A Pattern Language
for Water-Oriented Urban Development

Jiaqi Wang

TU Delft
BK Bouwkunde
Urbanism
environmental technology & design

COLOPHON

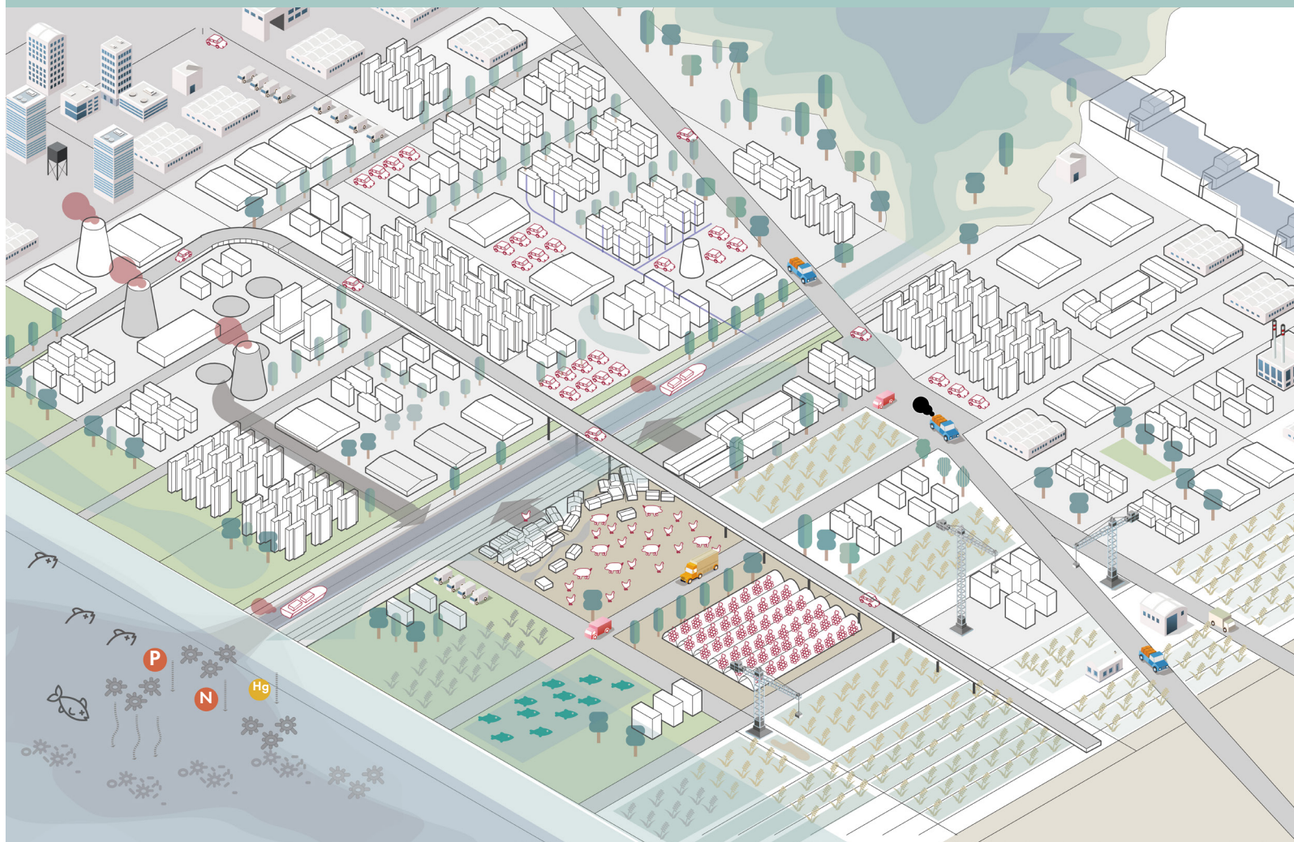
This booklet is the design output of the graduation project:
'Live with water: a sustainable water-oriented urban development pattern' by Jiaqi Wang
Supervised by Ir. Kristel Aalbers and Dr.Ir. R.M. (Remon) Rooij

MSc Architecture, Urbanism and Building Sciences-Track Urbanism
Urban Metabolism and Climate Lab

If you are curious about the method and theoretical underpinnings of the booklet, please read the project report from the Education Repository of TU Delft.

Delft University of Technology
June 2022

IMAGINE YOURSELF AS A DROP OF WATER, WHAT WILL YOU EXPERIENCE IN A MODERN CITY ?.....



MANIFESTO

Towards a water-oriented urban development

Water is a precious element on our planet, which also plays a significant role in nearly all socio-economic activities in our society.

However, with the intensified urbanisation process and climate change, more and more water challenges, including flooding, drinking water scarcity and water pollution, have occurred in many parts of the world.

Thus, it is high time that we switch towards a water-oriented urban development pathway, where effort from all walks of life is well needed.

No matter whether you are a decisionmaker, a community planner, a farmer, a worker, a business owner, a tourism investor, or a botanic student, you can be a valuable and unique contributor to a sustainable water system.

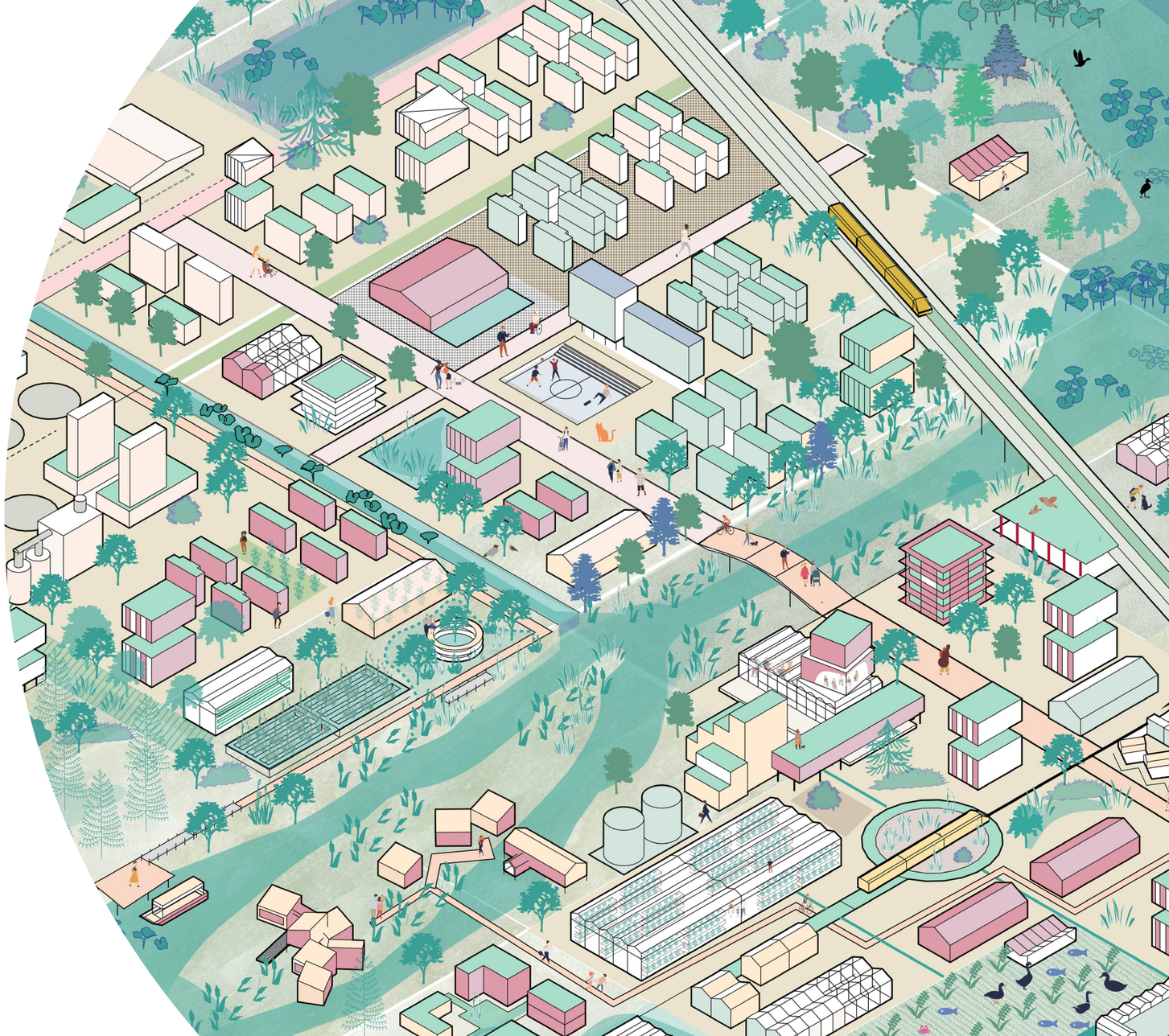
By gradually weaving this water-oriented pattern language web in our future cities, in either a bottom-up or a top-down manner, the landscape of urban areas could be redefined:

The boundary between agricultural production, the industrial zone and the residential zone will be blurred, so the water loop can be fully circular to minimize the freshwater consumption. The urban space will be built in a resilient way to ensure the citizens are fully protected from further flooding events. The ecosystem will also be regenerated for the flourishment of the waterscape, where the agricultural zone, natural reserve and urban areas will be interconnected with a dynamic green-blue network to boost the local ecology.

More importantly, by integrating all types of programmes into people s daily life and daily production, the mindset of people can be reoriented to a sustained commitment to the water and nature.

In this way, a systemic change will take place on our planet, where a future-proof relationship between humans and water could be expected!

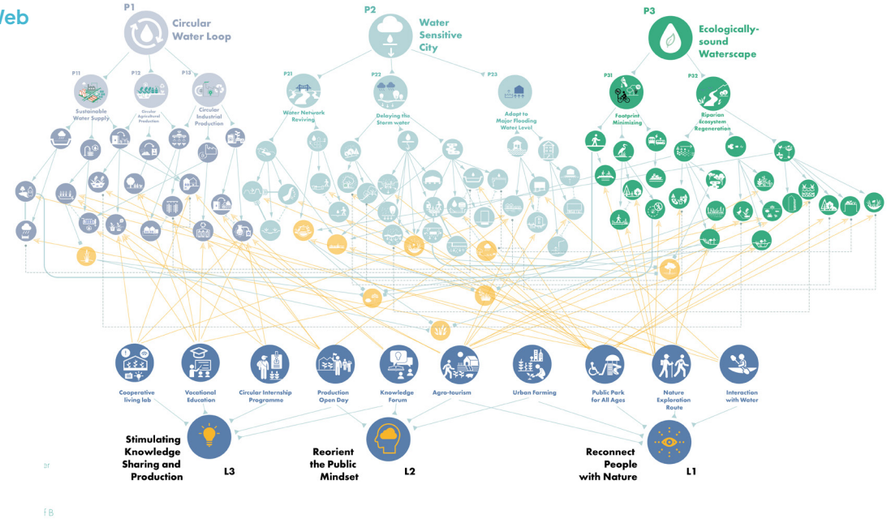
Do not wait! The future is in your hand.



INTRODUCTION

What does this booklet contain?

The Pattern Web



This pattern book consists of 108 patterns in total to frame a water-oriented urban development pattern web.

This includes 11 principles to obey, 3 leverage points to intervene in the system, 20 actions to take, 10 programmes to promote and 64 suggested measures.
Each pattern has its hypothesis and further practical implications.

The Pattern Catagory

page 12
PRINCIPLE
×11

page 16
LEVERAGE
×3

page 13
ACTION
×20

page 17
PROGRAMME
×10

page 14–15
MEASURES
×64

Explanation of the Evaluation Criteria

Transferability:How the pattern is suitable for implementation in a different regions.

Water Safety: How can the pattern protect us from flooding.

Water Quality: How the pattern could improve the quality either in the ecosystem or for the sake of other use.

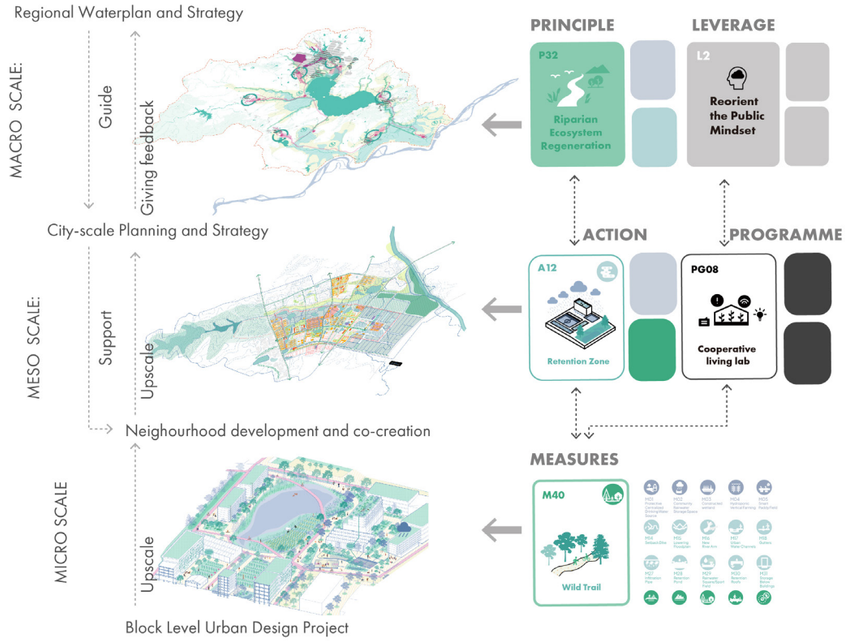
Water Quantity: How the pattern can help improve of the amount of water available for drinking or other sectors

SDG's:Sustainable Development Goals by the United Nations

The booklet allows you to find a pattern based on the topic that you want to explore, but also offers you further knowledge on its relation with other patterns, its contribution to different goals and its related stakeholders. You can either read in order to get an overall impression of the pattern language or use the catalogue from page 12 to page 17 to have a quick start from any pattern you are interested in.

Also, at the end of the book, you can find an example project constructed by this water-oriented pattern language which will provide you with a possible visualization of the implementation outcome.

Who is this booklet for?



The Implementation Framework

The booklet is written for multiple groups of readers.

If you are a planner or a designer, this pattern language could assist you to frame a strategy based on your own context and different scales. You can also use this pattern language to organize a co-creation activity with local communities.

If you are from a local authority, or from an environmental sector or waterboard, this booklet might also offer you some inspiration for formulating a better governance strategy or a new programme.

The reader can also be anyone who want to play a part in mitigating the water issues. For example, if you are from following sectors, or if you want to invest in the following sectors, you can choose from the suggested patterns to make your own contribution to water-oriented urban development:

Agricultural Sector

PG04 Agro-tourism
PG05 Circular Production Open Day
PG06 Urban Farming
PG07 Circular Knowledge Forum
PG08 Cooperative Living Lab
PG09 Circular Internship Programme
PG10 Vocational Education

M02 Community Rainwater Storage Space
M03 Constructed Wetland
M04 Hydroponic Vertical Farming
M05 Smart Paddy Field
M06 Rice-fish System
M07 Agroforestry
M08 Irrigation Water Reusing Greenhouse
M09 Greenhouse Complex
M12 Nutrient Recovery Plant
M13 Algae-based Material Hub
M33 Floating Greenhouse
M47 Ecological Polder Canal
M48 Crop Variation
M49 Integrated Waterfowl Farming
M50 Mixed Aquatic Cultivation

Industrial Sector

PG05 Circular Production Open Day
PG07 Circular Knowledge Forum
PG08 Cooperative Living Lab
PG09 Circular Internship Programme
PG10 Vocational Education

M02 Community Rainwater Storage Space
M03 Constructed Wetland
M10 Grey Water Recycling Plant
M11 Heavy Metal Recycling Plant
M12 Nutrient Recovery Plant
M13 Algae-based Material Hub
M25 Building without a Crawlspace
M26 Infiltration Boxes
M27 Infiltration Pipe
M31 Storage below buildings
M55 Eco-Facade

Tourism Sector

PG01 Interaction activities with water
PG02 Public Park for all ages
PG03 Nature exploration route
PG04 Agro-tourism
PG05 Circular Production Open Day

M01 Protective Centralized Drinking Water Source
M05 Smart Paddy Field
M06 Rice-fish System
M07 Agroforestry
M09 Greenhouse Complex
M15 Lowering Floodplain
M16 New River Arm
M17 Urban Water Channels
M23 Open Green Space
M32 Floating Housing
M33 Floating Greenhouse
M34 Buildings on stilts/(partly) in water
M38 Slow Traffic Bridge
M39 Green Waterbus
M40 Wild Trail
M41 Wood Deck
M43 River Terrace Green Belt
M44 Swamp Forest
M45 Wet Meadow
MG02 Floodable Wetland

OR, if you are from a knowledge institution, further implementation of the following patterns also needs your effort:

PG06 Urban Farming
PG07 Circular Knowledge Forum
PG08 Cooperative Living Lab
PG09 Circular Internship Programme
PG10 Vocational Education

M04 Hydroponic Vertical Farming
M05 Smart Paddy Field
M06 Rice-fish System
M07 Agroforestry
M11 Heavy Metal Recycling Plant
M12 Nutrient Recovery Plant
M13 Algae-based Material Hub
M33 Floating Greenhouse
M48 Crop Variation
M49 Integrated Waterfowl Farming
M50 Mixed Aquatic Cultivation
M55 Eco-Facade
MG01 Helophyte

OR, if you are a citizen who is passionate about doing more for the water system and making your neighourhood a better place, you can also engage more neighbours and promote the following patterns in your community together!

PG01 Interaction activities with water
PG02 Public Park for all ages
PG06 Urban Farming
PG08 Cooperative Living Lab

M02 Community Rainwater Storage Space
M03 Constructed Wetland
M10 Grey Water Recycling Plant
M17 Urban Water Channels
M19 Canopies for Interception
M21 Unpaved Area
M22 Infiltration Strips
M23 Open Green Space
M28 Retention Pond
M29 Rainwater Square/Sports field
M30 Retention roofs
M31 Storage below buildings
M35 Flexible Ground Floor
M37 Sealable Buildings
M38 Slow Traffic Bridge
M39 Green Waterbus
M52 Wet Biotope
M54 Rooftop Habitat
M55 Eco-Facade

In fact, no matter who you are, this pattern book will provide you with multiple ideas and inspiration to embrace a sustainable relationship with water in future urban development.

EVERYONE MATTERS in such a change!

PRINCIPLES

page18–29 Basic design principles for a water-oriented urban development

P1

Circular Water Loop

P11

Sustainable Water Supply

P12

Circular Agricultural Production

P13

Circular Industrial Production

P2

Water Sensitive City

P21

Water Network Reviving

P22

Delaying the Storm water

P23

Adapt to Major Flooding Water Level

P3

Ecologically-sound Waterscape

P31

Footprint Minimizing

P32

Riparian Ecosystem Regeneration

ACTIONS

page24–57 Actions need to be taken to tackle the water challenges.

A01

Rainwater Harvesting

A02

Grey Water Recycling

A03

Smart Irrigation

A04

Manure as Fertilizer

A05

Wastewater to Irrigation

A06

Industrial Wastewater Recycling

A07

Productive Wastewater Treatment

A08

Give Back Room to River

A09

Create Multiple Channels

A10

Green Defense

A11

Groundwater Recharging

A12

Retention Zone

A13

Build on Water

A14

Ground Floor Adjustment

A15

Pedestrianized Public Space

A16

Low-carbon Public Transport

A17

Keep Nature Wild

A18

Wetland-Upland Transition Zone

A19

Revive Natural Food Chain

A20

Urban Biotopes Network

M01 Protective Centralized Drinking Water Source
M02 Community Rainwater Storage Space
M03 Constructed wetland
M04 Hydroponic Vertical Farming
M05 Smart Paddy Field
M06 Rice-fish System
M07 Agroforestry
M08 Irrigation Water Reusing Greenhouse
M09 Greenhouse Complex
M10 Grey Water Recycling Plant
M11 Heavy Metal Recycling Plant
M12 Nutrient Recovery Plant
M13 Algae-based Material Hub

M14 Setback Dike
M15 Lowering Floodplain
M16 New River Arm
M17 Urban Water Channels
M18 Gutters
M19 Canopies
M20 Slope Reinforcement with Vegetation
M21 Unpaved Area
M22 Infiltration Strips
M23 Open Green Space
M24 Permeable Pavement
M25 Building without a Crawlspace
M26 Infiltration Boxes

M27 Infiltration Pipe
M28 Retention Pond
M29 Rainwater Square/Sport Field
M30 Retention Roofs
M31 Storage Below Buildings
M32 Floating Housing
M33 Floating Greenhouse
M34 Buildings onstilts (partly) in water
M35 Flexible Ground Floor
M36 Raised Constructions
M37 Sealable Buildings

M38 Slow Traffic Bridge
M39 Green Waterbus
M40 Wild Trail
M41 Wood Deck
M42 Buffer Zone
M43 River Terrace Green Belt
M44 Swamp Forest
M45 Wet Meadow
M46 Littoral Space
M47 Ecological Polder Canal
M48 Crop Variation
M49 Integrated Waterfowl Farming
M50 Mixed Aquatic Cultivation

M51 Open Soil Area
M52 Wet Biotope
M53 Vegetation Diversity
M54 Rooftop Habitat
M55 Eco-Facade

MG01 Helophyte
MG02 Floodable Wetland
MG03 Natural Ditches
MG04 Bioswales
MG05 Amphibious Park
MG06 Wet Soil Trees
MG07 Hygrophyte
MG08 Emergent Vegetation
MG09 Floating Vegetation

Circular Water Loop
page60–85

Water Sensitive City
page86–133

Ecologically-sound Waterscape
page134–169

All-in-ones!
page170–187

Measures are concretized ways to realize the actions on the previous pages. Measures contributing to the same action may have different performances.

MEASURES

LEVERAGES AND PROGRAMMES

page 30–33

L1

Reconnect People with Nature

L2

Reorient the Public Mindset

L3

Stimulating Knowledge Sharing and Innovation

page 188–209

PG01 Interaction with Water

PG02 Public Park for All Ages

PG03 Nature Exploration Route

PG04 Agro-tourism

PG05 Production Open Day

PG06 Urban Farming

PG07 Knowledge Forum

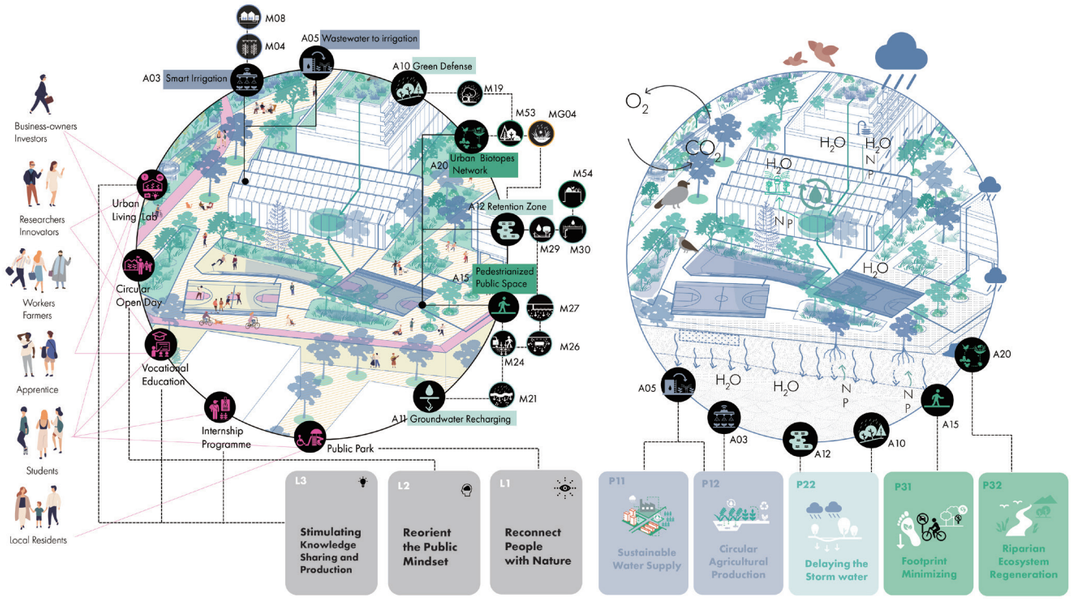
PG08 Cooperative living lab

PG09 Circular Internship Programme

PG10 Vocational Education

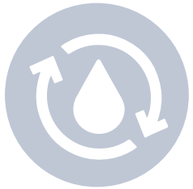
IMPLEMENTATION EXAMPLE

page 210–217



I.PRINCIPLES

for a Water-Oriented city



P01 Circular Water Loop

Hypothesis

Closing the water loop helps us to save clean water and manage the water resource more efficiently.

Theoretical Back-up

Clean water is a precious source for human society. It is important to close the water loop in the production and consumption activities where more reuse, reduction and recycling strategies should be adopted(Arup,2018). Additionally, there are opinions pointing out that the environmental footprint generated by the production, transmission and treatment of water should also be part of the circular water economy(Sebastien Sauve, et al, 2021).

