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Designing for Resilience in Rural Coastal Landscapes

Testing Future Scenarios on their Impact on Community Resilience of Barrier Islands in the Ria Formosa, Portugal

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Abstract

The Ria Formosa Nature Park in southern Portugal attracts thousands of tourists every year for its natural beauty and rich ecosystems. The saltwater lagoon and its sandy barrier islands form a unique landscape, which shelters the Algarve's capital Faro. But what shelters the communities living on the barrier islands themselves?

This paper aims to analyse what it means for rural coastal communities to be resilient, as demonstrated by the island community Farol and investigates the trends, which may lead to its future challenges. To connect various spatial and temporal scales, this study utilises both the hourglass method and iterative design thinking. Meaning, the research begins at the level of the Ria Formosa Nature Park, then zooms to a specific island (Culatra) and one of the communities on it (Farol). It then invents five future scenarios to explore growing threats and possible changes. While presented in a linear fashion, the scenarios were built and revised multiple times to increase their robustness, clarity and cohesion.

The composition of five future scenarios for the Farol community, allows contemporary environmental, social, and economic trends to be continued and attenuated. Each scenario shows potential developments and responses to trends visible today. The implications to resilience and possible alleviation strategies are suggested. The scenarios are then evaluated through comparisons of each other and their global templates.

The scenarios aren't intended as five best-case development plans, but rather reflections of future threats to resilience, which we can observe and anticipate today. Each situation has different challenges and a range of options to mitigate negative impacts. They can be used to inspire adaptation planning and encourage active steering by stakeholders towards the most desirable future.

Theoretical Background

Focus on rural coastal landscapes

Landscape architecture is rapidly rising in societal importance. The profession connects environmental and socio-economic concerns to generate solutions, which increase the sustainability and resilience of our communities. One can find examples of landscape projects of any scale and typology, yet the quantity of design research is heavily skewed towards medium-scale urban projects. Such designs, however, might not be applicable to rural contexts. Those areas, characterised by low population densities, limited economic capacities and weak institutions, require a very different and unique set of solutions to today's challenges (Cheng & Cheng, 2020).

While there is an undeniable importance to innovate urban infrastructure to better address contemporary and future issues, such as climate extremes, population growth, and safety, among others; rural landscapes are just as essential for our societies. We may overlook them, as they don't accommodate the same population densities or generate as much GDP as our cities, yet they are responsible for most of our food production, sources of raw materials, places for recreation and home to incredibly diverse fauna and flora species (Pedroli et al., 2007). Rural populations tend to preserve cultural practices more extensively, which are now being revived as potential solutions for more sustainable living (Williams et al., 2021). Thus, rural landscapes and rural communities should be paid more attention and their assets protected against future threats.

Rural populations have fundamentally different attributes from urban ones. Overall, they tend to be more self-sufficient and with a greater motivation to stay and adapt to changes in their environment. This may be due to receiving less assistance from public institutions, critical infrastructure that is widely dispersed and limited road connections (Bukvic & Harrald, 2019).

With such characteristics, rural communities face challenges vastly different from urban populations and it is usually not possible to simply copy-paste urban solutions to rural villages. For many places, new strategies must be created and tested, which reflect the unique conditions of the rural landscape.

Rural landscapes encompass a large diversity of landscape typologies, such as agricultural fields, mountains, forests and more. To delimit the scope of this study, coastal landscapes have been selected.

Coastal zones have always been very attractive to societies, with an abundance of natural resources and opportunities for travel. Today, around 40% of the global population lives within 100 km from the oceans and in the EU it's about 19% or 86 million people within 10 km of its shores. (Intergovernmental Oceanographic Commission in Tavares et al., 2021). Climate change - and with it rising sea levels, storms, erosion, drought - threatens all these people, but especially those in vulnerable rural areas. It highlights the societal importance of seeking new adaptation measures, which effectively remove the threat to such communities.

This landscape typology was additionally chosen due to its highly dynamic nature. One can observe an ever-present conflict between static infrastructure, based on a human desire for predictability, and the strong environmental forces relentlessly reshaping the natural environment. The securing of shorelines and a constant fight against erosion are easily visible examples of this struggle. Unfortunately, the hardening of our shorelines can exacerbate the very problems we try to solve through costly engineering measures. It also reduces the number of ecosystem services that these shorelines provide, such as fish nurseries, carbon storage, flood defence, recreation, tourism and biodiversity (Lansu et al., 2024). It is therefore imperative, that we continue to search for alternative ways, which allow people and nature to co-exist harmoniously.

Example - Barrier islands

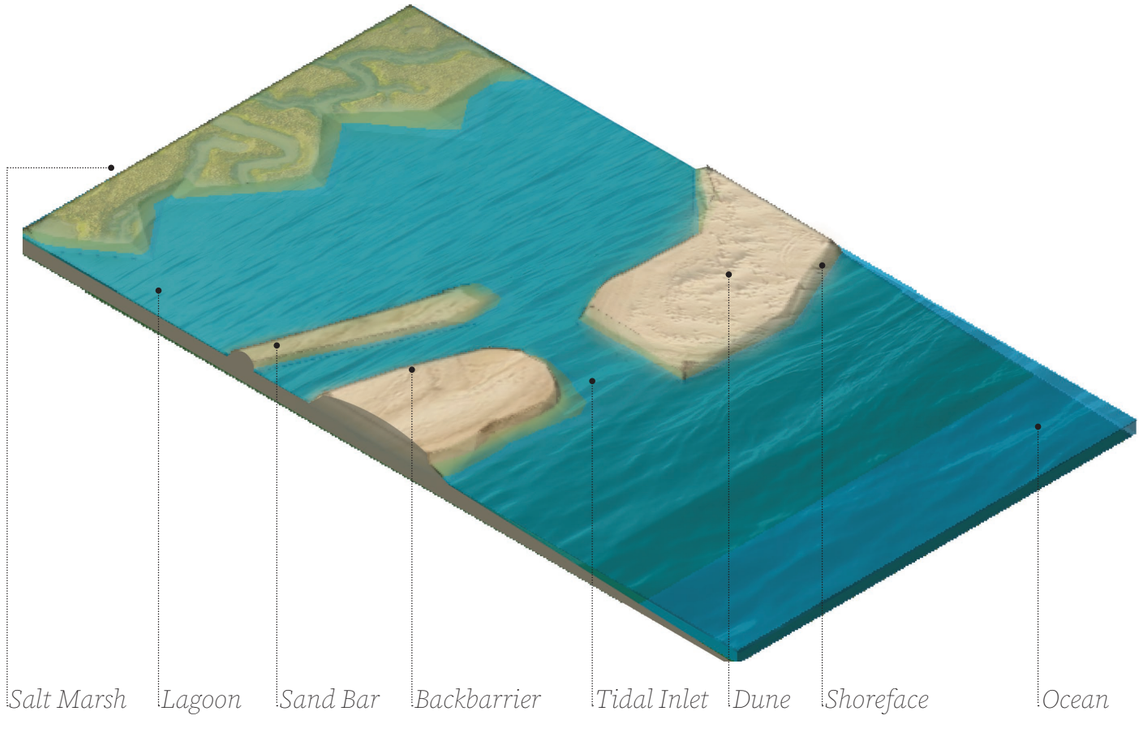
Rocky shorelines and cliffs require different planning approaches than gradual sandy shores. When discussing sea level rise and the flood risk of communities we tend to think of the latter, as the threat is much more pronounced. Some communities are able to retreat inland and avoid disaster, but many cannot. There could be physical barriers (mountains, small islands), social barriers (unwillingness to move, no new properties available) or economic barriers (no private/public funds available to relocate). Barrier islands have been chosen to serve as valuable examples of sandy shorelines, where retreat on the island is not possible and to the mainland not desirable.

As shown below, a barrier island is an elongated narrow ridge parallel to the adjacent mainland in gradual coastal zones. Typically made of unconsolidated sand or gravel, it protects the land and lagoon from harsh open-water processes, such as storms or strong waves. (Carrasco & Matias, 2019)

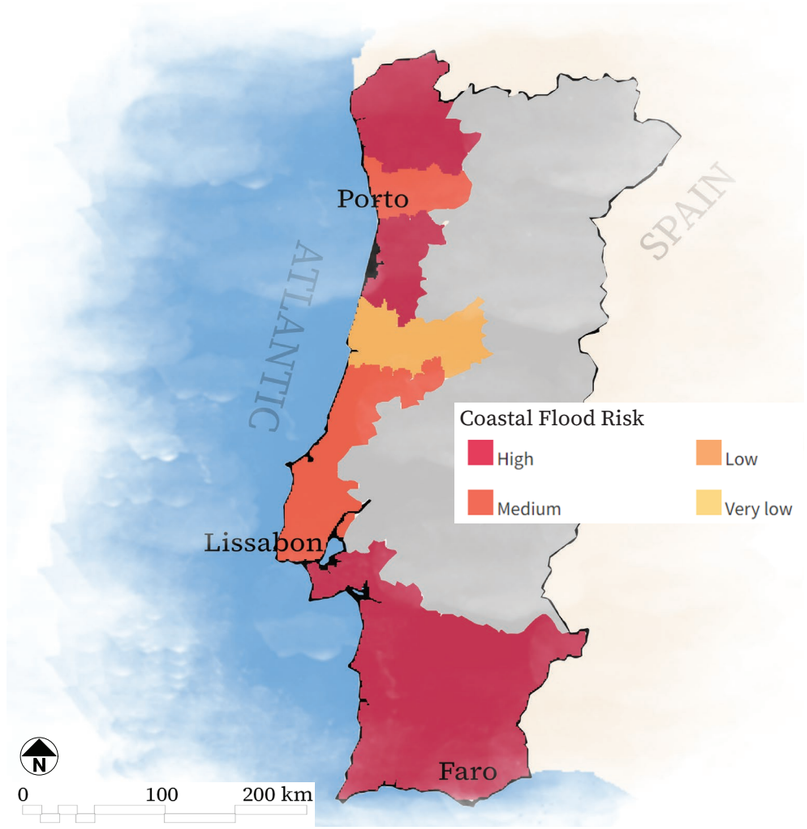
These very fragile, dynamic ecosystems are usually found in chains, separated by tidal inlets, which allows for the water exchange between the lagoon and the ocean (Freudenrich, 2023).

The shoreface or beach is shaped by wave action, whereas the following dune is primarily affected by the winds and stabilized by vegetation. The backbarrier or overwash is created when severe storm waves carry sediment over the dunes to the other side of the island, where it is colonized by new types of vegetation (Freudenrich, 2023).

Barrier islands are naturally formed and can be found all over the world. Within the past decade, they have been becoming increasingly popular for developments, such as hotels, fishing villages or summer homes, despite warnings from scientists and planners about their fragility and risk of coastal flooding (Kobell, 2015; Freudenrich, 2023).



Graphic 1 - Barrier Island Typology



Graphic 2 - Flood Risk Portugal

Graphic 3 - Coastal Erosion

Why Portugal?

There are many countries in the world with a need for adaptation in their rural coastal zones. Portugal stands out with the majority of its population responsible for 80% of its GDP living within threatened coastal zones" (Tavares et al., 2021). According to EU President Ursula von der Leyen, "Portugal is one of the countries most affected by climate change" (Silva, 2022).

The Floods Directive 2007/60/EC asks all EU members to create flood risk maps of their coastal areas and come up with management strategies for prevention, protection, and preparedness (Antunes et al., 2019). The map on the right shows the areas in Portugal most vulnerable to coastal flooding.

Pressure on the coastlines comes from a variety of sources, including the following:

» flooding from storm surges, precipitation and river overflows;

» shoreline retreat from erosion and sediment deficits;

» anthropogenic pressures, such as the reduction of native flora and fauna, or the construction of infrastructure, i.e. urbanisation, transport networks, harbours, intensive agriculture, defence structures, among others (Tavares et al., 2021).

Portugal's motivation to minimise global warming and invest heavily in carbon neutrality is likely fueled by the vulnerability of Portugal to climate change. Climate change is considered the primary cause of flooding along Portuguese coastlines. It includes rising sea levels, more frequent and intense storms, stronger waves, warmer ocean surface temperatures, and changed ocean chemistry (Ciampa et al., 2021)

Sea level rise and other environmental coastal hazards are not distributed uniformly around the world, with some areas being affected more dramatically than others. The Atlantic's sea level rose 2-3 mm/year on average, whereas the Mediterranean Sea only saw a rise of 1.5-2.5 mm/year. The observed sea level rise in the chosen study area would be expected to lie somewhere between these values. In the next 25 years, the Mediterranean is expected to further increase by 150 mm and somewhere between 500-1000 mm by 2100. (Antunes et al., 2019). Sea level rise has the side effect of added erosion with the Portuguese coastline currently retracting by 0.36 m every year, swallowing 320 km2 of waterfront and damaging even more under low tides (Antunes et al., 2019).

Despite these challenges and an outspoken political will to adapt and mitigate climate change, coastal policies have been rather ill-coordinated and lacking continuity (Schmidt et al., 2014). Unplanned urban sprawl, vast numbers of second homes and the high costs of retaining beaches make it even harder for policymakers to act (Schmidt et al., 2014).

Building a comprehensive, effective and integrated climate response starts with identifying coastal typologies that are most at risk from flooding (Tavares et al., 2021) To aid this process, the following pages aim to contribute to the discussion surrounding flood safety and erosion through the exploration of 'sandy barrier island'.

What is resilience?

This study focuses on resilience rather than the sustainability of future situations. Sustainability was coined in the 1983 Brundtland report, as "the ability of one society to meet their needs without compromising the ability of future generations to meet theirs" (Thomsen, 2013). The concept was created in light of climate change and large-scale environmental degradation. It has proven very useful when considering available quantities of a specific resource or budgeting pollution quantities that can be absorbed in a set timeframe.

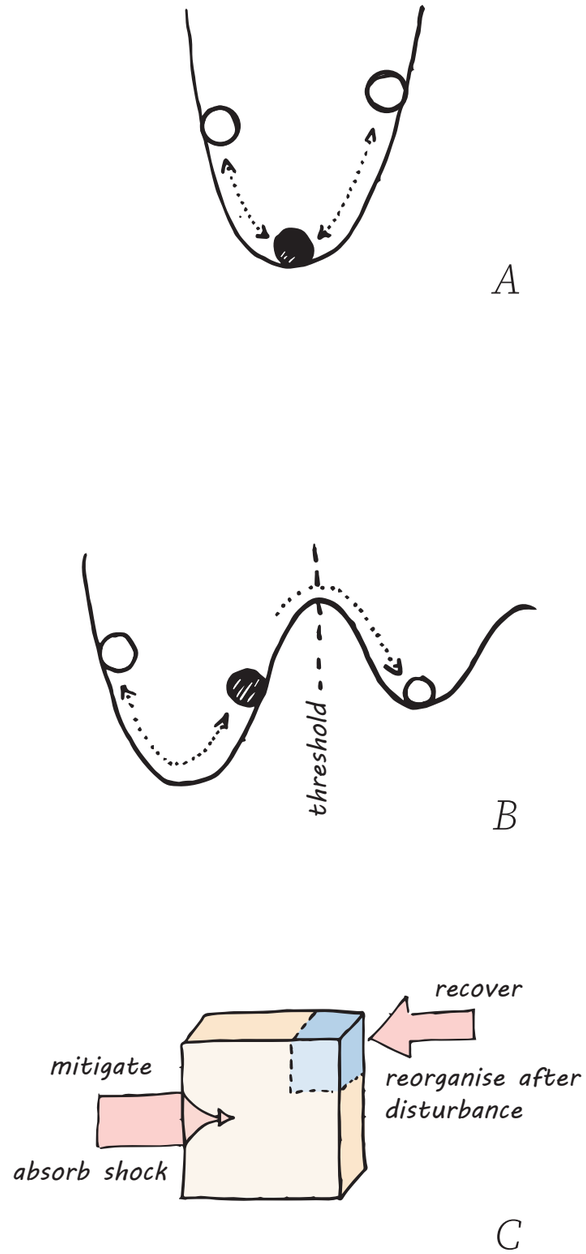
However, the term 'sustainability' performs less well, when discussing systems in flux or the evolution of communities. Broadly speaking, resilience can be defined as "the capacity of a system to deal with change and continue to develop" (Gocer et al., 2024). It was most commonly used in engineering practices to discuss the ability of a material or construct to absorb shock and return to its original state (see diagram A).

Ecological researchers have adapted the concept to describe natural communities. Kombiadou et al. (2020) define resilience as "the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same functions, structure, identity and feedbacks" (see diagram B).

