Landscape-inclusive agriculture and drowning deltas

improving food security and flood control

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2023

A thesis submitted for the requirements for the

MASTER OF SCIENCE IN

LANDSCAPE ARCHITECTURE

at

WAGENINGEN UNIVERSITY

by

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9th of March 2023

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Abstract

Climate change is projected to cause widespread disruptions to global food systems. Additionally, the UN projects a significant increase in the world population by 2100, putting additional pressure on food systems that are already struggling to keep pace with growing demand. At the same time, available arable land is declining due to sea level rise and ground subsidence, causing deltas to drown. The challenges to the foodscape are complex and interrelated and will require innovative and integrated solutions.

Drowning deltas (DDs) need an integral approach for both food security and flood control. Landscape-inclusive agriculture (LIA) is an approach to farming that takes into account the diverse ecological, social and economic components of a region, and integrates these elements into farming practices to improve both food production and ecosystem health. In this approach collaboration between actors and sectors is underlined to create sustainable agriculture systems that benefit both people and the environment.

With this thesis, the objective is to create new knowledge on how to employ landscape-inclusive agriculture and thereby improve the food security and flood control of drowning deltas. The focus areas is the north-eastern Italian coast, a low lying agricultural coast with high rates of ground subsidence. For this landscape, principles have been developed to guide the landscape towards a resilient, future proof agricultural system, that accounts for both food security and flood control, using the integral approach of LIA.

Keywords: **landscape-inclusive agriculture, food security, flood control, drowning delta, foodscape, design principles**

Preface

This thesis is part of the Master Landscape Architecture at Wageningen University.

My passion for landscape and cooking collide in foodscapes. During my master I have immersed myself in courses that were related to foodscapes and health. As you will read, the foodscape is reaching its limits. As sea levels rise, as droughts become more prevalent, and the food security is at risk, it is our job to take action and create resilient food systems.

I am grateful for the all the opportunities: for going to Bibione and Rosolina. Thank you Giovanni and Alberto for your time and knowledge.

I want to thank my friends for their continuous support. I want to thank my parents for believing in me. And I want to thank Tom for keeping me sane during insane times.

Last but not least, I would like to thank my supervisors Lisanne Struckman and Yuting Tai for their support.

Inge van Wijk,

9th of March, 2023
Wageningen

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1 Introduction

1.1 Food and flood

Reaching the limits of the foodscape

Climate change is projected to cause widespread disruptions to global food systems, including reductions in crop yields due to increased temperatures and changing weather patterns, increased pest and disease pressure, and more frequent extreme weather events such as droughts and floods (figure 1). Due to climate change, major crop yields have decreased globally over the past 30 years by 4–10% (high confidence) (IPCC, 2022). Additionally, the UN projects a significant increase in the world population by 2100, putting additional pressure on food systems that are already struggling to keep pace with growing demand (UN, 2022). At the same time, available arable land is declining due to a range of factors, including urbanization, soil degradation, water scarcity, and sea level rise, and thereby reaching the limits of the foodscape. The challenges to the foodscape are complex and interrelated and will require innovative and integrated solutions, in particular the promotion of sustainable agriculture practices, to enhance food access and availability.

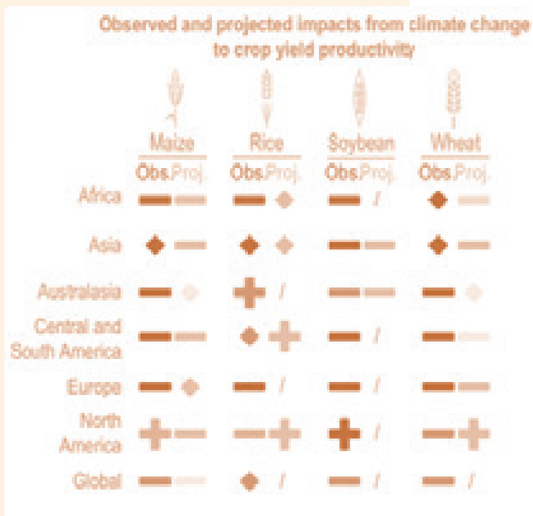


fig 1.projected crop yield (IPCC, 2022)

Fertile deltas under saline threat

With roughly 500 million people living in or close to river deltas, today's deltas are among the world's most densely populated regions (Edmonds et al., 2020). They have developed into centres of commerce and industry thanks to their incredibly fertile soil, convenient access to fisheries, and ideal location for major ports and harbours. However, deltas are particularly susceptible to natural disasters since their land is either very close to or completely -below sea level. Additionally, the majority of deltas are at risk of land subsidence, which increases their susceptibility to sea level rise, also known as a drowning delta (DD) (Schmidt, 2015).

It is in these areas specifically, where due to the fertile soils a significant amount of food is produced. Sea level rise increases the possibility of waterlogging, erosion, saltwater intrusion, and salinisation. These consequences all tend to have a negative impact on agriculture, which affects the food security of a region (Pacetti et al., 2017). Saltwater intrusion, for example, pushes farmers to (over)extract fresh water for their crops, resulting in increased ground subsidence rates and salinisation (Mastrocicco & Colombani, 2021). Salinisation has an impact on its environment by contaminating soils and waterbodies, impacting the area's food and water security (Herbert et al, 2015; Rahman et. al, 2019). Farmers rely on their expertise and experience, which is dependent on a stable climate. With climate change, their agricultural expertise and experience become rudimentary. As a result of climate change limiting farmers' ability to adapt, this puts farmers and, by extension, the food security of a region, at extreme risk (Turhan et al. 2015).

The case of the north-eastern Italian coast

A place where these food-flood problems are visible is the north-eastern Italian coast (figure 2). This area is characterised by a diverse agricultural sector, varying from maize to cattle, as well as ancient aquacultural practices. The Po delta, part of the north-eastern Italian coast, is of great economic importance accounting for roughly a thrird of Italy's GDP, with agriculture as leading sector (Bonaldo et al., 2022). The food security and flood risk of the north-eastern Italian coast are likely to be significantly impacted by climate change by the year 2100. According to projections, the region is expected to experience rising sea levels, increased frequency and severity of extreme weather events, and increased temperatures (IPCC, 2022). These changes will have significant impacts on the agricultural sector, affecting the food availability and accessibility. With the current climate reports, the IPCC predicts a 5mm global mean sea level rise per year by 2050. In the worst case scenario, a global mean sea level rise of 0.74m is predicted (IPCC, 2022). In addition to that, the area is prone to ground subsidence, with rates varying between 0-20 mm per year (Da Lio & Tosi, 2019). To address these challenges, it will be important for the north-eastern Italian coast to invest in adaptive measures such as coastal protection and resilient agricultural practices. Ultimately, there is a need to shift towards more sustainable and resilient food systems, including increased local food production and the promotion of sustainable agricultural practices.


REUTERS®

3 minute read · June 29, 2022 11:24 PM GMT+2 · Last Updated 7 months ago

Italy's drought-hit farmers face sea water threat

By Gabriele Pileri

fig 2 Italy’s drought-hit farmers face sea water threat (Reuters, 2022)

1.2 Problem statement & knowledge gap

The processes and impacts of sea level rise on agricultural deltas are known; however, there is very little research focussing on the implementation of adaptation responses into the landscape (Da Lio & Tosi, 2019), and therefore these studies fail to make the step to the spatial dimension. Solutions for flood control and food security have a significant impact on the current landscape, and will continue to do so. Scientific knowledge and tools developed for agriculture rarely support long-term goals, such as climate adaptation (Robertson & Murray-Prior, 2016). Short-term knowledge and tools significantly increase farmers' vulnerability to climate change and their capacity to adapt and, therefore, significantly decrease food security (Turhan et al., 2015). There are no design principles or guidelines stating how agriculture can be employed to improve the food security and flood control of an agricultural deltaic region.

For these reasons, the use of agriculture in the current assignment of designing future-proof deltaic landscapes remains an underexposed topic within the field of landscape architecture. Research is needed to develop a set of design principles which recognises the potential of landscape-inclusive agriculture to deal with food security and flood control. Landscape-inclusive agriculture (LIA) is an approach to farming that takes into account the diverse ecological, social and economic components of a region, and integrates these elements into farming practices to improve both food production and ecosystem health. In this approach collaboration between actors and sectors is underlined to create sustainable agriculture systems that benefit both people and the environment. This is a knowledge gap for landscape architects because the complex nature of the problem calls for an integral approach. It calls for a solution that does not only contribute to the agricultural sector and water management but also takes the surrounding landscape and other sectors into account (figure 3).

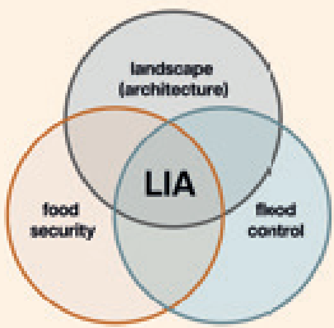


fig. 3 knowledge gap

1.3 Research objective and research questions

With this thesis, the objective is to create new knowledge on how to employ landscape-inclusive agriculture and thereby improve the food security and flood control of drowning deltas. This thesis also seeks to contribute to the higher goal of exploring the role and importance of flood-food nexus thinking has in the design of future-proofing deltaic regions. This refers to the interplay the interplay between food security and flood risks, considering both the immediate impacts of floods on food security and the underlying drivers of these impacts, such as climate change.

In order to reach the objective and fill the identified knowledge gap, the following main research question has been formulated:

What **design principles** can be developed to improve the **food security** and **flood control** of **drowning deltas** using **landscape-inclusive agriculture**?

To be able to answer the main research question (MRQ), the following sub research questions (SRQ) are formulated:

SRQ 1: What are the most important **landscape qualities** of the north-eastern Italian coastal landscape?

SRQ 2: What are the **future challenges** of drowning deltas and how does **landscape-inclusive agriculture** relate to these challenges?

SRQ 3: In what ways can **landscape-inclusive agriculture** improve the **food security** and **flood control** of north-eastern Italian **drowning deltas** in the future?

Expected outcomes for this thesis include:

1. A demonstration of how agriculture could be an opportunity, instead of a burden in a drowning landscape.
2. Generalised principles for agricultural deltaic regions, that show how landscape-inclusive agriculture can be used for designing and dealing with food security and flood control.
3. A demonstration of a variety of possible futures for agriculture in drowning deltas for the year 2100.

2 Research approach

In this chapter, the research methodology is described. Several concepts arise from the research objective and research questions, which are defined in section 2.1. Section 2.2 describes the research framework with overarching methodologies of Research for Design and Research through Design, and the used methods.

2.1 Concepts

Referring to the main research question:

'What **design principles** can be developed to improve the **food security** and **flood control** of **drowning deltas** using **landscape-inclusive agriculture**?',

the key concepts of this thesis are drowning delta, landscape-inclusive agriculture, food security, and flood control. These key concepts, among supporting concepts, can be found in the concept definition scheme (figure 4), and are highlighted in the paragraphs. The last three concepts (landscape quality, design principles, and scenarios) are not integrated into this scheme and are more important in setting baselines in relation to the methodology.

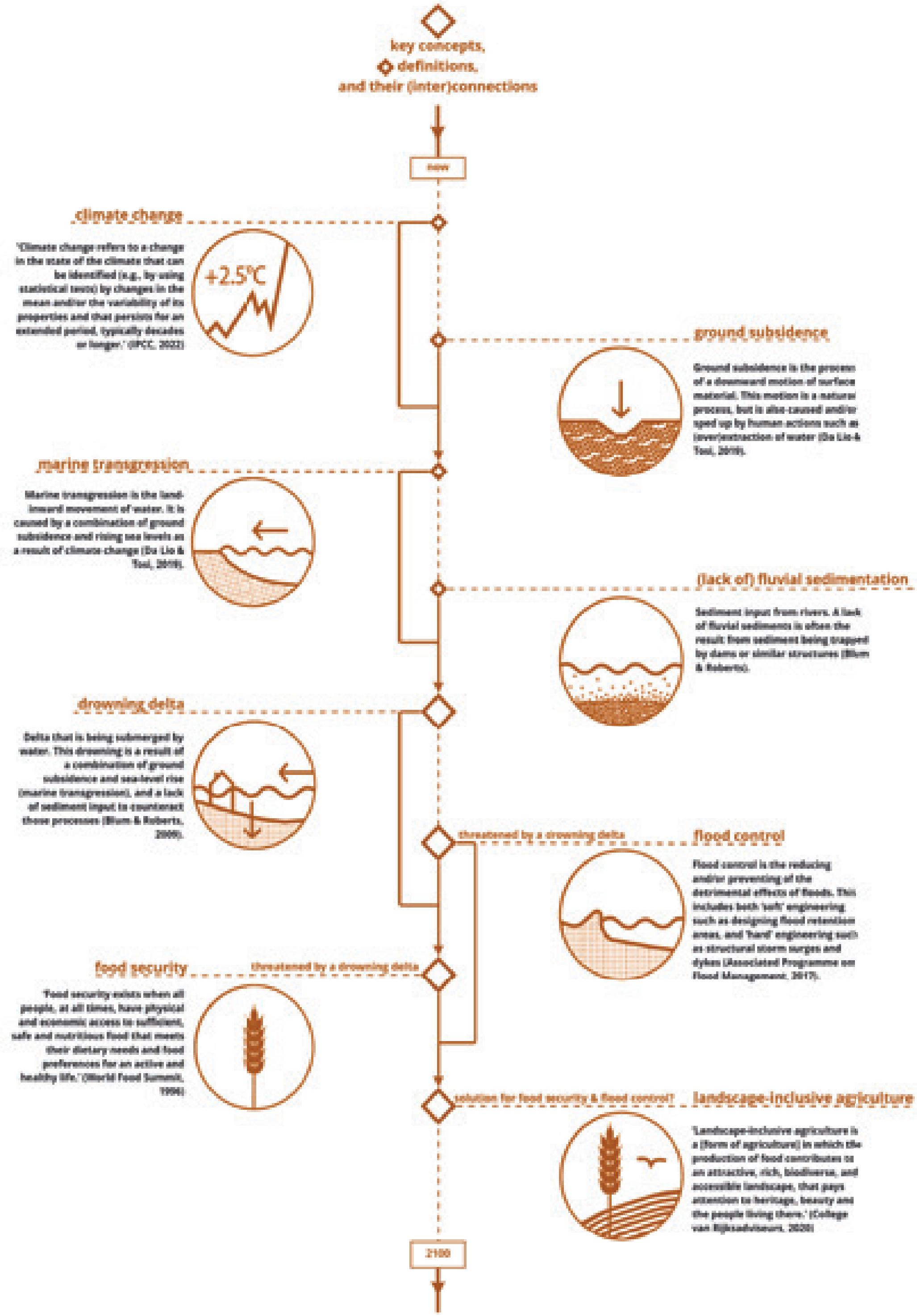


fig. 4 key concepts, definitions and their (inter)connections

Drowning delta

A **drowning delta (DD)** refers to a deltaic region that is under the pressure of sinking. Sea level rise due to **climate change** is increasingly making deltaic regions more vulnerable: in combination with **ground subsidence**, relative sea level rise is causing **marine transgression**. Marine transgression occurs when this relative sea-level rise cannot be compensated by a sufficient **sediment supply** (figure 4) (Rahman et al., 2019). This causes the sea to move land inwards, which is drowning deltas worldwide (Antonioli et al., 2017; Da Lio & Tosi, 2019). As DD's become increasingly vulnerable to sea-level rise and extreme weather events, food production can be severely affected by flooding, waterlogging (the ground being saturated with water), erosion, saltwater intrusion, and salinisation (Pacetti et al., 2017).

Landscape-inclusive agriculture

Landscape-Inclusive Agriculture (LIA) refers to an approach to farming that takes into account the diverse ecological, social and economic components of a region and integrates these elements into farming practices to improve both food production and ecosystem health (College van Rijksadviseurs, 2020). LIA is related to the more-known concept of nature-inclusive agriculture (NIA). LIA and nature-inclusive agriculture share many similarities in that both approaches aim to integrate natural elements, such as forests, wetlands, and wildlife, into agricultural systems. LIA, however, takes a broader view of the agricultural landscape, considering a region's diverse ecological, social, and economic components and the relationships between these elements. On the other hand, NIA focuses specifically on

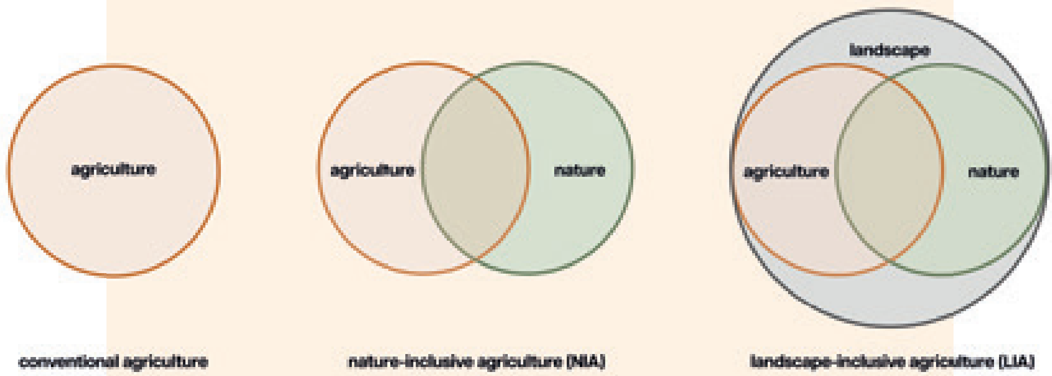


fig. 5 LIA and NIA

incorporating natural elements, such as wildlife and ecosystems, into agricultural systems (Westerink et al., 2021). Furthermore, LIA places greater emphasis on collaboration between systems, sectors, farmers, communities, policymakers, and other stakeholders to create sustainable agriculture systems. In contrast, NIA focuses on preserving and restoring natural ecosystems within agricultural landscapes (figure 5).

As introduced by the College van Rijksadviseurs, the definition of LIA is:

'[...] a [form of agriculture] in which food production contributes to an attractive, rich, biodiverse, and accessible landscape, that pays attention to heritage, beauty and the people living there.' (College van Rijksadviseurs, 2020)

The philosophy behind landscape-inclusive agriculture is rooted in recognising that food production and ecosystem health are inextricably linked, and that agricultural practices must be designed to support both. This approach is based on the belief that a healthy environment is essential for long-term food security and well-being and that food production must be sustainable, equitable, and resilient in the face of a changing climate.

LIA is a comprehensive approach that considers agriculture as part of the landscape system, while NIA focuses on enhancing biodiversity and ecosystem services within agricultural systems. This broad view and systems-thinking of LIA recognise the interconnectedness of food production and the landscape (including flood control), which is why it is a suitable concept for designing resilient agricultural systems in complex areas such as drowning deltas where water is both friend and foe.

Food security

Food security refers to the availability, access, and utilisation of food to meet the dietary needs and food preferences of people. The most common definition of food security is by the World Food Summit in 1996, and is still widely used as of today.

'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.' (World Food Summit, 1996)

The FAO has identified four pillars of food security:
-food availability
-food access,
-utilisation (non-food inputs),
-stability

Food availability focusses on a sufficient quantity of food (of appropriate quality), that is produced by farmers, domestic production and food import. This pillar will mainly be used in this thesis, as it applies best to agriculture: the supply side of food security. Additionally, food access (physical and economical) and stability (lack of disasters and conflict) are taken into account. Maintaining food security requires coordination among multiple sectors, including agriculture, trade, and social protection, which aligns with the comprehensive approach, and focus on collaboration of LIA (Vonthron et al., 2020).

Flood control

Flood control refers to measures taken to reduce or prevent damage caused by floods, such as building dams, levees, and other structures, as well as improving land use practices and developing early warning systems. This includes both 'soft' engineering such as designing flood retention areas, and 'hard' engineering such as structural storm surges and dykes (World Meteorological Organization, 2017). The goal of flood control is to minimise the negative impacts of floods on communities and the environment, while also promoting sustainable economic development.

Landscape quality

Furthermore, SRQ 1 mentions the concept of landscape qualities, which consists of landscape characteristics and landscape identity: the overall important elements of a landscape. Landscape characteristics refer to the physical and cultural features of a landscape, including topography, hydrology, vegetation and soil, among others (Sowińska-Świerkosz & Chmielewski, 2016). These characteristics define the form and function of the landscape. Landscape identity refers to the unique character, attributes, and cultural and historical heritage of a particular landscape, that distinguishes it from other landscapes (Stobbelaar & Pedroli, 2011). It encompasses the natural, cultural, and built elements that give the landscape its unique sense of place and contributes to its overall quality.

Design principles

SRQ3 and the MRQ refer to design principles, which will be the format of the final results. Design principles refer to a set of fundamental beliefs or values that guide the overall design process. These principles shape the design decisions made throughout the process, from concept to execution. Design principles are typically used to explain overarching ideas that apply to the entire design area. These concepts, which are abstract, are used to categorise functions that should be considered for a region and organise larger areas. Design principles differ from design guidelines in that design guidelines are site-specific, concrete rules or technical translations that provide direction and help to implement design principles (Etteger, 2016). In this research, the focus is on generating principles, as this creates knowledge that is more widely applicable.

Scenarios

ScenariosA scenario is a description of a possible or imagined situation or sequence of events. Scenarios can be used as a tool to understand potential future challenges and how to act on them (Harries, 2003). With scenarios, the uncertainty of the future can be emphasised, which helps bring awareness to the course of potential futures and its consequences.

2.2 Methodology

The research framework shows the steps and research methods (highlighted in bold orange) that will be used (figure 6). This study is split into two parts: Research for Design (RfD) and Research through Design (RtD). Through the use of these methods, potential solutions can be investigated to deal with several complex consequences of a drowning delta at once (Meyer, 2014; van der Meulen et al., 2020). This thesis uses the pragmatic research approach or worldview, as proposed by (Cortesão et al., 2019), within the RfD and RtD methodological portion. Research through design and research for design use the pragmatist worldview because they emphasise the importance of practicality and problem-solving. The pragmatist approach values action and experience as a means of acquiring knowledge and solving problems, which aligns with the design-oriented approach of research through design and research for design.

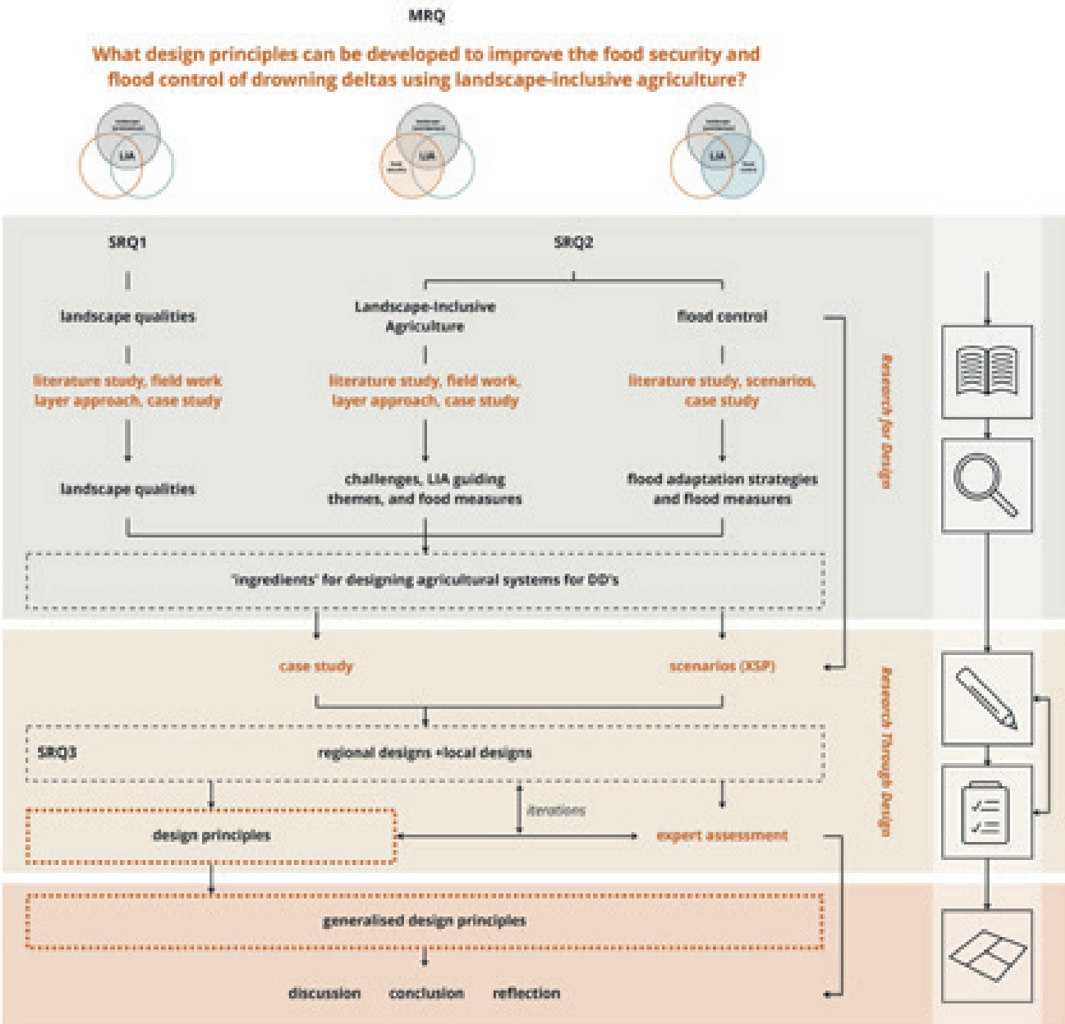


fig.6 research framework

Research for Design (RfD)

Research for Design (RfD) is research that is carried out to inform and support the design process. With RfD knowledge, data and insights are obtained, which are needed in order to make informed decisions (Lenzholzer et al., 2017). The approach recognises the complexity and interdisciplinarity of designing and that designers need access to relevant knowledge from various fields in order to create effective and innovative solutions.

Literature study

Literature study is needed on landscape-inclusive agriculture and its guiding themes. Secondly, the impacts of climate change on the north-eastern Italian coast are studied, as well as the coastal dynamics. Additionally, future challenges are researched. Furthermore, thorough literature research on food and flood measures is done.

Layer approach

In order to analyse the qualities of the landscape, the layer approach is used. The layer approach in landscape analysis refers to a method of organising and analysing different elements of a landscape in separate, distinct layers. This allows for a systematic and comprehensive analysis of the landscape, and helps to identify the interactions and relationships between different components of the landscape. Each layer typically represents a specific aspect of the landscape, such as vegetation, water bodies, land use, and infrastructure. By analysing each layer separately, and then considering the interactions between the layers, the layer approach can provide a more nuanced understanding of the landscape. The most rudimentary form of the layer approach is separating the landscape into three layers: the substratum layer, network layer, and occupation layer (figure 7) (van Schaick & Klaasen, 2011).

The substratum layer refers to the physical and geomorphological characteristics of the landscape, such as the geology, soils, relief, and drainage patterns. This layer is important for understanding the underlying conditions that influence the distribution of other landscape elements and processes. The network layer refers to the infrastructure, transportation, and communication networks that traverse the landscape. This layer includes elements such as roads and transportation corridors. The network layer is important for understanding the connections between different parts of the landscape and the ways in which human activities and development influence the landscape. The occupation layer refers to the use and occupation of the landscape. This layer includes elements such as land use, settlement patterns, and urban development. The occupation layer is important for understanding how human activities shape the landscape and the ways in which the landscape supports human populations. Expected outcomes of using the layer approach are a set of landscape qualities. Furthermore, the layer approach will be used for the case study and identifying future challenges.

Fieldwork

Multiple field visits allow for a thorough analysis of the landscape through sketching, field notes, and photographs. Prior to the field trip, an itinerary has been made with potential important locations and farms. Conversations with locals give insight into important landscape elements. Excursions to various aqua- and agricultural facilities enable the mapping of important factors of farming, and their vulnerabilities to future problems. An additional workshop week in the region is used for mapping future challenges. During this week, researchers from the University of Venice, farmers, and local stakeholders are consulted.

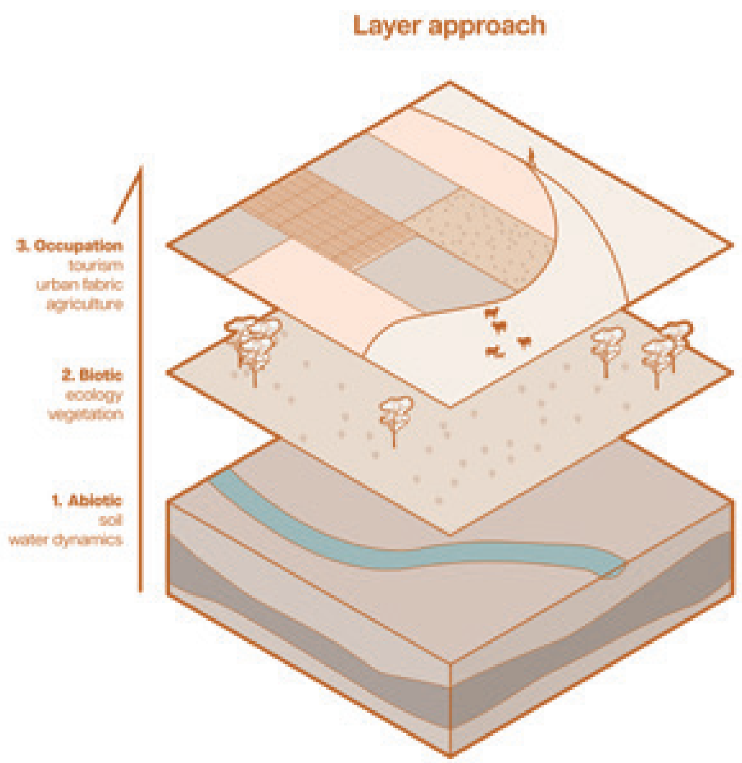


fig. 7 layer approach

Case study

The lagoon of Caorle and Bibione will be used as a testbed for the designs for the three scenarios. The site offers great diversity: the site has historical values (cities, aquaculture), there is a growing touristic element and, it is an important natural site for waterbirds. This diversity in actors and sectors could positively challenge the design process in pursuing LIA. For design-based research, compared to other lagoons along the northeastern Italian coast, the size of the lagoon of Caorle and Bibione is manageable; it offers an extensive water system, yet is small enough for design-based research given the timeframe of this thesis. The lagoon consists of different sub-water systems, making it a suitable site for testing designs. In addition to that, small lagoons and estuaries are under-researched compared to large lagoons and estuaries (Callaway et al., 2014).

Research through Design (RtD)

Research through design (RtD) uses design practices and processes to explore, understand, and address complex problems. Here, design methodologies, such as prototyping and iterative problem solving, are combined with theoretical and empirical research methods to generate new knowledge and insights about the design problem. The end goal is to produce new designs and gain new insights into the problem and context. The RtD approach values the design process as a form of inquiry and recognises the role of design in shaping and impacting the world around us (Lenzholzer et al., 2017).

Explorative Scenario Planning (XSP)

For this research scenario-based design is used. For this, open-source (spatial) data and literature is used to inform plausible contrasting scenarios for various courses of action. With this approach, the uncertainty of the future is emphasised, which helps bring awareness to the course of potential futures and its consequences. The used scenario approach in this thesis is exploratory scenario planning (XSP). XSP involves generating a broader range of scenarios that explore a wider variety of possible futures. The goal of XSP is to encourage the exploration of alternative perspectives and possibilities (Abou Jaoude, 2022). In particular, XSP can be useful in situations where with high degrees of uncertainty or complexity, which makes it suitable for creating scenarios for DD's.

Expert assessment

The designs will be evaluated by experts using a survey. This survey consists of four sections: landscape context, landscape-inclusive agriculture, food security, and flood control (figure 8), the experts will assess the section that matches their field of expertise. Every section contains criteria with a likert scale from 1 to 5 (1= strongly disagree – 5= strongly agree), where the experts can assess to what extend the design contributes to the said criterion. At the end of each section, an open text box is added to enable the addition of notes.

The assessment consists of two parts. Prior of the survey, the experts were briefed on the study area, and the scenarios and concept designs were explained. This allowed the experts to ask questions when necessary. After the briefing, the experts were sent the survey, which allowed them to fill it in at their own pace.

The evaluation of each criterion is based on corresponding indicators (figure 8), that are retrieved from literature. The LIA survey section consists of criteria based on a Dutch report 'op weg naar een New Deal tussen boer en maatschappij' (College van Rijksadviseurs, 2021). Here, the Sustainable Development Goals (SDG's) are transformed and then used as guiding themes. The criteria in the LIA survey section are based on these transformed SDG's (figure 9).

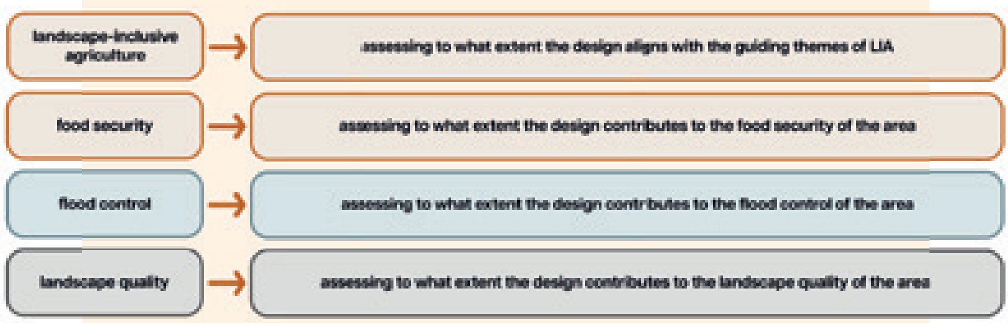


fig. 8 assessment domains

landscape-inclusive agriculture	assessing to what extent the design aligns with the guiding themes of LIA
climate-neutral	The design contributes to an agricultural system that promotes the SDG of becoming climate neutral where emissions are being managed and reduced where possible.
soil quality	The design contributes to an agricultural system that promotes a healthy soil and does not negatively impact the soil quality.
water quantity	The design contributes to an agricultural system that sparingly uses fresh water, does not (over)extract groundwater and retains rainwater where possible.
water quality	The design contributes to an agricultural system that does not pollute (ground)water or negatively impact the water quality.
nature and biodiversity	The design contributes to an agricultural system that works in harmony with nature and promotes the overall biodiversity.
closing cycles	The design contributes to an agricultural system that manages and uses (or finds use for) its residual flows and thereby closes.
landscape quality	The design contributes to an agricultural system that improves the overall landscape quality by being embedded into landscape.

fig. 9 LIA criteria

food security	assessing to what extent the design contributes to the food security of the area
diversity	The design contributes to food security by providing diversity in agricultuture types and crops.
quantity	The design contributes to food security by implementing agricultural practices that generate sufficient quantity for farmers to remain profitable and provide sufficient quantity for consumers in the region.
seasonality	The design contributes to food security by taking the seasonality of certain agriculture types and crops into account and compensating them where necessary.
vulnerability	The design contributes to food security by taking vulnerability of certain agriculture types and crops into account and compensating them where necessary.
accessibility	The design contributes to food security by providing sufficient infrastructure and thereby improving the accessibility.

fig. 10 food security criteria

Criteria in the food security survey section are based on the concepts of food availability and accessibility, which are two of the four pillars (availability, access, utilisation, and stability) of the concept of food security, as defined by the Food and Agriculture Organization of th e United Nations (FAO, 1996). The food availability pillar is mainly focused on the production side of food security, which involves landscape and landscape design the most. In addition to that, elements from the food accessibility pillar that involve the landscape are added, such as transport. The criteria mentioned in the survey directly correspond with elements from the two pillars, and thereby measure the landscape dimension of food security (figure 10).

The flood control section of the survey consists of criteria based on indicators as mentioned in the Integrated Flood Management Tools by the World Meteorological Organization and the Global Water Partnership (2017). This document offers information on how to assess flood control measures and suggests several criteria and indicators (figure 11).

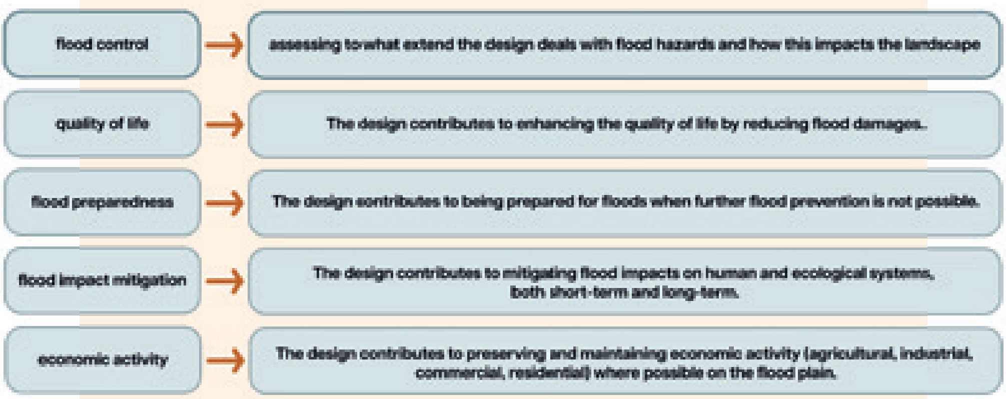


fig. 11 flood control criteria

The criteria of the landscape context section are based on a systematic review paper on landscape criteria trends (Medeiros et al., 2021). Here, 239 papers are systematically reviewed. This paper gives insight into landscape indicators and which landscape indicator categories are significantly overlooked. The paper seeks to investigate to 'what extent academic research shows interest in holistic, multidisciplinary, and integrative approaches combining a broad spectrum of indicators.'. In able to assess this, research outcomes are compared through the indicators that were used, uncovering a 'common ground', and thereby enabling a comprehensive analysis of indicators across different fields and topics (figure x).

