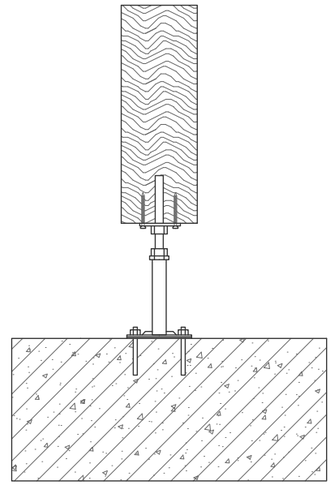


Details

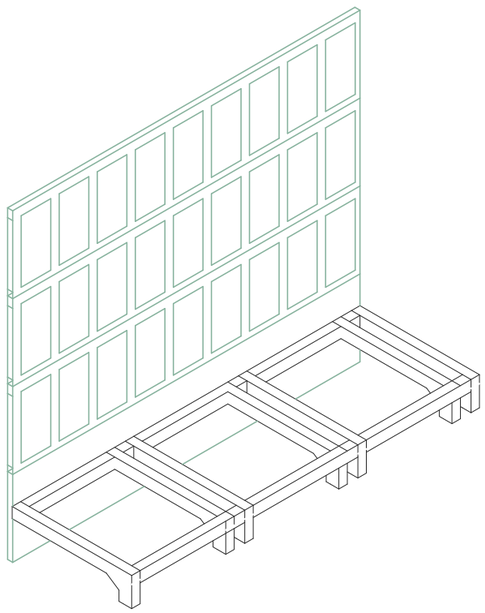

1.wooden pot
Gravel
light substrate
Mulch
Irrigation
Vegetation
2.Metal mesh
1
2

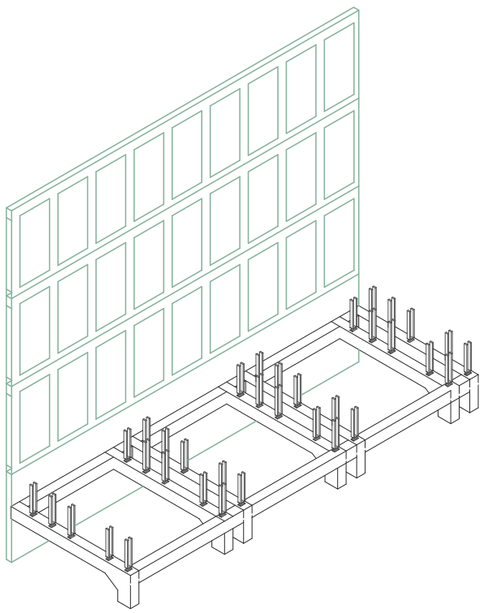

1.wood deck 25mm
wood decl substructure 60mm
pli-coating
water proof layer
CLT panel 140mm
2.duct/pipe
1
2