P11 Sustainable Water Supply

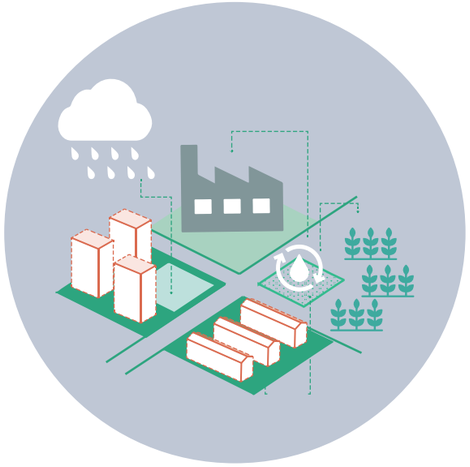
Hypothesis

Having access to sustainable water sources(such as rainwater and recycled water) reduces clean water consumption and mitigates the risk of water scarcity.

Practical Implication

In addition to centralized drinking water sources, it is wise for communities or industrial zone to consider their own decentralized backup water sources, such as rainwater harvesting(A01) and grey water recycling(A02).

A certain degree of mixed land use could facilitate the process. For instance, combining residential zone and agricultural zone together could promote to reuse of wastewater for irrigation(A05).



This pattern Includes:

A01 A02 A05

P12 Circular Agricultural Production

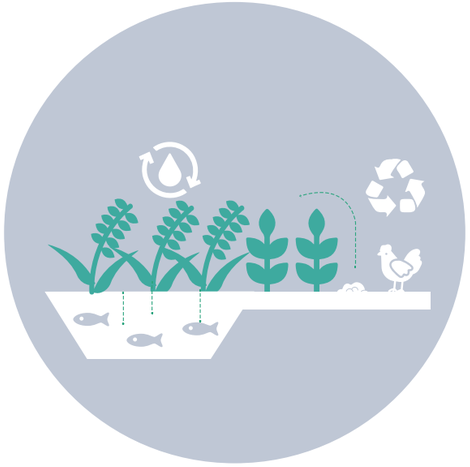
Hypothesis

A circular agricultural production system is essential to handle the water-scarcity challenge and minimize the impact of food production on the biophysical environment.

Practical Implication

One of the simplest ways to realize a circular agricultural system is via recycling water(A05 Wastewater to irrigation) and nutrients(A04 Manure as Fertilizer) in the agricultural production process. This will save resources such as synthetic fertilizer and fresh water, but also avoids soil and water pollution caused by nutrient leakage.

Meanwhile, using new technology(A03 Smart Irrigation) to reduce fresh water consumption in the agricultural production process offers a long-term solution to feed the growing world population.



This pattern Includes:

A03 A04 A05

P13 Circular Industrial Production

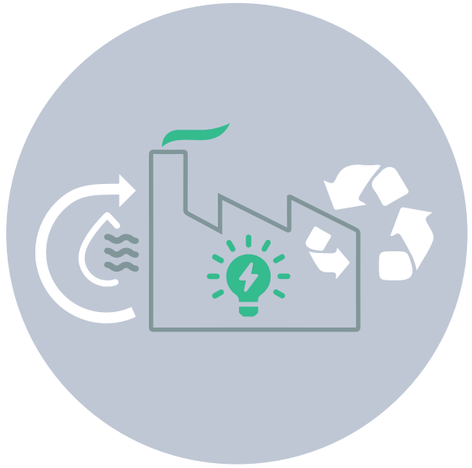
Hypothesis

Full use of raw materials and water resources allows for a healthy and future-proof industrial sector.

Practical Implication

A healthy industrial sector should not be based on overproduction and consumption. Instead, a long-run commitment to the environment is significant. It requires the circular consumption of water and other raw material. This involves establishing a series of new waste recycling and treatment infrastructures(A06 Industrial Wastewater Recycling, A07 Productive Wastewater Treatment) that helps business owners to adapt to the change.

In this process, innovation and knowledge sharing activities are also important, especially for small and middle-sized companies. This could be realized by launching different knowledge exchange and education programmes, such as PG09 Circular Internship Programme, PG07 Circular Knowledge Forum, and PG10 Vocational Education.



This pattern Includes:

A06

A07

P02 Water Sensitive City

Hypothesis

Our future city ought to be water-sensitive enough to get prepared for the increasing extreme flood events brought by climate change.

Theoretical Back-up

Instead of working against nature, the water management infrastructure in cities should be more resilient to handle the climate challenges in the future. By combining existing grey water management methods and natural-based solutions, many of the water-related risks could be cut down(UN-water, 2018).

P21 Water Network Reviving

Hypothesis

Reviving the water network in the region not only contributes to a climate-proof water system but also strengthens the city's image and cultural identity.

Practical Implication

Water network reviving includes making more room for rivers(A08) and revitalizing the surface water network(A09) in the cities. The latter can serve as a delayed pathway for water in parallel with the underground drainage system and has the potential to be further combined with other types of natural-based solutions such as helophyte filters or bioswale.

At the same time, a water network is also essential for cities with a history or tradition with water, reviving waterways in urban areas and integrating them with public spaces offers chances to improve residents' attachment to water as well as their belongings to the cities.

This pattern Includes:

A08

A09

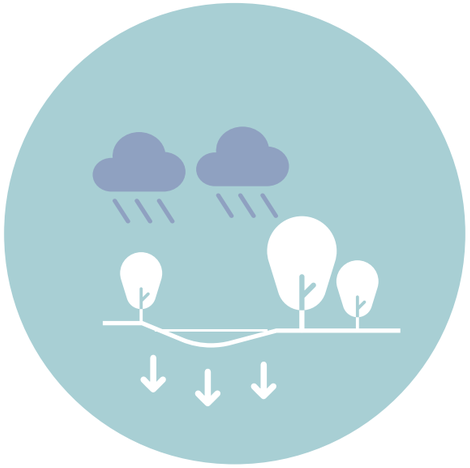
P22 Delaying the Storm Water

Hypothesis

Delaying the stormwater by infiltration and on-site storage cut down the run-off load during intense flooding and thus preserves the cities from waterlogging problems.

Practical Implication

Delaying stormwater includes using the vegetation to take in or intercept more water(A10 green defence), improving infiltration(A11 groundwater recharging) and creating more retention zone(A12). All of this assists to remove the burden on the grey drainage system and maintaining the balance of the natural water cycle.



This pattern Includes:

A10

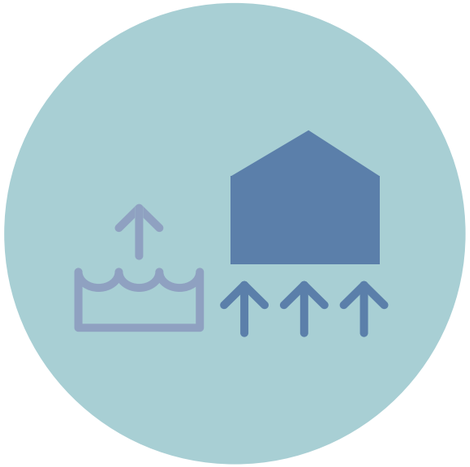
A11

A12

P23 Adapt to Major Flood Level

Hypothesis

Adapting the building to the increasing flood level is the way to live with changing climate.



Practical Implication

When densifying In a low-lying zone, new building prototypes can be introduced to minimize the loss of private property caused by flooding. Depending on the budget, this can be done by building on the top of water directly(A13) or adjusting the ground floor(A14) function or form of the buildings.

This pattern Includes:

A13

A14

P03 Ecologically Sound Waterscape

Hypothesis

Seeing surface water as an inseparable part of the ecosystem is crucial to a sustainable future.

Theoretical Back-up

Since the city has been regarded as the root of environmental problems, it now should search for its solutions to act and perform sustainably as an ecosystem (Tillie,2018) to face the upcoming challenges. By shaping the living environment to satisfy the demand of the ecosystem, future urban areas should be itself function as an ecosystem. In this sense, the waterway in the urban area should also carry out its ecological function. This not only concerns biodiversity inside the water body but also contains the ecosystem of the embankment and even the quality of groundwater that constantly flows into the surface water system.

P31 Footprint Minimizing

Hypothesis

Only by minimizing our disturbance to nature can make sure the nature's flourishment.

Practical Implication

Minimising human's negative influence on nature serves as the foundation of ecosystem regeneration. This can be done by prohibiting or limiting human activities in areas that are restored for nature(A17 Keep nature wild). This also concerns pedestrianizing more urban spaces(A15) and promoting green transportation(A16), so that further emissions into the surface water, air(which indirect cause water pollution in the form of acid rain), and soil (which affects the groundwater quality)could be inhibited.

This pattern Includes:

A15

A16

A17

P32 Riparian Ecosystem Regeneration

Hypothesis

A riparian zone acts as an ecological engineer for river health by delivering a range of ecosystem functions(Singh et al., 2021).

Practical Implication

The riparian ecosystem has its own transitional natural characteristics(Nicola et al., 2011) and concerns the survival and health of all types of animals that either nest next to the water, hunt for food in the water or breed in the shallow riparian zone. So, regenerating the ecosystem from upland to wetland needs to choose suitable types of local vegetation instead of purely planting monotonous vegetation along the river(A18 Wetland-Upland Transition). In the rural riparian areas, agricultural production should also learn to obey the natural food chain(A19) and contribute to local biodiversity. In the urban area, a connecting biotope network(A20) within the city should be established to boost the ecosystem within the urban area as well as the health of the water system.

This pattern Includes:

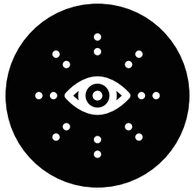
A18

A19

A20

II.
LEVERAGE POINTS
for a systemic change

L01 Reconnect People with Nature



Hypothesis

Reconnecting people with nature fosters people's awareness to protect nature and lead a sustainable life.

This pattern includes:

PG01 PG02 PG03 PG04

Theoretical Back-up

David J. Abson et al. (2017,p34) pointed out that 'how people perceive, value and interact with the natural world fundamentally shapes the goals and paradigms underpinning many systems of interest.'

This implies that exposing people to nature as much as possible could foster people's attachment to nature and awareness of the environmental problems, which potentially leads to a growing emphasis on sustainability from the whole society.

Practical Implication

In order to draw people's attention to the water system and allows them to appreciate the company of water, many programmes could be launched. For example, creating more opportunities for people to interact with water(PG01), including boating, swimming or just playing in small streams, could bring people and surface water together. In an urban context, building more parks for all ages(PG02) offer people chances to have access to nature in their neighourhood. Tourism also plays a role, which contains not only natural exploration tours (PG03) but also agri-tourism(PG04) in rural areas that allows people to enjoy the scenery.

L02 Reorient Public Mindset

Hypothesis

Promoting a circular production and consumption mindset makes the society to be more responsible for our planet.

This pattern includes:

PG04 PG05 PG06

Theoretical Back-up

Circular economy centres around closing loops and minimizing waste, turning goods in their end of service life into resources again (Stahel, W. R., 2016). However, adapting to such a production model is usually not a spontaneous move for many current businesses when focusing merely on profit. Thus, a reorienting of the mindset toward circular is urgently needed to engage more producers and consumers to get rid of the traditional linear mindset and take part in the movement of the circular economy.

Practical Implication

Providing more proximity between producers and consumers could add new value to the production process. Activities such as urban farming(PG06), agri-tourism(PG04) and circular production open days(PG05) can encourage more producers and consumers to switch from merely focusing on the product itself toward 'how we should produce and consume'.

L03 Stimulating Knowledge Sharing and Innovation

Hypothesis

Rethinking how knowledge is produced and transmitted around people is crucial for a socio-economic change towards sustainability.

This pattern includes:

PG07 PG08 PG09 PG10

Theoretical Back-up

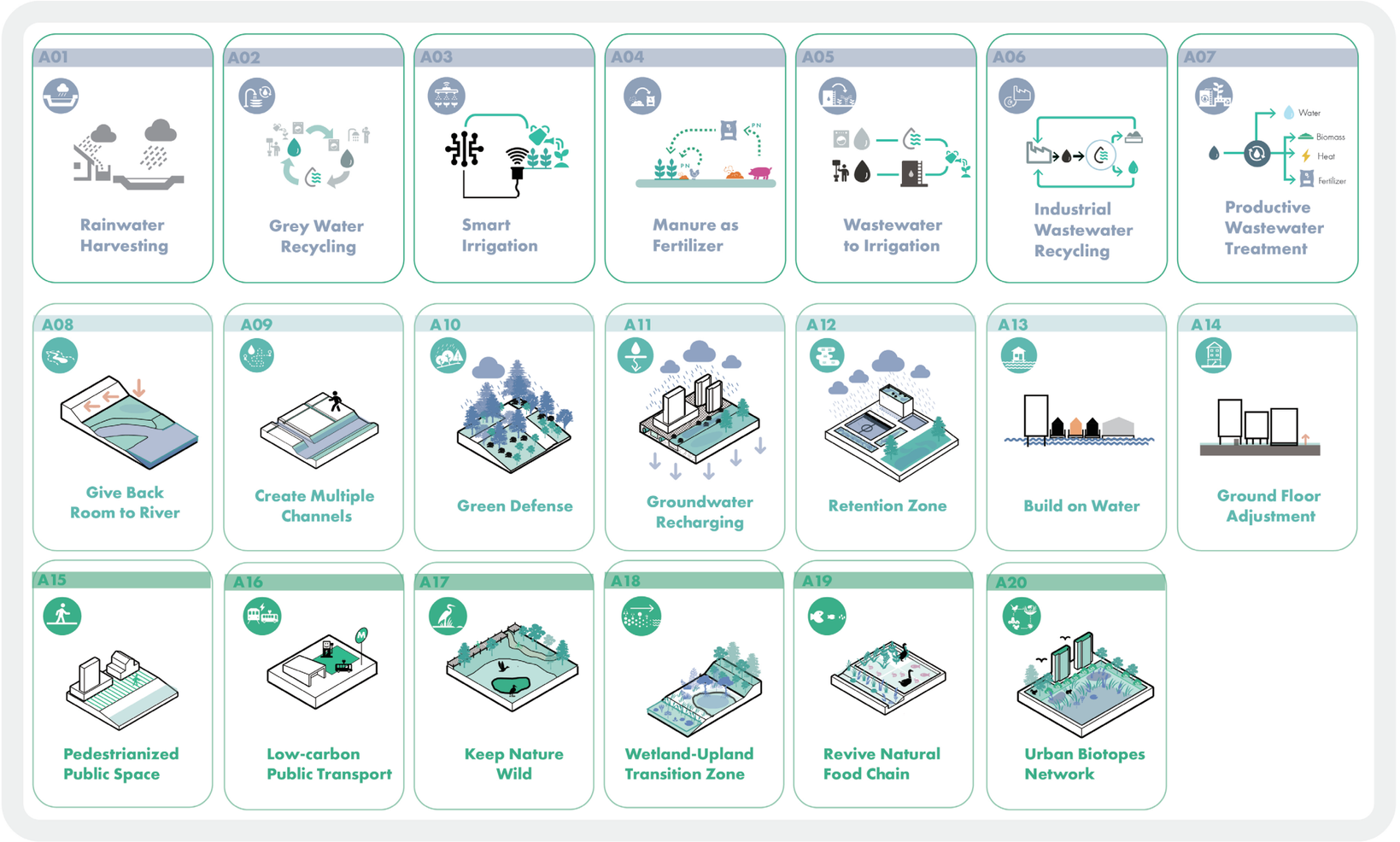
According to Simin Davoudi et al.(2013), learning capacity is an important part of a resilient and adaptive socio-economic system. Thus, the way of knowledge sharing between different institutions is vital to get fully prepared for the upcoming social-economic challenges.

Practical Implication

Knowledge shall not only be produced and learnt in schools or universities. In fact, much knowledge could be harvested from farmland, factories, streets and neighbourhoods by launching programmes such as Cooperative Living Lab(PG08), and Circular Internship Programme(PG09). Further cooperation between knowledge institutions and production sectors could also be realized through a Circular knowledge forum(PG07) or vocational education(PG10).

III.
ACTIONS
for a healthy water system

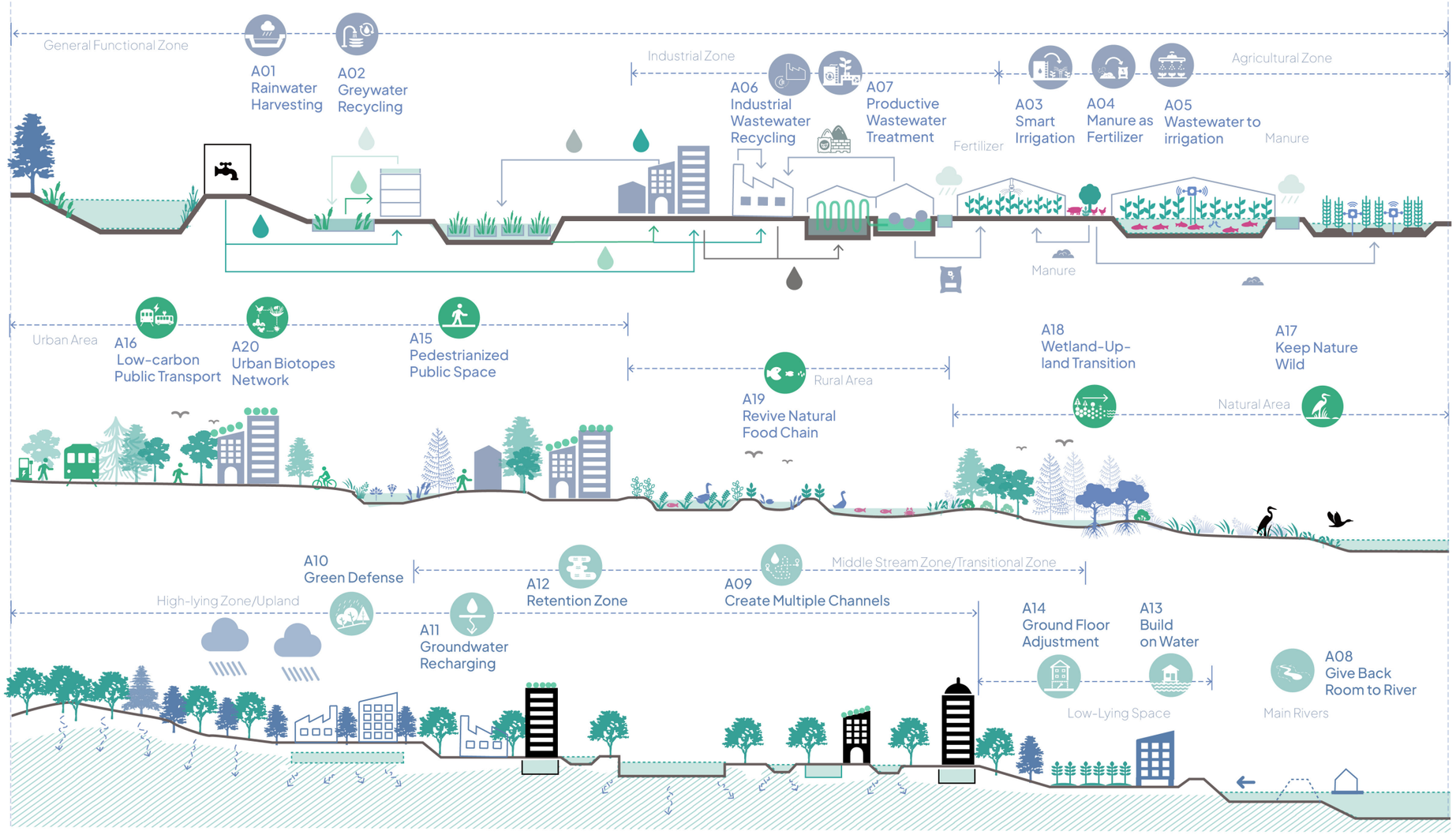
Find the right actions to take based on the aims and situations.



P01 Circular Water Loop

P02 Water Sensitive City

P03 Ecologically-sound Waterscape

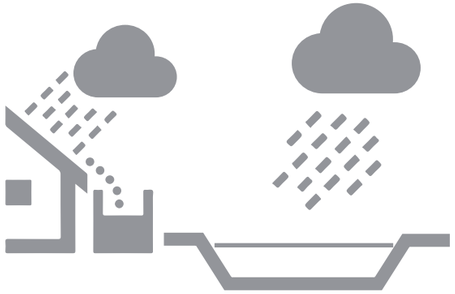


A01

A01 Rainwater Harvesting

Hypothesis

Collecting rainwater and using it as an alternative source offers a simple and effective pathway to embracing sustainable water consumption.



Theoretical Back-up and Practical Implication

Rainwater harvesting involves the collection and storage of rainwater with help of artificially designed systems. Yet usually done in a centralized way(M01), but it is also encouraged on a neighbourhood scale (M02) or even on in a private backyard. Such effort not only make a change in handling the water scarcity challenge but may also have an impact on mitigating flood risk if combining the water storage function with a retention space(A12).

Links with other patterns

Generalized by:

P11 Sustainable Water Supply

Concretized by:

M01 M02

Co-exist well with:

A12

A02 Greywater Recycling

A02

Hypothesis

Grey water recycling allows us to handle the challenge between population growth and the uneven distribution of wastewater resources.

Theoretical Back-up and Practical Implication

Greywater includes the household wastewater from showers, hand-washing basins, laundry, washing machines, and kitchen sewage, which contributes to 50%-80% of the total domestic water consumption volume and can be easily reused after simple treatment(Filali et al.,2022) Greywater can be treated in multiple ways, ranging from mechanical treatment methods(M10) to constructed wetlands(M03).

Also, the grey water from households can be recycled directly by the agri-food sector, considering the nutrients in it. Certain wastewater in the industrial process, such as car washing, can also be reused.

Links with other patterns

Generalized by:

P11 Sustainable Water Supply

Concretized by:

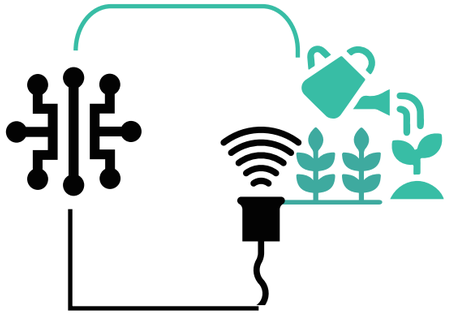
M10 M03

A03

A03 Smart Irrigation

Hypothesis

Smart irrigation maximizes water consumption efficiency by reducing water waste while maintaining plant health and quality to ensure food security.



Theoretical Back-up and Practical Implication

Smart irrigation relies on the weather data or soil moisture data to determine the irrigation need of the crops(Malarie Gotcher et al., 2017). It can be done in open field production with an automatic irrigation system(eg. M05 smart paddy field), while indoor vertical farming(M04 Hydroponic Vertical Farming) offers more desired conditions to control the soil moisture, air condition and temperature in order to optimize the smart water consumption.

Links with other patterns

Generalized by:

P12 Circular Agricultural Production

Concretized by:

M04 M05

A04 Manure as Fertilizer

Hypothesis

Manure, as a natural by-product of the livestock sector, is a valuable source to offer nutrients to plants and thus can be used as ideal fertilizer if recycled properly.

Theoretical Back-up and Practical Implication

Animal manures contain multiple nutrients that support the growth of crops. Meanwhile, it is a prerequisite to maintaining the health of the soil (Leenstra et al., 2019).

Manure or slurry can be recycled in multiple ways. One is collecting the manure from livestock farming fields and processing them into a concentrate which can replace artificial fertilizer. Another way is integrating the farming of fish and livestock with crop farming(See M06 Rice-fish System, M07 Agroforestry), where the manure can directly be recycled.

Links with other patterns

Generalized by:

P12 Circular Agricultural Production

Concretized by:

M06 M07 M09

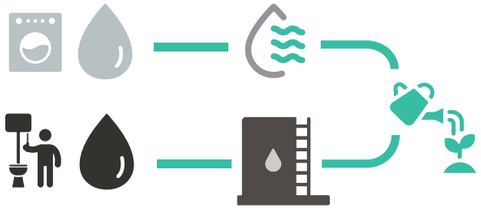
A01

A05

A05 Wastewater to irrigation

Hypothesis

Recycling wastewater provides a reliable water source for agricultural production and controls the potential emissions to surface water by wastewater discharge.



Theoretical Back-up and Practical Implication

Nowadays, the discharge from many waste treatment plants is still rich in nutrients and can cause eutrophication to a water body, but It is safe to use them as a water resource for irrigation. It is also a common idea to use greywater to irrigate, especially bringing benefits to the domestic practice.

However, when applied on a larger scale for agricultural production, it is still suggested to pretreat the greywater in advance to cater to the different needs of crops (Filali et al.2022). This can be more easily realized in irrigation water reusing greenhouses(M08) or greenhouse complexes (M09) where the wastewater flow can be better controlled. But it is still possible to realize this by directly integrating fishery with paddy field farming(M06).