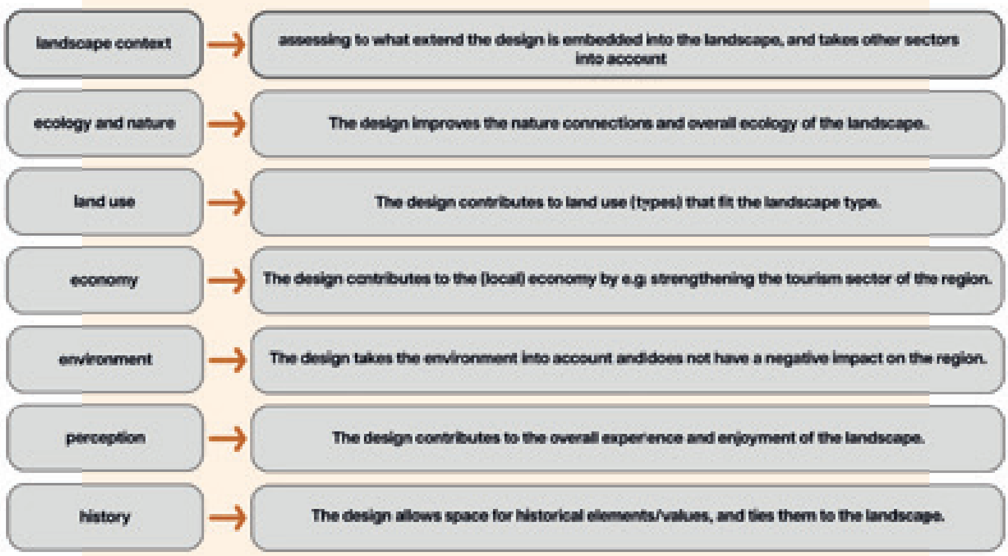


fig. 12 landscape context criteria

3 Research for Design

In this chapter, the results from the Research for Design phase are discussed. 3.1 contains the landscape qualities. In 3.2, the future challenges of the region and case study are analysed.

3.1 Lanscape qualities

In order to design for the future landscape, the most important landscape qualities and challenges were studied. The layer approach (figure 13), as described in paragraph 2.4, formed the foundation for studying both landscape qualities and future challenges. The landscape is predominantly analysed during the multiple site visits. This allowed for a thorough landscape analysis through sketching, field notes, photographs, and conversations with locals. The complete site visit reports can be found in the appendix.

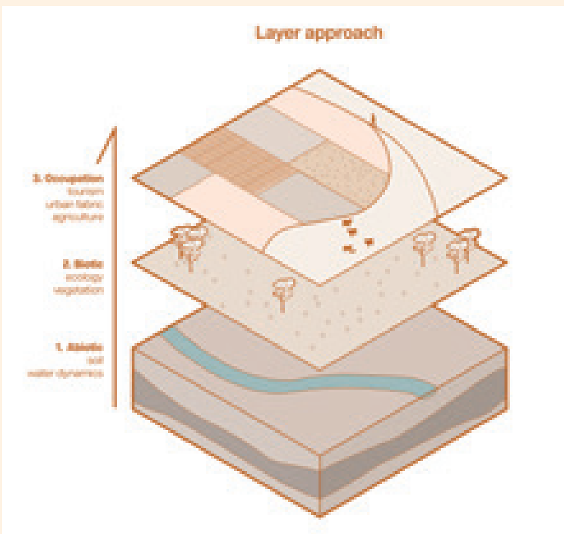


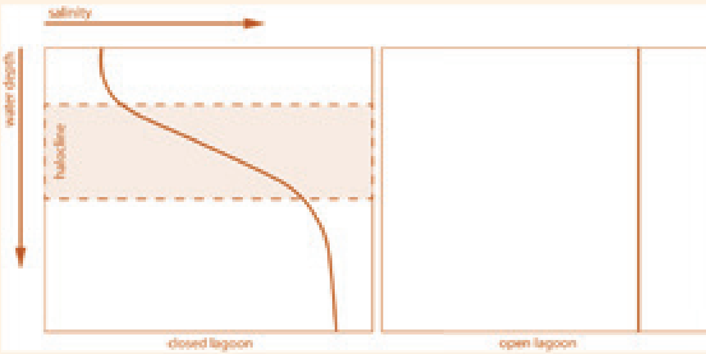
fig. 13 layer approach

Abiotic layer

The non-living components of the landscape, such as soil, water, air, climate, and topography, are referred to as the abiotic layer. These variables substantially impact the distribution and abundance of living species, as well as their interactions (van Schaick & Klaasen, 2011).

Water dynamics: interaction between salt- and freshwater

Lagoons are gradients where land and sea connect and interact. The currents and tides (figure 19: tide chart) provide a constant movement of sediment: both erosion and sedimentation. The degree of these processes (erosion and sedimentation) determines the shape and openness of a lagoon, which affects the chemical composition of the water. In the lagoons, the salty seawater and the freshwater from land inwards mix. This creates differences in chemical composition in dissolved oxygen and salinity throughout the lagoon (figures 14 and 15), which corresponds with a gradient of a great diversity of habitats (Bertolini et al., 2021). Lagoons are characterised by shallow, sheltered areas of water that are (partly) separated from the open sea by some type of



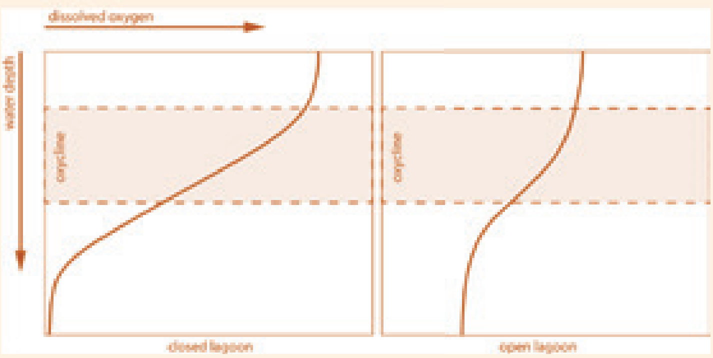


fig. 14 salinity curve fig. 15 oxygen curve barrier. In the deeper, mo re open waters of the lagoon, the flushing time is quick, meaning that there is good water circulation: the water is well-mixed and has high levels of salt and nutrients. Here you will mainly find species such as algae and seagrasses which form the base of the food chain, supporting a variety of larger organisms, such as crustaceans, shellfish, and small fish. Closer to the land, the water gradually becomes shallower and more sheltered, which can lead to the development of **mudflats** (figure 16) and **salt marshes** (figure 17). These areas are dominated by salt-tolerant plants, such as cordgrass and glasswort. The mudflats and salt marshes are important bird habitats. The lagoon extends into the landscape through (tidal) **creeks** (figure 18). These lagoon elements are important landscape qualities as they each provide different habitats, and are vital elements of a working lagoon system. Figure 19 shows an overview of the water dynamics; the mixing of fresh- and salt water.

fig. 16 mudflats

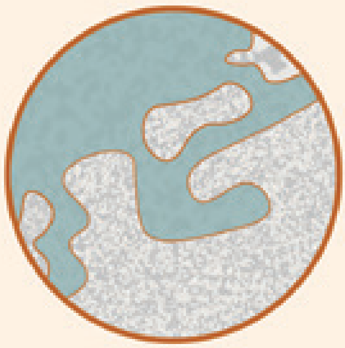


fig. 17 salt marsh

fig. 18 creeks

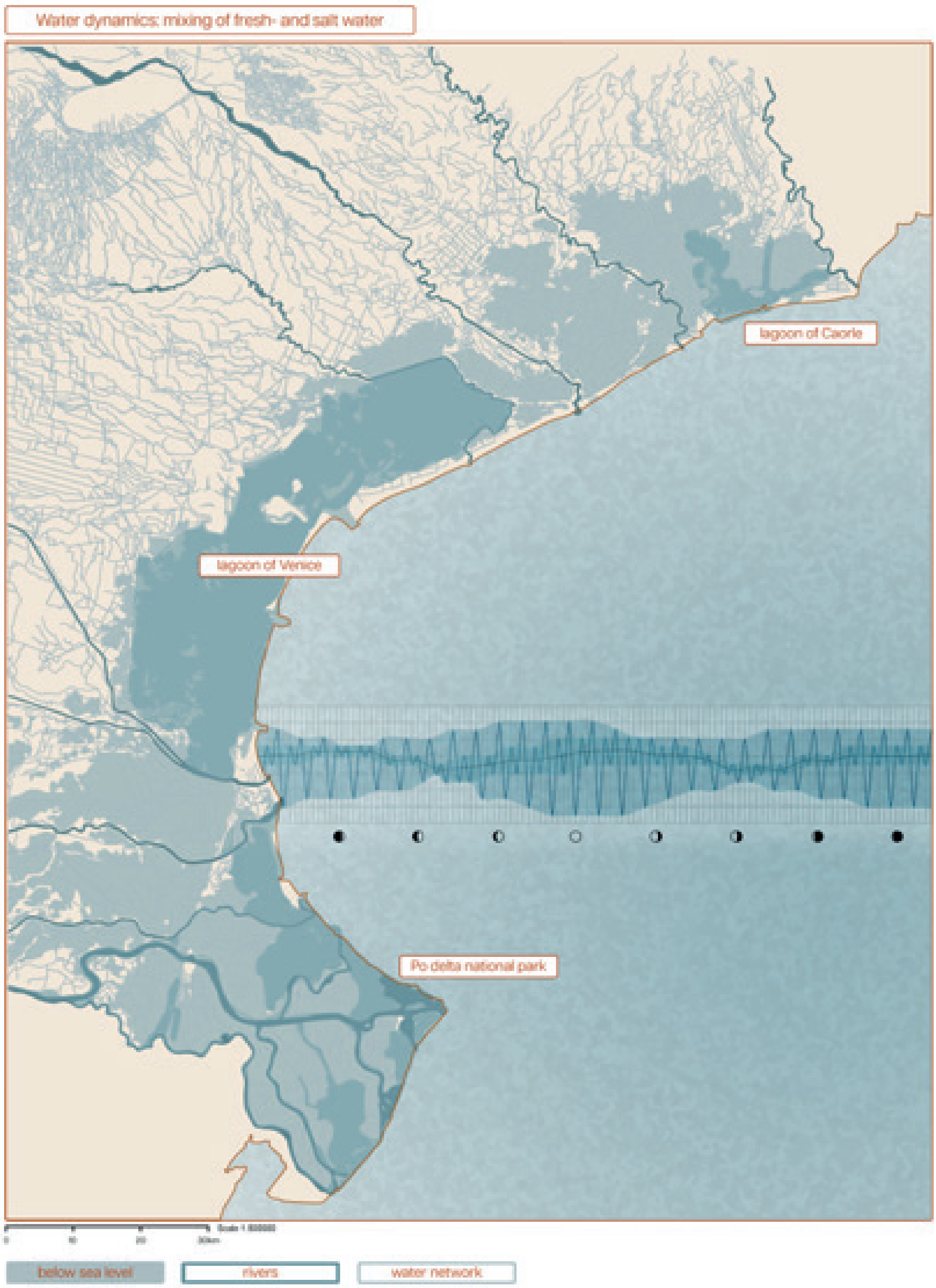


fig. 19 water dynamics

Soil: region of reclaimed lands and fertile soils

With the land reclamation process called 'bonifica', directly translated to the 'making good' [of land], lagoons and marshes were drained to turn them into arable lands (figure 20). For north-eastern Italy, many of the coastal agricultural lands have undergone this process. Because of the high accumulation of decaying organic matter in these areas, the soils are naturally rich in nutrients, making them the perfect base for high-production soils. In this region, a mix of alluvial, calcareous, and peaty soils can be found. After the bonifica drainage process, most of these soils had good permeability, and water-holding capacity, making them ideal for intensive agriculture (Salerno, 2019). These conditions allow for the cultivation of high-production crops, such as wheat, maize, and beets. This resulted in the establishment of highly productive and intensive agricultural systems in the region, contributing to the region's status as an important agricultural centre (figure 21).

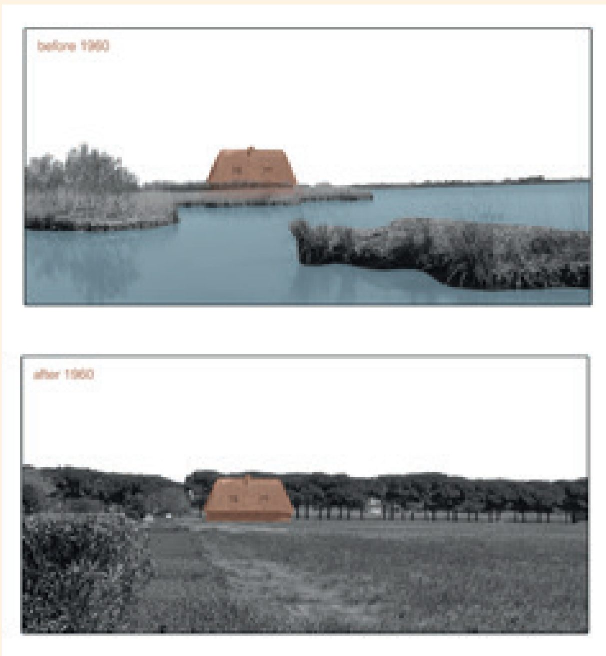


fig. 20 before and after reclamation

fig. 21 agricultural production intensity

Biotic layer

All living organisms in the ecosystem, including plants, animals, fungi, and microorganisms, are included in the biotic layer. These species interact with one another as well as with the abiotic layer, resulting in intricate food webs and nutrient cycles (van Schaick & Klaasen, 2011).

Vegetation: gradients and pine rows

Typical vegetation of the north-eastern Italian coastal landscape used to include oak and hornbeam forests, predominantly dominated by Quercus robur and Quercetum roboris (birch-oak forest). Now black locust (Robinia) and poplar trees (Populus) are the more dominant species, which can mainly be found as tree plantations as 'filler' vegetation between the more dominant urban, agricultural, and industrial land uses. Closer to the lagoon belt, the influence of the sea, lagoons, and dunes ridges create a habitat that houses typical coastal vegetation with species such as Cakiletea maritimae, Ammophiletae and Quercion ilicis. In terms of shaping the landscape, pine rows play a significant role in framing the landscape and the allotment patterns (Poldini et al., 2011). These **pine rows (figure 22)** create lines in a landscape of gradients, reinforcing the overall readability and coherence of the landscape.

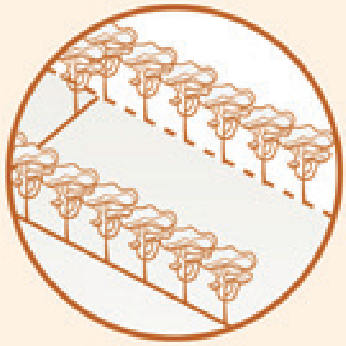


fig. 22 pine rows

Ecology: bird paradise and marine shelter

Important ecological structures are the Po Delta National Park, the lagoon belt, and the tegnue (coralline algae reefs). Po Delta is a vast area of wetlands, dunes, and forests that are home to a diverse range of flora and fauna, making it one of Italy's most important nature reserves. The Po delta and lagoons are important migratory bird stopovers. Many species of waterbirds, including wading birds, ducks, geese, and shorebirds, rely on the lagoons for survival (Stocco et al., 2023). These bird paradises make them a popular destination for birdwatching and ecotourism. One of the most striking birds is the pink flamingo. Furthermore, the tegnue are an important habitat for marine life, providing shelter for smaller fish, shellfish, and crustaceans (Fortibuoni et al., 2010). On the map (figure 23), the ecological network is laid out, with the Po delta national park, lagoons, tegnue, and ecological corridors.

fig. 23 core nature areas

Occupation layer

The occupation layer refers to the human use and control of the landscape, such as agriculture, forestry, urban development, and infrastructure. This layer is significant because human actions can substantially impact the abiotic and biotic layers, affecting the ecological functions and services of the landscape (van Schaick & Klaasen, 2011).

Agri- and aquaculture: rich history and stark contrasts

Piantata: historical plantation

The **piantata (figure 24)**is a historical mixed cultivation system that can be found throughout central and northern Italy. Each region has their own take on the system; however, the common denominator is connecting vines to guardian trees (figure 25). This agricultural system was adopted from the Romans, who in their turn have taken this knowledge from the Etruscans. Each region translated this system into original solutions of cultivation of the vine married to the tree, which gives the rural landscape an original note, a signature, of the different areas strictly connected to the type of environment. Traditional guardian trees were elms and field maple, as these provided nutritional leaves for cattle. However, willow, ash, poplar, mulberry, and occasionally fruit trees could also be found. The trees were placed in rows at a fixed distance: between trees in the row and between rows. Distances between trees can range up to 6 meters and between rows up to 30 meters (figure 26).

The result is a rich range of piantata types which remained almost unchanged until the beginning of the 20th century. Nowadays, most piantatas have disappeared from the landscape. The intensification of agriculture has almost wholly eradicated a system that held up for centuries. Tractors and larger and heavier machines to work the land are used. For these machines, the piantata is an obstacle: the marriage between tree and vine is broken, and the diverse leave and grass production for cattle has been found useless with cattle feed (Ferrario, 2021).

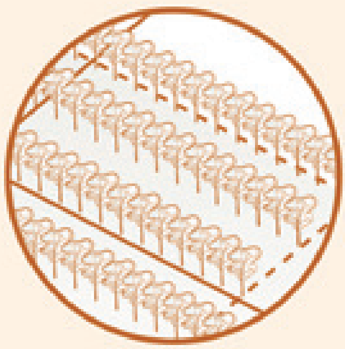


fig. 24 piantata

Fish valleys: historical aquaculture, bird habitat, and hunting grounds

Fish valleys (figure 28) are man-made structures in lagoons to catch fish. The origin of these structures dates back to the 5th century A.D. It consists of a ‘valley’, a semi-enclosed waterbody, that remains in contact with the lagoon and its tides. The fish valleys are a (semi)natural ‘shelter’ for juvenile lagoon- and sea creatures: it acts as a nursery. Fish valleys can be found along the vast lagoon belt from Ravenna to Aquileia. Fish valleys exploit the natural behaviour of certain fish species: during spring the natural instinct of these (mainly juvenile) fish is to swim upstream, into the river mouths where the fish valleys are located. The fish would stay and grow in the fish valleys. During the autumn, the fish’s natural instinct is to swim towards the sea again, in order to avoid cold waters. It is at this time, that the mature fish could be easily caught. Fishing activities mainly took place in shallow parts of the lagoon. During the Roman Empire until approximately the 15th century, nets and reed structures were used to fixate the system. These open ‘valleys’ had a direct connection with the lagoon and its tides. In order to cope with uncertainties and abandon this nomadic lifestyle, the fish valleys were embanked. This way, water levels could be managed, and juvenile fish could be kept in the valley, instead of being prematurely sold and consumed. During the summertime, fishermen would stay in huts made of reeds, called casone. These casone are still present in the current landscape. Even on reclaimed lands, casone can be found. They are landmarks of where once the lagoon ruled the landscape (Ferrario, 2021).

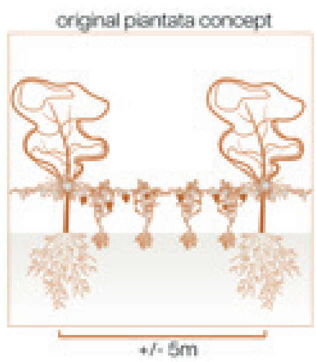


fig. 25 piantata concept

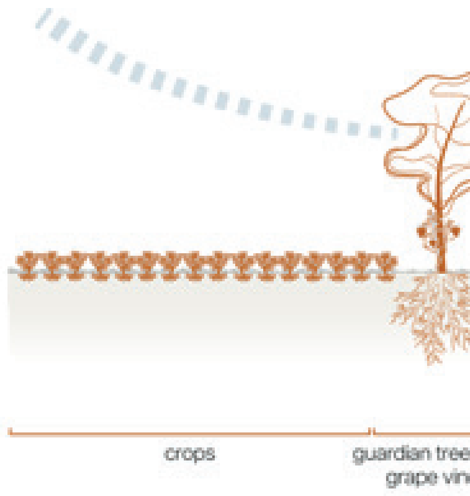


fig. 26 piantata concept section

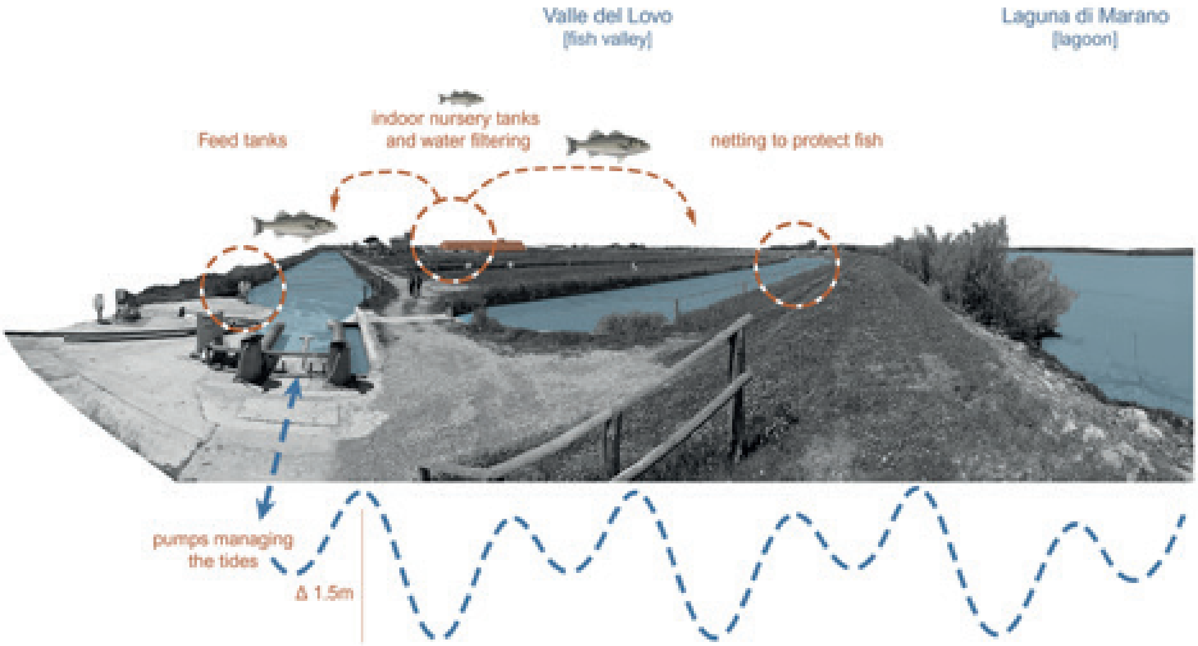


fig. 27 fish valley

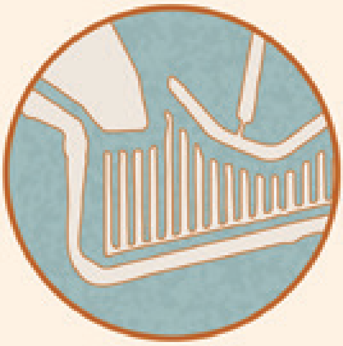


fig. 28 fish valley

Current fish valleys are reinforced with permanent embankments. The water and tides are carefully managed with sluices (figure 27). A welcome side effect of these permanent embankments is the protection of the brackish marshland that tends to erode quickly in open lagoons. The marshlands are an important landscape element for wildlife as it is ideal forage ground for birds. Nowadays, many fish valleys are (partly) abandoned, or only used during hunting season. The fish valleys are popular hunting grounds, as it is a perfect habitat for birds. The nutrient-rich and sheltered nature of the system is attractive for birds for wintering. In addition to that, north-eastern Italian coastal lagoons are an important layover spot for trekking birds. Here, they fatten up one last time, in order to cross the Mediterranean sea to warmer regions on the African and Asian continents (Ferrario, 2021).

Agricultural contrast: speciality foods and monoculture fields

There is a stark contrast between speciality food production and large monoculture fields for animal feed. On the one hand, the region is known for its production of high-quality, speciality foods, with a range of PDO products, which are usually produced using traditional, smaller-scale methods and techniques. These foods are highly valued for their unique flavours, quality, and cultural significance. Examples are the radicchio, vongole (clams), and purple artichoke (Salpina & Pagliacci, 2022). On the other hand, the region is a desert of large monoculture fields for animal feed production: large-scale, intensive, and industrial. Here, you will mainly find single-crop fields with maize or beets, resulting in a low diversity (figure 29).

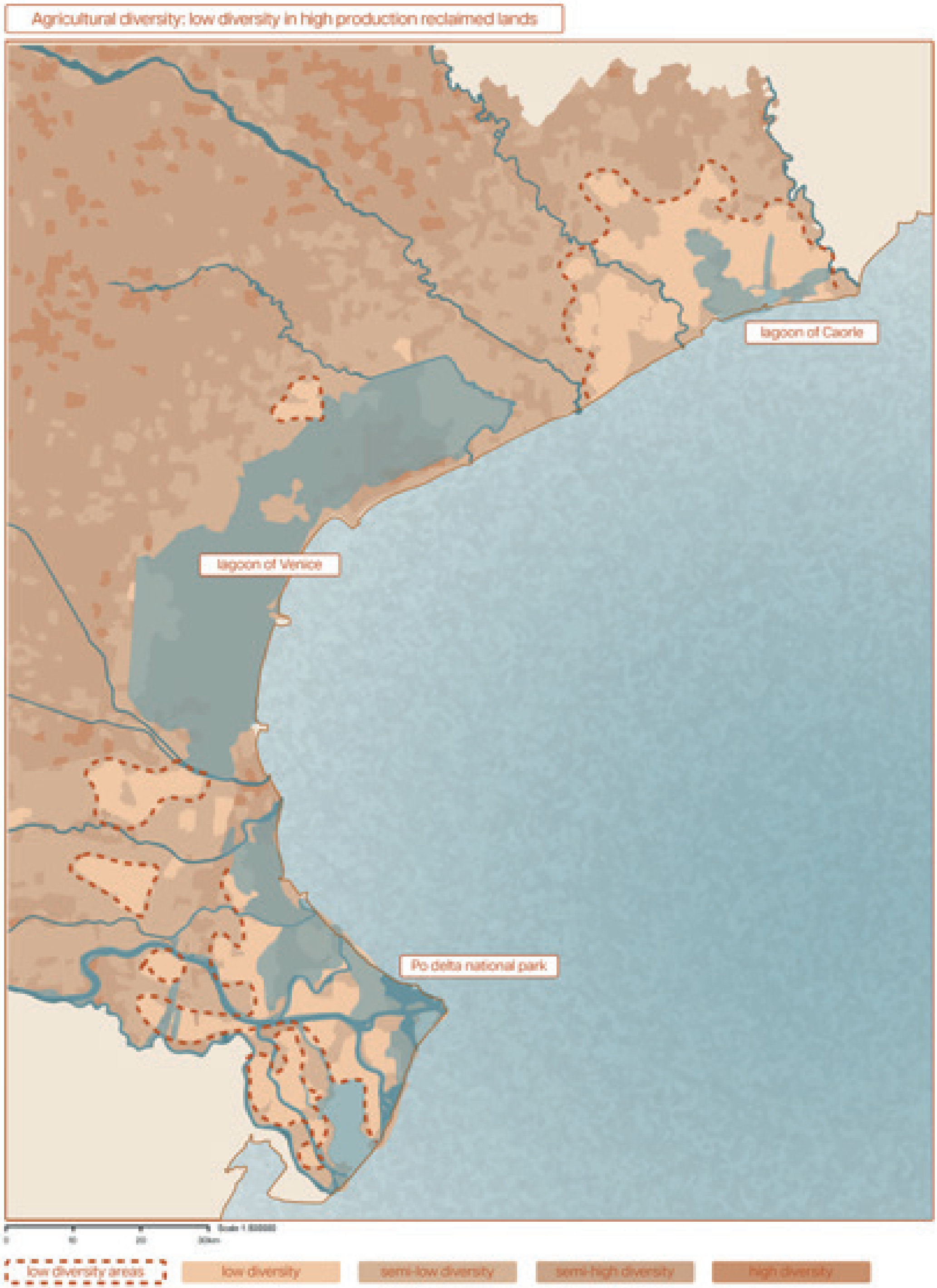


fig. 29 Agricultural diversity

Urban fabric: historical structures and urban sprawl

Historical structure of Graticolato Romano

The **Graticolato Romano (figure 30),** also known as the Roman grid, refers to a historical spatial layout system by the Romans. It is characterised by the regular layout of a square grid, which can take the form of roads, canals, or agricultural plots. The grid system allowed for easier navigation and was used to plan and organise cities and surrounding lands (Rodríguez-Antón et al., 2023). Padua and Verona were important Roman cities. Here, the grid layout is a tangible reminder of the rich cultural heritage. The layout has often been preserved and incorporated into the design of later cities and towns in the region, maintaining a sense of continuity and historical connection between the ancient and modern landscapes (figure 31).

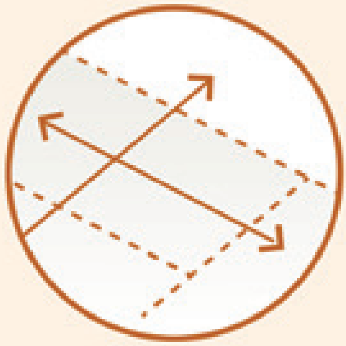


fig.30 graticolato romano

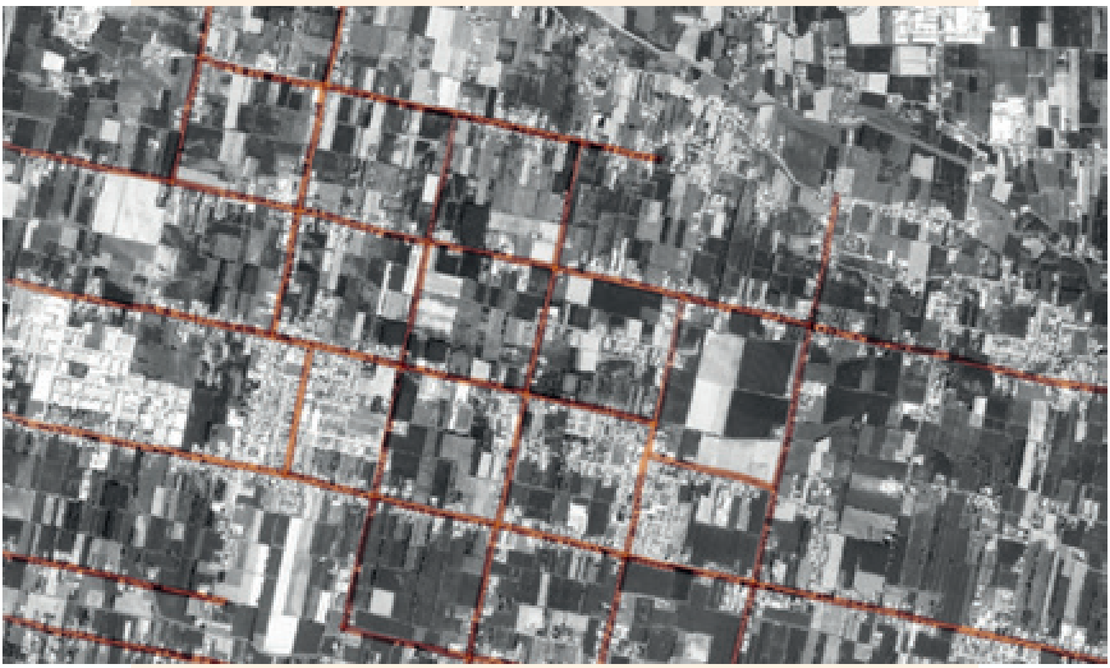


fig. 31 graticolato romano structure

Cities, coastal towns, and citta diffusa

The urban fabric of the northeastern Italian coastal landscape is composed of several different elements, including larger inland cities like Padua, smaller **historical coastal cities (figure 32)** like Caorle, and the citta diffusa. Larger inland cities like Padua serve as the economic and cultural centres for the region. Smaller historical coastal cities, like Caorle, have a rich cultural heritage and are popular destinations for tourists. These coastal towns are characterised by a strong connection with the sea with lungomares, lighthouses, and ports (figure 32. Fishing and the cultivation of clams and oysters are important economic activities. The citta diffusa, directly translated to diffused city, is urban sprawl, which is quite prevalent in north-eastern Italy. It can be characterised by low-de

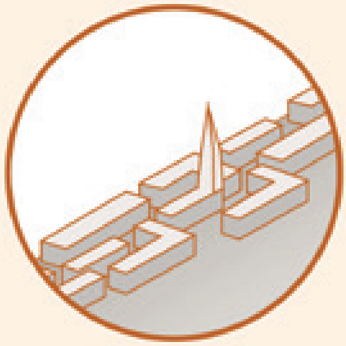


fig. 32 historical coastal city

fig. 33 Caorle

nsity, sprawling development that extends into the countryside and is often difficult to distinguish from its rural surroundings. This type of urban development can be traced back to the traditional rural settlements of the Veneto region, where the landscape was dotted with small towns and farms. Over time, as the population grew and economic development accelerated, these settlements expanded and merged, eventually forming the sprawling, dispersed cities that we see today (Cavalieri, 2020). The fragmented nature of the citta diffusa and lack of clear boundaries can make it difficult to implement effective measures to protect against the impacts of sea level rise. Prioritising areas for protection could be a difficult task and coordination and collaboration between different municipalities might be complex compared to a more centralised urban fabric.

Tourism: attraction of the seascape

The coastal region is a popular destination for both beach and bike tourism. The sandy **beaches (figure 34)** are popular among locals, and a favourite of the Germans. Many of the beaches are located close to historic coastal towns, with restaurants, shops, and hotels. In recent years, bike tourism has become increasingly popular in the region. Local authorities have invested in cycle routes along the coast, lagoons, and into agricultural lands. The tourist sector is a major source of income for the region as a whole.

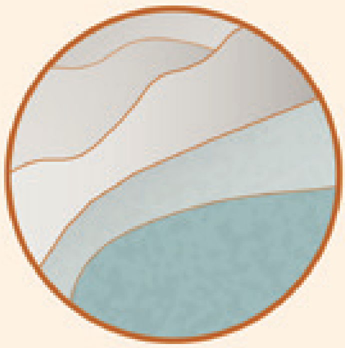


fig. 34 beaches

Landscape qualities in case study area: lagoon of Caorle and Bibione

The testbed for the Research through Design phase is the lagoon and reclaimed land of Caorle and Bibione (figure 35). Tidal creeks are turned into canals and the main vein of the lagoon is trapped between dykes. Drainage stations are scattered throughout the landscape and are a reminder that these reclaimed lands once were part of a vast lagoon system. The dominant crops found on the high-production agricultural lands are maize, sugar beets, and wheat. On slightly elevated parts young vineyards can be found. Most fish valleys are abandoned, or solely used as agriturismo during summer and hunting grounds during winter. A central axis cuts the lagoon system in two, forming a stark contrast with the old tidal creeks. Dune systems and beaches protect the majority of the area. The cities of Caorle and Bibione are popular destinations for beach and bike tourism. The landscape qualities are mapped in the case study area of Caorle (figure 36). In certain places, there are only traces of a quality left. For example, due to land reclamation tidal creeks are barely visible anymore. Landscape qualities such as pine rows are not visible on this scale but do appear when zooming in on the area.

