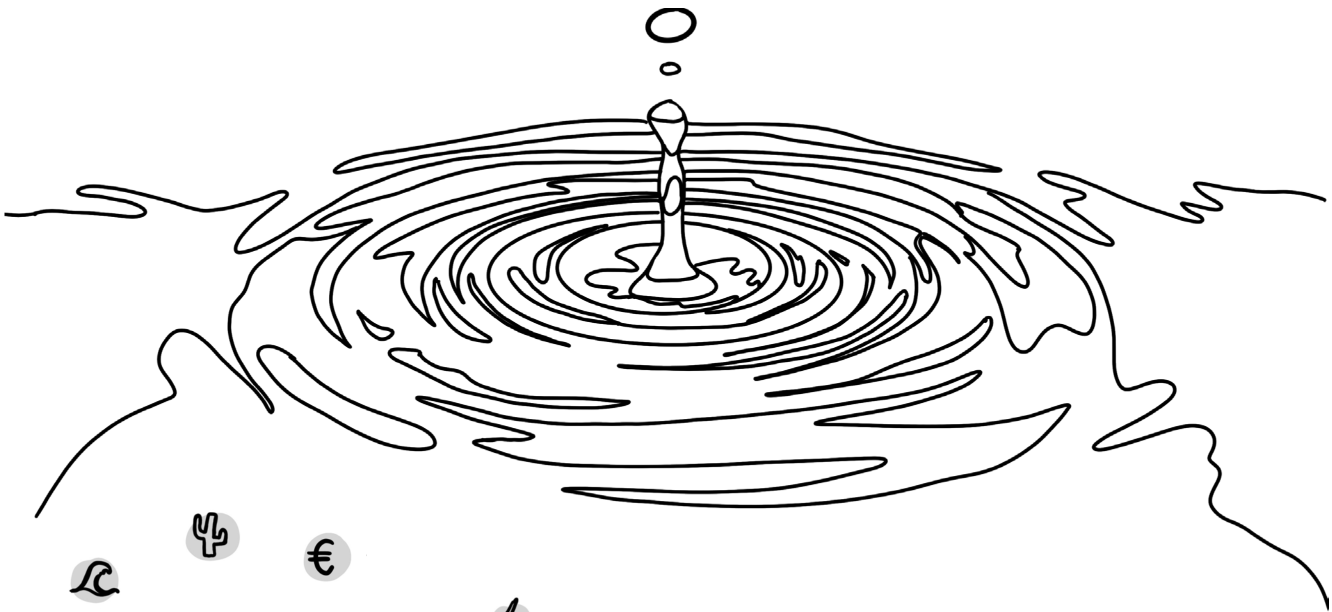
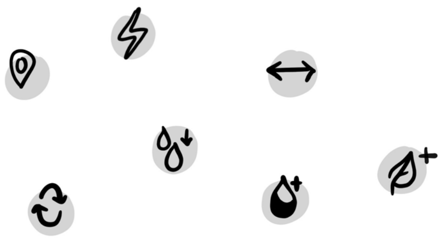
PATTERN LANGUAGE

FOR A SYMBIOTIC WATER SYSTEM





PATTERN BOOKLET

FROM

Graduation project: Ripples of Resilience
Delft University of Technology
MSC Architecture, Urbanism and Building Sciences
by: Sanne van Rees

As a part of the Master Thesis - P5 Pattern Booklet
MSc Architecture, Urbanism and Building Sciences - Track Urbanism
Faculty of Architecture and the Built Environment
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2025

Thesis Title: Ripples of Resilience
Thesis Subtitle: A symbiotic pathway design strategy for the water system transition to combat water scarcity and desertification in the Segura River Basin, Spain.

Pattern Book Title: Pattern language for a symbiotic water system

Graduation Lab - Metropolitan Ecology of Places

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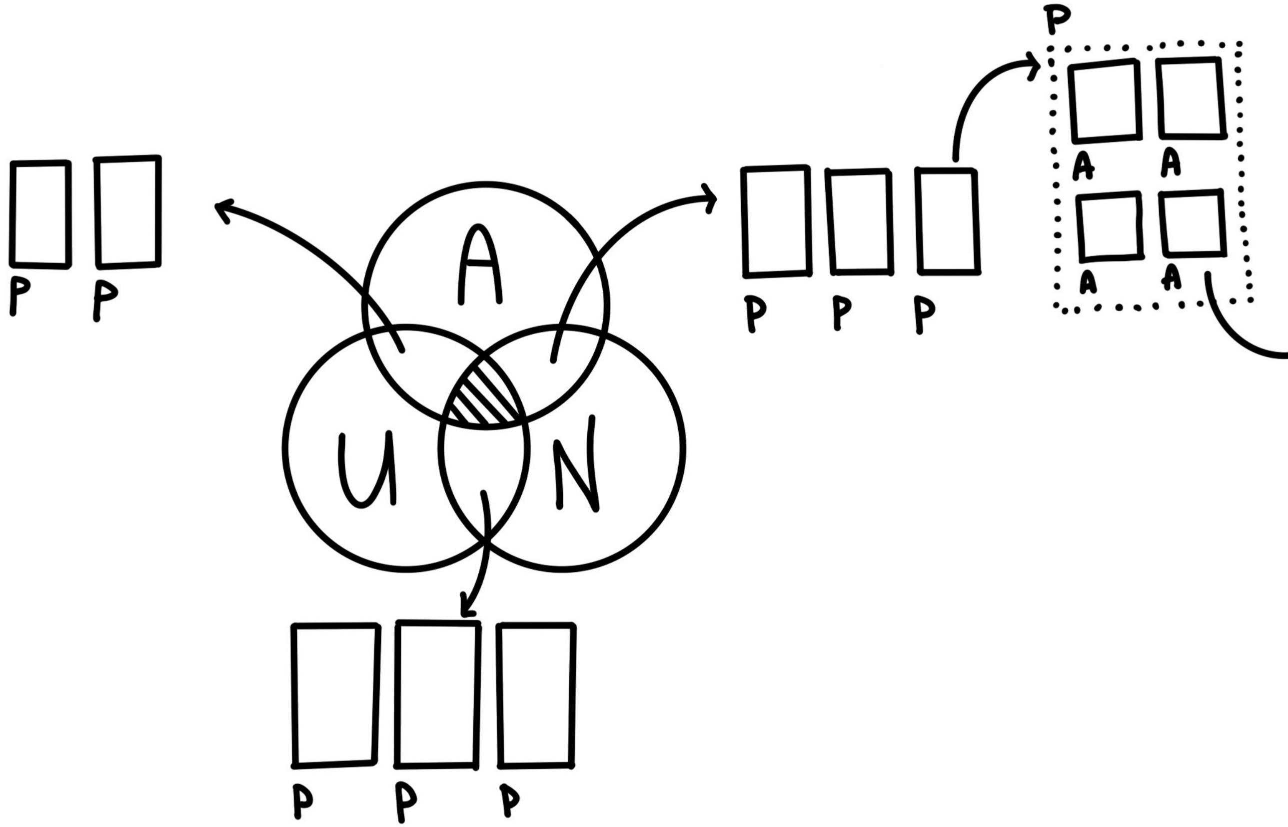
This pattern language builds on the previously made pattern languages in the field of urban design, first developed by Christopher Alexander (Alexander et al., 1977). A pattern language is a categorisaiton of cards, patterns, that show solutions to common problems in the design field, and communicate them in an understandable way. A system is created, where the solution cards can be linked to each other, explaining the way of use. In this way, unique languages can be created, that can form the bridge between different knowledges. It forms a communication and participation tool, which is especially relevant in the higly globalised and urbanised world of today. Combining new factors, disciplines and societal problems, each pattern language stands on its own. By building upon previously made pattern languages, each language can be expanded with new knowledge, creating a tool to be used by other designers and decision-makers.

This pattern lanugage is created as a final product of a master graduation thesis. It shows an overview of spatial and non-spatial design solutions for interconnected problems within different layers of the water system. It connects sectors and stakeholder perspectives, and links design ideas for a resilient future through multiple spatial and temporal scales.



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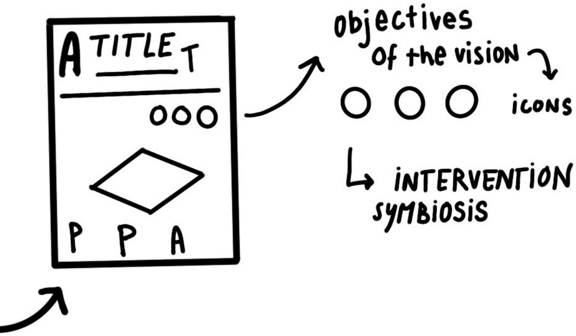


INTRODUCTION

This pattern booklet sets out a pattern language for symbiotic systemic design of the water system transition in arid regions of agricultural production.

This booklet is a design output of the graduation project: "Ripples of Resilience" by Sanne van Rees, supervised by Dr.Ir. A. Wandl and Ir. V. Muñoz Sanz.

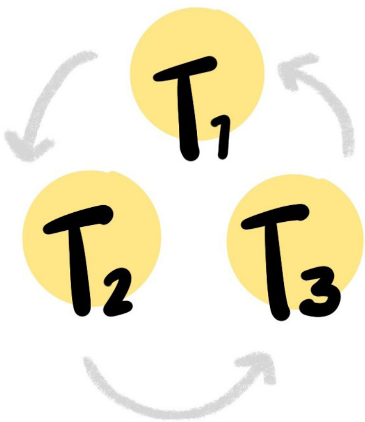
The pattern language contributes to the research gap between theory and practise related to the symbiotic systemic design of the transition towards a sustainable water system in (semi-)arid and water scarce regions. By approaching integrated problems related to drought, water supply, water use and eological well-being in a holistic manner, human-nature symbiosis is the goal to be achieved through a sustainable and socio-ecologically resilient water system.

The pattern language consists of 94 patterns that together frame a pattern-web for the transition towads a sustainable water system. The patterns operationalise three main transitions within the sustainable and symbiotic water system transformation, which are identified through an integrated analysis of the different layers of the water system in the Segura River Basin (Spain), the study area of the graduation project:

1. T1) Sustainable Agriculture Transition
2. T2) Renewable Water Network Transition
3. T3) Nature Restoration Transition

The aim of the pattern language is to integrate the design and operationalisation of these three transitions, to achieve a symbiotic pathway to systemic change.

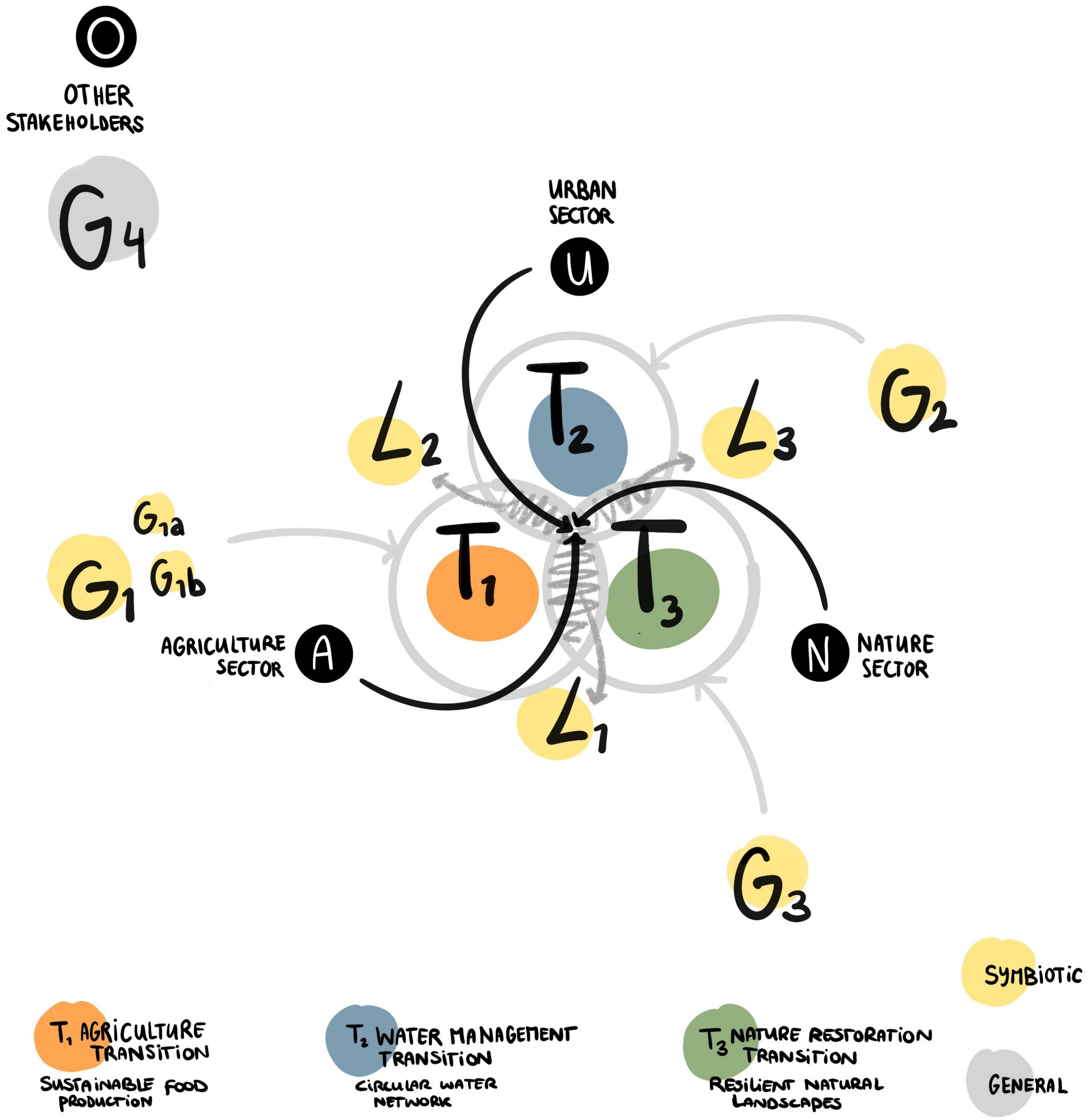
How the patterns are constructed, what their interrelations are, and how the symbiotic pathways can be created, are explained in this booklet, together with a design suggestion of how this pattern language can be applied in the region of the Segura River Basin. The full strategy for regional systemic and symbiotic design of the water system transition that is created with this pattern language is explained in the graduation report (van Rees, 2025).

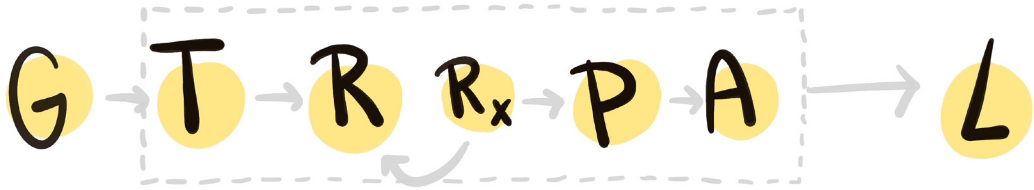

T1
T2
T3

CONTENTS

The pattern language consists of:

- Explanation of the interrelations of the patterns
- Pattern-web
- Explanation of the pattern build-up
- Legends used on the patterns
- Overview of actors involved
- Catalogue of patterns


O
OTHER STAKEHOLDERS
G4
URBAN SECTOR
U
T2
L2
L3
G2
G1a
G1
G1b
T1
T3
AGRICULTURE SECTOR
A
N
NATURE SECTOR
L1
G3
SYMBIOTIC
T1 AGRICULTURE TRANSITION
SUSTAINABLE FOOD PRODUCTION
T2 WATER MANAGEMENT TRANSITION
CIRCULAR WATER NETWORK
T3 NATURE RESTORATION TRANSITION
RESILIENT NATURAL LANDSCAPES
GENERAL



DESIGN FRAMEWORK

EXPLANATION PATTERN LANGUAGE COMPONENTS

The patterns are made out of a categorisation of possible symbiotic interventions to operationalise the design objectives that were created for the project of the water system transition. According to the objectives that belonged to the vision, and within the three transitions for systemic change that were identified, possible intervention solutions (P & A) were collected through precedent studies, desk research, literature study and fieldwork observations.

These interventions require certain political focus points or decisions (R & Rx). These political decisions are connected to the transitions (T). They can be seen as possible pathways to follow within the transition that is chosen to work on. All together, the transitions, regional political focus decisions, and the projects and interventions that result from them, are all formed and influenced by global drivers and mindset changes (G).

Creating the symbiotic changes in the system in turn contributes to achieving the leverage points for societal change (L). Three leverage points were identified from the analysis of the Segura River Basin (SRB) study case:

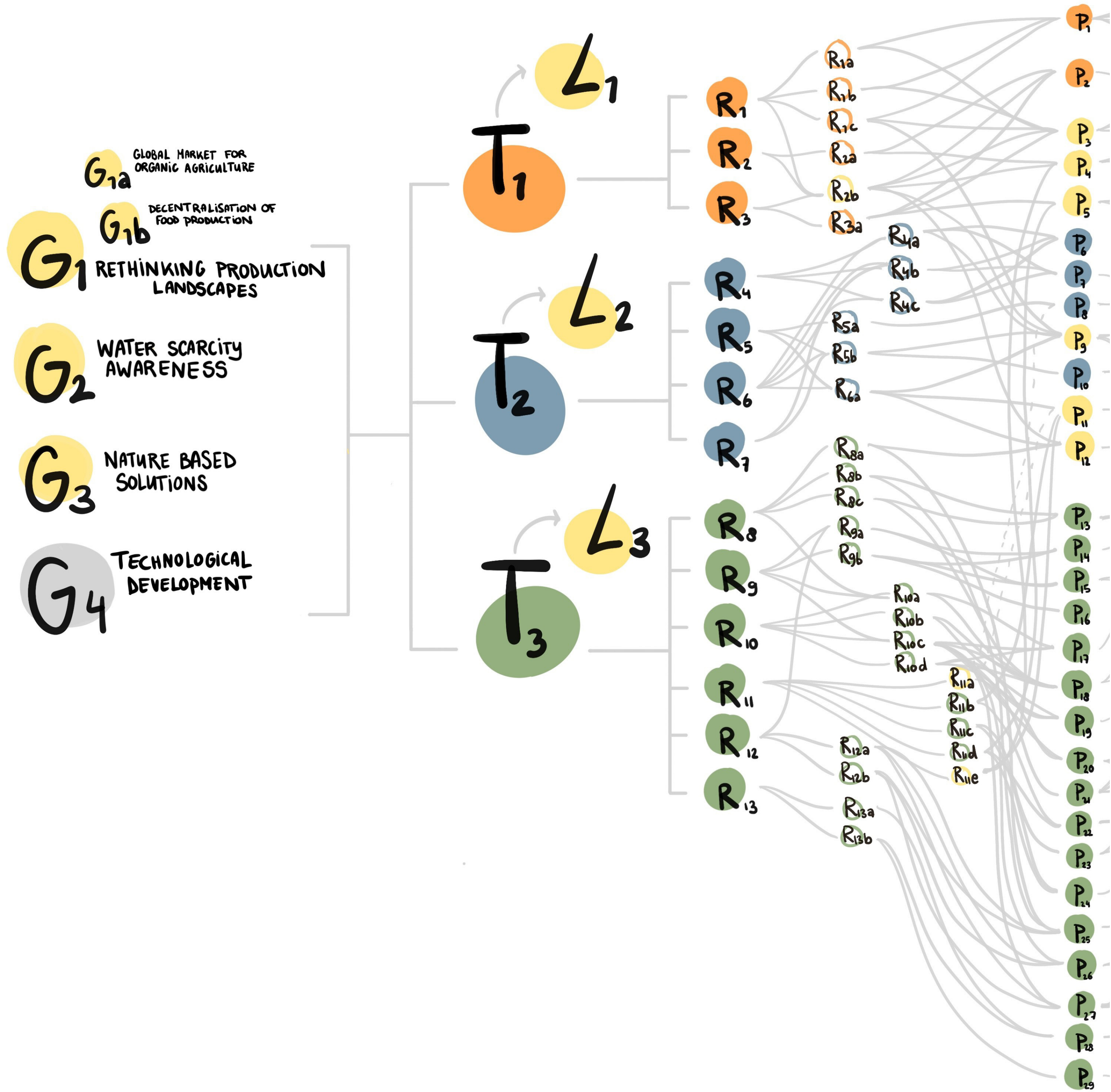
L1) a changed perspective on food production and consumption towards local food self-sufficiency and organic food consumption,

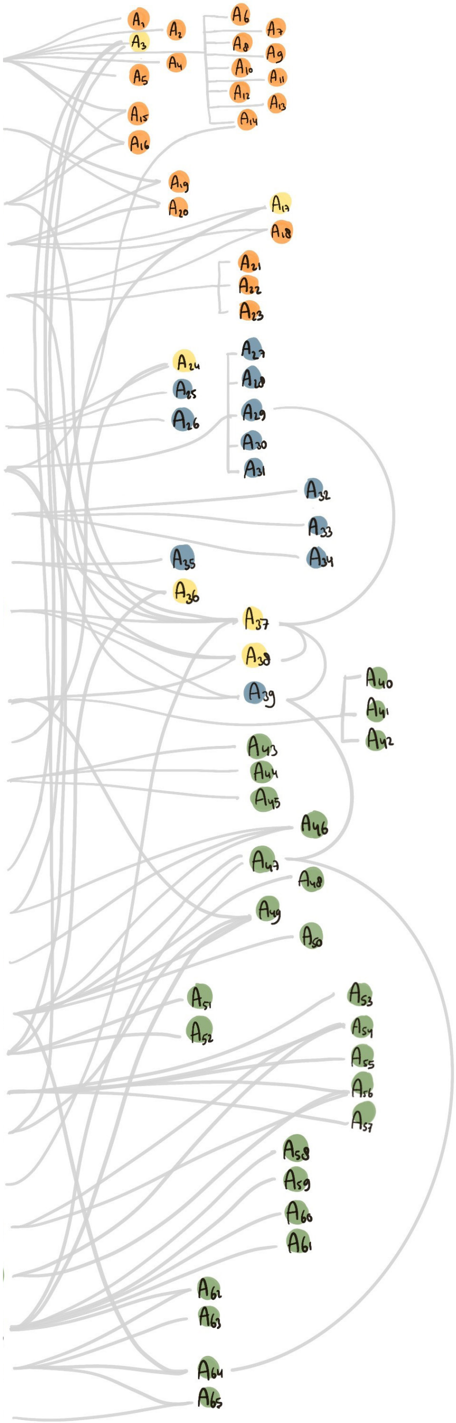
L2) a changed perspective on water use towards responsible consumption and on water supply towards renewable water production, fair distribution, and pricing, and

L3) a changed perspective on natural processes and the landscape towards a zero pollution tolerance, prioritizing nature-based solutions, expanding and protecting biodiversity and ecology, and responsible recreation.

The Figure to the left shows the vision framework that was used as a backbone for this pattern language.

Together, the patterns form a pattern-web (shown on the next page), which functions as a decision-tree for policy-makers, designers or stakeholders to choose their preferred interventions from.


G1a GLOBAL MARKET FOR ORGANIC AGRICULTURE
G1b DECENTRALISATION OF FOOD PRODUCTION
G1 RETHINKING PRODUCTION LANDSCAPES
G2 WATER SCARCITY AWARENESS
G3 NATURE BASED SOLUTIONS
G4 TECHNOLOGICAL DEVELOPMENT
T1
T2
T3
L1
L2
L3
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13
R1a R1b R1c R2a R2b R3a R4a R4b R4c R5a R5b R6a R8a R8b R8c R9a R9b R10a R10b R10c R10d R11a R11b R11c R11d R11e R12a R12b R13a R13b
P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20 P21 P22 P23 P24 P25 P26 P27 P28 P29



PATTERN-WEB

PATTERN INTERRELATIONS

For the pattern selection to create a strategy, different pathways of interventions can be chosen. These pathways are created by following a sequence of patterns though their interrelations. The regional focus decisions (R) guide those pathways, and form their starting point. In the pattern-web, the different pathways are shown. The pattern interrelations are formed during the decision-making and design process, where new connections of projects, actions and required focus decisions are discovered. Therefore, the pattern-web is never finished, as a new discovery would lead to new connections and pathways. Pattern connections are shown on the patterns themselves, and in the pattern-web.

From combining multiple pathways from the pattern web that fall within all three transitions, a strategy for the transition of the water system can be created.

A = AGRICULTURE SECTOR

- LOCAL FARMERS
- BIG PRODUCTION COMPANIES
- EXPORT INDUSTRY
- PACKAGING INDUSTRY
- TRANSPORT INDUSTRY
- IRRIGATION COMMUNITIES

N = NATURE SECTOR

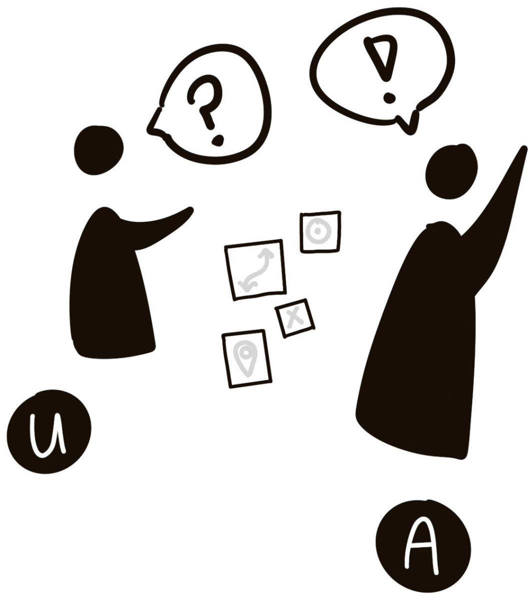
- NGO
- ACTIVISTS
- LOCAL COMMUNITIES
- LEGAL COURT
- NATURE CONSERVATORIES

U = URBAN SECTOR

- RIVER BASIN AUTHORITY – CHS
- MCT
- AQUAMED
- MUNICIPALITIES
- SACYR
- GOLF COURSES
- TOURISTS
- RESIDENTS

O = OTHER STAKEHOLDERS

- RESEARCH INSTITUTES
- NATIONAL GOVERNMENT
- MITECO
- TAJO BASIN AUTHORITY
- EU – WFD



ACTORS INVOLVED
OVERVIEW

A system symbiotic strategy can be created from combining multiple pathways from the pattern-web, through a collaborative decision-making process with multiple stakeholders. To indicate who is involved in which part of the decision-making, design, and operation process, a stakeholder analysis is needed beforehand of applying the pattern language. In this way, the actors involved in the operation process can be involved in the decision-process already, through participatory design and strategy-making. By integrating different stakeholder perspectives, a symbiotic strategy can be created.