Links with other patterns

Generalized by:

P11
Sustainable
Water Supply
P12
Circular
Agricultural

Concretized by:

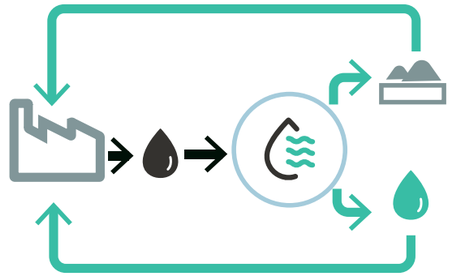
M08 M09 M06

A06

A06 Industrial Wastewater Recycling

Hypothesis

Though dirty and toxic it seems, there are precious elements in industrial wastewater that ought to be fully recycled and reused.



Theoretical Back-up and Practical Implication

There are multiple ways to make water consumption more circular based on different types of manufacturing and it can be done either within a single factory or in a collective way.

For example, in a car manufacturing factory, water consumption rinsing, washing or cooling can easily be recycled again after purification in a grey water recycling plant(M10).

In terms of other toxic wastewater, sharing wastewater treatment facilities could be considered, such as nutrient recovery plant(M12) or heavy metal recycling plant(M11) to stimulate the reuse of the elements inside the wastewater and facilitate wastewater recycling.

Links with other patterns

Generalized by:

P13
Circular
Industrial
Production

Concretized by:

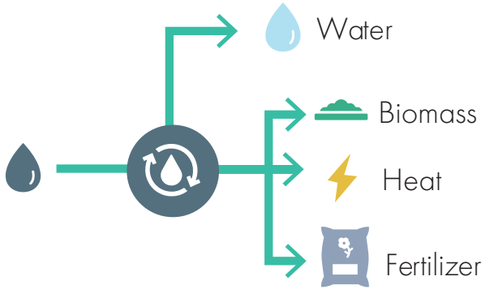
M10 M11

A07

A07 Productive Wastewater Treatment

Hypothesis

Shifting away from wastewater treatment plants to water resource recovery facilities allows for an environmentally and financially sustainable wastewater treatment sector.



Theoretical Back-up and Practical Implication

Traditionally, wastewater treatment is all about removing the contaminants from the water in order to discharge it safely to the environment. However, it is high time to rethink how different ingredients could be recovered from this process.(World Bank,2020)

There are multiple choices for recovering different resources from wastewater. It can be processed by a physical or chemical method which may generate heat for the surrounding neighbourhood at the same time(M12 Nutrient recovery plant). A biological pathway is also becoming more popular as an easy way of harvesting a large amount of biomass(M13 Algae-based material hub).

Links with other patterns

Generalized by:

P13
Circular
Industrial
Production

Concretized by:

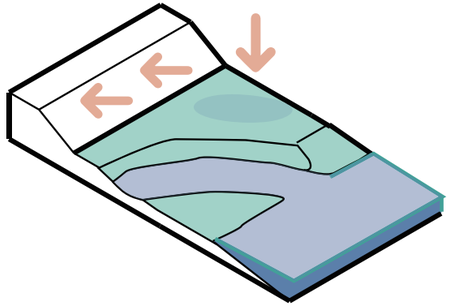
M12 M13

A08

A08 Give Back Room to River

Hypothesis

Giving back more natural space around the river helps us prepare for uncertain future climate challenges.



Theoretical Back-up and Practical Implication

Nature dynamics provides us with more adaptable solutions to face climate challenges. Making room for rivers could reduce the water level of excess flows when exposed to large floods and simultaneously contribute to water-related biodiversity which improves water quality (Deltares,2013).

To handle the tidal flooding of a river, removing the existing dikes(M14 setback dike) and lowering floodplains(M15) is usually the first step, and it might involve relocating residents or restoring farmland to wetland. This will lead to a floodable wetland zone that might bring further tourism and recreational functions. Meanwhile, creating a new river arm(M16) could also be considered where

Links with other patterns

Generalized by:

P21
Water Network
Reviving

Concretized by:

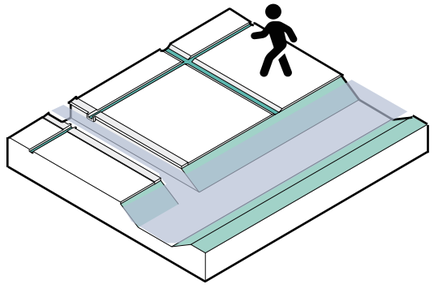
MG02 M14 M15 M16

A09

A09 Create Multiple Channels

Hypothesis

Creating alternative water channels in parallel with the existing underground water network mitigates the pressure on the water management system during heavy flooding.



Theoretical Back-up and Practical Implication

In urban areas, an open drainage network could be established by different forms of channels. This includes urban water channels(M17), gutters (M18), and natural ditches(MG03).

Natural ditches are the most ecological-friendly choice. However, it takes more space and might not be applicable in many urban contexts if not integrated by a green corridor or community parks. In this case, urban water channels are more suitable for commercial or other types of public spaces while more budget would be spent on design and maintenance costs. Gutters can be an alternative choice and it is easy to be installed along with the pavement while the ecological and esthetic value is limited.

Links with other patterns

Generalized by:

P21
Water Network Reviving

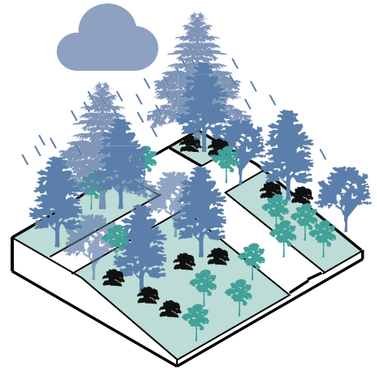
Concretized by:

MG03 M17 M18

A10 Green Defense

Hypothesis

Vegetations act as an effective defence in flash storms and they take in rainwater and protect the soil from erosion.



Theoretical Back-up and Practical Implication

Creating green defence firstly involves planting trees whose canopies(M19) intercept and intake rainwater. It is especially efficient when handling flash stormwater in a short period, while the performance of different types of trees could differ. Especially in mountainous or embankment areas, reinforcing the slopes with vegetation(M20) could prevent landslides from happening during heavy storm rain.

At the same time, vegetations offer other benefits such as providing shades, cooling, increasing moisture, taking in carbon dioxide emissions and mitigating air pollution. So introducing more urban trees and vegetation might achieve many things in one stroke for cities. However, it

Links with other patterns

Generalized by:

P22
Delaying the Storm Water

Concretized by:

M19 M20

Co-exist well with:

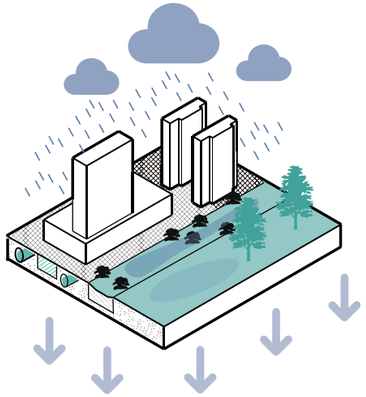
M16 M43

A11

A11 Groundwater Recharging

Hypothesis

Improving Infiltration in the built-up areas ensures a stable underground water level and also helps citizens get rid of water nuisance during the rainy days.



Theoretical Back-up and Practical Implication

To recharge groundwater, making room for unpaved areas(M21) is usually the effective and intuitive measure to consider. On a city scale, open green(M23) in urban areas is necessary. In areas where pavement is unavoidable(such as industrial zone, cycling and pedestrian path, and public plaza), permeable material(M24 permeable pavement) should be considered.
In densely built-up areas where urban waterlogging happens from time to time, infiltration of rainwater needs more artificial management. In such cases, infiltration stripes(M22), infiltration boxes(M26) and infiltration pipes(M27) could be implemented to assist the infiltration process. Also, a crawlspace or basement space might also affect the infiltration process. As a result, large scale horizontal buildings, especially industrial buildings could be built without a crawlspace(M25).

Links with other patterns

Generalized by:

P22 Delaying the Storm Water

Concretized by:

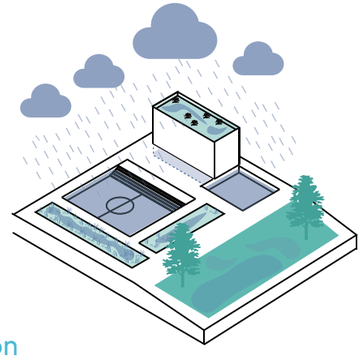
M21 M22 M23 M24 M25 M26 M27 MG03 MG04

A12

A12 Retention Zone

Hypothesis

Enough retention spaces allow the rainwater to stay during extreme flood events and minimize the pressure on the drainage system.



Theoretical Back-up and Practical Implication

There are many forms of retention space. Some of them already have permanent water storage capacity, such as a retention pond(M28), which has a permanent pond area that could be used for future consumption(M02, Community Rainwater Storage Space) but also provides additional storage capacity to buffer extra rainwater during flooding events (NWRM,2015). Moreover, a natural ditch or an urban canal, if properly designed to allow a fluctuation in water level, can also work as a retention zone.

Other retention spaces might also be referred to as 'detention spaces'. They are usually dry during the sunny period, but they can quickly be turned into a rainwater buffer during storm events. These include floodable wetland(MG02), bioswales(MG04), amphibious park(MG05), rainwater square/sports field(M29), Retention roofs(M30), Storage below buildings(M31). In this way, they maximize the utilization of space and improve the flood resilience of cities.

Links with other patterns

Generalized by:

P22 Delaying the Storm Water

Concretized by:

MG02 MG04 MG05 M29 M30 M31

Co-exist well with:

M02

A13

A13 Build on Water

Hypothesis

Using new technology and construction method allows buildings to float and protect the vulnerable region threatened by climate issues from inundation.

Theoretical Back-up and Practical Implication

Building on top of the water is not an old concept. No matter in prehistoric pile dwellings around the Alps or in the south area of China, buildings on stilts (M34) were popular already in the ancient world and still have a value today.

Modern technology also offers us new solutions. In Amsterdam, a floating housing(M32) programme called Schoonschip has already been realized to adapt to sea-level rise. This floating building prototype is also possible to be considered for other types of functions, such as a floating greenhouse(M33) to secure future agricultural production under climate impact.

Links with other patterns

Generalized by:

P23
Adapt to Major Flood Level

Concretized by:

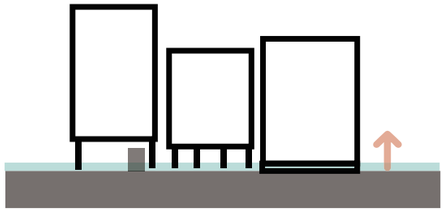
M32 M33 M34

A14

A14 Ground Floor Adjustment

Hypothesis

Adjusting the form or function of the ground floor of a building could secure the safety of residents and minimize the impact on residents' private property.



Theoretical Back-up and Practical Implication

The ground floor is usually the most vulnerable level of a building during flood events. To improve the water safety of the building, raised construction(M36) is the most effective way to safeguard the residents inside. Another measure to cut down the flood risk is to use the ground floor as a flexible public space(M35). It can be used to hold public activities or bicycle storage on normal days. During emergencies, it can be prepared for flooding. When the budget is limited or in areas where flooding is less often or intense, sealable buildings(M37) could be a choice to handle the water nuisance.

Links with other patterns

Generalized by:

P23
Adapt to Major Flood Level

Concretized by:

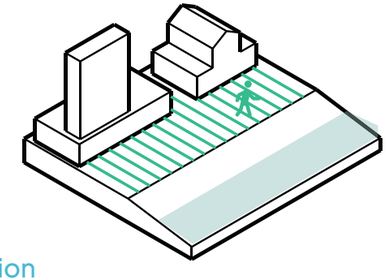
M35 M36 M37

A15

A15 Pedestrianized Public Space

Hypothesis

Giving more public space to pedestrians reduces the usage of cars and provides the possibility to embrace a more ecologically friendly and socially just living environment.



Theoretical Back-up and Practical Implication

The emissions caused by cars have already caused dramatic damage to the air, soil and water. Thus, restricting the use of cars in certain areas of the cities(such as riverfront areas and natural reserves) are critical move to protect our sensitive ecosystem. For example, a slow traffic bridge(M38) could be encouraged in the city to take the place of a motorway bridge.
Nextly, the car-oriented paradigm is also a major barrier when transiting toward a water-oriented city. The car-oriented urban not only affects permeability but also takes up many urban spaces that could have been used for more meaningful functions with ecological and social value.
By promoting a pedestrian-friendly district, many water-oriented measures become possible. The usage of the permeable pavement(M24) is just the first movement. Actually, when a street or other public plots are no more designed for cars or car parking, more spaces could be freed up for water-oriented elements, such as bioswales(MG04), rainwater square(M29), wet biotopes(M52) and amphibious parks(MG05).

Links with other patterns

Generalized by:

P31
Footprint
Minimizing

Concretized by:

M38

Complementary:

M24

Facilitating:

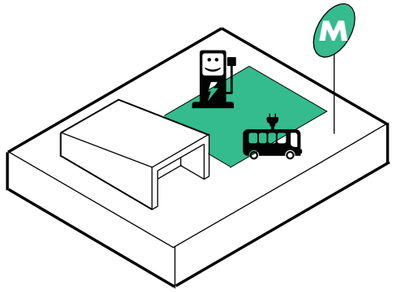
MG04 MG05
M29 M52

A16

A16 Low-carbon Public Transport

Hypothesis

Embracing public transport reduces the contaminations caused by fossil-fueled vehicles to air, soil and water.



Theoretical Back-up and Practical Implication

To transit from a car-oriented city toward a sustainable city, a strong public transport network is essential to enable people to commute conveniently. This includes metros, trams and buses. Especially, in cities where the waterway network is dense enough, water buses(M39) powered by green energy could be considered in parallel with other modes of public transportation. In this way, people could get close to the water and appreciate the accompany of water in their daily life.

Note: Further experience could be learnt from Dutch cities, such as Rotterdam, where waterbuses and ferries have been an important part of public transportation.

Links with other patterns

Generalized by:

P31
Footprint
Minimizing

Concretized by:

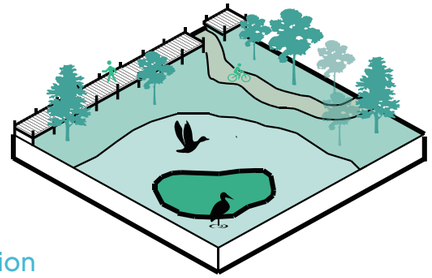
M39

A17

A17 Keep Nature Wild

Hypothesis

Nature is not anyone's private backyard. Keeping it wild and respecting its rhythm is the way to live with it.



Theoretical Back-up and Practical Implication

Though many natural reserves allow visitors, the impact of human activities should be minimized as much as possible. The most important is to create a buffer zone(M42) to limit human activities outside certain areas for the sake of wildlife. In spaces where tourists are allowed, interventions should be delicate enough to keep the original soil and water linkage in the ecological zone. In certain vulnerable ecological zones, especially wetlands or jungles where ground layers are more sensitive, wood decks(M41) should be implemented. In other situations, a wild trail(M40) rather than a paved path is suggested to keep the wildness of nature.

Meanwhile, this action is not only suitable for natural reserves. In fact, even in urban areas, keeping nature wild is also important for creating a robust ecological network. For example, wood decks could also be used when designing a community amphibious park(MG05) and other types of wet biotopes(M52).

Links with other patterns

Generalized by:

P31
Footprint
Minimizing

Concretized by:

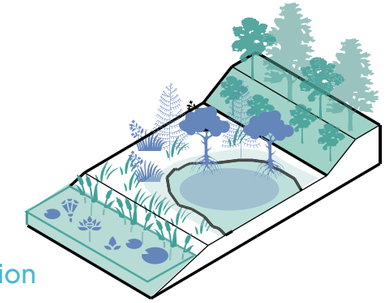
M40 M41 M42

A18 Wetland-Upland Transition

A18

Hypothesis

Naturally, the transition from upland to the wetland is complicated and is supported by multiple types of vegetation and a gradient landscape.



Theoretical Back-up and Practical Implication

The formation of the riparian zone is a long-term geographical movement, where the natural landscape also evolves based on humidity and soil types. Thus, a gradient change of vegetation species could be found next to the river from upland to wetland.

Such natural riparian landscapes could differ from river to river, but also different sections of one river. For example, some of them go through a valley surrounded by a steep slope(usually in the upstream or middle stream), where a river terrace green belt(M43) could be established. Others shape large and moisture floodplains, where swamp forests (M44), and wet meadows (M45) grow and flourish.

However, no matter many large rivers or small streams, they all have littoral spaces(M46) where the water level fluctuates in between, the ecological condition of which is the most sensitive and significant. Hence, it should be emphasized when regenerating the ecosystem of the surface water.

Links with other patterns

Generalized by:

P32
Riparian
Ecosystem
Regeneration

Concretized by:

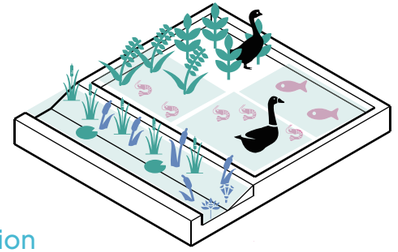
M43 M44 M45 M46 MG02

A19

A19 Revive Natural Food Chain

Hypothesis

Regenerating the natural food chain in agricultural production improves the resilience of the local ecological network and maximizes the use of nutrients.



Theoretical Back-up and Practical Implication

Farmland could function as an ecosystem where crops and livestocks have their own ecological niches. However, modern farming methods have largely destruct many of the natural cycles in the agricultural production process where input from pesticides and synthetic fertilizer become ubiquitous.

To restore the ecosystem in farmland, one common method is to diversify the crops in the farmland(M48 Crop variation). In the polder production zone, ecological polder canals are recommended to accommodate more diverse species in the polder landscape. By adopting integrated waterfowl farming(M49) and mixed aquatic cultivation(M50), the surface water ecology network in a polder agricultural zone can be strengthened.

Combining livestock farming and crop farming can also contribute to the ecosystem if less yield-oriented, such as the rice-fish system (M06) and other types of agroforestry(M07)

Links with other patterns

Generalized by:

P32
Riparian
Ecosystem
Regeneration

Concretized by:

M48 M49 M50

Co-exist well with:

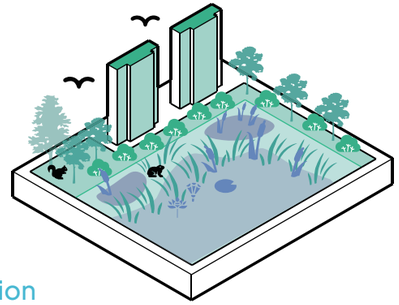
M07 M06

A20 Urban Biotopes Network

A20

Hypothesis

Cities are not only homes for humans. A well-connected urban biotopes network gives home to different types of flora and fauna and keeps a strong ecosystem of cities.



Theoretical Back-up and Practical Implication

Green and blue spaces are interdependent in urban areas to form a flourishing ecosystem. Thus, creating a strong urban biotopes network, especially along the water network is also fundamental for riparian ecosystem regeneration.

There are many ways to strengthen the urban biotopes network. Freeing up more open soil areas(M51) for nature is the foremost step. When designing urban green spaces, vegetation diversity(M53) should be emphasized.

Reproducing wet biotopes(M52) in urban areas brings the possibility for aquatic and amphibious species to stay in an urban context. Moreover, birds and insects should also be given attention by providing them food and spaces with rooftop habitats(M54) and eco facades(M55). All these small creatures could strengthen the resilience of the ecological network of the cities and contribute to the long-run sustainability of water ecology.

Links with other patterns

Generalized by:

P32
Riparian
Ecosystem
Regeneration

Concretized by:

M52 M54 M55

Contains

M51 M53

64 Measures to realize the actions and principles can be found in this chapter. The colour of the icons implies the dominant topics as follows:

M01... M13 — Circular Water Loop as the main aim

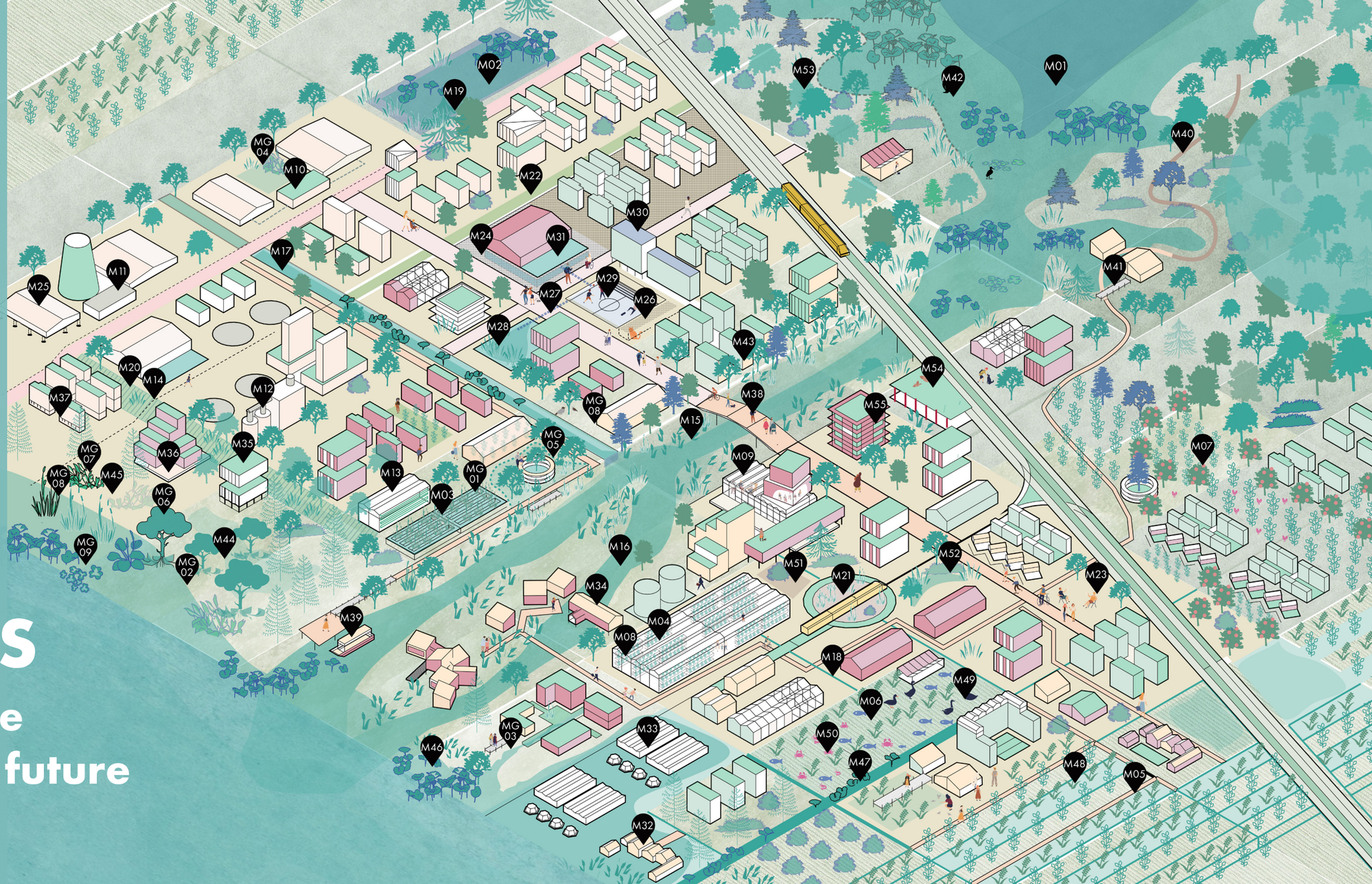
M14... M37 — Water Sensitive City as the main aim

M38... M55 — Ecologically-sound Waterscape as the main aim

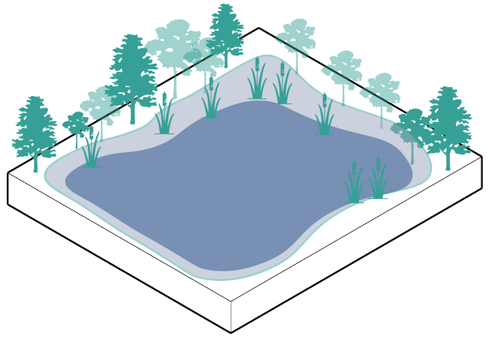
MG01.. MG10 — General Measures that play a role under all topics

IV. MEASURES

for a sustainable water-oriented future



M01 Protective Centralized Drinking Water Source



Hypothesis

Protecting natural water sources is a crucial step to guarantee the basic drinking supply of a city.

Links with other patterns

Contains:
MG01 Helophyte,
MG08 Emergent Vegetation

Contribute to Principle:
P11 Sustainable Water Supply

Complementary:
A17 Keep Nature Wild,
M42 Buffer Zone

Facilitated by:
PG02 Public Park for All Ages,
PG03 Nature Exploration route

Potential Facilitators

Hydrology or meteorological services

*Tourism Sector: when visitings are allowed according to ecological condition.