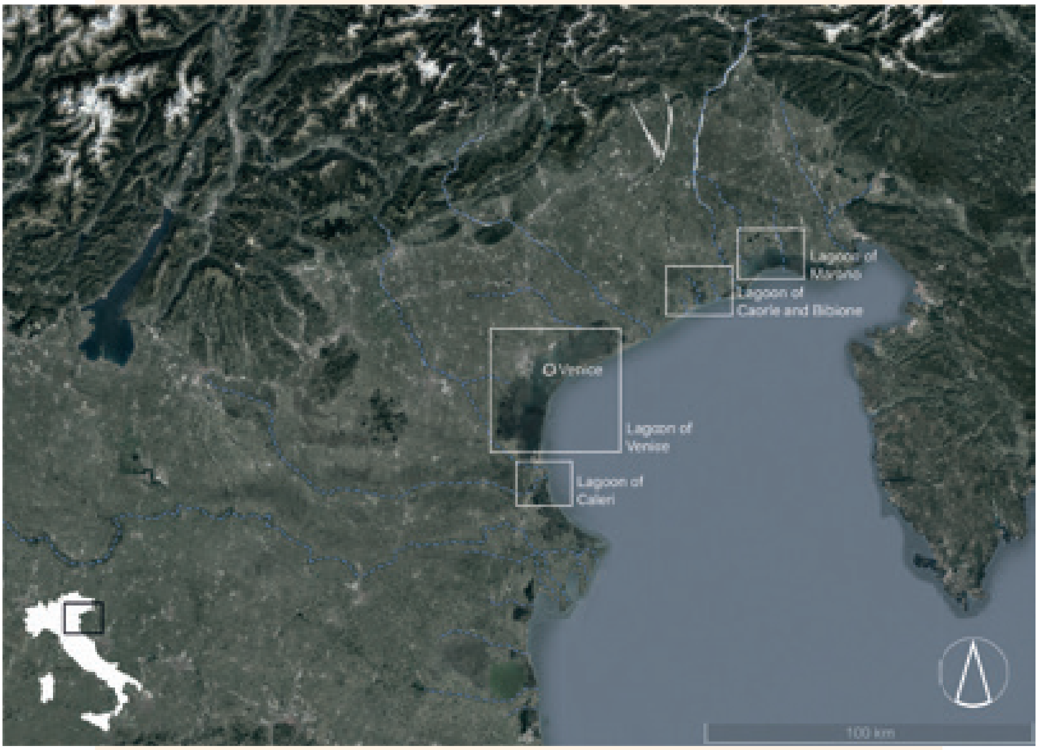


fig. 35 testbed location

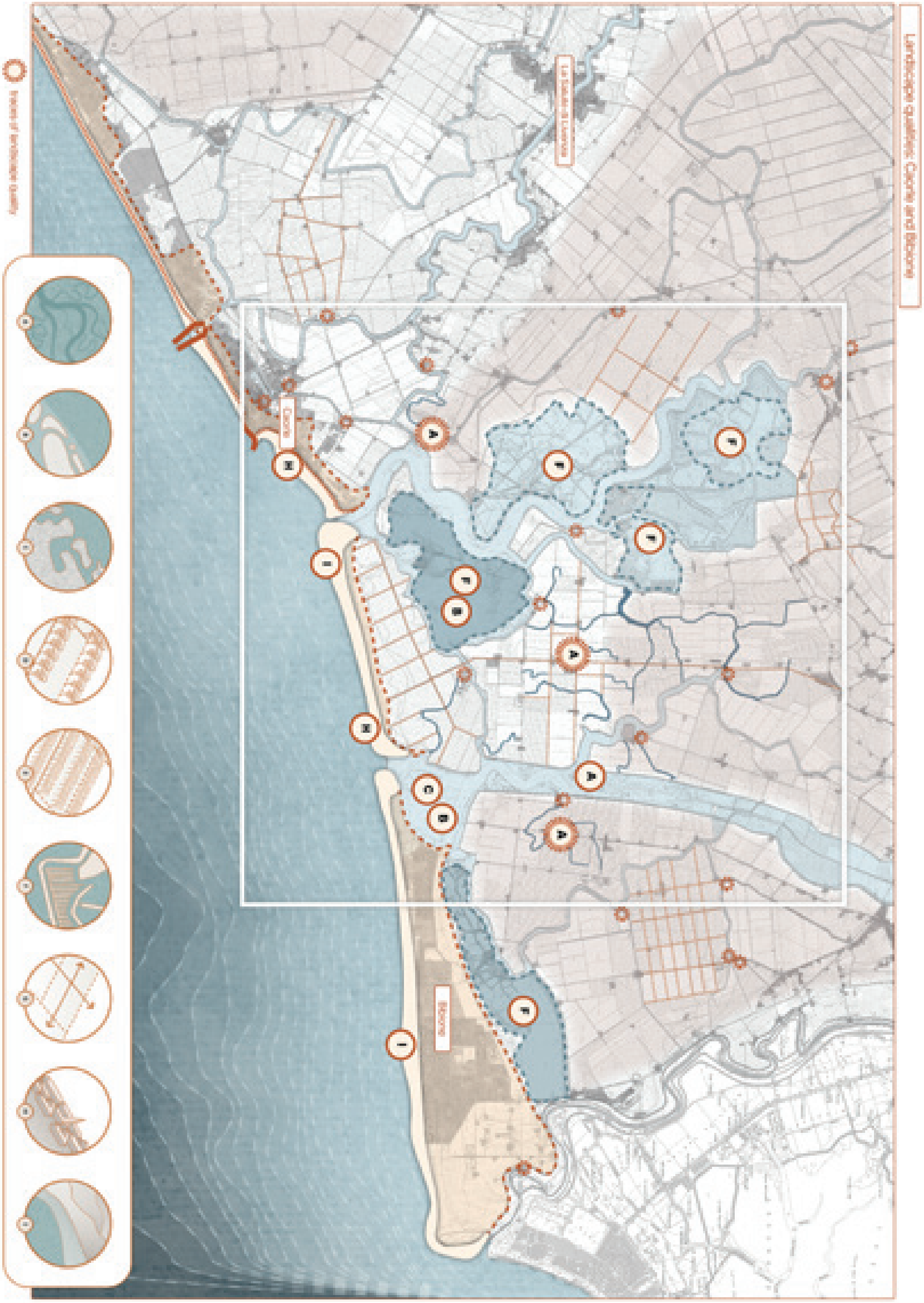


fig. 36 Landscape qualities map

Conclusion of SRQ 1: landscape qualities

Concluding research question 1: 'What are the most important landscape qualities of the north-eastern Italian coastal landscape?', the main qualities originate from the interaction between the fresh inland waters and salty sea waters. This interaction creates a gradient of non-saline to saline, enabling a great diversity of flora and fauna. In addition to that, the landscape has an elevation gradient from the coast (low) to the alps. This combination of gradients creates a high density of different habitats, resulting in a rich and diverse landscape. An overview of these gradients and landscape qualities can be found in the section of figure 37.

Landscape qualities that align with these gradients are the lagoons, with their creeks (A), mudflats (B), and salt marshes (C). Landscape elements of the graticolato romano (G) and pine rows (D) are 'structural' landscape qualities. These framing landscape elements strengthen the overall readability and coherence of the landscape. Furthermore, these landscape elements are an important part of the region's cultural and historical heritage. Important agricultural landscape qualities are the fish valleys (F) as well as the piantata (E); these elements are examples of agri- and aquacultural systems that work in harmony with the landscape. Historical coastal towns (H) can be considered landmarks. They are hubs of history, tourism, and fishing activities, as well as gateways to the rest of the landscape. Other landmarks are the casone, which refer to the strong connection between human and water in this region. In addition to that, bigger cities such as Padua and Venice are gravitational points of the region's economy and historical and cultural heritage. During the summer season, the beaches (I) and dune ridges attract beach- and bike tourism, which is of major importance to the local economy.

All these landscape qualities are important elements of the landscape and its identity, however, they are fragile. The landscape is suffering from the pollution of fertilisers, pesticides, and chemicals from industry and agriculture. This results in problems such as eutrophication and algal blooms, disrupting the landscape gradients and causing serious damage to the various habitats. In the next paragraph future challenges will be described.

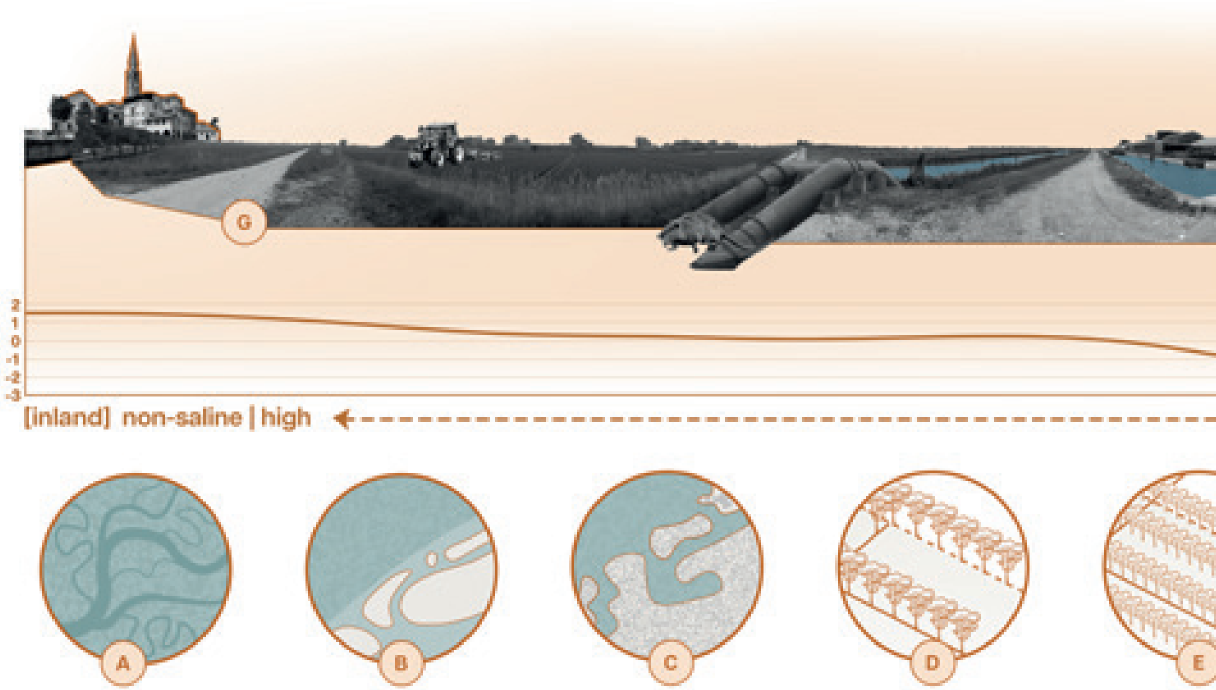
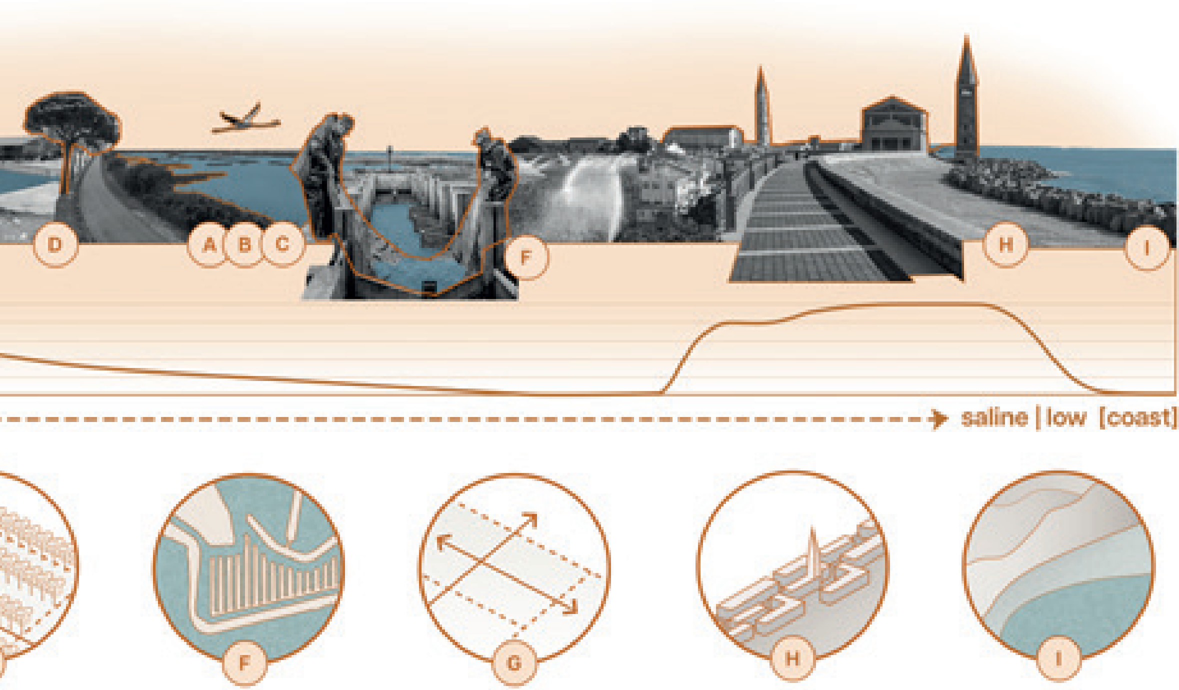


fig. 37 landscape qualities section


D
A
B
C
F
H
I
saline | low [coast]
F
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3.2 Future challenges

This section describes the main future challenges of drowning deltas in northeastern Italy, with a focus on agriculture.

Climate projections: too wet, too dry, too saline

In 2100, Italy is predicted to experience more wet and dry conditions, as well as increased salinity in the soil and water due to rising sea levels and changing precipitation patterns (figure 38) ((IPCC, 2022). This will majorly impact agriculture in the region, particularly in the low-lying areas, such as deltas. The main agricultural challenges in these areas are erosion, waterlogging, salinisation of soils and water bodies, and saltwater intrusion. Erosion can cause nutrient loss and reduce soil fertility, which can be particularly problematic in areas already experiencing saltwater intrusion. Due to changing precipitation patterns, heavy rainfall in a short time can result in waterlogging. In areas with low soil health, this is particularly damaging, as the water-holding capacity of these soils is low. Additionally, waterlogging can also be a result of sea level rise. Finally, an increasingly more saline environment due to salinisation and saltwater intrusion significantly decreases crop yields and the dependency on already scarce freshwater supplies. All these changing conditions make the agricultural sector more vulnerable, resulting in lower crop yields and further threatening food security (Pacetti et al., 2017).

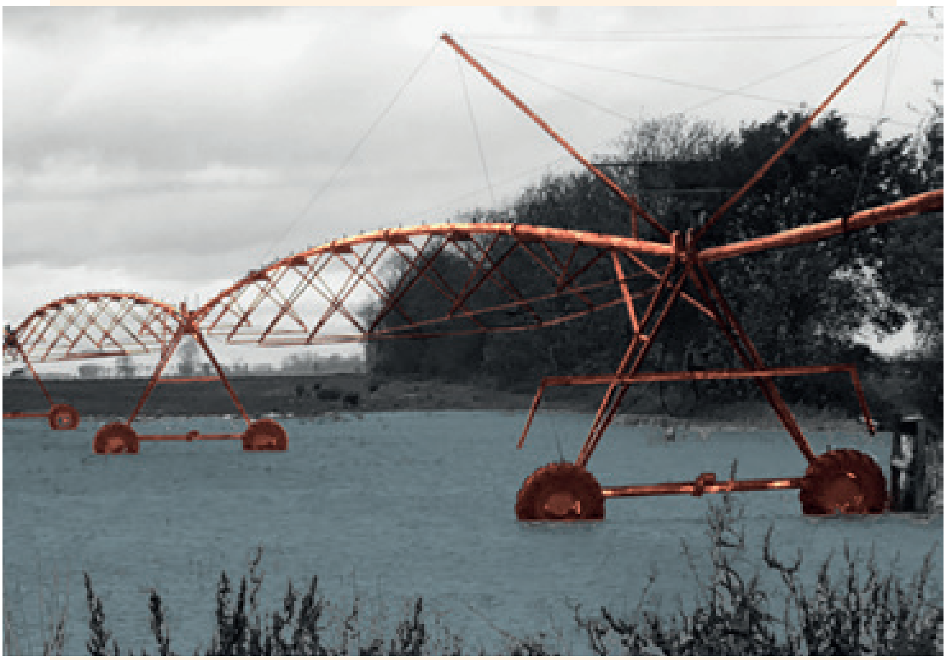


fig. 38 too wet, too dry, too saline

Accelerator of problems: groundwater extraction

(Over) extracting groundwater is done on a large scale. Especially during summer, farmers are looking for water for crops and livestock. As seen in figure 39, by (over) extracting groundwater, a positive feedback loop is created, moving the system away from a stable state. This can aggravate the risks of erosion, waterlogging, salinisation, and saltwater intrusion, making the (over) extraction of groundwater an accelerator of problems (Mastrocicco & Colombani, 2021). Dealing with these problems requires innovative and adaptive approaches, such as using salt-tolerant crops, new irrigation techniques, and land management practices that reduce erosion and promote soil health.

Disrupted lagoons: algal blooms and seagrass loss

Lagoons are disrupted by fertilisers, chemicals and pollutants from the industry. In addition to that, the projected rise in temperature will affect the water systems. Increased temperatures can cause increased growth of harmful algae, creating an algal bloom. These blooms harm marine life as they deplete oxygen levels of the water and release toxins that kill fish and other organisms (Ferrario, 2021). Furthermore, seagrass die-offs are more prevalent with higher temperatures and lower oxygen levels. Seagrass meadows form an essential habitat for marine life and play a key role in filtering the water of pollutants and excess nutrients. These water quality changes could also impact the tegnue reefs (Stocco et al., 2023).

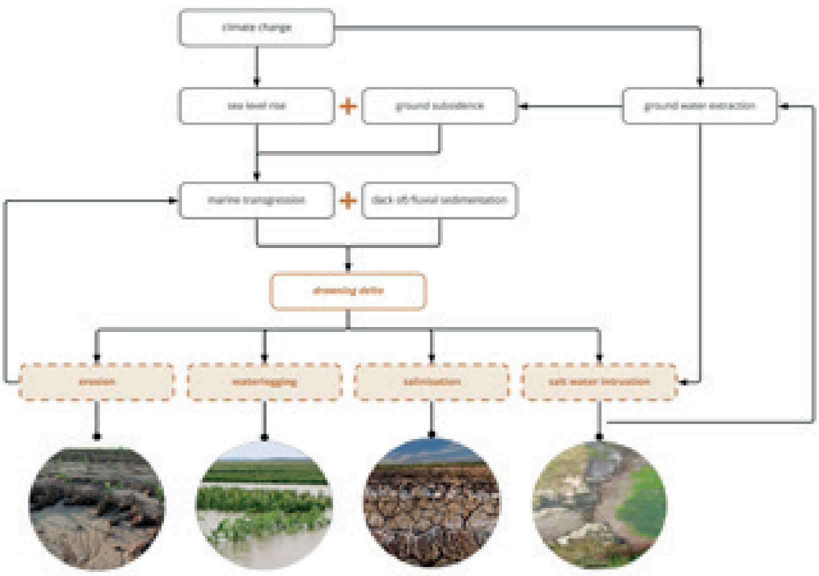


fig. 39 interrelations of problems

Disrupted water systems and aquaculture

The disrupted lagoon also impacts local aquaculture. Algal blooms and seagrass die-offs negatively affect water quality. Low oxygen levels could lead to decreased productivity and increased mortality of aquaculture species, such as seabass, sea bream, clams (vongole), oysters, mussels, and crustaceans. Due to the change in salinity, aquaculture farmers might be forced to focus on different species in order to remain profitable (Bertolini et al., 2021).. Furthermore, in the face of freshwater scarcity, freshwater-dependent aquaculture might be converted to other land/water uses. With aquaculture being a major economic activity, changes in this sector will significantly impact the local community.

Citta diffusa and flood control

The fragmented nature of the citta diffusa (diffused city) makes it challenging to protect the region against rising sea levels (Cavalieri, 2020). The lack of clear boundaries or a central area makes it hard to implement comprehensive protection measures. Designing flood control for drowning deltas requires clear prioritising and might result in difficult situations where there are no winners.

Future challenges in case study area: Lagoon of Caorle and Bibione

The map elevation and flood control (figure 41) further reveals that the majority of the area is in the range of -1 to -4 meters below sea level. The dykes along the rivers light up, as well as the lagoon canals. The map shows the vulnerability of the area and emphasises the flood risk in the future.

Map landscape qualities: Caorle and Bibione (figure 40) shows where the landscape qualities are visible. In certain places, there are only traces of a quality left. For example, due to land reclamation tidal creeks are barely visible anymore. Landscape qualities such as pine rows are not visible on this scale, but do appear when zooming in on the area.

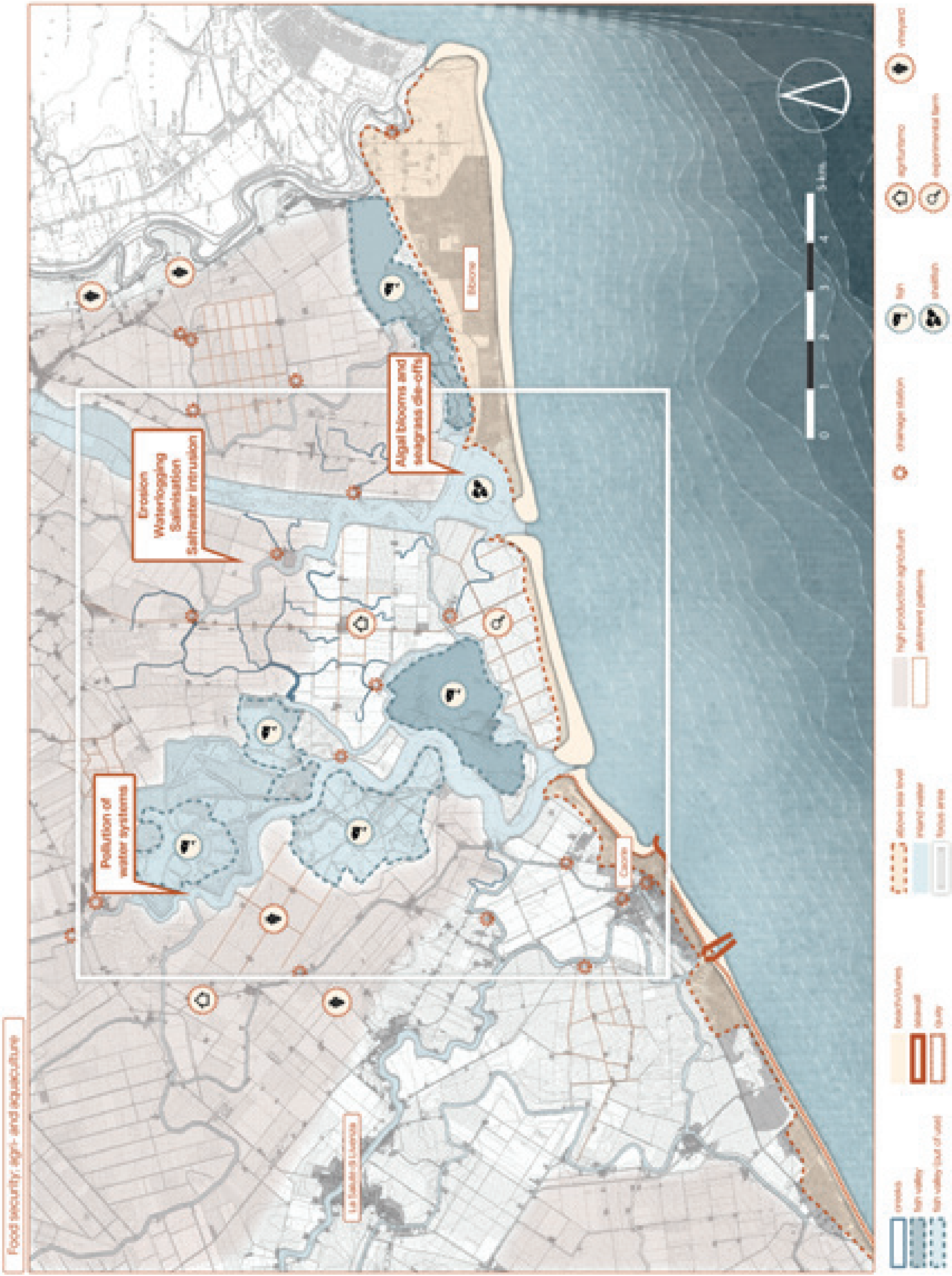


fig. 40 landscape qualities map Caorle

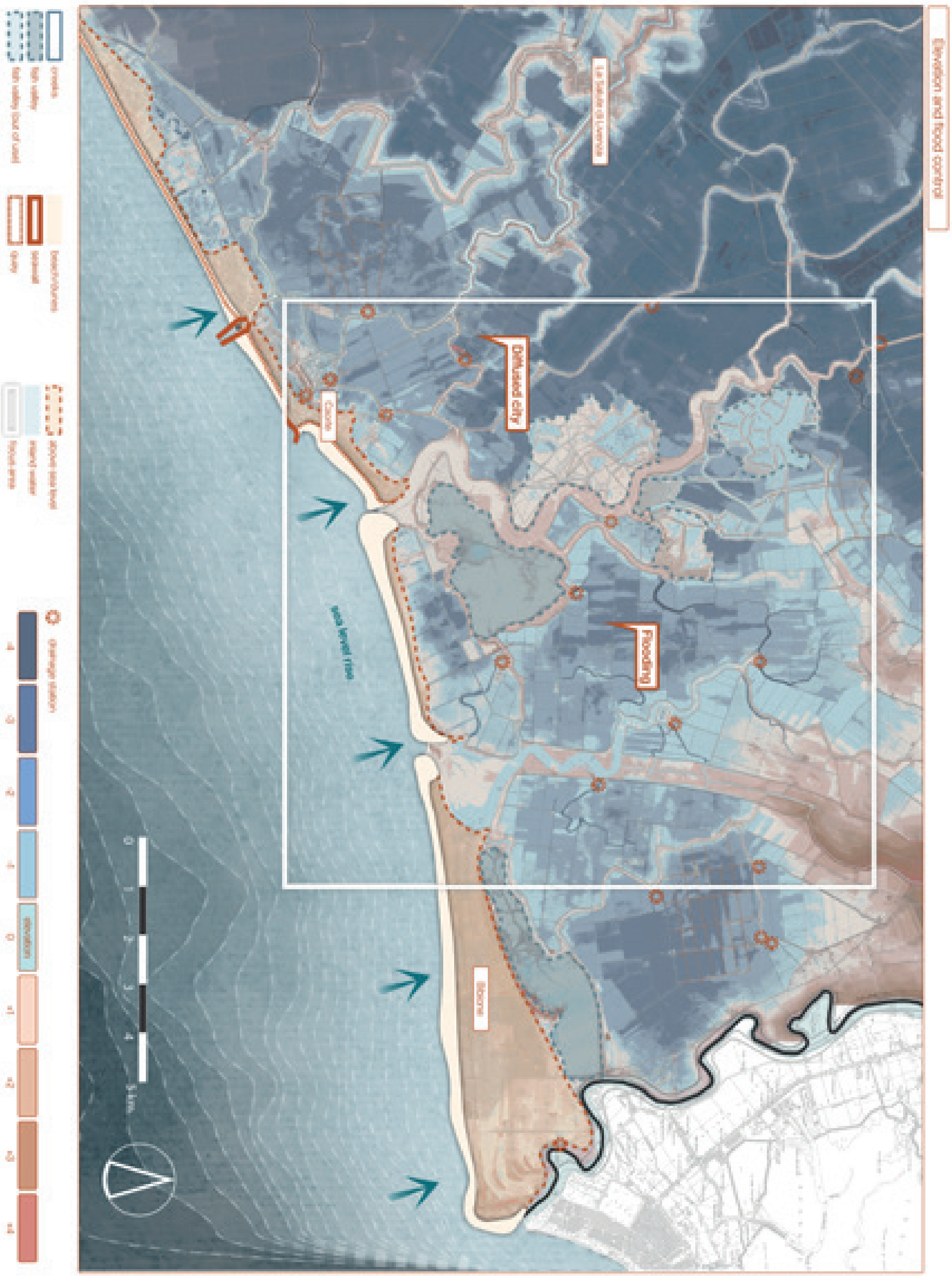


fig. 41 elevation and flood control

Conclusion future challenges

Concluding, the main future challenges of drowning deltas are centred around the climate projections of conditions becoming wetter, drier, and more saline. This affects the region's food security, as these changing conditions make it increasingly difficult for the agricultural sector to produce similar food quantities. Additionally, particular cultivation (methods) might not be profitable nor possible in the future. The (over) extraction of groundwater accelerates agricultural problems of erosion, waterlogging, salinisation, and saltwater intrusion, which forces serious restructuring of the agricultural system. The increase in temperature impacts the water systems, especially disrupting the lagoon system. This disbalance results in algal blooms and die-offs in seagrass, significantly reducing the water quality. Besides biodiversity loss, this also impacts the aquacultural practices in the region: decreased productivity and increased mortality make the sector vulnerable. Finally, the fragmented urban fabric of the citta diffusa will form a major challenge due to its lack of clear boundaries (figure 42).

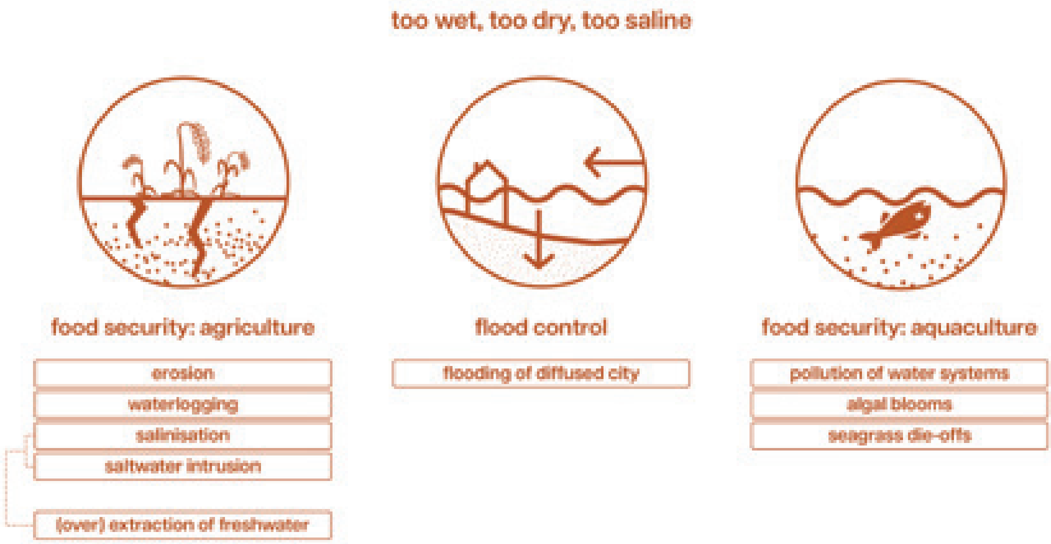


fig. 42 conclusion future challenges

3.3 Landscape-inclusive agriculture

Landscape-Inclusive Agriculture (LIA) refers to an approach to farming that takes into account the diverse ecological, social and economic components of a region, and integrates these elements into farming practices to improve both food production and ecosystem health. This approach involves collaboration between farmers, communities, policymakers, and other stakeholders to create sustainable agriculture systems that benefit both people and the environment. Landscape-Inclusive Agriculture's guiding themes are focused on key social concerns such as climate change, biodiversity loss, the elimination of unique landscapes, and the deterioration of natural and environmental quality. These are challenges for society as a whole, as well as for agriculture.

The United Nations has taken the most comprehensive approach to these societal concerns, resulting in the seventeen Sustainable Development Goals (SDG) that are implemented on a global scale (College van Rijksadviseurs, 2020).

Landscape-inclusive agri-culture: guiding themes

In order to combat the future challenges of a drowning delta, guiding themes of LIA are used. The College of Rijksadviseurs based these LIA guiding themes on research and trend analyses, which are then linked to the SDG's. This results in ten themes that are important for the transition to landscape-inclusive agriculture on their own but also in mutual coherence (College van Rijksadviseurs, 2020). All ten themes are essential, but depending on the location, goals may differ. The themes (I-X) are used to guide the Research through Design phase (figure 43) (box 1.

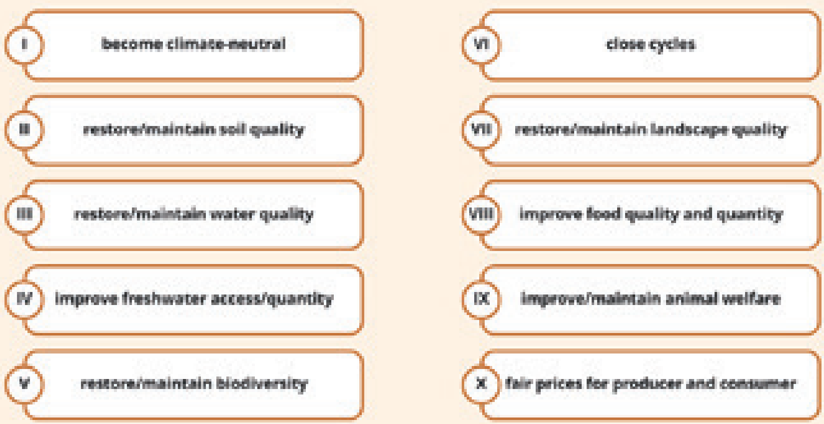


fig. 43 LIA guiding themes

Box 1: LIA guiding themes elaborated

I Become climate-neutral

With the Paris Agreement, serious goals are set: limit global warming to 2 degrees Celsius, preferably below 1.5 degrees Celsius. Becoming climate neutral means reducing emissions to net zero. Additionally, this means neutralising greenhouse gasses that have already been released into the atmosphere. In practice, neutralising greenhouse gasses could be achieved with carbon offsetting measures. When designing the future of drowning deltas, becoming climate-neutral could be achieved by restructuring the agricultural system and protecting and restoring forests and seagrass meadows.

II Restore/maintain soil quality

Soil quality is the basis of our land uses and is an essential element in food security, biodiversity, and water quality. Restoring and maintaining the soil is essential for maintaining high-quality production. Furthermore, a healthy soil is crucial for biodiversity, nature, and water quality and quantity. Restructuring the agricultural system, banning artificial fertilisers and chemical pollution, and investing in soil life and biodiversity are examples of practical measures to fulfil this goal.

III Restore/maintain water quality

The European Water Framework Directive aims to ensure the quality of surface- and groundwater. Water quality is essential for our health and ecosystem health. However, salinisation and nitrate leeching from agricultural sources pose a major threat. Promoting non-polluting agricultural practices can improve the water quality.

IV Improve the freshwater access/quantity

Conscious management of water quantity strives to avoid flooding (disasters) and water scarcity (drought). It is critical to have enough freshwater available to limit the detrimental effects of salinisation, such as silting up and salt stress. Effective measures, such as expanding the freshwater lens, water retention, and improving soil moisture balance, mitigate the harmful effects of salinization.

V Restore/maintain biodiversity

The Global Convention on Biological Diversity and the European Biodiversity Strategy define biodiversity goals and ambitions. Important objectives include redirecting biodiversity loss toward conservation and restoration. In recent decades, biodiversity in agricultural regions has dropped significantly: both in fields and soil. The use of artificial fertilisers, chemicals, and pollution from industry disrupts the ecosystem. Additionally, intensive monoculture fields have destroyed micro-reliefs and ecological infrastructure. Restoring biodiversity in agricultural regions can be done by preserving and restoring landscape elements that provide habitat for species on the fields.

Continuation of box x: 1 LIA guiding themes elaborated

VI Close cycles

In order for circular agriculture to work, closing cycles is important on both large and small scales. Circular agriculture is an approach to farming that mimics the circular processes found in nature. It involves designing agricultural systems that close loops, reduce waste and maximise resource efficiency. This is done by integrating livestock, crops, and other agricultural practices in a way that creates a closed system where waste products from one process become inputs for another. By closing cycles, a sustainable and resilient food system can be created.

VII Restore/maintain landscape quality

The European Landscape Convention (ELC6) was created in 2000 to promote the protection, management, and development of landscapes and collaboration among European countries in this field. Natural variations in the land have historically led to diverse landscapes, but modern intensification has reduced this diversity and separated natural and cultural areas. To enhance landscape diversity, land use should align with natural conditions, and efforts should be made to preserve and enhance unique qualities such as cultural, historical, scenic, and natural features. Additional qualities such as peace, naturalness, and identity can also be added where appropriate.

VIII Improve food quality and quantity

The Common Agricultural Policy (CAP) in the European Union has the objectives of ensuring sufficient food production at a reasonable cost while also ensuring consumers can buy agricultural products at reasonable prices and farmers can have a decent income. The food safety policy of the EU aims to protect consumers and maintain the proper functioning of the internal market, and food quality is important for human well-being and health.

IX Improve/maintain animal welfare

Animals possess intrinsic value, and being sentient beings, their quality of life is an essential consideration in animal welfare. Ensuring high levels of animal welfare is a critical future objective, whether it involves preserving current standards or striving towards better ones.

X Create fair prices for producers and consumer

Many of the services provided by farmers to society through their farms, whether positive or negative in net value, are often not priced or valued. The focus for many farmers is on production for the consumer, who is primarily interested in low prices. This does not encourage land management practices that aim to balance the provision of various ecosystem services.

3.4 Strategies and measures

Existing strategies: IPCC

The IPCC suggests three adaptation strategies for dealing with the rising sea levels: protect, accommodate, and retreat (IPCC, 2019). Strategy protect is focused on protecting the current coastline and way of living. Accommodate focuses on allowing the water in, meaning land uses are adapted, but stay in the same position, concerning reducing vulnerability to rising sea levels. Strategy retreat gives a free ball to the water and knows minimal flood protection measures. Instead, this strategy suggests moving to higher lands. Combined with IPCC climate projections, the IPCC strategies are used as a base for the scenarios, which form the starting point of the design.

Food security measures

Measures to counteract the main problems of drowning deltas are studied. Measures focused on food security were researched and divided into adapting and altering measures (figure 44). Four measures focused on adapting to the consequences of climate change on agriculture in drowning deltas were found. Adapting the cropping strategy to a fitting polyculture (measure 1) (e.g. agroforestry, intercropping, cover-cropping) can create a more resilient way of cropping. Additionally, adapting crop types according to their properties, for example: investing in shallow-rooted crops (measure 2), salt-tolerant crops (measure 3), or halophytes (measure 4), can maintain crop yields.

Furthermore, six measures focused on altering crop conditions were found. In an increasingly saline environment, windbreaks (measure 5) protect crops from harsh winds and salt accumulation. Water retention, for example, through gullies (measure 6), can collect water for irrigation. Differentiating ditch depth and width (measure 7) can create a more local freshwater bubble, countering salinisation. Soil conditions for crops can be improved by preventing contact with a saline environment by raising land (measure 8). Additionally, willow-poplar combinations (measure 9) can filter out pollutants and excessive nutrients. Wooded banks (measure 10) contribute to the overall biodiversity and offer structure to soils.