To apply the concept of resilience to social groups and communities, one can see resilience as "the ability of communities to withstand shocks to their social infrastructure" (Gocer et al., 2024). Or to be even more concrete for the purpose of this thesis, Gocer et al. (2024) explain "rural resilience as the capacity of rural areas and locals to adapt to changing external circumstances (mostly in relation to natural disasters) by resisting, adapting, reworking, transforming, etc., in such a way that rural stable characteristics are kept and satisfactory living standards for locals are maintained" (see diagram C).

Academic research on resilience tends to focus on either environment, society, or economics, but most rarely a combination of all three. Yet, in sustainability research, the interactions and weight of these pillars are seen as crucial, as sustainability can't be achieved without harmony between all three. Similarly, a community could be less resilient to external threats if they are lacking in either category. As a consequence, this study attempts to continuously analyse the combination of environmental, social, and economic drivers of resilience.

Building resilience requires continued efforts to learn and adapt to external challenges. Surprisingly, studies have shown that many vulnerable communities repeatedly neglect to reduce the risk of losing their homes and lives to environmental disasters (Bukvic & Harrald, 2019). In some areas, this could be due to a lack of resources for adaptation measures, whereas in others, it is more sociological and might stem from the inability to recognize the threat without experiencing it first-hand (Bukvic & Harrald, 2019). The choice of specific tactics is influenced by people's circumstances, including available resources, institutional capabilities, level of wealth, and sociocultural resolve to move from an unstable setting. It is frequently impacted by public and political pressures, regardless of the net advantages and long-term impacts, generally preferring structural fortifications over permanent retreat (Bukvic & Harrald, 2019)



Graphic 4 - Resilience Perspectives

Analysis Through Scenarios

In order to analyse the resilience of a rural coastal community, this thesis is utilising the perspective of five future socio-economic scenarios. Within each, current trends are extended and exaggerated. Through this method, it becomes easier to spot potential vulnerabilities and aid in the brainstorming of countermeasures (Reimann et al., 2021). In turn, such knowledge could be used to guide decision-making today and strengthen the resilience of an area.

Rather than going into technical depth and analysing, for example, if a sea barrier of a certain height will perform adequately, the scenarios try to paint a picture of how the community would change and express their values and needs through the modification of their infrastructure. Charlesworth and Fien (2022) phrased it quite elegantly; "in the increasingly complex and uncertain world of disaster-risk management, design thinking avoids linear thinking and, instead, looks to two iterative processes: (i) identifying and formulating the problems by understanding systemic relationships, and then (ii) developing and testing alternative solutions." The field of landscape architecture supports the design aspect, as well as a systemic way of thinking, which allows information from multiple professions (engineering, sociology, management, among others), to be combined into singular scenarios.

The chosen timeframe for the scenarios is 20 years and 50 years, which are also often used in climate studies and future predictions. Bukvic & Harrald (2019) suggest choosing a timeframe relevant to the public to make the scenarios accessible. 20 years could be compared to the time it takes for a child to grow up, or for someone in their 40s, the scenario would occur around the time they retire. 50 years might be a more abstract timeframe. Yet, it allows for more dramatic changes to be incorporated into the predictions, while still correlating with the lifespan of many structures and investments, and thus being easily

SSP Scenarios

To make the scenarios more realistic, each is based on a Shared Socioeconomic Pathway (SSP). The SSPs were developed for the IPCC Sixth Assessment Report on climate change in 2021 and describe five plausible alternative changes in aspects of our global society. They create storylines including demographic trends, urbanisation, economic shifts, technological advancements, social aspects, governance, and environmental factors. The SPPs are presented in qualitative narratives and quantitative variables. Both can further be used in integrated or large-scale impact models, as well as vulnerability assessments, in order to create cohesive predictions on a wide variety of topics. (O'Neill et al., 2017 & Reimann et al., 2021) The upper diagram shows how the SSPs were combined with CO_2 models to predict future global temperatures.

The five scenarios are selected to be realistic, distinct and cover most uncertainties regarding adaptation and mitigation, as visualised in the lower diagram. Mitigation refers to the avoidance of negative events; adaptation to measures, which would reduce their impact, such as protective infrastructure (Cassin et al., 2022).

The first SSP imagines minimal challenges for mitigation and adaptation as societies find ways to respect environmental boundaries. Effective collaborative processes aim for everyone's well-being, low energy demands and high investments into sustainable technologies.

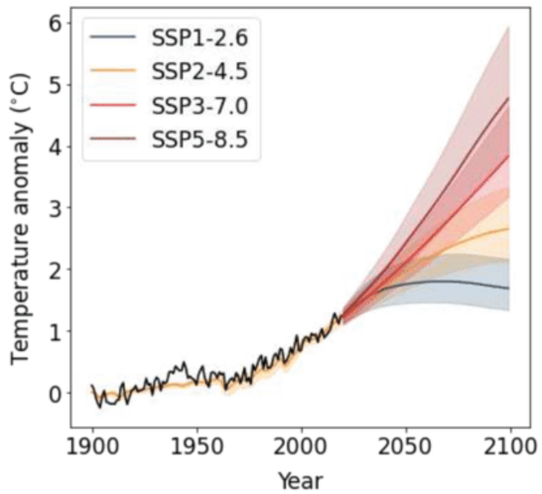
The second SSP observes a more or less continuation of historical patterns, which lead to intermediate challenges for mitigation and adaption. There are some moderate improvements to people's well-being, technological advances and environmental health.

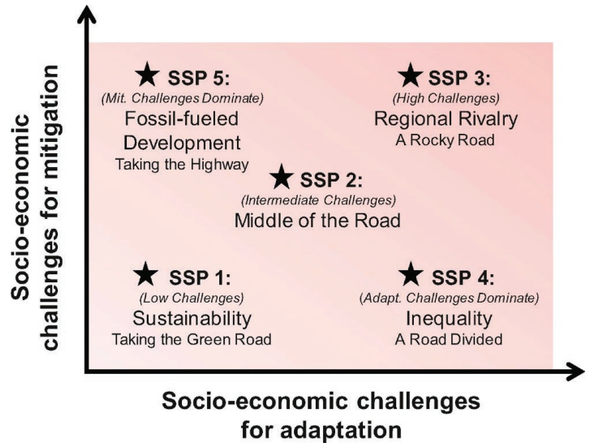
In the third SSP, the challenges for mitigation and adaptation become high, as the concern for the environment becomes overshadowed by resurgent nationalism and regional conflicts. Economic developments slow down, as do investments in education and innovation.

The fourth SSP expects high challenges for adaptation, as the disparities between societies become larger and larger. Conflict and unrest increase in frequency and intensity as a result of the uneven distribution of wealth and political power.

The fifth and last SSP is defined by high mitigation challenges. Rapid technological advancements and intense growth of the global economy fuel resource consumption and climate change. Highly engineered infrastructure supports energy intensive lifestyles and increasing standards regarding education and health.

The SSPs paint images of potential futures over the 21st century of global trends and economies. When looking at a more specific level, i.e. national, regional, or local, one can create so-called extended SSPs. These fit into the global trends but also incorporate local specificities and modify the narratives accordingly. The scenarios designed in this thesis will be such extended SSPs. In addition to the global SSP template and in-depth research into local drivers and circumstances, the presented scenarios draw inspiration from other studies into extended SSPs. For example, Reimann et al. (2017) describe five extended SSPs for the Mediterranean coastal zone through population projections and find plausible reasons for possible trends, such as urbanisation, industry changes, social concerns and environmental dynamics.





Graphic 5 - SSP Representations
produced by Dvorak et al.(2021)
produced by O'Neill et al.(2013)

Glossary

Adaptation:
dynamic process by individuals, groups or societies in response to challenging changes in their environment
(Edwards, 2024)

Barrier Island:
elongated ridges, usually made up of unconsolidated sand or gravel, which protect the nearby mainland from open-water processes, such as storms or erosion
(Carrasco & Matias, 2019)

Beach Berm:
natural bumps in a beach profile from onshore sediment transport and where the coarsest material of the beach is collected from the upwash process
(Zhu et al., 2022)

Beach Groyne:
man-made structures perpendicular to a beach to preserve updrift beaches or reduce longshore sediment transport
(National Park Service, 2019)

Coastal Barriers:
hard-engineering structures, which create new landforms at the land-sea interface and are often designed with concrete or sediments
(Ciampa, 2021)

Dune:
mounds of sand of various dimensions, formed by wind or waves
(Rutledge et al., 2024)

Eco-tourism:
beginning in the 70s, this type of tourism aims to protect the environment and benefit the well-being of the visited communities through interpretation and education
(Shasha et al., 2020)

Geographic Information System (GIS):
computer systems that capture, store, analyse, manage and visualise geospatial data
(Jonker, 2023)

(Coastal) Lagoon:
form when sections of gentle sloping coasts are separated from the open-water by islands, reefs or sand banks. Constant water exchange is facilitated through inlets
(NOAA, 2024)

Littoral/ Intertidal Zone:
a specific area in the land-sea interface, often defined by the extreme low water of spring tides and extreme high water of spring tides. Habitats, including rocky shores, mangroves, salt marshes and sandy beaches, are typically exposed at low tide and underwater during high tide
(Kon et al., 2020)

Littoral/ Longshore drift:
when waves approach the shore at an angle, material and sediment is transported along the coasts
(Bennett, 2023)

Mariculture:
a sub-category of aquaculture (includes all species living in water); mariculture specifically refers to the cultivation of produce (fish, plants, bivalves) in salt water
(Kim, 2022)

Mesotidal:
a classification for shorelines, where the tidal range is between 2–4 m
(Boothroyd, 1978)

Mitigation:
“the act or result of making something less severe, dangerous, or damaging”
(Merriam-Webster, 2019)

Nature-based Solutions (NBS):
aim to benefit people and nature through the protection, management and restoration of ecosystems
(IUCN, 2023)

Overtopping/overwash:
refers to waves exceeding the height of barrier islands, transporting water and sediment across dune crests and leaving washover deposits in the direction of the mainland
(Rodriguez et al., 2020)

Planetary Boundaries:
sustainability concept, which quantifies nine thresholds, under which the global society can continue to exist and thrive
(Ernstberger & Stockholm Resilience Center, 2023)

Polis Litoral Ria Formosa Society, S.A.:
was tasked with the management, coordination and execution of investments in the Ria Formosa, under the terms defined in the Strategic Plan 2008-2018 (ICNF, 2023)

Ria Formosa Nature Park (PNRF):
18,400 ha of protected lagoon and marshland in southern Portugal
(Expresso, 2016)

Rural:
quantified definition depends on geographical region, but overall refers to “sparsely populated regions predominantly composed of agricultural land, natural landscapes, and small settlements”
(What Is the Difference between Urban and Rural?» What Is the Differences?, 2023)

Saltmarsh/Saltflat:
wetlands in coastal zones, which are continuously flooded and drained by tidal waters
(NOAA, 2019)

Sea Level Rise (SLR):
spatially heterogenous rise of the ocean’s surface height, relative to neighbouring land, largely due to climate change
(Woods Hole Oceanographic Institution, 2024)

Sea Wall:
type of coastal barrier, designed to prevent and reduce oceanic flooding during storm surges and protect the people and structures behind them-
(Cornell et al., 2013)

Shared Socio-economic Pathways (SSP):
framework describing five possible future scenarios, factoring out climate policy
(Hausfather, 2018)

Stakeholders:
individuals, groups or organisations with an interest rightful interest in the decisions or activities of a business, organisation, project or place
(Barney & Holak, 2023)

Storm surge:
severe storms increase the height of astronomical tides. Portugal experiences average storm surges from 50 to 70 cm and 80 cm to 100 cm during 100 year events
(Antunes, 2019)

Tidal Prism:
volume of water that enters and leaves the lagoon associated with the tides
(AIA 2658, 2013)

Urban:
quantified definition depends on geographical region, but overall refers to “densely populated regions that are typically characterized by advanced infrastructure, a high concentration of buildings, commercial establishments, and various amenities”
(What Is the Difference between Urban and Rural?» What Is the Differences?, 2023)

Case Study 1

MVRDV Vancouver

The Dutch company MVRDV developed the Sea2City framework for a neighbourhood of Vancouver in 2022, showcasing strategies to increase resilience against coastal flooding. The selected area surrounding False Creek is highly threatened by sea level rise.

The framework included a vision, a master plan and a catalogue of possible solutions from now until 2100. To make it more tangible, there are suggestions for pilot projects and transitional stages.

Nowadays, the intertidal zone has disappeared and there is no room for the water body to naturally expand. During flood events, homes and infrastructure would be damaged. Raising the flood walls could be one option for Vancouver to protect its people and assets, though this would only move the problem to a neighbouring site without flood protection.

Part of the proposed solution is restoring the natural soft edge and living above the water. So instead of fighting against nature and excluding water, it is invited into the city. Floating architecture, houses on stilts and elevated walkways would encourage a symbiosis with the local flood cycles and allow for all functions to continue in otherwise hazardous conditions.

The proposals are not just concerned with flooding but aim to create additional benefits for the neighbourhood. These include the restoration of habitats in the intertidal zone and an increase in biodiversity, diverse public green spaces for leisure and other activities, as well as promoting a healthy connection with the water.

While designed for an urban not rural context, means that individual ideas might not be transferable, MVRDV's approach of envisioning long-term possibilities has inspired the method for the thesis.

(MVRDV, 2022)

Graphic 6 - Sea2City Catalogue
produced by MVRDV (2022)

Case Study 2

Climate Service for Flensburg

The coastal city of Flensburg observed a high risk of flooding and has been looking into adaptation measures to mitigate the effects of climate change and sea level rise on its urban infrastructure.

Together with stakeholders, the team EVOLVE developed four extended SSPs, utilizing the global SSPs as boundary conditions, as well as researching local conditions and trends. Their multi-scale co-production approach produced plausible alternative futures, which help to manage the uncertainties of adaptation measures.

Group discussions and scenario workshops aimed to include local stakeholders. The narratives were written in non-scientific language and created a bridge of understanding between neighbours and specialists. This process allowed for the effective integration of local knowledge, expert opinion, and research, for the creation of realistic and relevant scenarios. Rather than top-down informing locals of climate and environmental changes, this process, co-produces knowledge on local socioeconomic developments, as well as climate, which will make the implementation of adaptive measures much easier. As a direct result, participants were more aware of current socioeconomic trends and inspired to avert the negative consequences, of for example the 'Aging Flensburg' scenario (SSP3).

This case study has been a valuable example of how the global SSPs can be adapted to a local context. While the scope of this thesis delimits the number of participants, the aim will be to communicate the new SSPs in an easily understandable manner. This would make the result accessible to others and a potential conversation starter for local stakeholders.

(Reimann et al., 2021)

Graphic 7 - SSPs Flensburg
produced by Reimann et al. (2022)

Method

Graphic 8 - Site Visit

Graphic 9- Line Drawing Farol

To be able to respond to the complexities of the local landscape, the methodology chosen for this study utilizes the hourglass method. The hourglass refers to beginning at a grand scale and then getting closer and closer to the focus area before looking outwards again, spatially and temporally.

1) Desk Research

The foundation for the project was established through desk research. The theoretical background, case studies and generic potential solutions were mainly found in scientific journals, newspapers, and articles. Impressions of the site and clarification on specific infrastructure were sometimes found on tourist photos posted online. Maps and GIS data were mainly derived from a variety of EU and governmental sources, such as dgTerritorio Portugal.

2) Site Visit

The first site visit took place 05-12 January 2024. First impressions and observations were recorded in photos, sketches, and field notes. The main objective was to get a sense of the place and find particular values or challenges, which will influence the design process. The gathered material together with the desk research is demonstrated in the site analysis.

The second visit, 16-20 April 2024, provided clarification on locations that were missed the first time and allowed for a comparison between winter and early summer season. Conversations with locals further added to the understanding of the area.

3) Exploration of Scenarios

Several papers provided the background information on the global SSPs and their potential application to regional and local extended SSPs.

The next steps can be described as research through design. Brainstorming, mind maps and collages sketched an early vision of the Farol SSPs. In sections and plans, ideas were tested, shaped, exchanged and developed.

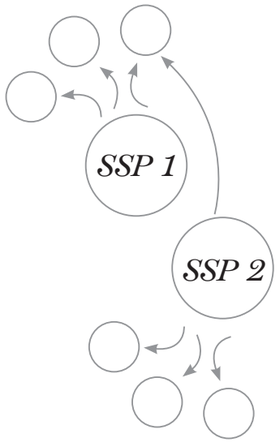
The base map for the scenarios was sourced from cadmapper.com and esri ArcGIS. Vectorworks Landmark was then used to modify the base map according to personal observations and later to design the future scenarios. The Portuguese national coordinate system ETRS1989/Portugal TM06 (ESPG:3763) was used for dataset projection throughout.