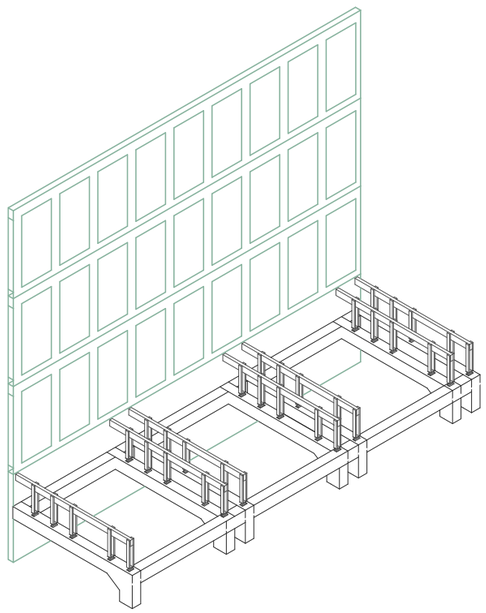

Glulam column
CLT panel

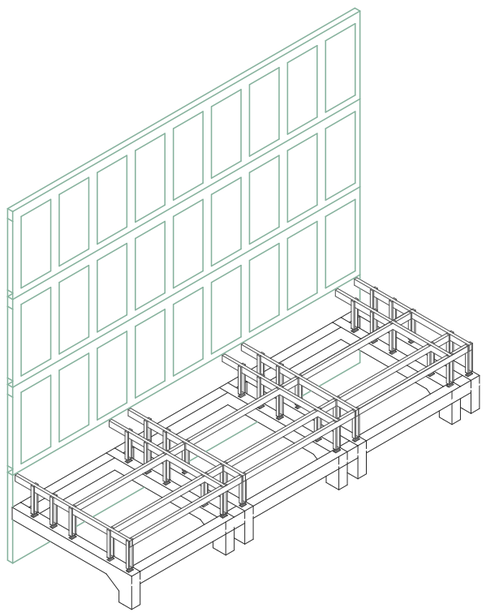


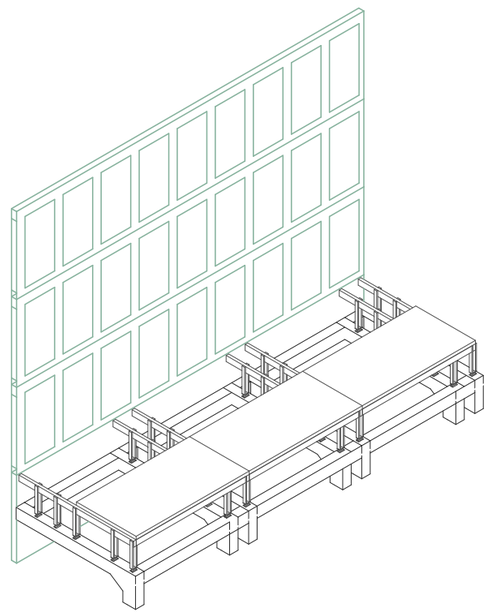
Structure