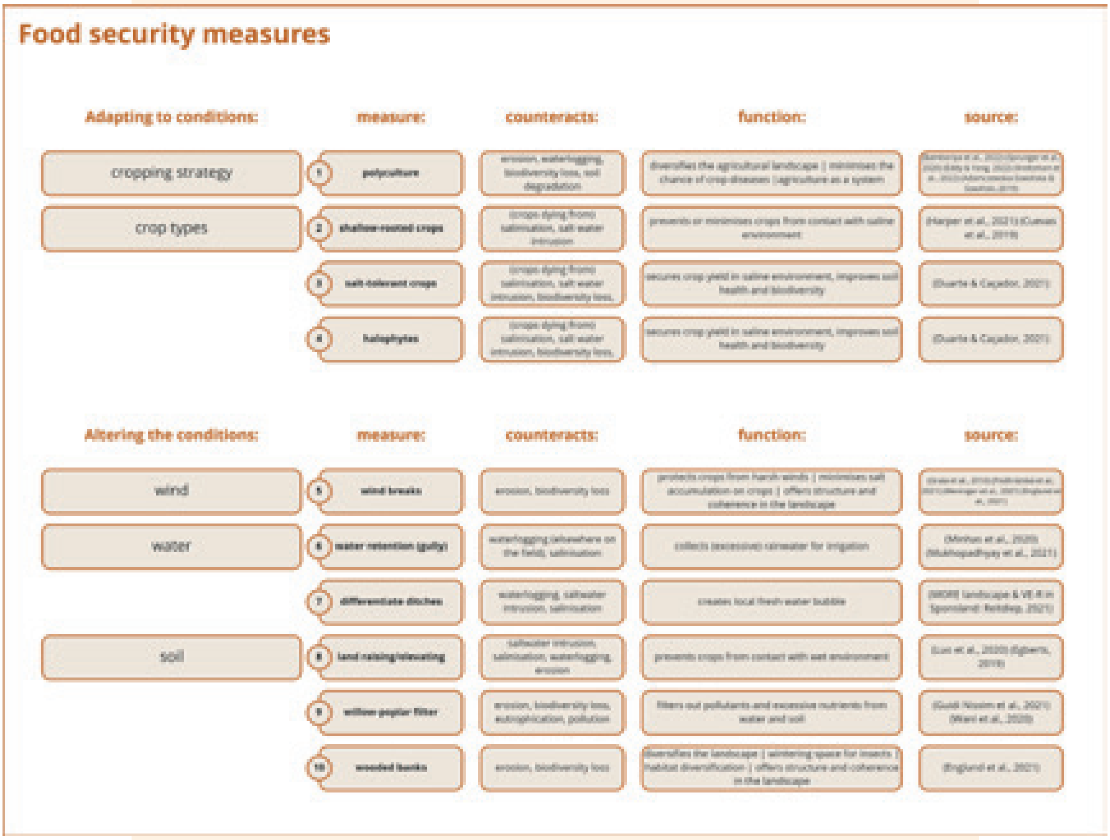


fig. 44 food security measures

Flood control measures:

Measures focused on flood control were researched and divided into solid and soft structures (figure 45). Six measures for solid structures were found. Wall structures such as seawalls (measure 11) and quays (measure 12) form a hard defence line against the water. Generally, these measures are used in areas where there is little space available, such as highly urbanised areas. Breakwaters (measure 13) are underwater structures that reduce wave energy, which limits coastal erosion and can minimise storm damage. Floodgates and sluices (measure 14) can manage or prevent water entering the land. Dykes (measure 15) are broader coastal defence structures. Wide green dykes (measure 16) are on the border of solid and soft measures and can also be used for other land uses such as recreation, nature, and agriculture.

Moreover, nine measures focused on soft structures were found. Flooding and erosion can be prevented by building vertically: raising the land. For example, by putting land uses on mounds (measure 17), or by creating barrier islands (measure 18). Natural found flood control can be found as dune systems (measure 19), a more engineered take on dune systems are sandy dykes (measure 20). These systems form important

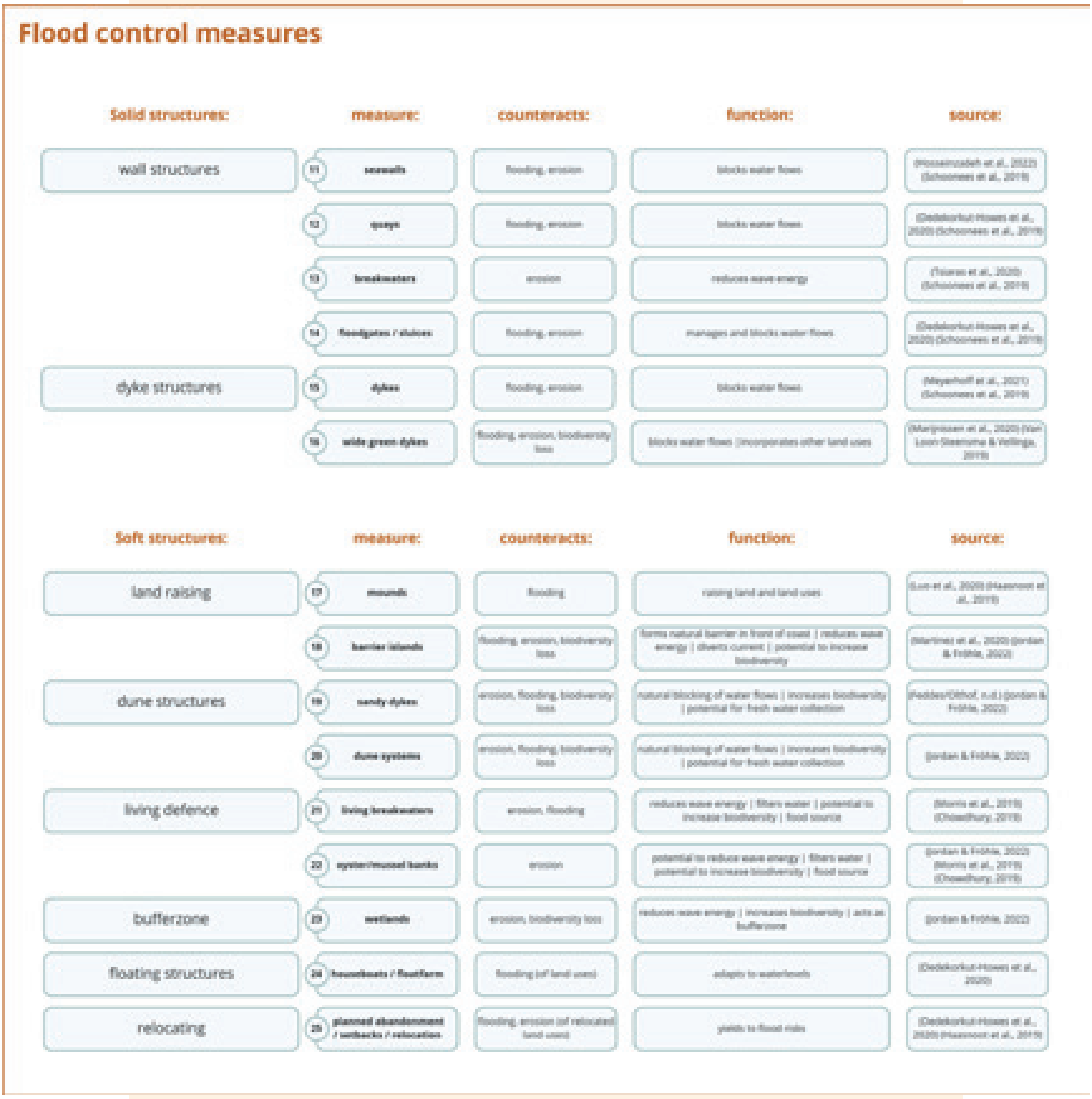


fig. 45 flood measures

habitats for flora and fauna, and in combination with beaches are popular tourist areas. Living defence, such as living breakwaters (measure 21) and oyster/mussel banks (measure 22) use and concentrate the natural wave breaking properties of shellfish. In addition to that, these creatures filter the water, while also being a sustainable food source. Buffer zones, such as wetlands (measure 23), exploit natural flood reducing properties of coastal vegetation. Flooding can also be mitigated by adapting to the rising water levels by investing in floating structures (measure 24). Land uses such as agriculture or housing can be adapted. Finally, avoiding flood risk can be done by (temporarily or permanently) leaving flood-prone zones, such as planned abandonment, setbacks, and relocation (measure 25).

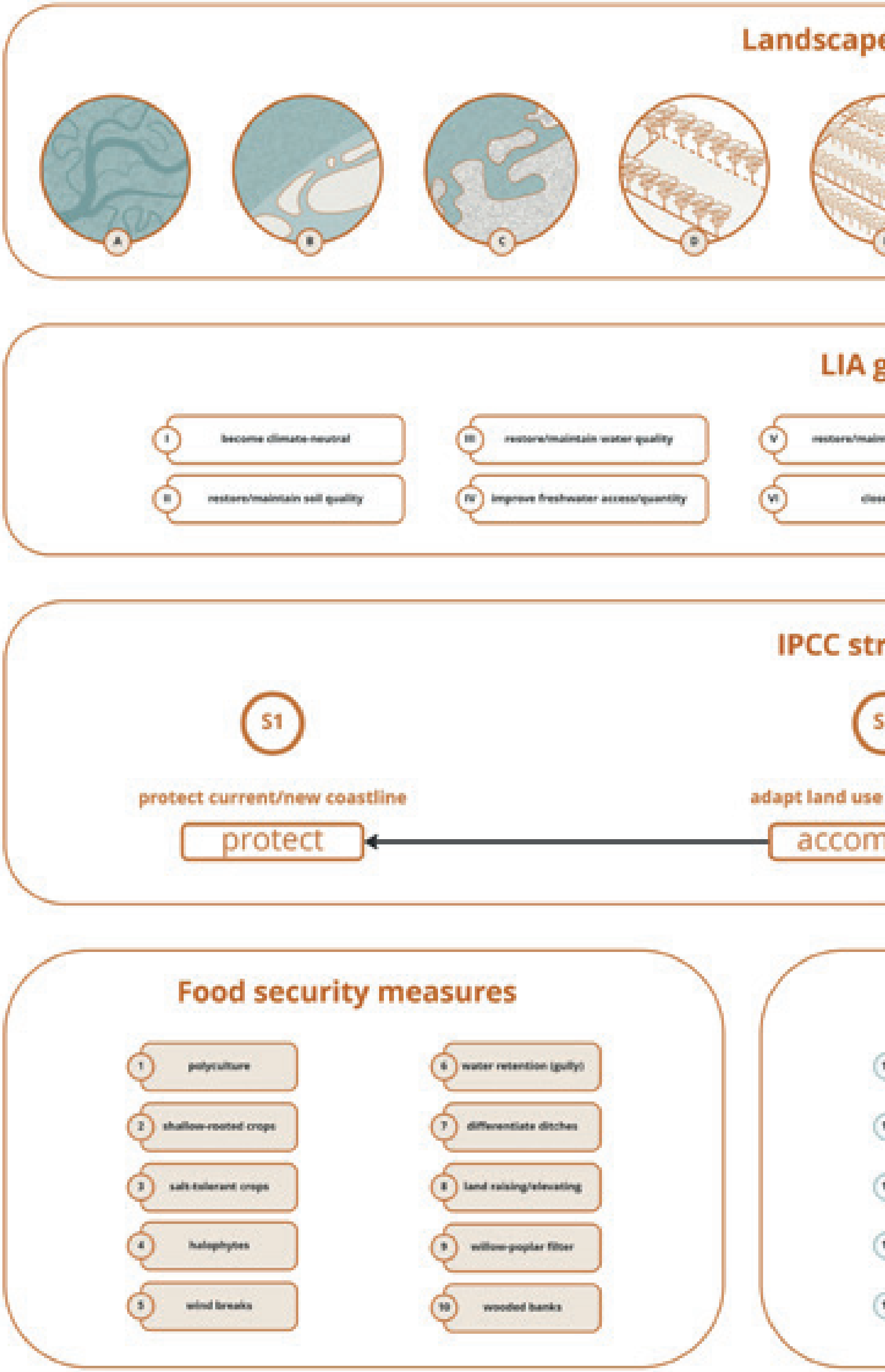


figure.46 design ingredients

e qualities
F
G
H
I
goals
tain biodiversity
e cycles
VII restore/maintain landscape quality
VIII improve food quality and quantity
IX improve/maintain animal welfare
X fair prices for producer and consumer
rategies
2
S3
and structures
relocate vulnerable functions
nodate
retreat
Flood control measures
seawalls
quays
breakwaters
floodgates / sluices
dykes
16 wide green dykes
17 mounds
18 barrier islands
19 sandy dykes
20 dune systems
21 living breakwaters
22 oyster/mussel banks
23 wetlands
24 houseboats / floatfarm
25 planned abandonment / setbacks / relocation

4 Research through Design

4.1 Scenarios

Combined with IPCC climate projections, the IPCC strategies of protect, accommodate, and retreat are used as a base for the scenarios (figure 46). Essentially, this determines to a great extent, the degree of salinity that impacts the landscape. Scenario 1: protect, will presumably face different consequences of a saline environment as opposed to scenario 3: retreat. Additionally, the focus of coastal protection measures in scenario 1: protect, will be on hard coastal defence, whereas in scenario 3: retreat, there is far more space for broader, soft coastal defence.

Applying the IPCC scenarios of protect, accommodate, and retreat to the case study, the found measures are assigned to the scenarios (figure x), which help construct the following explorative scenarios:

Scenario 1: Protect

In the scenario protect, water is kept out of the area. To limit the salinisation of the soils, one-way sluices are used to prevent salt water from entering the land. Dykes, and breakwaters protect the land. Additionally, a new lagoon is created in front of the historical town, providing coastal protection, while also preserving the strong connection to the water as well as ensuring a base for tourism and recreation. Agriculture will focus on conventional crops. Fish valleys can no longer exploit the tides and are converted into microalgae farms (open pond system). With these farms, biofuel is produced, which can be used for desalination plants, providing an additional freshwater source.

Scenario 2: Accommodate

In the scenario accommodate, water is let in in a controlled way. The lagoons are allowed more space in the landscape, which creates opportunities for saline agriculture. The landscape functions as a gradient in salinity, offering a great variety of crops. Here, the division between landscape and seascape fades. Tidal creeks reclaim the landscape and create new ecological corridors. The lagoons offer opportunities for macroalgae farming and shellfish farming. The fish valleys are used for fish farming and microalgae farming (open pond system). Coastal cities are protected by a combination of sand-dykes and aquaculture breakwaters.

Scenario 3: Retreat

In the scenario retreat, the water is invited into the landscape, which results in relocating vulnerable functions and land uses. The once reclaimed land is now returned to the lagoon. This archipelago creates opportunities for the area to reclaim its history in fish farming with its fish valleys. These calls for a new approach to farming, in order to make it profitable. The fish farming profits from the implementation of the touristic elements of agriturismo, and hunting rights during winter months. The coastal cities will now be surrounded by lagoons and sea, making them islands. They will be protected by sand-dykes and barrier islands. The barrier islands create new wetland structures for flora and fauna.

Assigning measures

Figure 47 shows the measures that align with the described scenarios. Together with the LIA guiding themes, landscape qualities, these measures form the ingredients for the concept designs.

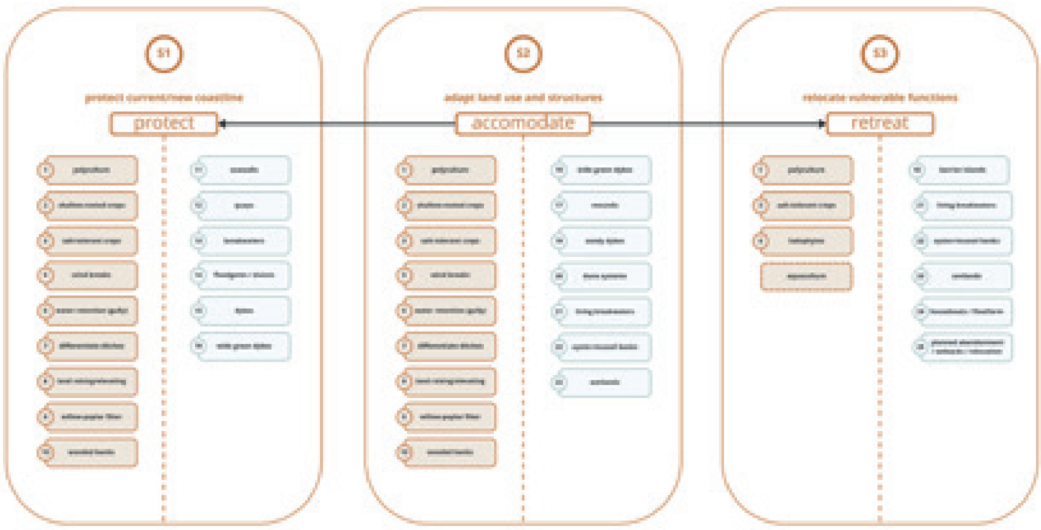


fig. 47 scenarios and measures

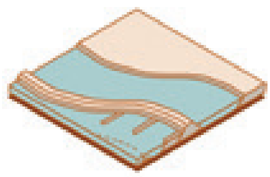
4.2 Concept designs

This section describes the concepts, followed by the scenario designs. With each concept LIA guiding themes are combined with the food- and flood measures. Below each concept, relevant feedback from the expert assessment test 1 (elaborated in section 4.3) can be found. The orange circles on the left indicate for which scenarios the are intended.

Concept 1: new city lagoon

S1 S2

- **Create seaward sea dyke**
  - Maintains historical connection between city and water
  - Promotes tourism and local economy by creating extension of lungomare promenade
- **Provide space for a new lagoon**
  - Promotes tourism and local economy
  - Increases biodiversity
- **Implement shellfish banks**
  - Food source: oyster, mussels, crabs
  - Improves water quality by filtering water
  - Decreases erosion by reducing wave energy



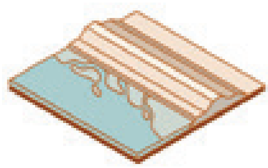
Expert feedback: new city lagoon

- Flood: Sea dyke could work, if designed well. Specify slope. Beware that groynes will alter sedimentation process.
- Food: Connection between historical city centre and water is important.
- Landscape: Historical connection with water.

Concept 2: wide green dyke

S1 S2

- **Create wide green dyke**
  - Gentle slope enables for combining land uses: agriculture, nature, energy, recreation
- **Implement footpaths and bicycle routes**
  - Promotes tourism and local economy
- **Provide nature development: living shoreline**
  - Tidal marshes strenghten dyke and boost biodiversity
- **Incorporate agriculture**
  - Dyke as food source: sheep, fodder, herbal 'teas'
- **Incorporate energy**
  - Climate neutral energy source: PV-panels
- **Use flowery top layer**
  - Increases biodiversity
  - Highlights structure: dyke as floral eyecatcher



Expert feedback: wide green dyke

- Flood: This dyke will require the least amount of change to the current landscape and the activites in there. At least in the short term.
- Food: Combining with sheep is a good idea, if dyke becomes big element in the landscape.
- Landscape: Dyke can be daunting structure when high (20m): contrast between worlds inside and outside of the dyke.

fig. 48 concept 1 and 2

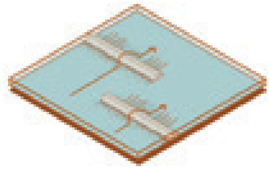
Concept 3: aquaculture breakwater

S1

- **Create aquaculture breakwater**
  - Decreases erosion by reducing wave energy
  - Food source: oyster, mussels
  - Improves water quality by filtering water

S2

- **Create microtopographies**
  - Increases biodiversity by providing artificial reef structures
  - Extends ecological network of tegnue reefs



Expert feedback: aquaculture breakwater

- Flood: Aquaculture breakwater will likely not reduce floodrisk. Height and lenght of breakwaters can significantly alter sedimentation process.
- Food: -
- Landscape: -

Concept 4: broad floodplain

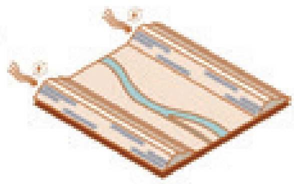
- **Create broad floodplain**
  - Buffers peak discharge
  - Increases fresh water quantity by providing space for water retention
  - Increases biodiversity by creating gradients in high-low and wet-dry
  - Food source: fish

S1

- **Implement willow-poplar forests**
  - Improves soil quality and water quality by filtering out pollutants and fertilisers
  - Source of fodder
  - Increases biodiversity

S2

- **Implement wooded banks**
  - Increases biodiversity
  - Connects floodplain to surrounding landscape elements
- **Implement livestock**
  - Food source: sheep, cattle, horses
  - Variety of livestock improves biodiversity by creating microhabitats due to different grazing patterns and trampling
- **Implement decked footpaths and bicycle routes**
  - Promotes tourism and local economy



Expert feedback: broad floodplain

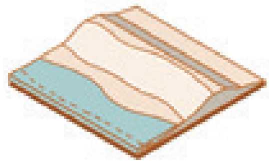
- Flood: More room for rivers, able to capture peak discharge. For wide solutions economic activities will need to adapt.
- Food: Agriculture will have to adapt. Unsure how this will work.
- Landscape: In the Maasdal, Limburg (NL), they have elevated fields: putting agriculture on mounds (bolakker/terpakker). Possibility for farming in these floodplains. Broad floodplain has potential to become a rich and diverse landscape.

fig. 49 concept 3 and 4

Concept 5: sandy dyke

S2
S3

- **Create broad sandy dyke**
  - Aligns with landscape context of beach and dunes
  - Increases biodiversity: dynamic nature of the structure creates a variety in habitats
- **Implement footpaths and bicycle routes**
  - Promotes tourism and local economy
- **Create microtopography**
  - Increases biodiversity by providing gradients in landscape



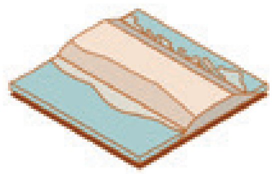
Expert feedback: sandy dyke

- Flood: Sandy dyke will still be effective in reducing waves and restricting flows than dykes which breach and degrade quickly once failled. The wide structure will be at the cost of the present-day salt marsh and mudlfats.
- Food: -
- Landscape: High-low gradients make this a rich structure for both nature and tourism.

Concept 6: barrier island

S2
S3

- **Create island row in front of the coast**
  - Maintains historical connection between city and water
- **Provide nature development: living shoreline**
  - Use natural flood defence properties of living shorelines
  - Increases biodiversity by expanding bird habitat
- **Implement footpaths and bicycle routes**
  - Promotes tourism and local economy



Expert feedback: barrier island

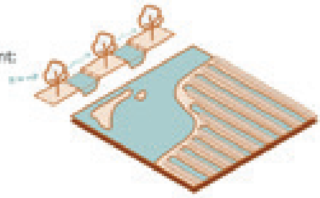
- Flood: Similar for the sandy dyke: For wider solutions like barrier islands economic activities will need to adapt. Wider measures like barrier islands will still be effective in reducing waves and restricting flows than dykes which breach and degrade quickly once failled. The wide structure will be at the cost of the present-day salt marsh and mudlfats.
- Food: -
- Landscape: Reserving the island for nature [development] could be beneficial in a tourist-heavy region.

fig. 50 concept 5 and 6

Concept 7: fish valley 2.0

S2 S3

- **Maintain / restore fish valleys**
  - Food source: sea bass, sea bream
  - Contributes to landscape quality by protecting mudflats
  - Structure is a landscape quality itself
  - Contributes to biodiversity by being an important forage and wintering bird habitat
- **Create a sheltered microclimate with windbreaks**
  - Makes heating basins with groundwater during winter redundant: becoming climate neutral and improves fresh water quantity
- **Implement seaweed production**
  - Improves water quality
  - Food source and fish feed
  - Closes cycles as nutrients between fish and plant are recycled
- **Implement willow-poplar filters**
  - Improves water quality and soil quality by filtering out pollutants and fertilisers.
- **Implement wooded banks**
  - Increases biodiversity by providing nesting, hiding and feeding places for insects, birds and mammals
  - Connects fish valley with surrounding landscape



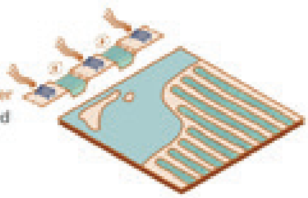
Expert feedback: fish valley 2.0

- Flood: -
- Food:
- Landscape: -

Concept 8: energy valley

S1 S2

- **Use fish valley structure**
  - Contributes to landscape quality by protecting mudflats
  - Structure is a landscape quality itself
- **Implement PV-panels**
  - Contributes to becoming climate neutral by generating energy
- **Implement microalgae production**
  - Food source: microalgae powder, fodder, natural fertiliser
  - Contributes to becoming climate neutral and improving freshwater quantity: microalgae can be turned into biofuel, which can be used for desalinisation plants.
- **Implement willow-poplar filters**
  - Improves water quality and soil quality by filtering out pollutants and fertilisers.
- **Implement wooded banks**
  - Increases biodiversity by providing nesting, hiding and feeding places for insects, birds and mammals
  - Connects fish valley with surrounding landscape



Expert feedback: fish valley 2.0

- Flood: -
- Food: -
- Landscape: -

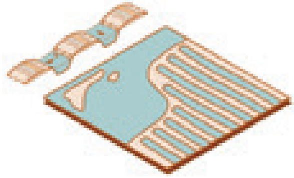
fig. 51 concept 7 and 8

Concept 9: agri-fish valley

S1

S2

- **Maintain / restore fish valleys**
  - Food source: sea bass, sea bream
  - Contributes to landscape quality by protecting mudflats
  - Structure is a landscape quality itself
  - Contributes to biodiversity by being an important forage and wintering bird habitat
- **Implement raised polyculture beds**
  - Food source: salt-tolerant crops
- **Implement seaweed production**
  - Improves water quality
  - Food source and fish feed
  - Closes cycles as nutrients between fish and plant are recycled
- **Implement willow-poplar filters**
  - Improves water quality and soil quality by filtering out pollutants and fertilisers.
- **Implement wooded banks**
  - Increases biodiversity by providing nesting, hiding and feeding places for insects, birds and mammals
  - Connects fish valley with surrounding landscape



Expert feedback: agri fish valley

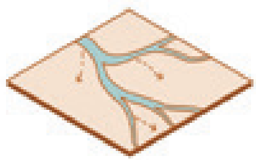
- Flood: -
- Food: In terms of carbon neutrality having a fish valley or a cultivated land isn't so different. The difference depends by how resources are used.
- Landscape: -

Concept 10: halophyte creek landscape

S2

S3

- **Restore old creek structures**
  - Contributes to landscape quality and promotes biodiversity by reintroducing saline gradients into the landscape
  - Promotes tourism and local economy by diversifying the agricultural landscape
- **Implement halophyte crops**
  - Food source: halophytes thriving on saline conditions
- **Implement gentle-sloped banks**
  - Contributes to biodiversity
  - Forms ecological network through agricultural landscape
  - Bufferzone between nature and agriculture



Expert feedback: halophyte creek landscape

- Flood: -
- Food: This allows for a constant process of salt water intrustion, which causes soil degradation. Unsure about halophyte profits.
- Landscape: Restoring creeks results in a rich and diverse landscape.

fig. 52 concept 9 and 10

fig. 53 base map

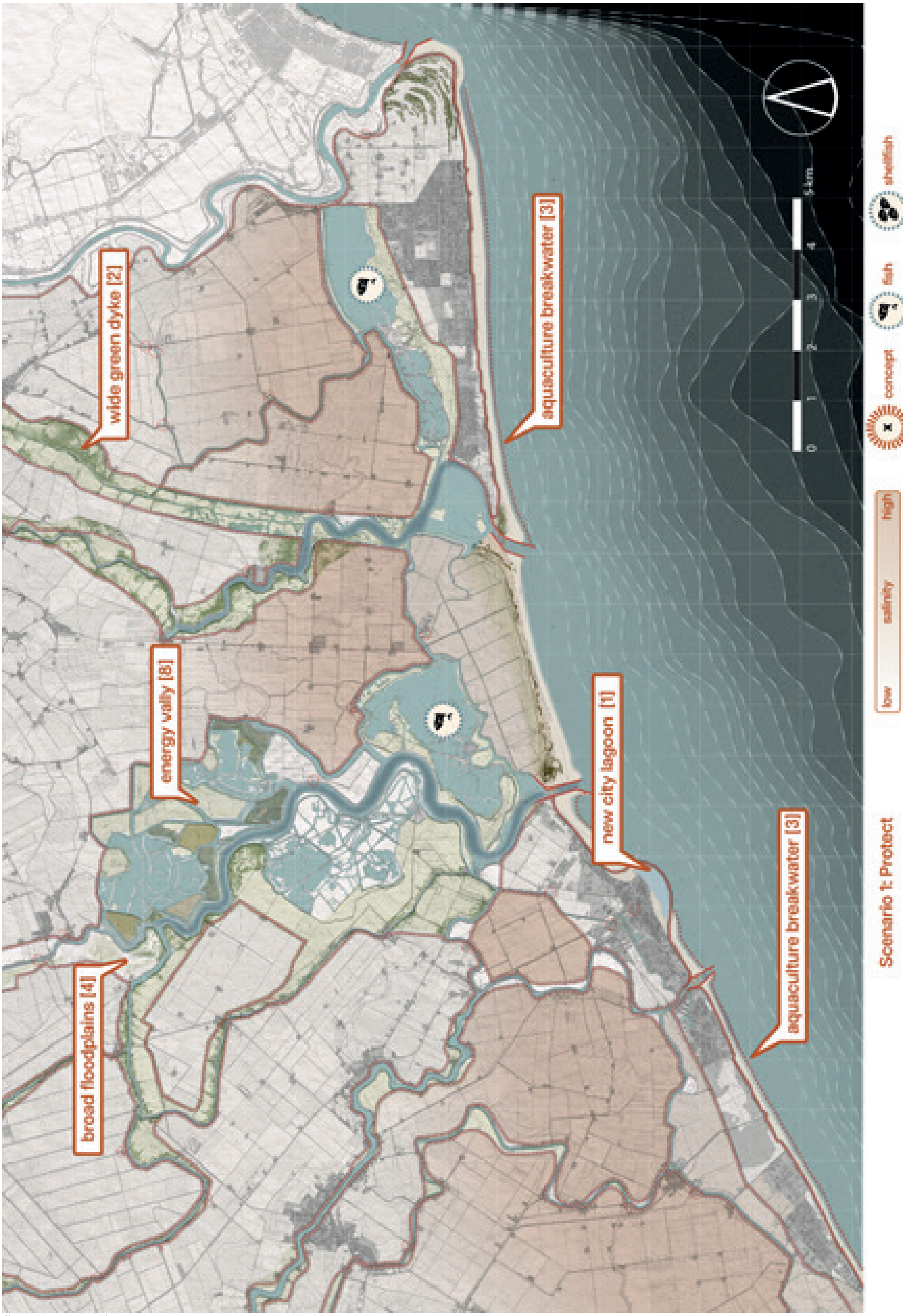


fig. 54 scenario 1: protect

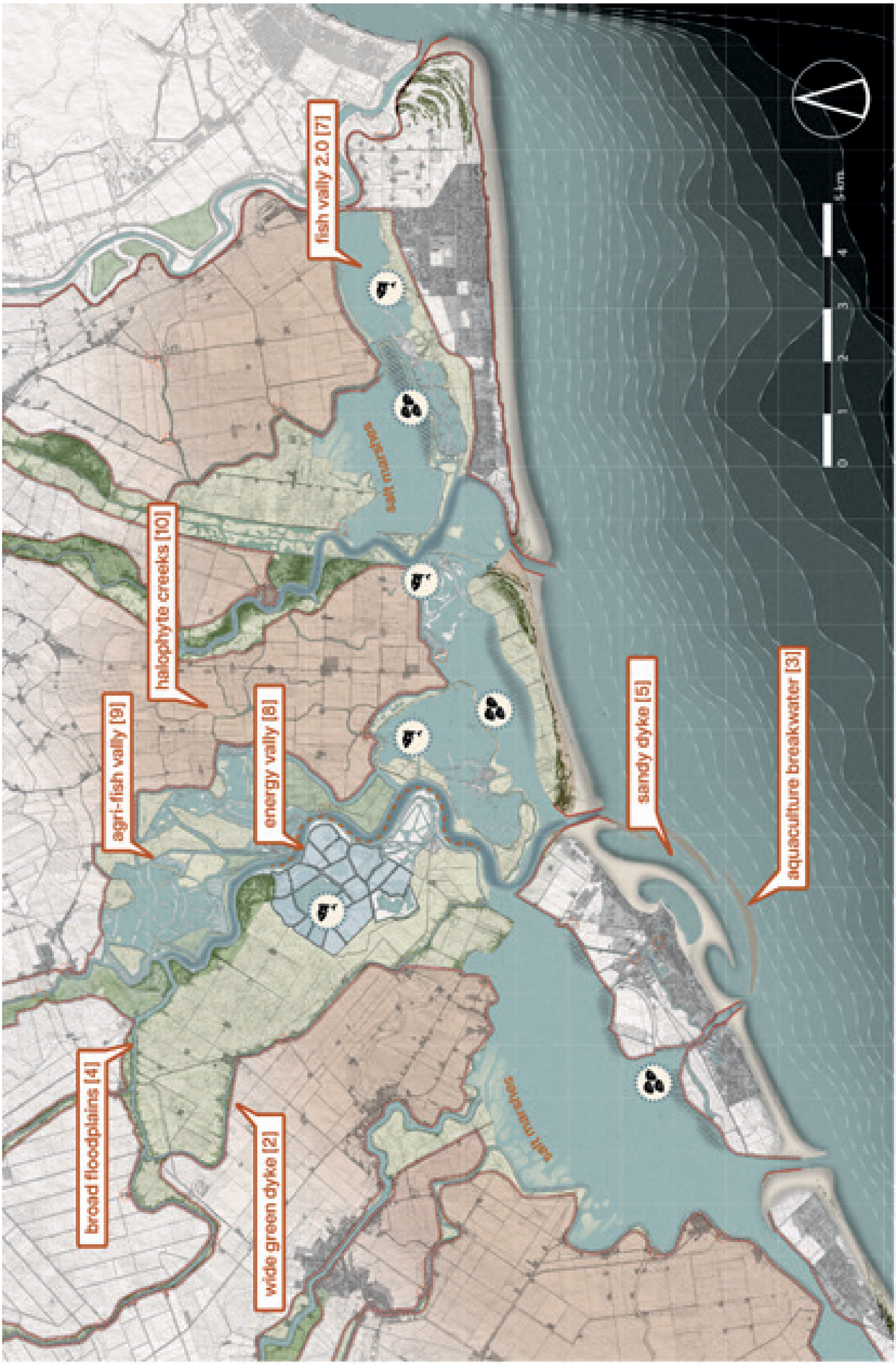


fig. 55 scenario 2: accommodate

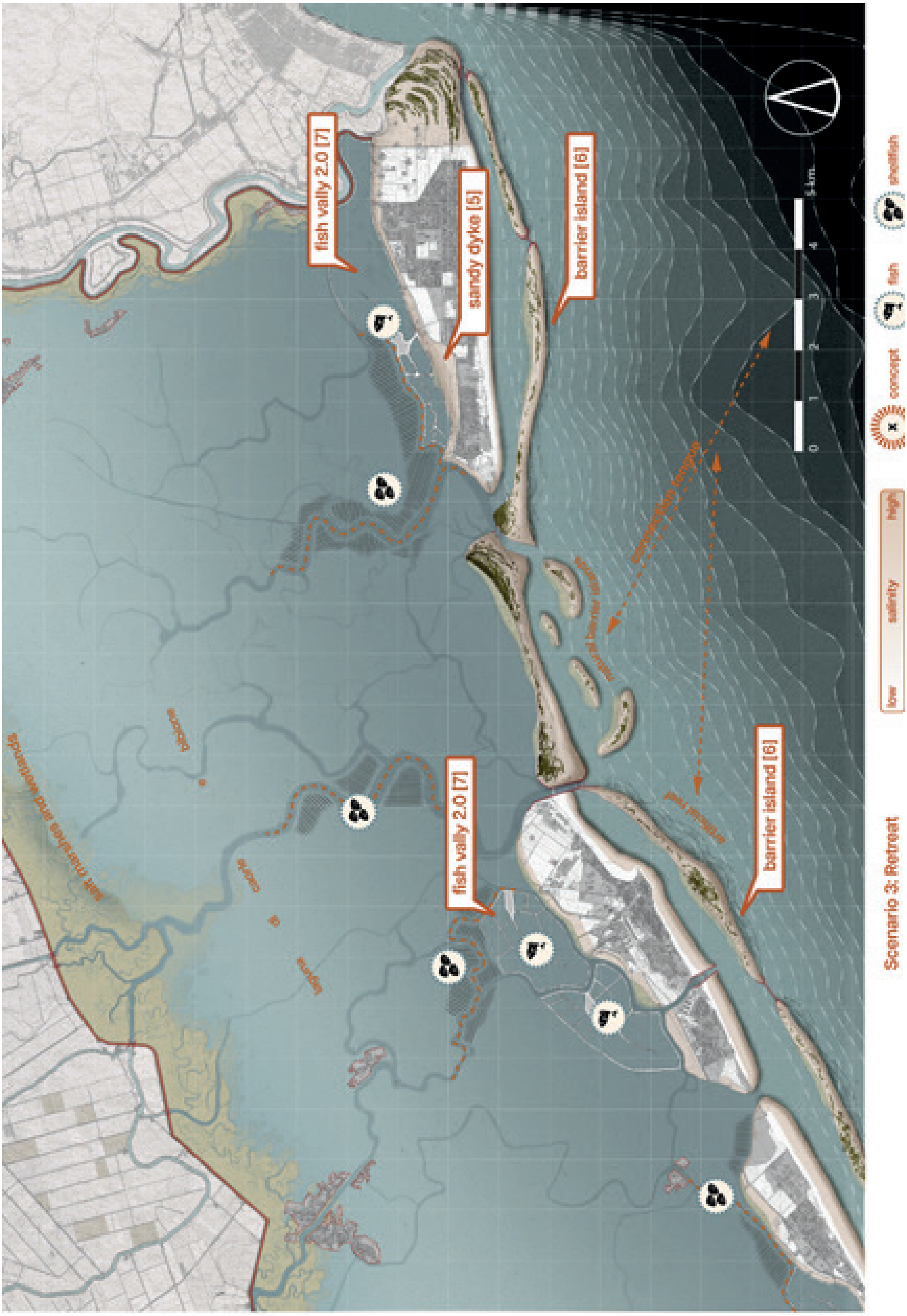


fig. 56 scenario 3: retreat

4.3 Expert assessment: test 1

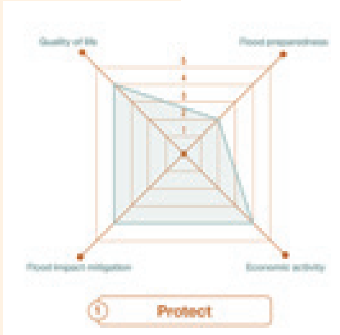
This section describes the results from the expert assessment test 1. The most relevant and notable results are discussed. Additionally, comments from the briefings are shared. Full transcripts of the assessment can be found in appendix B.