The plans depict Farol in 50 years time, but rather than potential development plans, the aim is to physically express the abstract predictions, such as economic downturns or greater environmental awareness, and to increase the sensitivity of the trends of the chosen SSP. Technical solutions can vary greatly in their predictions and include countless unknowns. Rather than focusing on individual elements, the site plans aim to visualise how different trends would interact and produce certain impressions on the landscape.

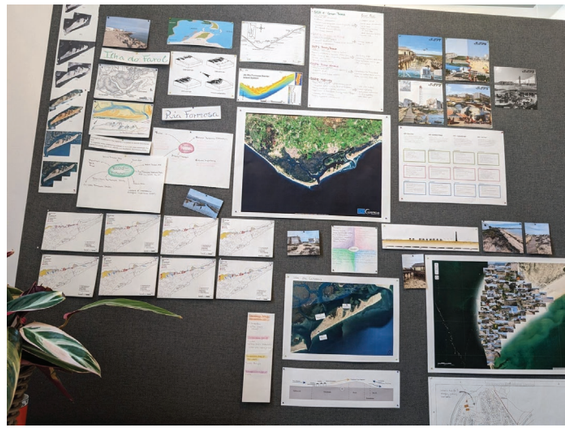
Next to sections and plans, smaller details show a variety of elements, which could feature under a certain scenario. While associated with respective scenarios, they are of course not limited to them. Repetition was simply avoided to provide a greater breadth of structural interventions. The catalogue is also not exhaustive and could feature many more elements, of which some might not have been invented yet. Each scenario includes a small discussion on how to mitigate the worst consequences. Some scenarios include greater threats than others, but adaptation and mitigation will be important in all of them.

4) Evaluation & Conclusion

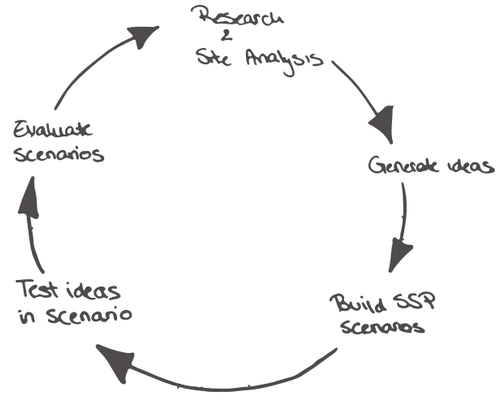
To compare all of the scenarios, a scoring system was designed based on personal judgment.
To evaluate the work of this thesis, each scenario was then compared with its global SSP.
These comparisons were then used again to further develop the scenarios in an iterative circular design process, to build up their robustness and comprehensibility.



Graphic 10 - Scheme of solution ideas



Graphic 11 - Working Board



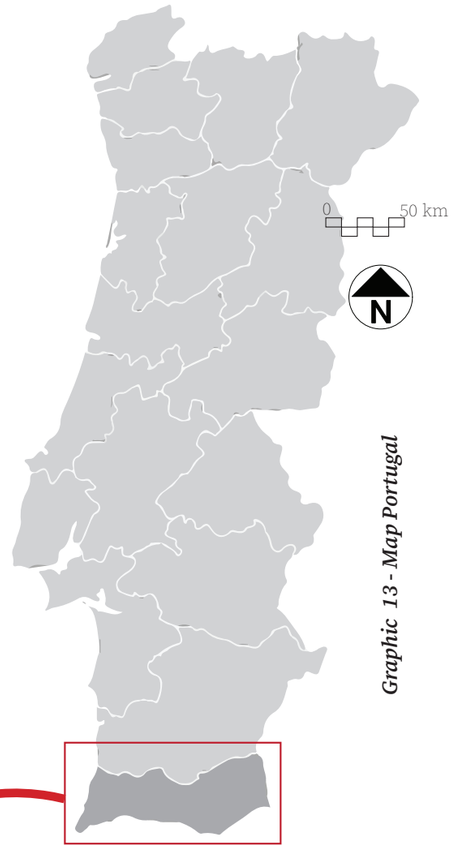
Graphic 12 - Scheme of an Iterative Design Process

Site Analysis -
Ria Formosa Nature Park

Located in the Algarve, in southern Portugal, the Ria Formosa Nature Park is a rich ecological and cultural landscape and one of the 7 natural wonders of Portugal (Expresso, 2016). The 55 km long shallow mesotidal lagoon provides unique and diverse habitats for much flora & fauna (Gari et al., 2014).

While other studies have investigated the watershed Ria Formosa or a specific area of this landscape, the following exploration is focusing on the Ria Formosa Nature Park (PNRF), concentrating on the interface between land and ocean.

The area was selected, as it provides many examples of the complex relationship between society and fluid coastal zones. In contrast to many other settlements, the river deltas here only have a negligible impact on the landscape dynamics, thus allowing to fully focus on the connection between people and the sea.



Graphic 13 - Map Portugal

Graphic 14 - Map Algarve

Environment

The ecological value of the PNRF is formally protected by local and international regulations since the 80s (Newton et al., 2022). Salt marshes, which can be found here, rank among the most productive ecosystems worldwide (Carrasco & Matias, 2019). The lagoon is almost exclusively fed by the ocean, with only a handful of seasonal streams entering the system (ICNF, 2023). Only 14% of the, on average, 2m deep lagoon is permanently flooded, creating a range of intertidal habitats (Sousa et al., 2020). The sheltered intertidal zone is an invaluable spawning and nursing area for aquatic animals and an important feeding ground for migratory birds (Sousa et al., 2020; ICNF, 2023).

Social

People have lived here since the Paleolithic period with anthropic modification of coastal landscapes visible for the past 3000 years (Sousa et al., 2020). Traces of Roman and Arab occupation can still be found today. Modern occupation has evolved slowly from fishermen's villages and agricultural fields. Now the Algarve and the settlements in the PNRF are booming with tourism and real estate markets. The landscape is experiencing stark changes due to human activities, such as developments, resource extraction, major infrastructures (i.e. airport) and modifications to water courses, among others (Newton et al., 2022).

Economics

Tourism is the most important income source for the people living within the PNRF, with a general focus on sun and sea activities (Agência Portuguesa do Ambiente et al., 2013). Aquaculture accounts for 80% and salt for 50% of the national production (Rodrigues et al., 2021). Shipping, fishing, agriculture, and sediment mining present other significant industries (Carrasco & Matias, 2019). Producing bivalves, such as clams and oysters, is equally important, with about 5000 people making a living from clams of the 100,000 people living in the PNRF (Carrasco & Matias, 2019).

Graphic 15 - Overview PNRF

Mapping the
Ria Formosa Nature Park

The PNRF encompasses 18,400 ha, from Ancão in the west to Manta Rota in the east (Harding, 2022). It connects the municipalities of Loulé, Faro, Olhão, Tavira and Vila Real de Santo António (Expresso, 2016).

Six inlets allow the sea to pass into the lagoon, which is sheltered by two sandy peninsulas (Ancão and Cacela) and five barrier islands (Barreta/ Deserta, Culatra, Armona, Tavira and Cabanas) (Rodrigues et al., 2021).

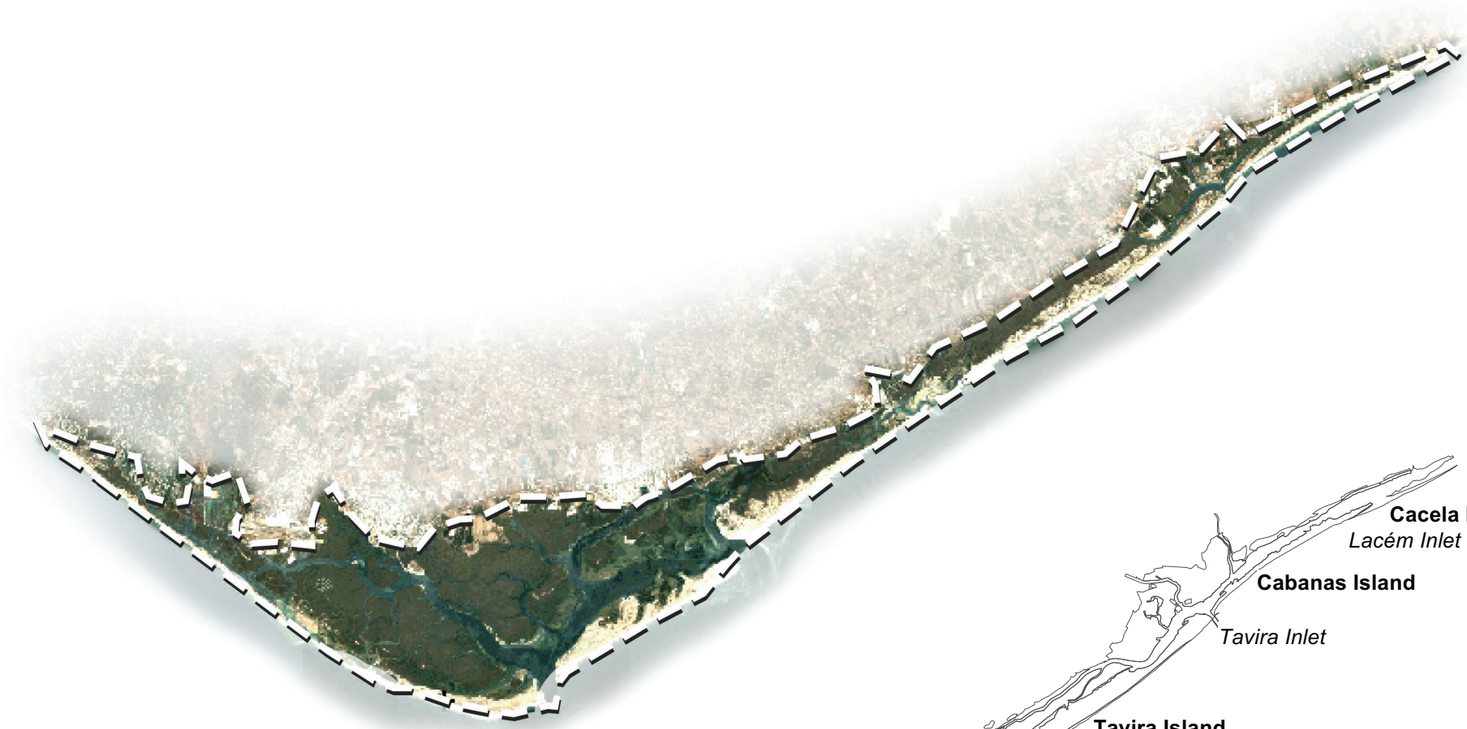
The water within the lagoon is predominantly moved by the semi-diurnal tides, which have a range of 2.8 and 1.3 m between spring and neap tides (Sousa et al., 2020). During high tide, approximately 3/4 of the lagoon water is renewed (Agência Portuguesa do Ambiente et al., 2013).

The cliffs between Ancão and Olhos de Água provide the majority of the sand, which is transported east along the shoreline. Perpendicular structures, such as the Faro-Olhão inlet jetties interrupt the coastal drift, accumulating sediment along the barrier islands. (Agência Portuguesa do Ambiente et al., 2013).

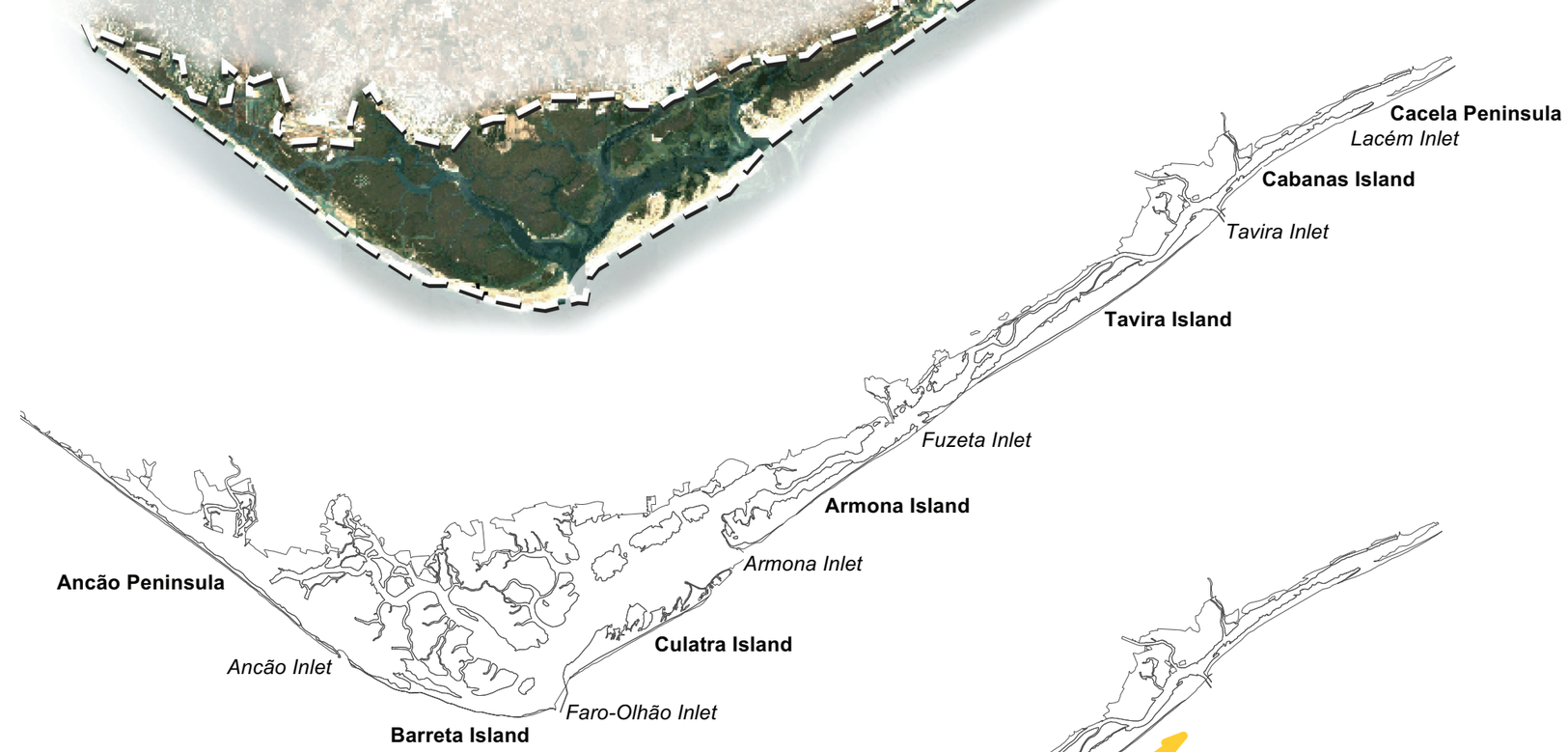
The system has historically always maintained four to seven inlets (Ferreira, 2016), which migrate east, before a new inlet opens in their previous location. The artificial opening and stabilisation of the Faro-Olhão inlet has a significant impact on the geomorphological dynamics.

Due to the sediment movement and sea level rise, the barrier islands migrate slowly inwards, accelerating the silting of the lagoon (Agência Portuguesa do Ambiente et al., 2013).