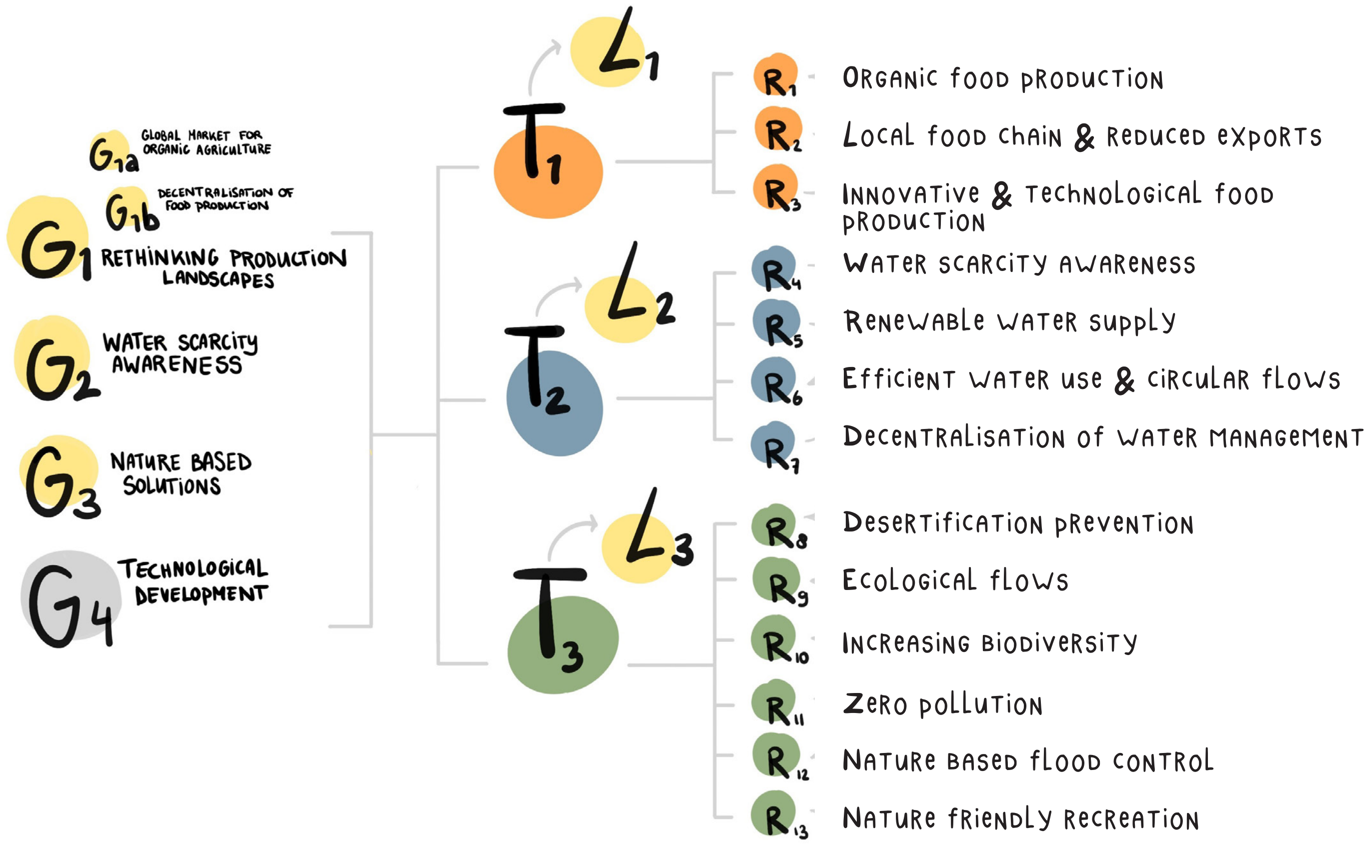
"WHAT CAN YOU DO?"

This pattern language is a collection of spatial and non-spatial interventions for the resilient water system transition in arid regions of agricultural production.

Apart from forming a design structure for spatial design strategies to be used by designers, this pattern language is also developed to be used by decision-makers, planners, farmers or individuals as inspiration to discover new ways to partake in the sustainable transition. It contains suggestions and design ideas for sustainable agri-food systems, circular and renewable water flows, ecological restoration and preservation, and climate-resilient urban development.

The interventions differ in size, scale of operation and amount of effort and investment that is required. To indicate the difference, and to communicate them in a transparent way, a suggested actor (group) to operationalise the intervention is shown on the pattern card with an icon.

The different actors considered are 1) farmers, 2) the municipality or regional / river baisn authority, 3) local community, and 4) individuals / residents. At the end of the document, an overview of the interventions clustered per actor (group) is given.


G1a GLOBAL MARKET FOR ORGANIC AGRICULTURE
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G3 NATURE BASED SOLUTIONS
G4 TECHNOLOGICAL DEVELOPMENT
T1
L1
T2
L2
T3
L3
R1 Organic food production
R2 Local food chain & reduced exports
R3 Innovative & technological food production
R4 Water scarcity awareness
R5 Renewable water supply
R6 Efficient water use & circular flows
R7 Decentralisation of water management
R8 Desertification prevention
R9 Ecological flows
R10 Increasing biodiversity
R11 Zero pollution
R12 Nature based flood control
R13 Nature friendly recreation

REGIONAL FOCUS DECISIONS

POLITICAL DECISIONS

The regional focus decisions guide the pattern selection process from a top-down perspective (where strategy-making started from a political standpoint), or form requirements to obtain to be able to operationalise the desired pattern interventions from a bottom-up perspective (starting at an operation pattern (marked with a P or A).

The regional focus decision patterns (R & Rx) are political standpoints on a regional scale, that are influenced by global drivers such as social movements and climatic pressures. They originate from a policy document analysis of current water system transition strategies, as well as the iterative design process of creating the pattern language. The different regional focus decisions are connected to the three transitions (T) that are identified, and categorised into sub-decisions (Rx). On the following pages, the different regional focus decisions and sub-decisions are presented.

R1 ORGANIC FOOD PRODUCTION

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Transitioning existing farms in the region to fit the organic food production requirements through:
R_{2B}, and:

R1A CREATE A MARKET FOR ORGANIC PRODUCTS

R1B IMPLEMENT REGULATIONS FOR ORGANIC FOOD PRODUCTION

R1C IMPLEMENT SUBSIDIES FOR ORGANIC FOOD PRODUCTION

R2 LOCAL FOOD SECURITY – REDUCED EXPORTS

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Reducing the food exports of the region, to produce, distribute and consume food locally, through:

R2A INVEST IN REGIONAL FOOD PROCESSING & DISTRIBUTION INFRASTRUCTURE

R2B CREATE A PARTICIPATORY FOOD PRODUCTION STRATEGY FOR THE REGION

R5 INCREASERENEWABLE WATER SUPPLY

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Increasing the (renewable) water supply within the region, through:
R_{6A}, and:

R5A STATE INVESTMENTS IN DESALINATION

R5B SUBSIDISE & STIMULATE RAINWATER COLLECTION

R6 WATER USE EFFICIENCY & CIRCULAR FLOWS

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Reducing the freshwater demand of households, industries and farms by focussing on circular flows and effeceint water use, through:
R_{4A}, R_{4B}, R_{4C}, R_{5B}, R_{7}, and:

R6A INVEST IN IMPROVING (AGRICULTURAL) RETURN FLOWS

R_3 INNOVATIVE FOOD PRODUCTION TECHNOLOGIES

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Innovative food production technologies, optimised greenhouse agriculture and smart farming, through:
R_{2B} AND:

- R_{3A} INVEST IN TECH COMPANIES
- R_{3B} IMPLEMENT SUBSIDIES FOR SMART FARMING

R_4 WATER SCARCITY AWARENESS

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Increasing the societal water scarcity awareness to change the consumptive behaviour, through:

- R_{4A} RAISE SOCIAL AWARENESS CAMPAIGNS TO REDUCE WATER USE
- R_{4B} IMPLEMENT A FAIR WATER PRICING & DISTRIBUTION SYSTEM
- R_{4C} UPGRADE WATER INTENSIVE INDUSTRIES TO CONSUME LESS WATER

R_7 DECENTRALISATION WATER MANAGEMENT

A REGIONAL POLITICAL DECISION TO FOCUS ON:

The decentralisation of water management from national and regional authorities to local communities, through:
R_{4B}, R_{5B}

R_8 DESERTIFICATION PREVENTION

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Preventing further desertification of the landscape in the region, through:
R_{10A}, AND:

- R_{8A} GROUNDWATER EXTRACTION REGULATIONS
- R_{8B} INVESTING IN SOIL MOISTURE TREATMENT PROJECTS
- R_{8C} INVESTING IN SOIL CONFINEMENT / EROSION CONTROL

R9 RESTORE ECOLOGICAL FLOWS

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Restoring ecological flows according to the rules set by the WFD, through:
R_{10A}, R_{10C}, and:

- **R 9A** REDESIGNING HYDRAULIC INFRASTRUCTURES TO NATURE-FRIENDLY FORMS
- **R 9B** ADJUSTING RESERVOIR EXTRACTION AND TRANSFER REGULATIONS

R13 NATURE FRIENDLY RECREATION

A REGIONAL POLITICAL DECISION TO FOCUS ON:

New forms of socio-ecological development in the form of nature-friendly tourism and informative recreation to restore the local identity, connect people to nature and minimise pollution, through:

- **R 13A** IMPLEMENT REGULATIONS FOR RECREATION IN PROTECTED NATURAL AREAS
- **R 13B** INVEST IN SUSTAINABLE RECREATION AREAS & THEIR MAINTENANCE

R10 INCREASE BIODIVERSITY

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Increasing, protecting and nurturing biodiversity and ecology in the region, through:

- **R 10A** INVESTMENTS IN NATURE RESTORATION & MAINTENANCE
- **R 10B** IMPLEMENT THE RIGHTS OF NATURE PRINCIPLE
- **R 10C** SUBSIDIES & REGULATIONS FOR URBAN GREEN-BLUE NETWORKS
- **R 10D** RESEARCH ON REGIONAL ANIMAL POPULATIONS, HABITATS & THE FOOD CHAIN

R 11 ZERO POLLUTION

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Reducing air, water and ground pollution already present in the basin and developing a zero pollution tolerance for current and future industries, through:
R_{2A}, R_{2B}, and:

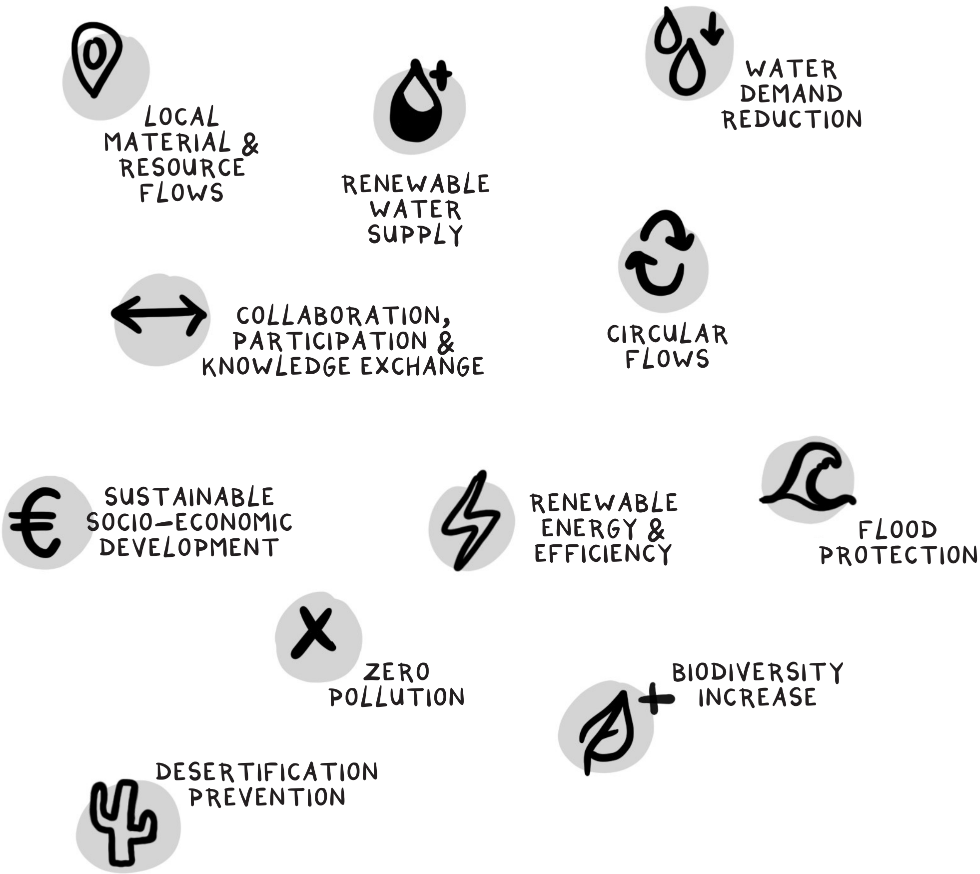
- R 11A — INVESTMENTS IN RENEWABLE ENERGY PRODUCTION PROJECTS
- R 11B — INVESTMENTS IN WATER & SOIL DECONTAMINATION PROJECTS
- R 11C — REGULATE & FINE WATER DISCHARGES
- R 11D — MONITOR & REGULATE CHEMICAL SUBSTATION OF WATER & SOIL
- R 11E — IMPLEMENT CIRCULAR MATERIAL FLOWS & WASTE REDUCTION CAMPAIGNS

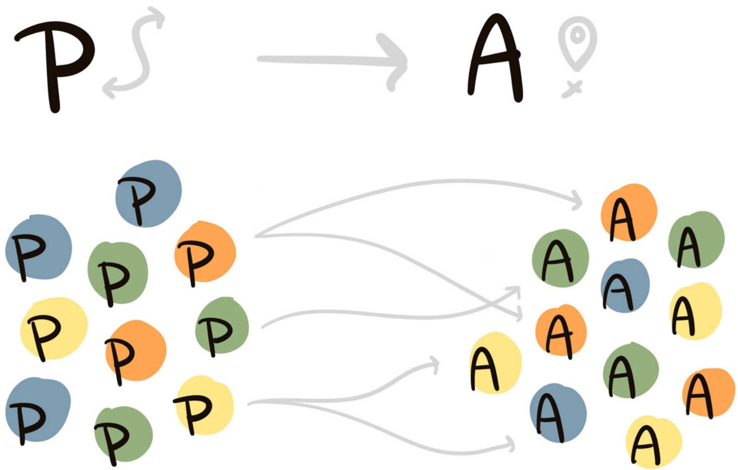
R 12 NATURE BASED FLOOD CONTROL

A REGIONAL POLITICAL DECISION TO FOCUS ON:

Increasing flood protection in the region through transforming current structures to or implementing new nature-based solutions for water storage, infiltration and drainage, through:
R_{9A}, and:

- R 12 A — INVESTMENTS IN NATURE-BASED FLOOD CONTROL MEASURES
- R 12 B — IMPLEMENT REGULATIONS FOR FLOOD CONTROL MEASURES IN NEW DEVELOPMENTS


LOCAL MATERIAL & RESOURCE FLOWS
RENEWABLE WATER SUPPLY
WATER DEMAND REDUCTION
COLLABORATION, PARTICIPATION & KNOWLEDGE EXCHANGE
CIRCULAR FLOWS
SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT
RENEWABLE ENERGY & EFFICIENCY
FLOOD PROTECTION
ZERO POLLUTION
BIODIVERSITY INCREASE
DESERTIFICATION PREVENTION


P
A

OPERATION PATTERNS

EXPLANATION

The operation patterns that follow from the regional focus decisions, form the solution interventions that operationalise the vision for the three transitions.

The operation patterns exist of;

1) Projects (marked with a P). Projects are interventions on the regional scale (spatial and non-spatial), to be operationalised by governance bodies, broad communities, sectors or generally bigger institutes. Due to their big operation scale, they are categorised under Projects.

2) Actions (marked with an A). Actions are smaller interventions that could be implemented to operationalise the Projects that they are related to, but could also be implemented from a bottom-up perspective as loose (or related) interventions. They are often implementable on a local scale, and by regional communities, businesses, farmers or individuals.

The different Projects and Actions in this pattern language are presented on the following pages.

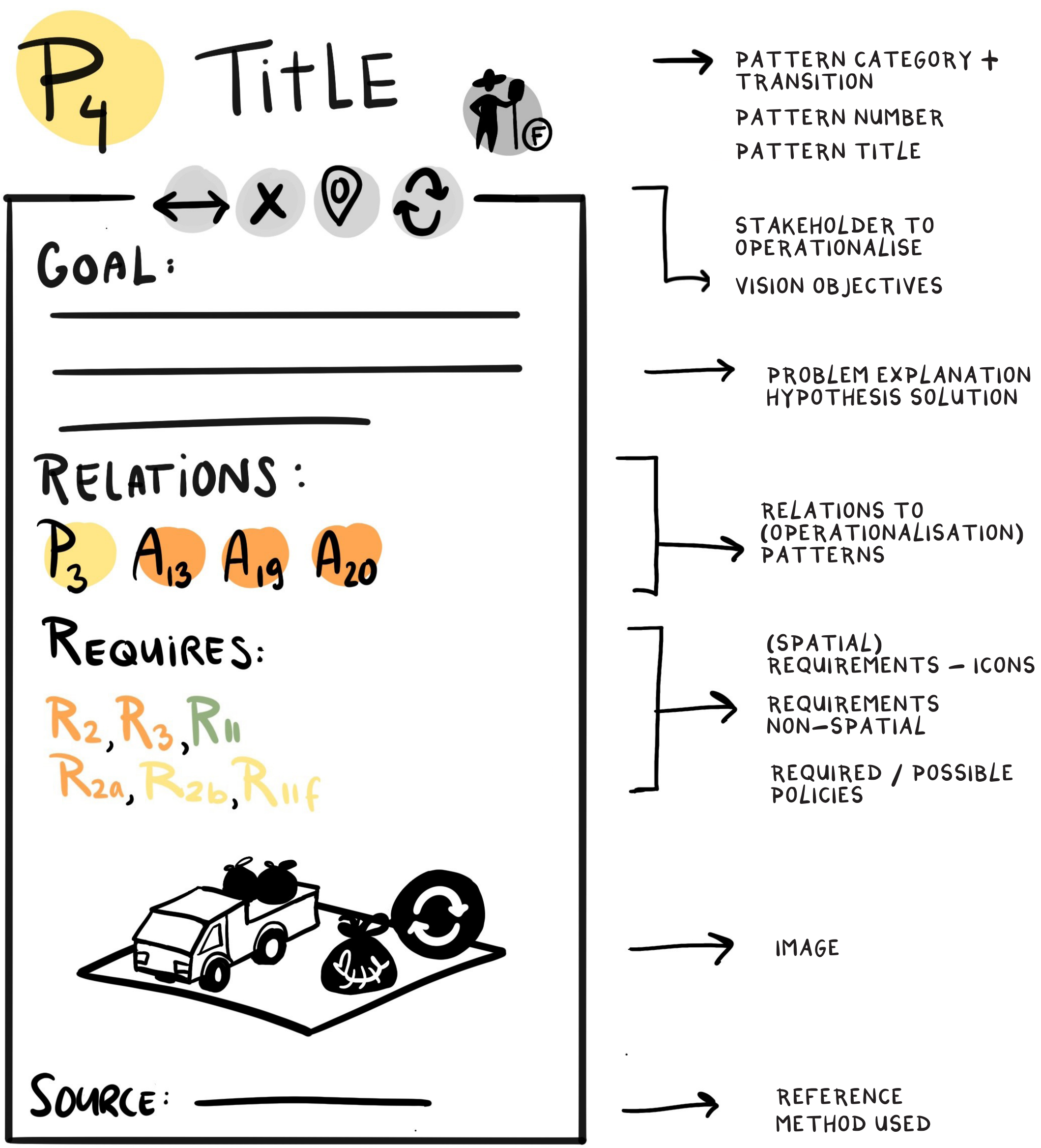
DESIGN OBJECTIVES

The patterns shown in this pattern booklet are selected and created through a Research by Design process, where spatial analysis, policy analysis and designing through different scales informs the pattern creation. The framework for the water system transition is the starting point of the research by design process.

According to the three transitions of the framework, in combination with a policy document analysis of current strategies for the water system in the region, design objectives for the water system transition are created.

The operational pattern interventions (P & A) are selected on the basis of a symbiotic design principle, where each intervention presented has to contribte to two or more objectives in order to be included in the symbiotic intervention pattern language.

To indicate the level of symbioticness of an intervention, the icons of the design objectives to which the pattern contributes are shown on the pattern.


P4
TitLE
F
GOAL:
RELATIONS:
P3 A13 A19 A20
REQUIRES:
R2, R3, R11
R2a, R2b, R11f
SOURCE:
PATTERN CATEGORY + TRANSITION
PATTERN NUMBER
PATTERN TITLE
STAKEHOLDER TO OPERATIONALISE
VISION OBJECTIVES
PROBLEM EXPLANATION HYPOTHESIS SOLUTION
RELATIONS TO (OPERATIONALISATION) PATTERNS
(SPATIAL) REQUIREMENTS – ICONS
REQUIREMENTS NON-SPATIAL
REQUIRED / POSSIBLE POLICIES
IMAGE
REFERENCE METHOD USED

PATTERN CARDS

EXPLANATION OF THE OPERATION PATTERN CARD BUILD-UP

Operation patterns are the more concrete interventions out of the pattern-web; the Projects (P) and the Actions (A). These interventions are presented with pattern cards that show additional information.

The framework used for the creation of the operation pattern cards is shown to the left. On the top of the card, the category of the decision-tree is shown, together with the number of the pattern and the title. The colour of the pattern number corresponds to the transition within the vision to which the pattern contributes. If the colour is yellow, the pattern contributes to more than one transition, making it a system symbiotic pattern. Below the title, the icons of the objectives to which the pattern contributes are shown. All patterns contribute at least to two objectives, making the interventions symbiotic as well.

Next, a brief explanation of the pattern is given. If necessary, possible execution is explained as well.

Afterwards, the possible links to other patterns below it are shown, corresponding to the links of the decision-tree.

On the project patterns (P), the possible regional focus decisions (R) and policies (Rx) that could facilitate the project are shown on the pattern card under requirements. Additionally, if the pattern is linked to another pattern as a requirement, this is shown as well. Furthermore, an indication of required investment of time, effort and money is given. If the pattern intervention requires a ceratin spatial condition in order to be effectively implemented, this is shown with an icon as well. The different legends of the icons on the patterns are presented on the next page.

Next, a small drawing of the pattern illustrates the intervention.

On the bottom of the pattern, sources or reference projects that were conducted for the creation of the pattern are shown.

DESIGN VISION OBJECTIVES

= local material– & resource flows

= collaboration, participation & knowledge exchange

= circular flows

= renewable water supply increase

= water demand reduction

= local material– & resource flows

= collaboration, participation & knowledge exchange

= desertification prevention & healthy soils

= eco–friendly flood protection

= renewable energy & resource efficiency

= sustainable socio–economic development

SPATIAL PRECONDITIONS

= proximity to the sea

= polluted area

= sloped terrain

= (proximity to protected) natural area

= (proximity to) urban core

NON–SPATIAL PRECONDITIONS

= (intersectoral / community) collaborations

= high (initial) investment costs

= connection to renewable energy production

ICON LEGENDS
EXPLANATION OF THE ICONS ON THE PATTERN CARDS

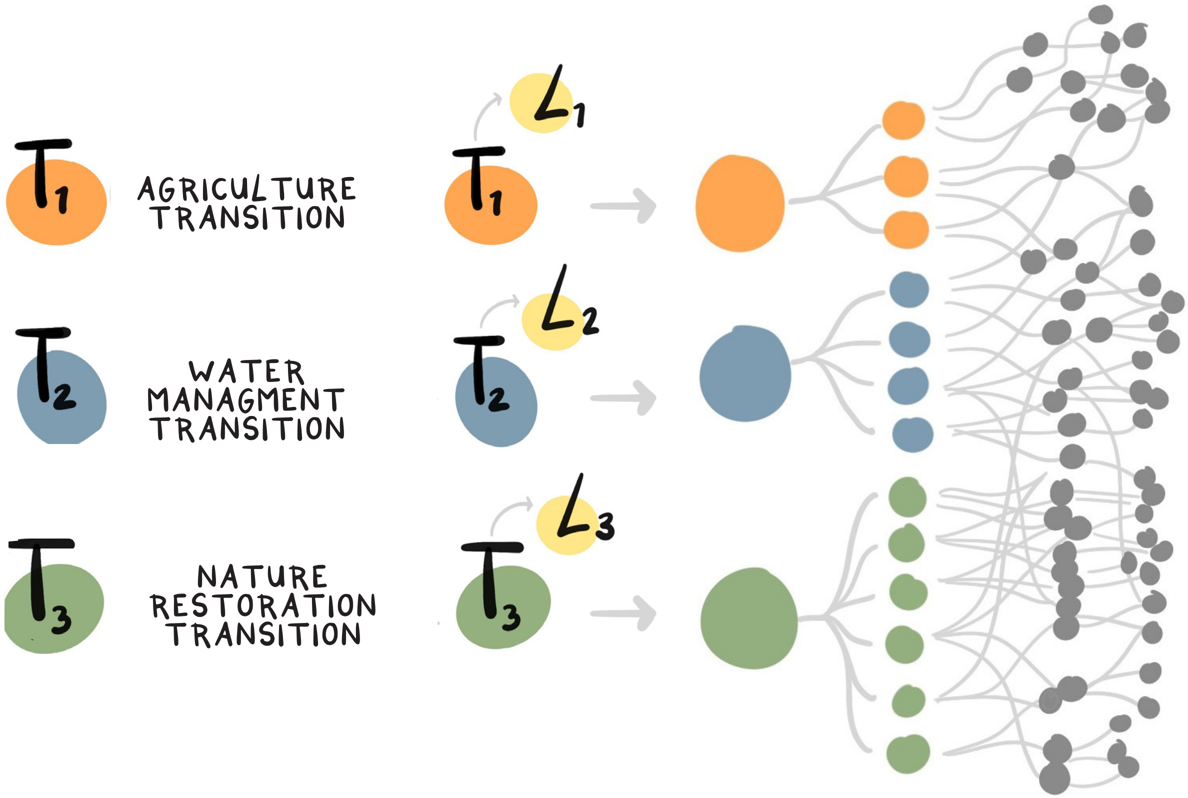
OPERATION ACTORS

= farmers

= municipality / regional / river basin authority

= local community

= individuals / residents


T1
AGRICULTURE TRANSITION
T2
WATER MANAGMENT TRANSITION
T3
NATURE RESTORATION TRANSITION
L1
T1
L2
T2
L3
T3

PATTERN CARDS
SPATIAL AND NON-SPATIAL INTERVENTIONS

P1 TRANSITION TO ORGANIC AGRICULTURE

GOAL:

Transitioning from intensive conventional agriculture to organic farming practices in arid regions can enhance socio-ecological resilience by improving soil health, increasing biodiversity, and reducing water-related risks. Organic agriculture, characterised by the exclusion of synthetic chemicals and genetically modified organisms, relies on natural processes and resources (Iberdrola, 2021). This approach aligns with the European Union's Farm to Fork Strategy, which aims to have at least 25% of EU agricultural land under organic farming by 2030, promoting sustainable food systems and environmental stewardship (European Commission, 2020). The anticipated benefits include higher crop yields, reduced costs for fertilisers and pesticides, and improved water retention in soils, collectively contributing to the mitigation of desertification and flood risks. Implementing this transition involves a series of coordinated actions focused on depolluting natural substrates, enhancing local biodiversity, and fostering sustainable agricultural practices.