For each segment experts are asked to assess the designs. For flood control, Richard Marijnissen was asked. Marijnissen, currently active at Arcadis, is an expert on water safety. At Wageningen University and Research, he has completed a PhD in the multifunctional use of flood defences and nature-based flood defence solutions.

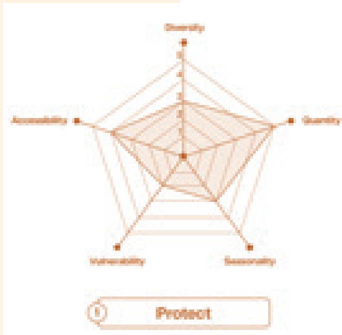
For food security (and LIA), Alberto Bonora was asked. Bonora is a researcher on spatial policy and part of the Planning and Climate Change Lab at the IUAV University of Venice Apart from being active in the research field, he is also a farmer in the Po-Delta. The combination of theory and practice, and knowledge of the conditions of the study area allows for valuable input and insights.

Landscape context is assessed by Michiel Bakx: PhD-candidate Landscape Architecture Wageningen University and Research. Here he researches spatial quality in flood risk management and investigates how spatial quality can be guaranteed in flood risk management projects.

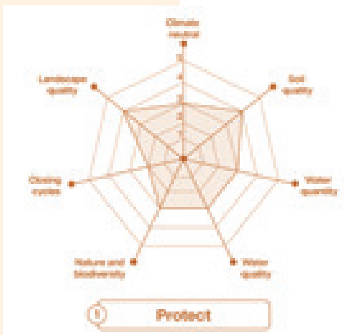
flood control



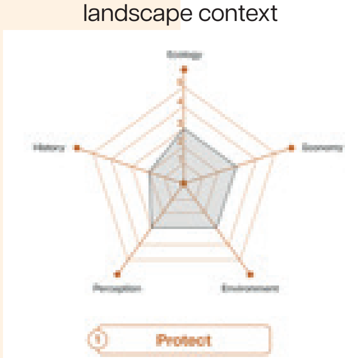
flood control

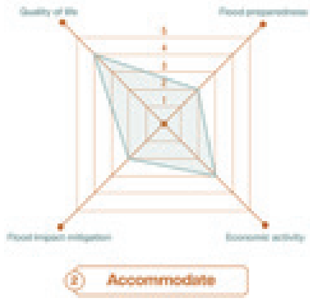


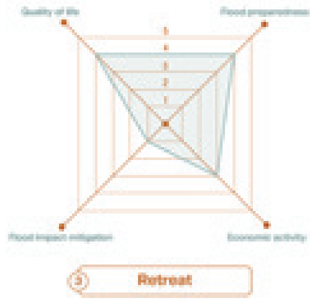
LIA

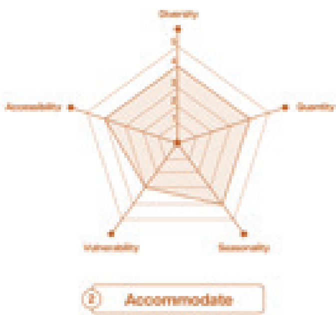


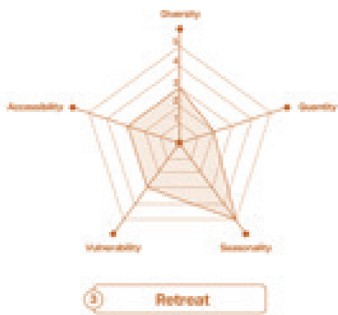
landscape context

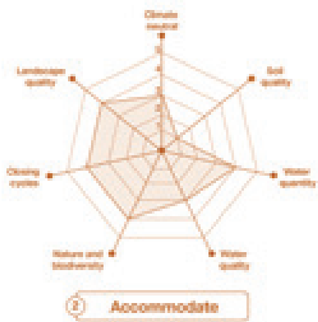


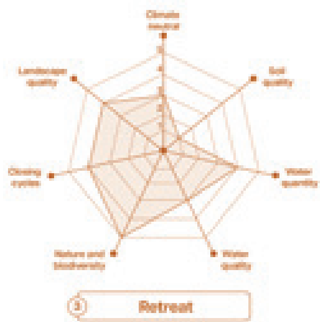

Quality of life
Flood preparedness
Flood impact mitigation
Economic activity
2 Accommodate

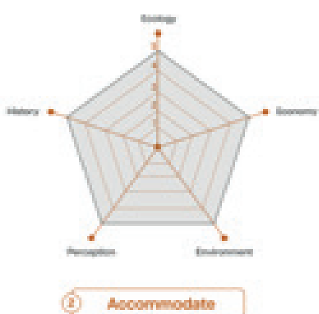

Quality of life
Flood preparedness
Flood impact mitigation
Economic activity
3 Retreat

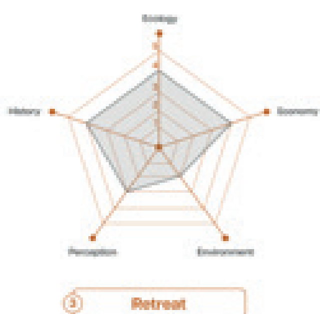

Diversity
Quantity
Seasonality
Vulnerability
Accessibility
2 Accommodate


Diversity
Quantity
Seasonality
Vulnerability
Accessibility
3 Retreat


Climate neutral
Soil quality
Water quantity
Water quality
Nature and biodiversity
Closing cycles
Landscape quality
2 Accommodate


Climate neutral
Soil quality
Water quantity
Water quality
Nature and biodiversity
Closing cycles
Landscape quality
3 Retreat


Ecology
Economy
Environment
Perception
History
2 Accommodate


Ecology
Economy
Environment
Perception
History
3 Retreat

Notable scores

Scenario 3: retreat scores low on flood impact mitigation. This is no surprise as in this scenario the water is let in and flood impact is allowed. However, this score could potentially be improved by suggesting floating structures.

On LIA both scenario 2: accommodate and scenario 3: retreat score low on soil quality. This is due to the fact that according to the expert, the soil quality will always decrease when allowing the process of salinisation: 'Where there is intrusion of salt water in the fields, there is a consequent process of soil degradation'. This also applies to water quality: when allowing the process of salinisation, the chance of salt water intrusion increases. Furthermore, the expert added that the way farmers use fresh water is more relevant than a landscape design. Water use and water contamination are topics to be tackled with policy. The trick here is to create conditions for farmers that enable sustainable land use. Restructuring the agricultural landscape system can contribute to this. In terms of climate-neutrality all scenarios score the same. Practicing aquaculture or agriculture do not differ that much on climate-neutrality. This mainly depends on how resources are used.

Based on landscape quality, scenario 2: Accommodate scores maximum points. This scenario is the 'inbetween' scenario, containing elements from both extremes. As a result, the landscape allows space for the wet-dry and saline-non-saline to be expressed. Diversity in the landscape is an opportunity for biodiversity and nature. Additionally, a diverse landscape offers opportunities for tourism.

Main takeaways and points for improvement

Concluding for flood control, all flood concepts except the aquaculture breakwater will reduce flood risk if designed well. Generally speaking, wider flood measures are robust compared to hard, narrow flood measures such as dykes. Wider measures such as the barrier islands and sandy dyke will still be effective in reducing flows, whereas dykes degrade quickly once failed. In terms of vulnerability, these broader measures could be considered safer in the long run. Additionally, wider measures create opportunities for biodiversity, agriculture, and tourism. Aquaculture breakwaters will not directly reduce flood risk, however, these structures can counteract coastal erosion. Furthermore, the dimensions of a breakwater significantly influence the sedimentation process.

1. Wider flood measures will be at cost of current existing salt marshes and mudflats. This loss of nature should be compensated and taken into account when designing these measures.
2. When space allows, wider flood measures are

preferred, as they are more robust, degrade slower when breached, and provide opportunities for biodiversity, agriculture, and tourism.

For food security and LIA, the concepts were not concrete enough yet, which impeded the assessment on certain criteria (e.g. climate-neutrality). The expert mentioned that the scenarios could also possibly function as a timeline, for example scenario 1 for 2040, scenario 2 for 2080, and scenario 3 for 2120. The future of predominantly saline agriculture (mono-crop) is questionable, as this does not promote landscape diversity, and could leave farmers vulnerable by only focussing on one crop-type. However, silvopasture and integrated aquaculture have potential. The long term focus will most likely involve an aquaculture-dominant region.

1. Aquaculture is less dependent on seasons, which can offset the seasonality that is apparent in many agricultural crops.
2. Soil degradation due to salinisation is inevitable.
3. Scenarios can also function as timeline and facilitate the transition of the landscape.

For landscape context, diversity was a key word. A diverse landscape allows space for gradients (wet-dry and saline-non-saline) to be expressed. Diversity in the landscape is an opportunity for biodiversity and nature. Furthermore, the contrast between the wide green dyke and the landscape are portrayed negatively. However, this contrast could also emphasise both landscapes. Dykes are lines that can frame the landscape and make it appear more as an entity.

1. Dykes can help frame the landscape and emphasise landscape elements.
2. Gradients in the landscape create diversity, which promotes biodiversity and tourism.

A general takeaway from this test, is that it became clear that in this case there should be an order of design. In the Research for Design phase, the layer-approach was used. Here, the abiotic layer is analysed first, followed by the biotic layer and finally the occupation layer. The abiotic layer impacts the type of ecosystem and what species can thrive, which in turn determines the land uses. When designing for agriculture, progressive insight is that this order also affects the design process. Designing flood control sets the conditions for agriculture. Additionally, flood control and agriculture ask for different design scales. For example, when setting the (abiotic) conditions with flood control, adapting the agricultural system to these conditions requires zooming in and testing new concepts.

The main points of improvement fall back to specifying flood control measures. A study on aquaculture breakwaters and their effects on water flows is needed to improve the concept. Additionally, in scenario 3: retreat, it is unclear how retreating from the area will happen. Flood measure 24 and 25, floating structures and planned abandonment/ relocation can be used for this. Finally, the concepts related to agriculture were not concrete enough yet and need exploration on a smaller scale. Based on the feedback, the scenario maps are improved. The main insights and main points of improvement are used for specifying concepts, designing new concepts and exploring designs for agriculture on a smaller scale.

4.4 New concepts and improving design

Based on test 1, feedback is incorporated into the scenario maps. This started with creating new concept 11: (farm) mounds, and new concept 12: houseboats (figure 57), which are based on measure 17: mounds, measure 24: floating strucutres, and measure 25: relocation. Other points of improvement will be addressed on the smaller scale, as this allows for more detailed designing. On the maps, the cut-out for the detailed design is highlighted in the red dotted square.

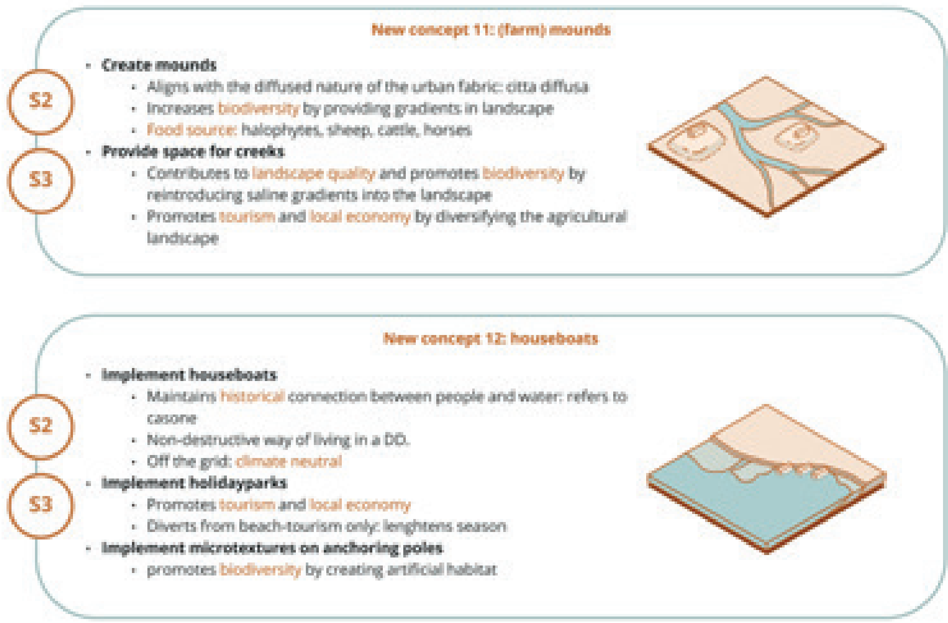


fig. 57 new concepts 11 and 12

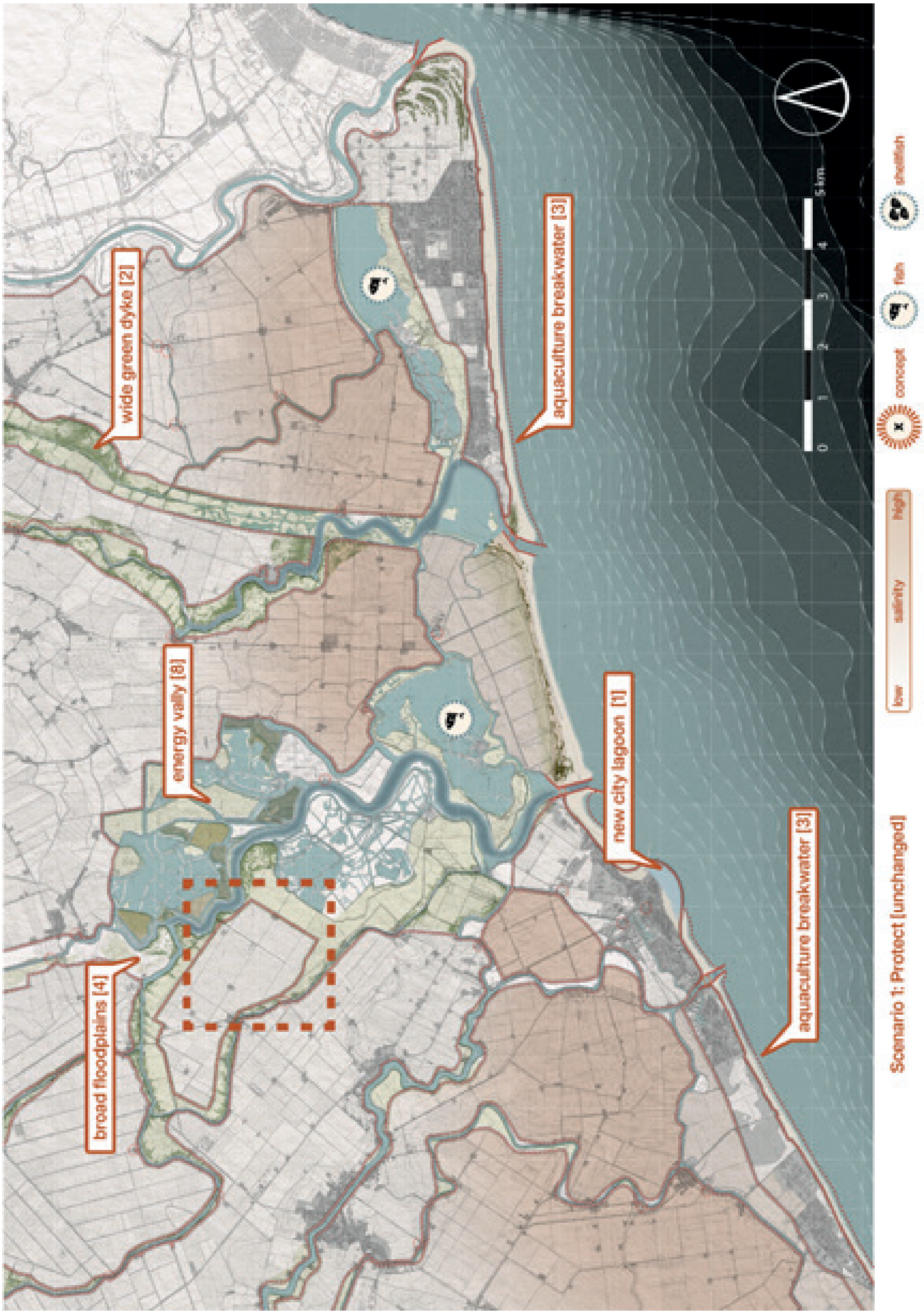


fig. 58 improved scenario 1: protect

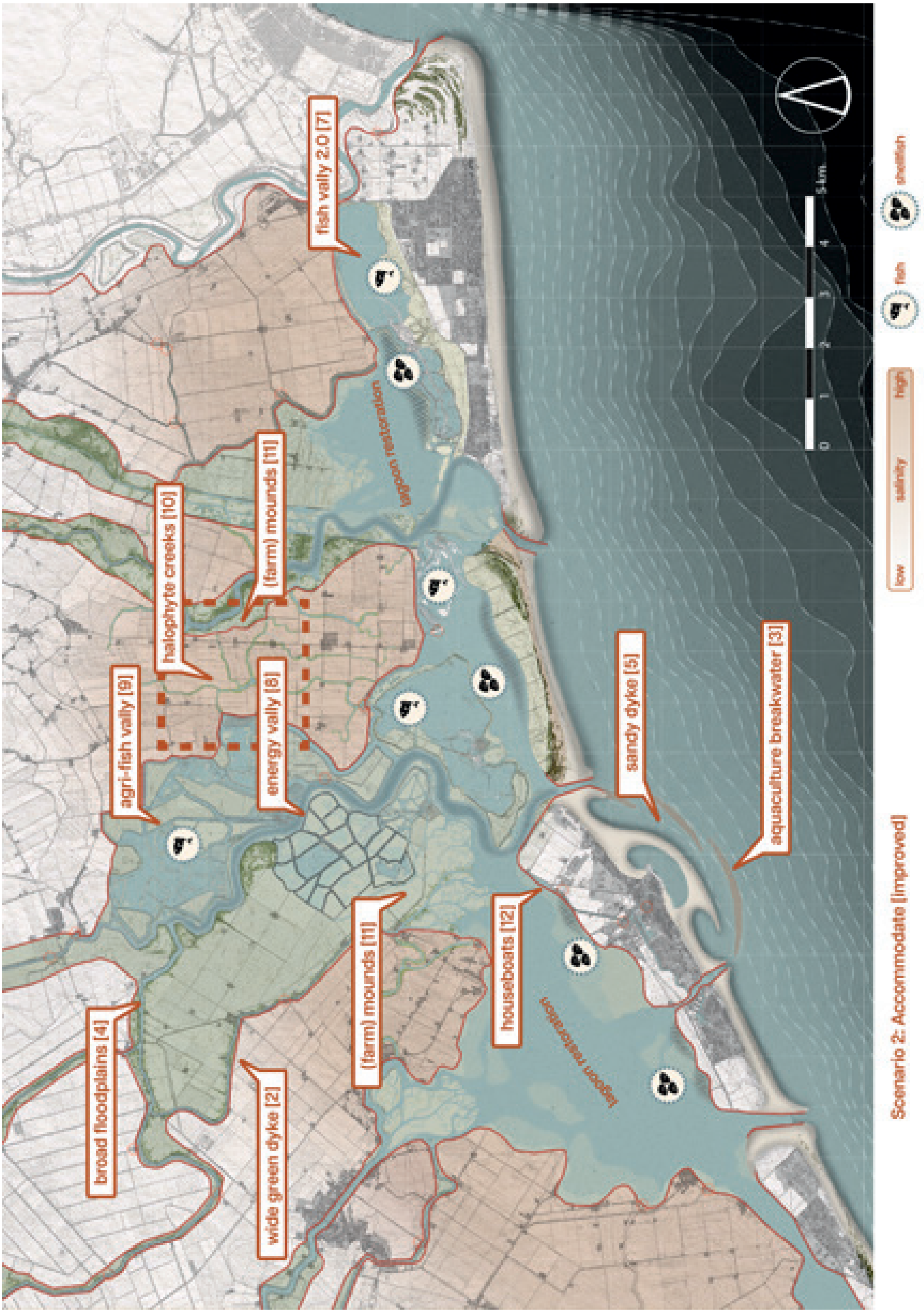


fig. 59 improved scenario 2: accommodate

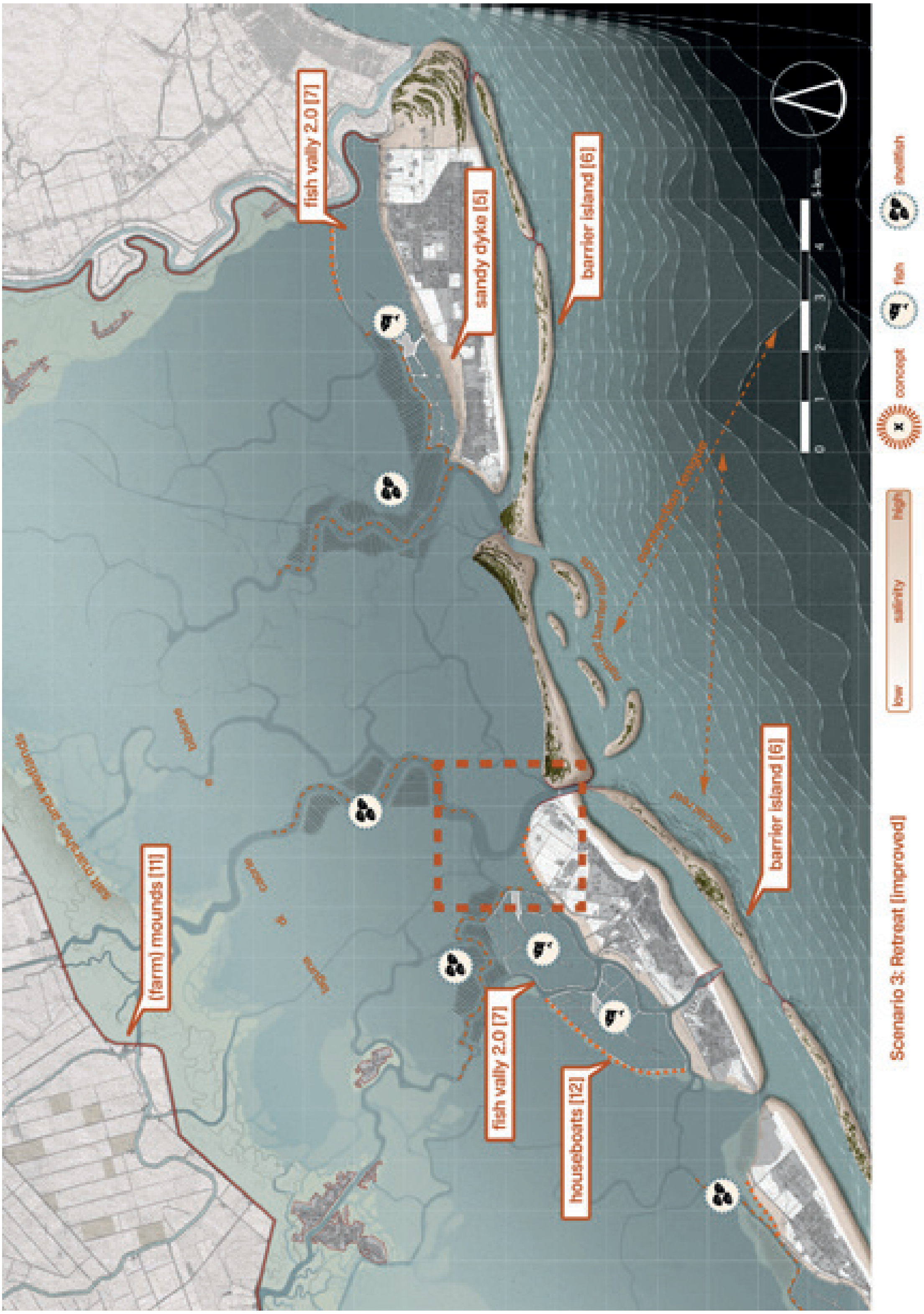


fig. 60 improved scenario 3: retreat

4.5 Scale jump: new concepts for agri-culture

The flood control measures have largely shaped the agricultural condition in terms of salinisation, saltwater intrusion, and fresh water. By zooming in, the agricultural system can be restructured and small(er) scale interventions can be designed. For each scenario, a zoom-in area is chosen, based on diversity in landscape elements that are relevant to the said scenario. To test the detailed designs, semi-structured interviews on food security, LIA, and landscape context are conducted. A semi-structured interview allows for an open discussion on the designs, which helps progress the designs.

For scenario 1: Protect, an area is chosen where the broad floodplain, fish valley, and high-production agriculture collide. Here, the focus is to fight the saline conditions and continue the current way of agriculture where possible.

Scenario 2: Accommodate, the creeks are a major landscape element. Zooming in on this area allows for designing possibilities for saline agriculture, and how this relates and interacts with other landscape elements such as the broad floodplain, fish valleys, and halophyte crops.

Scenario 3: Retreat, focuses on the historical city of Caorle and the restoration of the lagoon. Additionally, the interaction between fish valleys, saltpans, and halophytes is explored.

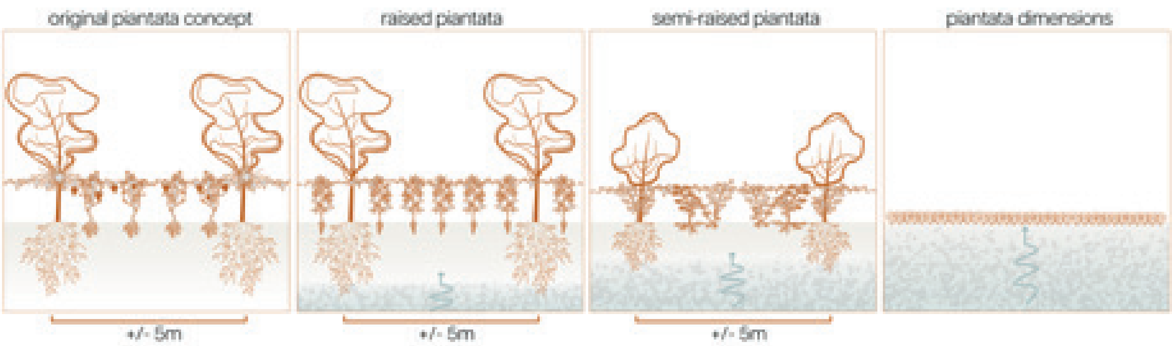


fig. 61 piantata concepts

New concepts: piantata

The following concepts are based on the piantata as described in chapter 3. The piantata is a historical mixed cultivation system that can be found throughout central and northern Italy. Vines were tangled with guardian trees (figure 61). These usually were elms and field maple, as these also provided fodder for cattle. However, willow, ash, poplar, mulberry, and occasionally fruit trees could also be found. Each region has its own take, with own fixed dimensions of the piantata, tailored to the landscape. Distances between trees can range up to 6 meters and between rows up to 30 meters.

This historical cultivation system is transformed into the following concepts:

New concept 13: raised piantata
New concept 14: semi-raised piantata
New concept 15: piantata dimensions

New concept 13: raised piantata

The raised piantata is tailored to scenario 1: protect. Saline conditions are avoided by raising the piantata. The trees are placed perpendicular to the dominant wind direction to protect crops from harsh winds and salt accumulation on leafs. Retention gullies collect rainwater for irrigation and decreases surface runoff erosion. Shallow-rooted crops minimise contact with saline environment (figure 62).

New concept 14: semi- raised piantata

The semi-raised piantata is tailored to scenario 2: Accommodate. The semi-raised banks temperthe saline conditions. Salt-tolerant crops can be cultivated here. Furthermore, halophytes are introduced. Just like the raised piantata, the semi-raised piantata has retention gullies to collect rainwater for irrigation and decreasing surface runoff erosion. Wind breaks perpendicular to the dominant wind direction protect crops from harsh winds and salt accumulation (figure 63).

New concept 15: piantata dimensions

This concept is tailored to scenario 3: retreat. Here, the process of salinisation is embraced. The focus is on cultivating halophytes. Additionally, retention gullies to collect rainwater for irrigation and decreasing surface runoff erosion are implemented (figure 64).

These new concepts are incorporated into the zoomed-in designs (figure 65, 66, and 67). The designs are then assessed by the experts on LIA, food security, and landscape context.

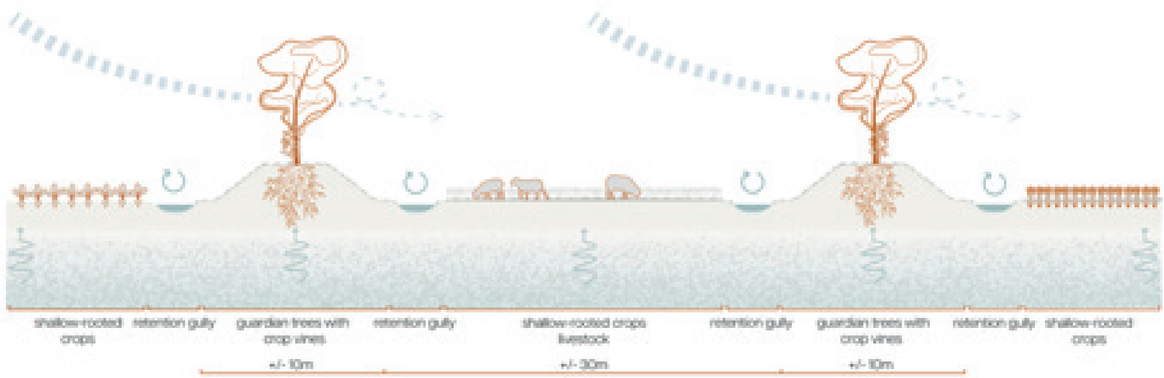


fig. 62 raised piantata

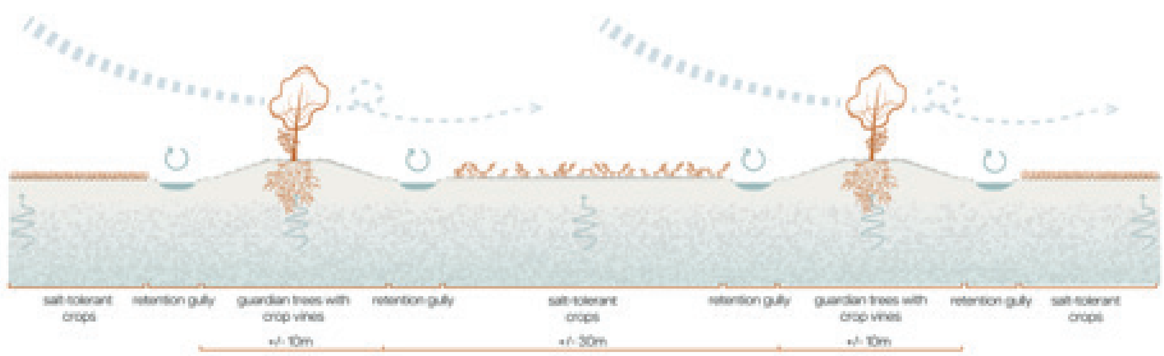


fig. 63 semi-raised piantata

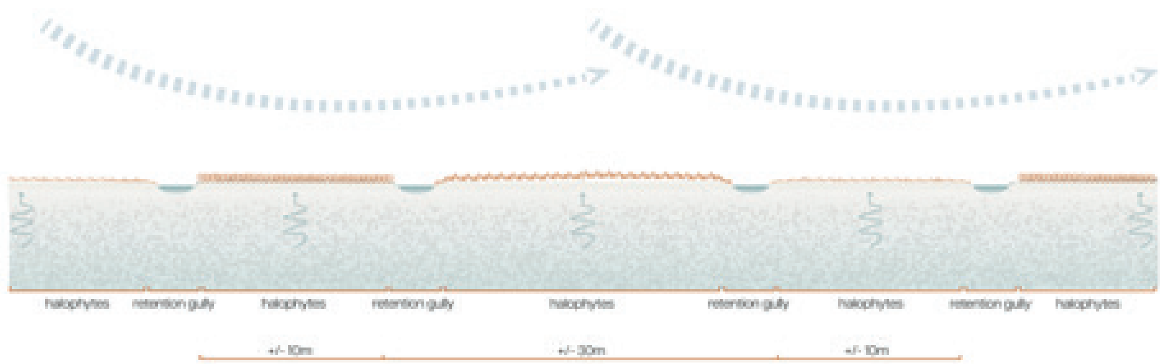


fig. 64 piantata dimensions

fig. 65 sketch inzoom scenario 1

fig. 66 sketch inzoom scenario 2

fig. 67 sketch inzoom scenario 3

4.6 Expert assessment: test 2

Here, the main take-aways and points for improvement are discussed. The full assessment notes can be found in appendix (x).

For landscape context the main takeaways are that lagoons are connective structures. Additionally, the tree rows used in the piantata structures, can help tie different landscape elements together. The spatial ‘language’ of the piantata can be used to transition one area into another area, while still maintaining a landscape unity. There seems to be a gradient with scenario 1 being most agriculture centred and scenario 3 most tourism centred. The main points of improvement for scenario 1 is to focus on the dynamic of the inner- and outer-dyke. These landscapes feel like two different worlds. The functions of these landscapes are different (agriculture and natural river), however, this does not mean that these worlds cannot be connected. The focus here is to look into transitioning these worlds into each other, as opposed to contrasting each other. Furthermore, for scenario 2, the axis of the graticolato romano can be emphasised. The creek beds can be more pronounced. Scenario 3 should focus on touristic housing.

For LIA and food security, the main takeaways are that the piantata structures can help create a robust and LIA system as it a polyculture system that aligns with the landscape identity. The different piantata structures can be used as a gradient, or transitional line, from non-saline dry to saline wet. The main point of improvement here is to alter the concept of piantata dimensions (15), as there is no actual tree plantation. A way to diversify the system is to add salt pans. Salt pans have high touristic value. The landscape in high saline circumstances could potentially be a more recreational and natural take on agriculture.

4.7 Final designs and principles

For the final designs, the concepts are revised and altered where necessary, based on the assessments. After the in-depth interviews, it was decided to arrange the final principles on gradients, as drowning deltas are gradients in high-low, wet-dry, and saline-non saline. Additionally, this could improve the over applicability of the final principles. Furthermore, this highlights the possible futures of drowning deltas and the possibilities of how to design for food security and flood control. For this, some of the concepts are rearranged or combined. The principles are arranged on:

Flood protection:
barrier island [6],
sandy dyke [5],
wide green dyke [2]

Foreshore measures:
wetland system,
artificial reef [1],
aquaculture breakwater [3]

Fishvalley structures:
energy fish valley [8+12],
agri- fish valley [9+12],
fish valley 2.0 [7+12]

Piantata structures:
raised-piantata [13],
semi-raised piantata [14],
saltpantata [15]

Water system restoration:
floodplain restoration [4+11],
creek restoration [10],
lagoon restoration

The numbers in the principles explain the spatial interventions and their effects. The letters are interventions specifically tailored for the northeastern Italian coast. These interventions do not affect the principles and can be ignored if outside this area. Below each design principle, overarching LIA principles for designing food security and flood control for drowning deltas can be found.

1.Diversify farms and farming practices. Diversifying farm and farming practices strengthens the economical resilienc improves biodiversity, and reduces crop diseases. [X: fair prices] [V: biodiversity]

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

2a. Aquaculture foreshore. Foreshore measures protect th coast from erosion and can be combined with aquaculture t improve water quality and biodiversity. [V: biodiversity] [III: water quality] [VIII: food]

2b. Repurpose agricultural heritage. Functional heritage will not vanish. Assigning additional functions to historical structures makes them more profitable and resilient, while simultaneously improving the landscape quality. [landscape quality]

3.Create gradients for (bio)diversity.

3a. Micro topographies and textures. Implementing micr topographies and textures into flood control structures are elementary interventions with a significant impact on biodiversity and water quality. [V: biodiversity] [III: water quality]

3b. Gentle slopes. Gentle slopes in flood control structure offer opportunities for agriculture, nature and biodiversity and tourism. Gentle slopes embed flood control structures into the surrounding landscape. [V: biodiversity] [VIII: food]

4.Restore and connect ecological structures. Restoring ecological structures improves the landscape quality and restores the resilient properties of the landscape, improvin biodiversity, soil quality, and water quality. Connecting landscape elements through blue-green structures strengthens ecological networks and corridors.[V: biodiversity] [II soil quality] [III: water quality]

5.Nature as a starting point. Adjust farming strategies to the natural landscape. Collaborate instead of manipulate wi the local conditions, as every landscape offers different an unique opportunities.