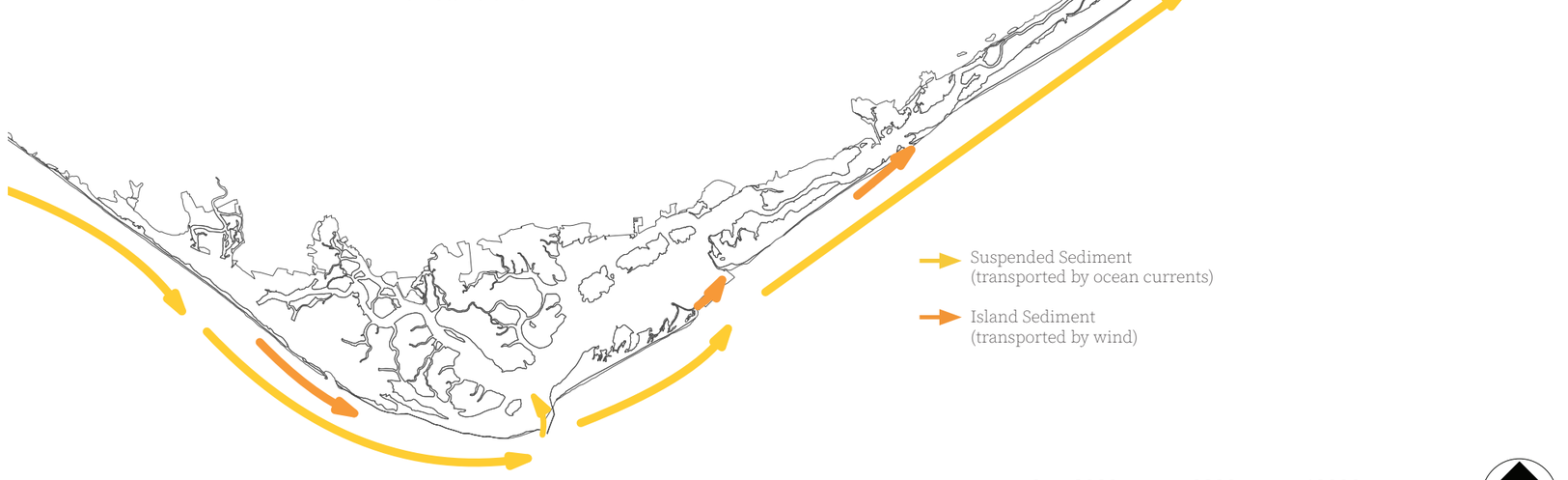
Graphic 16 - Park Limits



Graphic 17 - Place Names



Graphic 18 - Sediment Movement



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Ria Formosa
Landcover

Graphic 20 - Barrier Islands

On the barrier islands, one can find sandy beaches, grey dunes, overwash deposits and mudflats. They separate the Atlantic Ocean from the inner lagoon system. Five villages exist on these sandy strips of land (ICNF, 2023; Expresso, 2016).

Graphic 21 - Lagoon

The main lagoon area is defined by a myriad of channels and has areas with sandbanks, seagrass meadows, marshes and brackish water lagoons. People have built salt pans and tidal mill ponds into these landscapes (ICNF, 2023; Expresso, 2016).

Graphic 22 - Forest

On the mainland, there are mixed pine forests and freshwater ponds on ancient paleodunes (CEAM, 2024). Human interventions include agricultural areas, settlements, and transportation networks.

Graphic 19 - Landcover

0 2000 6000 10000 m

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Legend

- Continuous Urban Fabric
- Dense Urban Fabric
- Low Density Fabric
- Industrial, commercial, public & military
- Road networks & associated land
- Railways & associated land
- Fishing Port
- Marinas
- Local multi-functional harbours
- Shipyards
- Dump sites
- Construction sites
- Land without current use
- Green urban, sports, leisure facilities
- Arable land
- Greenhouses
- Vineyards, fruit trees, berry plantations
- Olive groves
- Annual crops associated with permanent crops
- Complex cultivation patterns
- Agriculture with significant natural vegetation
- Agro-forestry
- Natural & semi-natural broadleaved forest
- Natural & semi-natural coniferous forest
- Transitional woodland & scrub
- Semi-natural grassland
- Sclerophyllous scrubs
- Sparse vegetation on sands
- Sandy beaches
- Dunes
- Salt marshes
- Salines
- Intertidal flats
- Natural & semi-natural water courses
- Highly modified water courses
- Natural lakes
- Lagoons

Graphic 23 - Section PNRF

Ria Formosa Fauna

The Ria Formosa is home to incredibly species-rich ecosystems. According to the European Environment Agency, the park protects 121 species of the Nature Directives and 19 different habitat types of the Habitats Directive (Newton et al., 2022). Over 20,000 wintering birds can be observed yearly, inspiring bird-watching and eco-tourism activities (Lands, 2021; Sousa et al., 2020).

Graphic 24- Birds Ria Formosa

Over 200 bird species can be observed, including storks, flamingos, swamphens, wigeons, plovers, ducks, seagulls and many more (CEAM, 2024).

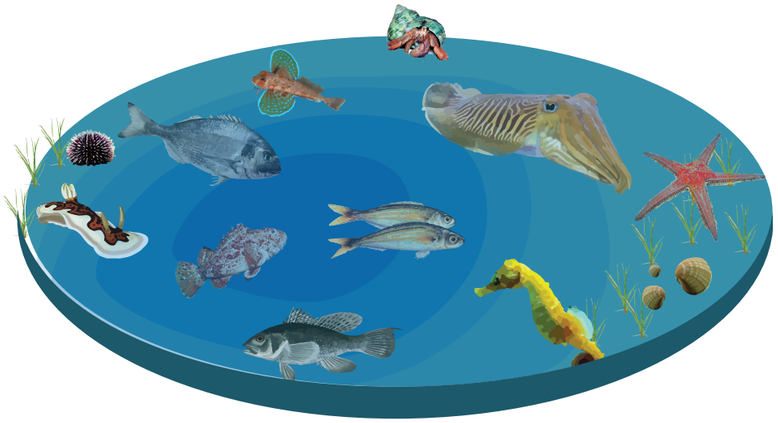
While some bird species call the Ria a permanent home, others only spend the winter season or use this space as a stop-over during their migration (CEAM, 2024).

The audouin gull and the little tern of Portugal only breed on these barrier islands (LIFE Ilhas Barreira, 2024).

Graphic 25- Terrestrial Species Ria Formosa

Only 34 mammals occupy this space, such as otters, genets, Egyptian mongooses, stone martens, red foxes, and badgers (Expresso, 2016). Even less diverse are reptiles, with only 19 species, and amphibians, 12 species (CEAM, 2024).

The chameleon is very popular with visitors and in Portugal can only be found in the Algarve. The Montpellier snake and the Algerian Psammodromus are other reptiles of interest. (CEAM, 2024)



Graphic 26- Aquatic Species Ria Formosa

99 fish species can be found, many of which use the lagoon as a spawning ground (CEAM, 2024). Sea horses, nudibranchs and sea cucumbers share the underwater landscape. 284 species of molluscs exist in the PNRF (CEAM, 2024). Bivalves, such as oysters and clam shells are collected and grown for consumption.

Sea basses, seabream, bogue, and sardines are an invaluable source of food and income to the local population (CEAM, 2024).

Ria Formosa Flora

Dunes

Seaside Chamomile
Anthemis maritima

Spiny Thrift
Armeria pungens

Viper's Bugloss
Echium vulgare

Stonecrop
Sedum sediforme

Saltflats

Bushy Sea-lavender, Grand statice
Limoniastrum monopetalum

Yellow Broomrape
Cistanche phelypaea

Sea Asparagus
Salicornia sp.

Herbaceous Seepweed
Suaeda maritima

Maritime Pine Forest

Fan Palm
Chamaerops humilis

Rock Rose
Cistus crispus

Maritime Pine
Pinus pinaster

Carob
Ceratonia siliqua

Open Meadows

Alkanet
Anchusa azurea

Common Andryala
Andryala integrifolia

Hairy Greenweed
Genista hirsuta ssp. algarbiensis

Borage
Borago officinalis

Graphic 27- Flora Ria Formosa

Ria Formosa Development

Environmental

1999/2008
Natura 2000 Network Special Protection Area for Wild Birds

1987, 2009
Declared National Park

1980
Declared Ramsar Site (212)

1978
Declared Nature Reserve

Environmental Regulations

Tree Coverage

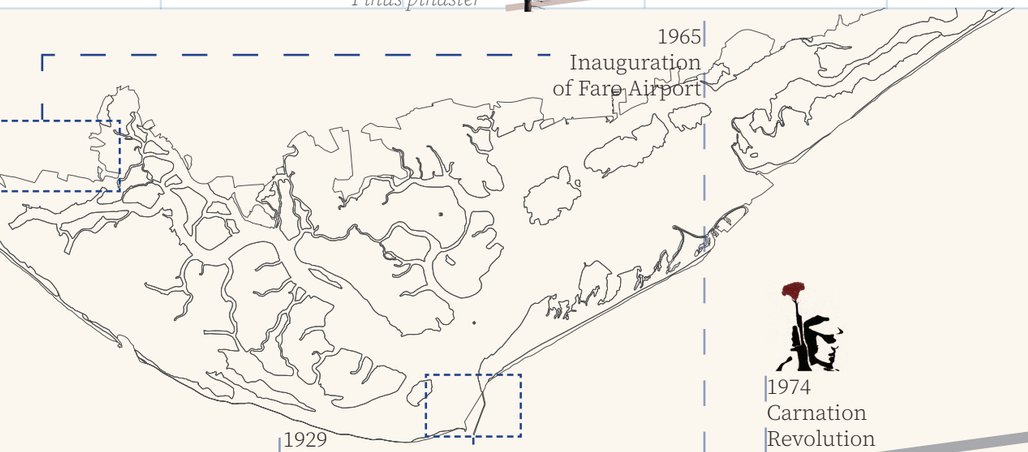
Endangered Species

Pollution

Cork Oak
Quercus suber

Wild Olive
Olea europea var. sylvestris

Maritime Pine
Pinus pinaster



1965
Inauguration of Faro Airport

1851
Cabo de Santa Maria Lighthouse

1929
Faro-Olhão Inlet opening

1974
Carnation Revolution

Social

2018-
Faro Council

2008-2018
Polis Litoral Ria Formosa Society

2005
Coastal Land Use Management Plan

Management

Anthropic Land Use

2000 ha/ 20% of area converted

Population

Occupied second homes

nationally 12% empty, 2014

sea bass

sea bream

horse mackerel

sardine

Economical

mid 20th C
Economic downturn of agriculture & industry in southern Portugal

1992-1997
Odeleite Dam (intensive irrigated crops replaced rainfed orchard

1885-mid 20th C
Landuse policy guided by regional seafood preservation industry
Wetlands diked, drained & excavated for salt farms

1980s
Unproductive diked area coverted for aquaculture with EU funding

General Trends

Tourism

Salt production

Fishing

Aquaculture + Bivalve Production

Agriculture

nuts, citrus, olives

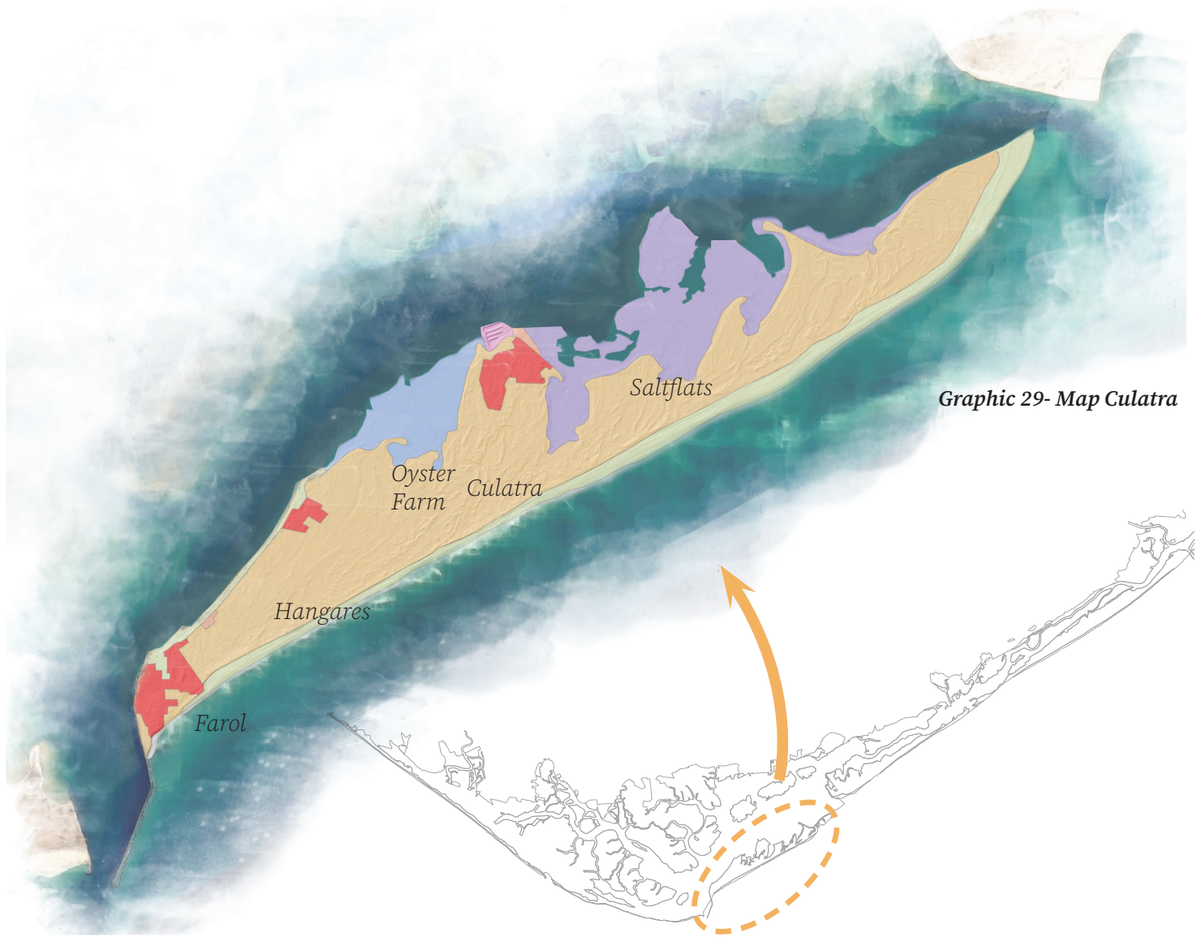
1500-1700 | 1700-1900 | 1900-20 | 1920-40 | 1940-60 | 1960-80 | 1980-2000 | 2000-2020

Graphic 28- Development Matrix

Site Analysis -
Ilha da Culatra

Culatra Island is one of the few occupied islands in the Ria Formosa with three settlements - Farol, Hangares and Culatra, which are all part of the municipality of Faro, Union of Parishes of Sé and São Pedro (Tommasi, 2022). Permanent housing developments began roughly 150 years ago and has risen to about 1000 people living there today (Pacheco et al., 2022; Clean energy for EU Islands Secretariat, n.d.). There are no paved roads, and the mainland is connected only by ferry or private boat (Clean energy for EU Islands Secretariat, n.d.).

Culatra Island is about 7 kilometres long and 1.2 kilometres wide (Tommasi, 2022), with a long sandy beach to the southern ocean side, a wide flat vegetated dune ridge, and overwash areas with intertidal zones and saltflats on the lagoon side.



Graphic 29- Map Culatra

Threats to Resilience

Environmental

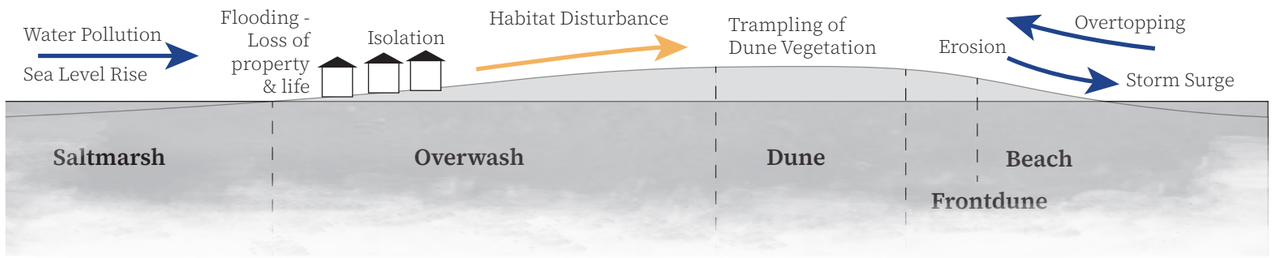
Barrier islands are very dynamic environments, which fauna and flora have adapted to. It can become problematic for static settlements and threaten the livelihoods and lives of residents through flooding and erosion. Nature Park regulations can slow down adaptation measures.

Social

The isolated nature of the villages can affect their political inclusion. The unique cultural identity can easily be overpowered by an influx of tourists. Public services might not be available compared to urban areas. Sewage and waste management become more complicated.