RELATIONS WITH:

Operationalised by: A1-A5 + A6-A14

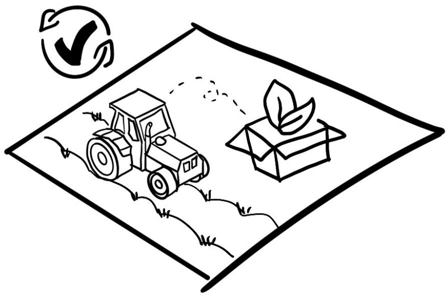
Related to: A17, A18

To be combined with: P2, P3, P4, P9, P13, (P5), (P12), (P18), A15, A16, A19, A20, A21-A23, A27-A31, A37, A38, A39, A40-A42,

REQUIRES:

Focus: R1

Policies: R1a, R1b, R1c



SOURCE: (Iberdrola, 2021), (European Commission, 2020)

OBTAINED THROUGH: Design intuition | Literature study

P2 LOCAL FOOD PROCESSING & DISTRIBUTION HUBS

GOAL:

Conventional agri-food systems often rely on long supply chains that contribute to high emissions, energy use, and food waste, while disconnecting producers from consumers. Establishing local food processing and distribution hubs near production and consumption areas enhances the sustainability and resilience of regional agri-food systems. These hubs reduce greenhouse gas emissions and water use for cooling by minimising transportation distances and enabling efficient, small-scale food processing and distribution. Economically, they lower logistics and packaging costs, generate local employment, and retain value within the regional economy. When integrated with farmers' markets, cooperatives, or community-supported agriculture schemes, they help improve food security and community well-being by reinforcing producer–consumer connections and supporting shorter, more transparent supply chains. This intervention aligns with the Farm-to-Fork strategy of the EU Green Deal (European Commision, 2020).

RELATIONS WITH:

Operationalised by: A19, A20

Related to: P3, P4, P1, P5

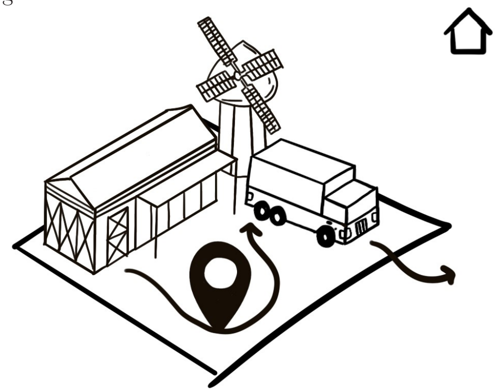
To be combined with: P3, P4, P5, P1, A15, A16, A21, A65

REQUIRES:

Focus: R2

Policies: R2a, R2b, (R3a)

Spatial conditions: close to urban transportation cores, located in agricultural areas.



SOURCE: (European Commission, 2020)

OBTAINED THROUGH: Design intuition | Literature study

P3 FOOD POLICY COUNCILS

GOAL:

Fragmented governance and top-down policies often fail to address the complex, place-specific challenges of transitioning to sustainable and equitable agri-food systems, especially when also considering climate resilience. Establishing Food Policy Councils, multi-stakeholder platforms that enable inclusive governance of food system transitions at a local or regional level, can solve this issue (Dubbeling et al., 2011). These councils bring together actors across the food chain (farmers, consumers, businesses, NGOs, and public authorities), and use participatory methods to co-develop food strategies tailored to regional needs. When well-implemented, Food Policy Councils foster cross-sector collaboration, empower underrepresented voices, and improve food security, economic resilience, and environmental sustainability. By shaping food policies from the ground up, they help envision and implement just, climate-resilient, and locally anchored food futures.

RELATIONS WITH:

Possible Actions: A19, A20

To be combined with: P1, P2, P4, P5, P9, (P10), (P12)

REQUIRES:

Focus: R2, R1, (R3), (R6), (R7), (R11)

Policies: R2b, R1a, R1b, R1c, R2a, (R3a)

SOURCE: (Dubbeling et al., 2011)

OBTAINED THROUGH: Literature study | Precedent study

P4 CROSS-SECTORAL ORGANIC WASTE SYSTEM

GOAL:

Linear waste systems in agriculture and urban areas often lead to nutrient loss, pollution, and increased dependency on synthetic inputs. Implementing a cross-sectoral organic waste collection and reuse system focusing on composting, manure exchange, and inter-sectoral redistribution, addresses these inefficiencies by closing nutrient loops at the regional scale. By transforming local organic waste into valuable inputs such as compost, biochar, or organic mulch, the system promotes soil restoration, reduces reliance on chemical fertilisers, and supports organic farming practices. Additionally, facilitating manure exchange among farmers or between sectors like agriculture, landscaping, and golf courses reduces logistical burdens, prevents over-application and runoff, and helps combat desertification. This systemic approach supports circularity, enhances ecosystem resilience, and creates shared economic and ecological value across urban-rural interfaces (FAO, 2025).

RELATIONS WITH:

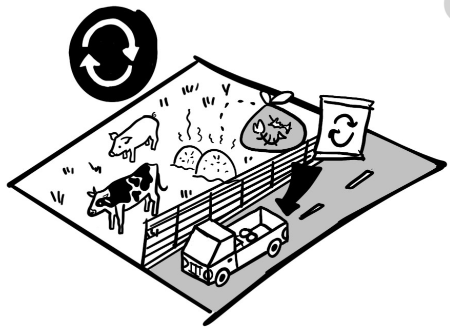
Possible Actions: A7, A8, A13, A15, A16, A19, A36, A42

To be combined with: P1, P2, P3, P5, P9, P11, P13, P22, P24

REQUIRES:

Focus: (R1), R2, R11

Policies: (R1a, R1b, R1c), R2a, R2b, (R8c), (R10c), R11e



SOURCE: (FAO, 2025)

OBTAINED THROUGH: Design intuition | Literature study

P5 TECHNOLOGICAL GREENHOUSE HUB

GOAL:

A trend in the region has been noticed towards an increase in greenhouse agriculture. However, current greenhouse practices in the region rely heavily on low-tech, non-permanent plastic structures, which generate significant plastic waste, offer limited control over growing conditions, and lead to inefficient use of water, space, and energy. Improving existing greenhouses to form a technological innovative food production hub can increase yields, economic profit and result in more efficient food production systems in terms of resource use, spatial claim and workload. This can contribute to the development of the area, science on food production, local food security, a reduction of water use, and ecological benefits. An example is Tomatoworld in Honselersdijk, the Netherlands, which serves as an interactive information and education center focused on innovative greenhouse horticulture (Tomatoworld, n.d.).

RELATIONS WITH:

Operationalised by: A21-A23

Related to: A20, A17, A18, A37, A38

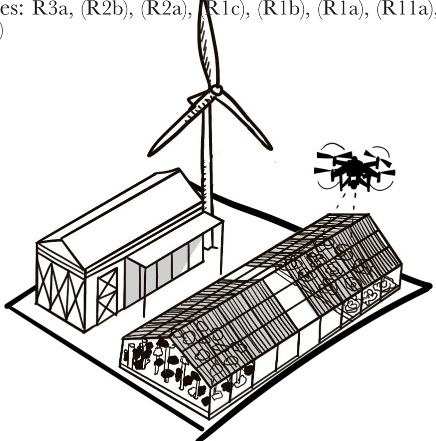
To be combined with: P2, P4, P3, A19, A3, A20, A17, A18, A37, A38, A51, A52

REQUIRES:

High investment costs, knowledge about the systems applied, renewable energy demand.

Focus: R3, (R2), (R11), (R6)

Policies: R3a, (R2b), (R2a), (R1c), (R1b), (R1a), (R11a), (R11e)



SOURCE: (Tomatoworld, n.d.).

OBTAINED THROUGH: Fieldwork observations | Precedent study

P6 ADAPTIVE GROUNDWATER MANAGEMENT

GOAL:

Groundwater overextraction in semi-arid regions, exacerbated by climate change and poor management, threatens aquifer health, increases salinisation, and undermines water security. Adaptive groundwater extraction and pricing (based on real-time aquifer levels, seasonal forecasts, and climate conditions) can enhance ecological resilience, reduce overextraction, and mitigate flood risk. In response to increasingly variable rainfall and prolonged droughts, dynamically adjusting extraction volumes can protect aquifers, prevent salinisation and pollution, and support balanced water cycles. The results from Tapia-Villaseñor et al. (2022), who evaluated the sustainability of this approach in Mexico, support this hypothesis. Flexible water pricing (raising prices during droughts) can also promote water-saving, rainwater harvesting, and fairer allocation of resources.

RELATIONS WITH:

Related to: P7, P8, P9, P10, P11, P12, P16, P14

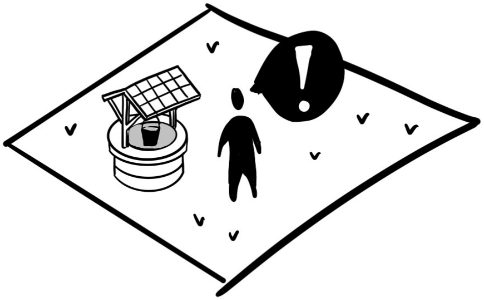
To be combined with: P8, P9, P10, P11, P12, P16, P14

REQUIRES:

This strategy requires the implementation of monitoring infrastructure, weather prediction systems, and enforcement mechanisms such as well closures.

Focus: R4, R9, (R5), (R6)

Policies: R4a, R4b, R9b, R8a



SOURCE: (Tapia-Villaseñor et al., 2022).

OBTAINED THROUGH: Design intuition | Literature study

P7 COST RECOVERY PRINCIPLE

GOAL:

Public water systems often fail to reflect the true costs of water extraction, distribution, and infrastructure maintenance, resulting in underinvestment in nature restoration and unsustainable water use. The Cost Recovery Principle, as outlined in the EU Water Framework Directive (2000/60/EC), requires that water tariffs cover not only operational and capital costs but also environmental and resource costs. Internalising these costs through fair and transparent pricing structures helps promote water-saving behaviour, reduces wastage, and secures long-term funding for infrastructure upgrades. This principle supports economic equity by ensuring that all users (including large industries and commercial agriculture) contribute proportionally to the services they consume.

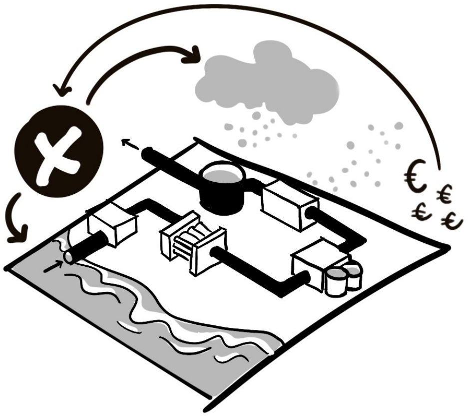
RELATIONS WITH:

Related to: P6, P8, P11, P16
To be combined with: P8, P11, P16, P6, P10

REQUIRES:

Focus: R4, R5, R6

Policies: R4b, (R5a), (R4a)



SOURCE: (EU WFD, 2000).

OBTAINED THROUGH: Literature study

P8 REGIONAL DESALINATION NETWORK

GOAL:

Desalination is a promising form of renewable water production, that is already present in the region. However, not all areas are connected to the desalination network, and the plants are not yet operating at their full capacity. Improving the desalination network provides opportunity for increased supply of renewable water, relieving water stress on the environment and improving water security in the region. However, desalination is a costly practice, has an impact on the ecological environment, and requires a lot of energy, as well as infrastructure adjustments to expand the network. Therefore, it is required to integrate this solution in a bigger strategy that is connected to the renewable energy and ecological restoration transitions.

RELATIONS WITH:

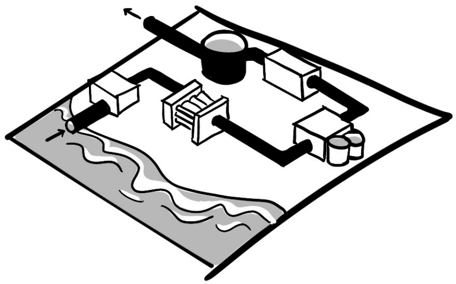
Operationalised by: A24, A25, A26
Related to: P7, P21, P6, P16, P11
To be combined with: P11, P10, P9, P1, P5, P7, P21

REQUIRES:

Connection to: P21, P7

Focus: R5

Policies: R5a



OBTAINED THROUGH: Literature study, Precedent study, Fieldwork observations

P9 UTILISING INDIGENOUS KNOWLEGDE

GOAL:

Rainwater harvesting is necessary for dry farming in arid regions. The use of (indigenous) water harvesting techniques on farms can prevent erosion and desertification, improve soil moisture, reduce water use for irrigation, improve soil health and reduce water run-off and evaporation. Therefore, dry farming should be stimulated, especially in desertified regions or regions that are disconnected from a renewable water supply source. Through workshops and online platforms, knowledge can be shared and farmer communities can be created that stimulate a transition to organic agriculture, dry farming, and co-management of rainwater collection systems together.

RELATIONS WITH:

Operationalised by: A1, A14, A27-A31, A37

To be combined with: P1, P3, P2, P10

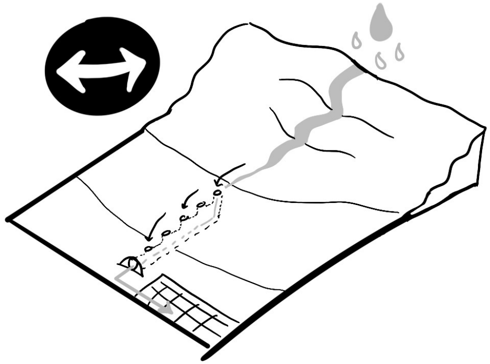
REQUIRES:

Spatial requirements, Installation costs & effort, (collaboration between farmers), results initially in lower yields.

Focus: R5, R6, R4, (R7), R8, (R1)

Policies: R5b, R6a, R1c, (R8a)

P6



SOURCE: (Beckers et al., 2013)

OBTAINED THROUGH: Literature study | Precedent study

P10 CENTRALISED RAINWATER COLLECTION

GOAL:

The region faces significant water shortages exacerbated by outdated and leaky water infrastructure and high evapration rates, leading to structural water deficits and inefficient use of available rainfall. Centralised rainwater collection systems, integrating both large-scale reservoirs and numerous small-scale catchment projects, can significantly enhance water availability and supply reliability. By capturing and storing rainwater from rooftops, urban surfaces, and natural catchments, these systems reduce dependency on overexploited groundwater and surface water sources. Implementing centralised rainwater harvesting can be synergistically combined with upgrading outdated sewage and stormwater infrastructures to reduce leakages and manage urban runoff more effectively.

RELATIONS WITH:

Operationalised by: A32-A34, A28, A39, A47, A58, A59

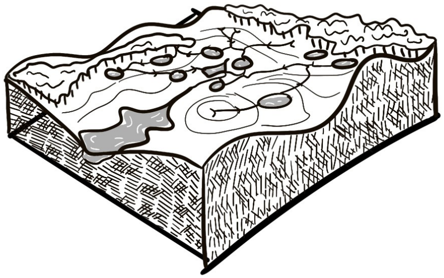
To be combined with: P11, P22, P25, P27, P9, P12

REQUIRES:

Such systems require investments in interconnected storage tanks, pipelines, filtration units, and smart monitoring technologies to optimise water capture, storage, and distribution. Collaboration between municipal water authorities, urban planners, and local communities is crucial to design and maintain these infrastructures.

Focus: R6, R5, (R7), R4, (R12)

Policies: R5b, (R6a)



OBTAINED THROUGH: Design intuition

P11 REGIONAL WASTE WATER TREATMENT

GOAL:

In semi-arid regions, insufficiently treated wastewater poses environmental and public health risks while valuable water resources are lost. Wastewater treatment systems use physical (screening, sedimentation), biological (microbial degradation), and chemical (disinfection, nutrient removal) processes to clean water before safe discharge or reuse. Enhancing the regional wastewater treatment network by constructing new plants and upgrading existing facilities can increase the availability of water, support circular water management by reducing freshwater demand, and mitigate environmental degradation by preventing pollution from contaminants. Especially on-site treatment systems like septic tanks, constructed wetlands, and composting latrines has potential in contributing to sustainability as they do not rely on energy and chemical intensive processes, and return nutrients to the surrounding environment (Muga & Mihelcic, 2007).

RELATIONS WITH:

Operationalised by: A35, A36, A37

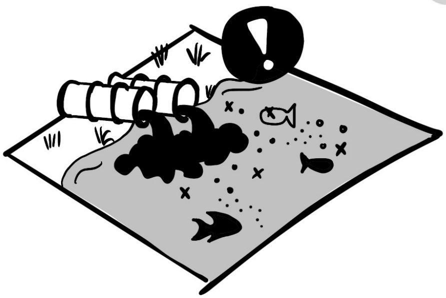
To be combined with: P8, P10

REQUIRES:

Coordination among municipalities, industries, and agricultural users is essential to optimise reuse applications and infrastructure investments.

Focus: R5, R6, R4

Policies: R6a



SOURCE: (Muga & Mihelcic, 2007).

OBTAINED THROUGH: Literature study

P12 REGIONAL WATER CO-MANAGEMENT

GOAL:

Fragmented water governance and top-down management often lead to inefficient water use and conflicts over scarce water resources in agricultural regions. Regional water co-management, where farmers, local communities, and authorities collaboratively collect, store, and distribute water, fosters sustainable and equitable water use. This participatory approach promotes water reuse and enhances agricultural return flows, improving local water security while empowering communities. Moreover, increased local stewardship supports the protection of ecosystems and vital ecosystem services by aligning water management with environmental conservation goals. Successful examples of water co-management demonstrate improved resource allocation and social cohesion, highlighting its potential to address water scarcity challenges effectively (Pahl-Wostl et al., 2010).

RELATIONS WITH:

Operationalised by: P3, P9, A37, A38, A39, A28

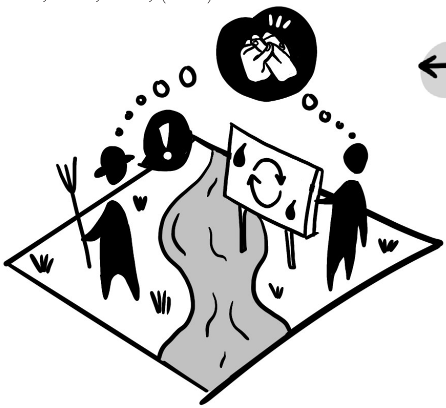
To be combined with: P3, P9, P10, P11, P6, P16

REQUIRES:

Collaboration among farmers, irrigation communities and water managing authorities is crucial.

Focus: R7, R6, R5, R4

Policies: R6a, R4a, R5b, (R2b)



SOURCE: (Pahl-Wostl et al., 2010).

OBTAINED THROUGH: Literature study | Precedent study

P13 SOIL TREATMENT

GOAL:

Desertification and land degradation threaten agricultural productivity and ecosystem health in dry regions. Soil treatment projects aim to combat these issues by improving soil moisture retention and enhancing the chemical composition of soils to increase fertility and support plant growth. Farmers can implement soil amendments and organic matter additions on their land, promoting root development that stabilises soil and prevents erosion. Enriching soil microbial communities also facilitates the breakdown of organic material and attracts beneficial fauna, enhancing biodiversity and soil resilience. Effective soil treatment can reverse degradation trends, improve crop yields, and contribute to ecosystem restoration (Lal, 2016). This project can be combined with nature restoration efforts or land transformations from farmlands to natural areas.

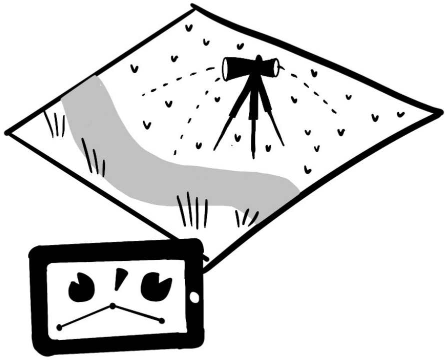
RELATIONS WITH:

Operationalised by: A40-A42, A2, A49, P9, A13, A11, A9, A7, A6, A12, A14
To be combined with: P1, P9, P3, P25, P20, P22

REQUIRES:

Focus: R8, (R10), R12

Policies: R8a, R8b, R8c, R10a, R10b, R10c, R11c, R11d



SOURCE: (Lal, 2016).
OBTAINED THROUGH: Literature study

P14 REGULATE WATER OF INTER-BASIN TRANSFERS

GOAL:

The SRB area is now highly dependent on unsustainable inter-basin water transfers for water supply, causing socio-political and socio-environmental problems for both basins. Setting and communicating clear regulations by law about the volumes to be transfered, and operation times of the transfer, gives farmers and water management institutes more clearance and prevents further conflict, as well as uncontrolled irrigation expansions (as has happened due to poor management in the past). By cutting transfered volumes through a collaborative strategy, tensions are prevented, regional water security can be improved, and alternative water sources can be focussed on. This also gives justice to nature by restoring the ecological flows, as a requirement to be met before 2027, set by the EU Water Framework Directive (EU WFD, 2000).

RELATIONS WITH:

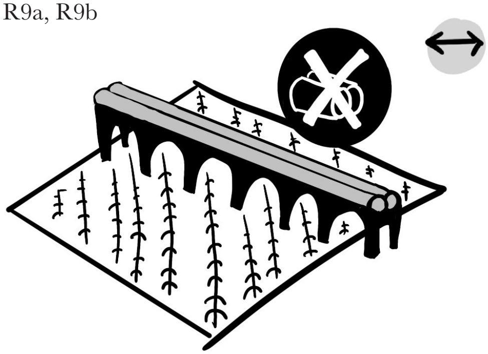
Operationalised by: A24, A37
To be combined with: P12, P16, P6, P7, P8, P9, P10, P11

REQUIRES:

Required for this intervention is a clear communication to the farmers and people in the region, formulating a collaborative strategy, and integrating plans for alternative water supply sources.

Focus: R9, R8, R7, R6, (R5)

Policies: R9a, R9b



SOURCE: (EU WFD, 2000)
OBTAINED THROUGH: Literature study | Design intuition

P15 ECO-FRIENDLY DAMS & RESERVOIRS

GOAL:

The EU WFD (2000) has pressed the need for a restoration of the ecological flow of all rivers and surface water bodies in the EU, with a law that requires restoration before 2027. With the amount of artificial reservoirs and dams in the SRB region, the ecological flow of the rivers has been drastically modified. By transforming these constructions to eco-friendly versions, ecological corridors can be created, regional biodiversity can improve, and desertification can be prevented. Next to this, in some cases, it can lead to improved flood control.

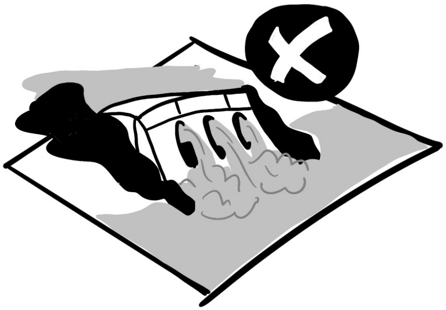
RELATIONS WITH:

Operationalised by: A43- A45, A46, A49
To be combined with: P14, P18, P25

REQUIRES:

Focus: R9, R10

Policies: R9a, R9b, R10a, R10b



SOURCE: (EU WFD, 2000)

OBTAINED THROUGH: Literature study | Design intuition

P16 ADAPTIVE EXTRACTION MANAGEMENT FOR RIVERS & RESERVOIRS

GOAL:

Water availability is influenced by climatic events as precipitation or droughts. With climate change, weather contitions are becoming more various, resulting in short periods of heavy reainfall and long periods of extreme drought. River, aquifer and reservoir levels change accordingly. A constant volume of water extraction does not collaborate with this system, as too much extractions harm the ecology and cause water pollution and salinisation, and too little extractions could result in floods. Adaptive water management of rivers and reservoirs is aimed at changing and regulating water extractions according to the level of water that is (expected to be) in the reservoir or river.

RELATIONS WITH:

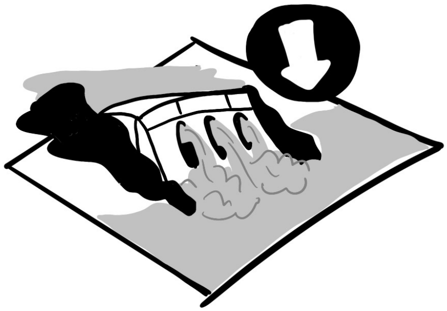
To be combined with: P3, P12, P11, P10, P25, P9, P8, P14, P15

REQUIRES:

This project requires careful monitoring and precise weather predictions, as well as investment in those systems.

Focus: R9, R10, R7

Policies: R9b, R9a, R10b



OBTAINED THROUGH: Design intuition

P17 REFORESTATION

GOAL:

The SRB area contains large regions of spacely vegetated land that is prone to forest fires and desertification. In order to prevent further soil erosion and desertification, and to improve local biodiversity, reforestation projects can be implemented. Through planting native trees, a thicker density of roots and forest cover can be created, providing soil confinement, shelter and habitat for animals, and a cooled down environment. The roots of the plants hold the soil in place, preventing erosion, and improving the soil moisture retention capacity. Organic matter from the trees and the animals the newly created habitat attracts, enriches the soil, supporting the local food chain.

This project can be integrated with soil restoration (P13) and decontamination efforts (P22), and land transformation projects (P1, P19).