5a. Use salinity. Salinity is an asset: it offers opportunities fo halophyte cultivation, saltpans, and aquaculture. [VIII: food]

6.(Agricultural) landscape as a system. Approaching the (agricultural) landscape as a system promotes collaboratio between sectors and actors, which offers opportunities for closing cycles and becoming climate-neutral. [VI: close cycle [I: climate-neutral]

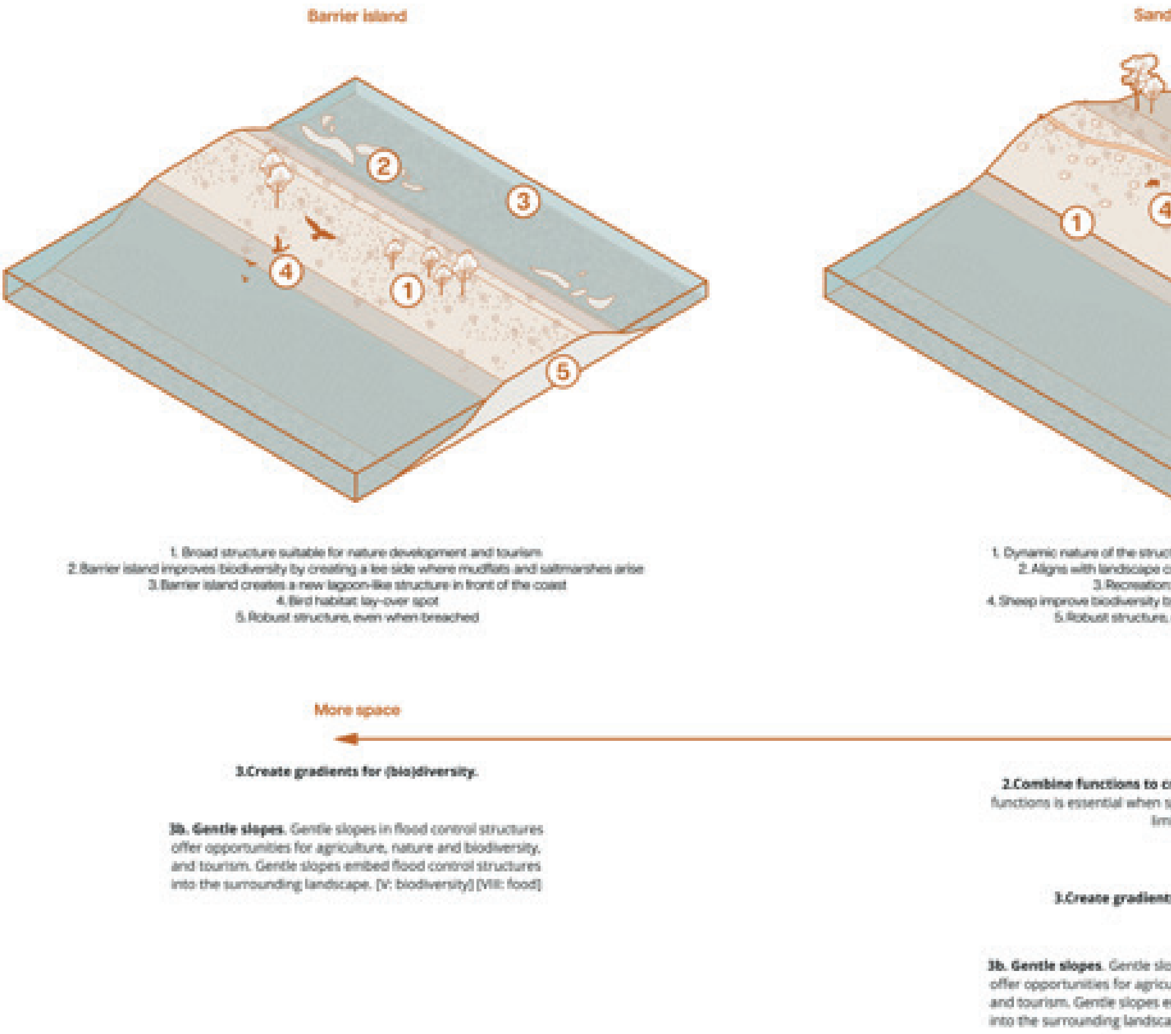
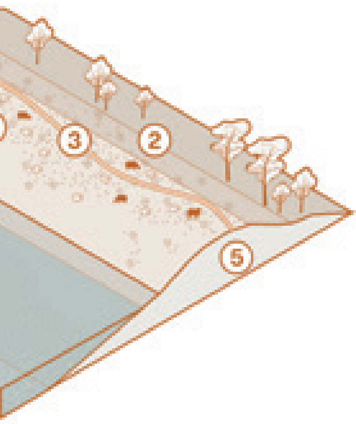
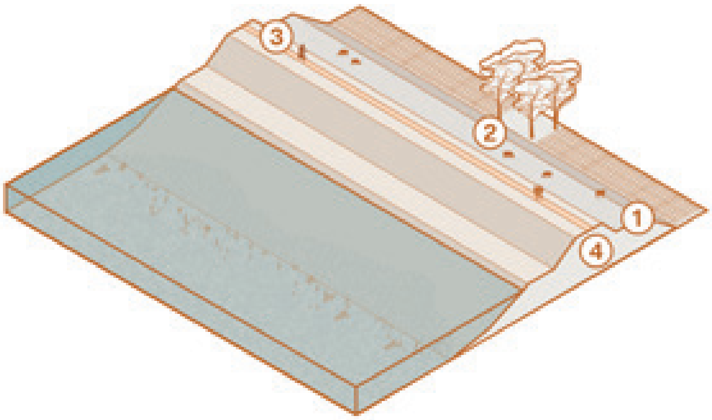


fig. 68 flood protection principles

y dyke



Wide green dyke



ure creates a variety in habitats
ontext of beach and dunes
hiking, cycling
 trampling and grazing patterns
even when breached

1. Gentle slope enables for combining land uses: agriculture, nature, energy, recreation
2. Dyke as food source: sheep, fodder, herbal 'teas'
3. Recreation: hiking, cycling
4. Robust structure

Less space

eate synergies. Combining
pace is becoming increasingly
ited.

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

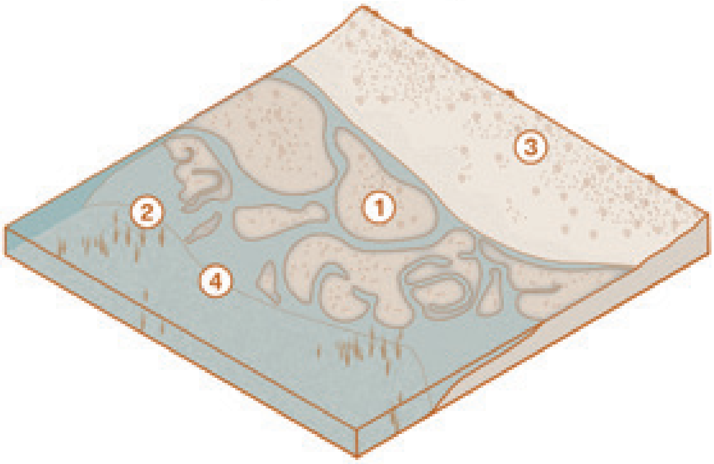
s for (bio)diversity.

3.Create gradients for (bio)diversity.

pes in flood control structures
ture, nature and biodiversity,
nbed flood control structures
pe. [V: biodiversity] [VIII: food]

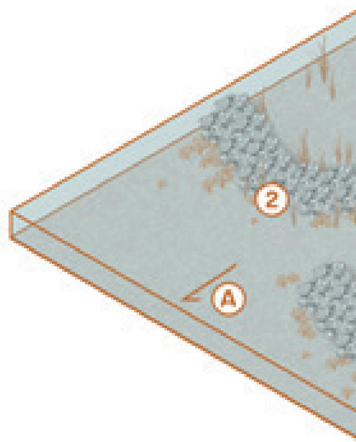
3b. Gentle slopes. Gentle slopes in flood control structures offer opportunities for agriculture, nature and biodiversity, and tourism. Gentle slopes embed flood control structures into the surrounding landscape. [V: biodiversity] [VIII: food]

Wetland system: natural foreshore protection



1. Salt-marshes reduce wave energy, silt up the land, and act as flood-buffer
2. Important habitat for sea grasses and macroalgae, that filter water
3. Slow gradient provides a high degree of biodiversity
4. Important habitat for sealife

Artificial reef: semi-engineered



1. Microtopography creates h
2. Texture -variety attracts
3. Shellfish improve the water quality
4. Low-impact an

A. Hard structure

low hydroforce, lot of space

4.Restore and connect ecological structures. Restoring ecological structures improves the landscape quality and restores the resilient properties of the landscape, improving biodiversity, soil quality, and water quality. Connecting landscape elements through blue-green structures strengthens ecological networks and corridors.[V: biodiversity] [II soil quality] [III: water quality]

2.Combine functions to c functions is essential when s lim

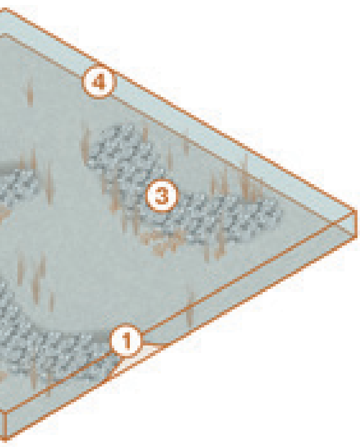
2a. Aquaculture foreshore. F coast from erosion and can be improve water quality and bi water quali

3.Create gradient

3a. Micro topographies and topographies and textures in elementary interventions biodiversity and water quali qu

fig. 69 foreshore principles

aquaculture foreshore protection



iding spaces and living habitats
a diversity in small organisms
by filtering out pollutants and fertilisers
d dynamic structure

xtends tegnue reefs

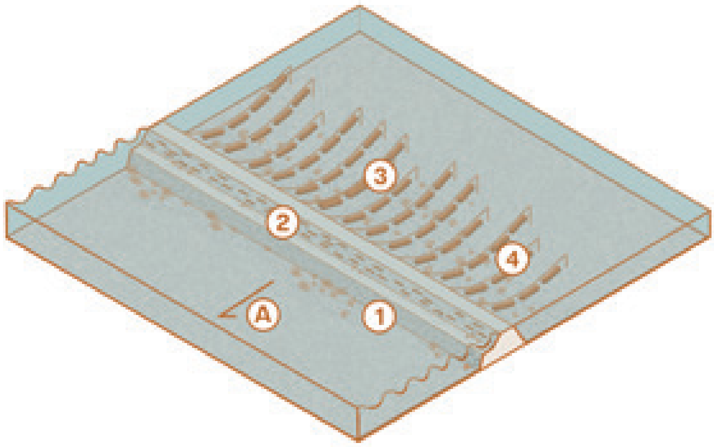
reate synergies. Combining
pace is becoming increasingly
ited.

Foreshore measures protect the
e combined with aquaculture to
odiversity. [V: biodiversity] [III:
ty] [VIII: food]

s for (bio)diversity.

textures. Implementing micro
to flood control structures are
with a significant impact on
ity. [V: biodiversity] [III: water
ality]

Aquaculture breakwater: engineered aquaculture foreshore protection



1. Microtopography creates hiding spaces and living habitats
2. Texture -variety attracts a diversity in small organisms
3. Shellfish improve the water quality by filtering out pollutants and fertilisers
4. (Aqua)productive way of reducing wave energy

A. Hard structure extends tegnue reefs

high hydroforce, limited space

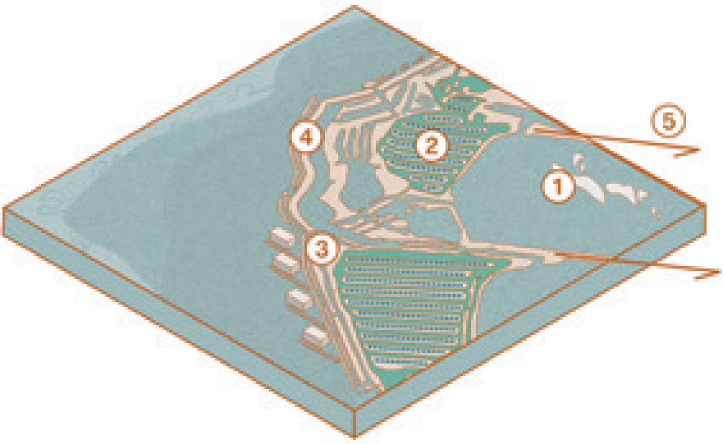
2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

2a. Aquaculture foreshore. Foreshore measures protect the coast from erosion and can be combined with aquaculture to improve water quality and biodiversity. [V: biodiversity] [III: water quality] [VIII: food]

3.Create gradients for (bio)diversity.

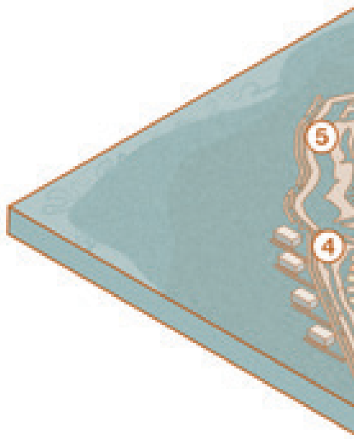
3a. Micro topographies and textures. Implementing micro topographies and textures into flood control structures are elementary interventions with a significant impact on biodiversity and water quality. [V: biodiversity] [III: water quality]

Energy fish valley



1. Open basin as bird habitat and for mudflat protection
2. Microalgae biofuel production and PV-panels provide multiple-energy sources
3. Houseboats promote tourism and local economy, and provides farmer with extra source of income
4. (Cycle) paths and hiking trails promote tourism and local economy
5. Hedgerows connect energy valley with the surrounding landscape

Agri- fi



1. Open basin as bird habitat, extensive fis
2. Macroalgae production provides food, fodder, improves
3. Raised polyculture bed
4. Houseboats promote tourism and local econom
5. (Cycle) paths and hiking trails pr
6. Hedgerows connect energy vall

low tidal influence
less saline

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

2b. Repurpose agricultural heritage. Functional heritage will not vanish. Assigning additional functions to historical structures makes them more profitable and resilient, while simultaneously improving the landscape quality. [landscape quality]

5a. Use salinity. Salinity is an asset: it offers opportunities for halophyte cultivation, saltpans, and aquaculture. [VIII: food]

1.Diversify farms and farmi
and farming practices strengt
improves biodiversity, and r
prices] [V:

2.Combine functions to c
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2b. Repurpose agricultural
will not vanish. Assigning ad
structures makes them more
simultaneously improving the
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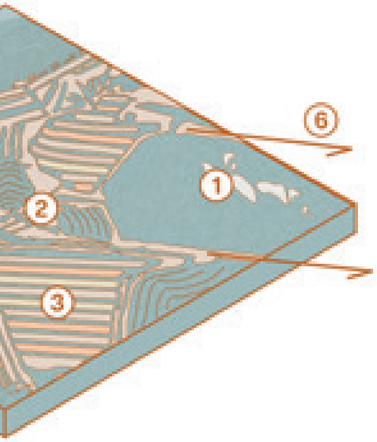
5a. Use salinity. Salinity is an a
halophyte cultivation, saltpans

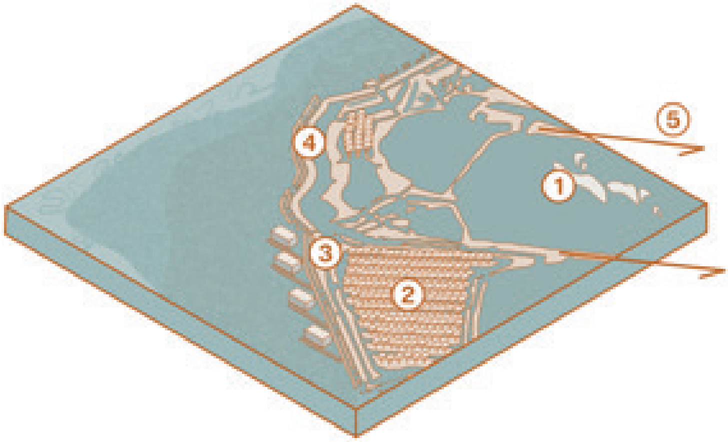
fig. 70 fish valley principles

sh valley



n production and for protection of mudflats
water quality, and cycles nutrients between fish and plant
s with salt-tolerant crops
y, and provides farmer with extra source of income
omote tourism and local economy
ey with the surrounding landscape

Fish valley 2.0



1. Open basin as bird habitat, semi-intensive fish production and for protection of mudflats
2. Shrubs create a sheltered winter habitat for the fish, making heating basins redundant
3. Houseboats promote tourism and local economy, and provides farmer with extra source of income
4. (Cycle) paths and hiking trails promote tourism and local economy
5. Hedgerows connect energy valley with the surrounding landscape

high tidal influence
more saline

g practices. Diversifying farms
hens the economical resilience,
reduces crop diseases. [X: fair
biodiversity]

reate synergies. Combining
pace is becoming increasingly
ited.

heritage. Functional heritage
ditional functions to historical
profitable and resilient, while
landscape quality. [landscape
ality]

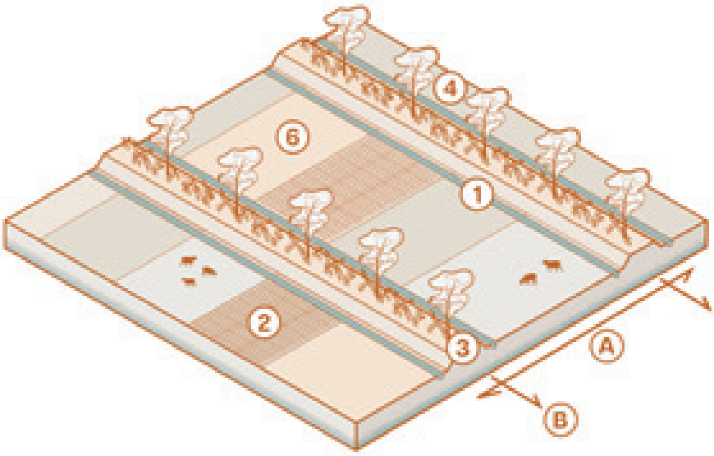
asset: it offers opportunities for
, and aquaculture. [VIII: food]

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

2b. Repurpose agricultural heritage. Functional heritage will not vanish. Assigning additional functions to historical structures makes them more profitable and resilient, while simultaneously improving the landscape quality. [landscape quality]

5a. Use salinity. Salinity is an asset: it offers opportunities for halophyte cultivation, saltpans, and aquaculture. [VIII: food]

Raised piantata: saline-resilient diverse agricultural system



1. Retention gullies collect rainwater for irrigation and decreases surface runoff erosion
2. Shallow-rooted crops minimise contact with saline environment
3. Raised banks prevent crops from contact with saline environment
4. Wind breaks perpendicular to the dominant wind direction protect crops from harsh winds and salt accumulation
5. Polyculture decreases the change of crop diseases, improves biodiversity, and closes (agricultural) cycles
6. Salt-tolerant plants

A. Restore piantata by using the local dimensions
B. Extend and align the piantata into the graticolato romano

low-saline

1.Diversify farms and farming practices. Diversifying farms and farming practices strengthens the economical resilience, improves biodiversity, and reduces crop diseases. [X: fair prices] [V: biodiversity]

5.Nature as a starting point. Adjust farming strategies to the natural landscape. Collaborate instead of manipulate with the local conditions, as every landscape offers different and unique opportunities.

6.(Agricultural) landscape as a system. Approaching the (agricultural) landscape as a system promotes collaboration between sectors and actors, which offers opportunities for closing cycles and becoming climate-neutral. [VI: close cycles] [I: climate-neutral]

Semi-raised piantata: saline-tole

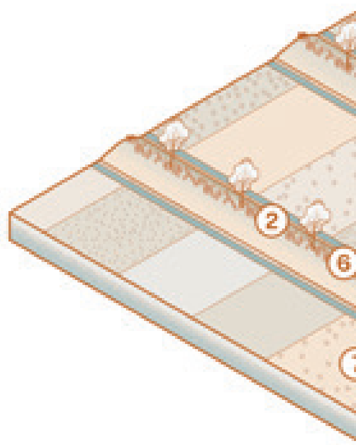


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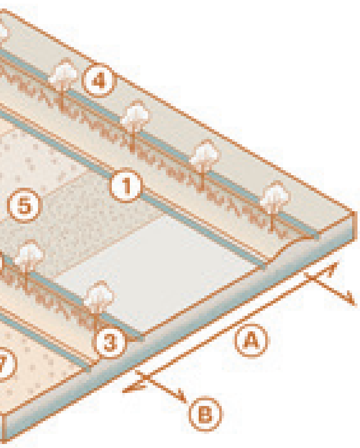
fig. 71 piantata principles

rant diverse agricultural system



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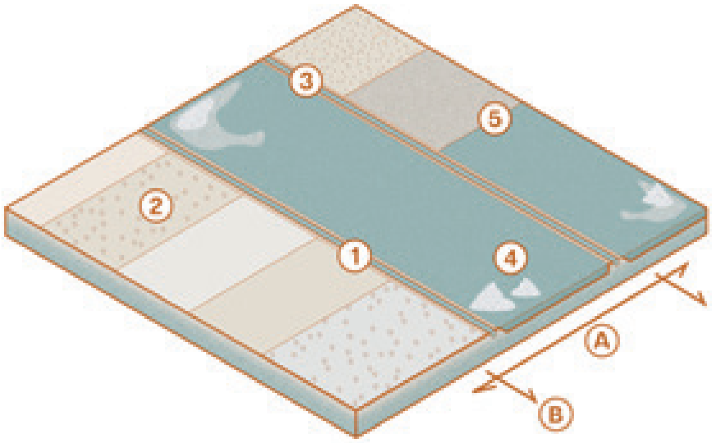
Saltpantata: halophilous diverse agricultural system



1. Retention gullies collect rainwater for irrigation and decreases surface runoff erosion
2. Halophytes: profit from saline environment
3. Polyculture decreases the change of crop diseases, improves biodiversity, and closes (agricultural) cycles
4. Salt pans: profit from saline environment
5. Flood buffer-zone

A. Restore piantata structure by using the local dimensions
B. Extend and align the saltpantata into the graticolato romano

high-saline

g practices. Diversifying farms
hens the economical resilience,
reduces crop diseases. [X: fair
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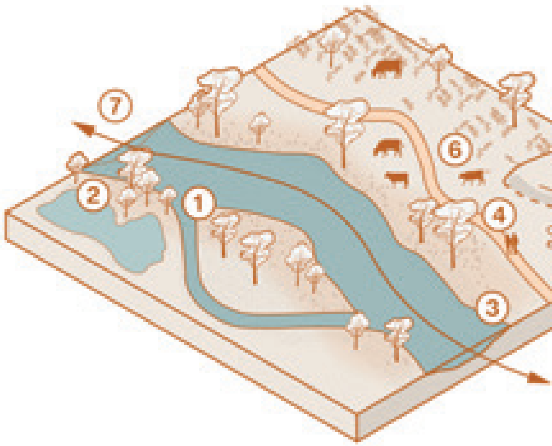
6.(Agricultural) landscape as a system. Approaching the (agricultural) landscape as a system promotes collaboration between sectors and actors, which offers opportunities for closing cycles and becoming climate-neutral. [VI: close cycles] [I: climate-neutral]

Floodplain restoration: interplay of wet and dry



1. Broad floodplain enables meandering and habitat diversification
2. Basins retain water for dry periods
3. Gentle-sloped banks promote biodiversity
4. Floodplain recreation: hiking, fishing
5. Farm mounds: no flood hazard during wet season
6. Cattle increases biodiversity by grazing patterns, trampling, and manure
7. Ecosystem corridors: connecting element

low saline, land-inwards

1.Diversify farms and farming practices. Diversifying farms and farming practices strengthens the economical resilience, improves biodiversity, and reduces crop diseases. [X: fair prices] [V: biodiversity]

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

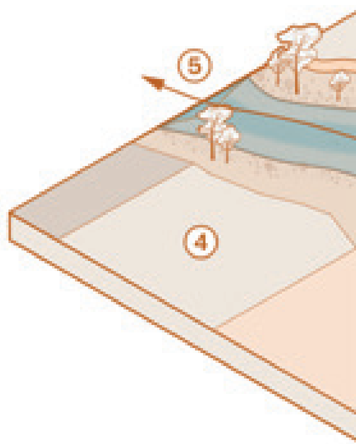
3.Create gradients for (bio)diversity.

3b. Gentle slopes. Gentle slopes in flood control structures offer opportunities for agriculture, nature and biodiversity, and tourism. Gentle slopes embed flood control structures into the surrounding landscape. [V: biodiversity] [VIII: food]

4.Restore and connect ecological structures. Restoring ecological structures improves the landscape quality and restores the resilient properties of the landscape, improving biodiversity, soil quality, and water quality. Connecting landscape elements through blue-green structures strengthens ecological networks and corridors.[V: biodiversity] [I soil quality] [III: water quality]

5.Nature as a starting point. Adjust farming strategies to the natural landscape. Collaborate instead of manipulate with the local conditions, as every landscape offers different and unique opportunities.

Creek restoration:



1. Creek restoration creates gradients i
2. Gentle-sloped bank
3. Recreation: cyc
4. Halophyte and
5. Ecosystem corrido

1.Diversify farms and farmin and farming practices strengt improves biodiversity, and r prices] [V: I

2.Combine functions to c functions is essential when s lim

3.Create gradient

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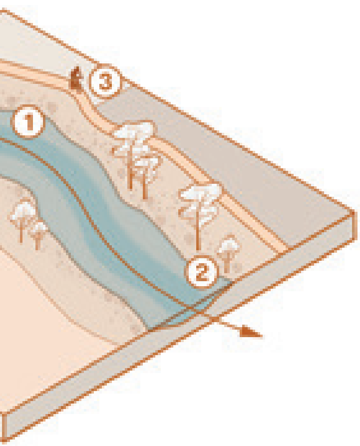
4.Restore and connect eco ecological structures impro restores the resilient propert biodiversity, soil quality, ar landscape elements thro strengthens ecological r biodiversity] [I soil qu

5.Nature as a starting poin the natural landscape. Collabo the local conditions, as every unique op

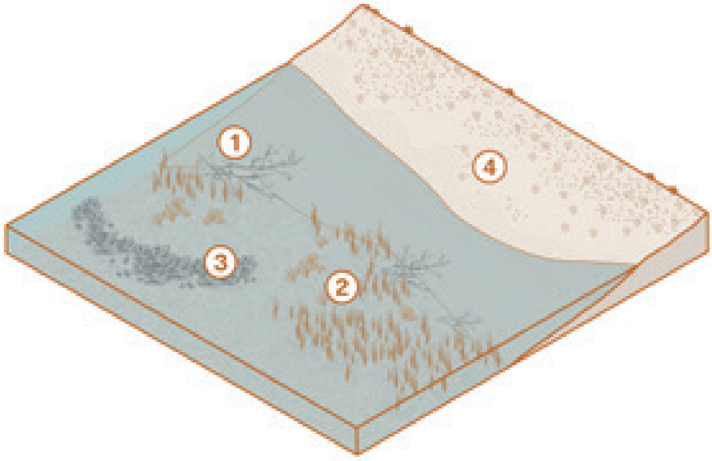
5a. Use salinity. Salinity is an halophyte cultivation, saltpans

fig. 72 Ecosystem restoration principles gradients in salinity



n salinity, enabling habitat diversification
s promote biodiversity
ding, hiking, fishing
salt-tolerant crops
rs: connecting element

Lagoon restoration: between sea and land



1. Implementing driftwood shelters juvenile seagrasses and helps them to develop
2. Seagrass meadows store co2 and filter out pollutants and fertilisers
3. Shellfish improve the water quality by filtering out pollutants and fertilisers
4. Gentle-sloped banks promote biodiversity

high saline, sea-outward

g practices. Diversifying farms
thens the economical resilience,
reduces crop diseases. [X: fair
biodiversity]

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Final design scenario 1: Protect

Scenario 1: protect aims to keep the water out and focus on conventional crops. The agricultural landscape consists of the raised piantata, which creates a diverse and sheltered landscape inside the wide green dyke. Outside the wide green dyke, the fish valleys can be found. The energy valley combines microalgae production with PV-panels, providing energy which can be used to desalinate water. The outside and inside of the dyke are connected with each other through wooded banks. The broad floodplain allows the river to take its place again. The dynamic floodplain is a stark contrast with the overarching graticolato romano grid inside the dyke. From the dyke these differences can be observed. The wide green dyke forms a border between these two worlds, where at the same time it acts as a connecting element. The wide green dyke offers opportunities for agriculture with different crops and livestock, as well as recreation (cycling, hiking). The floodplain has a decked path through the wet nature area. The foodscape of scenario 1: protect is centred around high production crops, such as corn, beets and soy, alternated with fruit and nut trees (figure 73). Furthermore, the fish valleys provide fish and algae and on the floodplain cattle grazes. Overall, this results in a landscape both diverse and high production (figure 74).

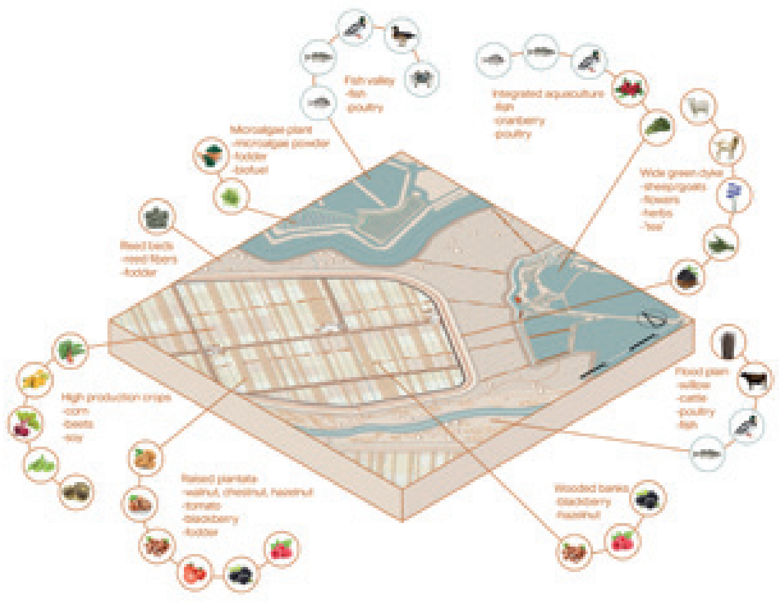


fig. 73 foodscape impression scenario 1

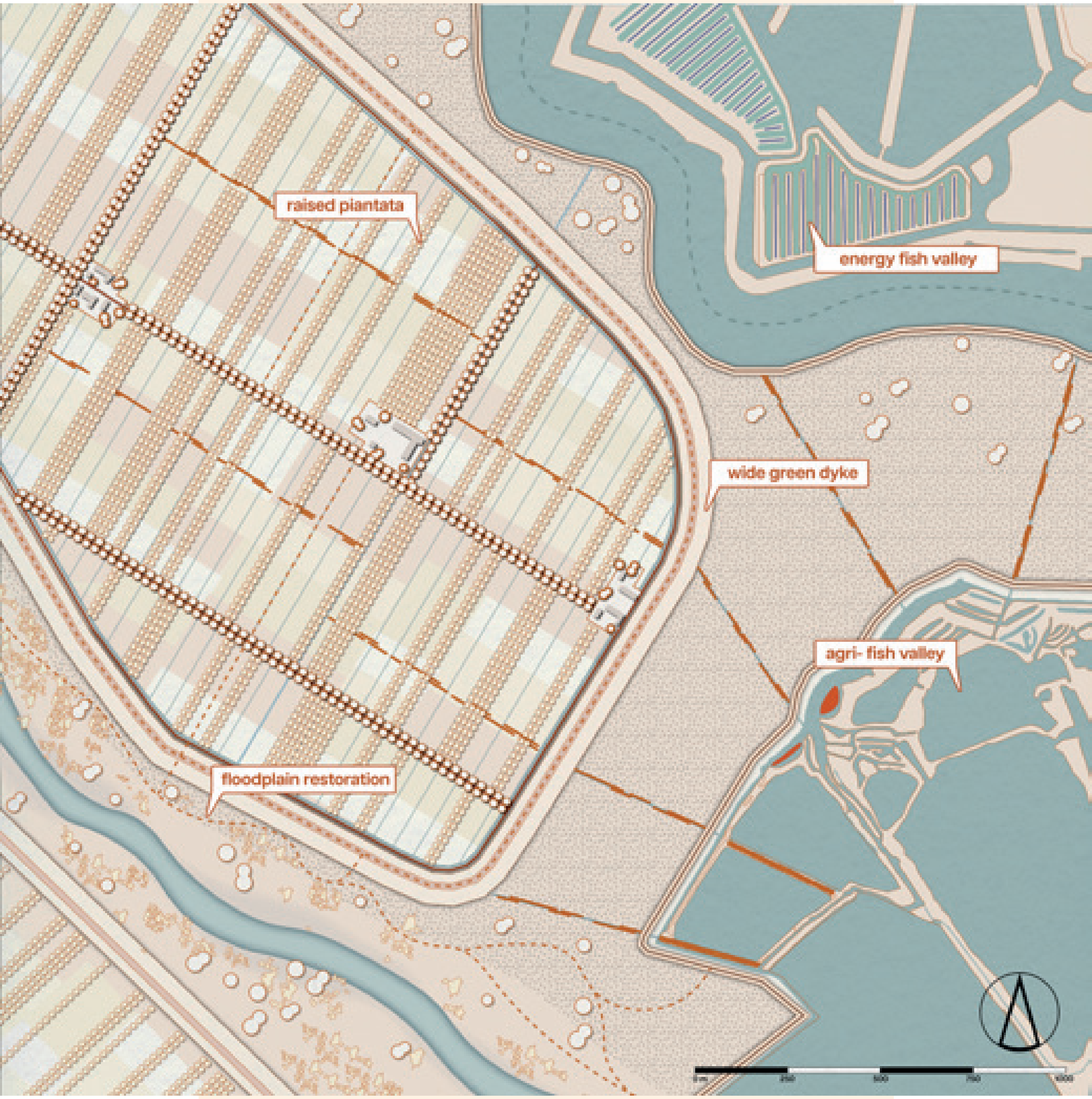


fig. 74 Final design scenario 1: protect

Final design scenario 2: Accommodate

Scenario 2: accommodate aims to welcome the water, and thereby also saline conditions. The old creek structures are restored, meaning there flows a saline vein through the landscape. The creeks and creek beds increase the biodiversity and form a stark contrast with the central axis of the graticolato romano. The semi-raised piantata also allows for crops that are not accustomed to saline conditions. Furthermore, salt-tolerant crops and halophytes are mainly cultivated here. The diversity of landscape elements makes this an interesting area for tourism. Cycling and hiking from the fish valley, along the creeks through the saline agricultural landscape, and onto the wide green dyke overlooking the dynamic broad floodplain. Here, a decked path (figure 78) leads you through the biodiverse floodplain that houses mound farms and where cattle grazes and fish can be caught. Along the central axis, agriturismo's offer a place to stay for tourists. The foodscape of scenario 2: accommodate is centred around living with the different water flows (figure 74). Inviting saline conditions into the landscape means a focus on salt-tolerant crops and halophytes. Overall, this landscape thrives on diversity, making it both a place of agricultural and touristic importance (figure 75).