Economical

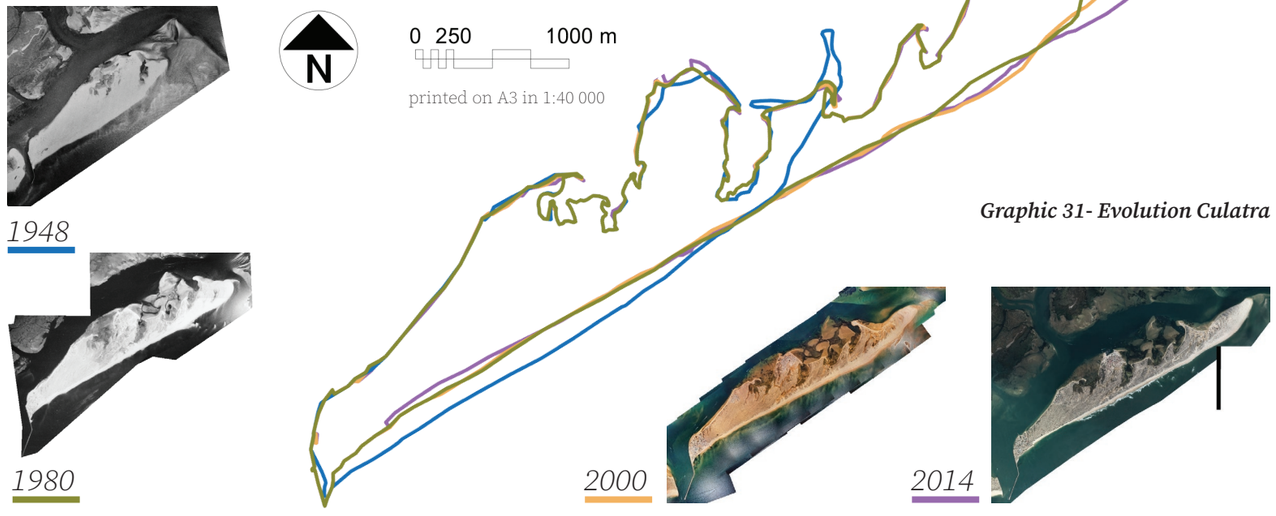
Income relies solely on fishing and seasonal tourism, with the latter becoming more dominant. Low income reduces the ability to invest in protective infrastructure, climate adaptations and to recover after disaster. The isolation makes diversifying the economy difficult.



Graphic 30- Diagram Culatra Island

The dimensions and shape of Culatra island has been highly dynamic over time. Prior to 1929, the eastern Armona inlet was the most significant opening into the lagoon (Ferreira et al., 2016). The construction of the Faro-Olhão inlet jetty drastically shifted the tidal action to the western end of Culatra and allowed for the Armona inlet to silt up rapidly (Ferreira et al., 2016). The jetty additionally intercepts the litoral drift of sand and without artificial beach nourishment, one would be able to see high erosion rates on Farol's beach (Carrasco & Matias, 2019).

Coastal flooding or overwash events have been rare since the 70s. Prior, the cyclone of 1941 caused immense damage to Culatra and the 1961 and 69, the island experienced threatening storms (Kombiadou et al., 2024).



Graphic 31- Evolution Culatra

Site Analysis –
Ilha do Farol

Farol is the permanent home of 160 to 180 people (Pires, 2024), and with an estimated twice as many summer homes. Originally this area was only used seasonally by fishermen, though the stabilisation of the island's western end, the construction of the jetty, as well as the name-giving lighthouse, encouraged permanent settlers in the 1940s and 50s. With the boom of tourism, many houses were converted into rented-out summer homes.

Today, it is very popular with tourists, who arrive by ferry and spend the day at the beach and enjoy the many bars and restaurants.

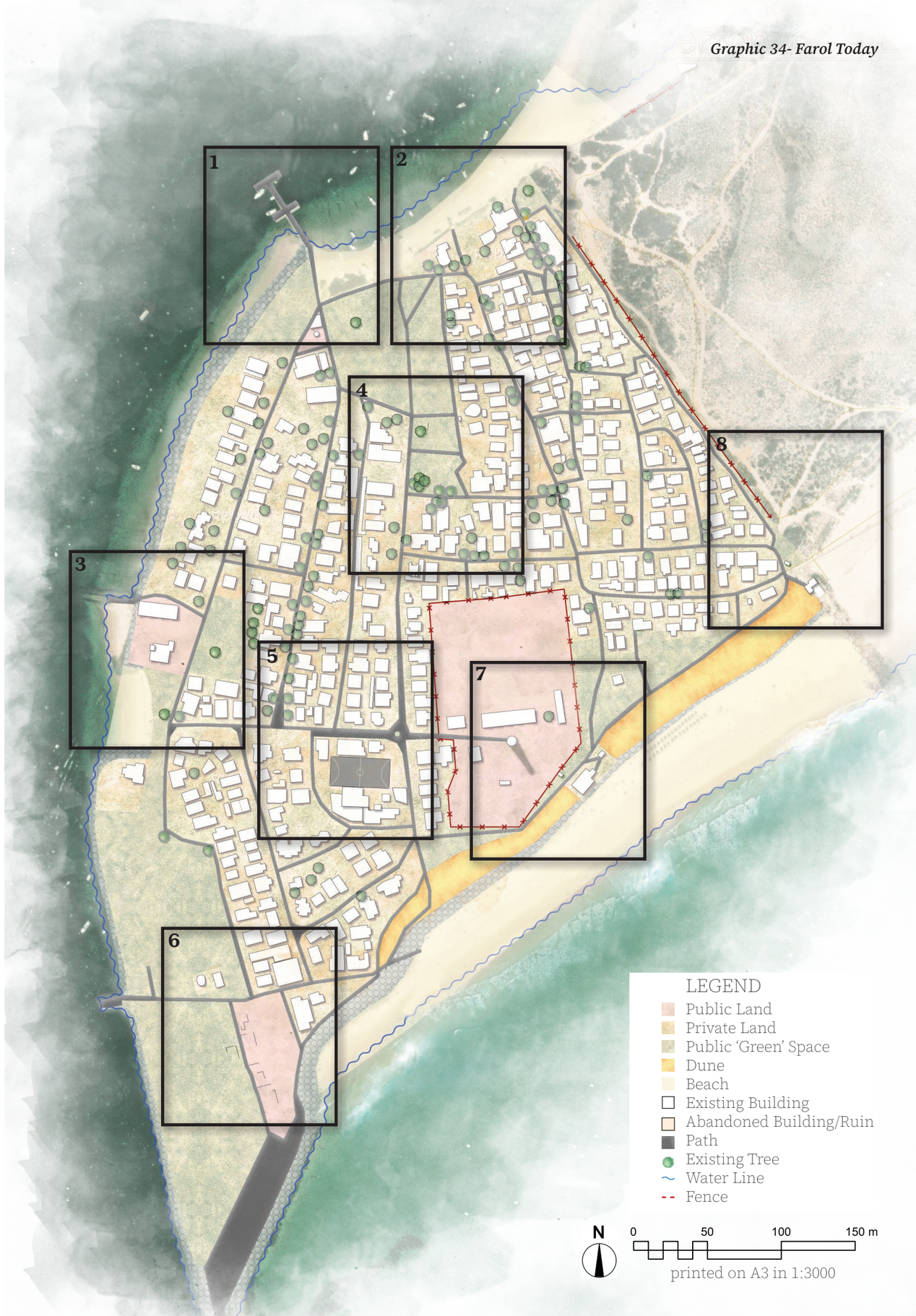
Graphic 32- Lighthouse Cabo de Santa Maria

Graphic 33- Faro-Olhão Jetty

The community is protected from the ocean by Faro-Olhão jetty, a stone sea wall, and a sea groin. Channel excavations and beach nourishment are used to maintain current conditions.

The eastern boundary of the Farol is created by an old, barbed fence, which marks the beginning of the property of the Portuguese navy.

Graphic 34- Farol Today



Area 1: Arrival Area

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Graphic 35- Arrival Area

The ferry, tourist vessels and fishing boats dock at the main pier. The temporary fix is planned to be overhauled in the near future.

The first building sells ferry tickets in summer and the two following are restaurants. The central square is unused with vegetation of heather and sea lavender growing here.

Area 2: Working Fishermen

Graphic 36- Working Fishermen

Local fishermen use the beach to temporarily store their boats and equipment. Some tourist boat companies also stop here. Plastic chairs are placed around for resting.

Area 3: Little Beach

Graphic 37- Little Beach

The Instituto de Socorros a Naufragos (rescue of shipwrecked people) and police have their own dock for sea rescues. The beach is used by swimmers and sun bathers, as well as the neighbouring sailing school.

Area 4: Village Center

Graphic 38- Village Center

Many nice looking summer houses are dotted around. Private gardens sometimes spill over into the public realm. The private gardens boast a variety of plants, including many exotics.

Area 5: Community Hub

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Graphic 39- Community Hub

The collection of buildings houses the Ilha do Farol Residents Association, a soccer pitch, a playground, a market hall, an infirmary, a laundromat and restaurants.

Area 6: Abandoned Buildings

Graphic 40- Abandoned Buildings

The municipality of Faro acquired these housing ruins in 2024 and is considering alternative uses, such as a fire department, an art studio or research for the University of Algarve (Pires, 2024). The neighbouring buildings are summer homes.

Area 7: Sea Wall

Graphic 41- Sea Wall

A rocky seawall precedes the dunes and protects Farol against erosion. Two beach bars are set up along this edge. The dunes are quite flat with many informal trails running across. The concrete path is continued with wooden planks.

Area 8: Dunes

Graphic 42- Dunes

The edge of the village is marked by a decaying fence from the military. Beyond the groin, a beach can be followed until Culatra. The beach berm is clearly visible.

SSP Overview

SSP1- Green Waves

A shifting mindset prioritizes a healthy natural environment and puts people's well-being over economic growth. Slow retreat is combined with innovative solutions & local knowledge to build resilience. Strong regional, and international connections.

Environmental

~High environmental awareness
~Stringent regulations
~Eco-tourism
~Low disaster risk
~High nature restoration
~Good management of commons

Social

~Population grows
~High cooperation & inclusion of locals
~High education/health investments
~High living standards
~Strong social cohesion
~Low crime rates
~Strong cultural identity

Economical

~Limited economic growth
~High investment into sus. infrastructure
~Resource efficient
~Reduced poverty
~Diverse nature-supporting industries
~Integrated into markets
~More national tourists than international

SSP2 - Calm Waters

Historical patterns continue with infrastructure being maintained, but not expanded upon. Mitigation & adaptation proceed slowly, keeping many locals vulnerable to extreme climate events. Slow degradation of natural capital encourages fishermen to seek jobs in the cities.

Environmental

~Medium environmental awareness
~Some regulations
~Some eco-tourism
~Medium disaster risk
~Some nature restoration
~Medium management of commons

Social

~Population shrinks
~Tension between locals & municipality
~Limited education/health investments
~Medium living standards
~Social cohesion within villages
~Low crime rates
~Shifting cultural identity

Economical

~Slow economic decline
~Limited investment in infrastructure
~Efforts to reduce material/energy consumption
~Medium poverty
~Mainly nature tourism & aquaculture
~Integrated into national markets
~International tourism dominates

SSP3 - Stormy Waters

Regional rivalry reduces tourism and shipping but increases the importance of local food production. Living standards decrease. Environmental concerns are pushed aside. Economic vulnerabilities grow dramatically.

Environmental

~Low environmental awareness
~Reduced regulations
~Few local tourists
~High disaster risk
~Some nature restoration
~Overexploitation of commons

Social

~Population shrinks & ageing
~Distrust against outsiders
~Limited education/health investments
~Low living standards
~Social cohesion within villages
~High crime rates
~Cultural identity strongly defended

Economical

~Economic decline
~Limited investment in infrastructure
~Max. use of available resources
~High poverty
~Mainly fishing + aquaculture
~Focus on local markets
~No international tourists, few regionals

SSP4 - Oceans Apart

Foreign investment in tourist infrastructure marginalises the local fishermen, who exploit nature to survive. Local voices are excluded from decision-making. Social cohesion degrades and crime rates increase. Environmental & social resilience is low.

Environmental

~Medium environmental awareness
~Conflicting regulations
~Intensive tourism
~High disaster risk for local population
~No nature restoration
~Uneven exploitation of commons

Social

~Population stabilises
~Locals with no political power
~Limited education/health investments
~Stratified living standards
~Diminishing social cohesion
~High crime rates
~Cultural identity pushed aside

Economical

~Economic separation
~Investment into external infrastructure (tourism, second-homes)
~Stark differences in consumption
~High poverty
~Cultural tourism & aquaculture
~Focus on local markets
~International tourism dominates

SSP5 - High waves

High investment into the area attracts new residents. The availability of services and living standards are improved for all. Disaster risk is mitigated through geo-engineering and adapted infrastructure. Biodiversity is limited to protected few land pockets.

Environmental

~Low environmental awareness
~Few regulations
~Highly intensive tourism
~Low risk for smaller disasters, high risk for bigger disasters
~Further nature exploitation
~High exploitation of commons

Social

~Population grows & youthful
~Participatory processes
~High education/health investments
~Very high living standards
~Good social cohesion
~Medium crime rates
~Cultural identity reinvented

Economical

~High economic growth
~High investment into intensive infrastructure
~High material/energy consumption
~Low poverty
~Mainly tourism/ real estate
~Integrated into international markets
~Equally split international + regional tourists

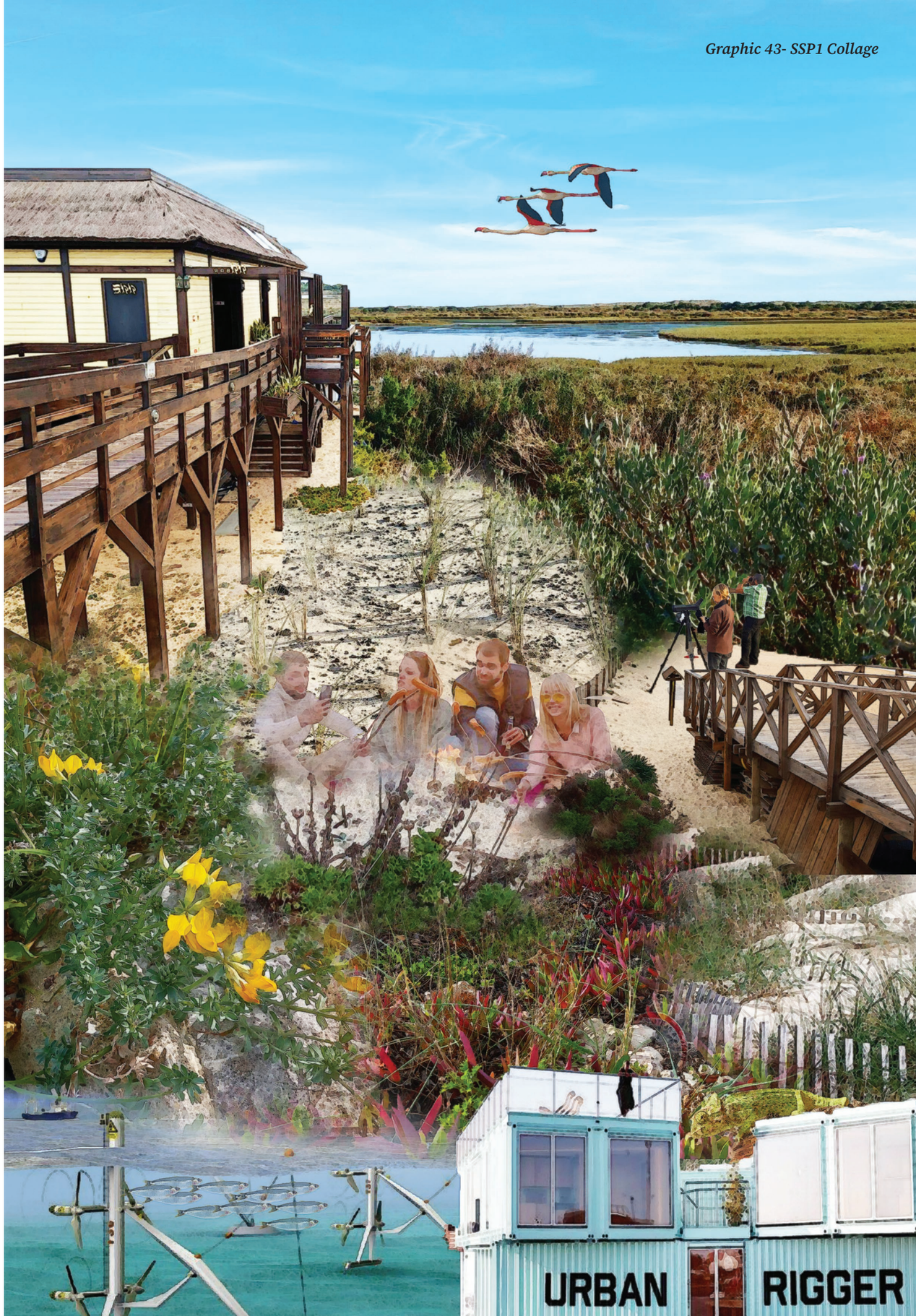
Scenario 1
Green Waves

Narrative

A healthy natural environment takes the highest priority with an increased appreciation for the fluidity of the geomorphology of barrier islands. Conflicting infrastructure is removed, and efforts are taken to restore natural conditions. Habitat restoration and recovery efforts prove successful in reversing recent trends of species decline. Global efforts succeed in minimising climate change and its effects, while regional initiatives make pollution an object of the past.