RELATIONS WITH:

To be combined with: P22, P25, P1, P23, P19, P20, P13, P24, P26, P27, P28, A3

REQUIRES:

Focus: R8, R10, R12 (R13)

Policies: R8b, R8c, R10c, R10a, R10b, R10d, (R11b), R12b

OBTAINED THROUGH: Design intuition

P18 ECOLOGICAL CORRIDORS

GOAL:

Habitat fragmentation caused by urbanisation, agriculture, and infrastructure disrupts species movement, reduces biodiversity, and weakens ecosystem resilience. Establishing ecological corridors (linear or patch-based connections between fragmented habitats) can restore ecological flows, enhance biodiversity, and support species migration, pollination, and genetic exchange. These corridors, which may include hedgerows, riverbanks, reforested strips, or underpasses, function most effectively when connecting ecological hotspots or protected natural areas. Beyond biodiversity gains, ecological corridors can also contribute to flood mitigation, carbon sequestration, and desertification control by stabilising soil and regulating water flows. Strategic implementation across scales and land uses requires cooperation among environmental agencies, municipalities, and private landowners (Hilty et al., 2020).

RELATIONS WITH:

Operationalised by: A3, A46, A49, A43, A44, A54-A57, A59, A61

To be combined with: P25, P22, P23, P24, P26, P27, P20, P17 ,P15, P13, P19

REQUIRES:

Focus: R10, R8, R12, R13, R9

Policies: R8c, R12a, R10a, R10b, R10c, R10d, R11b

SOURCE: (Hilty et al., 2020).

OBTAINED THROUGH: Literature study | Design intuition

P19 EXPAND PROTECTED LANDSCAPES

GOAL:

Witin the SRB, many specially protected areas on multiple levels exist in the form of wetlands, bird habitats and forests, wich cover a big percentage of the landcover. Expanding these areas in their size would offer more chances for endangered or protected species to nest in the area, contributing to the protection of biodivrsity and ecology. Stricter rules on activities in and around these areas can be implemented, by connecting this pattern to the rights of nature principle. Mar Menor, the saline lagoon located in the SRB, is a local example where community-led action and involvement from the EU have led to changes in the law, allowing for legal protection of the specially preserved natural area against pollution.

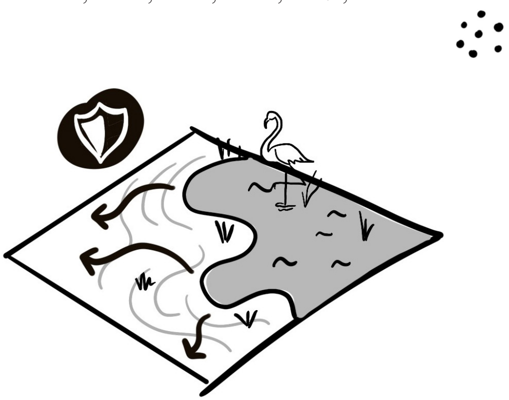
RELATIONS WITH:

To be combined with: P18, P17, P25, P23

REQUIRES:

Focus: R10, R9, R13

Policies: R10a, R10b, R10c, R10d, R12b, R9a



OBTAINED THROUGH: Fieldwork observations | Precedent study

P20 LOCAL BIODIVERSITY PROJECTS

GOAL:

Biodiversity loss due to monoculture farming, urban expansion, and habitat degradation is reducing ecosystem services and increasing vulnerability to climate impacts. Local biodiversity projects such as planting native vegetation, installing green roofs, bird houses or small ponds offer scalable, low-cost solutions that can be implemented by farmers, schools, municipalities, and residents alike. While small in scale, these interventions cumulatively improve habitat quality, regenerate soil life, enhance water retention, and provide cooling effects in urban and rural environments. Over time, such efforts contribute to aquifer recharge, healthier crops, and improved well-being for both humans and non-humans. Supporting these projects through community programs, agricultural subsidies, or educational initiatives can accelerate their spread and long-term impact.

RELATIONS WITH:

Operationalised by: A46-A50, A58, A59, A60, A61, P1, A63

To be combined with: P1, P13, P15, P17, P18, P19, P22, P25, P23, P26, P28

REQUIRES:

Focus: R10, R8, R9, R13, R12

Policies: R10c, R10d

OBTAINED THROUGH: Design intuition

P21 RENEWABLE ENERGY PRODUCTION

GOAL:

The reliance on fossil fuels for water and food systems contributes to greenhouse gas emissions and environmental degradation, undermining sustainability efforts. Transitioning to 100% renewable energy production, distribution, and usage across all industries is essential for developing sustainable water and food systems that operate in harmony with nature. In arid regions, photovoltaic (PV) systems can be installed on building roofs, over parking spaces, on water bodies (floatovoltaics), or within agricultural fields. Wind turbines offer a viable solution in windy areas. Integrating renewable energy is particularly crucial for energy-intensive technologies and systems, such as desalination plants, to ensure their operations are environmentally sustainable. Implementing these renewable energy solutions not only reduces carbon footprints but also enhances energy security and resilience in water and food production systems.

RELATIONS WITH:

Operationalised by: A51-A53, A36, A17

To be coordinated with: P5, P8, P11

REQUIRES:

High investment costs, installation, maintenance
Focus: R11, R5
Policies: R11a

OBTAINED THROUGH: Design intuition

P22 SOIL & WATER DECONTAMINATION

GOAL:

Long-term agricultural, industrial, and urban activities have led to widespread soil and water contamination, degrading ecosystems and threatening human and environmental health. Improving the ecological well-being of a region requires the decontamination of polluted soils and water bodies, alongside enforcing regulations to prevent further pollution. This approach aligns with the EU's Zero Pollution Strategy, aiming to restore natural systems and protect biodiversity (European Commission, 2021). Nature-based solutions such as phytoremediation (using plants to absorb, degrade, or stabilise contaminants) and carbon sequestration projects help remove pollutants from air, soil, and water, transforming them into less harmful compounds or storing them safely. These practices not only restore ecosystem functions but also improve agricultural productivity, reduce erosion, and support climate mitigation goals.

RELATIONS WITH:

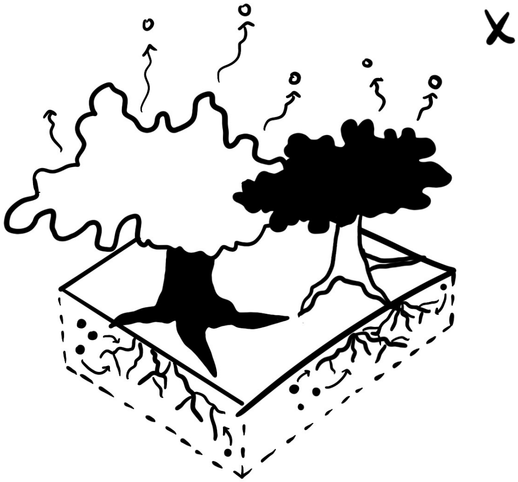
Operationalised by: A53, A54-A57, A59

To be coordinated with: P1, P25, P13, P17, P23, P20

REQUIRES:

Focus: R11, R10

Policies: R11b, R11c, R11d, R11e, R12a, R10b



SOURCE: (European Commission, 2021).

OBTAINED THROUGH: Literature study

P23 RIPARIAN BUFFER ZONES

GOAL:

Freshwater ecosystems are increasingly threatened by land-use intensification and agricultural runoff in areas adjacent to rivers and wetlands, leading to water pollution, habitat fragmentation, and biodiversity loss. Riparian buffer zones in the form of transitional areas between protected natural landscapes and more intensively used land, can mitigate these impacts by filtering pollutants, preventing erosion, and enhancing ecological connectivity. These zones can range from vegetated strips to multi-kilometre zones surrounding natural sites, depending on the vulnerability and size of the ecosystem. While they allow limited anthropogenic activities such as low-intensity farming or recreation, strict regulations on pollution, construction, and water extraction are essential to safeguard nearby protected areas. Riparian buffers also offer co-benefits such as microclimate regulation, improved water retention, and wildlife habitat corridors (Mayer et al., 2007).

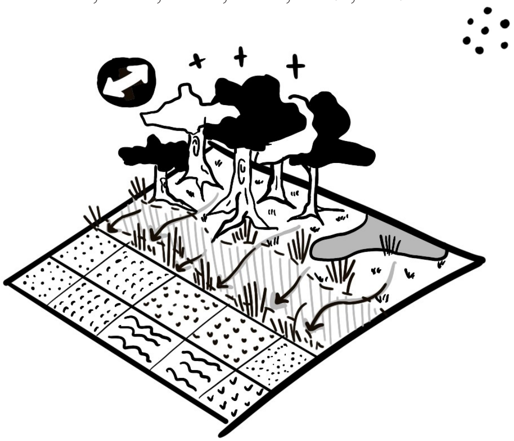
RELATIONS WITH:

To be coordinated with: P1, P3, P19, P22, P24, P25, P26

REQUIRES:

Focus: R11, R10, R9, R12

Policies: R11b, R11c, R11d, R11e, R12a, R12b



SOURCE: (Mayer et al., 2007).

OBTAINED THROUGH: Design intuition | Literature study

P24 POLLUTER PAYS PRINCIPLE

GOAL:

Unaccounted pollution from agriculture, industry, and urban activities contributes to ecosystem degradation, groundwater contamination, and increasing costs for public water treatment. The Polluter Pays Principle ensures that those responsible for environmental damage (such as chemical runoff, illegal discharges, or overuse of harmful substances) bear the costs of mitigation, clean-up, and ecological restoration, by increasing the price of polluting products and services (OECD, 2022). This principle not only creates incentives for polluters to reduce harmful practices but also relieves the financial burden on public institutions and nature. Mechanisms include fines, pollution taxes, mandatory restoration projects, and pollution-linked permits. Transparent regulation and enforcement by environmental agencies are crucial for its success.

RELATIONS WITH:

To be coordinated with: P22, P23, P28, P29, P7

REQUIRES:

Focus: R11

Policies: R11c, R11d, R11a, R11b, R13a, R10b

SOURCE: (OECD, 2022).

OBTAINED THROUGH: Literature study | Precedent study

P25 EXPAND WETLANDS

GOAL:

Widespread land conversion, river canalisation, and urban development have drastically reduced wetland areas, weakening natural flood buffers and reducing ecological resilience. Expanding and restoring wetlands increases the landscape's capacity to retain excess water during floods and recharge aquifers during dry periods. Wetlands function as vital ecosystems that purify water, store carbon, and provide habitat for diverse species. They also offer crucial co-benefits such as climate regulation, sediment capture, and recreational value. Interventions can include re-meandering rivers, converting low-value agricultural land into wetland habitat, or protecting existing wetland zones from encroachment. Strategic wetland expansion (particularly in flood-prone zones and ecological corridors) can be led by regional water authorities, environmental planners, and nature conservation agencies.

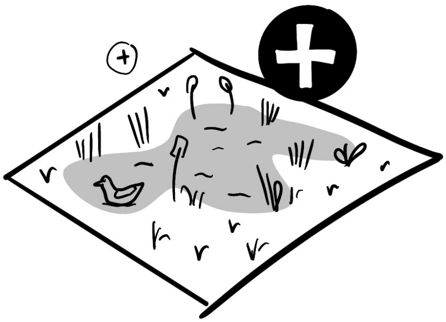
RELATIONS WITH:

To be combined with: P26, P27, P23, P19, P22

REQUIRES:

Focus: R12, R10, R11

Policies: R12a, R12b, R10c, R10a



OBTAINED THROUGH: Design intuition | Fieldwork observations

P26 EXPAND RAMBLAS & FLOODPLAINS

GOAL:

Ramblas are natural flood rivers in Spain, that are usually dry, unless there has been an event of heavy rainfall. Although they are dry most of the year, the roots of the plants hold water in the soil, providing crucial support for small plants and animals. They are important for flood protection, as well as desertification prevention and regional biodiversity. Expanding the Rambla network and connecting it to natural floodplain areas significantly increases the flood resilience of the lowlands of the basin, while at the same time increasing biodiversity and mitigating desertification.

RELATIONS WITH:

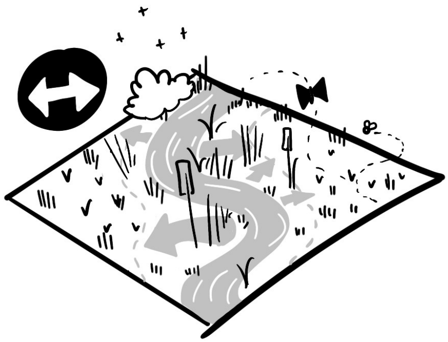
Operationalised by: A54, A56, A3, A29

To be combined with: P16, P20, P23, P22, P25

REQUIRES:

Focus: R12, R8, R10

Policies: R12a, R12b, R8b, R10a



OBTAINED THROUGH: Design intuition | Fieldwork observations

P27 WATER RETENTION IN URBAN LANDSCAPES

GOAL:

Rapid urbanisation driven by tourism and economic growth often replaces permeable natural surfaces with concrete and asphalt, leading to reduced water infiltration, increased runoff, and a heightened risk of urban flooding. As climate change intensifies rainfall variability, integrating water retention strategies into urban design becomes essential for flood resilience and local water availability. Retention can be achieved through small-scale interventions such as permeable pavements, green strips, rain gardens, and water squares, as well as larger systems like wadis, urban wetlands, and enhanced stormwater infrastructure. These interventions improve groundwater recharge, reduce sewer overflows, and create cooler, greener urban environments. Local governments, urban planners, and landscape architects play a key role in implementing these measures through planning policies, building codes, and public space design.

RELATIONS WITH:

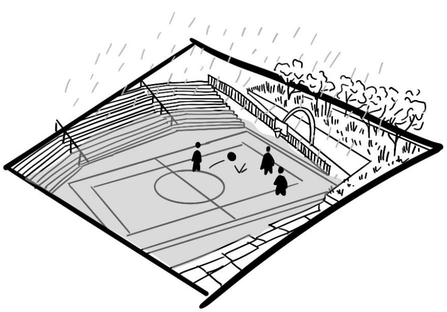
Operationalised by: A58-A6, A62, A49

To be combined with: P22, P25, P26, P28

REQUIRES:

Focus: R12, R10, R13

Policies: R10c, R12a, R12b, R13b



OBTAINED THROUGH: Design intuition | Fieldwork observations

P28 ECO-TOURISM

GOAL:

Mass tourism in environmentally sensitive regions often leads to resource overuse, pollution, habitat disruption, and pressure on local water and food systems, especially in arid regions during the summer season. Transitioning to eco-tourism offers an alternative that aligns economic activity with environmental conservation. Eco-tourism is a nature-based form of tourism where visitors are motivated by the observation and appreciation of nature, often combined with education and cultural exchange (UN tourism, 2025). By minimising ecological footprints and supporting local communities, eco-tourism can contribute to biodiversity conservation, landscape protection, and environmental awareness. Infrastructure for eco-tourism may include nature trails, eco-lodges, interpretive signage, and locally guided tours, implemented with the involvement of conservation organisations, municipalities, and residents.

RELATIONS WITH:

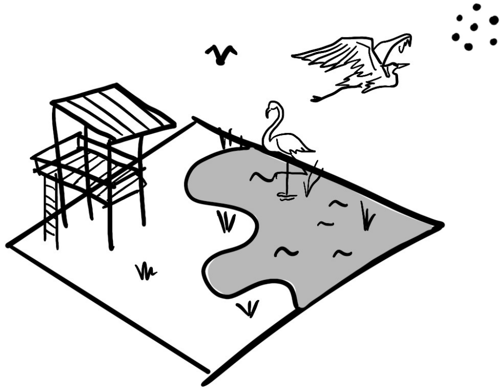
Operationalised by: A62, A63, A64, A65

To be combined with: P25, P23, P22, P17

REQUIRES:

Focus: P13, P11, P8, P10

Policies: R13a, R13b



SOURCE: (UN tourism, 2025)

OBTAINED THROUGH: Literature study | Precedent study

P29

AGRITOURISM

GOAL:

The current tourism industry in many regions places increasing pressure on local ecosystems, water resources, and infrastructure, often offering little benefit to rural communities. Agritourism provides a sustainable alternative by integrating tourism with environmentally responsible agricultural practices. Visitors can learn about indigenous, organic, or innovative farming methods, participate in farm-based activities, and directly purchase local produce, creating an immersive experience that raises awareness and promotes sustainable consumption. In doing so, agritourism supports rural economies, builds new markets for organic products, and reduces the ecological footprint of tourism.

RELATIONS WITH:

Operationalised by: A64, A65, A19, A16, A15, P9

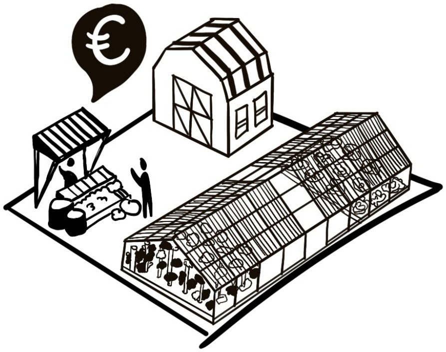
To be combined with: P1, P5, P3, P28

REQUIRES:

Coordination between farmers, tourism operators, and local governments to ensure accessibility, quality, and environmental integrity.

Focus: R13, R11, R1, R2

Policies: R1a, Rrb, R2a, R13b



OBTAINED THROUGH: Design intuition

A1 CHANGE TO DROUGHT-TOLERANT CROPS

GOAL:

In arid and semi-arid regions, conventional crops often require unsustainable irrigation volumes, leading to aquifer depletion, soil salinisation, and regional water scarcity. Drought-tolerant crop change offers a solution by transitioning to crops that require minimal or no irrigation, especially in dryland or organic farming systems. These crops are adapted to grow in water-scarce conditions by efficiently using soil moisture and withstanding prolonged dry periods. This approach not only conserves water but also enhances climate resilience, supports food security, and enables more sustainable land use. Research has shown that adopting drought-tolerant crops can significantly reduce irrigation needs while maintaining or even improving yields in water-stressed regions (Daryanto et al., 2017).

OPERATIONALISES:

P1, P6

REQUIRES:

Crop change, rainwater harvesting, (drip irrigation)

SOURCE: (Daryanto et al., 2017).

OBTAINED THROUGH: Design intuition | Literature study

A2 TERRACING AGRICULTURE

GOAL:

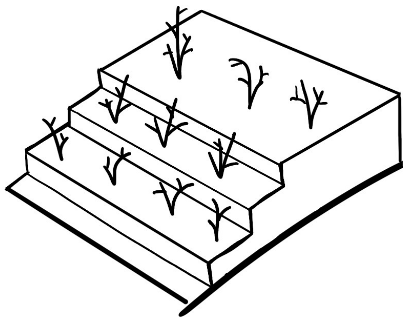
In sloped arid areas, rapid water runoff causes significant soil erosion, loss of soil fertility, and reduced water availability for crops, contributing to desertification and declining agricultural productivity. Terracing is an ancient agricultural technique that modifies the landscape by creating step-like flat surfaces or terraces along the contours of the slope. This slows down surface runoff, allowing rainwater to infiltrate the soil more effectively, increasing soil moisture retention and reducing evaporation. Terracing thus improves soil health, conserves water, and reduces the need for irrigation. The terraces can support diverse agricultural systems, including agroforestry, reforestation, and both permanent and seasonal crops, contributing to biodiversity and ecosystem restoration. Studies demonstrate that terracing significantly reduces runoff and erosion while increasing crop yields in dry and mountainous regions (Gómez et al., 2016). The intervention can be combined with agroforestry, reforestation, or the cultivation of permanent and non-permanent crops.

OPERATIONALISES:

P1, P13

REQUIRES:

Investment and effort to adjust the terrain.
Most effective on sloped terrain



SOURCE: (Gómez et al., 2016), (Beckers et al.,2013)

OBTAINED THROUGH: Design intuition | Precedent study

A3 LAND TRANSFORMATION TO NATURAL LANDSCAPE

GOAL:

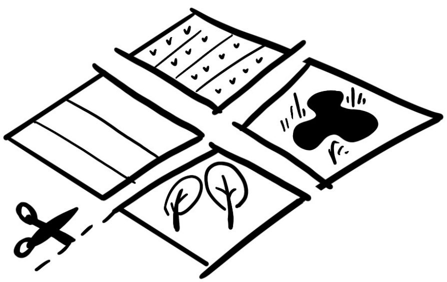
As a part of the EU Green Deal Farm-to-Fork strategy to transition to organic agricultural production, partial land transformation to natural area is a cruial element (EC, 2020). In order to reduce the water footprint of a production landscape in an arid region, some water consuming activities have to transition to more sustainable activities. This would in most cases lead to land use change of (a part of) a parcel, farm or territory. By integrating ecological patches in the form of biodiversity corridors or natural drainage areas, water can infiltrate and be stored in underground aquifers, forming a freshwater source and natural flood control. Biodiversity can grow, leading to soil health to combat desertification, and conrtibuting to the restoration of nature and the ecological surplus. When combined with the promotion of organic agriculture and / or promotion of a self-sufficient food system, land use diversification could also mean crop change, leading to a more diverse production in the region.

OPERATIONALISES:

P1, P17, P18, P19, P20, P23, P25, P26, P27

REQUIRES:

Willingness of farmers to change activities, sell or transform (a part of) their land through subsidies, regulations and awarness campaings. Requires high investment costs for the municipality and the maintenance of natural areas.



SOURCE: (EC, 2020)

OBTAINED THROUGH: Design intuition | Literature study

A4 CHANGE TO SALT-TOLERANT CROPS

GOAL:

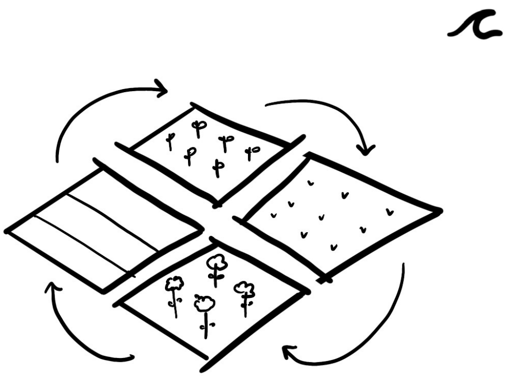
In lowland areas, sealevel rise and overexploitation of groundwater aquifers are causing salinisation of the groundwater. By switching to salt-tolerant crops, agricultural practices can continue in these areas, and crop yields can be improved. Soil salinisation reduces agricultural productivity in arid regions. Cultivating salt-tolerant crops, such as barley or quinoa, allows farming on saline soils, enhancing food security and utilising marginal lands effectively. This involves selecting appropriate crop varieties and implementing suitable agronomic practices.

OPERATIONALISES:

P1, P6

REQUIRES:

Crop change, initially results in lower yields



OBTAINED THROUGH: Design intuition | Literature study

A5 SEAWEED FARMING

GOAL:

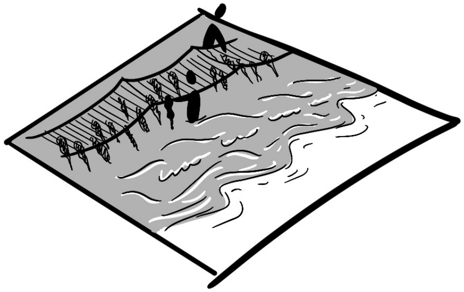
Farmers that are required to or willing to transition to sustainable forms of agriculture often face difficulty to change their current practices, out of fear to lose profits. In areas close to the sea, seaweed farming could form a sustainable farming alternative. Seaweed farming is a simple and eco-friendly form of sustainable development in coastal regions, as it requires little investment and is easy to install. Marine algae farming helps to mitigate climate change problems by lowering ocean acidification and removing nutrients from eutrophic waters. The seaweed can be used as biomass for food production, reducing the pressure on land and providing new livelihoods for the local community (Jagtap & Meena, 2022).

OPERATIONALISES:

P1, P6

REQUIRES:

Proximity to the sea or saltwater, crop change or change of land use, small investment and effort to set up the farm, maintenance.



SOURCE: (Jagtap & Meena, 2022)

OBTAINED THROUGH: Literature study | Precedent study

A6 VEGETATED PARCEL BORDERS

GOAL:

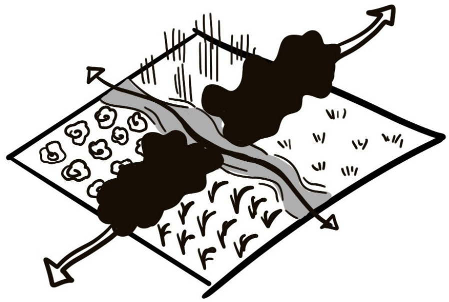
Monoculture farming often results in decreased biodiversity, increased soil erosion, and vulnerability to pest outbreaks, which negatively impact ecosystem health and long-term agricultural productivity. Vegetated parcel borders in the form of strips of native grasses, shrubs, or other vegetation planted along the edges of agricultural fields, serve as ecological corridors that provide habitat and food sources for beneficial wildlife and pollinators. These green buffers reduce soil erosion by stabilising the soil at field margins and improve natural pest control by supporting populations of predatory insects and birds. Additionally, they contribute to the connectivity of green-blue infrastructure networks, enhancing landscape resilience and water regulation. Research indicates that vegetated borders increase biodiversity and decrease the reliance on chemical pesticides, fostering more sustainable farming systems (Haaland, Naisbit, & Bersier, 2011).

OPERATIONALISES:

P1, P18, P20

REQUIRES:

Little installation effort.



SOURCE: (Haaland, Naisbit, & Bersier, 2011)

OBTAINED THROUGH: Design intuition | Literature study

A7 CONSERVATION TILLAGE

GOAL:

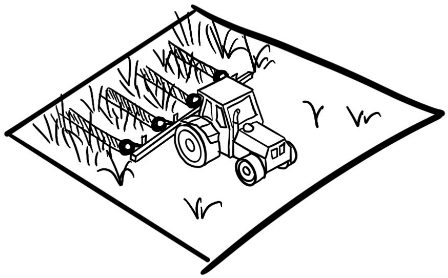
Traditional tillage practices often leave soil bare and vulnerable to erosion, degradation, and loss of moisture, which contributes to desertification and declines in soil fertility. Conservation tillage, by leaving crop residues on the soil surface, protects the soil from direct exposure to wind and rain, enhancing water infiltration and retaining soil moisture. This practice promotes a healthier soil ecosystem by supporting microbial diversity and earthworm activity, which improve nutrient cycling and soil structure. The improved soil health reduces the need for synthetic fertilizers and pesticides, thereby lowering nitrogen pollution and chemical runoff into nearby water bodies. Studies demonstrate that conservation tillage is an effective sustainable agriculture practice that balances productivity with environmental protection (Holland, 2004).

OPERATIONALISES:

P1, P4, P13

REQUIRES:

Requires additional effort for the farmer.



SOURCE: (Holland, 2004).