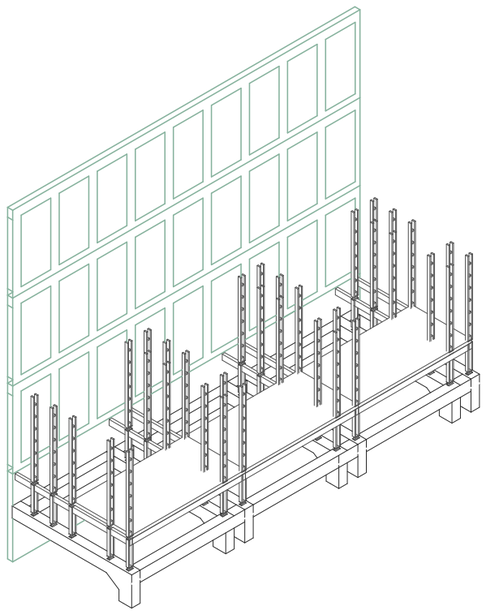


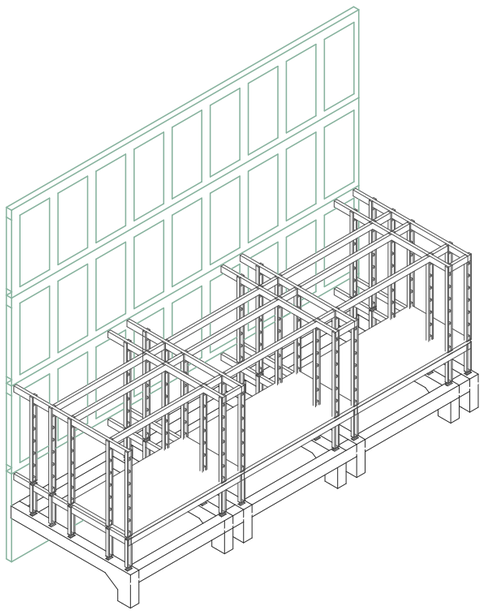


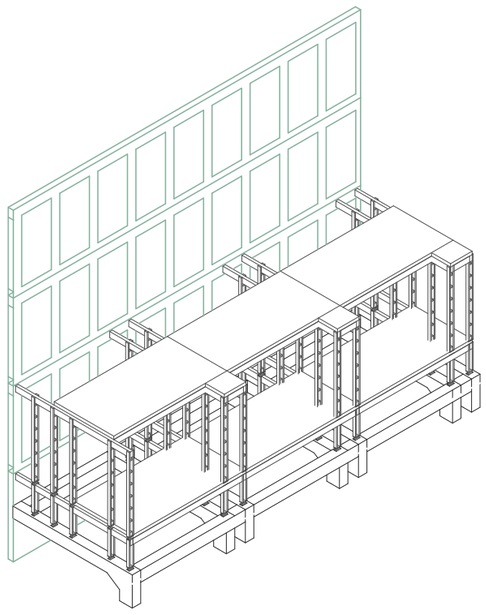


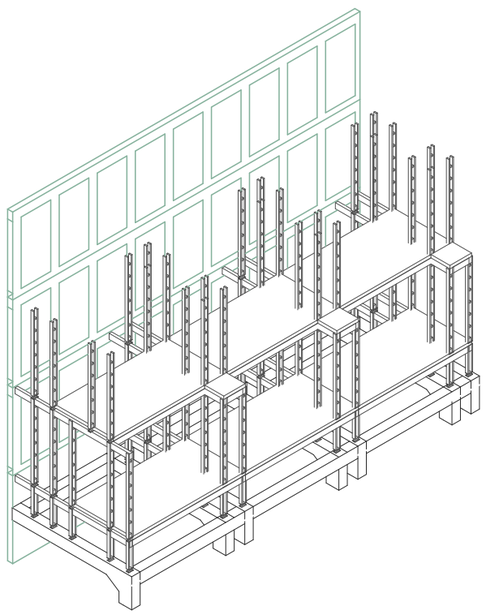


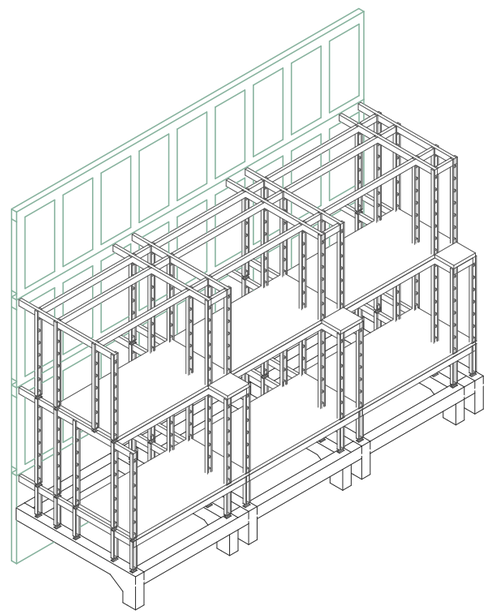