Prioritising the well-being of the community drives investment in education. Infrastructure is transformed to be self- and resource efficient. Local identity is fostered, and social cohesion is strengthened. Seasonal homes are discouraged and abandoned buildings are removed, slowly decreasing the village footprint without losing the feeling of community or angering residents. Decisions affecting the community are made democratically, involving all stakeholders.

Innovation in non-destructive industries, such as tidal energy or Fleur de sel harvesting, and respectful, low-impact tourism, account for decent wages and a way of life, which supports the natural environment. The high quality of natural spaces and ecological richness draw local, national, and international visitors. Additionally, the unique landscape and ecosystem services are considered to be very important by national and international institutions, which offer financial incentives to preserve them. The local economy is intrinsically integrated into regional and international markets. Shipping lanes are maintained open to enable trade.



Graphic 43- SSP1 Collage

Political Power of Nature Park

The PNRF has to sign off on all new projects in the Public Marine Domain, ensuring nature to remain the top priority (Sousa et al., 2020)

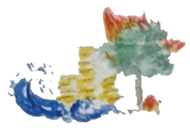
Tourists interested in nature

The global ecotourism market is predicted to grow at 15.2% annually from 2022 to 2030, and already has reached a market size of 185.87 billion dollars. (Grand View Research, 2020)

External Trends

Irreplaceable Nesting Site

The sandy barrier islands offer a unique and essential nesting area for birds, such as Little Terns (*Sterna albifrons)* or Snowy Plover (*Charadrius alexandrinus*) (Sousa et al., 2020)



Climate Change Visible

Portugal has lost about 6.7 million euros to climate-related hazards between 1980 to 2013 (Silva, 2022).

Culatra's Sustainability Projects

As part of the Culatra 2030 project, the Culatra Island Residents Association (AMIC) is collaborating with different partners for a clean energy transition and other sustainability projects (AMIC, 2019)

Based on the aforementioned external trends, the following lists of tangible, such as infrastructures or land uses, and intangible changes, such as institutional decisions, organisation or communication, has been compiled.

Tangible Changes

- Energy production
- Land-based Food production
- Aquaculture
- Housing Adaptations
- Removal of obsolete infrastructure including hard coastal protection
- Restoration + protection of dunes

Intangible Changes

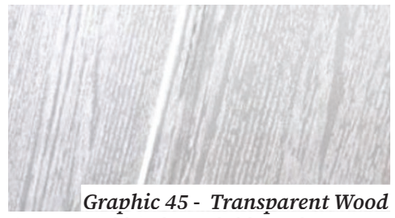
- Policy regarding seasonal homes
- Cultural events to foster identity
- Promote/provide eductaion incl. environmental awareness
- Promote sharing of resources

Material Palette

The focus of the materials is on sustainability and innovation. They are preferably locally sourced, recycled or certified cradle-to-cradle. They should have a very high longevity, self-healing or be made to be replaced easily.

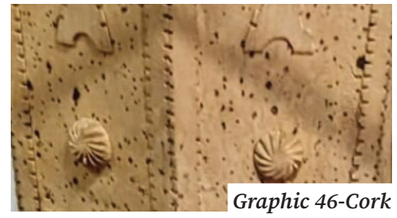
Graphic 44- Sand

Sourced from unavoidable channel dredging or urban mines; used in dune reconstruction.



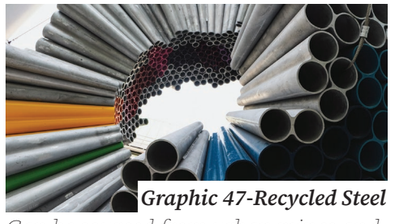
Graphic 45 - Transparent Wood

A potential biodegradable replacement for glass, which is still being researched (BigRentz , 2018)



Graphic 46-Cork

It grows locally and is a very versatile product, that can be used for surfaces, buoys, clothing or decorations.



Graphic 47-Recycled Steel

Can be sourced from urban mines and used to reinforce structures and as connectors in boardwalks.

Graphic 48- Mycelium

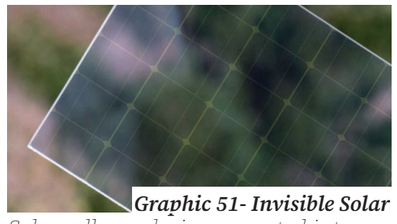
Mushroom roots can be cultivated on any local organic waste and be shaped to any form for insulation, furniture.

Graphic 49- Hemp Rebar

Including hemp has proven to reduce corrosion, tripling a structures lifespan (Aouf , 2022)

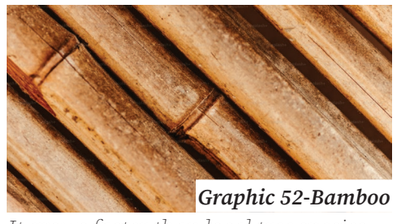
Graphic 50- Reclaimed Timber

When free of chemicals, its not harmful to the environment and is not contributing CO2.



Graphic 51- Invisible Solar

Solar cells can be incorporated into regular windows or glass doors (BigRentz , 2018)



Graphic 52-Bamboo

It grows faster than local tree species, has a high strength and versatility (Istchuk, 2023)

Graphic 53-
Section Now (SSP1)

0 10 30 50m

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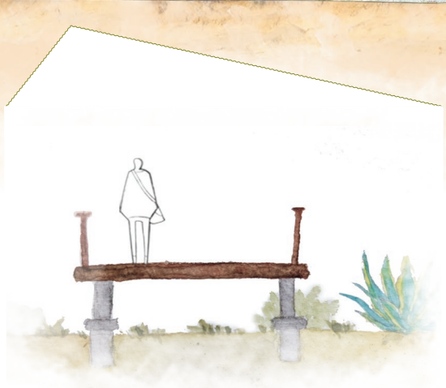
Graphic 54-
Section Short Term (~ 20 years)
(SSP1)

During the repair, the pier is elongated to account for future sand movements.



Concrete paths are replaced with partially raised wood walkways.

A solar park covers Farol's energy needs and is interplanted with stabilising vegetation.

Rock coastal protection is slowly removed.

Dunes are heightened, stabilised, planted and fenced off.

Graphic 55-
Section Long Term (~ 50 years)
(SSP1)

Eco-moorings offer non-destructive anchoring, allowing a rich ecosystem to around the seagrass communities.

All housing is flood-proofed and self-reliant (improved insulation, energy-efficient, solar roofs).

Original native trees, such as cork oak, strawberry treem olive and carob trees, have grown to provide shade and stabilising the core of the barrier island.

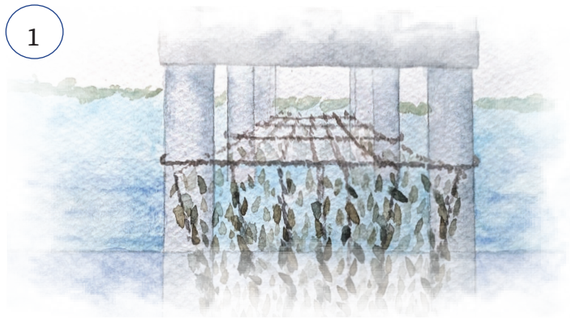
Dune vegetation develops naturally. A wooden boardwalk allows beach access and an exploration of the dunes without causing damage.

Graphic 56-
Map ~ 50 years (SSP1)

Below are further suggestions, what else one could create within Farol in the future, as also shown on the site plan to the left.

Further Ideas

1



Retrofitted pier with oyster farm maintaining cultural production without consuming natural areas

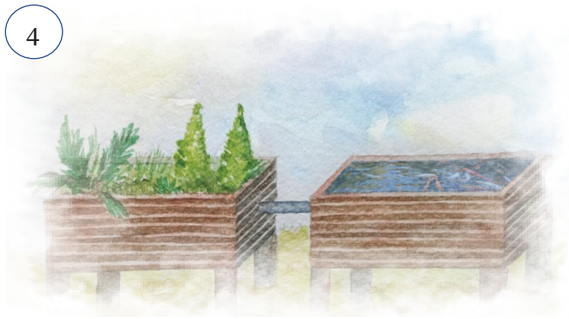
2

Wildlife numbers boom and can be observed through observational towers and huts.

3

Boat Dry Stack to efficiently use space and protect boats from harsh weather.

4



Raised aquaponic systems for increased self-sufficiency with fish, vegetables and herbs.

Biggest Hurdles

- Sand erosion
- People unwilling to move
- High initial investment
- Flood risk

Resilience Strategies

- Monitor/understand natural processes
- Be innovative in how to respond
- Attractive compensation
- Co-creation of future plans
- Shared knowledge on coastal dynamics
- External funds from EU, national, municipal, private investors, etc.
- Clear plan & desired outcome
- Early warning system and practiced evacuation strategies

Scenario 2
Calm Waters

Narrative

Steady, but slow environmental improvements are accomplished by policy makers and conservationists. More efforts against pollution and environmental degradation are taken, but struggle to reach their goals against increasing urbanisation, industrial agriculture practices and resource consumption. Climate change, extreme weather events and beach erosion eventually force adaptation measures in the landscape.

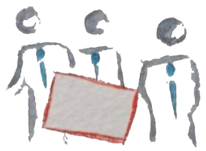
Limited cooperative efforts between Farol and external institutions slow any needed improvements. The number of houses slowly declines. Existing summer homes are given a legal status and can then be taxed and insured. This encourages more promotion of vacation homes and increases occupation in the summer to the point that there are more temporary residents than locals. Differences in income remain, with the standard of living for the poorest quintile improves only marginally.

Development, especially linked to tourism, maintains the fast growth of today before slowly levelling off. The majority of locals will be employed directly or indirectly in the tourism industry. Blue tourism and yachting become especially important (Tommasi, 2022). Globally connected markets benefit the fishing and shipping sectors. Yet overall, as fish populations decline, more and more fishermen seek other employment in Faro or Olhão to improve their income. Eventually, this leads to the loss of local knowledge of the Ria Formosa and traditional fishing/gathering practices.

Graphic 57- SSP2 Collage

Existing Tensions

The nature protection status of the PNRF often clashes with the needed economic development of the area (Sousa et al., 2020)



Faro takes over Management

"We can't build, build new buildings, new housing, new hotels, absolutely nothing(...) the idea and practice is to maintain what it is, and to requalify the public space" (Mayor Rogério Bacalhau in Pires, 2024)

External Trends

Decreasing mariculture activities

Although seafood consumption in Portugal is high and 60% of the Ria's fish species have high commercial value, the number of fisheries is decreasing (Serpa et al., 2005; CEAM, 2024)

Booming tourism

Compared to pre-pandemic, the Algarve's tourist sector grows at 1.4% and continues seeing record numbers of visitors (Stilwell, 2024)

No strategic planning

"It will not be necessary to make a Detailed Plan.(...) For now it is necessary to regularize the legal situation of several houses, especially with regard to inheritances."(Mayor Rogério Bacalhau in Pires, 2024)

Based on the aforementioned external trends, the following lists of tangible, such as infrastructures or land uses, and intangible changes, such as institutional decisions, organisation or communication, has been compiled.

Tangible Changes

- Infrastructure maintained adequately
- Abandoned buildings are renovated and used either privately or publicly
- Individual projects to protect specific aspects of nature ie. dune, bird species

Intangible Changes

- Limited motivation for local civil society
- Individual rules in the PNRF are adjusted, but no replacement of overarching managment, similar to Polis Litoral

Material Palette

The majority of today's materials will still be used with few introductions of product improvements. Materials are chosen to be cost-effective and durable.

Graphic 58- Linen

Used commonly for sails, the material can also be used for shade structures.

Graphic 59 - Rope

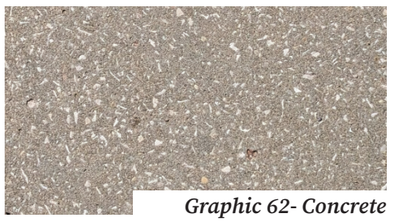
Its aesthetically connected to the fishing industry and sometimes used to decorate gardens or as railings.

Graphic 60-Weathered Wood

Its visually appealing, can be sustainably sourced and used for boardwalks, cladding, furniture and more.

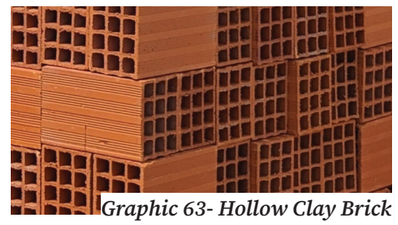
Graphic 61- Composites

Highly resistant against saltwater, it looks like wood, but with a much longer shelf-life



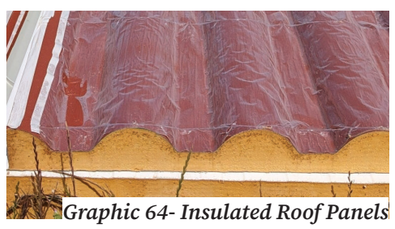
Graphic 62- Concrete

Its durable, very affordable and can be mixed with different aggregates for unique colours and textures.



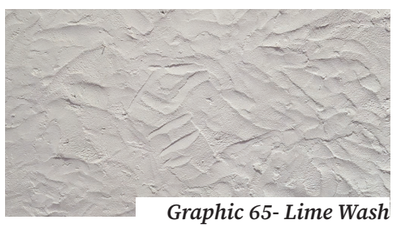
Graphic 63- Hollow Clay Brick

Significantly lighter and cheaper than solid bricks and can be reinforced with steel (Rethinking The Future , n.d.).



Graphic 64- Insulated Roof Panels

Looks like a traditional roof, but is much more affordable.



Graphic 65- Lime Wash

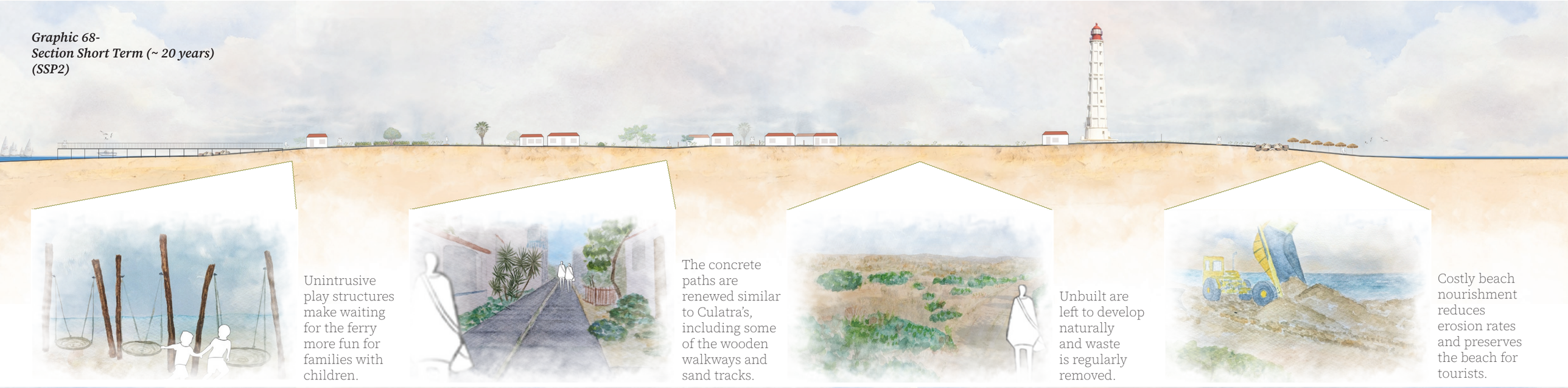
Many buildings are painted white, with a high albedo and low production cost.

Graphic 66- Natural Rock

Found rocks and boulders could be used for boundaries, low walls, veneers.