OBTAINED THROUGH: Design intuition | Literature study

A8 ORGANIC MULCHING

GOAL:

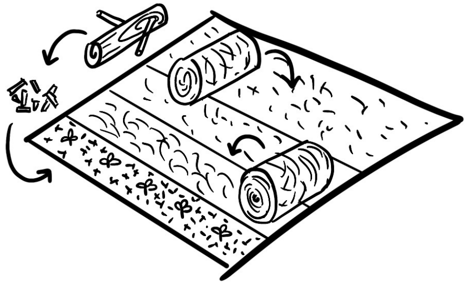
Soil erosion and moisture loss are major challenges in agriculture, especially in arid and semi-arid regions, contributing to soil degradation and desertification. Organic mulching involves applying a layer of organic materials such as wood chips, straw, or leaves over the soil surface, which protects it from direct exposure to rainfall and wind. This layer reduces surface water runoff and enhances water infiltration into the soil, improving groundwater recharge and soil moisture retention. Additionally, mulching supports soil biodiversity by providing habitat and food for beneficial microorganisms and insects that contribute to nutrient cycling and soil health. By promoting better water infiltration and reducing runoff, organic mulching also helps minimize nitrogen leaching into surface waters, reducing pollution. The use of diverse organic materials further stabilises the soil and enhances ecosystem resilience (Kaspar & Singer, 2011).

OPERATIONALISES:

P1, P4, P13, P20

REQUIRES:

Requires effort to strategically place, collect and sell mulch



SOURCE: (Kaspar & Singer, 2011).

OBTAINED THROUGH: Design intuition | Literature study

A9 CROP ROTATION

GOAL:

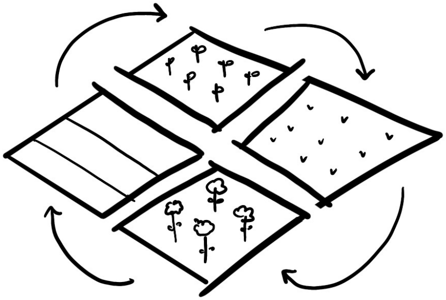
In arid and intensively farmed regions, continuous monoculture practices often lead to soil erosion, desertification, declining soil fertility, and increased reliance on synthetic fertilisers. Crop rotation addresses these issues by alternating different crops on the same land across seasons or years, which disrupts pest and disease cycles, improves soil structure, and enhances water retention capacity. Rotating deep-rooted and shallow-rooted crops, as well as nitrogen-fixing legumes with nutrient-demanding plants, promotes soil biodiversity and nutrient balance. This practice reduces the need for chemical fertilisers, lowers nitrogen runoff into surrounding ecosystems, and increases long-term productivity. Studies confirm that crop rotation contributes to healthier soils, improved yields, and greater resilience to climate stress in organic farming systems (Liu et al., 2022).

OPERATIONALISES:

P1, P13, P20

REQUIRES:

Investment and effort to plant and harvest additional crops or vegetation, land use diversification, transition from monocultures



SOURCE: (Liu et al., 2022).

OBTAINED THROUGH: Literature study

A10 NATURAL PEST CONTROL

GOAL:

Pest problems in agriculture often harm and pollute the environment though the use of pesticides. Natural pest control is used in organic agriclutre methods to prevent the use of pesticides by using for instance pest repellent plants, trap crops, companion planting (combining plant characteristics), beneficial insects (natural predators) or physical barriers such as row covers. Additionally, neem oil is a natural pesticide that can be home-made and is not harmful (Huskins, 2023). Crop rotation is a form of natural pest control. Natural pest control is used in organic agriculture.

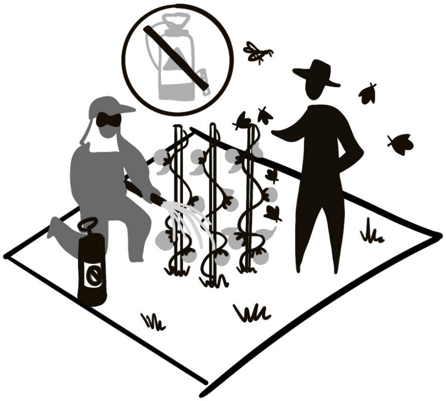
Additional benefits are increased soil health, biodiversity and economic benefits in the form of reduced costs for pesticides.

OPERATIONALISES:

P1, P20, P22

REQUIRES:

Knowledge about plants, natural predators and organic pesticides, maintenance.



SOURCE: (Huskins, 2023)

OBTAINED THROUGH: Literature study | Precedent study

A11 STRIP CROPPING

GOAL:

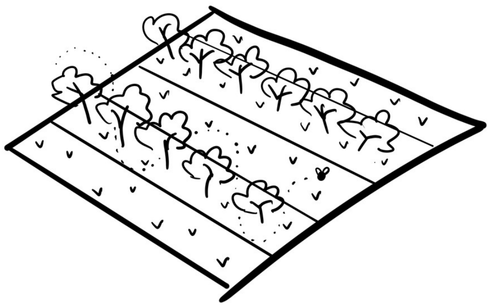
In semi-arid and degraded agricultural landscapes, monocultures and conventional ploughing practices accelerate soil erosion, nutrient depletion, and desertification. Strip cropping addresses these issues by planting alternating rows or strips of different crops on the same field. These strips are often composed of complementary species, such as deep- and shallow-rooted plants or nitrogen-fixing legumes and cereals that interact beneficially with each other and the environment. The varied root systems hold the soil more effectively, reducing erosion and desertification. Additionally, strip cropping improves water infiltration and retention, boosts soil microbial activity, and disrupts pest cycles through increased plant diversity, lowering the need for chemical pesticides and fertilisers. Research shows that strip cropping increases biodiversity, improves yields, and significantly reduces nitrogen runoff (Wageningen university & research (n.d.); Zhang et al., 2020).

OPERATIONALISES:

P1, P13, P20, P22

REQUIRES:

Requires transitioning from monocultures to small scale crop production. Requires more effort to harvest and plant the different crops. Management and irrigation may be more difficult.



SOURCE: (Wageningen university & research (n.d.), (Zhang et al., 2020).

OBTAINED THROUGH: Design intuition | Precedent study

A12 COVER CROPS & INTERCROPPING

GOAL:

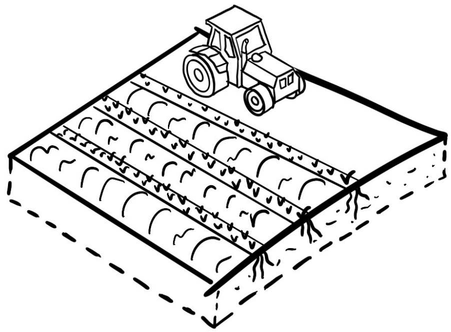
Soil degradation, erosion, nutrient loss, and biodiversity decline are major challenges in arid and semi-arid agricultural regions, exacerbated by monoculture practices and bare soil exposure. An integrated approach combining cover crops and intercropping can address these problems by protecting and enriching the soil while optimizing land use. Cover crops grown between main cropping cycles protect soil from erosion, improve moisture retention, enhance soil organic matter, and reduce nutrient runoff. Intercropping (growing complementary crops simultaneously) provides shade, natural pest control, and improved nutrient cycling, increasing biodiversity and crop resilience. Together, these techniques reduce the need for chemical inputs, combat desertification, and improve water efficiency by maintaining soil cover and microclimates favorable for plant growth. This integrated system supports sustainable, climate-resilient agriculture by enhancing ecosystem functions and stabilising yields.

OPERATIONALISES:

P1, P13

REQUIRES:

Requires investment and effort to plant and harvest additional crops or vegetation



OBTAINED THROUGH: Design intuition

A13 SILVOPASTURES

GOAL:

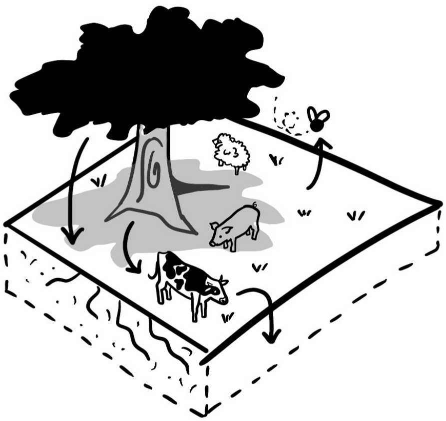
Conventional grazing can lead to erosion, soil degradation, and desertification. Silvopastures integrate trees into pastureland to stabilise the soil, enhance biodiversity, and improve soil health. Tree roots prevent erosion, while organic matter from animals and vegetation enriches the soil. Residual flows such as manure are composted and used to nourish trees or sold as natural fertiliser. This closed-loop system promotes resilient, multifunctional landscapes that benefit both livestock and ecosystems. Reallocating the land cover occupied by pastures can be integrated with reforestation plans to prevent erosion and desertification even more. Manure can be collected and used or sold locally as fertiliser.

OPERATIONALISES:

P1, P4, P13, P17, P20

REQUIRES:

Investment and effort to plant vegetation, (co-management between farmers), most effective in desertified areas or areas prone to erosion, most effective on slopes and near natural forest areas.



OBTAINED THROUGH: Design intuition

A14 (INDIGENOUS) DRY FARMING TECHNIQUES

GOAL:

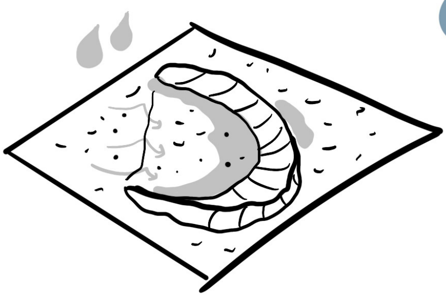
In arid and semi-arid regions, water scarcity threatens the viability of conventional irrigation-based agriculture. Implementing dry farming techniques (such as deep planting, soil mulching, and timing cultivation to seasonal moisture) can significantly reduce reliance on irrigation. These traditional and often indigenous practices conserve soil moisture, enhance resilience to drought, and promote long-term soil health. Integrating this knowledge into modern agricultural systems supports the transition towards water-efficient and climate-adaptive farming, which is crucial for sustainability in water-scarce regions. Indigenous communities in arid regions all over the world have been using dry farming techniques for centuries. Discovering, sharing and implementing this knowledge in other regions could be very valueable.

OPERATIONALISES:

P1, P6, P9

REQUIRES:

Dry farming requires integration with organic farming and adaptive groundwater management in order to be affective. Implementing these methods involves understanding local soil and climate conditions, and will initially lead to lower yields than with monocultural agriculture.



OBTAINED THROUGH: Design intuition

A 15 ORGANISE FARMER WORKSHOPS

GOAL:

Literature research and fieldwork observations have concluded that farmers often struggle with the same issuses, searching for answers. Especially related to the sustainability transition and the incorporation of new technologies on farms may be difficult to understand for some. A knowledge gap between theory and practise has been found. Educating local farmers and forming farmer communities can overcome this gap, for instance through organising farmer workshops. Knowledge sharing and convincing to transition towards more sustainable forms of agricultural production and water use is more effective when practical, in-field examples are shown and farmers that know eachother can work together. Additionally, co-farming or water sharing and reusing collaborations can emerge.

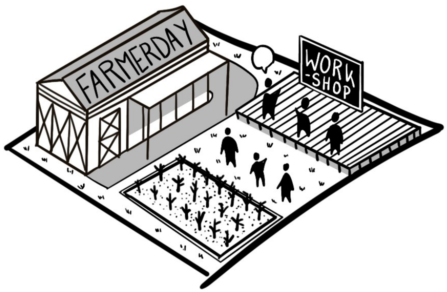
Through similar workshops, other residents and tourists could obtain knowledge about sustainable farming as well, boosting the local economy and spreading knowledge about sustainability transitions.

OPERATIONALISES:

P1, P3, P5, P9, P29

REQUIRES:

Effort, time, and investment to organise and join the workshops, knowledge about (technological) systems or (indigenous) practices discussed.



OBTAINED THROUGH: Design intuition

A 16 FARMER KNOWLEDGE PLATFORMS

GOAL:

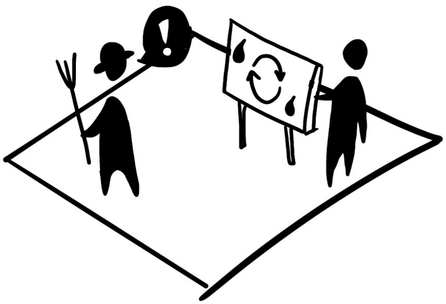
The knowledge gap between researchers and farmers in practice hinders sustainable agricultural transitions. Creating an online platform for farmers to ask eachother questions, help eachother out, share knowledge or ideas and create bonds or communities could help to bridge this gap and unite farmers all over the world to contribute to the sustainable agriculture transition.

OPERATIONALISES:

P1, P3, P5, P9, P29

REQUIRES:

Effort, time, and investment to create a platform, and to avertise it. Willingness of farmers to spend time and effort in helping others through the platform and create connections and collaborations.



OBTAINED THROUGH: Design intuition

A17 AGRIVOLTAICS

GOAL:

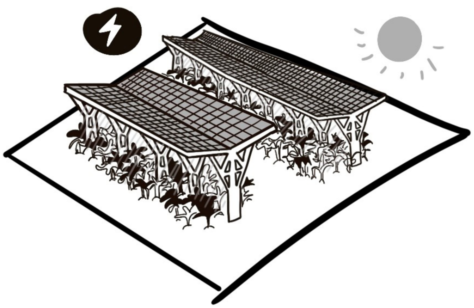
With the transition to sustainable forms of agriculture, renewable forms of energy are required to support the technologies and food industry. However, allocating renewable energy production landscapes can be difficult in a dense or naturally preserved environment. Agrivoltaics combine solar photovoltaic (PV) systems with agriculture or grazing, to make more use out of the same plot. The solar panels provide shade for the grazing animals and protect the crops underneath by reducing evaporation, thus maintaining humidity and reducing the water footprint (Widmer et al., 2024). At the same time, biodiverstiy and ecosystem services are protected, and air pollution is reduced due to a decreased reliance on fossil fuel energy.

OPERATIONALISES:

P1, P5, P21

REQUIRES:

High initial investment costs, (crop change)



SOURCE: (Widmer et al., 2024)

OBTAINED THROUGH: Literature study | Precedent study

A18 AI FARMING

GOAL:

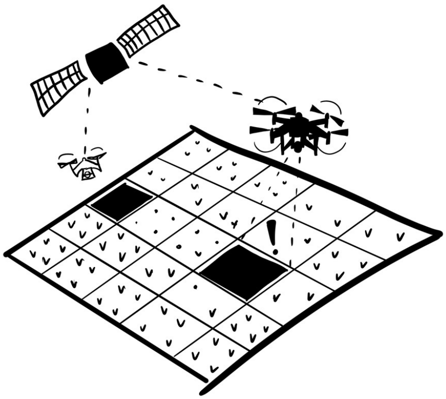
Traditional farming methods are often inefficient in resource use and polluting the environment through fertiliser and pesticide use, and diseases that are related to monocultural farming. Integrating Artificial Intelligence (AI) through the use of innovative technologies into agriculture enhances efficiency and promotes environmental conservation. Drones and satellites are used to retrieve and map data on soil conditions and diseases, which enables precise resource allocation and preventive actions (Assoualma, 2025). The use of AI systems in agricultural production therefore enhances efficiency and promotes environmental conservation. Different forms of AI farming are: Precision Farming (optimised resource use through ground sensors and drones), Crop Monitoring and Pest Management (AI detects early signs of pests), Automated Irrigation (optimal water use), and Soil Health Management.Researchers at the University of Florida's institute of Food and Agricultural Sciences (UF/IFAS) monitored crop growth and optimised fertiliser and resource use through drone monitoring (Rajagopal & Murugan, 2023).

OPERATIONALISES:

P1, P5

REQUIRES:

Knowledge about technology, high initial investment costs, a focus on technological developments, (governmental subsidies)



SOURCE: (Assoualma, 2025), (Rajagopal & Murugan, 2023)

OBTAINED THROUGH: Literature study | Precedent study

A 19 REGULAR LOCAL FARMER MARKETS

GOAL:

Long supply chains disconnect consumers from the origins of their food, contribute to pollution, and increase dependency on global systems. Introducing regular local farmers' markets reconnects producers and consumers, building social ties that support sustainable food consumption and regional agriculture. These markets promote local knowledge sharing, encourage healthier eating habits through access to fresh and seasonal produce, and reduce the need for preservatives and cooling due to shorter distribution distances. By shortening food supply chains, they also lower transport-related emissions and costs, contributing to a more circular and resilient food economy. Organising regular markets involves collaboration with local producers, securing accessible venues, and engaging communities to ensure broad participation. Implementing it on a large scale could set a regional mindset shift in motion towards increased support of local small farms, disconnecting the area from the global food chain.

OPERATIONALISES:

P1, P2, P3, P4

REQUIRES:

Shift in mindset from industrial export production to local food chains including organic agriculture, crop change and land use diversification

OBTAINED THROUGH: Design intuition | Fieldwork observations

A 20 URBAN FARMING & ALLOTMENT GARDENS

GOAL:

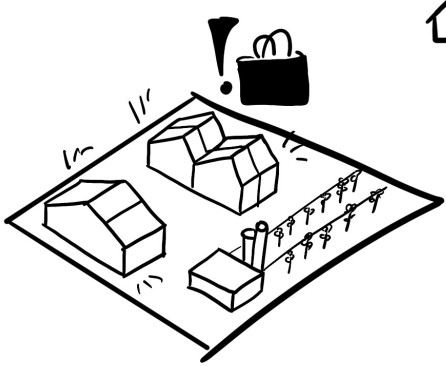
Urban areas often face limited communal green spaces, and residents are not connected to the farmer that supplies the food they consume, as global food chains and supermarkets process regionally produced foods in other locations, selling anonymous and generalised foods. Locally produced food contributes to the sustainable agriculture transition as it reduces pollution, connects consumers with the food production industry, and improves local food security. Community gardens and urban farms offer residents access to fresh produce, promote sustainability, and enhance urban biodiversity, while supporting community-building and increased awareness and support of organic produce. These spaces can be established on vacant lots, nearby farms, or rooftops. Though urban farming, food is produced and consumed locally, reducing pollution and transportation costs, and improving local knowledge about (innovative and organic) food production and local food security. Additionally, it reduces the pressure on agricultural land around the urban areas, allowing for more land transformation to natural land.

OPERATIONALISES:

P1, P2, P3, P4

REQUIRES:

Effort and time to organise and install allotment gardens and a shared farming concept, willingness of farmers and residents to cooperate, and community involvement.



OBTAINED THROUGH: Design intuition | Fieldwork observations

A21 VERTICAL FARMING

GOAL:

With the sustainable agriculture transition, land transformation to natural area as a required step, causes more pressure on the reduced agricultural production landscapes. To keep supporting the global food industry, smart famring techniques that use the available space more efficiently are crucial. Vertical farming, which involves stacking crops in controlled environments, enables higher yields on smaller land areas with reduced resource use. By repurposing unused urban or farm buildings and integrating renewable energy sources, vertical farming can alleviate land pressure and contribute to sustainable agriculture (Wageningen University & Research, n.d.). In the Netherlands, Siberia B.V. operates a high-tech greenhouse where each acre yields as much lettuce as 10 outdoor acres, reducing chemical use by 97%. This showcases the potential of vertical farming in enhancing efficiency and sustainability (Viviano, 2017).

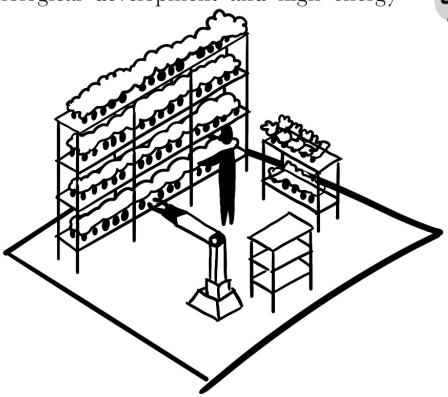
OPERATIONALISES:

P1, P5

REQUIRES:

P21

High investment costs, knowledge about vertical farming, improvement of greenhouses, a focus on technological development and high energy inputs.



SOURCE: (Wageningen University & Research, n.d.), (Viviano, 2017).

OBTAINED THROUGH: Literature study | Precedent study

A22 HYDROPONICS

GOAL:

Traditional agriculture requires significant land and water resources and often contribute to environmental degradation. Hydroponics offers a sustainable alternative by growing plants in nutrient-rich water solutions without soil. This method uses up to 90% less water than conventional farming, reduces the need for chemical fertilizers, and eliminates soil erosion and runoff. It also allows year-round production in controlled environments, making it ideal for urban areas or regions with limited arable land. Additionally, hydroponics reduces transportation emissions by enabling local food production near consumption points (Resh, 2022).

The company Agrotonomy (2025), operating in Almería, Spain, uses vertical hydroponic systems to grow leafy greens in desert conditions with minimal water use. Their system demonstrates how hydroponics can support sustainable food production in semi-arid climates like the Segura River Basin.

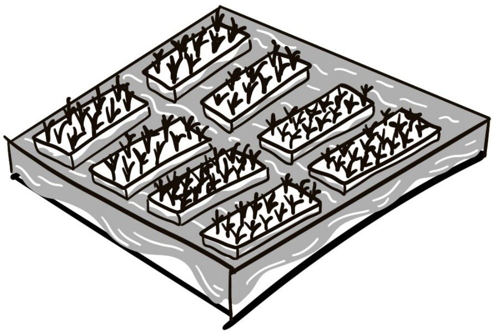
OPERATIONALISES:

P1, P6, P5

REQUIRES:

P21

High investment costs, knowledge about hydroponics and setting up controlled environments like greenhouses or indoor setups. Those setups require high (renewable) energy inputs.



SOURCE: (Resh, 2022), (Agrotonomy, 2025)

OBTAINED THROUGH: Literature study | Precedent study

A23 AQUAPONICS

GOAL:

Conventional agriculture and aquaculture require high water, land, and resource inputs, which are unsustainable in arid areas with limited space and high temperatures. Aquaponics combines hydroponics (soilless plant cultivation) and aquaculture (fish farming) into a closed-loop system, where fish waste provides nutrients for plants, and plants clean the water in return. This symbiotic process reduces water use and eliminates the need for chemical fertilisers and waste discharge, improving productivity per unit of water and space (National Agricultural Library, n.d.; Yoho, 2024). In arid regions, high temperatures challenge crop growth, but technologies like evaporative cooling with pad-fan systems, outdoor shading, and mechanical cooling enable aquaponics to function effectively (Zhu et al., 2024). Although mechanical cooling increases energy demand, combining the system with renewable energy sources ensures environmental sustainability. The Sahara Forest Project in Qatar showcases this approach by integrating aquaponics with solar power and saltwater-cooled greenhouses to support food and water resilience in desert conditions (Sahara Forest Project, n.d.).

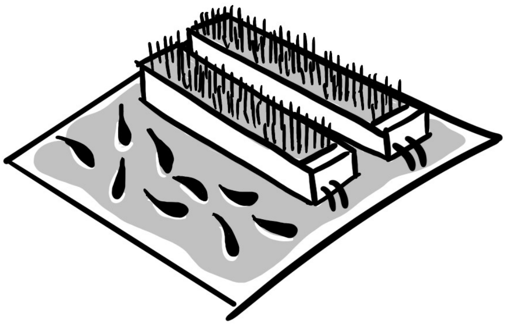
OPERATIONALISES:

P1, P4, P5

REQUIRES:

P21

High investment costs, installation effort, renewable energy production, technological development, and knowledge about aquaponics.



SOURCE: (National Agricultural Library, n.d.), (Yoho, 2024), (Zhu et al., 2024), (Sahara Forest Project, n.d.).

OBTAINED THROUGH: Literature study | Precedent study

A24 TRANSFORM THE TST INFRASTRUCTURE

GOAL:

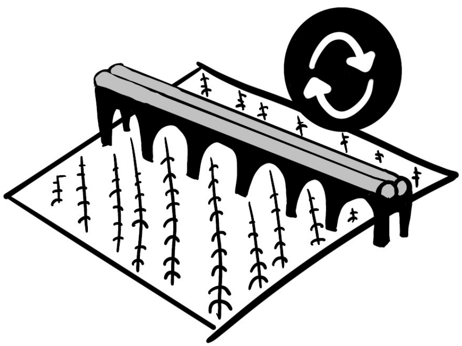
The operation of the Tajo-Segura Transfer (TST) in the Segura River Basin is highly debated for many years, and full closure of the transfer is likely to happen soon, in response to the environmental movement and ecological flow restoration efforts required by the Water Framework Directive. This offers potential for transforming the infrastructure to support a new centralised water network for renewable water supply, and a green-blue corridor through the basin.

OPERATIONALISES:

P8, P10, P14, P15, P16, P18

REQUIRES:

High investment costs, labour and time



OBTAINED THROUGH: Design intuition | Fieldwork observations

A25 NEW DESALINATION PLANTS

GOAL:

Water scarcity in arid regions is often created by a lack of available natural freshwater resources. Desalination as a technique to create drinkable water from seawater forms a renewable source of water supply. While desalination already exists in the Segura River Basin, currently, not all agricultural and urban regions are connected to the supply network. To improve the network and create a centralised system that replaces conventional water supply with non-conventional water, new desalination plants can be built along the coastline, accompanied by new infrastructure connections.

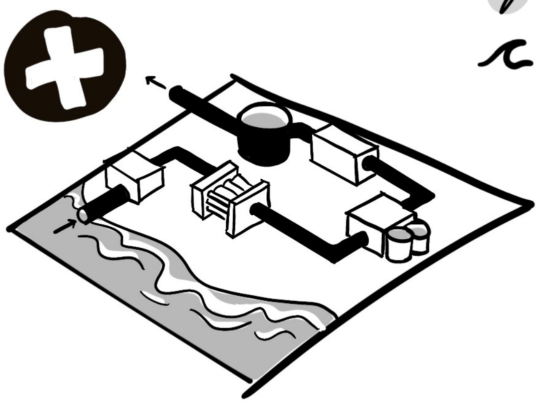
OPERATIONALISES:

P8

REQUIRES:

P21

High investment costs in the form of national funds, renewable energy production, careful natural considerations, infrastructure planning and design.



OBTAINED THROUGH: Fieldwork observations | Design intuition

A26 EXPAND/UPGRADE DESALINATION PLANT

GOAL:

Water scarcity in arid regions is often created by a lack of available natural freshwater resources. Desalination as a technique to create drinkable water from seawater forms a renewable source of water supply. While desalination already exists in the Segura River Basin, currently, the plants that are operative do not operate on their full capacity due to a lack of investment and insufficient infrastructure capacity and renewable energy availability. Upgrading these plants to their full potential would reduce the region's reliance on water transfers and groundwater extractions. Additionally, the current systems could be optimised and renewed, improving the sustainability further.