Photo source:
: Dongpu Reservior by Hefei Environmental Protection Institution, https://m.huanbao-world.com/list.php?tid=119

Transferability

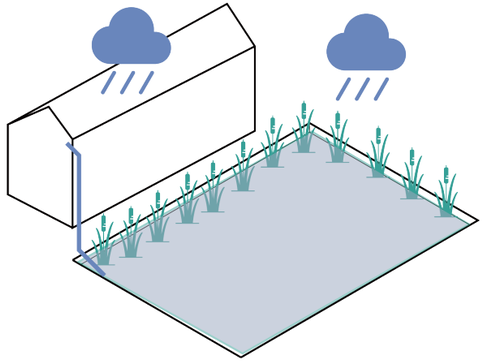
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M02 Community Rainwater Storage Space



Hypothesis

Having access to decentralized rainwater storage space allows local community to have enough water supply in dry period.

Links with other patterns

Contains:
MG01 Helophyte,
MG08 Emergent Vegetation

Conponents of Action:
A01 Rainwater harvesting

Coexist well with:
M28 Retention Pond

Facilitated by PG02,PG01

Potential Facilitators

In Residential Zone:
Neighborhood committee
Local residents
In Production Zone:
Agrifood Sector, Industrial Sector

Photo source:
Storm water pond in Twin Oak Park, by Watershed Management Commissions
http://www.shinglecreek.org/completed-projects.html

Transferability

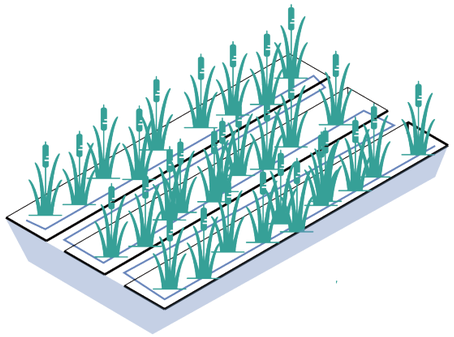
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M03
Constructed Wetland



Hypothesis

Using constructed wetland to purify contaminated rain water and grey water helps enhance perception of space and create awareness of water recycling.

Links with other patterns

Complementary:
MG01 Helophyte,

Alternative:
M10 Grey Water Recycling Plant

Contribute to:
A02 Grey Water Recycling

Facilitated by:
PG02 Public Park for all ages
PG08Cooperative Living Lab

Potential Facilitators

Waste Management Services
Neighborhood committee
Local residents
Agrifood Sector
Industrial Sector

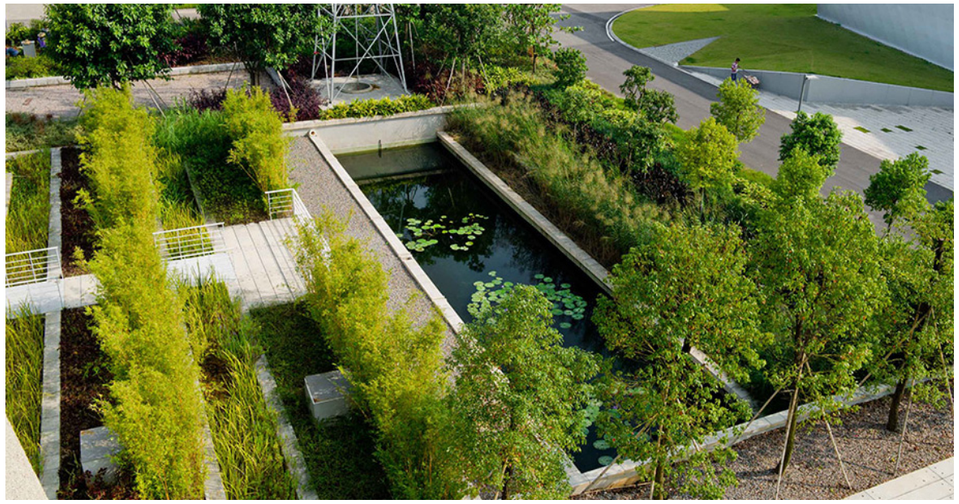


Photo source:
Vanke Architecture Research Center, by Z + T STUDIO on gooood,
https://www.gooood.cn/vanke-research-center-by-zt.htm

Transferability

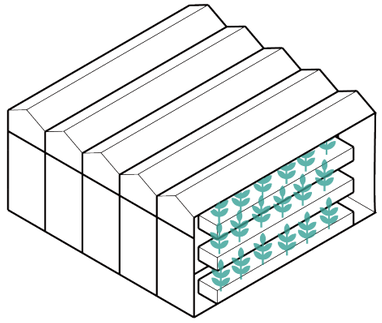
High transferability to other areas

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M04
Hydroponic Vertical Farming



Hypothesis

Vertical farming saves the land, water and increases crop yields drastically and is regarded as the future of agriculture production.

Links with other patterns

Contribute to:
A03 Smart Irrigation

Facilitated by:
PG05
Circular Production Open Day
PG07
Circular Knowledge Forum
PG09
Circular Internship Programme
PG10
Vocational Education

Potential Facilitators

Agrifood Sector
Local Farmers
Innovators and Engineers
Knowledge Institutes

Photo source:
Vertical Farming, Holland Hydroponics USA, LLC,
https://hollandhydro.com/project/vertical-farming/

Transferability

Technology and incentives needed.

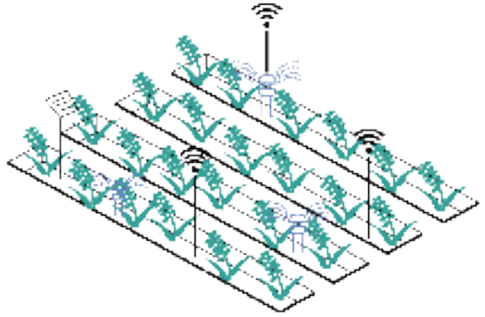
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M04

M05
Smart Paddy Field



Hypothesis

Reducing water waste in paddy fields is essential to provide stable nutrients to the populace in Asia under climate change.

Links with other patterns

Complementary:
M47 Ecological Polder Canal

Alternative:
M06 Rice-fish System,
M49 Integrated Waterfowl Farming

Contribute to:
A03 Smart irrigation,
A05 Wastewater to irrigation

Facilitated by:
PG05 Circular Production Open Day
PG07 Circular Knowledge Forum
PG08 Cooperative Living Lab
PG09 Circular Internship Programme
PG10 Vocational Education

Potential Facilitators

Agrifood Sector
Tourism Sector
Local Farmers
Innovators and engineers
Knowledge institutes

Photo source:
Smart Paddy Field System, by Century Ruitong, https://zhuanlan.zhihu.com/p/393404262

Transferability

Suitable for rice farming countries;
Knowledge and incentives needed.

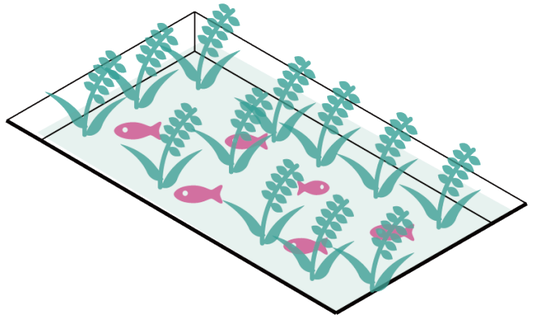
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
2 ZERO HUNGER
12 RESPONSIBLE CONSUMPTION AND PRODUCTION

M06
Rice-fish System



Hypothesis

The rice-fish system is a highly-valued historical farming method which optimizes the resource flows in the field. It brings economic, social and environmental benefits to rural areas in Asian countries.

Links with other patterns

Complementary:
M47 Ecological Polder Canal

Alternative:M05 Smart Paddy Field

Contribute to:A04 Manure as Fertilizer ,A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism,
PG09 Circular Internship Programme
PG10 Vocational Education

Potential Facilitators

Agrifood Sector
Tourism Sector
Local Farmers
Knowledge Institutes
Ecological Department

Photo source:
Rice-fish Farming Experimentation Field launched by Zhejiang University, The paper , https://www.thepaper.cn/newsDetail_forward_7404381

Transferability

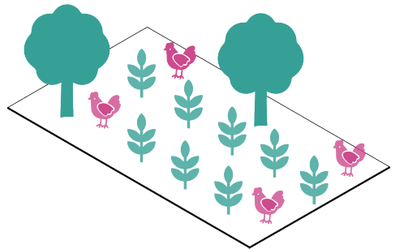
Applicable for south-eastern Asia while incentives and knowledge are needed.

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M07
Agroforestry



Potential Facilitators

Agrifood Sector
Tourism Sector
Local Farmers
Knowledge Institutes
Ecological Department

Hypothesis

By integrating trees, shrubs into crops and livestock farming, it provides the farmers with opportunities of a healthy long-term production.

Links with other patterns

Complementary:
M48 Crop Variation

Contribute to:A04 Manure as Fertilizer,A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism,
PG09Circular Internship Programme
PG10 Vocational Education

Photo source:
Agroforestry for poultry systems in the Netherlands, AGFORWARD, https://www.agforward.eu/agroforestry-for-poultry-systems-in-the-netherlands.html

Transferability

Knowledge and incentives and cooperation are needed.

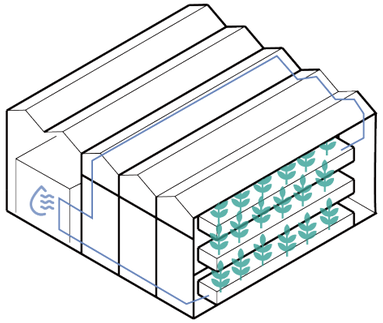
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

Further reading: https://www.usda.gov/topics/forestry/agroforestry/agroforestry-frequently-asked-questions

M08 Irrigation Water Reusing Greenhouse



Hypothesis

Circulating the water flow in greenhouse is vital to get rid of intensive fresh water consumption in horticulture

Links with other patterns

Complementary:
M04 Hydroponic Vertical Farming

Contribute to:
A05 Wastewater to irrigation

Facilitated by:PG07
Circular Knowledge Forum
PG09
Circular Internship Programme
PG10
Vocational Education

Potential Facilitators

Agrifood Sector
Local Farmers

Photo source:
By Greenhouse Management
https://www.greenhousemag.com/article/why-we-need-horticulturists-wapost/

Transferability

Technology and incentives needed.

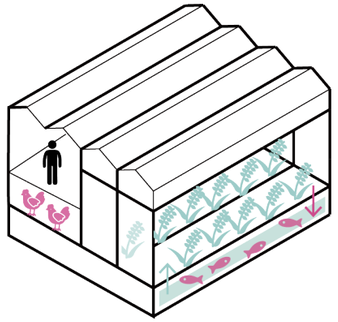
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M08

M09
Greenhouse Complex



Hypothesis

Accommodating more human activities and livestock farming functions in the greenhouse allows for a more circular water utility in the greenhouse.

Links with other patterns

Complementary:
M04 Hydroponic Vertical Farming

Contribute to:
A04 Manure as Fertilizer.
A05 Wastewater to irrigation

Facilitated by:
PG05 Circular Production Open Day,
PG06 Urban Farming
PG08Cooperative Living Lab

Potential Facilitators

Agrifood Sector
Tourism Sector
Local Farmers
Innovators and Engineers
Housing developer

Photo source:
MILAN EXPO HORIZONTAL FARM // FIRST PRIZE Ex Aequo - Christian Sibilde, Haissahm Jijakli, Klaus Ralph, Edrisio Bruletti - ITALY & BELGIUM
http://awrcompetitions.blogspot.com/2016/10/milan-expo-horizontal-farm-first-prize.html

Transferability

Knowledge and incentives and cooperation are needed.

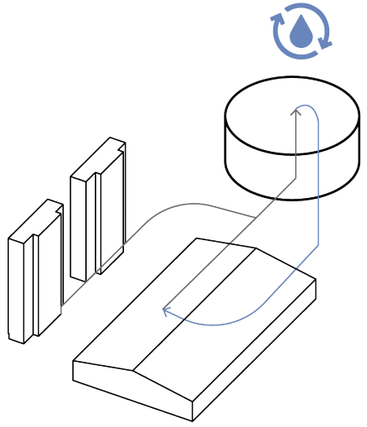
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M09

M10
Grey Water Recycling Plant



Hypothesis

A community mechanical grey water recycling plant is efficient to allow the industrial zone to reuse the grey water from the whole district.

Links with other patterns

Alternative:
M03 Constructed Wetland

Contribute to:
A02 Grey Water Recycling,
A06 Industrial Wastewater Recycling

Facilitated by:
PG10 Vocational Education

Potential Facilitators

Municipal utilities management
Waste Management Services
Industrial Sector, Local Factory Owners
Neighborhood committee
Local residents

Photo source:
MILAN EXPO HORIZONTAL FARM // FIRST PRIZE Ex Aequo - Christian Sibilde, Haissahm Jijakli, Klaus Ralph, Edrisio Bruletti - ITALY & BELGIUM
http://awrcompetitions.blogspot.com/2016/10/milan-expo-horizontal-farm-first-prize.html

Transferability

High transferability to other areas with certain cooperation

Contribution to Water System

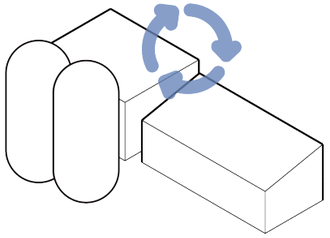
Water Safety
Water Quantity
Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS

6 CLEAN WATER AND SANITATION

M11
Heavy Metal Recycling Plant



Hypothesis

A heavy metal recycles plants recover valuable elements, mitigating pollution risk from industrial production.

Links with other patterns

Contribute to:
A06
Industrial Wastewater Recycling

Facilitated by:
PG05
Circular Production Open Day
PG09
Circular Internship Programme
PG10
Vocational Education

Potential Facilitators

Industrial Sector
Waste Management Services
Local Factory Owners
Innovators and engineers
Knowledge institutes

Photo source:
Electroplating Nickel Resource Reuse centre, Shanghai Shunfan Environmental Protection Technology Co., Ltd.,
https://www.12345ep.com/product-item-12.html

Transferability

Incentives,technology, investment and cooperation needed.

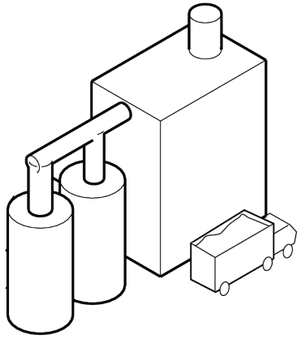
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M11

M12
Nutrient Recovery Plant



Hypothesis

A nutrient recovery plant is a choice for sustainable wastewater treatment, where phosphorus is harvested while extra heat is generated as energy supply.

Links with other patterns

Contribute to:
A07
Productive Wastewater Treatment

Facilitated by:
PG05
Circular Production Open Day
PG09
Circular Internship Programme
PG10
Vocational Education

Potential Facilitators

Agrifood Sector
Industrial Sector
Municipal utilities management
Waste Management Services
Knowledge institutes

Photo source:
Sustainable sewage sludge incineration for Zürich canton, Metso Outotec ,
https://www.mogroup.com/corporate/media/news/2016/3/sustainable-sewage-sludge-incineration-for-zurich-canton/

Transferability

High transferability to other areas with certain investment needed.

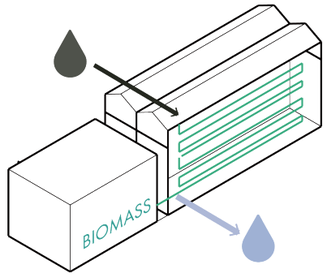
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M12

M13
Algae-based Material Hub



Hypothesis

Using algae in wastewater treatment not only removes the contamination effectively the but also allows for easier, faster, and cheaper biomass harvesting. (Mehariva et al., 2021)

Links with other patterns

Contribute to:A07
Productive Wastewater Treatment

Facilitated by:
PG05
Circular Production Open Day,
PG07
Circular Knowledge Forum
PG08
Cooperative Living Lab
PG09
Circular Internship Programme,
PG10
Vocational Education

Potential Facilitators

Agrifood Sector
Industrial Sector
Waste Management Services
Local Factory Owners ,Local Farmers
Innovators and engineers
Knowledge institutes

Photo source:
Schematic photobioreactor design, as follows a horizontal tubes. ,
Abdel-Raouf, N., Al-Homaidan, A. A., & Ibraheem, I. (2012). Microalgae and wastewater treatment. Saudi journal of biological sciences, 19(3), 257–275.

Transferability

Incentives,technology, investment and cooperation needed.

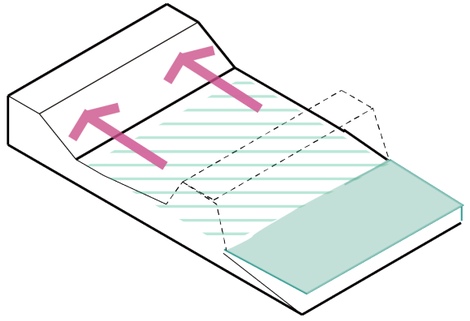
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M13

M14
Setback Dike



Hypothesis

By setting back the existing dike, more room could be created for rivers to safeguard the local residents during the flooding.

Links with other patterns

Contribute to:
A08 Give Back Room to River

Complemantary for:
MG02 Floodable wetland
M15 Lowering Floodplain,
M16 New River Arm

Facilitated by:
PG03
Nature exploration route

Potential Facilitators

Hydrology or meteorological services

*When considering the relocation situation: Agrifood Sector .Local Farmers . Local residents

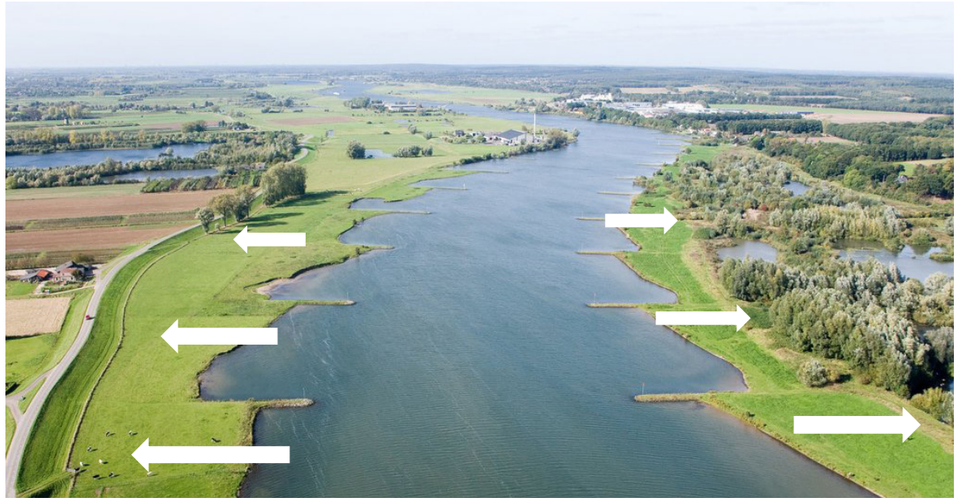


Photo source:
Room for the river, in the Netherlands. https://nlintheusa.com/room-for-the-river/

Transferability

High transferability while support and administration from government needed

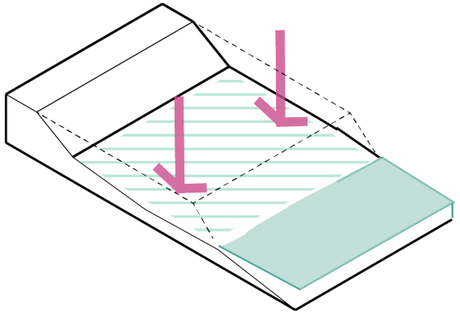
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M14

M15
Lowering Floodplain



Potential Facilitators

Tourism Sector
Hydrology or meteorological services
Ecological department

Hypothesis

Lowering the floodplain creates a larger buffer zone to accommodate the changing water level, which also gives the possibility for the riverfront ecosystem to flourish.

Links with other patterns

Contribute to:
A08 Give Back Room to River

Need M14 Setback Dike to complete.

Facilitated by:
PG03
Nature exploration route

M15

Photo source:
Room for the river, https://www.rijkswaterstaat.nl/en/about-us/gems-of-rijkswaterstaat/room-for-the-river

Transferability

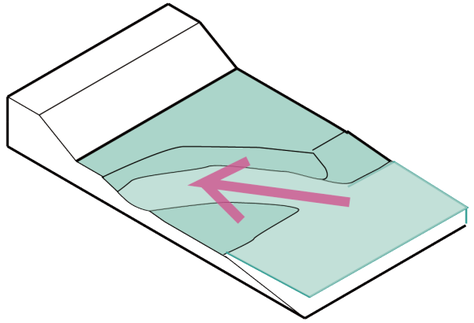
High transferability while support and administration from government needed

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M16
New River Arm



Hypothesis

A new river arm next to the main channel helps to manage the water flow, which not only prevent the flooding issues but has the possibility to ensure the irrigation water quantity.

Links with other patterns

Contribute to:
A08 Give Back Room to River

Need M14 Setback Dike to complete.

Facilitated by:
PG03
Nature exploration route

Potential Facilitators

Tourism Sector
Hydrology or meteorological services
Ecological department
*When involving irrigation function:
Agrifood Sector , Local Farmers

Photo source:
Room for the river,
https://worldlandscapearchitect.com/room-for-the-river-nijmegen-the-netherlands-hns-landscape-architects/#.Yl6-suhBy3A

Transferability

High transferability while support and administration from government needed

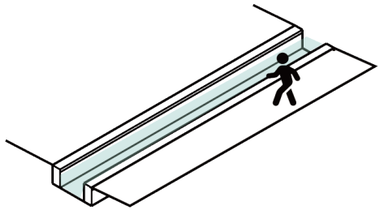
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M16

M17
Urban Water Channels



Hypothesis

An urban water channel creates an alternative and spacious route for rainwater during flooding. Meanwhile, it also allows the existence of aquatic species inside the water.

Links with other patterns

Contains:
MG09 Floating Vegetation
Alternative:
MG03 Natural Ditches,
M18 Gutters

Contribute to:
A09 Create Mutiple Channels

Facilitated by:
A15 Pedestrianized Public Space
PG01 Interaction with water
PG02 Public Park for all ages

Potential Facilitators

Tourism Sector
Housing developer
Neighborhood committee
Local residents

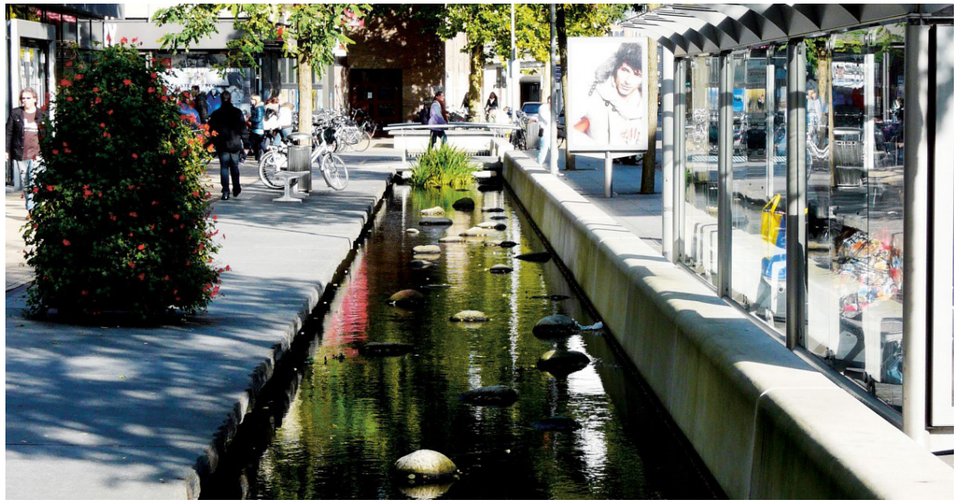


Photo source:
https://www.urbangreenbluegrids.com/measures/open-water-channels/

Transferability

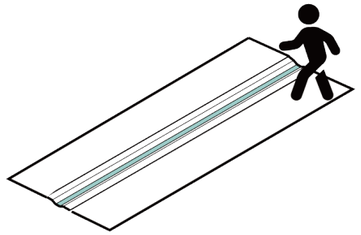
High transferability to other areas

Contribution to SDG's

Contribution to Water System

Water Safety
Water Quantity
Water Quality

M18
Gutters



Potential Facilitators

Municipal utilities management
Housing developer

*When in industrial zone:
Local Factory Owners

Hypothesis

Open gutters make the drainage system visible again and are also a cost-benefit choice for separating rainwater and sewage water.