Graphic 67-
Section Now (SSP2)

Graphic 68-
Section Short Term (~ 20 years)
(SSP2)



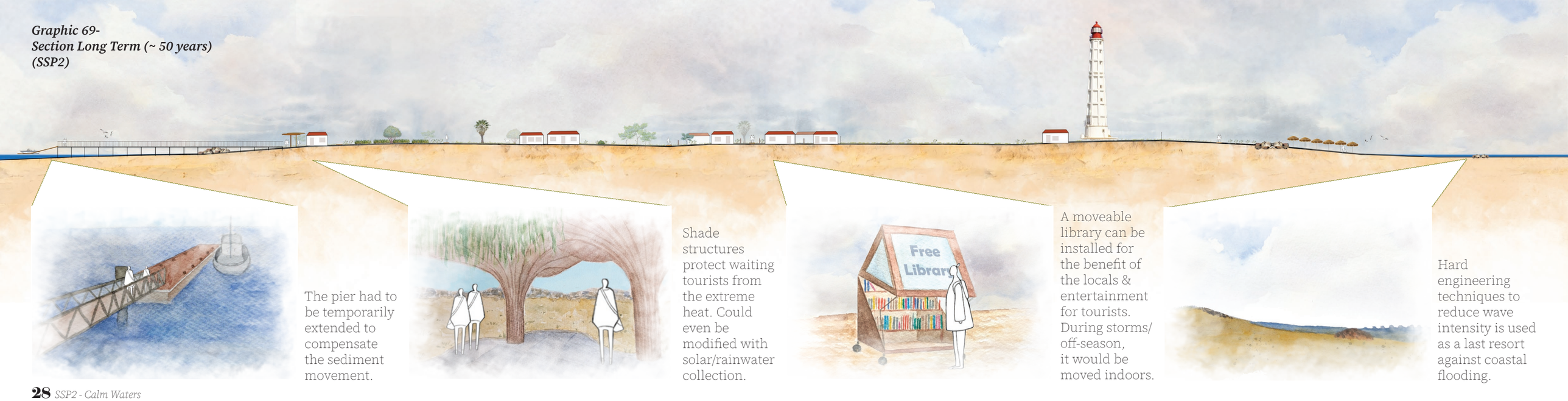
Unintrusive play structures make waiting for the ferry more fun for families with children.

The concrete paths are renewed similar to Culatra's, including some of the wooden walkways and sand tracks.

Unbuilt are left to develop naturally and waste is regularly removed.

Costly beach nourishment reduces erosion rates and preserves the beach for tourists.

Graphic 69-
Section Long Term (~ 50 years)
(SSP2)



The pier had to be temporarily extended to compensate the sediment movement.

Shade structures protect waiting tourists from the extreme heat. Could even be modified with solar/rainwater collection.

A moveable library can be installed for the benefit of the locals & entertainment for tourists. During storms/ off-season, it would be moved indoors.

Hard engineering techniques to reduce wave intensity is used as a last resort against coastal flooding.

Graphic 70-
Map ~50 years (SSP2)

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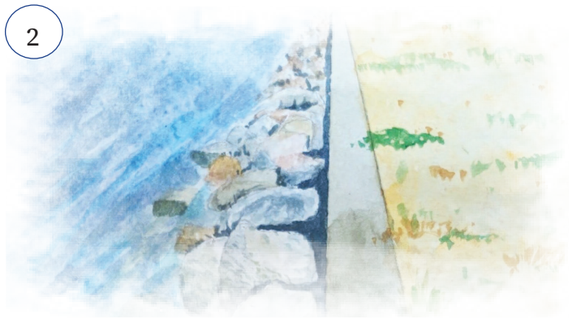
Below are further suggestions, what else one could create within Farol in the future, as also shown on the site plan to the left.

Further Ideas

1

The University of Algarve proposed to set up a research hub for CCMAR (Centro de Ciencias do Mar)

2

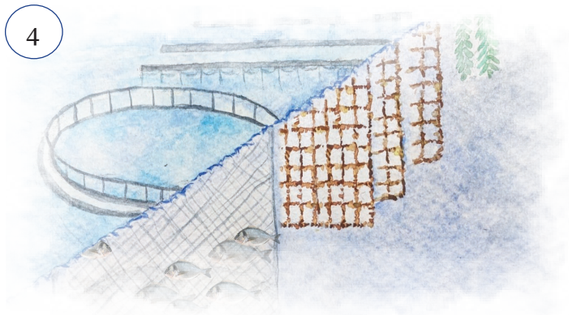


Fortified concrete seawall with riprap around all Farol to reduce erosion.

3

Sculptures exhibited along paths, showcasing aspects of local culture and raising env. awareness

4



Offshore Aquaculture incl. fish, bivalves and algae to complete nutrient cycles

Biggest Hurdles

- Cost of adaptation strategies is relegated to future generations
- Higher environmental risks due to inaction
- False sense of security from costly sea walls/ do the costs justify the benefits?
- Legalisation of summer homes

Resilience Strategies

- Economic capacity for worst-case scenarios can be planned for today
- Rather than incremental, mitigation/adaptation measures would be enforced quickly. Informed and included stakeholders increase the chances of success of these strategies
- Improve awareness of flood risk and discourage further investment into island developments
- Have a municipal vote whether to keep/demolish Farol's sea wall
- Finding owners & collecting tax can pay for flood protection

Scenario 3
Stormy Waters

Narrative

Environmental concerns are overshadowed by the resurgence of nationalism and protective attitudes towards culture. Local production gains great importance, fostering overfishing and a heavy exploitation of natural resources, in an attempt to be more physically and financially independent from international markets. Industrial salt harvesting and sand mining regain importance. Park regulations and other environmental policies are frequently disregarded.

General distrust degrades relationships with the municipal management of Faro and reduces collaborative decision-making. Migrants and seasonal residents are met with scepticism. The lack of opportunities forces people to relocate to the mainland, creating uncomfortable gaps in the social fabric. The Portuguese navy reactivates its base on Culatra, using the island and the offshore waters for naval and marine training. To make the old aviation center functional, the navy invests in new piers and flood protection. Their presence and training activities discourage visitors to Farol.

Tourism almost breaks away completely and all connected industries struggle to adapt. Declining investments in education and innovation slow down economic growth and sustainable developments. The EU stops providing funds, further reducing the community's ability to adapt to and mitigate extreme events from climate change. Costly measures, which currently maintain the island, such as beach nourishment or the strengthening of the seawall, become unaffordable.

Graphic 71- SSP3 Collage

Important Bivalve Production

Almost 400 ha of intertidal flats are occupied by bivalve farms, raising oysters and carpet shell clams, accounting for 90% of the national production (Sousa et al., 2020)

Centro de Aviação Maritima do Algarve

1917-52 the Portuguese navy maintained a naval aviation center on Culatra, for anti-submarine hydroplanes (memorial Hangares). While never used in the world wars, the navy still owns large areas of Culatra island.

"This area has been used for deactivating explosives, training divers and marines. These actions will continue and be reinforced" (Admiral Silva Ribeiro (Head of the Portuguese Navy) in Shareit, 2017)

External Trends

Vulnerability of tourism

The Covid-19 pandemic had a severe instantaneous impact on the Algarve's tourism, highlighting how quickly things can change. The energy crisis, inflation and high construction costs pose further challenges (Graeme, 2023)

Strong conflict with Polis Litoral

"After the mess they've created for 11 years Polis is finally winding itself up" (António Terramoto in Donn, 2019)

Portuguese Strategic Plan for Aquaculture

Portugal has the highest per capita consumption of seafood in Europe and plans to expand aquaculture in wetland zones (Sousa et al., 2020)

Far-right narratives in Portuguese politics

"In 2019, the newly-formed rightwing political party Chega! conquered one seat in the Portuguese Parliament. Roughly 3 years later, in the 2022 general election, it multiplied that result winning a total of 12 seats after receiving 7.2% of votes." (Carbonaro, 2023)

Based on the aforementioned external trends, the following lists of tangible, such as infrastructures or land uses, and intangible changes, such as institutional decisions, organisation or communication, has been compiled.

Tangible Changes

- Abandoned structures are left in place
- Renovations/repairs are often done with cheap materials
- Pockets of extreme poverty become visible
- Military fence is reinforced
- Second homes and B&Bs used by locals or abandoned.

Intangible Changes

- Environmental regulations are relaxed or disregarded
- Strong separation between national/ regional top-down initiatives and small island initiatives
- Limited employment opportunities (no tourism, difficult to work in Faro and live on the island

Material Palette

Materials tend to be low cost, locally sourced and requiring little expertise for installation. Their performance (durability, longevity, efficiency) might be compromised. A focus is placed on materials and techniques with cultural values and tradition of the area.

Graphic 72- Azulejos

Decorative tiles, which are popular in Portuguese culture and reflect traces from the Arab occupation.

Graphic 73 - Mixed Debris

Piled together or collected in mesh bags, the material are used to reduce erosion.

Graphic 74-Tin Sheets

Very affordable roofing material.

Graphic 75- Shells

Highlights the island culture and can be used to decorate walls or gardens.

Graphic 76- Plastics

Affordable and lightweight, plastics can be shaped in any form for diverse uses, such as outdoor furniture.

Graphic 77- Terracotta Tiles

More traditional roof material. Have also been used as decorative garden elements in Farol.

Graphic 78- Palm Weaving

Originally essential for farming products, now primarily sustainable, ornamental products (TASA Project).

Graphic 79- Wooden Trellis

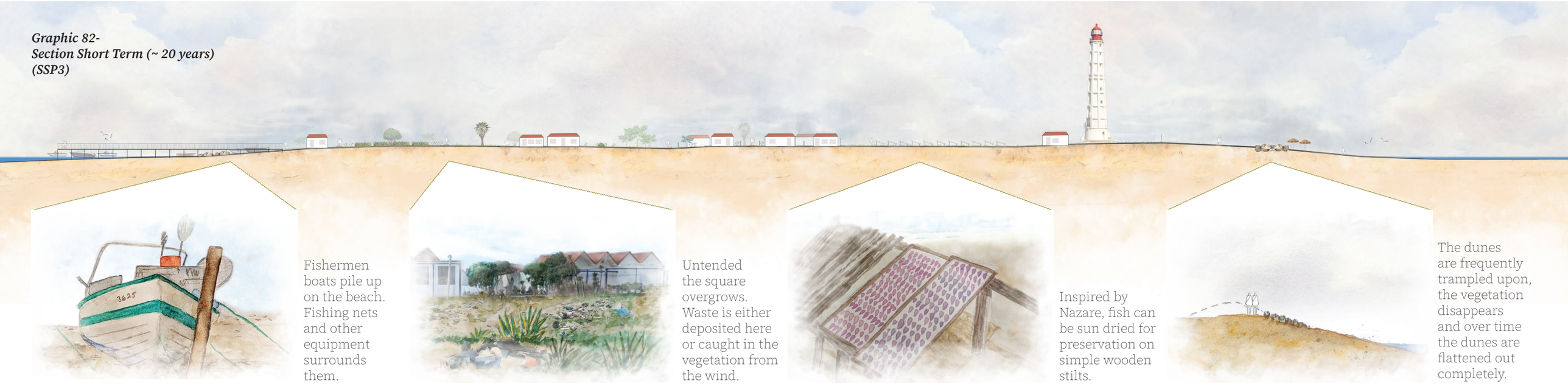
Architectural heritage from Arab occupation for doors and windows (Museu Regional do Algarve, 2024).

Graphic 80- Shipping Container

Leftover from the harbours in Faro/ Olhão, they can be refurbished as freezers, greenhouses and more.

Graphic 81-
Section Now (SSP3)

Graphic 82-
Section Short Term (~ 20 years)
(SSP3)



Fishermen boats pile up on the beach. Fishing nets and other equipment surrounds them.

Untended the square overgrows. Waste is either deposited here or caught in the vegetation from the wind.

Inspired by Nazare, fish can be sun dried for preservation on simple wooden stilts.

The dunes are frequently trampled upon, the vegetation disappears and over time the dunes are flattened out completely.

Graphic 83-
Section Long Term (~ 50 years)
(SSP3)

A harbour similar to Culatra offers space and protection for fishing vessels.

Abandoned buildings have collapsed and empty ruins are the last reminders of the summer homes.

Fences are erected or renewed to protect public infrastructures from vandalism.

The seawall is intensified through the addition of construction waste and materials found around the island, to adress rising sea levels.

Graphic 84-
Map ~50 years (SSP3)

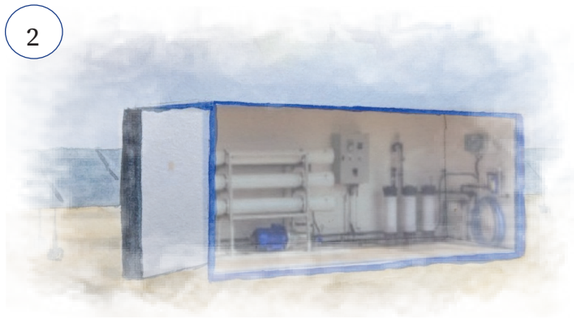
Below are further suggestions, what else one could create within Farol in the future, as also shown on the site plan to the left.

Further Ideas

1

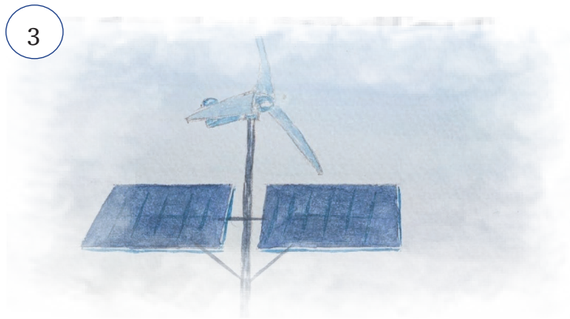
Raised planters, which are cheap and easy to build and can be placed anywhere, including intertidal flats.

2



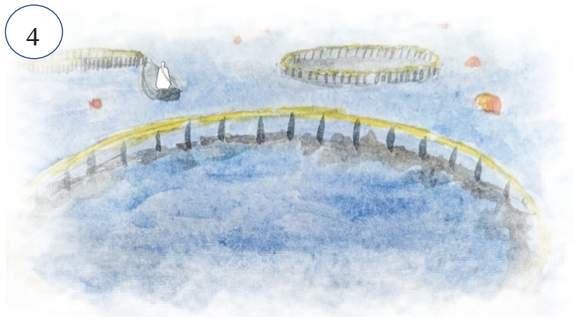
Desalination plants fitted into old shipping containers and powered by solar panels for more independence from the mainland.

3



Energy Park with second-hand wind and/or solar technologies.

4



Intense aquaculture to counteract declining natural fish populations.

Biggest Hurdles

- Poverty
- Environmental Degradation (habitat depletion, water pollution)
- Environmental Disasters

Resilience Strategies

- Encourage the sharing of resources among residents
- Find alternative sources of income which aren't connected to fish or tourism
- Foster community support groups for disadvantaged members
- Highlight people's benefits from protecting nature & thinking long-term
- Agree on local environmental protection & good behaviour, without relying on top-down regulations
- Experiment with innovative low-tek, indigenous solutions against flooding, erosion or drought

Scenario 4
Ocevans Apart

Narrative

Environmental policies reflect the desires of wealthy tourists and exclude the local fishermen from the decision-making process. Rather than a cohesive sustainable set of regulations which support a healthy ecosystem, selected rules are enforced, which aim to create pleasing aesthetics and enjoyment for international tourists. Coastal flood protection for the hotels benefit everyone, while no extra protection against precipitation or extreme heat is offered to the remaining population.

The increasing disparities and political exclusion lead to unrest, conflict, and growing crime rates. Distrust from the Farol population against the municipality and higher political entities is expressed regularly. Tourism becomes more focused on selected high-quality infrastructure designed for the international wealthy; low to mid-price ranges disappear, as do national tourists. No interest and/or capacity to connect with surrounding villages in similar predicaments. Low population growth and drastically reduced migration, overall decrease the occupied area of Farol.

Reduced access to education and higher barriers for locals to participate in activities surrounding tourism keep more people in the fishing trade. Environmental regulations limit quotas and innovative developments, making them less and less economically viable. Overall, this leads to reduced profits and very low wages, which is the beginning of a downward spiral for many. The community as a whole lacks the financial capacity to offer improvements.

Graphic 85- SSP4 Collage

Europe's Shrinking Middle Class

The middle class is shrinking in many places. Between 2004 and 2011, there was a 2.3% decrease in Europe (ILO, 2016)

Portuguese Dualism

"This crisis is different. If Portugal was forgotten before, now it has become an oasis for millionaires who are crushing the middle class for good" (Almeida 2022)

Failed POLIS programme

The top-down strategic plan, which included the removal of Hangares and homes from Farol ended in lawsuits and the dissolution of the Polis Litoral management.