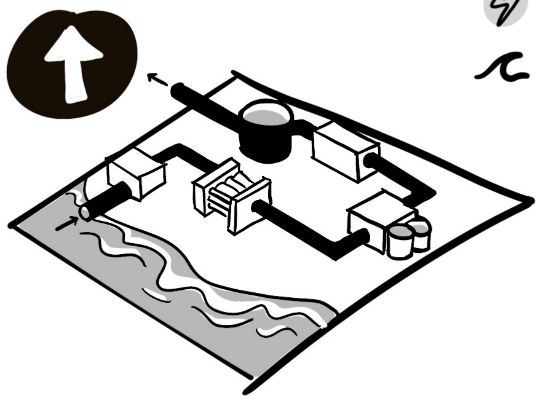
OPERATIONALISES:

P8

REQUIRES:

P21

High investment costs in the form of national funds, renewable energy production.



OBTAINED THROUGH: Fieldwork observations | Design intuition

A27 TRAPEZOIDAL BUNDS

GOAL:

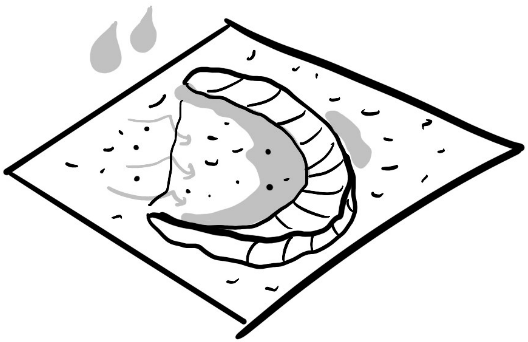
Many small farmers in arid regions lack the financial resources and means to transition to sustainable agricultural practices, leading to ongoing soil erosion, desertification, and reduced crop productivity. Trapezoidal bunds, an indigenous rainwater harvesting and dry farming technique, can address these issues by trapping rainwater and cooling the soil, thereby improving water infiltration, soil moisture, and fertility (Abraham, 2025). This small-scale, low-cost intervention enables grasses and crops to grow more effectively while being easily implementable by local communities. For instance, a Justdiggit project in Amboseli National Park, Kenya, in 2021 demonstrated that constructing trapezoidal bunds collectively not only enhanced soil water retention but also fostered farmer community bonding and knowledge sharing (Justdiggit, 2021). Therefore, trapezoidal bunds offer a practical solution for improving agricultural resilience and productivity among resource-limited farmers in arid landscapes.

OPERATIONALISES:

P1, P9, A14

REQUIRES:

A14
Effort and time to dig.



SOURCE: (Abraham, 2025), (Justdiggit, 2021)
OBTAINED THROUGH: Literature study | Precedent study

A28 QANAT SYSTEM

GOAL:

In arid and semi-arid sloped terrains, water scarcity and evaporation reduce available water for irrigation and contribute to soil erosion and desertification.

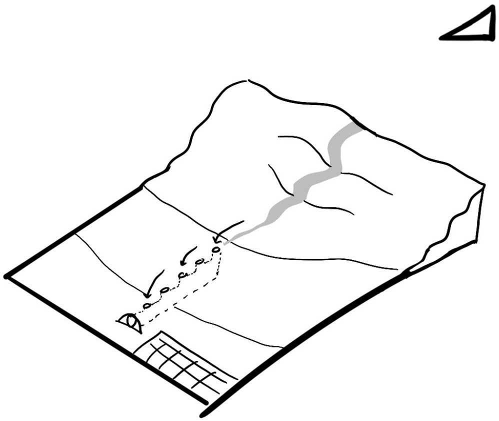
Implementing qanat systems can sustainably harvest rainwater by channeling runoff through underground tunnels to reservoirs, minimizing evaporation and runoff. This indigenous technique improves soil moisture, reduces irrigation water demand, and helps prevent erosion and desertification on farms. It is an indigenous rainwater harvesting technique used in sloped terrains to capture rainwater in arid regions. Drains catch the run-off water, and bring it to a reservoir at the bottom of the hill through underground pipes to prevent evaporation. An example is the ancient qanat systems in the Yazd region of Iran (Manuel et al., 2018). This technique can be used on farms to prevent erosion and desertification, improve soil moisture, reduce water use for irrigation, improve soil health and reduce water run-off and evaporation.

OPERATIONALISES:

P9, P10

REQUIRES:

Investment and effort to install the techniques, reorganisation of the terrain, (collaborations between farmers), sloped terrain.



SOURCE: (Beckers et al., 2013), (Manuel et al., 2018)
OBTAINED THROUGH: Literature study | Precedent study

A29 DITCHES SYSTEM

GOAL:

Many small farmers in arid regions lack the financial resources, knowledge and means to transition to sustainable agricultural practices, leading to ongoing soil erosion, desertification, and reduced crop productivity. Digging ditches in and between agricultural fields is a relatively easy measure to improve water retention capacity of the soil, prevent run-off and pollution through nitrates. These ditches can form a local agricultural return flow system, helping farmers to manage their water use, discharges and reuse.

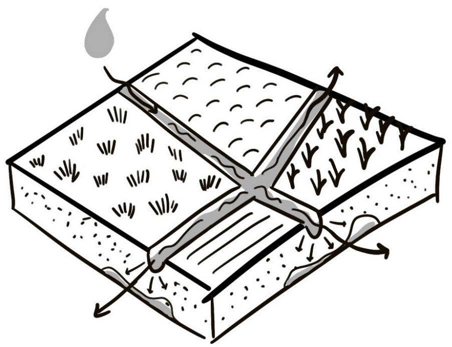
In the Alpujarra region of Andalusia, ancient irrigation canals called acequias, originally constructed over a thousand years ago during the Moorish period, are being restored and revived to address contemporary challenges due to drought (Alpujarra Experience, 2022).

OPERATIONALISES:

P1, P9, P10, P12, P18, P26

REQUIRES:

Collaborative effort and time.



SOURCE: (Alpujarra Experience, 2022).

OBTAINED THROUGH: Design intuition | Precedent study

A30 PLANTING PITS

GOAL:

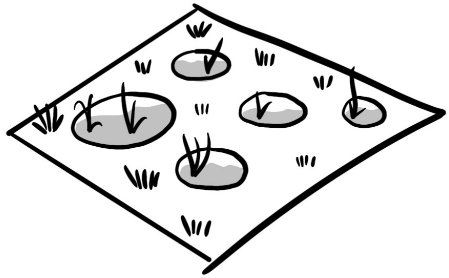
Many small farmers in arid regions lack the financial resources, knowledge and means to transition to sustainable agricultural practices, leading to ongoing soil erosion, desertification, and reduced crop productivity. Planting pits could form a solution for local farmers to start transitioning to dry agriculture and harvest rainwater in their fields. Planting (or Zaï / Chololo) pits are small basins digged in the soil where the seeds of crops are planted in, after which they are covered with Mulch, (organic) manure or good soils (*Greener.Land* (n.d.). It is an indigenous water harvesting method from Africa that is aimed at increasing soil fertility and water retention capacity. Additionally, it increases vegetation, improves soil health, prevents erosion, reduces run-off and increases crop yields (Temu et al., 2022).

OPERATIONALISES:

P1, P9, P10

REQUIRES:

Collaborative effort and time.



SOURCE: (Temu et al., 2022), (Greener.Land. (n.d.)

OBTAINED THROUGH: Literature study | Precedent study

A31

SILT TRAPS

GOAL:

Agricultural runoff can carry sediments into waterways, harming ecosystems. Silt traps capture sediment from runoff, preventing water pollution and soil loss. These structures are installed in drainage paths to settle out sediments before water enters streams. They can be introduced in an agriculture return flow system of ditches, and are relatively easy to install for local farmers themselves.

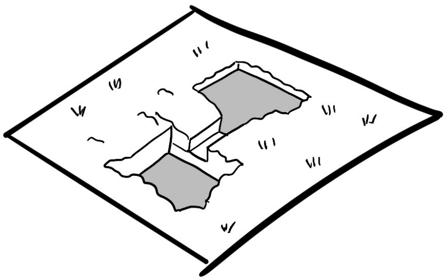
At Wayland Farms, an outdoor pig farming operation, silt traps were installed to address sediment runoff that was affecting nearby roads and drains, potentially impacting the River Nar, a sensitive chalk stream. The silt traps, along with buffer strips and track restoration work, effectively slowed down polluted runoff, allowing sediments and associated nutrients to settle out before reaching the river system (Agricology, 2023).

OPERATIONALISES:

P9, P22

REQUIRES:

Collaborative effort and time.



SOURCE: (Agricology, 2023).

OBTAINED THROUGH: Literature study | Precedent study

A32

FOG WATER HARVESTING

GOAL:

In arid regions that are disconnected from a renewable water supply source, farmers struggle to collect rainwater to water for irrigation due to high evaporation rates. Small techniques as using fog harvesting nets could provide solutions for small farms to obtain water in times of need. Fog harvesting is a technique to capture moist out of fog that goes through a net. The water molecules stick to the net and end up in a rain barrel where they cannot evaporate out of.

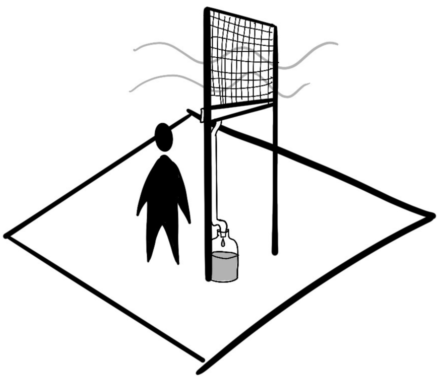
A notable example of farmers utilising fog harvesting nets is found in the Anti-Atlas Mountains of southern Morocco. The nonprofit organisation Dar Si Hmad implemented a fog-harvesting project to provide clean water to rural communities that previously lacked access to potable water (Agrawal et al., 2022). This initiative not only supplied drinking water but also supported local agriculture by reducing reliance on scarce groundwater resources.

OPERATIONALISES:

P9, P10

REQUIRES:

Installation investment, effort and time for the water collecting.



SOURCE: (Agrawal et al., 2022)

OBTAINED THROUGH: Literature study | Precedent study

A 33 RAINWATER BARRELS

GOAL:

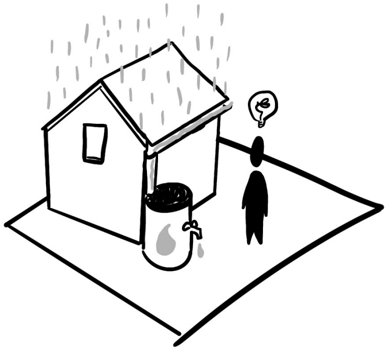
In water scarce regions, there is a high pressure on the water supply system due to the mismatch in water demand and availability. Because of climate change, more sudden rain events will cause urban runoff to contribute to water wastage and flooding. As a solution to these problems, rainwater barrels can be installed that collect rooftop runoff and conserve water for irrigation, while reducing stormwater impact. Installation involves connecting barrels to downspouts to capture and store rainwater. Implementing many smallscale rainbarrels for watering plants can reduce water use of domestic households and farms. This intervention can be included in newly built urban expansion projects, tourism resort converstions and by residents themselves as a relatively easy sustainable solution that reduces the pressure on the water supply system in water scarce regions.

OPERATIONALISES:

P6, P7, P10, P14

REQUIRES:

Little installation investment and effort



OBTAINED THROUGH: Design intuition

A 34 UNDERGROUND WATER STORAGE

GOAL:

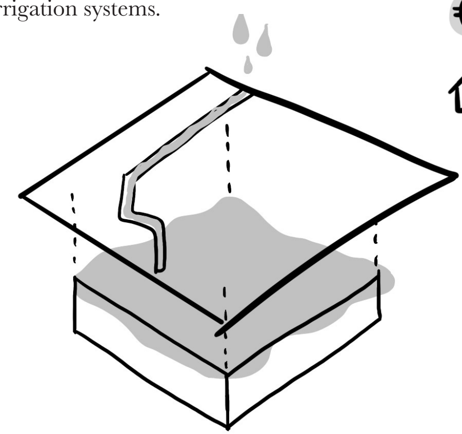
In semi-arid regions and urban areas increasingly affected by extreme rainfall and prolonged droughts, two critical challenges arise: frequent flooding and a lack of reliable water supply for irrigation. Underground water storage systems offer a solution by capturing and storing excess rainwater below the surface. These systems are typically installed beneath roads, parks, or agricultural fields, where they protect water from high evaporation rates and contamination. An example is found in Hungary's Middle Tisza River Basin, where six underground floodwater reservoirs were constructed to temporarily store floodwaters and reduce downstream risks, while also allowing water reuse during dry seasons (European Environment Agency, 2015). Similarly, research in Southern Punjab, Pakistan, demonstrated that underground floodwater storage significantly supports irrigation during droughts, increases agricultural resilience, and reduces damage from floods (Hassan et al., 2024). By integrating such systems into both urban and agricultural planning, communities can address climate-driven water extremes more effectively.

OPERATIONALISES:

P10, P16, P27

REQUIRES:

Installation effort, time and investment, connection to irrigation systems.



SOURCE: (European Environment Agency, 2015), (Hassan et al., 2024).

OBTAINED THROUGH: Design intuition | Precedent study

A 35 LOCAL WASTEWATER TREATMENT

GOAL:

In regions where centralised wastewater systems are inefficient (particularly in remote areas), untreated discharges can lead to environmental contamination. Implementing local wastewater treatment plants addresses this challenge by ensuring effective wastewater management at the community level. These systems employ physical, biological, and chemical processes to treat water, making it safe for discharge or reuse. By treating wastewater locally, these plants reduce the burden on centralised systems, minimise environmental pollution, and enhance water availability for non-potable uses such as irrigation. A notable example is the Noorderhoek district in in the Netherlands, where a decentralised sanitation system has been implemented. In this project, wastewater is separated at the source into black water (toilet waste) and grey water (from showers, sinks, etc.). The grey water undergoes treatment through a bio-oxidation process, while the black water is processed separately (WaterSchoon, n.d.). This approach not only treats wastewater efficiently but also recovers energy and nutrients, contributing to a circular economy.

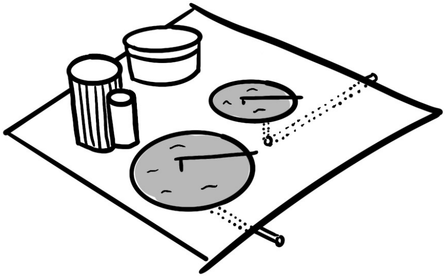
OPERATIONALISES:

P11, P22

REQUIRES:

P21

High installation investment through national funds and renewable energy as a resource.



SOURCE: (WaterSchoon, n.d.)

OBTAINED THROUGH: Literature study | Precedent study

A 36 ALGAE MATERIAL HUB

GOAL:

Conventional wastewater treatment is often energy-intensive and lacks circularity, failing to recover valuable resources. The algae-based wastewater treatment model offers a sustainable alternative by purifying water while producing reusable biomass. Algae absorb excess nutrients like nitrogen and phosphorus and release oxygen through photosynthesis, making the process faster and more energy-efficient than traditional methods (Mohsenpour et al., 2021). The resulting biomass can be harvested and converted into biofuels, bioplastics, fertilizers, or animal feed, closing key loops in the water-energy-material cycle. An example is the All-Gas Project in Chiclana, Spain, where algae cultivated in wastewater are transformed into biogas to fuel vehicles and power the treatment plant itself (Freyberg, 2013). This system reduces emissions, cuts treatment costs, and adds value by integrating renewable energy and resource recovery. Algae-based systems thus help reduce environmental impact, lower treatment costs, and contribute to a more circular, resilient urban metabolism.

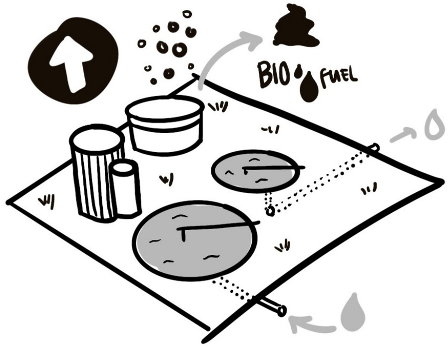
OPERATIONALISES:

P4, P2, P11, P13, P22

REQUIRES:

P21

High installation investment through national funds, knowledge and implementation of high tech systems and renewable energy as a resource.



SOURCE: (Freyberg, 2013), (Mohsenpour et al., 2021).

OBTAINED THROUGH: Literature study | Precedent study

A 37 AGRICULTURE RETURN FLOW SYSTEMS

GOAL:

Agricultural runoff is often rich in nutrients but becomes a major source of pollution when it enters rivers, aquifers, or natural ecosystems untreated. This pollution contributes to eutrophication, soil degradation, and biodiversity loss. At the same time, the nutrients and water in these flows represent valuable resources that are often wasted. An agricultural return flow system addresses this by capturing and reusing nutrient-rich runoff for irrigation and soil enhancement. Through community-managed infrastructure (such as small canals, retention basins, and filtration zones), these flows can be redirected, treated if necessary, and redistributed across farms. This reduces the need for additional irrigation water and synthetic fertilisers, while also preventing contamination of nearby ecosystems. This system fosters co-management among farmers in water reuse and pollution prevention at the local level. When implemented on a small scale and tailored to regional conditions, it can form part of a circular, regenerative agricultural model that protects nature, saves resources, and strengthens farmer networks.

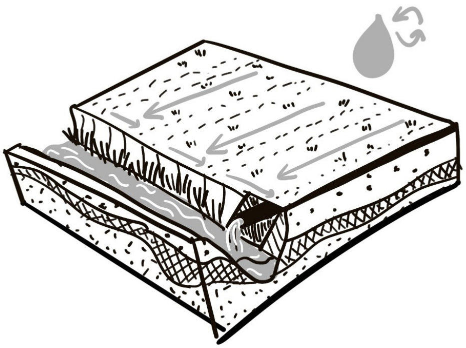
OPERATIONALISES:

P1, P9, P10, P11, P12, P22

REQUIRES:

A29

Collaboration between farmers, construction of a transportation network (ditches), (wastewater treatment and reuse).



OBTAINED THROUGH: Fieldwork observations | Design intuition

A 38 DRIP IRRIGATION

GOAL:

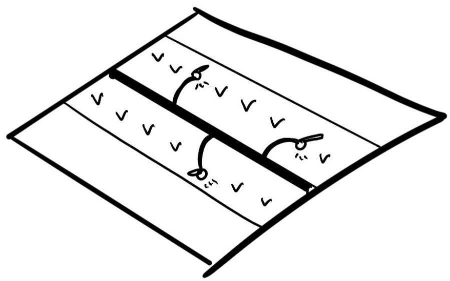
Water scarcity and inefficient irrigation practices in agriculture contribute significantly to resource depletion and reduced crop yields, especially in arid and semi-arid regions. Drip irrigation systems address this problem by delivering water directly to the plant roots through small holes in tubing, significantly reducing water use compared to traditional irrigation methods. Research shows that drip irrigation can reduce water use by up to 50% while increasing crop yields and improving water productivity (Postel et al., 2001). When combined with smart sensors and AI farming technologies, drip irrigation can be precisely controlled to meet plants' specific water needs, further enhancing sustainability. Although many agricultural areas in the region have already adopted drip irrigation, challenges remain due to the fragility of plastic tubing, which often gets damaged during plowing, as fieldwork observations have revealed, indicating opportunities for technological and material improvements.

OPERATIONALISES:

P1, P6, P13

REQUIRES:

Investment costs and effort to apply the system & strict regulations on the implementation and irrigated expansions to prevent the Jevons Paradox.



SOURCE: (Postel et al., 2001)

OBTAINED THROUGH: Literature study | Fieldwork observations

A 39 AGRICULTURAL PONDS

GOAL:

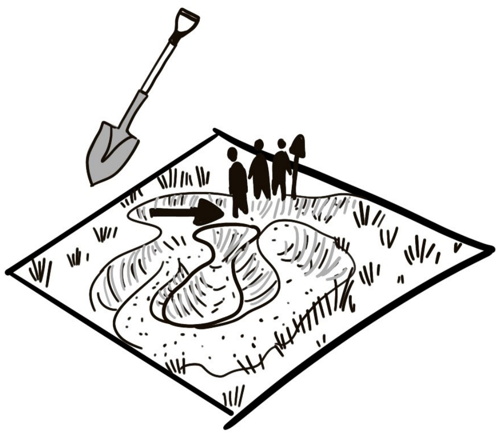
In agricultural landscapes, rainfall runoff often results in water wastage and erosion, particularly in semi-arid regions. Farm ponds or rainwater harvesting ponds, offer a sustainable solution by capturing and storing excess rainwater. These ponds are typically constructed by excavating shallow basins or damming small catchments, and they are often integrated into a broader system that channels runoff from surrounding fields through drains or ditches (Boers & Ben-Asher, 1982). The stored water can be reused for irrigation, livestock, or even aquifer recharge during dry periods, thereby reducing pressure on groundwater sources. To reduce evaporation losses, ponds can be shaded with vegetation, covered with floating solar panels, or treated with biodegradable surface films (Roy et al., 2024). When combined with drip irrigation or other efficient delivery systems, agricultural ponds become vital tools for climate-resilient farming.

OPERATIONALISES:

P6, P9, P10, P12

REQUIRES:

Collaborations between farmers and installation effort.



SOURCE: (Boers & Ben-Asher, 1982), (Roy et al., 2024)

OBTAINED THROUGH: Literature study | Fieldwork observations

A 40 WATER INFILTRATION BOXES

GOAL:

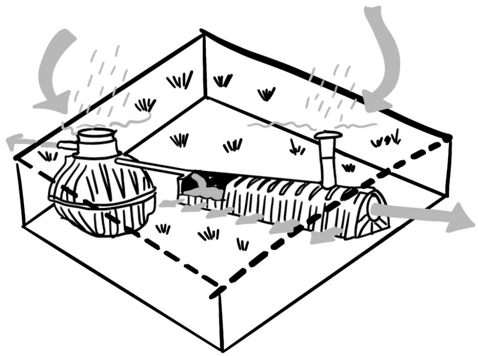
In arid and urbanised regions, soils often develop hydrophobic crusts that prevent water absorption, causing rainwater to run off rapidly during storm events. This leads to flooding, erosion, and pollution of local water bodies. Water infiltration boxes offer a local solution by allowing stormwater to percolate slowly into the subsoil, recharging groundwater while minimising runoff. These modular, underground containers, typically made from durable plastic or concrete, are installed beneath permeable surfaces like parking lots, gardens, or unpaved streets. The boxes collect stormwater from surrounding areas, filter it through gravel or geotextiles, and release it gradually into the underlying soil. This reduces pressure on drainage systems and supports water retention in the local ecosystem. Studies show infiltration systems significantly improve stormwater management and help mitigate the urban heat island effect by enhancing soil moisture content (Fach & Geiger, 2005). In the Port of Pančevo, Serbia, infiltration boxes were integrated into the stormwater system to reduce flooding and recharge groundwater (Stojanović et al., 2022).

OPERATIONALISES:

P13, P27

REQUIRES:

Investment, effort and time to install.



SOURCE: (Fach & Geiger, 2005), (Stojanović et al., 2022).

OBTAINED THROUGH: Literature study | Precedent study

A41 SOIL NETS/COVERS

GOAL:

Arid regions are particularly susceptible to soil erosion and desertification due to wind and water forces, leading to land degradation and reduced agricultural productivity. Implementing soil nets and covers can stabilise the soil surface, prevent erosion, and retain moisture, thereby combating land degradation and enhancing soil health.

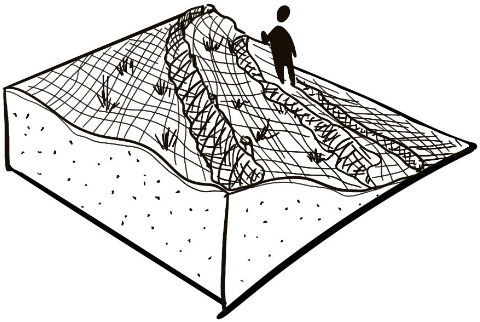
Soil nets and covers are materials applied over vulnerable soils to protect against erosive elements. These materials can be biodegradable or synthetic and are laid over the soil surface to shield it. They help in maintaining soil moisture by reducing evaporation rates, which is vital for plant growth in arid environments (AbdelRahman, 2023). Their application is crucial in areas with sparse vegetation cover, where the soil is exposed to the elements. These interventions are typically applied by land managers, farmers, and conservationists aiming to rehabilitate degraded lands and prevent further degradation. The implementation can be part of an integrated land management strategy.

OPERATIONALISES:

P1, P9, P13, P17

REQUIRES:

Effort and time to install and remove the covers.



SOURCE: (AbdelRahman, 2023)

OBTAINED THROUGH: Literature study | Fieldwork observations

A42 BIOCHAR/HYDROGELS

GOAL:

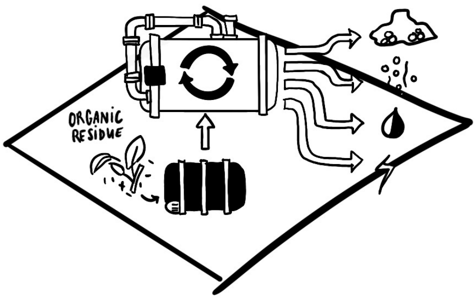
Degraded soils in arid regions often suffer from poor structure, low nutrient content, and limited water retention capacity, reducing agricultural productivity and ecosystem resilience. Incorporating biochar and hydrogels into the soil can significantly improve both fertility and moisture retention, supporting healthier plant growth and increasing drought resilience. Research shows that integrating biochar with hydrogels improves water use efficiency and crop performance in dryland farming (Głąb et al., 2016). Biochar, a carbon-rich byproduct of biomass pyrolysis, improves soil structure, enhances nutrient retention, and increases microbial activity. Hydrogels, superabsorbent polymers, can retain large volumes of water relative to their mass and release it slowly to plant roots during dry periods. Combined, biochar and hydrogels enhance the physical and chemical properties of the soil, reducing the need for irrigation and chemical fertilizers, and increasing crop yields sustainably. These materials are typically mixed into the topsoil by farmers or land managers during field preparation.

OPERATIONALISES:

P1, P9, P13

REQUIRES:

Investment to buy biochar and hydrogels and effort and time to mix the toplayer of the soil.



SOURCE: (Głąb et al., 2016).

OBTAINED THROUGH: Literature study

A43 SAND DAMS

GOAL:

In arid and semi-arid regions, conventional dams often disrupt river ecosystems, block sediment flow, and lead to high water loss through evaporation. Sand dams offer a more sustainable alternative by supporting ecological flow while storing water efficiently. Built across seasonal riverbeds, sand dams are simple concrete or stone barriers that allow sand and coarse sediment to accumulate during rainy seasons, with water trapped between the sand particles.