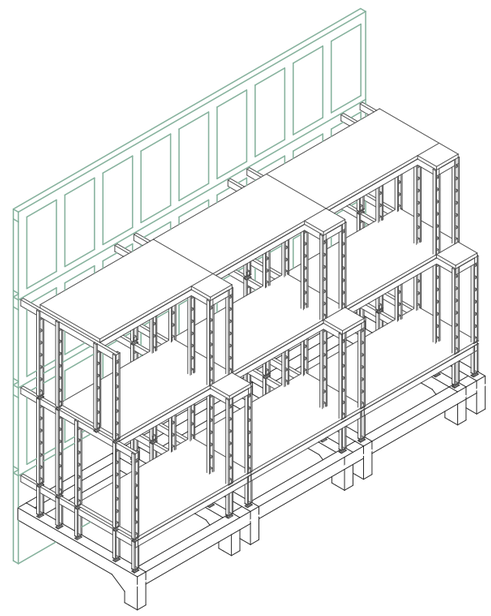




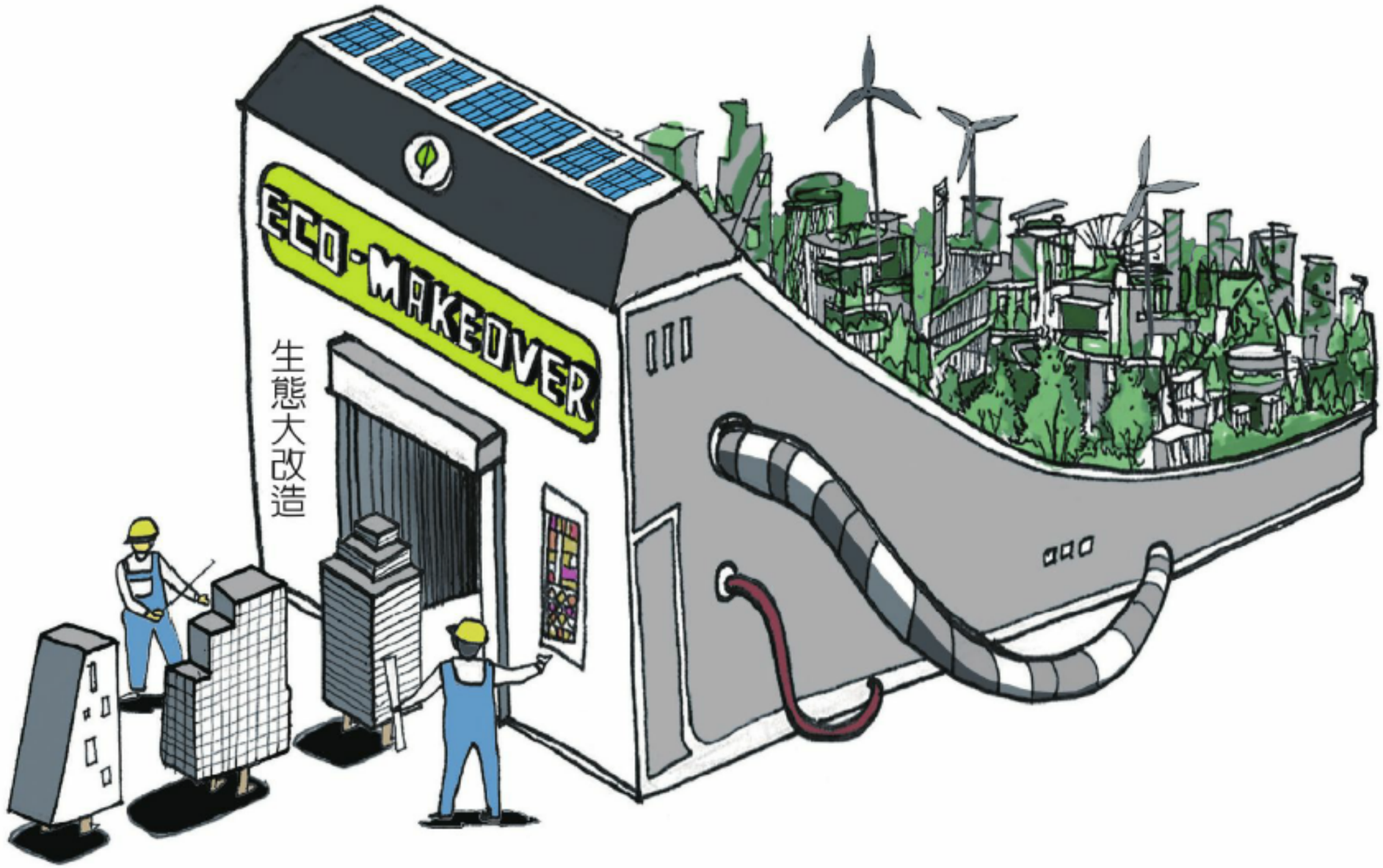








Future dream



Drawing from Ken Yeang 'It's not easy being green'

Thank you!