Links with other patterns

Alternative:
MG03 Natural Ditches,
M17 Urban Water Channels

Contribute to:
A09 Create Mutiple Channels

Facilitated by:
A15 Pedestrianized Public Space
PG02 Public Park for all ages

Photo source:
Bo02 Hammarby Sjöstad, Stockholm, Sweden © atelier GROENBLAUW, Madeleine d'Ersu
https://www.urbangreenbluegrids.com/uploads/022-Bo02-Hammarby-Sjoestad-003-Madeleine-dErsu-472x630.jpg

Transferability

High transferability to other areas

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M18

M19
Canopies

Hypothesis

Over ten percent of the rainfall could be captured and stored by the canopies of trees (Leonard, 1961).

Links with other patterns

Complementary:
M53 Vegetation Diversity

Co-exist well with:
MG06 Wet Soil Trees

Contribute to:
A10 Green Defense

Facilitated by:
PG02 Public Park for all ages

Potential Facilitators

Housing developer
Local residents
Ecological department

*When in industrial zone:
Local Factory Owners

Photo source:
https://www.pottstowntrees.org/K1-Other-resources.html

Transferability

High transferability to other areas

Contribution to Water System

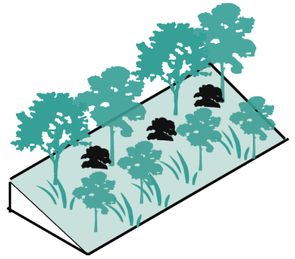
- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M19

M20

M20
Slope Reinforcement with Vegetation



Hypothesis

Using trees and vegetation to reinforce the slopes prevent landslides and soil erosion during storms and also allows biodiversity.

Links with other patterns

Complementary:
M53 Vegetation Diversity

Contribute to:
A10 Green Defense

Co-exist well with:
M43 River Terrace Green Belt

Potential Facilitators

Hydrology or meteorological services
Ecological department

Photo source:
River embankment, Gresford, Nr Wrexham
https://www.externalworksindex.co.uk/entry/106743/Grass-Concrete/River-embankment-adjacent-to-the-A484-Gresford-Wales/

Transferability

High transferability to other areas

Contribution to Water System

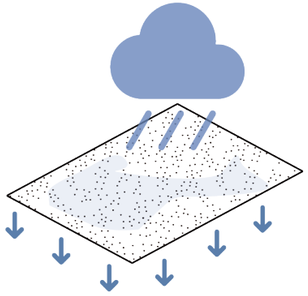
- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
3 GOOD HEALTH AND WELL-BEING
13 CLIMATE ACTION

M20

M21
Unpaved Area



Hypothesis

Leaving as much space unpaved as possible in the urban area benefits infiltration thus mitigating the flood risk.

Links with other patterns

Specialized by:
M22Infiltration Strips,M23Open Green Space, MG04 Bioswales MG05 Amphibious Park M52 Wet Biotope

Co-exist well with: M51 Open Soil Area

Contribute to:
A11 Groundwater Recharging

Facilitated by:
PG02 Public Park for all ages ,
PG06 Urban Farming

Potential Facilitators

Housing developer
Local residents
Ecological department

Photo source:
Sankt Kjeld's Square and Bryggervangen
In Copenhagen, https://www.sla.dk/cases/sankt-kjelds-square-and-bryggervangen/

Transferability

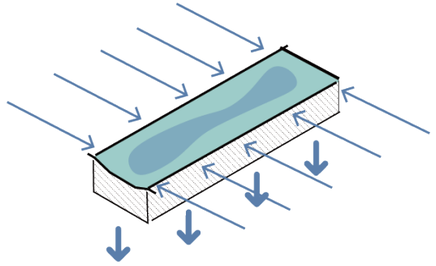
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M22
Infiltration Strips



Hypothesis

An infiltration strip on the streets can temporarily stores the rainwater and release it slowly into the ground afterwards.

Links with other patterns

Contains:
MG07 Hygrophyte
Alternative:
MG03 Natural Ditches
MG04 Bioswales

Contribute to:
A11 Groundwater Recharging

Facilitated by:
PG02 Public Park for all ages ,

Potential Facilitators

Municipal utilities management
Housing developer
Local residents
Also encouraged in industrial zone:
Local Factory Owners

Photo source:
Infiltration Strips in Hamburg
https://www.urbangreenbluegrids.com/measures/urban-infiltration-strips/

Transferability

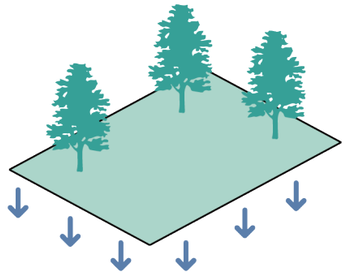
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M23
Open Green Space



Hypothesis

Open green space in the urban area accelerate infiltration and mitigate urban heat island effect.

Links with other patterns

Complementary:
M19 Canopies for Interception
M53 Vegetation Diversity

Contribute to:
A11 Groundwater Recharging

Facilitated by:
PG02 Public Park for all ages ,

Potential Facilitators

Tourism Sector
Neighborhood committee
Local residents
Ecological department

Photo source:
At Birkenhead Park, outside Liverpool, by Andy Haslam for The New York Times
https://www.nytimes.com/2019/10/30/travel/footsteps-frederick-law-olmsted-parks.html

Transferability

High transferability to other areas

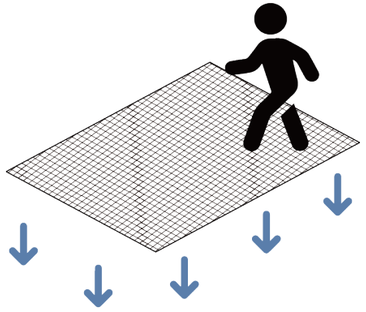
Contribution to SDG's

Contribution to Water System

Water Safety
Water Quantity
Water Quality

M23

M24
Permeable Pavement



Hypothesis

Permeable pavement improves infiltration and makes flood proof built-up area.

Links with other patterns

Components of:
A15 Pedestrianized Public Space

Contribute to:
A11 Groundwater Recharging

Facilitated by:
PG02 Public Park for all ages ,
A15 Pedestrianized Public Space

Potential Facilitators

Municipal utilities management
Local Factory Owners
Housing developer

Photo source:
https://www.portland.gov/bes/stormwater/managing-rain-your-property/permeable-pavement

Transferability

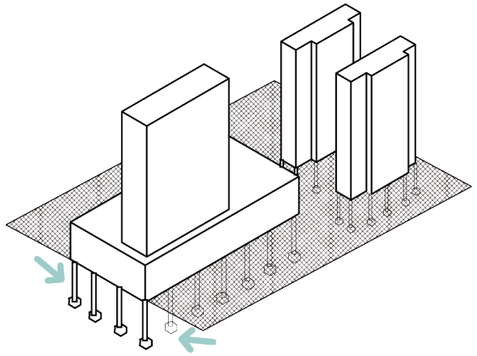
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M25 Building without a Crawlspace



Hypothesis

Building without a crawlspace make sure that the groundwater level is staying the same below the building which benefits water balance.

Links with other patterns

Complementary:
M24 Permeable Pavement
M26 Infiltration Boxes

Co exist well with:
M27 Infiltration Pipe

Contribute to:
A11 Groundwater Recharging

Potential Facilitators

Housing developer

In industrial zone:
Industrial Sector
Local Factory Owners

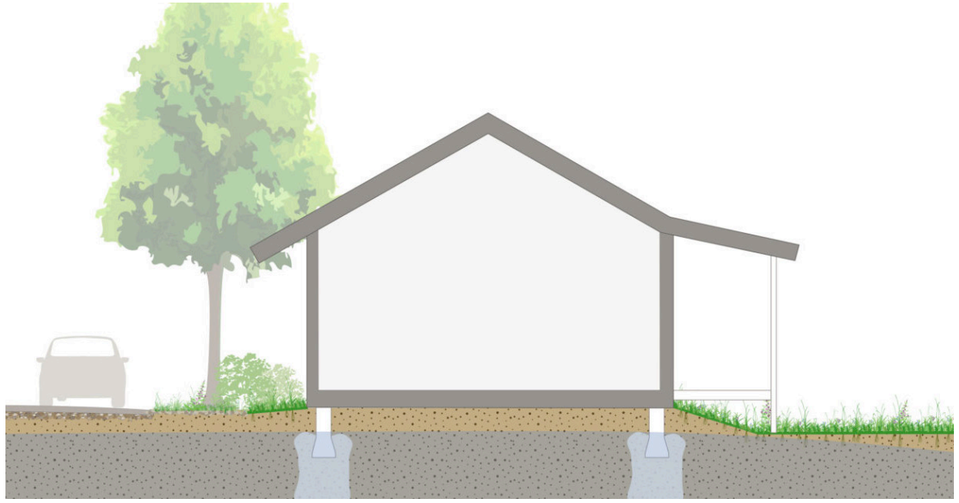


Photo source:
20180423 Schema Kruipruimteloos bouwen [atelier GB]
https://www.urbangreenbluegrids.com/uploads/20180504-Schema-Kruipruimteloos-bouwen-atelier-GB-1300x650.jpg

Transferability

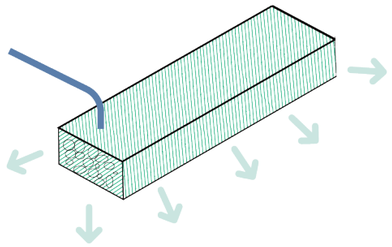
High transferability to other areas while needs to persuade clients.

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M26
Infiltration Boxes



Hypothesis

Infiltration boxes collect rainfall and release it into the subsoil and contribute to the water balance in the paved urban district.

Links with other patterns

Alternative:
M27 Infiltration Pipe

Contribute to:
A11 Groundwater Recharging

Potential Facilitators

Housing developer
Municipal utilities management

Industrial Sector
Local Factory Owners

Photo source:
https://www.adverterenbijeisma.nl/2016/08/blog-water-managen-wildkamp/

Transferability

High transferability to other areas

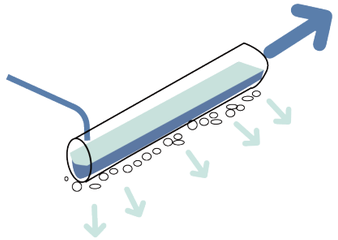
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
6 CLEAN WATER AND SANITATION
13 CLIMATE ACTION

M27
Infiltration Pipe



Hypothesis

The infiltration pipe system not only allows water to infiltrate into the surrounding soil but also has the ability to transport the rainwater flow so as to collect it for future consumption.

Links with other patterns

Alternative:
M26 Infiltration Boxes

Complementary for:
M28 Retention Pond,M29 Rainwater Square/Sports field

Co-exist well with:
M25 Building without a Crawlspace
M24 Permeable Pavement

Contribute to:
A11 Groundwater Recharging

Potential Facilitators

Housing developer
Municipal utilities management

Industrial Sector
Local Factory Owners

Photo source:
Joachim Drüke(2015) , Moist and wet meadows, https://www.naturschaetze-suedwestfalens.de/var/sauerland/storage/images/media/bilder/naturschaetze/buchfotos/03_s1_ueberschwemmte-wiese_5559_jd/507689-1-ger-DE/03_S1_ueberschwemmte-Wiese_5559_JD_front_magnific.jpg

Transferability

High transferability to other areas

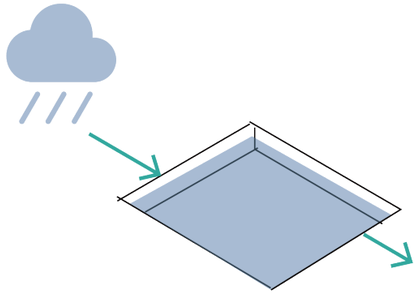
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M27

M28
Retention Pond



Hypothesis

Retention ponds collect rainwater in heavy rain and make it possible for future consumption.

Links with other patterns

Contains:
MG01 Helophyte, M46 Littoral Space

Co-exist well with:
M02 Community Rainwater Storage Space, MG05 Amphibious Park

Alternative:
M29 Rainwater Square/Sports field

Contribute to:A12 Retention Zone

Facilitated by:PG01 Interaction with water , PG02 Public Park for all ages

Potential Facilitators

Hydrology or meteorological services
Neighborhood committee
Ecological department

Photo source:
https://i.pinimg.com/originals/2e/5a/6d/2e5a6d1197a748b00ada5fd180ce4a4e.jpg

Transferability

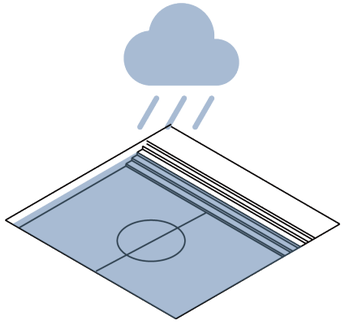
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M29 Rainwater Square/ Sports field



Hypothesis

A rainwater square or sports field allows people to enjoy dynamic urban life during sunny days while protecting residents nearby from water nuisance during rainy days.

Links with other patterns

Alternative:
M28 Retention Pond, MG05 Amphibious Park

Contribute to:
A12 Retention Zone

Facilitated by:
PG02 Public Park for all ages A15 Pedestrianized Public Space
:

Potential Facilitators

Hydrology or meteorological services
Housing developer
Neighborhood committee
Local residents

Photo source:
Joachim Drüke(2015), Moist and wet meadows, https://www.naturschaetze-suedwestfalens.de/var/sauerland/storage/images/media/bilder/naturschaetze/buchfotos/03_s1_ueberschwemmte-wiese_5559_jd/507689-1-ger-DE/03_S1_ueberschwemmte-Wiese_5559_JD_front_magnific.jpg

Transferability

High transferability to other areas

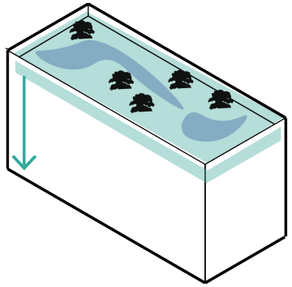
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M29

M30
Retention roofs



Hypothesis

Using the roof as retention space not only delays the rainwater flow but also has the potential to be transformed into a rooftop garden or farming space.

Links with other patterns

Specialized by:
M54 Rooftop Habitat

Alternative:
M31 Storage below buildings

Contribute to:
A12 Retention Zone

Facilitated by:
PG06 Urban Farming

Potential Facilitators

Housing developer
Local residents

Photo source:
https://www.optigruen.com/system-solutions/retention-roof/overview-retention-roofs/

Transferability

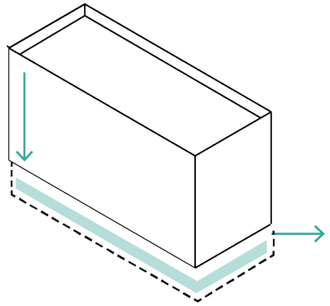
High transferability to other areas with certain investment and policy

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M31
Storage below buildings



Hypothesis

When there is not enough empty space inside cities, water storage space below buildings improves the capacity of rainwater storage.

Links with other patterns

Alternative:
M30 Retention roofs

Contribute to:
A12 Retention Zone

Potential Facilitators

Housing developer
Local residents

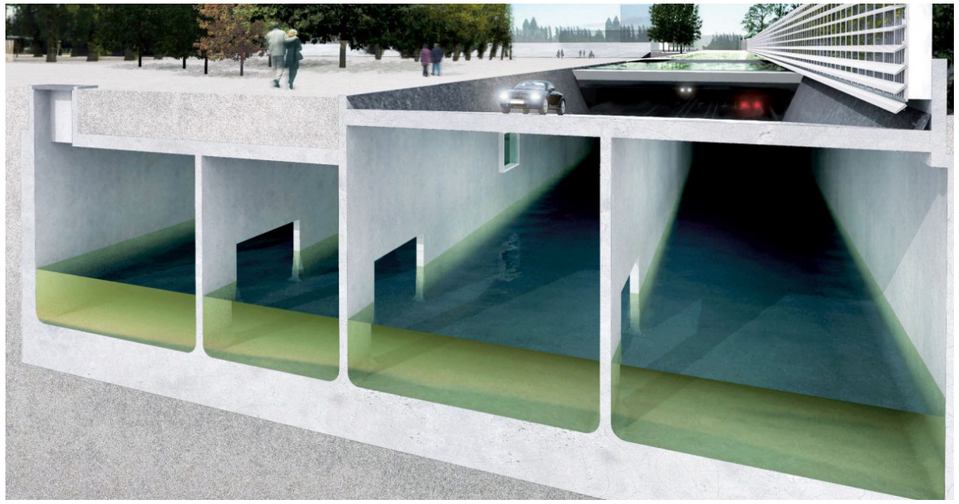


Photo source:
https://www.urbangreenbluegrids.com/measures/rainwater-storage-below-buildings-such-as-parking-garages/

Transferability

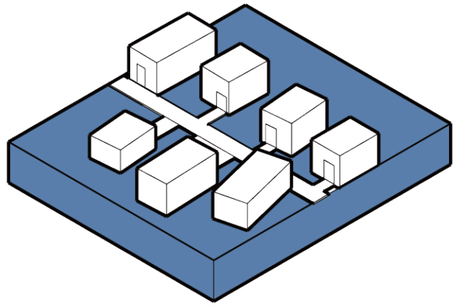
High transferability to other areas with certain investment and policy

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M32
Floating Housing



Hypothesis

Floating housing adapts to the changing water level like boats and offers a new possible alternative for future community life.

Links with other patterns

Alternative:
M34
Buildings on stilts (partly) in water

Contribute to:A13 Build on Water

Facilitated by:
PG04 Agro-tourism

Potential Facilitators

Tourism Sector
Innovators and engineers
Housing developer

Photo source:
https://www.yankodesign.com/2020/12/20/these-floating-homes-in-amsterdam-are-designed-to-beat-the-rising-sea-levels-and-escape-the-growing-city-population/

Transferability

Technology, investment,and policy needed.

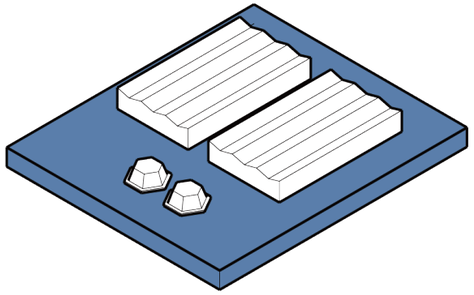
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M32

M33
Floating Greenhouse



Hypothesis

A floating greenhouse makes it possible to produce food in an efficient and land-saving method, leaving out enough space for surface water or rainwater storage.

Links with other patterns

Contribute to:A13 Build on Water

Facilitated by:

PG06 Urban Farming
PG08 Cooperative Living Lab

Potential Facilitators

Agrifood Sector
Tourism Sector
Local Farmers
Innovators and engineers
Knowledge institutes

Photo source:
https://www.eea.europa.eu/signals/signals-2011/galleries/designing-the-future/greenhouse/image_view_fullscreen

Transferability

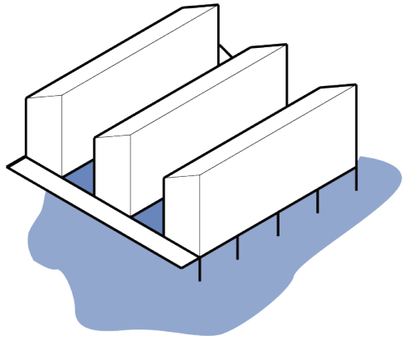
Technology, incentives and policy needed.

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M34 Buildings on stilts (partly) in water



Hypothesis

Building on stilts above water(or retention zone) mitigates the flood risk while giving more room for surface water.

Links with other patterns

Co-exist well with:
A12 Retention Zone

Alternative:
M32 Floating housing,
M35 Flexible Ground Floor

Contribute to:A13 Build on Water

Facilitated by:
PG01 Interaction with water,
PG03 Nature exploration route
PG04 Agro-tourism,

Potential Facilitators

Tourism Sector
Housing developer

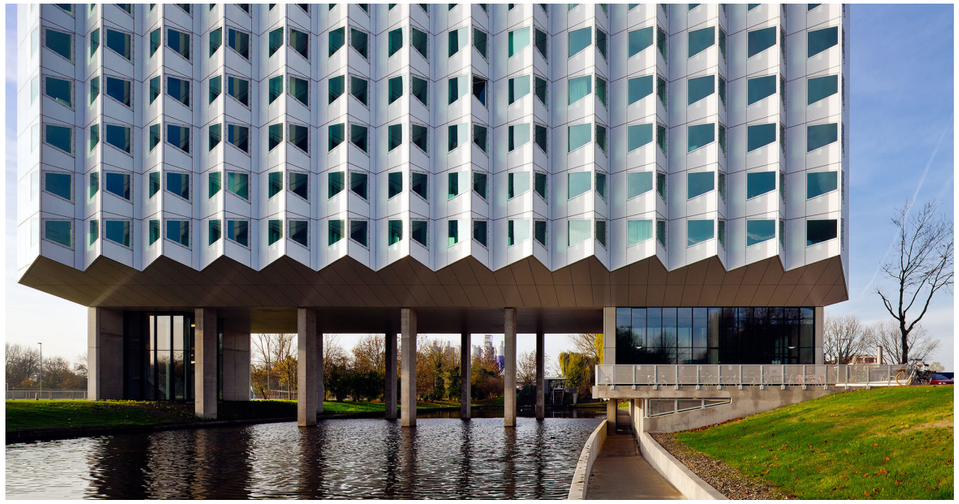


Photo source: Studentenhuisvesting Delft
By De Zwarte Hond

Transferability

High transferability to other areas

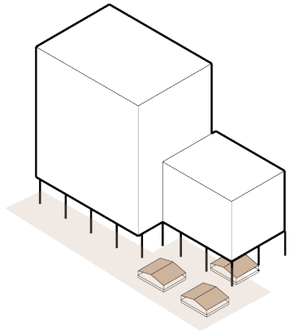
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M34

M35
Flexible Ground Floor



Hypothesis

Making an open and flexible ground floor for public use minimises the potential risk of any private property during extreme flooding.

Links with other patterns

Complementary:
M25
Building without a Crawlspace

Alternative:
M36 Raised Constructions,
M34 Buildings on stilts/(partly) in water

Contribute to:
A14 Ground Floor Adjustment

Potential Facilitators

Housing developer
Local residents

Photo source:
© Studioninedots and DELVA Landscape Architects
https://aasarchitecture.com/wp-content/uploads/Team-REBEL-presents-Kop-Zuidas-Amsterdam-07.jpg

Transferability

High transferability to other areas while land use policy might be needed.

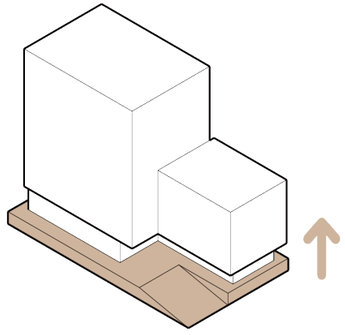
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M35

M36
Raised Constructions



Hypothesis

Raising the construction of buildings in the low-lying zone mitigates the flood risk for the people living on the ground floor.

Links with other patterns

Alternative:
M37 Sealable buildings
M35 Flexible Ground Floor

Contribute to:
A14 Ground Floor Adjustment

Potential Facilitators

Housing developer
Local Factory Owners

Photo source:
Raised construction, Hafencity Hamburg © Mathieu Schouten
https://www.urbangreenbluegrids.com/measures/measures-for-separate-buildings/raised-constructions/

Transferability

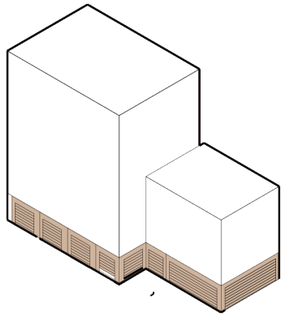
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M37
Sealable Buildings



Hypothesis

Sealing the doors and windows on the ground floor keeps the water outside the building during emergency situations.

Links with other patterns

Alternative:
M35 Flexible Ground Floor
M36 Raised Constructions

Contribute to:
A14 Ground Floor Adjustment

Potential Facilitators

Municipal utilities management
Hydrology or meteorological services
Neighborhood committee

Photo source:
https://www.urbangreenbluegrids.com/measures/measures-for-separate-buildings/sealable-buildings/

Transferability

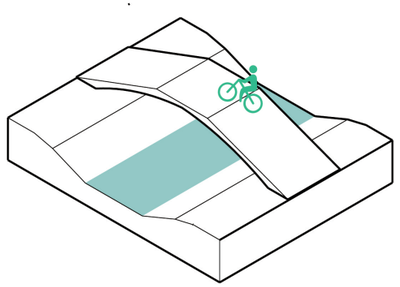
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M38
Slow Traffic Bridge



Hypothesis

Protecting natural water sources is a crucial step to guarantee the basic drinking supply of a city.