Over time, these dams create natural underground reservoirs that significantly reduce evaporation losses and provide communities with a reliable source of clean water throughout the dry season (Mureithi, 2024). They are community-managed, low-cost, and long-lasting, making them particularly suitable for decentralised, climate-resilient water strategies.

OPERATIONALISES:

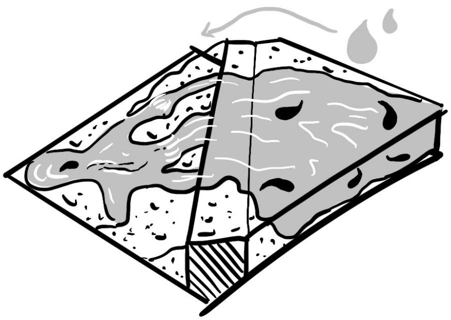
P12, P15

REQUIRES:

P14, P16

R9 / R12

Community involvement and changed policies on the management of dams and reservoirs.



SOURCE: (Mureithi, 2024)

OBTAINED THROUGH: Literature study | Precedent study

A44 FISH BYPASSES NEAR INFRASTRUCTURES

GOAL:

Dams and culverts can obstruct wildlife migration routes. Installing bypasses allows fish and other aquatic species to navigate around barriers, maintaining ecological connectivity and biodiversity. These structures are integrated into existing infrastructures to facilitate safe passage. This intervention contibutes to the restoration of ecological flows of rivers, a requirement set by the EU WFD that needs to be met before 2027.

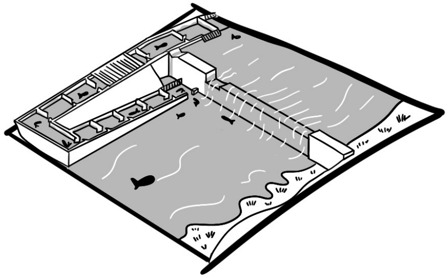
For instance, the Hemelinger Dam on the Weser River in Germany features a fishway system that includes a bypass channel designed to aid salmon, trout, and eels in their migration (Zumbrägel, 2024). This design, developed in collaboration with Norwegian experts, has been instrumental in restoring access to upstream habitats for these species.

OPERATIONALISES:

P15, P18

REQUIRES:

Research on fish populations present and investment, time and effort to install fish bypasses.



SOURCE: (Zumbrägel, 2024).

OBTAINED THROUGH: Literature study | Precedent study

A45 CULVERTS

GOAL:

In agricultural and peri-urban landscapes, unmanaged surface water flow through ditches and channels can cause significant erosion, infrastructure instability, and disruption of aquatic and riparian habitats. Culverts offer a sustainable engineering solution to control this flow, prevent erosion, and protect surrounding ecosystems.

Culverts are enclosed structures (typically made of concrete, steel, or plastic) installed beneath roads, field crossings, or embankments to allow water to pass through while maintaining surface connectivity. When designed and placed strategically, they regulate stormwater discharge, reduce sediment transport, and support biodiversity by maintaining hydrological and ecological continuity in waterways. Properly designed culverts can mitigate erosion and sustain aquatic biodiversity (O'Shaughnessy et al., 2016).

OPERATIONALISES:

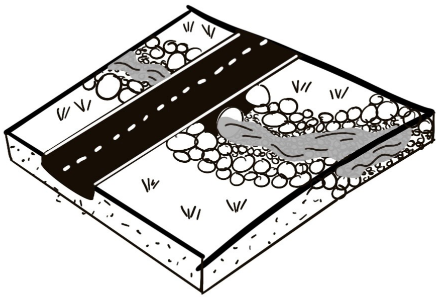
P18, P20

REQUIRES:

A29 / A37

Effort and time to install the culverts.

A29



SOURCE: (O'Shaughnessy et al., 2016).

OBTAINED THROUGH: Design intuition | Literature study

A46 ANIMAL CROSSING NEAR ROAD INFRASTRUCTURES

GOAL:

Expanding road infrastructure in rural and natural areas often leads to habitat fragmentation, wildlife mortality due to vehicle collisions, and disruption of ecological connectivity. Animal crossings, including vegetated overpasses and tunnel-like underpasses, are effective mitigation strategies that restore habitat continuity and ensure safe passage for wildlife across transport corridors.

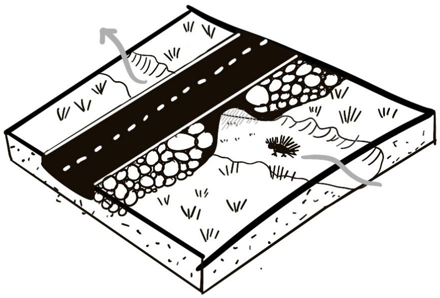
These structures are designed based on species-specific movement patterns, terrain, and surrounding ecosystems. Overpasses are typically covered with native vegetation to mimic natural landscapes, while underpasses may be dry or stream-adapted tunnels that support terrestrial and aquatic species. Research has demonstrated their effectiveness in increasing wildlife movement and decreasing mortality (van der Ree et al., 2015).

OPERATIONALISES:

P18, P20, P23

REQUIRES:

Investment, effort and time to install the structures.



SOURCE: (van der Ree et al., 2015).

OBTAINED THROUGH: Design intuition | Literature study

A 47 GARDEN & URBAN PONDS

GOAL:

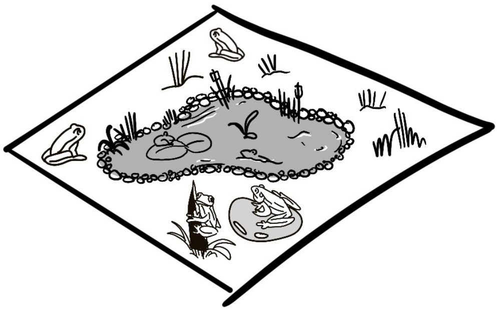
Urbanisation reduces natural water bodies, leading to biodiversity loss, poor microclimate regulation, and increased runoff. Integrating urban ponds and fountains into green spaces reintroduces aquatic ecosystems, supports local wildlife, and enhances stormwater management. Designed with native plants and varied depths, they provide habitats, cool urban spaces, and store rainwater. Implementation could be as small and easy as a water bucket installed in a garden by an individual resident. Larger water features also contribute to recreational and aesthetic quality and temperature control of the urban area. When connected to green-blue infrastructure or rainwater systems, they become vital components of urban climate adaptation and biodiversity strategies.

OPERATIONALISES:

P20, P27

REQUIRES:

Depending on the size of the installation, little to moderate installation investment and effort.



OBTAINED THROUGH: Design intuition

A 48 BEE HIVES & BUG-PLANTS

GOAL:

Pollinator populations are rapidly declining due to habitat fragmentation, pesticide use, and climate stress, threatening both food security and ecosystem resilience. The installation of bee hives, combined with bug-attracting plants, strengthens local pollinator networks and supports biodiversity in agricultural and urban areas. Managed hives provide habitat for honeybees, boosting pollination for fruit trees, vegetables, and flowering crops. Complementary planting of pollinator-friendly species such as Buddleja davidii (butterfly bush), lavender (Lavandula angustifolia), echinacea, wild thyme, and native flowering herbs increases nectar availability and attracts a range of beneficial insects, including butterflies, solitary bees, and ladybugs. These insects contribute to natural pest control, soil health, and ecosystem stability.

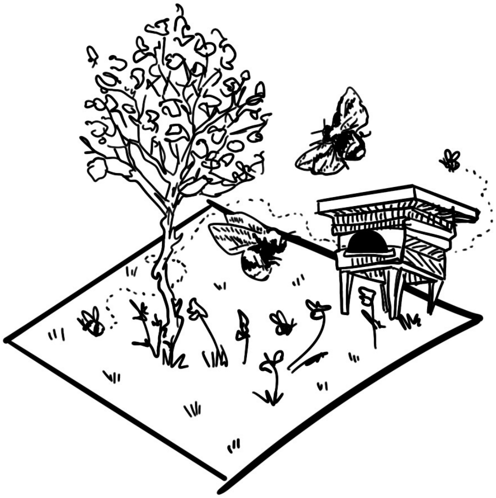
By integrating hives and targeted planting schemes into green infrastructure or farm edges, this intervention creates microhabitats, improves yields, reduces dependency on chemical inputs, and contributes to resilient landscapes.

OPERATIONALISES:

P1, P13, P20, P23

REQUIRES:

Research on pollinators and bug-attracting plants, effort and time to install and manage bee hives.



OBTAINED THROUGH: Design intuition

A 49

URBAN GREEN STRIPS

GOAL:

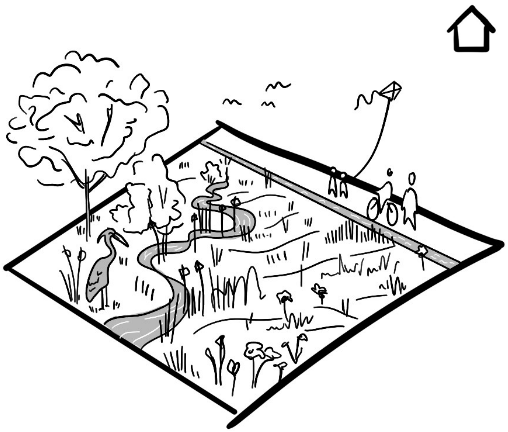
Dense urban areas often suffer from heat islands and poor air quality due to a lack of green spaces. Fieldwork observations have revealed that urban areas in the region often lack green spaces that could provide cooling of the environment. Integrating green strips along streets and between buildings can mitigate these issues by enhancing urban biodiversity, lowering temperatures, and improving air quality. These vegetated corridors also promote water infiltration, increasing soil moisture and aiding flood control. Incorporating green strips into urban planning offers multifunctional ecological benefits that improve the livability and resilience of cities.

OPERATIONALISES:

P13, P18, P20, P27

REQUIRES:

Investment and installation of green(-blue) infrastructures.



OBTAINED THROUGH: Design intuition

A 50

BIRD HOUSES

GOAL:

In the Segura River Basin, habitat fragmentation due to agriculture and urban development has led to a decline in nesting sites for cavity-nesting birds, impacting biodiversity and ecosystem services. Installing bird houses offers a practical solution to provide essential nesting habitats, particularly for species such as the Eurasian hoopoe (Upupa epops), European roller (Coracias garrulus), great tit (Parus major), and little owl (Athene noctua). Strategically placing these bird houses on trees, poles, or structures near fields, orchards, and riverbanks can enhance breeding opportunities. Complementary planting of native vegetation, including holm oak (Quercus ilex), Aleppo pine (Pinus halepensis), mastic tree (Pistacia lentiscus), and strawberry tree (Arbutus unedo), provides food sources and shelter, further supporting avian populations.

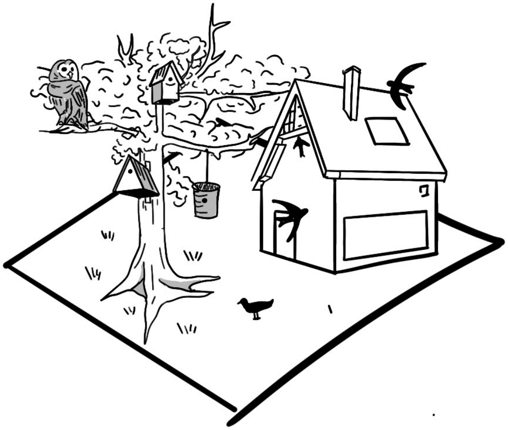
For practical implementation, resources such as the NestWatch program offer guidance on constructing and placing bird houses suitable for various species (NestWatch, 2024).

OPERATIONALISES:

P1, P18, P20, P23

REQUIRES:

Research on native bird species and their nesting behaviour, installation of specific bird houses and / or planting of special trees.



SOURCE: (NestWatch, 2024).

OBTAINED THROUGH: Design intuition | Desk research

A51 WIND ENERGY FARMS

GOAL:

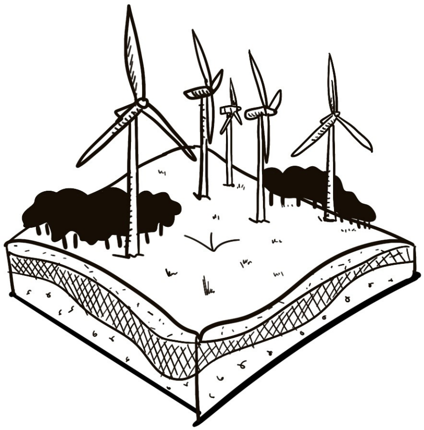
High fossil fuel dependency limits the sustainability of energy-intensive systems like desalination or industrial agriculture. Wind energy farms offer a clean alternative by harnessing kinetic wind energy through turbines, reducing carbon emissions and supporting green infrastructure. Placing turbines in consistently windy areas or integrating them into agricultural settings (like greenhouse farms) can meet local energy demands sustainably. For example, in the Netherlands, entrepeneurs and residents of the village Reissel initiated the "Agro-wind" project in 2016, which combines wind energy production with greenhouse farming, powering local food production with on-site renewable electricity (Vereniging High Tech Agro Campus, n.d.).

OPERATIONALISES:

P5, P8, P21

REQUIRES:

High investment costs and installation effort, consideration of nature and visual disturbance, connection to energy-intensive industries and the elektricity network.



SOURCE: (Vereniging High Tech Agro Campus, n.d.).

OBTAINED THROUGH: Design intuition | Precedent study

A52 SOLAR FARMS

GOAL:

Traditional energy production contributes significantly to greenhouse gas emissions. Solar farms utilizing photovoltaic (PV) panels offer a renewable alternative by converting sunlight into electricity. Deploying PV panels in open areas, on rooftops, agricultural fields, or over water bodies maximizes solar energy capture. Integrating these systems with energy-intensive industries (such as cooling facilities, desalination plants, and wastewater treatment) enhances sustainability. Updating greenhouses can include the installation of PV panels as well.

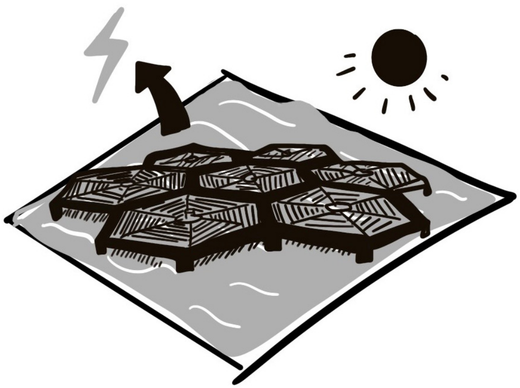
A notable example is the "Sun-on-canal" pilot project in the Netherlands, where solar panels were installed over a canal to generate energy for a nearby fish lift, demonstrating efficient land use and renewable energy production (Dutch water sector, n.d.).

OPERATIONALISES:

P5, P8, P21

REQUIRES:

Investment costs, installation and connection to the energy network.



SOURCE: (Dutch water sector, n.d.).

OBTAINED THROUGH: Design intuition | Precedent study

A53 SOIL WASHING

GOAL:

Contaminated soils threaten ecosystems and human health, especially in former industrial, mining, or dumping zones. In order for these areas to transition to natural areas or farmland, the soil has to be decontaminated and treated first. Soil washing is a remediation technique that physically or chemically separates pollutants (such as heavy metals or hydrocarbons) from soil particles. This method enables the safe reuse of land for natural regeneration or urban development. In highly polluted zones where phytoremediation is insufficient, soil washing offers an effective first step. For example, the Bunker Hill Superfund site in Idaho, USA, successfully applied soil washing to remove lead contamination from residential yards (US EPA, 2012).

SYMBIOSIS:

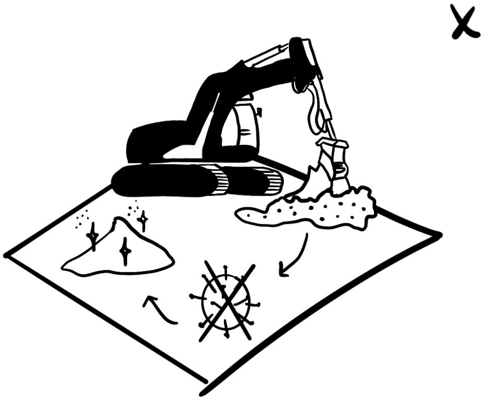
This intervention can be well compared with land transformation to natural area of former farmlands (P1), or reforestation projects in former urban mining areas (P18).

OPERATIONALISES:

P13, P22

REQUIRES:

Investment, effort and time to treat the soil. Causes disruption of the local natural environment.



SOURCE: (US EPA, 2012)

OBTAINED THROUGH: Literature study

A54 HELOPHYTE FILTERS

GOAL:

Wastewater discharge can degrade aquatic ecosystems by introducing excess nutrients and pollutants. Helophyte filters are implementd in constructed wetlands that use rooted wetland plants (like Phragmites australis) that naturally treat wastewater by filtering and breaking down contaminants. When integrated into wadis or constructed wetlands, they enhance water quality and restore habitats for birds, fish, and other aquatic species. A notable example is the use of helophyte filters in the Horstermeer Polder, Netherlands, which improved water quality while supporting biodiversity recovery (Tanner, 2001).

SYMBIOSIS:

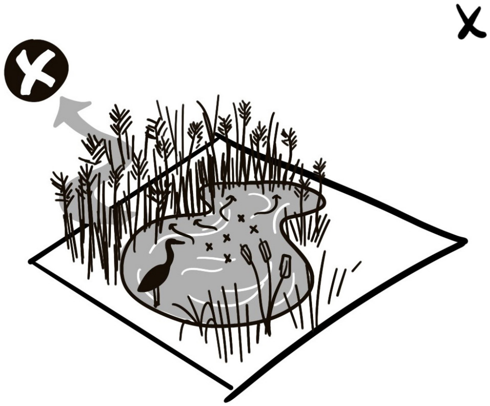
This intervention can be well compared with land transformation to natural area of former farmlands (P1), expanding protected nature (P19) or wetland areas (P25) and floodplains (P26), or local wastewater treatment, for instance in the form of agricultural return flow systems (P9/A39).

OPERATIONALISES:

P11, P13, P22

REQUIRES:

Research on the right filtering plants for the situation, investment in and the planting of the plants, and time for the plants to do the work.



SOURCE: (Tanner, 2001)

OBTAINED THROUGH: Literature study

A 55 PHYTOEXTRACTION

GOAL:

Heavy metals in soils can be toxic to life forms and threaten ecosystem and food chain health. Phytoextraction involves cultivating hyperaccumulator plants that absorb heavy metals such as lead, cadmium, or arsenic through their roots, gradually cleaning the soil. These plants are harvested and safely disposed of or processed. For example, Thlaspi caerulescens has been successfully used in contaminated sites in Europe to extract zinc and cadmium from soils, offering a sustainable remediation alternative to excavation (McGrath & Zhao, 2003).

SYMBIOSIS:

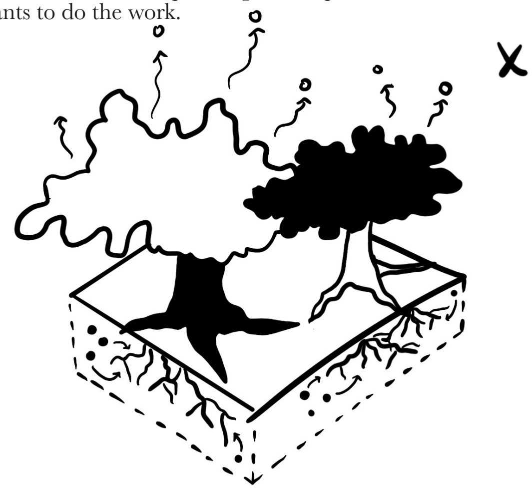
This intervention can be well compared with land transformation to natural area of former farmlands (P1), or reforestation projects in former urban mining areas (P18).

OPERATIONALISES:

P13, P22

REQUIRES:

Research on the right filtering plants for the situation, investment in and the planting of the plants, and time for the plants to do the work.



SOURCE: (McGrath & Zhao, 2003)

OBTAINED THROUGH: Literature study

A 56 PHYTOSTABILISATION

GOAL:

Contaminated soils can spread pollutants such as heavy metals or excess nitrates to surrounding ecosystems and water sources. Phytostabilisation uses specific plant species to immobilise these contaminants in the soil, reducing their mobility and ecological risk. This technique is especially valuable in agricultural areas with nitrate accumulation. For instance, in Spain's Guadiamar River valley, native plants like Populus alba (white poplar) and Tamarix gallica were used to stabilise toxic metals after a mining spill, effectively containing soil contamination and supporting vegetation recovery (Madejón et al., 2004).

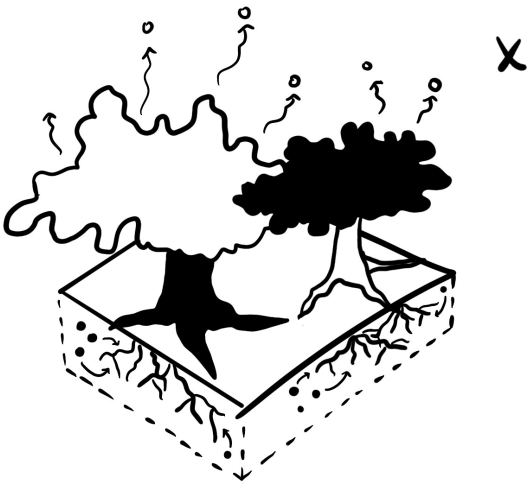
SYMBIOSIS:

This intervention can be well compared with land transformation to natural area of former farmlands (P1), or reforestation projects (P18).

OPERATIONALISES:

P13, P22

REQUIRES:



SOURCE: (Madejón et al., 2004).

OBTAINED THROUGH: Literature study

A 57 PHYTODEGRADATION

GOAL:

Organic pollutants in soils and water can persist and harm ecosystems. Phytodegradation employs specific plant species to enzymatically break down organic contaminants into less harmful substances, offering a natural and cost-effective solution for environmental remediation. For example, hybrid poplar trees have been successfully used to degrade trichloroethylene (TCE), a common industrial solvent, at contaminated sites in the U.S., where they helped reduce soil and groundwater pollution (EPA, 2000). This demonstrates the potential of phytodegradation in mitigating chemical pollution in vulnerable landscapes.

SYMBIOSIS:

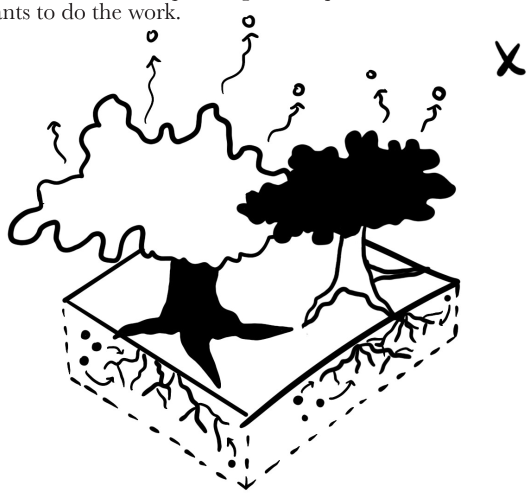
This intervention can be well compared with land transformation to natural area of former farmlands (P1), expanding protected nature areas (P19), or reforestation projects (P18).

OPERATIONALISES:

P13, P22

REQUIRES:

Research on the right filtering plants for the situation, investment in and the planting of the plants, and time for the plants to do the work.



SOURCE: (EPA, 2000)

OBTAINED THROUGH: Literature study

A 58 RAIN WATER COLLECTION ON ROOFTOPS

GOAL:

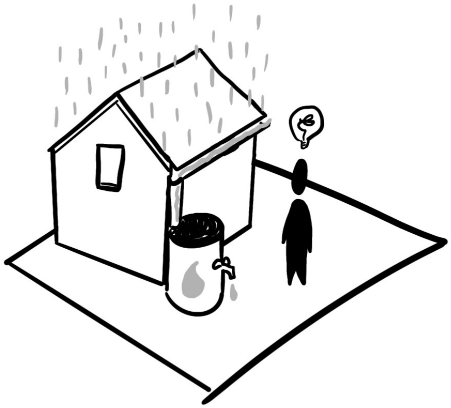
Urban runoff wastes valuable freshwater and contributes to flooding. By collecting rainwater from rooftops, cities can reduce this loss and create a decentralised, non-potable water source for irrigation, cleaning, or toilet flushing. Simple gutter systems and rooftop tanks enable efficient capture. Green roofs further enhance rainwater retention while cooling urban areas and improving air quality. This relatively small intervention contributes to a reduction in domestic water demand, improves water resilience and climate adaptation, particularly in arid regions with seasonal rainfall, by increasing the storage capacity and providing a water buffer in times of need.

OPERATIONALISES:

P7, P10, P27

REQUIRES:

Little investment and installation effort.



OBTAINED THROUGH: Design intuition

A59 WADIS & URBAN WATERSQUARES

GOAL:

Flash floods in arid regions can cause erosion and property damage. Wadis, or dry riverbeds, channel stormwater during rains, reducing flood risks and replenishing groundwater. These natural or engineered channels are maintained to manage episodic water flows. Next to this advantage, they improve water infiltration in the soil as water can be drained better. An example is the case of water qows through Jeddah city in Saudi Arabia that were installed after modelling that was done as a response to the flash floods of 2009 (Marko et al., 2022). Watersquares can be installed in urban spaces such as playgrounds or empty plots, to form temporal water buffers in heavy rain events, without compromising the urban space for natural area. An example is the water square in Rotterdam, where a sportsfield, playground and water buffer are combined in one area (de Urbanisten, 2013).

SYMBIOSIS:

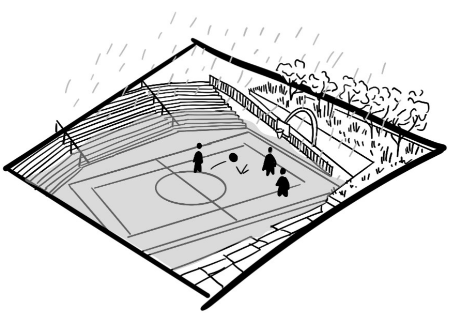
This intervention can be well compared with water infiltration boxes (A40).

OPERATIONALISES:

P13, P26, P27

REQUIRES:

Investment, effort, space in urban areas and time to plant and install the wadis or water squares. Attachment to a drainage system.