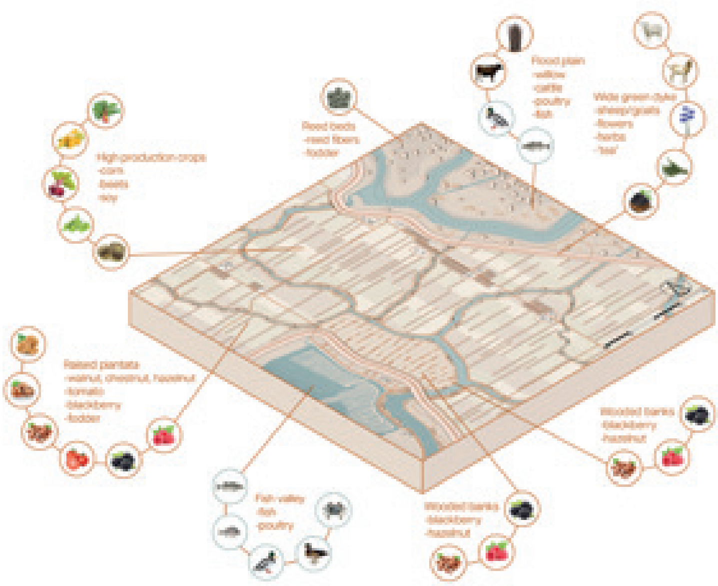


fig. 74 impression foodscape scenario 2

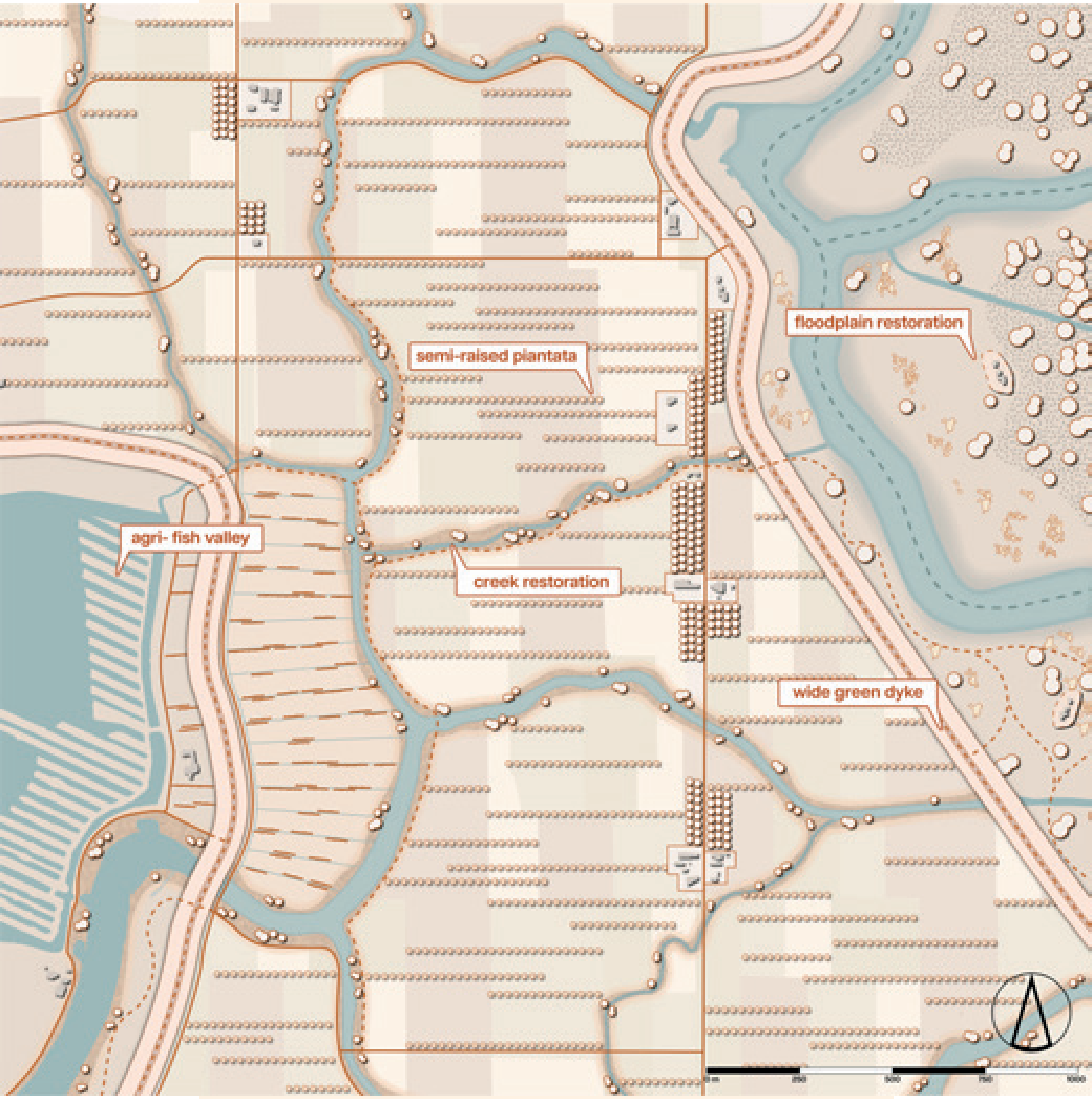


fig. 75 Final design scenario 2: accommodate

Final design scenario 3: Retreat

Scenario 3: retreat is the landscape between land and sea. The lagoons are restored, which offers great opportunities for aquaculture. This aligns with the rich aquacultural history of fish valleys and cultivation of clams. The sandy dyke fortifies the archipelago of historical coastal cities. This broad structure aligns with the popular beach tourism. Additionally, along the wide green dyke, houseboats are located. A decked path leads you through the saltmarshes and mudflats (figure 78). Fish valleys are restored, which together with the saltpantata, offer ways to use the saline conditions. Macroalgae and molluscs filter the water, while simultaneously being important food sources. Furthermore, halophytes and salt-tolerant crops are cultivated (figure 76). Overall, this landscape is a more natural and touristic take on agriculture, compared to the other scenario designs (figure 77).

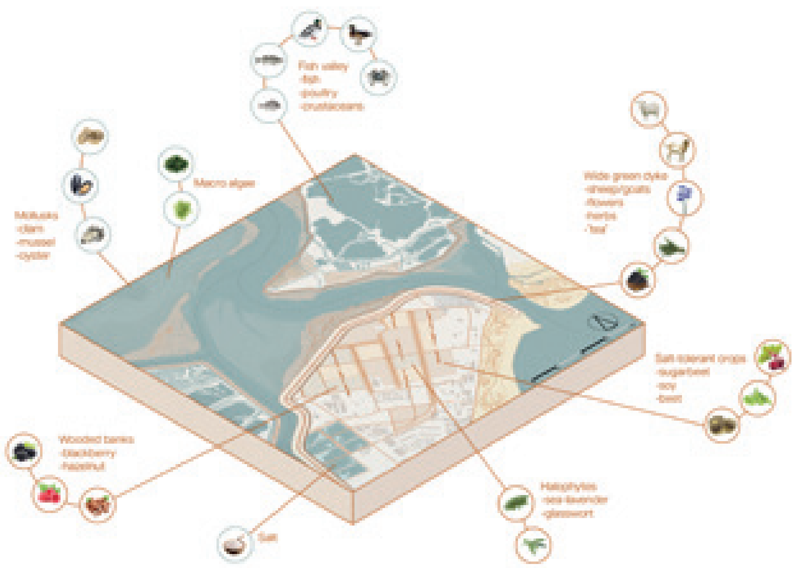


fig. 76 impression foodscape scenario 3

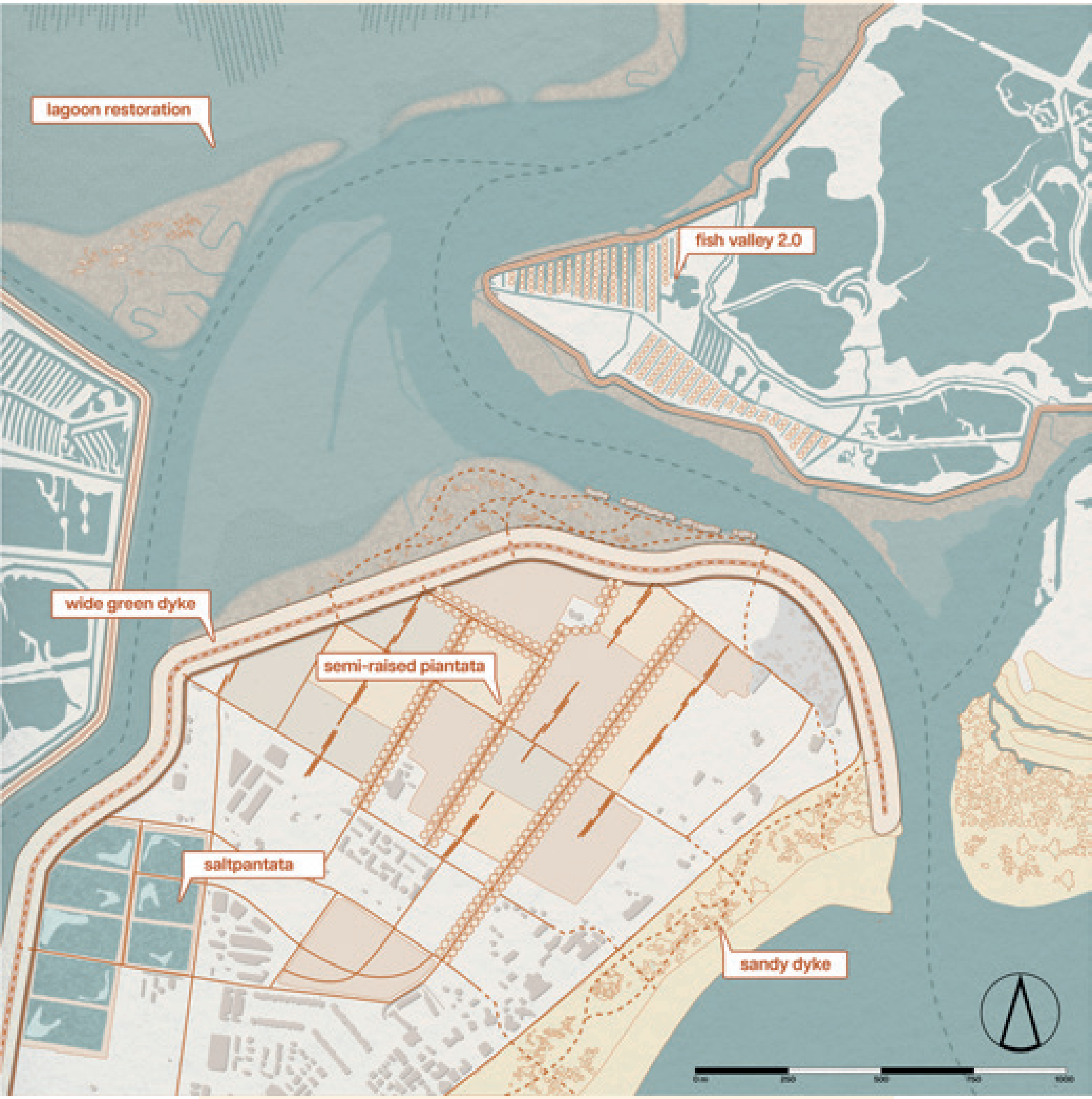


fig. 77 Final design scenario 3: retreat

fig.78 decked path along wide green dyke with houseboats

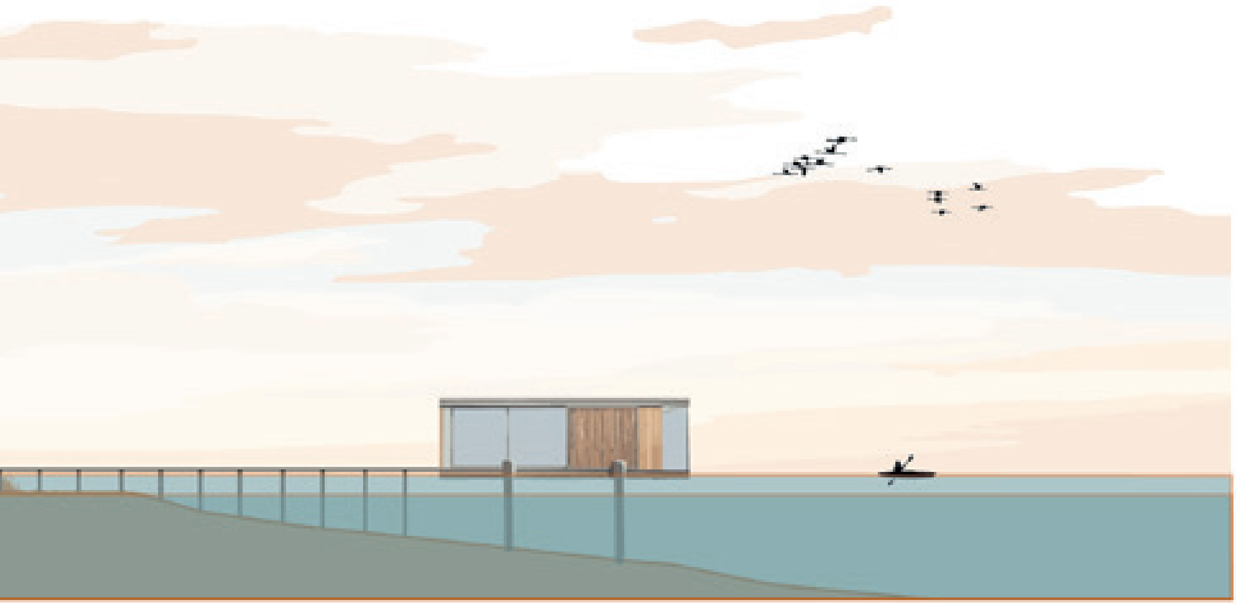
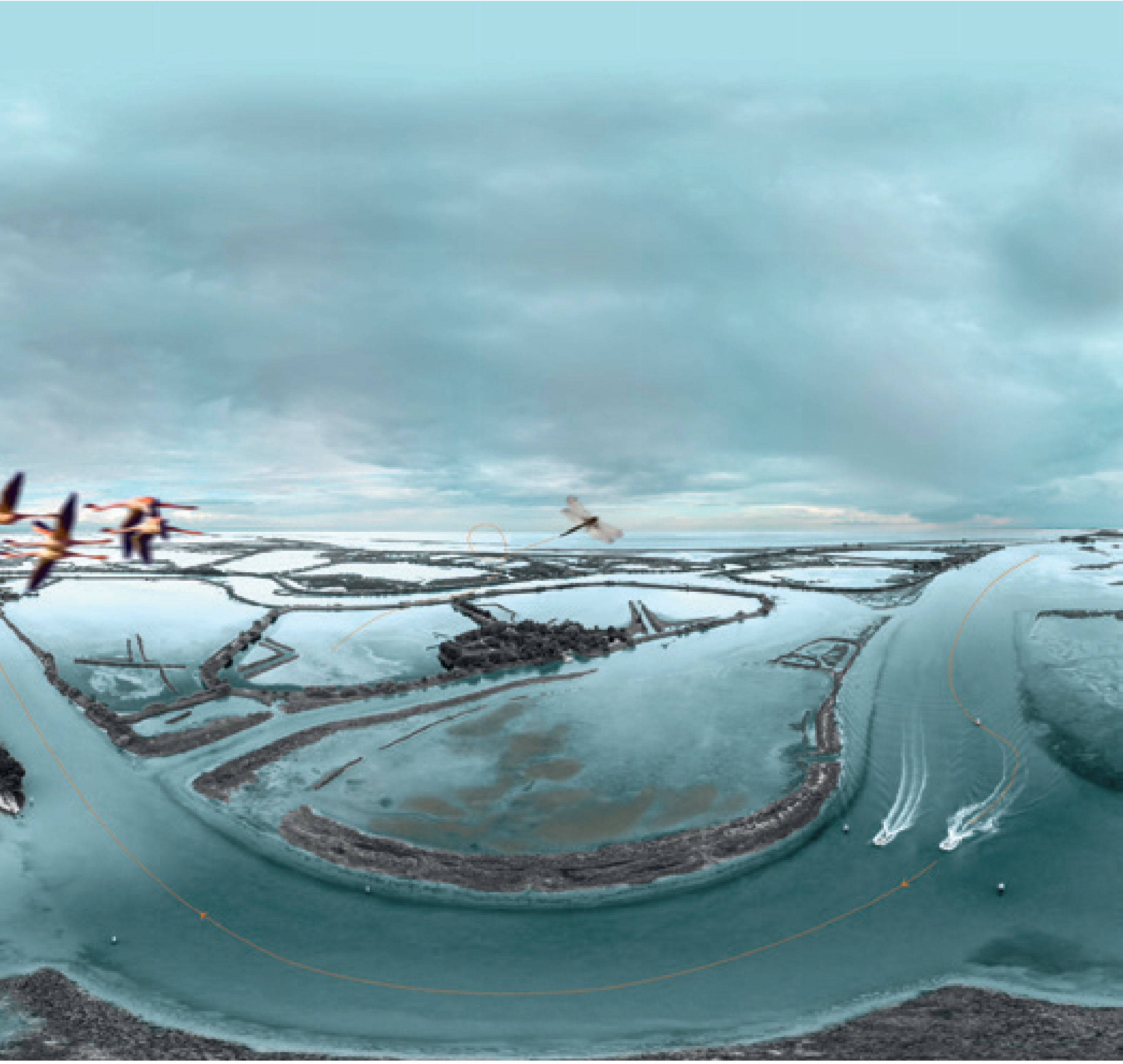


fig. 79 lagoon panorama



5 Discussion

5.1 Comparing results to literature

The final set of design principles and overarching principles can be used for designing for food security and flood control in drowning deltas. Certain principle gradients are relatively general and well-known solutions, such as the flood protection principles of a wide green dyke and barrier islands. For the wide green dyke, literature states that wide dyke structures are suitable for combining functions. This aligns with the principle, as it is suggested to combine wide green dykes with agriculture, recreation and nature development. What is added is that the principle suggests suitable crops. No correspondence on the piantata and fish valleys were found. However, they use common measures of implementing polycultures. The detailed principles are based on common gradients that can be found in drowning deltas, as well as in other areas. This makes the results generic (overarching principles) and simultaneously detailed (detailed principles). Compared to the existing research that was mentioned, the principles are relevant for designing food security and flood control in drowning deltas. The principles represent multiple goals at once and embody landscape as a system. Furthermore, the dynamic and uncertainties of drowning deltas is represented. Therefore, the results of this thesis are considered relevant as they create new knowledge on how to design for, and how to get grip on the uncertainties of drowning deltas in relation to food security and flood control.

5.2 Limitations

Limitations in knowledge

For this research, background information is needed. Here, several limitations are present. First of all, there is very little data on sediment supply. Most studies contain rough estimates of where there is accretion or erosion, but lack information on long-term trends. In combination with working with scenarios, making well-informed assumptions is a challenge.

Sediment trends are important information for designing coastal defence structures, in particular nature-based solutions such as the concept of the sandy dyke.
Secondly, uncertainties in land subsidence rates arise. Land subsidence rates for north-eastern Italy are known, however, local data is unavailable. Besides, one of the main drivers of land subsidence is the (over) extraction of groundwater and the extraction of gas, resulting in local subsidence rates varying.

Thirdly, climate change projections in themselves include a large degree of uncertainty. Changing projections could impact this thesis. Even though this thesis tries to include uncertainties by using scenarios, changing projections could impact the relevance of the results. Additionally, this could lead to necessary alterations to certain principles in order to still be relevant. Ultimately, the variables of sedimentation, land subsidence, and sea level rise essentially determine to what degree a delta will drown, impacting the salinisation and possibilities for agri- and aquaculture.

Furthermore, bathymetry data of the Adriatic sea lacks resolution: the topography of the seabed is limited to larger scales. Microtopography data was unavailable, making designing foreshore structures and aquaculture systems that fit the seascape challenging. Tegnue reefs are located, but without detailed bathymetry analysing the seascape and favourable topographies compels making assumptions.

Additionally, designing seascapes remains an underexposed topic within landscape architecture, which means there are few cases available to observe and analyse possible solutions and approaches.

Limitations in maps

Obtaining maps for this study can be considered a limitation. The study area consists of the coast of northeastern Italy, which roughly translates to the regions of Friuli-Venezia-Giulia, Veneto, and Emilia-Romagna. Each region has their own geoportal with map data. However, the availability of maps varies greatly per region. For example, Friuli-Venezia-Giulia's geoportal contained only general maps such as elevation, whereas Veneto's geoportal contained detailed maps on agricultural diversity and intensity, as well as high-quality historical maps. Matching map data from different geoportals also proved to be difficult with differences in date, scale, resolution, and way of measuring variables. Additionally, certain map data require a formal request form. The processing speed of these requests appears to be very low with multiple requests denied after 2-3 months of waiting, impacting the time available for this research. Therefore, mainly maps from the region of Veneto are used in this study.

Limitations in analysing

landscape qualities and future challenges

During field visits, the landscape qualities and future challenges were analysed. The first field visit was done in spring in 2022. At this time, tourist season had not started yet. This means that the conditions could differ drastically a few weeks later; I have been unable to capture the impact of tourism on the area. Furthermore, many sites were closed. The majority of ferries were inoperative, which withheld me to experience the lagoon from the water.

Limitations in strategies and measures

A literature review was conducted in order to study adaptation strategies and tactics. This provided a brief summary of strategies and measures. Including case studies might have produced more detailed or concrete measures and strategies. Nevertheless, it is unclear whether this would have resulted in different strategies and measures.

Limitations in designing and testing

Test 1 was done using a digital form. Beforehand a briefing on the designs and the study area was done. After this briefing, the digital form was sent. A semi-structured interview or a discussion afterwards could possibly provide better results, as there would be an opportunity to discuss the feedback. However, the digital format of the test allows for flexibility for the expert. The expert is given the opportunity to fill in the form in their own time and at their own pace, which could result in more thorough and thought-out feedback. Furthermore, including an expert from the region could influence the objectivity of the test results. However, excluding experts coming from the region could lead to incorrect results, as the expert lacks knowledge of the functioning of the landscape. This limitation could be vanquished by including both local experts and external experts for every research subject (food, flood, landscape).

Limitations in scenarios

The scenarios are based on adaptation strategies and climate projections by the IPCC. These projections and scenarios are based on models and assumptions, which contain a degree of uncertainty (e.g. data gaps, modelling limitations). Additionally, scenarios are abstract representations of the future: the physical reality is simplified which makes assumptions about the future that might not reflect all potential outcomes.

Limitations in principles

One of the LIA guiding themes is animal welfare. This guiding theme is not used in the final principles. Considering animal welfare should be included, but it was hard to relate this to landscape architecture. When designing for a specific farm animal, this might be possible, however for bigger scales it is questionable. One could argue that not all themes are represented and therefore the final principles are not entirely landscape-inclusive. However, in this thesis the focus is on landscape systems, instead of individuals such as a farm animal. It is therefore likely that the final principles are not affected.

5.3 Validity and reliability

Internal validity

nternal validity examines whether the manner in which a study was designed, conducted, and analysed allows trustworthy answers to the research questions in the study. First of all, methodological triangulation was reached by using both qualitative (landscape quality and future challenges) and quantitative (test 1) research methods. All research steps and results are described and documented. Furthermore, RtD allows for testing and refining designs based on feedback and data. This process helps to minimise bias and ensure that the observed effects are due to the design intervention rather than other factors. This indicates that the final design principles are based on the test results.

Field visits were done to determine the landscape qualities and future challenges of the region, including qualitative research methods. As a researcher, this means that prior experiences, assumptions and beliefs could influence the research process. In addition to that, being a Dutchwoman researching an Italian landscape could potentially lead to different results when done by an Italian person. In terms of reflexivity, coming from the dyke-country the Netherlands and the town where dredging originated (Sliedrecht), engineering the landscape is the order of the day to me. Whereas when talking to locals in the towns of Bibione, Caorle, and Rosolina, the thought of engineering the landscape evoked resistance. These differences in mindset and values could affect findings.

During the field visits, data triangulation is used to enhance the validity of findings by collecting and analysing data from multiple sources and methods. For example, conversations with farmers and local entrepreneurs, and collecting data through pictures and sketches. This variety of multiple sources and methods helps to ensure that the observed effects are consistent across different data sources and methods, increasing confidence in the results.

External validity

External validity refers to whether the findings of a study can be generalised to other contexts. The main results of this study consist of principles, which are tailored to being generalisable and widely applicable. The guiding principles developed are general and not tailored to a specific setting or place. Therefore, they must adapt to different situations, and this adaptation could affect the actual effectiveness of the used principle (van den Brink et al., 2017). Essentially, this is the trade-off between generating design principles that are more widely applicable, and design guidelines that are specifically tailored and 'ready for use' for a specific landscape. The principles contain suggestions for integrating landscape qualities of the specific northeastern Italian coastal landscape, however, these are optional and do not affect the generalisability or applicability of the principles.

Reliability

Reliability describes the consistency with which results are obtained. The reliability of this thesis is ensured by documenting the research methods, steps and results. The variables that were assessed during the testing iterations are for most parts the same. Progressive insights from the first test iteration have resulted in slight changes in variables, as this allowed for more in-depth feedback for more detailed designs. Testing the designs was done on different scales. This makes it hard to compare results, as the abstraction levels per scale are different. Additionally, the design phase revealed that designing for flood control required a different scale than designing for food security. It was therefore decided to focus the second test on food security and landscape context. Testing on flood control was left out, as this played a minor role in the zoomed-in designs for agriculture. This denotes that the tested aspects differ per test, however, this was a necessary step to improve the designs and allowed for testing in more detail. The reliability could be improved by testing on the same scales and testing the same aspects per test. Furthermore, increasing the number of iterations will lead to better, and potentially more detailed results. Finally, each knowledge field (food, flood, landscape) was represented by a single expert. Using multiple experts in each area of expertise to assess the designs could increase reliability as well.

Feasibility and preconditions

Policy and societal backing are crucial for the feasibility of the design and principles. To make LIA more appealing to farmers, policy support is required to remove regulatory roadblocks. Changes must be made to laws and regulations to make it possible, among other things, to pay farmers for delivering ecosystem services, motivating them to switch to more sustainable agricultural practices. Also, customers must alter their purchasing habits and either be willing to pay more for locally produced goods or buy their goods directly from the farmer. For the farmer to be able to keep selling their goods, society must support farmers. These preconditions cannot be influenced by landscape architects, however, potentially are of importance for the principles to reach their intended goals.

6 Conclusion

6.1 Answering RSQ's

This section contains a summary of the results by answering the sub-research questions and the main research question. The aim of this thesis is to develop LIA principles for designing food security and flood control in drowning deltas. A combination of RfD and RtD were used. Landscape qualities and future challenges were identified, followed by research into LIA, food measures and flood measures. Altogether, these elements consisted of the ingredients for the RtD phase. The RtD phase started with informing the scenarios using explorative scenario planning (XSP), after which the concept designs were created. The scenario designs and concepts were assessed twice by experts. Test 1 focused on both flood control and food security, whereas test 2 focused on food security alone. The designs were improved and general overarching principles and specific principles were generated in order to answer the main research question.

Answering the first research question: 'What are the most important landscape qualities of the north-eastern Italian coastal landscape?',
the main qualities originate from the interaction between the fresh inland waters and salty sea waters. This interaction creates a gradient of non-saline to saline, enabling a great diversity of flora and fauna. In addition to that, the landscape has an elevation gradient from the coast (low) to the alps. This combination of gradients creates a high density of different habitats, resulting in a rich and diverse landscape. The most important landscape qualities include: creeks, mudflats, salt marshes, graticolato romano, pine rows, fish valleys, piantata, historical coastal towns, and beach.

The second research question is: 'What are the future challenges of drowning deltas and how does landscape-inclusive agriculture relate to these challenges?'.
The main future challenges of drowning deltas are centred around the climate projections of conditions becoming wetter,

drier, and more saline which affect food security and make it difficult for agriculture to produce the same quantities of food. The (over) extraction of groundwater accelerates agricultural problems of erosion, waterlogging, salinisation, and saltwater intrusion. The increase in temperature disrupts water systems leading to algal blooms and die-offs in seagrass which impacts biodiversity and aquaculture. Finally, the fragmented urban fabric of the citta diffusa will form a major challenge due to its lack of clear boundaries. Landscape-inclusive agriculture (LIA) is an approach to farming that takes into account the diverse ecological, social and economic components of a region, and integrates these elements into farming practices to improve both food production and ecosystem health. LIA suggests 10 guiding themes which can aid towards a resilient agricultural system. In combination with the landscape qualities, food measures and flood measures were used to guide the design of different scenario designs and concepts.

Sub research question 3 denotes: 'In what ways can landscape-inclusive agriculture improve the food security and flood control of north-eastern Italian drowning deltas in the future?'

The principles help steer the designs in approaching the (agricultural) landscape as a system as agriculture and its surroundings are interconnected. The designs result in a variety of futures, each with its pros and cons. It demonstrates the interplay between food and flood and shows long-term solutions for agricultural landscapes in drowning deltas. Additionally, the designs can be perceived as a timeline; transitioning from non-saline to saline. Landscape-inclusive agriculture can improve food security and flood control by forcing you to combine functions, which in its turn allows space for nature and ecological structures, restoring the landscape and its resilient properties. The landscape is no longer a monoculture desert. The design uses the natural gradients in the landscape of high-low, dry-wet, and non-saline- saline. The result is a diverse agricultural landscape, where every landscape type has agricultural practices that fit the habitat. Furthermore, flood control structures are part of the landscape and create synergies with other functions. Concluding, LIA steers the design towards diversity and synergies which restore landscape elements and its restorative properties, improving the overall food security and flood control.

Finally, answering the main research question: 'What design principles can be developed to improve the food security and flood control of drowning deltas using landscape-inclusive agriculture?'. The results from the sub research questions inform this answer. Using Research through Design, the scenario designs and concepts were refined with the help from experts: turning general LIA guiding themes into LIA principles for designing food security and flood control in drowning deltas.

The overarching LIA principles for designing food security and flood control in drowning deltas conclude:

1.Diversify farms and farming practices. Diversifying farm and farming practices strengthens the economical resilienc improves biodiversity, and reduces crop diseases. [X: fair prices] [V: biodiversity]

2.Combine functions to create synergies. Combining functions is essential when space is becoming increasingly limited.

2a. Aquaculture foreshore. Foreshore measures protect th coast from erosion and can be combined with aquaculture t improve water quality and biodiversity. [V: biodiversity] [III: water quality] [VIII: food]

2b. Repurpose agricultural heritage. Functional heritage will not vanish. Assigning additional functions to historical structures makes them more profitable and resilient, while simultaneously improving the landscape quality. [landscape quality]

3.Create gradients for (bio)diversity.

3a. Micro topographies and textures. Implementing micr topographies and textures into flood control structures are elementary interventions with a significant impact on biodiversity and water quality. [V: biodiversity] [III: water quality]

3b. Gentle slopes. Gentle slopes in flood control structures offer opportunities for agriculture, nature and biodiversity, and tourism. Gentle slopes embed flood control structures into the surrounding landscape. [V: biodiversity] [VIII: food]

4.Restore and connect ecological structures. Restoring ecological structures improves the landscape quality and restores the resilient properties of the landscape, improving biodiversity, soil quality, and water quality. Connecting landscape elements through blue-green structures strengthens ecological networks and corridors.[V: biodiversity] [II soil quality] [III: water quality]

5.Nature as a starting point. Adjust farming strategies to the natural landscape. Collaborate instead of manipulate wi the local conditions, as every landscape offers different and unique opportunities.

5a. Use salinity. Salinity is an asset: it offers opportunities fo halophyte cultivation, saltpans, and aquaculture. [VIII: food]

6.(Agricultural) landscape as a system. Approaching the (agricultural) landscape as a system promotes collaboratio between sectors and actors, which offers opportunities for closing cycles and becoming climate-neutral. [VI: close cycle [I: climate-neutral]

6.2 General insights

Apart from answering the research questions, the research process also generated some general insights:

1. There is an order of design.
In the Research for Design phase, the layer approach was used. The abiotic layer impacts the type of ecosystem and what species can thrive, which in turn determines the land uses. When designing for agriculture, progressive insight is that this order also affects the design process. Designing flood control sets the conditions for agriculture. Additionally, flood control and agriculture ask for different design scales. For example, when setting the (abiotic) conditions with flood control, adapting the agricultural system to these conditions requires zooming in and testing new concepts. This order of design corresponds with the layer approach.

2. Scenarios can function as timelines.
Coastal landscapes are landscapes of gradients. Designing in gradients improves the applicability of the principles. Approaching scenarios as a timeline is similar to a gradient, namely, a gradient in time. Furthermore, the transitionality of the gradient design principles could be an interesting addition, as change does not go overnight. Design principles that follow up with each other could help with the feasibility and real-life applicability of the designs. In this thesis this could denote facilitating the transition from a conventional crop-, to a saline agriculture-, to an aquaculture-dominant system.

3. Soil quality in relation to salinisation is relative.
Soil quality is an important pillar of LIA. Generally speaking, the process of salinisation negatively impacts the quality of the soil. However, this is dependent on the desired land use. For cultivating conventional crops salinisation is undesirable, but for halophytes, salinisation is a prerequisite. Additionally, eventually, there will be a tipping point when the salinisation of soils cannot be prevented. This requires taring the scales and redefining the concept of soil quality.

4. Designing for systematic change requires preconditions.
Certain challenges can only be vanquished with policy changes, laws, or societal backing. For example, soil quality and water quality are majorly affected by pollution from industries and excessive fertilisers from farmers. Implementing filtering structures, such as willow-poplar filters can reduce pollutants and thereby improve soil- and water quality. However, this comes down to symptom control, instead of treating the cause. In this case, the precondition of a ban on excessive fertilisers and the dumping of pollutants is needed.

5. Designing for agriculture means designing favourable conditions.

As a landscape architect, knowledge of farming and agricultural practices is not your expertise. Designing for agriculture means designing a framework, which is the landscape, in which farming can take place. Suggestions on farming methods and crops can be made, but are not the end goal nor determine the design.

6.3 Recommendations

The discussion points out several aspects that require further research. First of all, the effectiveness of the principles should be tested more thoroughly. Modelling design interventions and testing them in controlled experiments could improve the designs. The effectiveness of design interventions or elements can be tested by creating multiple versions of an intervention and comparing them. Additionally, involving more experts, both locals and externals, is recommended.

Secondly, further research is needed on the sedimentation processes, as this impacts the longevity and applicability of coastal defence and foreshore measures. This is also the case for designing seascapes and aquacultural systems. Seascapes remain an underexposed field in landscape architecture, while coastal challenges are becoming increasingly apparent. Besides, seafood is a major food source projected to only become more essential in the coming decades in the face of food security as the limits of the (land-based) foodscape are in sight. Furthermore, sustainable aquaculture is still in its early stages; there is a lot to gain in terms of land/seascape-inclusiveness. Generating seascape-inclusive aquaculture principles could be an opening for a new research project.

Finally, researching and developing the transitionality of design principles could be a valuable addition. Facilitating gradual change could improve the feasibility and real-life applicability of designs. For this thesis, transitional design principles could denote facilitating the transition from a conventional crop-, to a saline agriculture-, to an aquaculture-dominant system.

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Figures

All figures are made by the author, unless stated otherwise

Appendices

Appendix A: Fieldwork
Appendix B: Expert assessments:

Appendix A: Fieldwork

Fieldwork

Lignano – Bibione – Caorle: Lagoons of Veneto and Friuli-Venezia-Giulia, Italy.

FW1: surroundings

Tagliamento river

The Tagliamento river cuts through the landscape. It is the last remaining river which course has been unchanged. The river divides the two regions Veneto and Friuli-Venezia-Giulia; very few bridges 'break' this natural border. The name Tagliamento probably originates from the word 'telia'/'tilia', which refers to lime tree. This makes the Tagliamento the river flanked by lime trees. Especially downstream in the lower areas the Tagliamento river is framed by embankments, fortifying the division between the two regions.

Vegetation

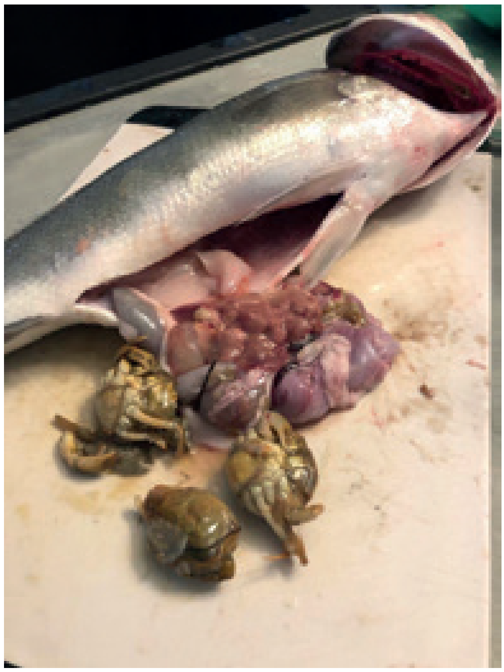
Reeds, pine trees (Pinus pinea), willows, grassland. Cork oaks: Quercus suber. The typical vegetation of the low Venetian plain used to include oak and hornbeam forests, predominantly dominated by Quercus robur and attributable to Asparago tenuifolii-Quercetum roboris (birch-oak forest). Now black locust (Robinia pseudoacacia L.) and poplar trees (e.g. Populus nigra L.) are more frequently met as a consequence of degraded areas and tree plantations standing between a complex system that mixes urban, agricultural and industrial areas. Close to the Venice lagoon, the influence of the sea and of lagoons and dune ridges favour the formation of a coastal area that includes typical plant communities such as Cakiletea maritimae, Ammophiletae and Quercion ilicis.

FW2: Valle Pantani

On day 2 fish valleys were visited: Valle Pantani, an organic extensive fish valley and Valle del Lovo, a semi-intensive fish valley. At Valle Pantani the natural tides of the lagoon are used to provide the valley of water. Two sluices control the waterflow of the system. Fingerling (juvenile fish) seabass and seabream are caught on the lagoon within a 10 km radius of the property. These fingerlings are raised in a nursery basin. This basin is netted to prevent birds (mainly Cormorants (*Phalacrocorax))* from eating the fingerlings and small fish.

The property is approximately 100 hectares, with a big open water area of 20 hectares. During the winter the property hosts large quantities of birds for wintering. This ecosystem is the strength of Valle Pantani: the sea bass and sea bream do not need to be fed, as the system provides the fish of food. The fish eat crustaceans, small crabs, and algae generated by the sun. The reeds provide shade and shelter and filter the water. Autumn is harvest season: the fish are caught with nets with big mesh, in order to only catch the mature fish (3-5 years). Buyers are mainly restaurants for now, as the harvest quantity is not compatible with commercial supermarkets. In addition to that, the fish' price is approximately €20,- per kg, which is in the higher price range for farmed fish. However, the way of farming is comparable, if not better than wild caught fish. For wild caught (hook and line) sea bass, €20,- per kg is an average price.

Sea bass is farmed in open cages in the Mediterranean Sea. Unfortunately, there are problems with this form of aquaculture, as the used fish feed is unsustainable and the seawater is polluted by chemicals and faeces. There are also risks of escapement which brings farmed sea bass into contact with wild sea bass which may result in physical abnormalities in the wild sea bass population due to genetic differences in the farmed population. Wild fish can be caught with nets, for example bottom trawling. This is harmful for the seabed and sea life in general, and also results in large quantities of by-catch. Advantages of fish farming like Valle Pantani is that it is in no way harmful for the environment. As a matter of fact, Valle Pantani contributes to the biodiversity of the area by being a wintering hotspot for birds.



FW2: Valle del Lovo

The system

Valle del Lovo is a semi-intensive fish valley. It consists of circa 50 basins (100x15x3 meters), where water moves following the tides by using pumps. These pumps allow to manage the quantity and speed of the water, based on what is needed for optimal production. Where in ancient fish valleys juvenile fish would enter the lagoon in spring, at Valle del Lovo juvenile fish are caught in countries such as France. These juvenile fish are then placed into the nursery to grow out into fish that are large enough to go into the outside basins. This so called pre-fattening of the juvenile fish has a separate closed water recirculation system that reduces the environmental impact of pre-fattening close to zero. In the autumn fish in ancient fish valleys would move towards the sea again, to avoid cold waters. In Valle del Lovo, in autumn the fish remain in the basins. To avoid fish from dying in the cold seasons, warm ground water from deeper layers (4 hot water wells in this case) is pumped to the surface to heat up the basins.