Links with other patterns

Contribute to:
A15 Pedestrianized Public Space

Facilitated by:
PG03 Nature exploration route

Potential Facilitators

Tourism Sector
Neighborhood committee
Local residents

Photo source:
Bicycle bridge in Copenhagen by Wilkinson Eyre Architects.
https://www.gooood.cn/lille-langebro-by-wilkinson-eyre.htm

Transferability

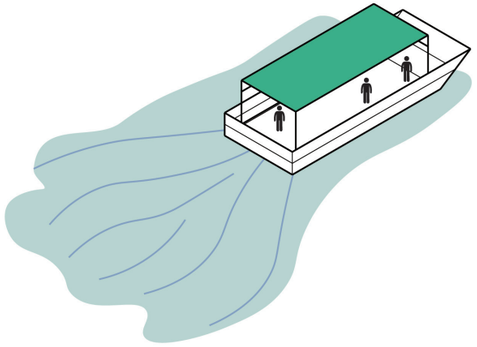
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M39
Green Waterbus



Hypothesis

A waterbus powered by green energy prevents pollution of the water while connecting people's daily life with water more.

Links with other patterns

Contribute to:
A16 Low-carbon Public Transport

Facilitated by:
PG01 Interaction with water
PG03 Nature exploration route
PG04 Agro-tourism

Potential Facilitators

Tourism Sector
Innovators and engineers
Local residents

Photo source:
The prototype of the electric waterbus. By Volvo Penta≣
https://www.maritiemnederland.com/nieuws/elektrische-waterbus-stuift-met-65-km-h-over-het-water

Transferability

Technology, incentives and convenient waterway connection .needed.

Contribution to SDG's

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

M40
Wild Trail

Hypothesis

A wild trail allows people to enjoy and appreciate the wildness of nature in a eco-friendly manner.

Links with other patterns

Alternative:
M41 Wood Deck

Contribute to:
A17 Keep Nature Wild

Facilitated by:
PG03 Nature exploration route

Potential Facilitators

Tourism Sector

Photo source:
https://pxhere.com/en/photo/1362819

Transferability

High transferability to other areas

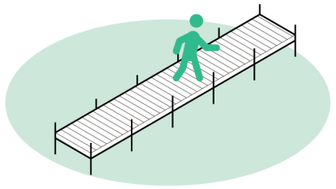
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M40

M41
Wood Deck



Potential Facilitators

Tourism Sector

Hypothesis

By using the wood deck in the natural reserve, people could visit nature elegantly without damaging the natural landscape.

Links with other patterns

Alternative:
M40 Wild Trail

Contribute to:
A17 Keep Nature Wild

Facilitated by:
PG03 Nature Exploration Route

Photo source:
Grand Voyeux Natural Reserve by Territoires + Charles Henri TACHON + Nicolas Granger ©Nicolas Waltefaugle
https://www.gooood.cn/grand-voyeux-natural-reserve-by-territoires-charles-henri-tachon-nicolas-granger.htm

Transferability

High transferability to other areas

Contribution to Water System

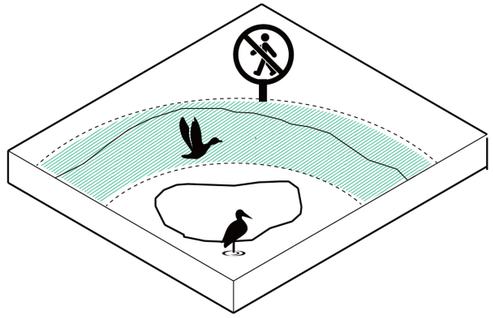
- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
3 GOOD HEALTH AND WELL-BEING
6 CLEAN WATER AND SANITATION
15 LIFE ON LAND

M41

M42
Buffer Zone



Hypothesis

A buffer zone protects the animals' daily activities in natural reserves from the disturbance of humans so as to preserve biodiversity.

Links with other patterns

Contribute to:
A17 Keep Nature Wild

Facilitated by:
PG03 Nature Exploration Route

Potential Facilitators

Ecological department

Photo source:
Grand Voyeux Natural Reserve by Territoires + Charles Henri TACHON + Nicolas Granger ©Nicolas Waltefaugle
https://www.gooood.cn/grand-voyeux-natural-reserve-by-territoires-charles-henri-tachon-nicolas-granger.htm

Transferability

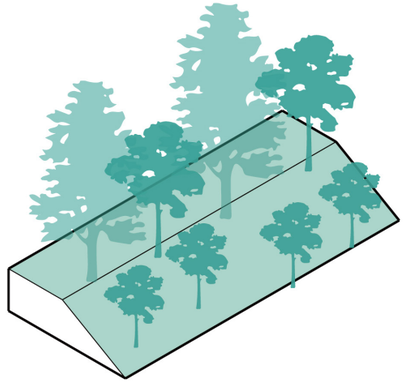
High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M43
River Terrace Green Belt



Hypothesis

Creating a continuous ecological zone along the river terrace prevents soil erosion and nutrients leakage which guarantee both the water quality and water safety.

Links with other patterns

Complementary:
M19 Canopies for Interception
M53 Vegetation Diversity

Contribute to:
A18 Wetland-Upland Transition

Facilitated by:
PG02 Public Park for all ages

Potential Facilitators

Tourism Sector
Ecological department

Photo source:
Ted McGrath, The photo of middle Rhine River Valley,
https://cdn.britannica.com/12/189812-050-05F09500/Katz-Castle-Sankt-Goarshausen-Rhine-River-Rhineland-Palatinate.jpg?w=690&h=388&c=crop

Transferability

Transferable to areas with river valleys.

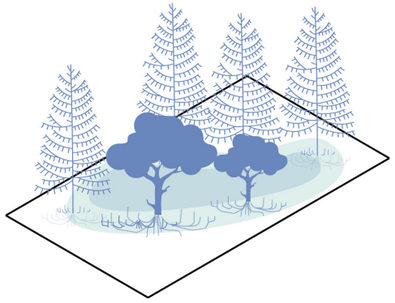
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M43

M44
Swamp Forest



Potential Facilitators

Tourism Sector
Ecological department

Hypothesis

Swamp forest is among the most valuable ecosystem on the earth, which takes in water during the flooding, and purifies the water naturally while storing the carbons effectively.

Links with other patterns

Conponents of:
MG02 Floodable Wetland

Contains:MG06 Wet Soil Trees

Contribute to:
A18 Wetland-Upland Transition

Facilitated by:
PG03 Nature exploration route

Photo source:
Doronenko, Flooded forests alongside the Morava river in spring.
https://upload.wikimedia.org/wikipedia/commons/3/3e/Morava%27s_flooded_forest_02.jpg

Transferability

Transferability to areas with natural swamp.

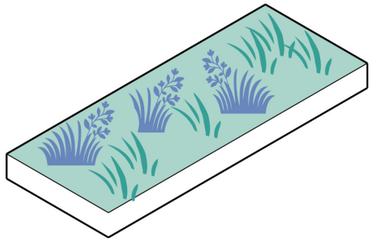
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M44

M45
Wet Meadow



Potential Facilitators

Tourism Sector
Ecological department

Hypothesis

The wet meadows could absorb the rich nutrients accumulated by the water runoff and feed different types of animals and insects.

Links with other patterns

Conponents of:
MG02 Floodable Wetland

Contains:MG07 Hygrophyte

Contribute to:
A18 Wetland-Upland Transition

Facilitated by:
PG02 Public Park for all ages

Photo source:
Joachim Drüke(2015) , Moist and wet meadows, https://www.naturschaetze-suedwestfalens.de/var/sauerland/storage/images/media/bilder/naturschaetze/buchfotos/03_s1_ueberschwemmte-wiese_5559_jd/507689-1-ger-DE/03_S1_ueberschwemmte-Wiese_5559_JD_front_magnific.jpg

Transferability

High transferability to areas with high soil moisture.

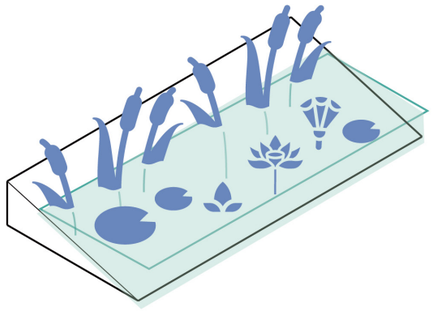
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
6 CLEAN WATER AND SANITATION
13 CLIMATE ACTION
15 LIFE ON LAND

M46
Littoral Space



Potential Facilitators

Tourism Sector
Ecological department

Hypothesis

The littoral space of rivers and lakes provides food and habitats for aquatic and amphibious animals and it thus plays an important role in maintaining a healthy water ecosystem.

Links with other patterns

Contains:
MG01 Helophyte
MG08 Emergent Vegetation
MG09Floating Vegetation

Contribute to:
A18 Wetland-Upland Transition

Facilitated by:
PG01 Interaction with water

Photo source:
Yeyahu Wetland Park in Beijing, China
https://www.visitbeijing.com.cn/article/47QIGqrdDvv

Transferability

High transferability to other areas

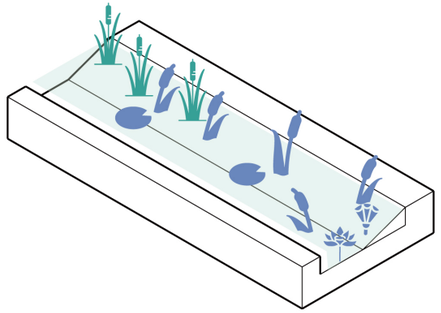
Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M46

M47
Ecological Polder Canal



Hypothesis

In polder agricultural zone, purification vegetation in the polder canal ensures the water quality and improve the ecological resilience.

Links with other patterns

Contains:
MG01 Helophyte
MG08 Emergent Vegetation
MG09Floating Vegetation

Contribute to:
A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism

Potential Facilitators

Agrifood Sector
Local Farmers
Ecological department

Photo source:
Ecological polder canal in Jiaxing, Zhejiang Province , China
https://www.cnjxol.com/51/202005/t20200512_616510.shtml

Transferability

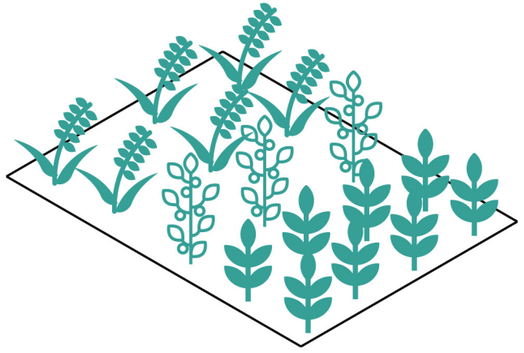
Suitable to polder agricultural areas.

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M48
Crop Variation



Hypothesis

Combining different crops in the same land controls the emission to the soil while also improving the biodiversity in the field.

Links with other patterns

Co-exist well with:
M07 Agroforestry

Contribute to:
A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism
PG08 Cooperative Living Lab

Potential Facilitators

Agrifood Sector
Local Farmers
Knowledge institutes
Ecological department

Photo source:
Combining Peanut and Maize Farming
https://www.sohu.com/a/393461288_120564502

Transferability

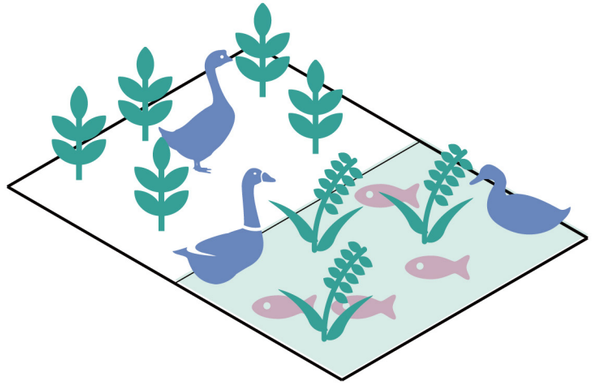
High transferability while knowledge support needed.

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M49 Integrated Waterfowl Farming



Hypothesis

Introducing waterfowl farming to the rice farming offers a more ecological-sound pathway for paddy fields.

Potential Facilitators

Agrifood Sector
Local Farmers
Knowledge institutes
Ecological department

Links with other patterns

Complementary:
M47 Ecological Polder Canal

Contribute to:
A04 Manure as Fertilizer
A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism
PG08 Cooperative Living Lab
PG10 Vocational Education

Photo source:
Integrating Waterfowl Farming with Paddy Field in Anhui Province
by 21st Century Business Review.
http://www.21cbr.com/article/85493

Transferability

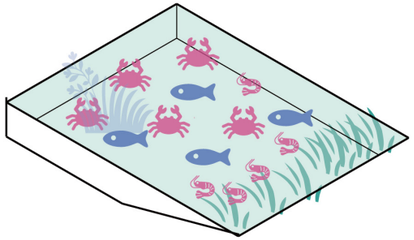
Suitable to areas with paddy field.
Incentives and knowledge needed.

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M50
Mixed Aquatic Cultivation



Hypothesis

By integrating different aquatic cultivation together to mimic a natural ecosystem, there will be fewer emissions to surface water.

Links with other patterns

Complementary:
M47 Ecological Polder Canal
M46 Littoral Space

Contribute to:
A19 Revive Natural Food Chain

Facilitated by:
PG04 Agro-tourism
PG08 Cooperative Living Lab
PG10 Vocational Education

Potential Facilitators

Agrifood Sector
Local Farmers
Knowledge institutes
Ecological department

Photo source:
Mixed aquatic farming in China
http://www.kudiaoyu.com/baike/6431.html,
https://www.zhifure.com/snzfj/66909.html

Transferability

Incentives and knowledge needed.
Suitable for areas with aquatic farming.

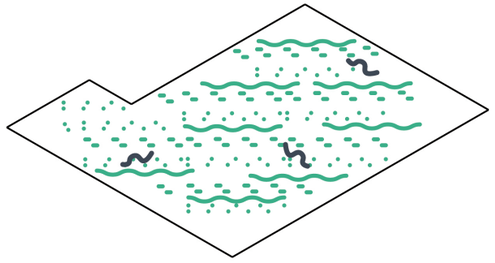
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M50

M51
Open Soil Area



Hypothesis

Open soil space as much as possible gives the potential for the local flora to grow, which lays the foundation for the flourishment of the ecosystem.

Links with other patterns

Contribute to:

A20 Urban Biotopes Network
A11 Groundwater Recharging

Facilitated by:
PG02 Public Park for all ages

Potential Facilitators

Housing developer
Ecological department

Photo source:
Open Soil Zone for gardening in Municipality of Porto by Filipa Brito, https://www.porto.pt/_next/image?url=https%3A%2F%2Fmedia.porto.pt%2Foriginal_images%2Ffib_horta_paranhos_04.jpg&w=1460&q=85

Transferability

High transferability to other areas

Contribution to SDG's

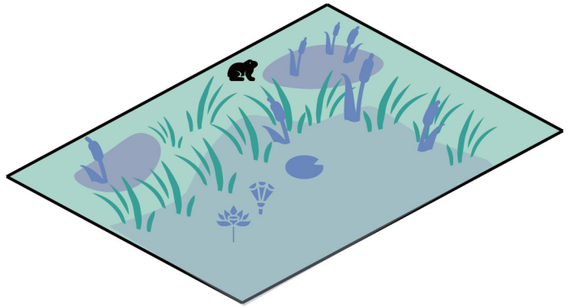
Contribution to Water System

Water Safety

Water Quantity

Water Quality

M52
Wet Biotope



Hypothesis

Creating wet biotopes in the urban areas helps amphibians animals to find their room in the city and thus strengthens the urban ecological network.

Links with other patterns

Contains:
MG06 Wet Soil Trees ,MG07 Hygrophyte.
MG08 Emergent Vegetation, MG09 Floating Vegetation

Specialized by: MG03 Natural Ditches
MG05 Amphibious Park

Co-exist well with: MG04 Bioswales

Contribute to:
A20 Urban Biotopes Network
A11 Groundwater Recharging

Facilitated by:
PG01 Interaction with water
PG02 Public Park for all ages

Potential Facilitators

Housing developer
Neighborhood committee
Local residents
Ecological department

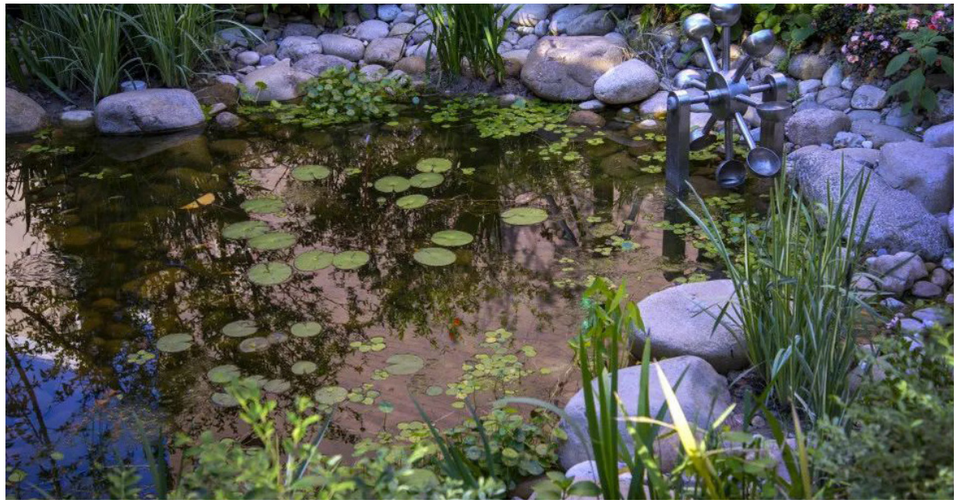


Photo source:
Changning District Community Biotope Garden byShanghai Environment
https://www.shobserver.com/sgh/detail?id=553397

Transferability

High transferability to other areas while climate condition should be considered.

Contribution to Water System

Water Safety
Water Quantity
Water Quality

Contribution to SDG's

M52

M53
Vegetation Diversity

Hypothesis

In a neighbourhood, the presence of different types of vegetation (both trees and bushes, both ever-green and deciduous) can create stronger ecosystem to accommodate more creatures.

Links with other patterns

Complementary for :
M19 Canopies
M23 Open Green Space
M43 River Terrace Green Belt
M54 Rooftop Habitat

Contribute to:
A20 Urban Biotopes Network

Facilitated by:
PG02 Public Park for all ages

Potential Facilitators

Ecological department

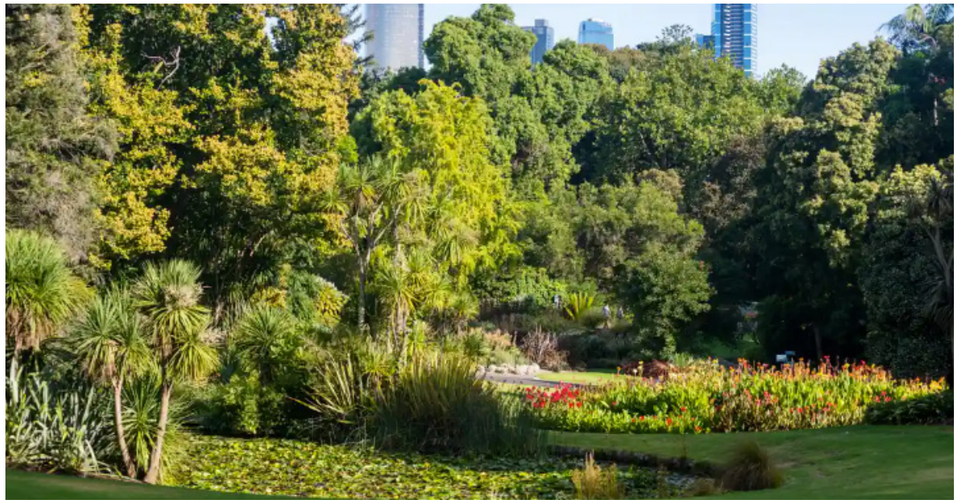


Photo source:
Andrew Michael/UIG/Getty Images/Collection
https://www.theguardian.com/lifeandstyle/2020/apr/20/the-coronavirus-has-made-me-so-grateful-for-city-parks-we-should-fight-for-them

Transferability

High transferability to other areas

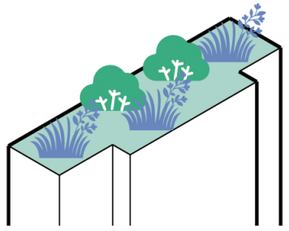
Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

M53

M54
Rooftop Habitat



Hypothesis

Creating green spaces with diverse vegetation on the rooftop can make a habitat for small insects and attract birds to hunt for food.

Links with other patterns

Complementary:
M53 Vegetation Diversity

Co-exist well with:
M30 Retention roofs

Contribute to:
A20 Urban Biotopes Network

Potential Facilitators

Housing developer
Local residents
Ecological department

Photo source:
Rooftop garden by Tribu,
https://blog.mybespokeroom.com/hs-fs/hubfs/getuigenissen-new-luxury-rooftop-gardens-3n1a8410.jpg?width=1118&name=getuigenissen-new-luxury-rooftop-gardens-3n1a8410.jpg

Transferability

High transferability to other areas

Contribution to SDG's

Contribution to Water System

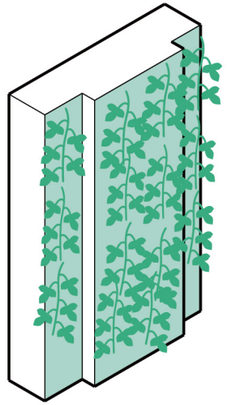
Water Safety

Water Quantity

Water Quality

M54

M55
Eco-Facade



Hypothesis

Eco-facade provides room for insects, improves the micro-climate of around the buildings and save energy consumption.

Links with other patterns

Contribute to:
A20 Urban Biotopes Network

Potential Facilitators

Housing developer
Local residents
Knowledge institutes
Ecological department
*Also possible in industrial zone or office building: Industrial Sector

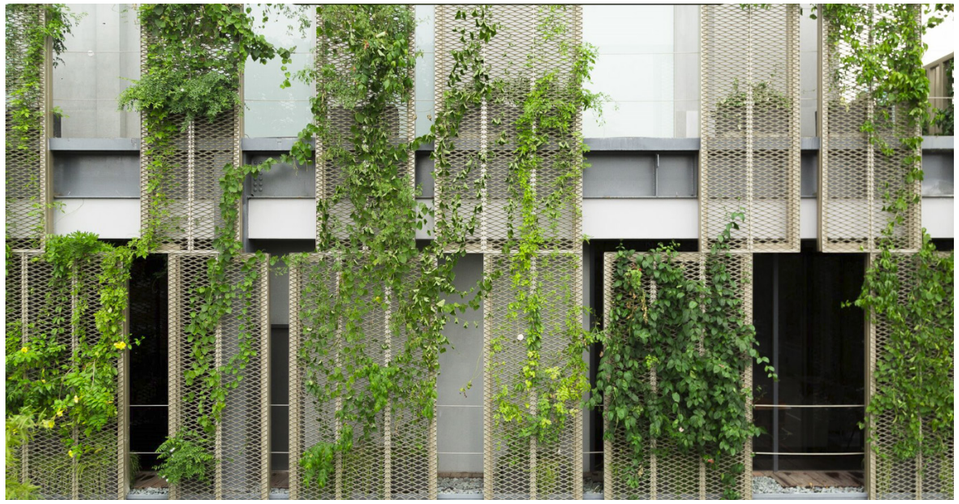


Photo source:
Green Facade by Shang Kai Steel
https://sksteeltw.com/wp-content/uploads/2018/10/d3EaTDOj.jpeg

Transferability

High transferability to other areas

Contribution to Water System

- Water Safety
- Water Quantity
- Water Quality

Contribution to SDG's

MG 01

MG01 Helophyte

Hypothesis

Helophytes not only commonly work as effective filters for wastewater treatment but also is a natural connector for terrestrial and aquatic ecosystems (Coops, H.,1996).

Links with Other Patterns

Components of:
M01,M02,M03,,M28,M46,M47, M52

Contribute to:
A01,A02,A12,A18,A19,A20

Facilitated by:
PG02,PG04,PG01

Practical Implications

The Helophyte is macrophyte that has purification capacities. They can be either emergent plants or rooted floating vegetations(Nanninga,2011) and are most commonly used in the constructed wetland(M03) for greywater treatment. Though there are much knowledge and experience of the application of them greywater treatment in developed countries such as the Netherland, the functioning of different types of helophyte might differ from area to area. So more research still needs to be carried out on the performance of helophytes in different contexts.

In bioswales(MG03) and other types of ponds(M01, M02, M28), helophytes also play the role of filtering the rainwater or surface water runoff and add both ecological and aesthetic value to the built-enviroment. However, it should be noted that it is important to use native species and avoid invasive species.

Photo source:
Helophytes used for constructed wetland
https://zhuanlan.zhihu.com/p/127838144

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas

Contribution to SDG's

MG 01

MG 02

MG02
Floodable Wetland

Hypothesis

Large wetland zone should be given back to nature so that they can change according to the rhythm of natural water cycle.

Links with Other Patterns

Specialized by:M44,M45

Complementary:MG08.MG09

Contribute to:A08,A17,A18

Facilitated by:PG01,PG02,PG03

Practical Implications

Many once natural riverplain zone is nowadays urban space with concrete dikes. However, if a floodable wetland zone is on the lowest part of the riverfront, it can retent excess rainwater and tidal water during flooding events. There are many existing cases to remove current dikes and create large scale floodable wetlands as a buffer zone next to the river, including the famous 'Room for river' project in the Netherland. In China, similar projects are also launched in many cities, such as Weiliu Wetland Park along the Wei River by Yifang Ecoscape.