SOURCE: (Marko et al., 2022), (De urbanisten, 2013)

OBTAINED THROUGH: Literature study | Precedent study

A60 PERMEABLE PAVEMENTS

GOAL:

Urban areas with high percentages of impervious surfaces contribute to excessive runoff, flooding, and groundwater depletion. By applying permeable materials such as porous asphalt, permeable concrete, semi-paved surface, or semi-permeable surfacing like gravel or stabilised sand, water can infiltrate the soil, reducing flood risks and supporting aquifer recharge. Incorporating these materials into sidewalks, streets, and public spaces, especially in new developments, enhances urban climate resilience while improving the quality and usability of public space.

SYMBIOSIS:

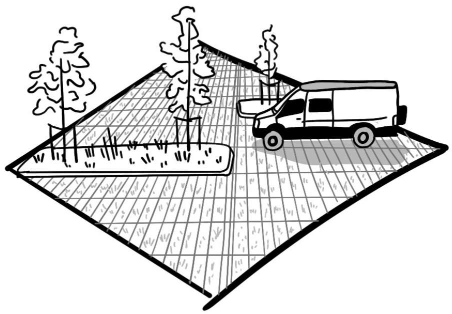
This intervention can be well compared with water infiltration boxes (A40).

OPERATIONALISES:

P13, P27

REQUIRES:

Effort and investment to change the pavement.



OBTAINED THROUGH: Design intuition

A61 URBAN VEGETATED FLOOD QUAYS

GOAL:

Urban rivers often lack natural floodplains, resulting in increased flood risk, ecological degradation, and limited public engagement with water. By implementing multi-level vegetated flood quays, cities can provide controlled space for river overflow, reducing the impacts of floods while enhancing erosion control and riverbank stability. These green river edges also support urban biodiversity and create accessible, attractive public spaces. In Murcia, for example, the Segura River's lower cycling paths illustrate how such quays can be both functional and recreational. Expanding and greening these quays can turn rivers into shared, resilient urban assets and contribute to the restoration of the ecological flow of rivers and establishment of nature-based recreation possibilities.

SYMBIOSIS:

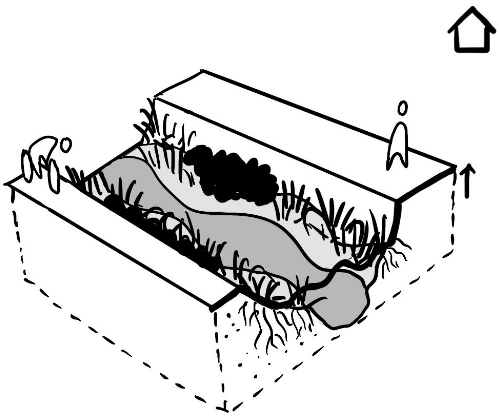
This intervention can be well compared with urban green strips (A49) to create a green-blue network in the form of ecological corridors (P18).

OPERATIONALISES:

P18, P20, P26, P27

REQUIRES:

Investment, time and effort to create vegetated floodways and change current quays.



SOURCE: Murcia, Segura river
OBTAINED THROUGH: Fieldwork observations | Precedent study

A62 CLIMATE NEUTRAL GOLF COURSE TRANSFORMATION

GOAL:

Conventional golf courses in arid regions consume large amounts of water, degrade local ecosystems, and contribute little to climate resilience. Transforming these spaces into climate-neutral ecotourism centres can reduce environmental impact while preserving their recreational and economic function. By repurposing existing infrastructure for sustainable lodging, environmental education, and low-impact tourism, these resorts can promote awareness of water scarcity, biodiversity, and land restoration. Such adaptive reuse fosters a shift in mindset toward responsible recreation and supports regional sustainability goals. Examples of such transitions exist already. For instance, Helidon Spa in Queensland Australia is an example where a golf course has transitioned to an agrotourism centre in the form of a climate-neutral eco-village (Helion Spa Eco Village, n.d.).

SYMBIOSIS:

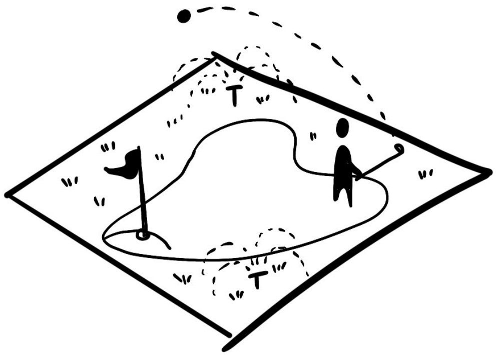
This intervention can be well compared with expansion of protected natural areas (P19).

OPERATIONALISES:

P22, P28

REQUIRES:

Attraction of a different kind of tourist, social acceptance and a changed perspective related to climate adaptation and nature restoration efforts.



SOURCE: (Helion Spa Eco Village, n.d.)
OBTAINED THROUGH: Design intuition | Precedent study

A 63 ELEVATED WALKING PATHS

GOAL:

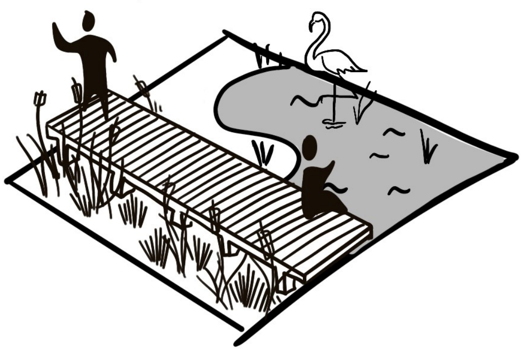
Flood-prone and wetland areas often remain underutilised due to limited accessibility, which restricts public engagement and ecological awareness. Fieldwork observations have shown a disruption of the natural landscape due to a lack of walking paths in natural areas. Introducing elevated walking paths can provide safe access to these sensitive environments while minimising ecological disturbance. By lifting foot traffic above ground level, boardwalks protect habitats, reduce soil compaction, and enable eco-tourism and educational activities. This low-impact infrastructure encourages stewardship of wetland ecosystems and helps integrate natural landscapes into recreational and urban planning strategies.

OPERATIONALISES:

P22, P28

REQUIRES:

Investment, effort and time to install the paths, maintenance.



OBTAINED THROUGH: Fieldwork observations | Design intuition

A 64 AMPHIBIOUS RECREATIONAL PARKS

GOAL:

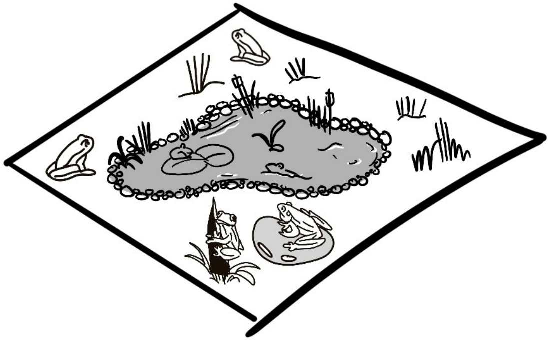
Urban development often disconnects people from aquatic ecosystems, while flood-prone zones remain underused. Amphibious parks create adaptable public spaces that respond to fluctuating water levels. By combining wetlands, floating elements, and elevated walkways, they support recreation, flood resilience, and biodiversity. Frogs and small wildlife thrive here, attracting birds and enriching the food chain. Maintaining these parks and opening them for recreation and educative purposes can improve the human-nature connection. An example in the region is the Carrascoy and El Valle Regional Park near Murcia, which hosts CRFS El Valle, a wildlife recovery and education centre that exemplifies how green spaces can merge ecological and social goals. The park's combination of natural habitats, educational centres, and recreational amenities exemplifies how urban-adjacent green spaces can support both ecological and social objectives.

OPERATIONALISES:

P20, P27, P28

REQUIRES:

Investment, effort and time to install, as well as surveillance and maintenance.



OBTAINED THROUGH: Fieldwork observations | Design intuition

A 65 INFORMATIVE ECOTOURISM ROUTES & CENTRES

GOAL:

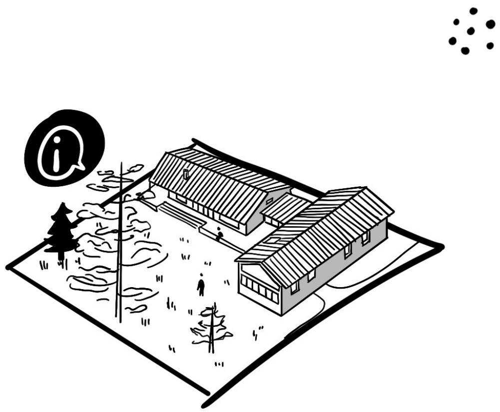
Public unawareness of local ecosystems and water challenges can lead to environmental neglect and unsustainable tourism, as fieldwork analysis has revealed. Informative ecotourism routes and centres educate visitors about ecological processes, biodiversity, and sustainable water use, fostering stewardship and local economic benefits. Trails, signage, and visitor centres are developed in collaboration with local communities and ecologists to highlight key natural and cultural features. For instance, the cultural heritage of the water system and information about special bird species and the value of salt mines can be explained in this route. When combined with agrotourism, the knowledge about indigenous dry farming, organic agriculture and innovative farming can be displayed. This approach not only educates tourists but also promotes conservation efforts and supports local economies. For instance, the Bay of Santander in Northern Spain demonstrates how community-led ecotourism initiatives can successfully conserve biodiversity while providing economic benefits to local residents (Sur de la Bahia, 2025).

OPERATIONALISES:

P22, P26, P27

REQUIRES:

Investment, time and effort to build information centres. Knowledge, survaillanve and maintenance.



SOURCE: (Sur de la Bahia, 2025)

OBTAINED THROUGH: Fieldwork observations, precedent study

1. FOOD INDUSTRY LENS

Figure 1. Scenario 1 Organic Produce: interventions of the territorial lens: agriculture and food industry. Source: made by author.

2. NATURAL LANDSCAPE LENS

Figure 2. Scenario 1 Organic Produce: interventions of the territorial lens: natural layer. Source: made by author.

DESIGN SUGGESTION
SCENARIO BUILDING PROCESS

3. WATER MANAGEMENT LENS

Figure 3. Scenario 1 Organic Produce: interventions of the territorial lens: (urban) water management. Source: made by author.

Through following the relations between the patterns in the Pattern-Web structure from the top-down perspectice, and through the lens of a systemic layer, a design scenario can be created. To create a symbiotic design scenario for the water system transition, combinations within the three layers combined need to be made. Viewing the design from three lenses: the agriculture lens, the water management and urban planning lens, and the nature restoration lens, results in three different pattern-implementation layers per scenario. Combining them creates a symbiotic scenario. Through prioritising different pattern structures, different scenarios can be created. Combining these scenarios reveals patterns that are favoured in multiple situations, by multiple actors. These patterns can be called Symbiotic Interventions, or no-regret measures, and form the basis to a regional strategy.

How the first scenario is constructed is shown in Figures 1-5. More information about the project location, the scenarios, and the design process is given in the thesis report.

Figure 4. Map of the patterns applied in the sub-basin according to scenario 1. Source: made by author.

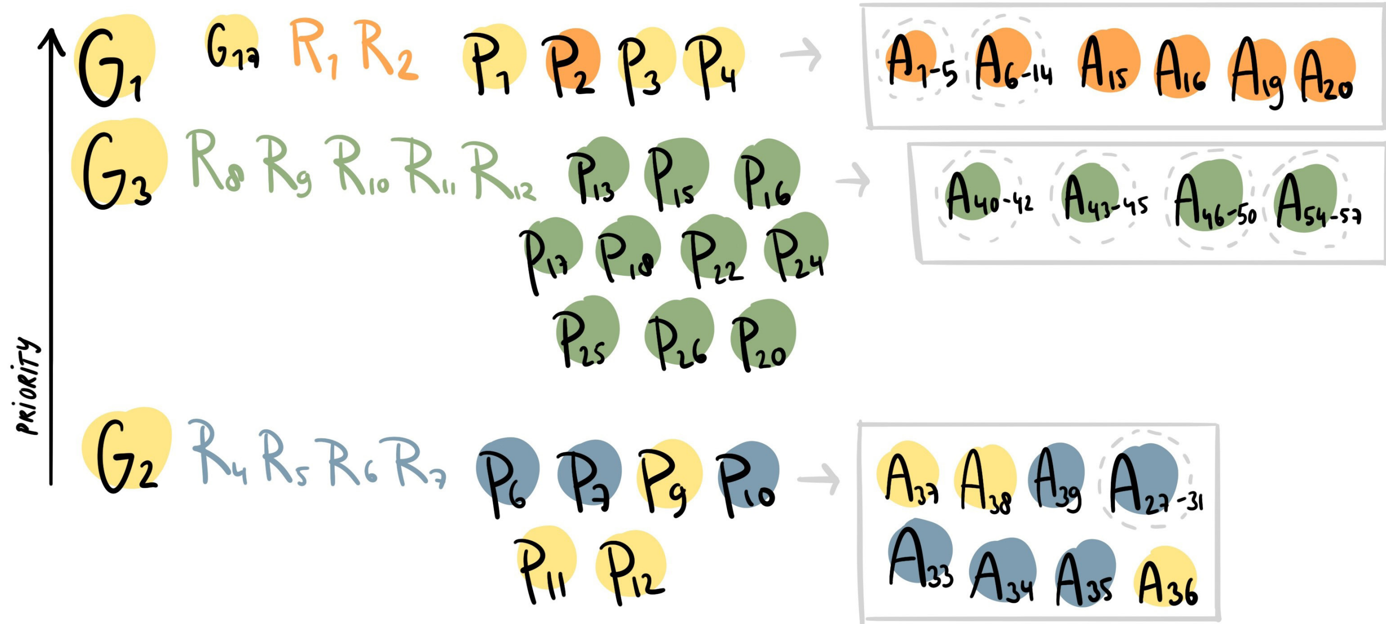
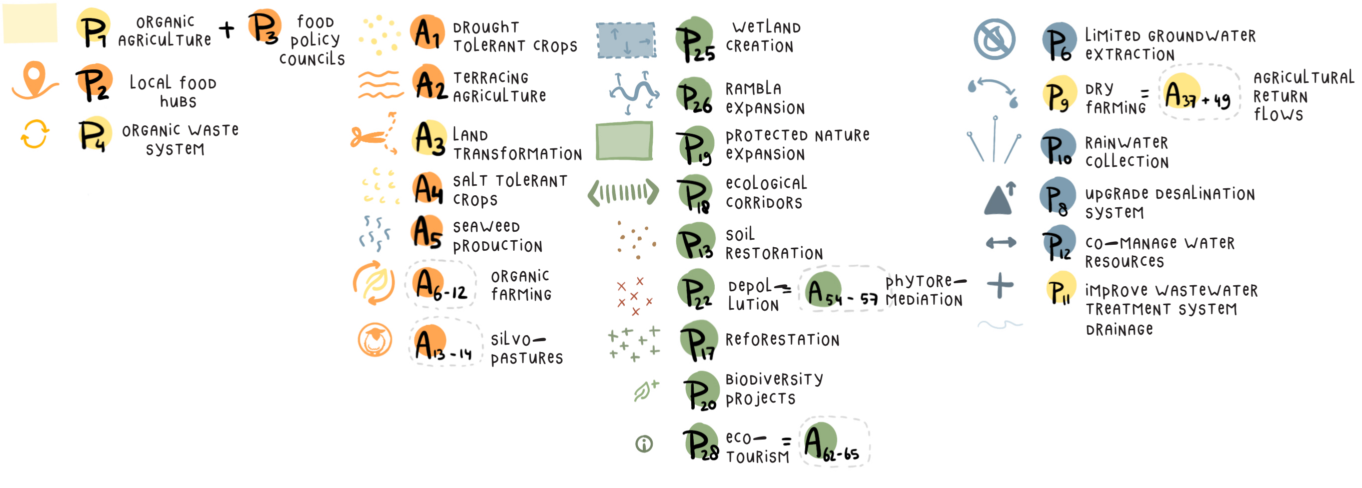
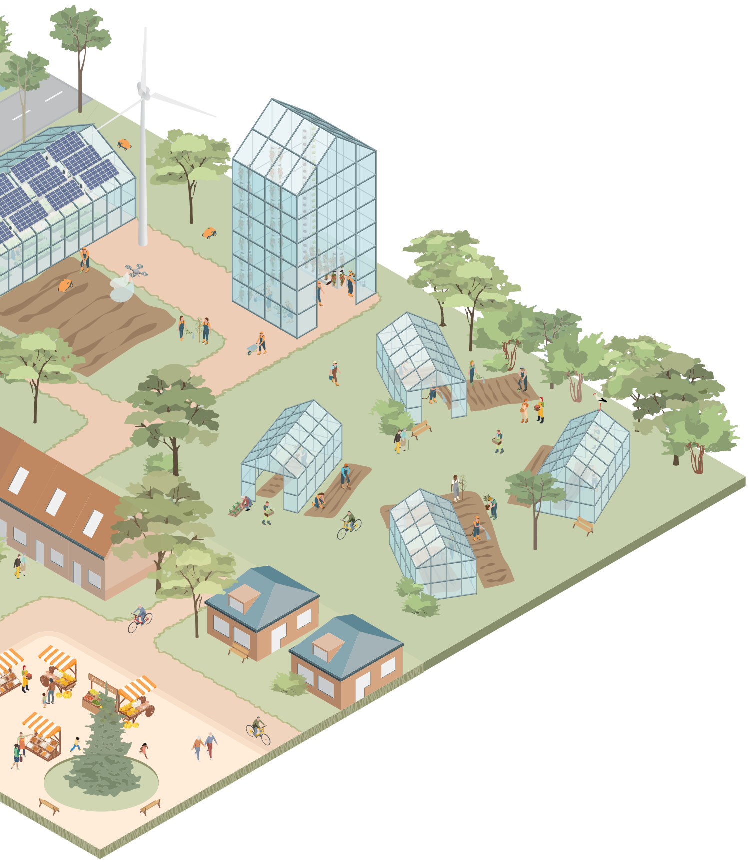


Figure 5. Selection of scenario based patterns for scenario 1. Source: made by author.



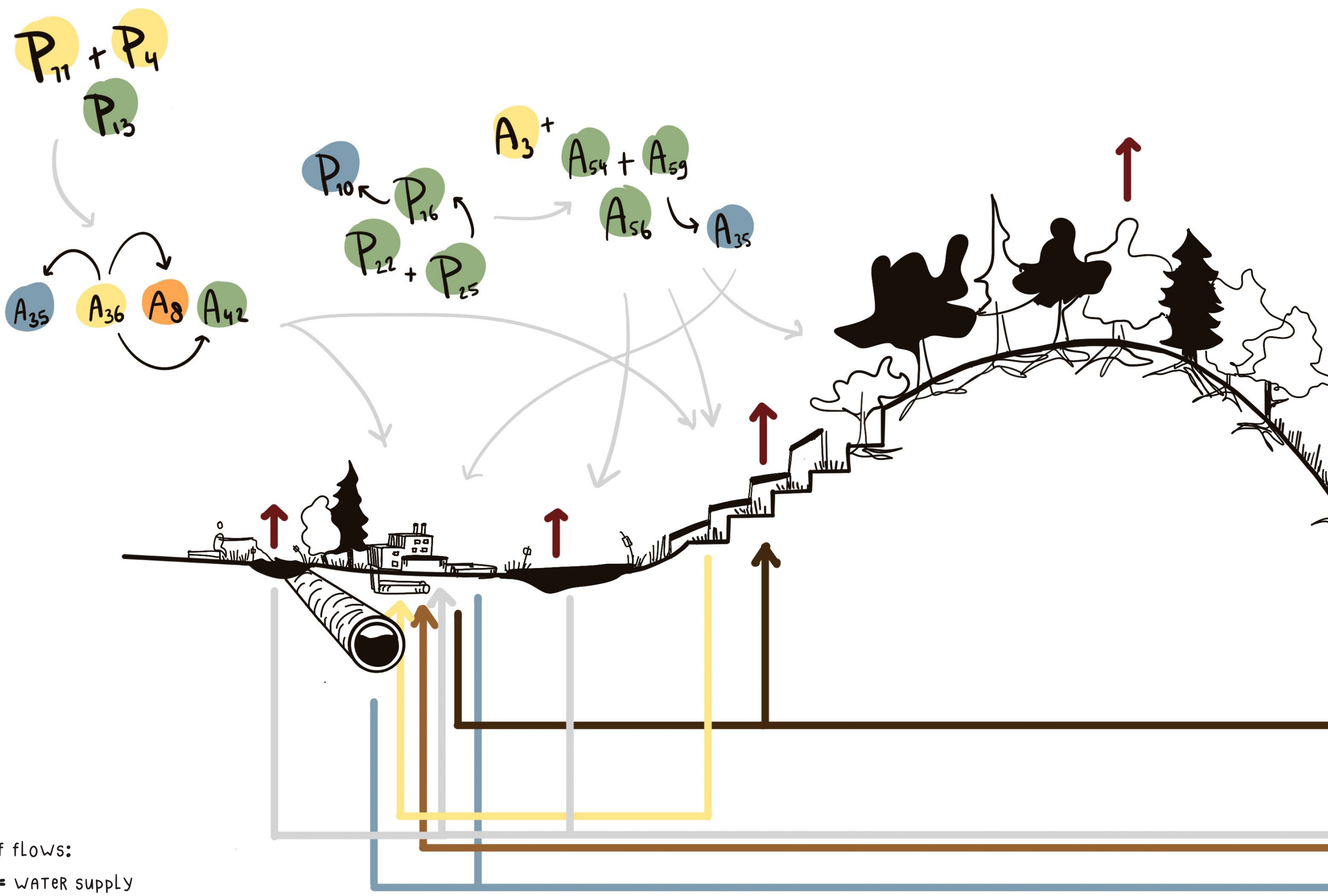

Visitor's Centre
Distribution



SYMBIOTIC PATTERN IMPLEMENTATION

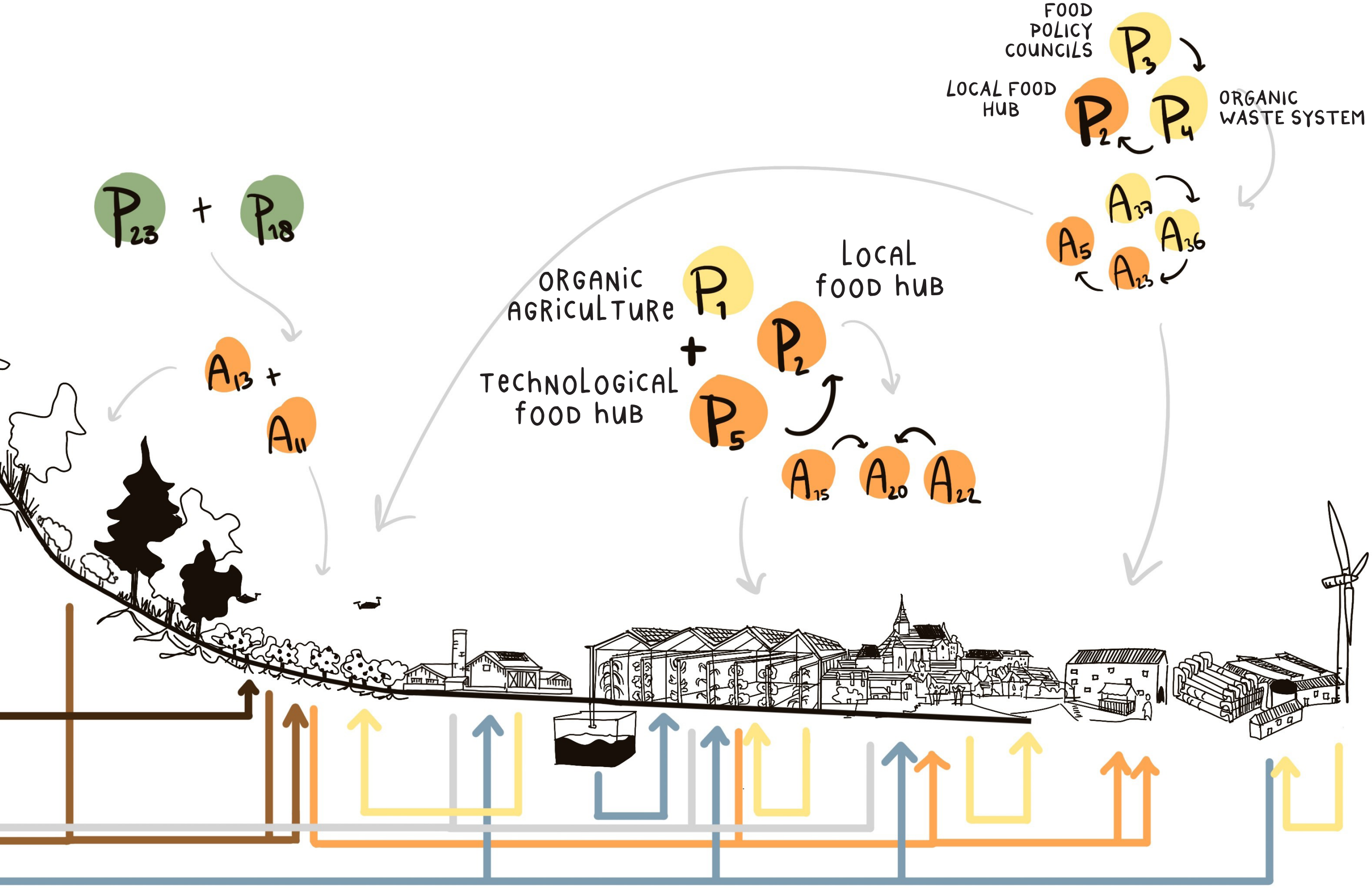
With this pattern language, a strategic project called "Pilot Greenhouse Hub" is created for a design location within the study area of the thesis. It forms one of the symbiotic pathways to complete the regional strategy, and is constructed by following the pathway structure from a bottom-up perspective, creating new pattern combinations.

This thesis shows that a symbiotic design method offers a promising approach to navigating the complexity of water system transitions in arid regions. By focusing on relationships between people, sectors, and ecosystems, the design strategy moves beyond fragmented solutions toward integrated, context-sensitive transformation. When diverse actors align around shared goals, systemic change becomes possible. The project facilitates this, by combining participatory methods and bottom-up initiatives with top-down governance, while using different tools to work through the scales and deal with stakeholder preferences and future uncertainties. The pattern language plays a key role in this, serving as a practical and expandable tool that helps people from different backgrounds understand each other, collaborate, and act. In this way, the project illustrates how designing for symbiosis can turn complexity into opportunity.



Legend of flows:

- = water supply
- = greywater
- = biochar
- = manure / organic mulch
- = pollution
- = food produce
- = energy


FOOD POLICY COUNCILS
LOCAL FOOD HUB
ORGANIC WASTE SYSTEM
P3
P2
P4
A37
A36
A5
A23
P23 + P18
A13 +
A11
ORGANIC AGRICULTURE
P1
+
P2
Local food hub
TECHNOLOGICAL food hub
P5
A15
A20
A22

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