Compared to intensive aquaculture practices, Valle del Lovo has a low density of fish. While in the intensive system the biomass per cubic meter can reach up to 50kg, in the Valley the biomass does not exceed 1kg/m^3. Contrary to the principle of intensive aquaculture, where the fish are "pushed" with 100% artificial feeding, here fish are fed for most of their life in a natural way. The fish eat what they can find in the micro-ecosystem of the basins (small fish, bivalves, shrimps, algae and crabs). The valley is fed by the play of the tides, therefore with a continuous exchange between the internal and external waters. The advantages lie in the fact that in the valley it is possible to control the water and the seabed and possibly intervene - if necessary - with biological filters. Only during the summer months the fish are supplemented with artificial feed, as the energy needs of the fish tend to increase during the hot season. This way of feeding -or lack thereof- also affects the growth rate of the fish. Intensive farmed sea bass needs about 2 years to reach 1kg, whereas fish from the valley takes at least 4 years to reach that weight. The water to fish ratio in the valley is low; intensive fish farms reach a density of 35-40 kg/m^3, whereas the valley only reaches a density of 2 kg/m^3. This makes valley fish close to wild caught fish: they are overall healthier, leaner, and contain less pesticides and other pollutants.

Farming fish in a valley is different from conventional fish farming. Out of the 100 juvenile fish, only half of those can be harvested at the end. In addition to that, the conditions of the natural system are less predictable and manageable compared to conventional fish farming. Even though in the long run, the fish valley is more resilient and resistant, it also copes with problems regarding temperature regulation and diseases. In addition to that, despite protective netting a part of the fish are eaten by birds such as seagulls and cormorants.

The future of the fish valley according to the owner

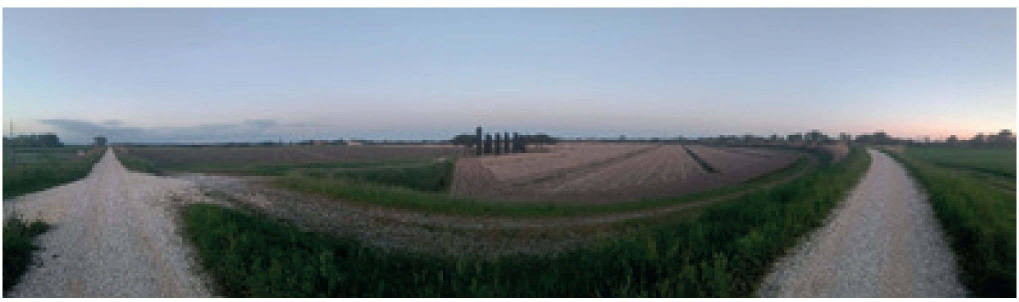
“A quality production like ours involves many difficulties, risks and constant losses; so much so that we are the only active fishing valley in the area, when, years ago, there were 40 of them. Fortunately, there is good food that rewards us: from the moment we are chosen as a partner, the customer does not abandon us more, demonstrating a true appreciation for the quality fish product. "

"It is desirable to overcome the legislative gap relating to the traceability of fish, possibly with the creation of a regional brand that highlights the quality of the valley fish compared to the product of intensive farming and that protects both local producers and consumers who buy consciously a quality product. "

“Another initiative could be to give visibility to the fishing valleys not only as a production site, but also as a center capable of attracting sustainable and environmental tourism. It is from this idea that we started a collaboration with the Department of Agriculture, to which we would also like to add Promoturismo: the environment of the valleys is unique and could be included in environmental tours that include the entire area of the Marano Lagoon. Lagunare and Grado, where there are both protected areas, including those of the casoni, and wonderful resurgence rivers such as the Stella, which flows into the lagoon. The goal would be to bring people here, starting with children: you can get there either by land, from Carlino, or through a suggestive navigation through the lagoon canals, starting from Lignano or Marano Lagunare.’’.

FW2: reclaimed fields

Observing the transition sea-lagoon-fields, one can see big pumping stations. These stations provide the right circumstances for farmers, and make sure that their crops do not drown.



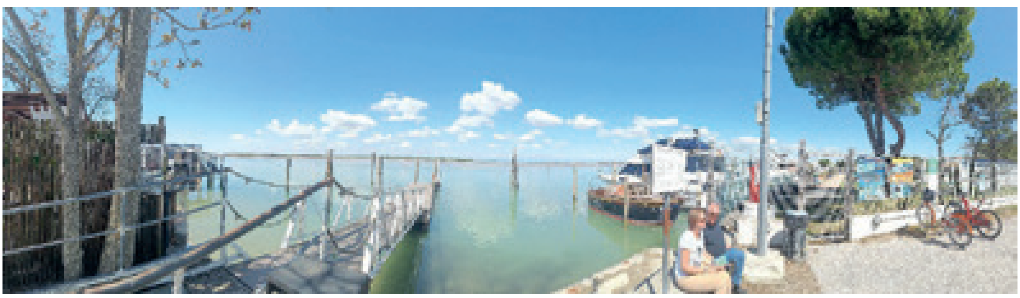
FW3: seaside and lagoon

Tourism

The area is a popular holiday spot. Mainly Germans visit the area for the beach and cycling opportunities. As a matter of fact, close to the beach the majority of signs are in German instead of Italian. In addition to that, German music can be heard in beach bars and the menu is in German. According to locals, property is rapidly bought by Germans. One local referred to the coast as 'little Germany' and referred to the harbour accommodations as a German village. The touristic peak season is from half May until the beginning of October. Off season beach bars, shops and restaurants close to the harbour and certain parts of the town where a lot of accommodations are located are deserted.

Apart from the water activities, the area also promotes cycling tourism. There are several bike routes, ranging from short 10km routes to long 50km routes. Some routes are suited for city bikes, whereas on other routes a mountain bike is advised. Along the coast is a wooden cycle path that connects the town to all the beach bars and camping sites. The further you move land inwards, away from the coast, the cycle routes are getting less cycle-friendly. This is reveals itself in no cycle paths -cycling on a 80km/h motorist road-, a lack of signage, and fairly dangerous crossings.

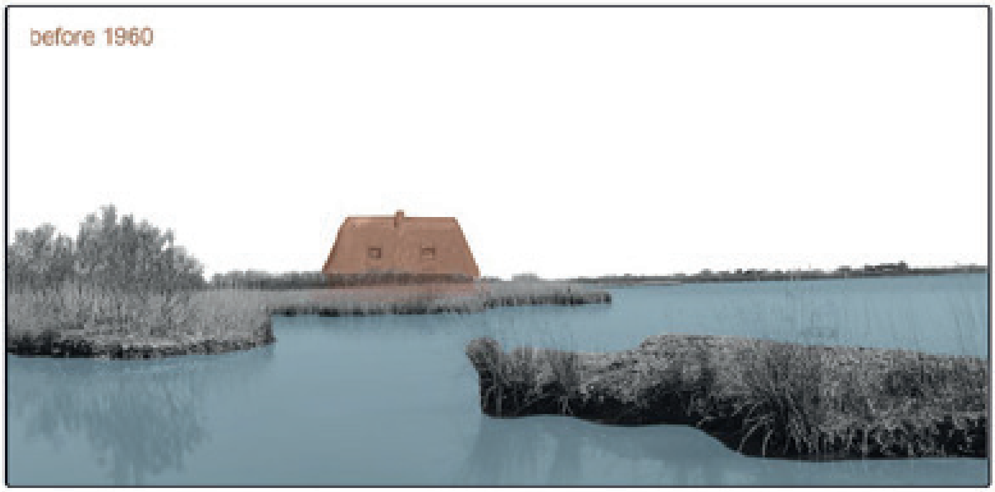
The current lagoon

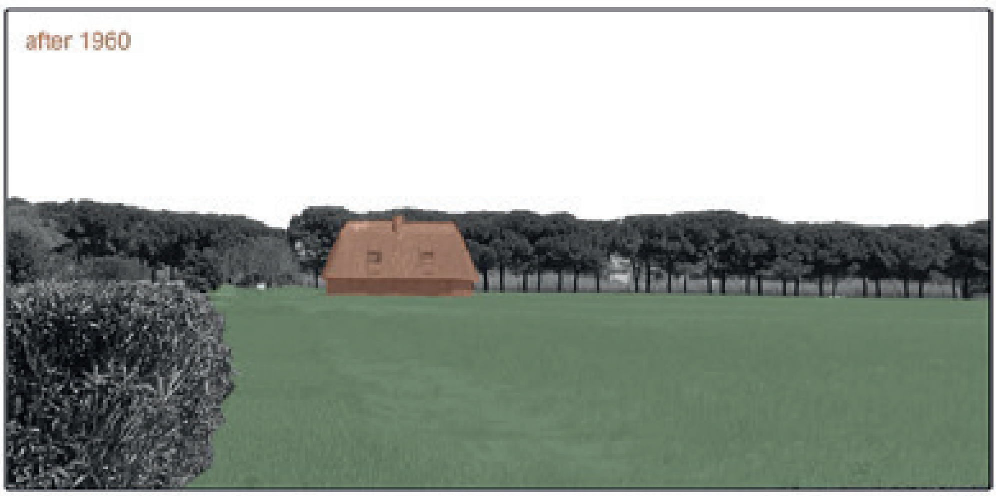


Traces of the old lagoon

Before large parts of the lagoon were reclaimed, the lagoon was an open system under influence of the tides.

Traces of the old lagoon can be seen in the presence of historical fish valley houses, called *Casoni*. These houses were the home of fishermen that would spend the time managing the fish valleys (*Valle da Pesca*).





Po Delta: *See beyond the Sea*

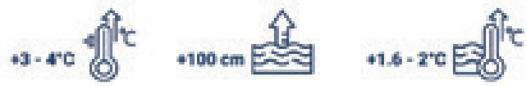
2022 - 2070

INGE VAN WIJK, SAVINGSCAPES LEARNING LAB DELTA PO, JULY 2022

INTRODUCTION

THE IMPORTANCE OF THIS AREA

THE CHALLENGE



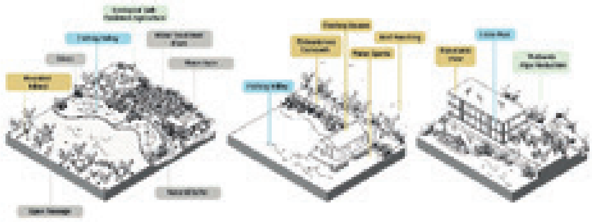


FIGURE 1: DESIGN PRINCIPLES

CONCEPT AND VISION

FIGURE 2: TOURISM STRATEGIES

TOURISM: NOW AND FUTURE

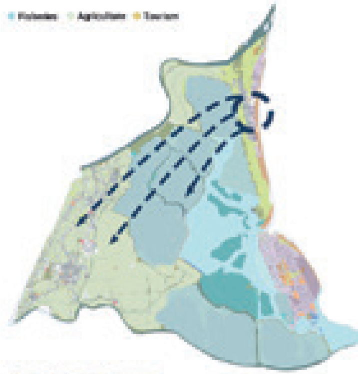


FIGURE 3: CURRENT SITUATION

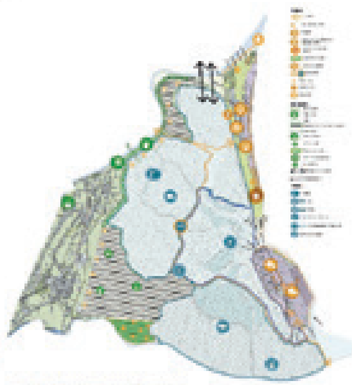


FIGURE 4: SPATIAL DESIGN PROPOSAL

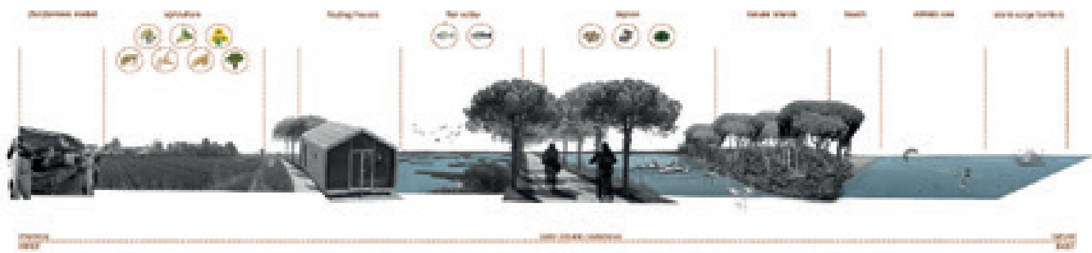


FIGURE 5: GRADIENT OF THE NEW PO DELTA: SEE BEYOND THE SEA

CITIZEN SCIENCE

Positive aspects

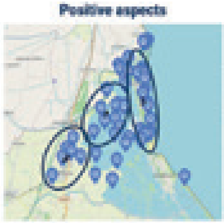


FIGURE 6: CITIZEN SCIENCE POSITIVE ASPECTS

Negative aspects

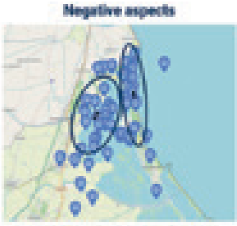


FIGURE 7: CITIZEN SCIENCE NEGATIVE ASPECTS

CONCLUSION AND DISCUSSION

Appendix B: Expert assessments

Results expert assessments test 1

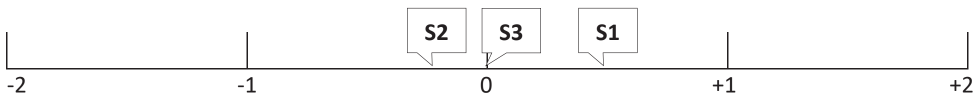
Flood control [Richard Marijnissen (Arcadis)]

→results survey

Scenario 1: 2/4= 0.5 [between neither agree nor disagree (0) and agree (1)]

Scenario 2: -1/4= -0.25 [between disagree (-1) and neither agree nor disagree (0)]

Scenario 3: 0/4= 0 [neither agree nor disagree]



Expert comments:

I think all options except the aquaculture breakwater will reduce flood risk if designed well.

- ➔ However, aquaculture breakwaters prevent flood measures from degrading, and can be of great importance in storm conditions.

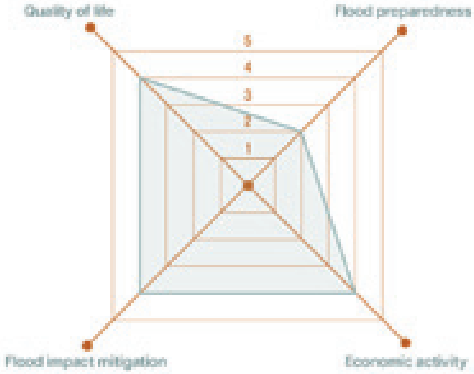
Wider measures like the barrier island in S3 will still be effective in reducing waves and restricting flows than dykes which breach and degrade quickly once failed.

- ➔ Wider measures could be considered more safe, as they are more robust.

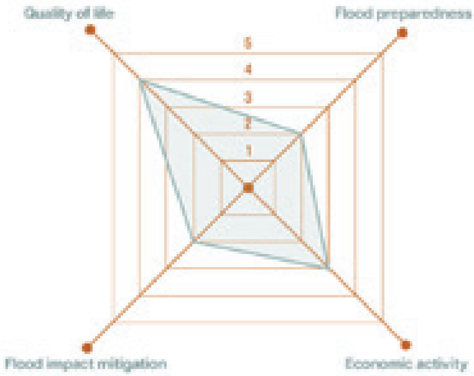
The wider solutions in S3 and S2 will be at the cost of the present-day salt marsh and mudflats.

- ➔ Yes, but there will be more space for salt marsh and mudflat development, especially in S3.

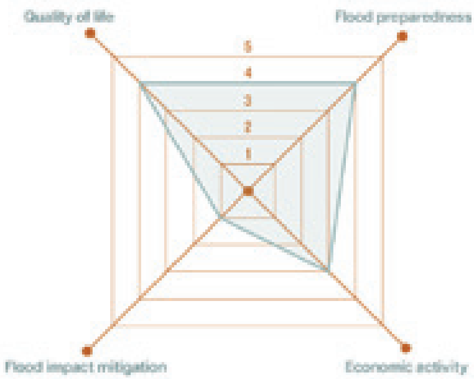
A hard dyke will require the least amount of change to the current landscape and the activities in there. At least in the short term. For wider solutions like barrier islands economic activities will need to adapt.



① Protect



② Accommodate

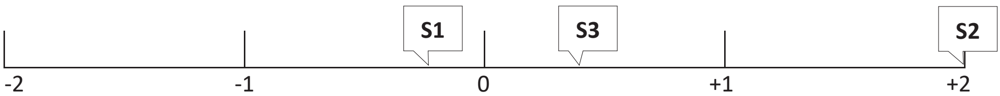


③ Retreat

Landscape context [Michiel Bakx (WUR)]

→results survey

Scenario 1: -1/5=	-0.2	[between disagree (-1) and neither agree nor disagree (0)]
Scenario 2: 10/5=	**2**	**[strongly agree]**
Scenario 3: 2/5=	0.4	[between neither agree nor disagree (0) and agree (1)]



Expert comments:

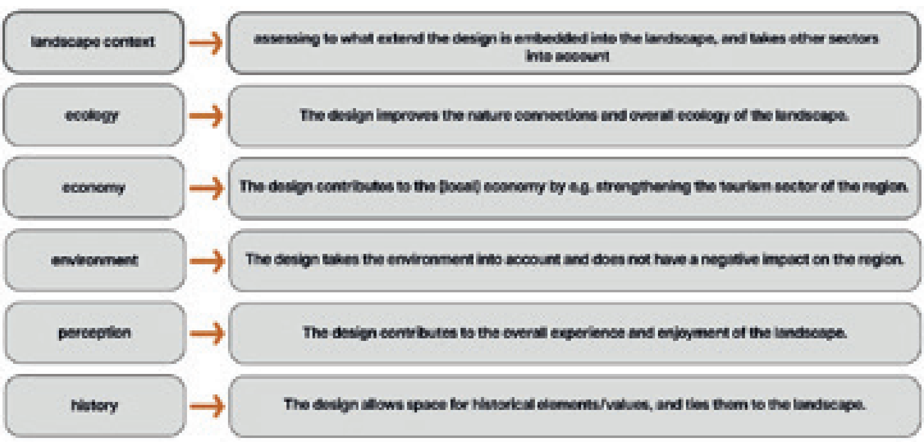
Hard-soft contrast between hard dyke and landscape is now portrayed as something negative. However, hard structures such as dykes also create (guide)lines in the landscape. This contrast can also emphasise both landscapes.

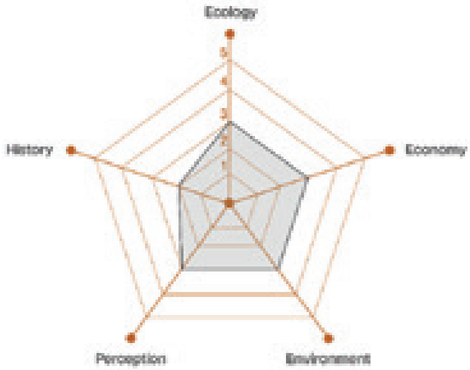
Deltares has scenarios: landwards/seawards.

Look into saltpans. Climate projections might be favourable for developing this industry.

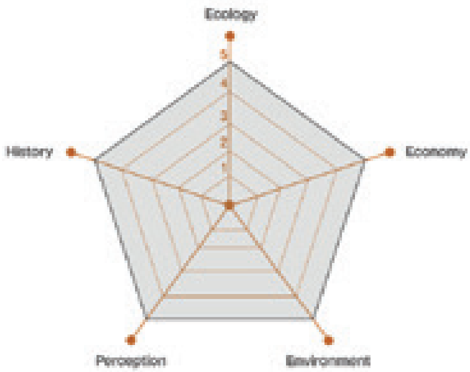
In the Maasdal, Limburg (NL), they have elevated fields: putting agriculture on mounds (bolakker/terpakker).

- ➔ These mounds could be interesting in S1 and S2.

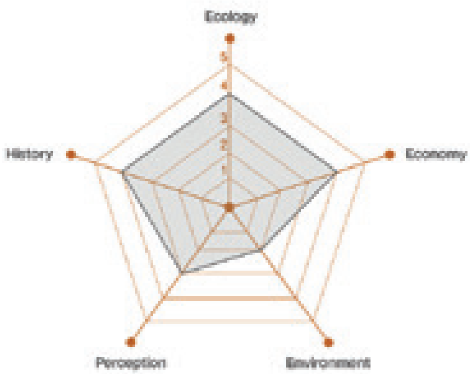




① Protect



② Accommodate



③ Retreat

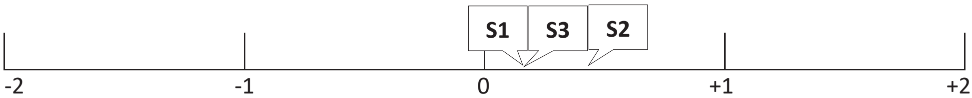
Agriculture [Alberto Bonora (IUAV)]

→results survey

Scenario 1: 2/9= 0.22 [between neither agree nor disagree (0) and agree (1)

Scenario 2: 4/9= 0.44 [between neither agree nor disagree (0) and agree (1)

Scenario 3: 2/9= 0.22 [between neither agree nor disagree (0) and agree (1)

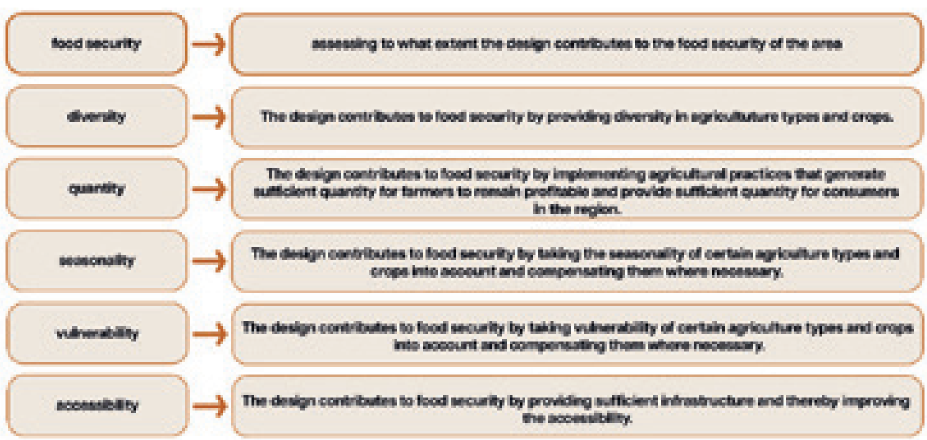


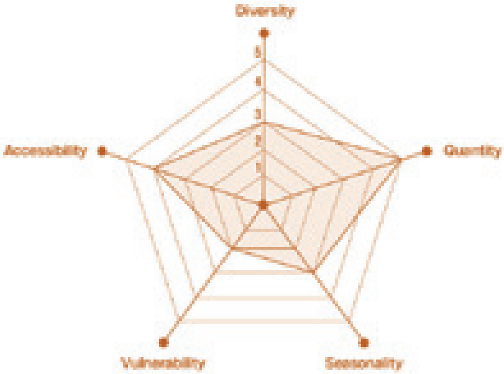
Expert comments:

The scenarios could also function as a timeline. Scenario 1 for 2040, scenario 2 for 2080, scenario 3 for 2120.

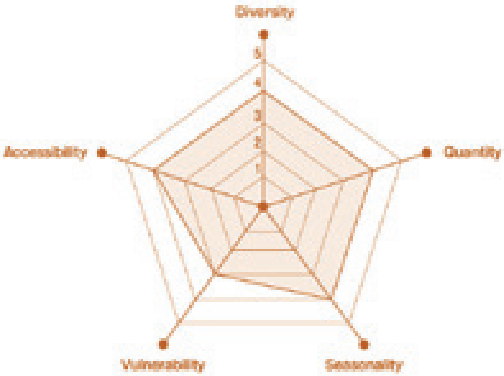
Profitability/future of saline agriculture (mono-crop) is questionable. However, silvopasture and integrated aquaculture have potential. Long term focus on aquaculture.

Conservation of historic city centre of Caorle and its interaction with the sea is appreciated. Important for the cultural-historical dimension of the landscape.

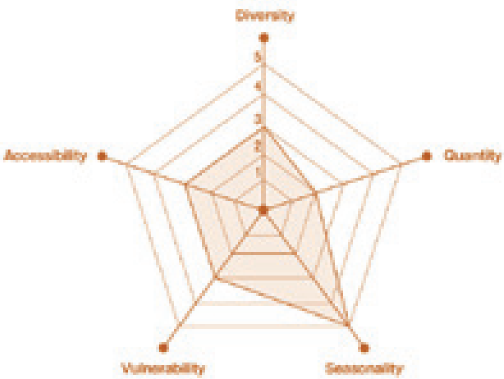




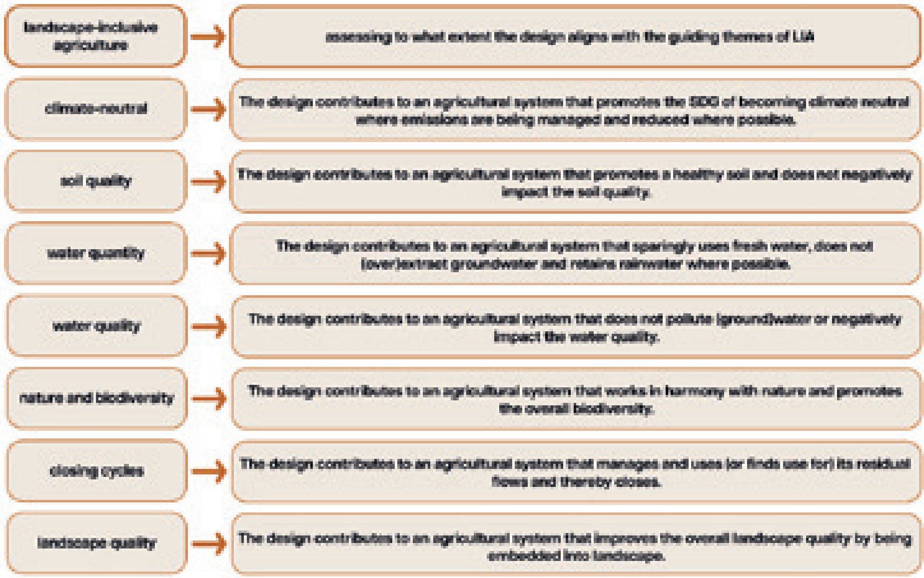
1 Protect

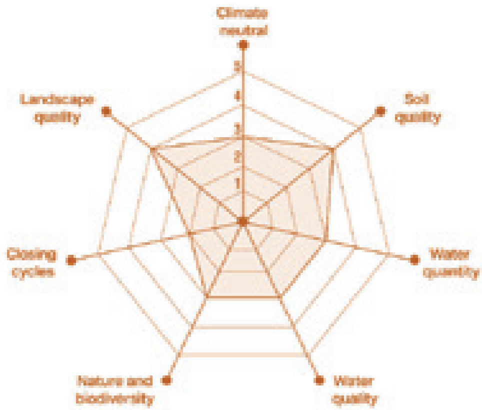


2 Accommodate

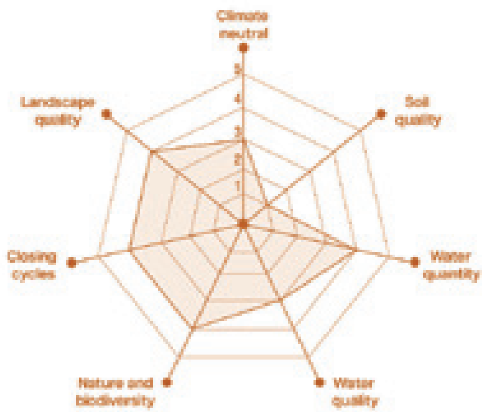


3 Retreat

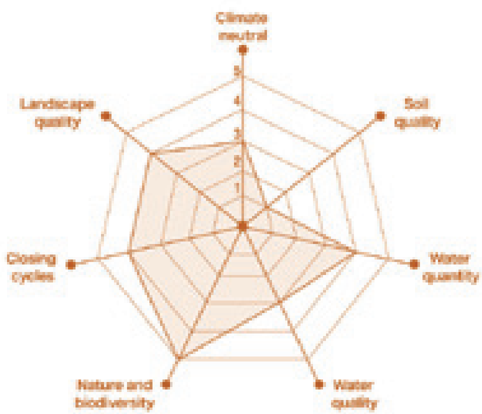

landscape-inclusive agriculture
assessing to what extent the design aligns with the guiding themes of LIA
climate-neutral
The design contributes to an agricultural system that promotes the SDG of becoming climate neutral where emissions are being managed and reduced where possible.
soil quality
The design contributes to an agricultural system that promotes a healthy soil and does not negatively impact the soil quality.
water quantity
The design contributes to an agricultural system that sparingly uses fresh water, does not (over)extract groundwater and retains rainwater where possible.
water quality
The design contributes to an agricultural system that does not pollute (ground)water or negatively impact the water quality.
nature and biodiversity
The design contributes to an agricultural system that works in harmony with nature and promotes the overall biodiversity.
closing cycles
The design contributes to an agricultural system that manages and uses (or finds use for) its residual flows and thereby closes.
landscape quality
The design contributes to an agricultural system that improves the overall landscape quality by being embedded into landscape.



① Protect



② Accommodate



③ Retreat

Results expert assessments test 2

Follow-up interview: landscape context

Michiel Bakx PhD at WUR

→Assessing landscape context; to what extent the design is embedded into the landscape, and takes other sectors into account.

1. The design improves the nature connections and overall ecology of the landscape

Scenario 1: Protect

The wide river bed ensures a free-flowing river, with various high-low and wet-dry gradients, strengthening the nature connection and overall ecology of the landscape. The wide green dyke has a slope that could potentially facilitate great diversity in flora. The piantata is a refreshing take on agriculture compared to the current monoculture beet fields.

Scenario 2: Accommodate

This design offers a similar natural wide riverbed with various high-low and wet-dry gradients. In addition to that, historical creeks are reintroduced into the landscape, connecting different landscape elements and further strengthening the nature connections and overall ecology. Due to the higher salinity levels, piantata tree rows are less prominent. Halophytes transition landscape between fishing valleys and salt-resistant crops

Scenario 3: Retreat

Lagoon can function as a spatial connector. Wide sandy dyke is a softer, more natural structure as opposed to the daunting big dyke.

Comparing the scenarios

Scenario 2 compared to scenario 1 feels less like individual landscape elements. Here, the creeks contribute to the overall connectedness of the landscape.

Overall: 3 most connected, 1 least connected.

2. The design contributes to the (local) economy by e.g. strengthening the tourism sector of the region

Scenario 1: Protect

The piantata offers a great diversity of crops, which could potentially lead to a more robust system. The wide green dyke forms a ribbon through the landscape from which the surrounding landscapes can be viewed. The landscape's diversity mainly lends itself to hiking and cycling. The piantata feels enclosed, whereas on the other side of the dyke the landscape feels more open. Unsure whether this contrast is too harsh or showcases and accentuates different landscape experiences.

Scenario 2: Accommodate

Relatively comparable to scenario 1. More agriturismo's; more diverse landscape. Hiking, cycling, bird watching, fishing.

Scenario 3: Retreat

Most potential for tourism. Emphasise with ports and more hotels/apartments/housing. Lagoon tourism lengthens the tourist season: not only beach tourism.

Comparing the scenarios
1&2 relatively comparable, 3 most touristic/ local economy potential

3. The design contributes to the overall experience and enjoyment of the landscape

Scenario 1: Protect
Compared to the current situation, the overall experience and enjoyment of the landscape is significantly enriched as the landscape now offers different sub-areas. However, the wide green dyke could both be perceived as a connecting and dividing structure. Its height is rather daunting, and could feel like a border. The low-lying piantata is a fishbowl or bathtub when viewed from the wide green dyke. The reedbeds look like monoculture crops; try to incorporate the wooded banks more and look for crop diversity.

Scenario 2: Accommodate
The piantata feels like a larger 'scale'. More openness, spacious compared to piantata from scenario 1, yet still easily readable. Interesting dynamic between more open and flowy river landscape and more enclosed and gridded piantata. Restored creeks add a new dimension to the landscape: guide through different cultivations. Boardwalk.

Scenario 3: Retreat
New perspective: lagoon, mudflats. Dunes, natural coastal protection. Boardwalk. Salt-centred landscape elements; both land and water.

Comparing the scenarios
2 most diverse, most experiences, 3, 1 least: harsh contrast?

4. The design allows space for historical elements/values, and ties them to the landscape

Scenario 1: Protect
The reintroduction of the ancient cropping method (piantata) holds great historical value, and is incorporated, intertwined, with the more recent square allotment structure. Combining these layers in the landscape shows multiple leading events in time. In addition to that, historical fishing huts (casone) are preserved and connected to the rest of the landscape.

Scenario 2: Accommodate
This piantata is less historical compared to scenario 1 piantata, however, still works. Creeks are of major historical value. Casone, fishing valleys.

Scenario 3: Retreat
Big, drastic intervention. Polder structure vanishes. Maybe closer to 'genius loci', but definitely some historical values lost.

Comparing the scenarios
2 most, 1 and 3 comparable, however, 3 is very drastic.

5. What would you add/ what do you think that needs more focus in this scenario?

Scenario 1: Protect

The inner- and outer-dyke landscapes feel like two different worlds. Even though the functions are different (agriculture and natural river), this does not mean that these worlds cannot be connected. Try to transition these worlds into each other, as opposed to contrasting each other.

Scenario 2: Accommodate
Focus on axis: emphasise. Emphasise creek beds. Transition halophytes to salt resistant, and show more of the ditches (and its banks).

Scenario 3: Retreat
More focus on touristic housing: fill void, 'tussenruimte'.

6. Which landscape element(s) do you think add most to the landscape context? Which element(s) help with the overall embeddedness of the proposed design interventions?

Scenario 1: Protect
The piantata structure makes for a readable and 'cosy' landscape. The tree rows used here, can help tie different landscape elements together. The spatial 'language' of the piantata can be used to transition one area into another area, while still maintaining a landscape unity.

Scenario 2: Accommodate
Creeks tie the landscape together, as well as the square allotment: creates a 'web', structure. Contrast natural and agricultural, yet intertwined unity.

Scenario 3: Retreat
Mudflats (driftwood), piantata.

Follow-up interview: agriculture and food security
Alberto Bonora farmer, research fellow and MSc environmental planning and policy at IUAV

1. *The design contributes to food security by providing diversity in agriculture types and crops*

Scenario 1: Protect
Piantata and floodplain offer diversity.

Scenario 2: Adaptation
2 is most diverse due to the diversity in landscapes.

Scenario 3: Retreat
More aquaculture, tourism and nature based than agricultural crops

2. *The design contributes to food security by implementing agricultural practices that generate sufficient quantity for farmers to remain profitable and provide sufficient quantity for consumers in the region*

Scenario 1: Protect
Crops are more profitable than saline agriculture, as for now.

Scenario 2: Adaptation
In combination with agriturismo and tourism, then yes.

Scenario 3: Retreat
This scenario probably profits more form tourism than agriculture.

3. *The design contributes to food security by taking in the seasonality of certain agriculture crops into account and compensating them where necessary*

Scenario 1: Protect

Scenario 2: Adaptation

Scenario 3: Retreat
1 and 2 are more or less similar. 3 is less season-dependent due to more aquaculture and tourism.

4. *The design contributes to food security by taking vulnerability of certain agriculture types and crops into account and compensating them where necessary*

Scenario 1: Protect
Crops in 1 will always remain vulnerable to saline conditions.

Scenario 2: Adaptation
Crops are adapted to saline conditions.

Scenario 3: Retreat
Thriving on saline conditions.

5. *What would you consider to be the most viable way of agriculture in this scenario?*

Scenario 1: Protect
Drought -resistant and salt tolerant cropping. Broad floodplain has potential, also for fish.

Scenario 2: Adaptation
Saline agriculture, in combination with agriturismo/tourism. Unsure if saline alone is profitable enough.

Scenario 3: Retreat
Fish valleys in combination with other aquaculture.

Would these new piantata structures help create a robust and landscape-inclusive agricultural system?
For sure, it offers a polyculture system that aligns with the landscape identity. However, as these plots are significantly smaller, more narrow compared to the current plots, these piantata structures make it impossible to access the land with heavy machinery such as combines and tractors. This requires a big investment for farmers in lighter machinery and robots. But with the timeframe of 2100 in mind, this is not impossible.
The different piantata structures can be used as a gradient, or transitional line, from non-saline dry to saline wet. The piantata structures align with the larger landscape structure of *graticolato romano.* The piantata proposals can be altered to different regions as each region has unique piantata dimensions.
The way the wind is taken into account is a plus. Winds will become harsher, which can damage crops. In addition to that, salt gets transported with the wind, which can accumulate on the leaves of crops. The raised and semi-raised piantata could potentially reduce wind damage.

The original piantata might not be resistant to the challenges of 2100 in terms of salinity and fresh water supply, however, it remains a good reference for local polycropping.

'Piantata' dimensions' does not qualify as a piantata, as there is no actual tree plantation. However, using similar dimensions to the piantata can help create unity in the landscape. As this is in high saline circumstances, the main concern is if this land and way of agriculture is profitable enough to maintain.
→*Author suggests adding salt pans*
Salt pans could potentially solve this problem. In addition to that, salt pans has high touristic value. Look into Sant'Erasmo natural island. The landscape in high saline circumstances could potentially look like this: a more recreational and natural take on agriculture.

Landscape-inclusive agriculture and drowning deltas

improving food security and flood control