When such projects are implemented under a cross-disciplinary and multilevel governance process with the socio-economic context considered, more benefits and added values (including flood risk management value, recreational and tourism value, and ecological value) are foreseeable(Zevenbergen et al., 2013).

Photo source:
Joachim Drüke(2015) , Moist and wet meadows, https://www.naturschaetze-suedwestfalens.de/var/sauerland/storage/images/media/bilder/naturschaetze/buchfotos/03_s1_ueberschwemmte-wiese_5559_jd/507689-1-ger-DE/03_S1_ueberschwemmte-Wiese_5559_JD_front_magnific.jpg

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas

Contribution to SDG's

MG 02

MG03
Natural Ditches

Hypothesis

Natural ditches work as an open drainage system which allows infiltration and can contribute to biodiversity.

Links with Other Patterns

Complementary:M46

Alternative:M17,M18,M22

Components of:M52

Contribute to:A11,A09,A20

Facilitated by:PG01,PG02,PG04

Practical Implications

Natural ditches can be used in both urban and rural areas as an irrigation system, or supplementary drainage system. But most importantly, unlike an urban water canal(M17) with an artificial embankment for contextual reasons or gutters(M18) with a focus exclusively on water management function, It has a natural littoral zone and can thus accommodate multiple types of aquatic species. This ecological feature makes it not only suitable for water management but also has the potential to be integrated with parks for children(since such ditches are usually shallow and safe for children to play around).

Proper but less frequent management is recommended to let nature flourish on its own while still maintaining a range of different conditions (such as vegetation types difference and water level differences)to benefit biodiversity(DEFRA,2021). Thus, it is necessary to trace the ecological health condition of natural ditches from time to time to protect the well-being of local wildlife.

Photo source:
Stream Restoration Project on Shingle Creek
by Shingle Creek and West Mississippi
Watershed Management Commissions
http://www.shinglecreek.org/connections-at-shingle-creek.html

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas.

Contribution to SDG's

MG04
Bioswales

Hypothesis

A bioswale maximizes the time that stormwater spends in the swale while removing the pollutants in the water and contributes to local ecology if well designed.

Links with Other Patterns

Complementary:M46

Alternative:M22

Components of:M52

Contribute to:A11,A12,A20

Facilitated by:PG02

Practical Implications

A bioswale collects stormwater from rooftops and streets before it goes to the sewers via gutters(M18), ditches(M17 Urban Water Canals, MG03 Natural Ditches) or via overflowing from Infiltration strips(M22, only during heavy rain).

It has a top layer with vegetation, where hygrophytes(MG07) that can handle wet soil conditions are recommended. Below the layer, gravel, scoria or other porous material could be considered to provide more empty space for rainwater(Groenblauw,n.d.). An infiltration pipe(M27) or drainage pipe is usually paved under the second layer to direct overflows to surface water bodies or larger retention spaces nearby(can be M28 Retention Pond, M29 Rainwater Square/Sports field, M31Storage below buildings).

Further reading: https://www.urbangreenbluegrids.com/measures/bioswales/

Photo source:
Bioswale in Kronsberg, Hannover, Germany by Atelier Dreiseit
https://www.urbangreenbluegrids.com/uploads/002-Kronsberg-008-Dreiseitl-1300x650.jpg

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas with certain knowledge needed.

Contribution to SDG's

MG 05

MG05
Amphibious Park

Hypothesis

An amphibious park turns flooding events into an attraction. It stores and purifies the stormwater and provides ecological services to the local community.

Links with Other Patterns

Complementary:M45,M46

Alternative:M28,M29

Contribute to:A10,A11,A12

Facilitated by:PG02

Practical Implications

An amphibious park can be considered on a large scale in a floodable wetland(MG02) zone. However, it is also possible to implement it on a neighourhood scale together with a retention pond or bioswale in part of the neighourhood that are vulnerable to urban waterlogging. It is also possible to integrate wet biotope(M52) in such a park when a certain part of the park is designed to be a permanent pond.

Based on the weather condition and different seasons, the landscape can change in an amphibious park which allows different activities and forms interesting experiences for local people.

Photo source:
Yangpu Rainwater Park in Shanghai by Zhuyun Jiang
http://wenhui.whb.cn/zhuzhan/cs/20200719/361651.html

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas with certain cooperation needed.

Contribution to SDG's

MG 05

MG 06

MG06
Wet Soil Trees

Hypothesis

Wet soil trees have adapted to high groundwater levels and some of them even have special roots that allow them to survive in long-time flooded areas.

Links with Other Patterns

Components of:M44,M52

Contribute to:A10,A18,A20

Facilitated by:PG02,PG03

Practical Implications

Naturally, wet soil trees can be found near rivers or form into a swamp forest (M44) since they can handle high moisture. With their canopies(M19), their values in both water safety management and ecology are high.

Hence, when creating amphibious parks or other spaces with retention functions, wet soil trees are highly recommended since it can intercept rainwater, provide shades and release oxygen to support the health of the neighourhood. While there are many common types of wet soil trees (such as willows) which are easy to find around the world, different areas should prioritize their own native species with similar functions.

It should also be noted that during droughts or especially hot summers, they may need supplemental watering(Leonard,2021).

Photo source:
Taxodium distichum in Taiwan by Taichung Tanzi District Office
https://www.ettoday.net/news/20130322/179573.htm_5559_JD_front_magnific.jpg

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas with certain ecological knowledge needed.

Contribution to SDG's

MG 06

MG 07

MG07 Hygrophyte

Hypothesis

Though growing above ground, hygrophytes adapt to wet soil and moist air and thus can stand during flood conditions.

Links with Other Patterns

Components of:M20,M22

Contribute to:A10,A11,A18,A20

Facilitated by:PG02,PG03

Practical Implications

Hygrophytes are born in areas with plentiful moisture, such as a wet meadow(M45) or in a swamp forest(M44).

Considering their resistance to moisture soil, they are suitable for the design of infiltration stripes(M22) and bioswales(MG04).

However, extra watering and management are needed especially during drought season and this can also depend on different types of hygrophytes. Different areas should thus explore further to find out their own cost-effective types of hygrophytes when designing these retention spaces.

MG 07

Photo source:
Violaceae in wet soil, from Pixabay

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Transferability

High transferability to other areas with certain ecological knowledge needed.

Contribution to SDG's

MG08
Emergent Vegetation

Hypothesis

Emergent plants have strong ability to purify the water and vitalize riparian ecosystem.

Practical Implications

Emergent plants grow along the bank. They have their root in the deep bottom of the ponds or rivers and thus stabilize shallow soils at the waterfront(Utah State University, 2020), while their leaves are above the water's surface.

They have commonly been used as helophyte(MG01) filters in constructed wetlands(M03) with their strong purification capacity.

They are also an important element for creating an ecologically-friendly littoral zone(M46), which takes in nutrients and carbon dioxides and provides habitats for aquatic creatures. And emergent vegetation thus also plays a significant role when creating ponds (M01 Protective Centralized Drinking Water Source, M02 Community Rainwater Storage Space,) and ditches(MG03 Natural Ditches) as well as designing urban biotopes(M52).

Links with Other Patterns

Components of:
M01,M02,M46,M47,M52

Contribute to:
A01,A18,A19,A20

Facilitated by
PG01,PG02,PG03

Photo source:
Pontederia cordata, from Wikipedia
https://en.wikipedia.org/wiki/Pontederia_cordata#/media/File:Pickerelweed,_Rideau_River.jpg

Contribution to Water System

Water Safety ■■□□

Water Quantity ■■■□

Water Quality ■■■■

Transferability ■■■■■

High transferability to other areas with certain ecological knowledge needed.

Contribution to SDG's

MG 09

MG09
Floating Vegetation

Hypothesis

The floating vegetation safeguard the water ecosystem by cooling down the water temperature, preventing algae growth and providing breeding space for fish.

Links with Other Patterns

Components of:
M17,M46,M47,M52

Contribute to:
A09,A18,A19,A20

Facilitated by:
PG01,PG02,PG03

Practical Implications

Floating vegetation includes free-floating vegetation(with no anchored roots) and submerged vegetation (with anchored roots). Though they can be attractive for a pond, it is suggested that floating plants should not only cover more than 20% of surface water considering their negative effects on oxygen exchange and photosynthesis in the water(Clemson University,2022). Meanwhile, the mobility of the free-floating vegetation can be a threat in stormwater ponds because it might disturb the function of the rainwater ponds.

It should also be noted that most of the floating vegetation has very fast growth rates and can cause serious problems to the whole ecosystem when not controlled properly. Thus they should be managed under the guidance of the ecology and biologic experts.

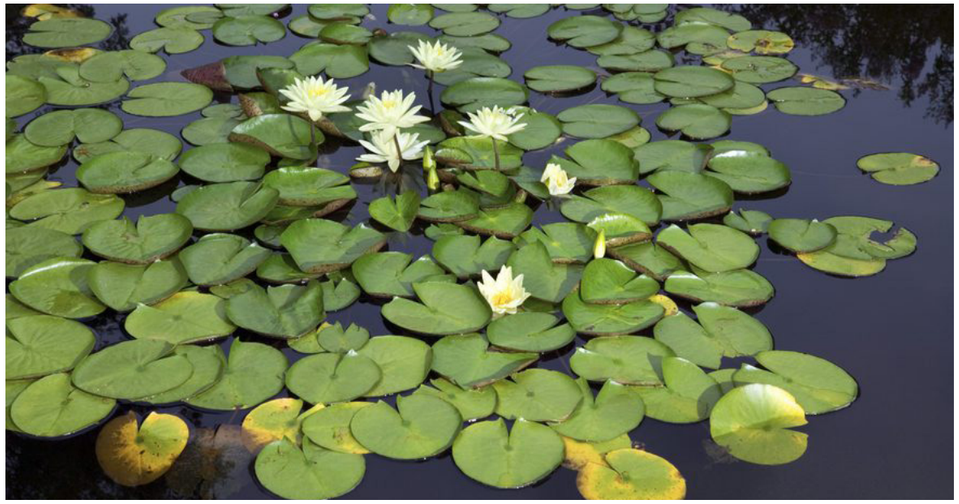


Photo source:
Floating vegetation, by Kasco
https://kascomarine.com/blog/common-floating-plant-identification/

Contribution to Water System

Water Safety

Water Quantity

Water Quality

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS

3 GOOD HEALTH AND WELL-BEING

15 LIFE ON LAND

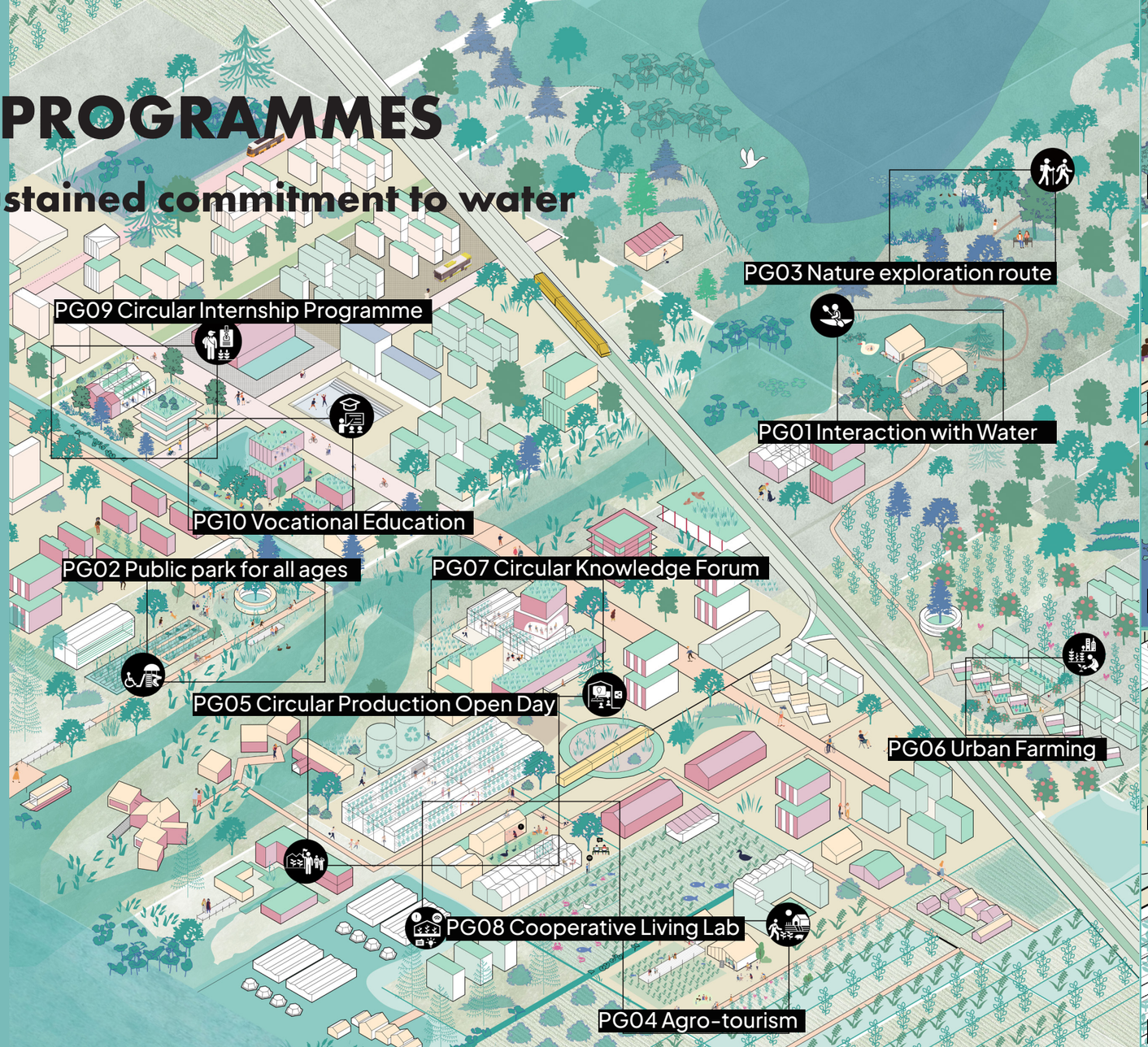
Transferability

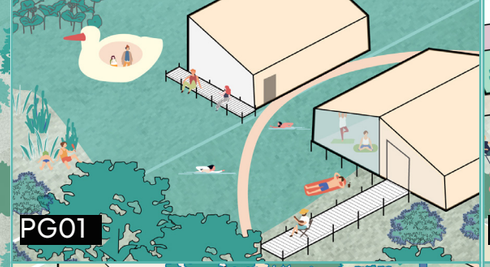
High transferability to other areas with certain ecological knowledge needed.

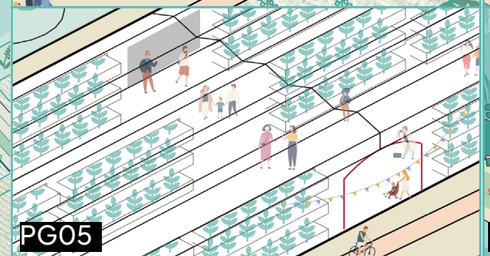
MG 09

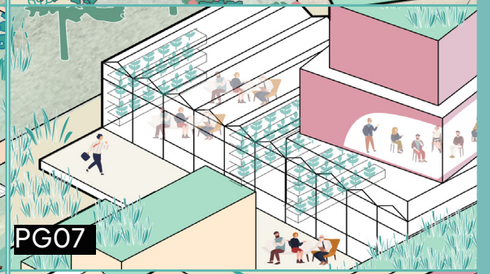
V. PROGRAMMES

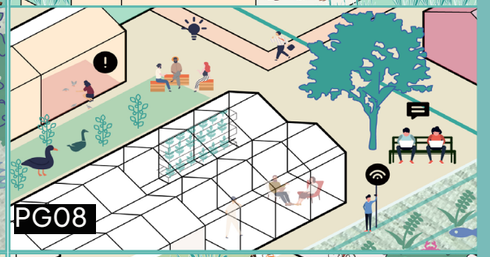
a sustained commitment to water











PG 01

PG01
Interaction with water

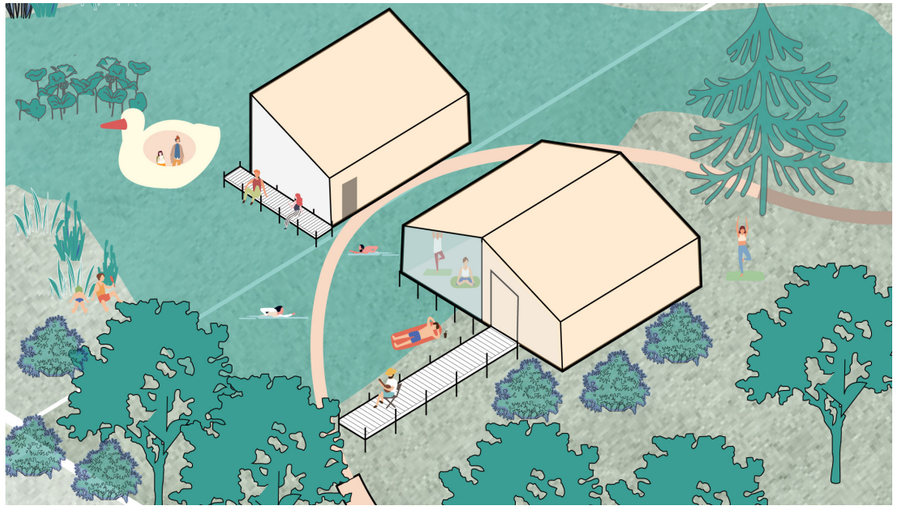
Hypothesis

Interaction with water allows people to grow an attachment to water and rediscover its social and cultural value.

Stakeholders

Municipal Government
Tourism Sector
Housing developer
Neighborhood committee
Local residents

Photo source:
Oosterpark Paddling Pool in Amsterdam by Carve
https://oss.gooood.cn/uploads/2016/06/002-Oosterpark-Paddling-Pool-by-Carve-960x640.jpg



Transferability

High transferability to other areas

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
6 CLEAN WATER AND SANITATION
13 CLIMATE ACTION
15 LIFE ON LAND

Facilitating the following patterns:

M02 M17 M28 M34 M39 M46 M52 MG05

PG 01

PG02
Public park for all ages

Hypothesis

Creating public parks for all ages improves citizens' overall health and well-being and fosters social coherence and belonging.

Stakeholders

Municipal Government
Tourism Sector
Housing developer
Neighborhood committee
Local residents

*When in ecological zone:
Ecological department

Photo source:
Honghu Park ,Shenzhen NODE Architecture & Urbanism
https://www.gooood.cn/landscape-design-for-shenzhen-lotus-water-culture-base-and-ground-level-of-honghu-park-water-purification-plant-china-by-node.htm

Transferability

High transferability to other areas

Contribution to SDG's

Facilitating the following patterns:

A15 M01 M02 M03 M17 M18 M19 M21 M22 M23 M24 M28 M29

M43 M51 M52 M53 MG01 MG03 MG04 MG05 MG06 MG07 MG08 MG09

PG03
Nature exploration route

Hypothesis

Providing a route for people to explore nature links people with the ecosystem together and creates an awareness of environmental protection imperceptibly.

Stakeholders

Provincial/Municipal Government

Tourism Sector

Ecological department

Photo source:
Grand Voyeux Natural Reserve by Territoires + Charles Henri TACHON + Nicolas Granger ©Nicolas Waltefaugle https://oss.gooood.cn/uploads/2019/04/022-grand-voyeux-natural-reserve-by-territoires-charles-henri-tachon-nicolas-granger-960×641.jpg

Transferability

High transferability to other areas

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS

3 GOOD HEALTH AND WELL-BEING

15 LIFE ON LAND

Facilitating the following patterns:

M01 M14 M15 M16 M34 M38 M39 M40 M41 M42 M44

MG02 MG06 MG07 MG08 MG09

PG04
Agro-tourism

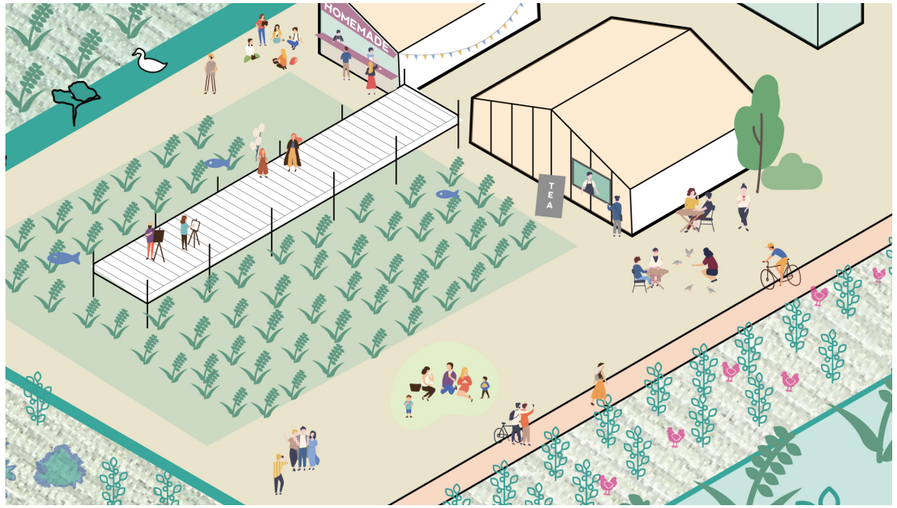
Hypothesis

Urban residents understand and appreciate the food production process better through agro-tourism, which forms a dialogue between urban and rural areas.

Stakeholders

Agrifood Sector
Industrial Sector
Tourism Sector
Waste Management Services
Local Factory Owners
Local Farmers
Innovators and engineers
Neighborhood committee
Local residents

Photo source: Poster from Mokumoku Handmade Farm in Japan, http://www.moku-moku.com/nougakusya/index.html



Transferability

High transferability to areas with agricultural culture.

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
3 GOOD HEALTH AND WELL-BEING
8 DECENT WORK AND ECONOMIC GROWTH
15 LIFE ON LAND

Facilitating the following patterns:

M06 M07 M32 M34 M47 M48 M49 M50

PG05 Circular Production Open Day

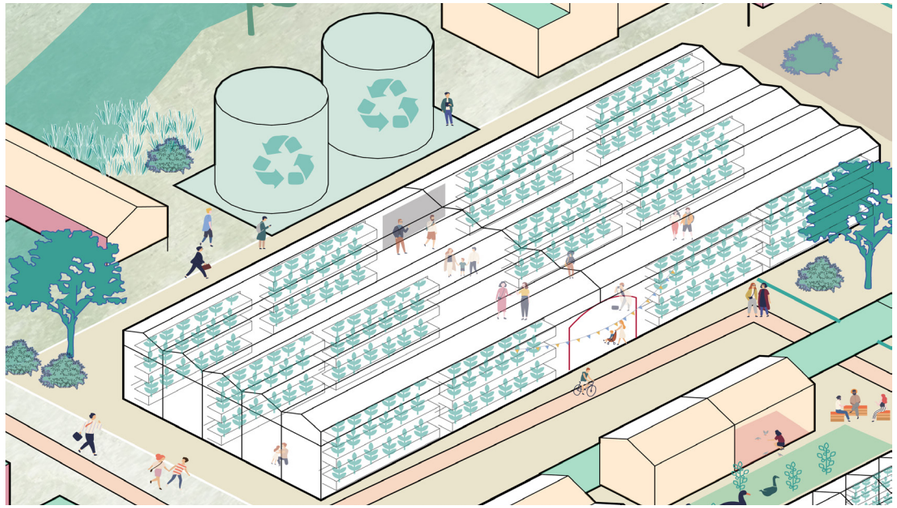
Hypothesis

Making the industrial and agricultural production process transparent to visitors during a certain time of the year not only connects the consumers and producers tightly but also brings attention to the importance of circularity.

Stakeholders

Agrifood Sector
Industrial Sector
Tourism Sector
Waste Management Services
Local Factory Owners
Local Farmers
Innovators and engineers
Neighborhood committee
Local residents

Photo source: COUNTRYLIFE ,https://blog.countrylife.ie/news-events/garden-centre-customer-open-days/



Transferability

Technology, incentives, investement and cooperation needed.

Contribution to SDG's

Facilitating the following patterns:

M04 M05 M09 M11 M12 M13 M31

PG 06

PG06
Urban Farming

Hypothesis

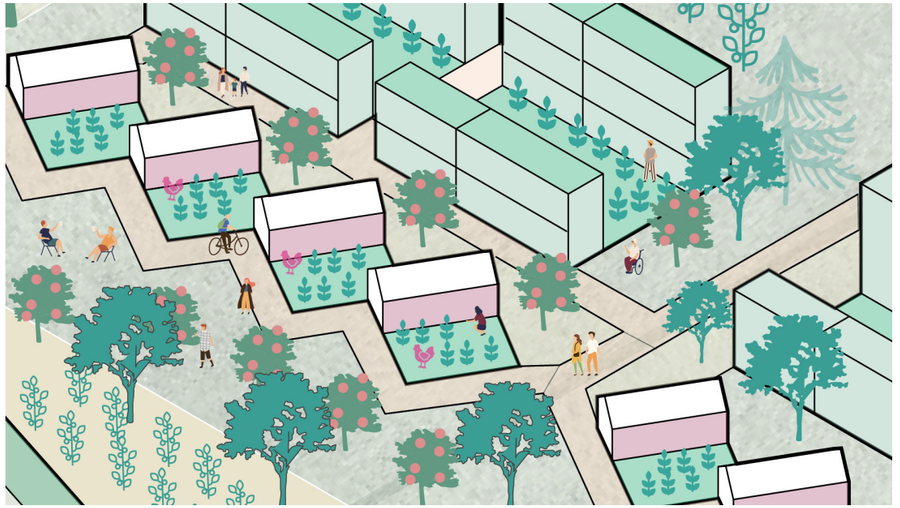
Bringing farming back to the city blurs the boundary between urban and rural, offers new opportunities for waste management in the cities and creates added income for farmers.

Stakeholders

Agrifood Sector
Waste Management Services
Local Farmers
Neighborhood committee
Local residents
Knowledge institutes

Photo source:
Urban farming
by Wagening University

https://www.wur.nl/en/newsarticle/urban-greenhouse-talks-a-new-podcast-about-urban-farming.htm



Transferability

High transferability to other areas with incentives and policy needed.

Contribution to SDG's

Facilitating the following patterns:

A04 A05 M09 M21 M31 M33

PG07
Circular Knowledge Forum

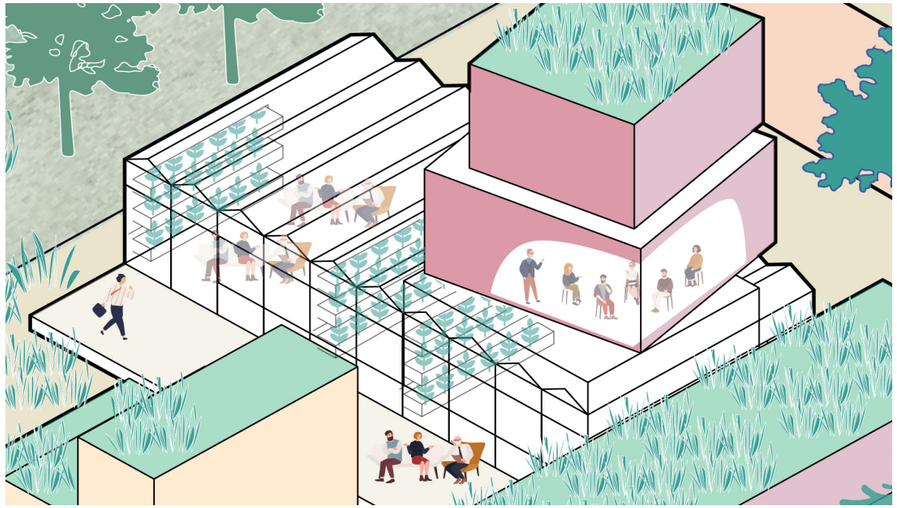
Hypothesis

Establishing a circular knowledge forum provides a platform for business owners, researchers and consumers to share their insights on the circular economy.

Stakeholders

Agrifood Sector
Industrial Sector
Waste Management Services
Local Factory Owners
Local Farmers
Innovators and engineers
Knowledge institutes

Photo source:
Circular Economy conference by SINTEF, NTNU, Nord University, Innovation Norway and UN Global Compact Norway. https://www.sintef.no/en/latest-news/2020/knowledge-and-innovation-for-circular-transition/



Transferability

High transferability to other areas with certain cooperation needed.

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
8 DECENT WORK AND ECONOMIC GROWTH
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION

Facilitating the following patterns:

M04 M05 M08 M11 M13

PG08
Cooperative Living Lab

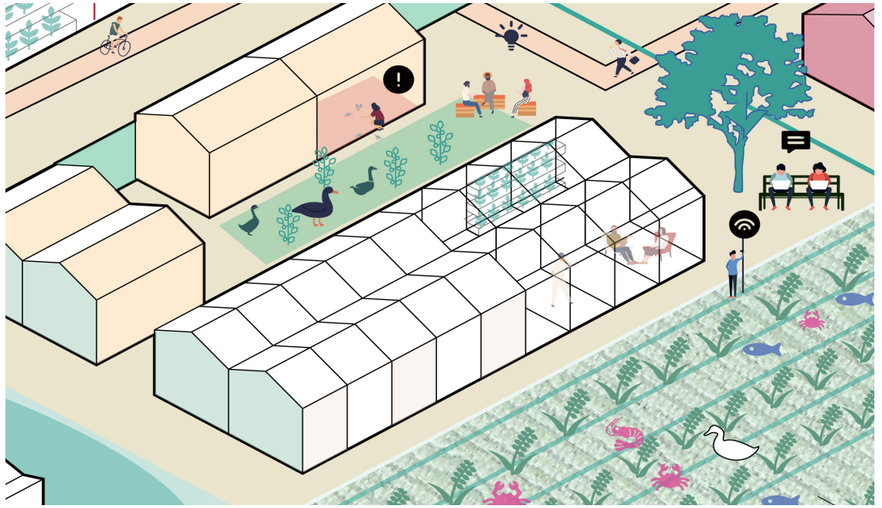
Hypothesis

A cooperative living lab is supported by real-time data and feedback of the experimental zone which allows multi-disciplinary cooperation between sectors and institutions and thus accelerates innovation and knowledge sharing.

Stakeholders

Agrifood Sector
Industrial Sector
Waste Management Services
Innovators and engineers
Neighborhood committee
Local residents
Knowledge institutes
Ecological department

Photo source:
Rooftop Living Lab
https://www.cgi.com/en/corporate-social-responsibility/communities/using-technology-to-optimize-urban-farming



Transferability

Interdiscplinary cooperation and coordination are needed.

Contribution to SDG's

Facilitating the following patterns:

PG 08

PG09 Circular Internship Programme

Hypothesis

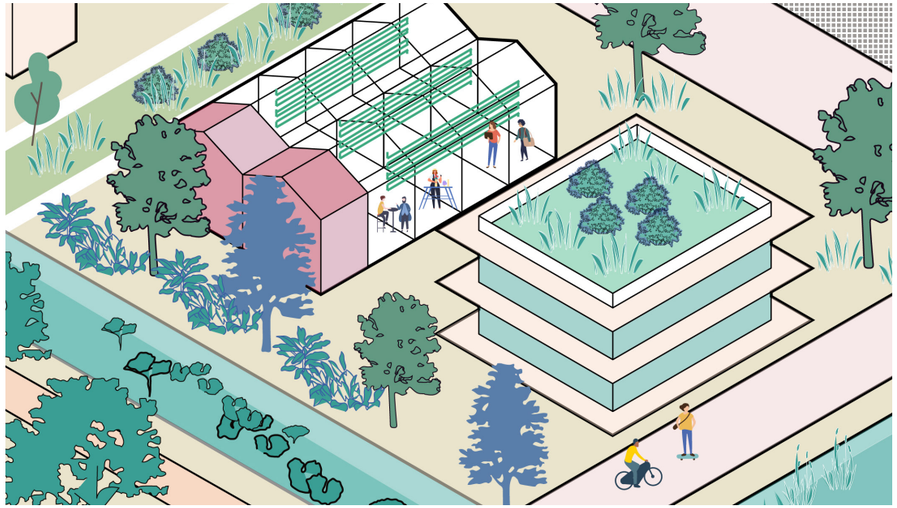
Launching an internship programme between knowledge institutions and business owners can largely shorten the knowledge exchange cycle between theory and practice and better orient research and innovation activities.

Stakeholders

Agrifood Sector
Industrial Sector
Waste Management Services
Innovators and engineers
Trainees/University students
Knowledge institutes

Photo source: Internship at wastewater treatment plant by King County Wastewater Treatment Division , https://kingcounty.gov/depts/dnrp/wtd/about/jobs/internships.aspx

PG 09



Transferability

Interdiscplinary cooperation and coordination are needed.

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
4 QUALITY EDUCATION
8 DECENT WORK AND ECONOMIC GROWTH
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION

Facilitating the following patterns:

M04 M05 M06 M07 M08
M11 M12 M13

PG10
Vocational Education

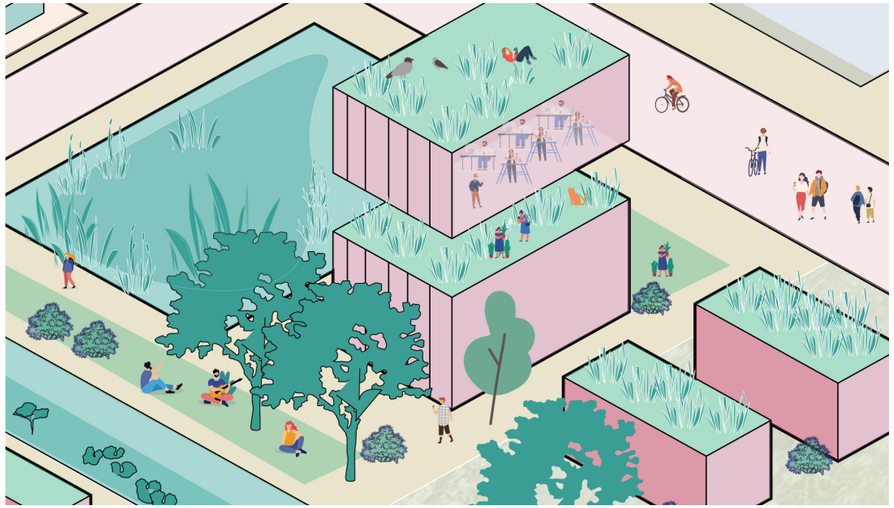
Hypothesis

Emphasizing sustainable technology and innovations in vocational education programmes ensures the practice of sustainability ideas and innovations on a larger scale and longer-term.

Stakeholders

Agrifood Sector
Industrial Sector
Waste Management Services
Local workers
Knowledge institutes

Photo source: Horticulture Degree Programme https://cals.cornell.edu/school-integrative-plant-science/school-sections/horticulture-section/degrees-and-programs-horticulture



Transferability

High transferability to other areas while incentives and investment needed.

Contribution to SDG's

SUSTAINABLE DEVELOPMENT GOALS
4 QUALITY EDUCATION
8 DECENT WORK AND ECONOMIC GROWTH
12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Facilitating the following patterns:

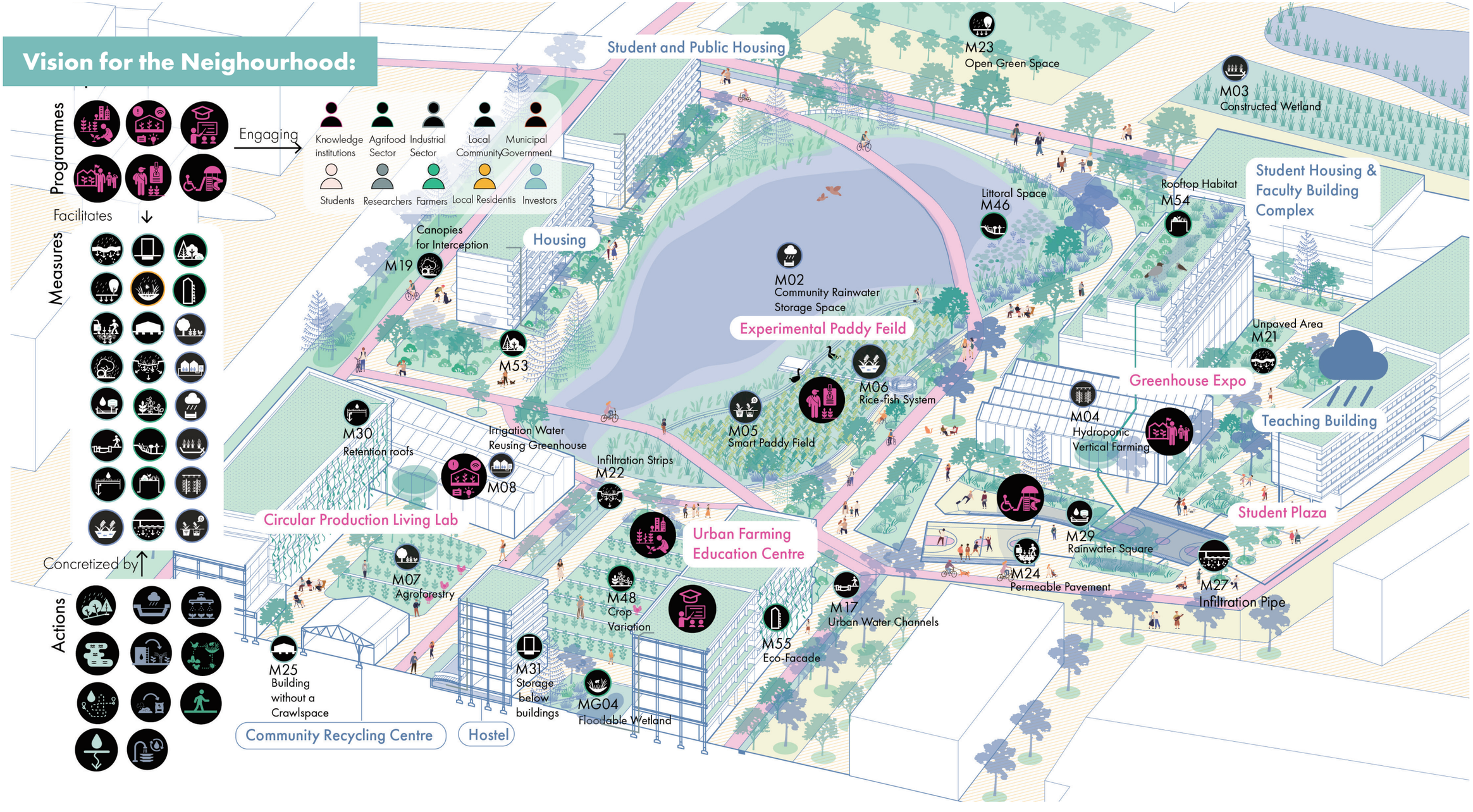
M04 M05 M06 M07 M08 M10 M11 M12 M13 M49

PG 10

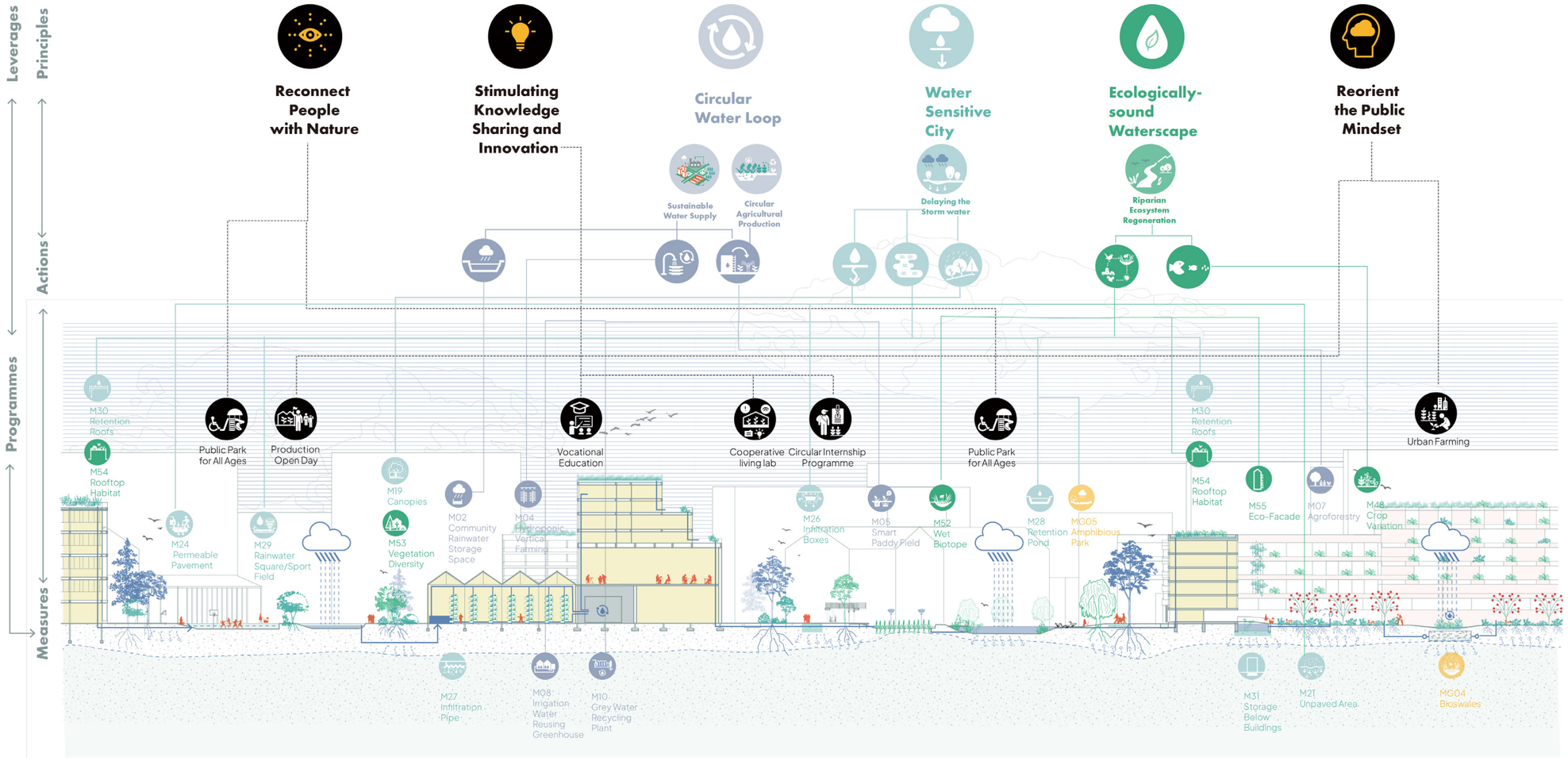
IMPLEMENTATION EXAMPLE

New campus and innovation zone in Tanchong River Basin

Vision for the Neighourhood:



Section

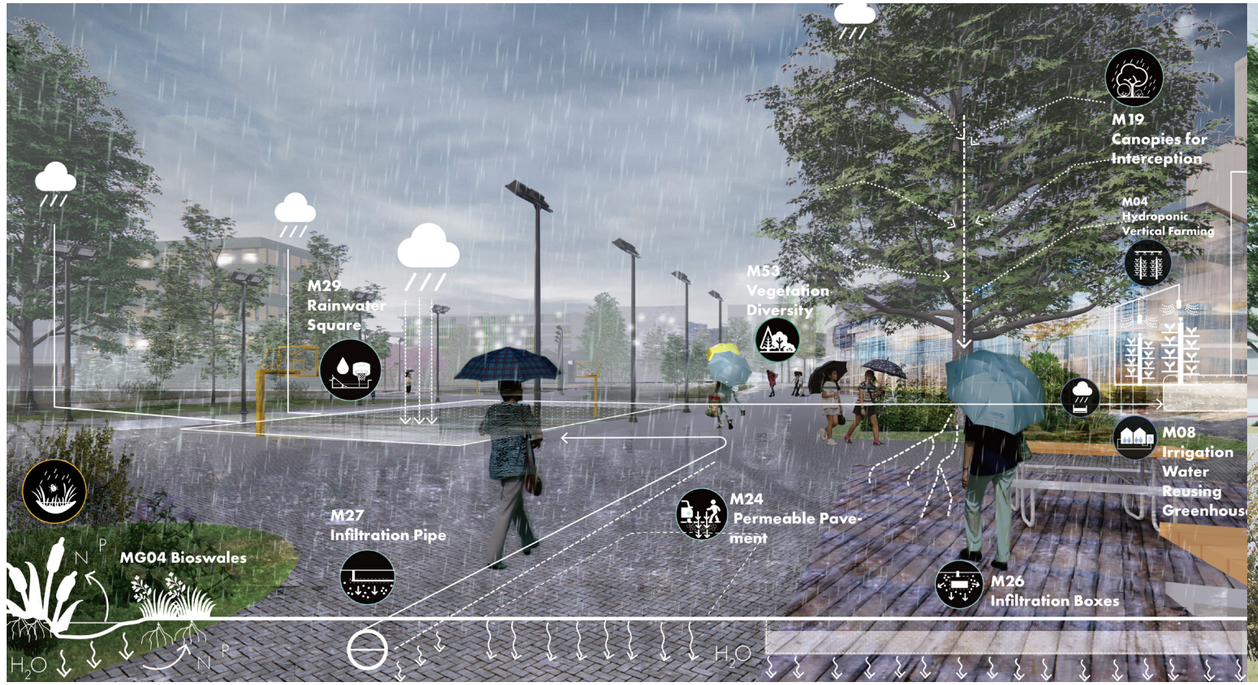


Student Plaza

Experimental Paddy Field Park

Urban Farming Education Centre

Student Plaza in rainy days



Student Plaza in sunny days

Experimental Paddy Field Park

Urban Farming Education Centre

Bibliography

Tillie, N. (2018). Synergetic urban landscape planning in Rotterdam: Liveable low-carbon cities. *A+ BE| Architecture and the Built Environment*, (24), 1-284.

Antonio Ruiz(2021), Comparing soil moisture sensors for smart irrigation systems, https://www.hackster.io/antonio-ruiz/comparing-soil-moisture-sensors-for-smart-irrigation-systems-caa7aa

Gotcher, M., Taghvaeian, S., & Moss, J. Q. (2014). Smart irrigation technology: controllers and sensors. Oklahoma Cooperative Extension Service.

NWRM. (2015). *Retention Ponds | Natural Water Retention Measures*. Natural Water Retention Measures. http://nwrm.eu/measure/retention-ponds

Singh, R., Tiwari, A. K., & Singh, G. S. (2021). Managing riparian zones for river health improvement: an integrated approach. *Landscape and Ecological Engineering*, *17*(2), 195-223.

Arup. (2019). Water and Circular Economy: A white paper. https://www.arup.com/-/media/arup/files/publications/w/water_and_circular_economy_whitepaper.pdf

Sauvé, S., Lamontagne, S., Dupras, J., & Stahel, W. (2021). Circular economy of water: Tackling quantity, quality and footprint of water. Environmental Development, 39, 100651.

Clemson University. (2022). *Floating Aquatic Plants*. Clemson University Cooperative Extension Service. https://www.clemson.edu/extension/water/stormwater-ponds/problem-solving/aquatic-weeds/floating-plants/index.html

Nanninga, T. A. (2011). Helophyte Filters, Sense of Non-sense? A Study on Experiences with Helophyte Filters Treating Grey Wastewater in The Netherlands. *Master's Thesis*.

Zevenbergen, C., Rijke, J., Van Herk, S., Ludy, J., & Ashley, R. (2013). Room for the River: International relevance. *Water Governance*, *2*, 24-31.

Department for Environment, Food & Rural Affairs. (2021, June 7). *Create and manage ditches for wildlife*. GOV.UK. https://www.gov.uk/guidance/create-and-manage-ditches-for-wildlife#why-you-should-manage-ditches

Groenblauw. (n.d.). *Bioswales*. Urban Green-Blue Grids. Retrieved 2022, from https://www.urbangreenbluegrids.com/measures/bioswales/

Leonard, C. (2021, August 5). *Everything you need to know about planting a tree in wet soil*. HappySprout. https://www.happysprout.com/gardening/wet-soil-trees/

Utah State University. (2020). *Emergent, Floating and Submersed Plants*. Extensions Utah State University. https://extension.usu.edu/waterquality/learnaboutsurfacewater/propertiesofwater/emergentandfloatingplants

Filali, H., Barsan, N., Souguir, D., Nedeff, V., Tomozei, C., & Hachicha, M. (2022). Greywater as an Alternative Solution for a Sustainable Management of Water Resources—A Review. *Sustainability*, *14*(2), 665.

Leenstra, F., Vellinga, T., Neijenhuis, F., de Buisonjé, F., & Gollenbeek, L. (2019). Manure: a valuable resource. Wageningen UR Livestock Research. https://edepot.wur.nl/498084

Abson, D. J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., ... & Lang, D. J. (2017). Leverage points for sustainability transformation. *Ambio*, *46*(1), 30-39.

Baghel, R., Stepan, L., & Hill, J. K. (Eds.). (2017). *Water, knowledge and the environment in Asia: Epistemologies, practices and locales*. Taylor & Francis.

Mehariya, S., Goswami, R. K., Verma, P., Lavecchia, R., & Zuorro, A. (2021). Integrated approach for wastewater treatment and biofuel production in microalgae biorefineries. *Energies*, *14*(8), 2282.