External Trends

Inequalities breed crime

Structural inequalities and social stratification account for criminal motivations among the deprived (Ousey & Lee, 2012)

Automation of work

New technologies are expected to replace many jobs, especially low-skilled employments might become redundant. Managing such technologies may require a high level of education.

Similar developments on Praia do Faro & Olhão

On Praia do Farol and along Olhão's waterfront, one finds new hotel and housing blocks. Just a few streets further, there are much smaller, older homes in need of repairs or improvements.

Based on the aforementioned external trends, the following lists of tangible, such as infrastructures or land uses, and intangible changes, such as institutional decisions, organisation or communication, has been compiled.

Tangible Changes

- Energy production
- Land-based Food production
- Aquaculture
- Housing Adaptations
- Removal of obsolete infrastructure incl. hard coastal protection
- Restoration + protection of dunes

Intangible Changes

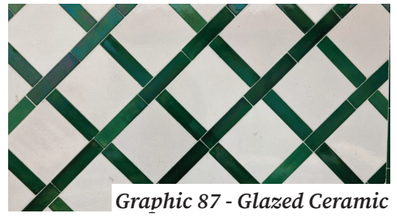
- Policy regarding seasonal homes
- Cultural events to foster identity
- Promote/provide education including environmental awareness
- Promote sharing of resources

Material Palette

From the material palette alone, it becomes obvious on which side of the island you are. Tourist resorts invest in high quality, aesthetically pleasing materials, while the locals build with what they can find.

Graphic 86- Mosaic

Often used on the mainland to decorate pavements, they contribute to setting relaxing atmospheres.

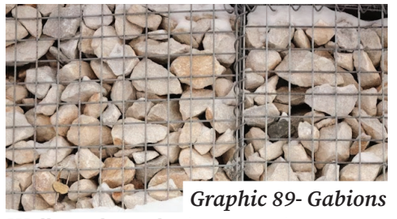


Graphic 87 - Glazed Ceramic

The shiny colours and patterns set the buildings apart and contribute to creating luxurious environments.

Graphic 88-Stonework

Custom masonry requires skilled labour and could use local or imported stone.

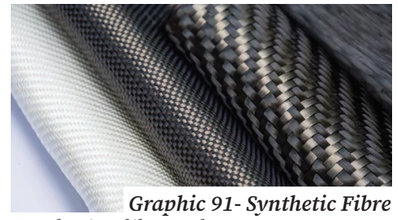


Graphic 89- Gabions

Walls, as boundaries or erosion control, can be cheaply erected in gabion cages.

Graphic 90- Reinforced Concrete

Durable, affordable and with a high load capacity. Can be used for bearing walls or paths.



Graphic 91- Synthetic Fibre

Synthetics, like Kevlar, are very durable in harsh conditions. Used for cables, shade sails (Nerea, 2023)

Graphic 92- Boulders

They can be especially useful in reducing erosion, but also as borders or decorative elements.

Graphic 93- Street Art

It can be a nuisance or an amelioration, sharing knowledge of the local community.

Graphic 94-Construction Waste

Leftover bricks or beams can creatively be used to stabilise existing structures.

Graphic 95-
Section Now (SSP4)

Graphic 96-
Section Short Term (~ 20 years)
(SSP4)

Fishing vessels and equipment clutters the beach front.

In a free market area, reusable materials can be left and picked up as needed.

Private rainwater collection becomes essential to supplement water from the municipality.

The sea wall is renewed to be more effective, less intrusive and more appealing to tourists.

Graphic 97-
Section Long Term (~ 50 years)
(SSP4)

Clam Garden - traditional basic construction of a sheltered habit to increase bivalve growth.

To reduce the import of food from the mainland, crops are cultivated in the sandy soil.

Improvised playground and soccer field replace the old infrastructure from the community center.

Permanent beach shelters offer much needed shade and seating for all visitors, supplementing the parasols for rent.

Graphic 98-
Map ~50 years (SSP4)

Below are further suggestions, what else one could create within Farol in the future, as also shown on the site plan to the left.

Further Ideas

1

Luxury hotels are constructed with ocean views, outdoor pools, beach bars and more amenities for the guests.

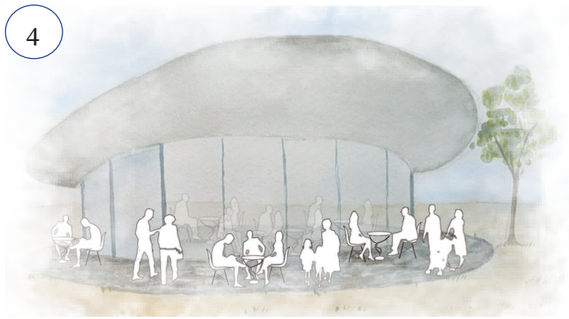
2

Strolling around the island is made more comfortable by shade pergolas of differing sizes.

3

The tourist resorts are made more attractive to families with playgrounds and outdoor activities.

4



The southern pier is renovated and reserved for guests, which are welcomed at a new bistro.

Biggest Hurdles

- Stratification of society/ How to meet everyone's needs
- Water pollution, eutrophication, decrease in mariculture & human poisoning
- Invasive species (ie. from anchor lockers)

Resilience Strategies

- Make services available to all
- Invest in public spaces equally
- Provide plenty of education opportunities
- Encourage ethical tourism & cultural outreach
- Invest in waste management systems
- Economic instruments to encourage coastal actors to treat their waste
- Increase water circulation by dredging
- Park regulations & environmental programs should not be relaxed to benefit tourism
- Visitors should be informed on the ecosystem's need & best behaviour

Scenario 5
High Waves

Narrative

People enjoy high-energy-intensive lifestyles at the cost of the natural environment. As this would be a global trend, climate change occurs most drastically without adaptive measures taken. Severe storms, flooding, and heat waves regularly threaten the people and the infrastructure on the island. Environmental vulnerabilities are compensated with costly engineered solutions, such as sea walls and flood-proof architecture. The built-up areas are allowed to grow without restrictions, consuming all land on the barrier island and even moving beyond into the channel areas. The sandy barrier islands are stabilized in place and sediments are moved around the PNRF artificially to keep the channels open and the beaches looking nice for visitors.

Increased tourism boosts income and investments in public infrastructure, leading to higher standards of living. Great efforts are taken to ensure that all residents benefit from the development and have access to better education and healthcare. Better connections to the mainland, an increase in public services and a variety of entertainment make living on Culatra much more attractive. The influx of new residents and tourists heavily changes the local culture and social cohesion.

High international investments are combined with careful local planning and regulations, ensuring benefits to the local community. The growth and diversification of the job market raise the average income and disposable income, which is reinvested into the community. Higher education levels and access to remote jobs add to this effect. Traditional knowledge of mariculture jobs becomes inconsequential.

Graphic 99- SSP5 Collage

Continued rise in tourist revenue

"The transaction volume of hotels in the Portuguese hospitality real estate market has been nothing short of staggering over the past years, going from €53 million in 2017 – the year the tourism boom began — to €904 million in 2022." (Graeme, 2023)

More disposable income and possibilties to work remotely

Kayak ranked Portugal as the best country for remote work, incentivised by the Digital Nomad visa since 2022 (Gomaa, 2024)

External Trends

Destination for Retirement

Forbes called Portugal the best place to retire, with tax incentives and Golden Visas (Silva, 2022)

Social media encouraging lavish lifestyles

Seeing other people's supposed luxury, promotes higher personal spendings and lifestyle inflations (Frazier, 2024)

Rapid advances in telecommunications

New technologies offer e-learning, e-health, e-shopping, teleconferencing, among others to everyone, diminishing the importance of mobility (Bosworth et al., 2020)

Based on the aforementioned external trends, the following lists of tangible, such as infrastructures or land uses, and intangible changes, such as institutional decisions, organisation or communication, has been compiled.

Tangible Changes

- Energy production
- Land-based food production
- Aquaculture
- Housing adaptations
- Removal of obsolete infrastructure including hard coastal protection
- Restoration and protection of dunes

Intangible Changes

- Policy regarding seasonal homes
- Cultural events to foster identity
- Promote/provide education including environmental awareness
- Promote sharing of resources

Material Palette

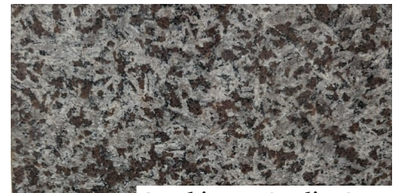
The materials are chosen based on performance and visual appeal. Their costs, environmental impacts or CO_2 emissions only play a secondary role. Rather than conveying cultural values, the aesthetics are selected to be modern and enticing.

Graphic 100- Graphene Compounds

Ultra-light weight and 10x stronger than steel, it improves stability of constructions on sand (1build, 2020).

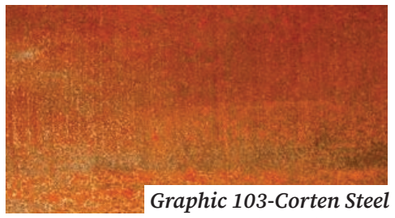
Graphic 101 - Transparent Aluminium

Its fully see-through, 3x harder than steel, used for armored windows and optical lenses (Neenu S K, 2022)



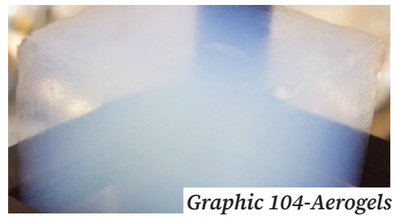
Graphic 102-Quality Stone

Visible walls and pavings are made from selected stones, such as marble, granite, among others.



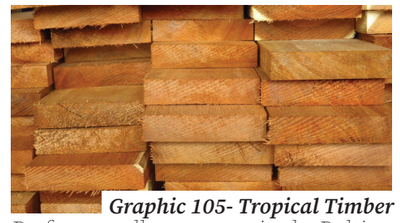
Graphic 103-Corten Steel

Popular aesthetic for outdoor planters, borders or veneers.



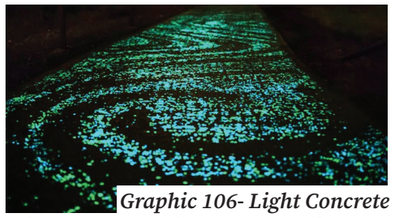
Graphic 104-Aerogels

Used as insulation, it improves indoor climate, while being incredibly lightweight.



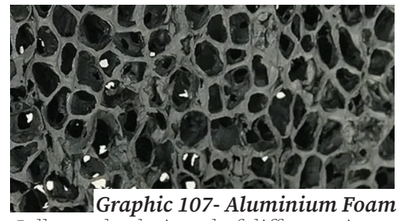
Graphic 105- Tropical Timber

Performs well as groynes in the Baltic Sea (Staatliches Amt für Umwelt und Natur Rostock Abteilung Küste , 2022)



Graphic 106- Light Concrete

Fibre optic strands incorporated can provide signage within the pavement or emit light passively (1build, 2020).



Graphic 107- Aluminium Foam

Cells can be designed of different sizes to create unique shade, facades or sound absorbing panels (Sadana, 2020)

Graphic 108-Smart Windows

Adjusts the tint automatically to reduce heat and glare (Viracon, 2023)

Graphic 109-
Section Now (SSP5)

Graphic 110-
Section Short Term (~ 20 years)
(SSP5)

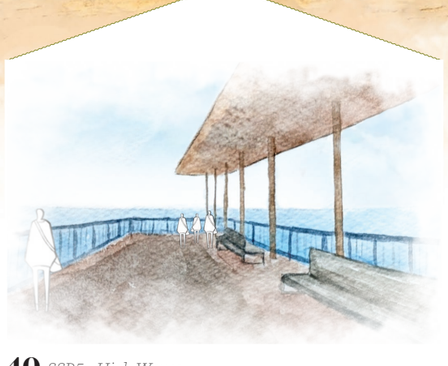
Welcoming spacious playground for children and potentially adults.

In addition to the renovation of ageing homes, new houses are built in vacant lots, of often more luxurious designs.

Construction workers are living in temporary accomodations next to stored construction materials.

The promenade would be raised against floods and designed to include multiple functions. On the upper level, exotic plants create attractive spaces.

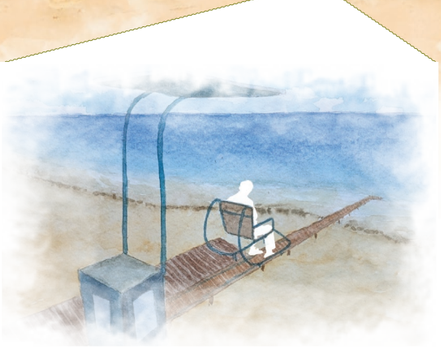
Graphic 111-
Section Long Term (~ 50 years)
(SSP5)



The harbour is conceived for a variety of boat types and invites for leisurely strolls on the pier.

The public spaces offer anything the heart desires - shade, seating, wifi, drinking fountains and more.

Large events are either held on the beach or in a newly built tent structures.



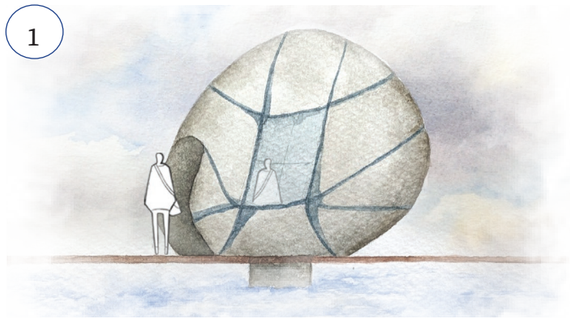
Beach infrastructure includes wheelchair accessible paths and ramps to be inclusive to everyone.

Graphic 111-
Map ~50 years (SSP5)

Below are further suggestions, what else one could create within Farol in the future, as also shown on the site plan to the left.

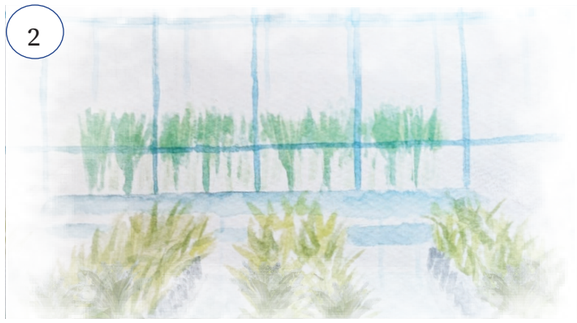
Further Ideas

1



New floating architecture would allow an expansion of the settlement into the Ria.

2



High-tech greenhouses with vertical farming would provide fresh produce to the restaurants, complementing the catch of the day.

3

Increased health care would make it attractive to retirees and support locals in all stages of life.

4

Promenade could be extended along today's dunes . At the end could be a viewing platform, a restaurant or other feature.

Biggest Hurdles

- Keeping the local community involved
- Monster Waves
- Biodiversity & a healthy ecosystem

Resilience Strategies

- To benefit all, the locals have to be part of the whole process and share the profits equally. Their culture must be represented authentically.
- The coastal protection would be engineered according to standard practice. Unpredictable extreme events could cause immense loss of life and damages.
- Big developments would displace flora & fauna, which must be compensated elsewhere.

Comparison of Resilience through scoring

Each scenario comes with its own benefits and challenges. To make comparison easier, a scoring system is suggested below, which ranks environmental, social and economic impacts. A higher score would indicate stronger resilience.

SSP1
Green Waves

Environmental
Flood safety: ●●●●●
Erosion protection: ●○○○○
Waste Removal: ●●●●●
Clean Water: ●●●●●
Renewable Energy: ●●●●●
Land Consumption: ●●●●●

Social
Social Cohesion: ●●●●○
Safety: ●●●●○
Education: ●●●●○
Equality: ●●●●●
Political power: ●●●●●
Migration: ●●●●○
Connection to mainland: ●●●●○
Well-being: ●●●●●

Economical
Employment opportunities: ●●●●○
Income: ●●●●○
Diversity of jobs: ●●●●○
Investments innovation: ●●●●●
Adaptation Costs: ●●○○○
External Funding: ●○○○○

81/100

SSP2
Calm Waters

Environmental
Flood safety: ●●○○○
Erosion protection: ●●●●○
Waste Removal: ●●●○○
Clean Water: ●●●○○
Renewable Energy: ●●●●○
Land Consumption: ●●●○○

Social
Social Cohesion: ●●○○○
Safety: ●●●○○
Education: ●●●○○
Equality: ●●●●○
Political power: ●●●○○
Migration: ●●●●●
Connection to mainland: ●●●○○
Well-being: ●●●○○

Economical
Employment opportunities: ●●●○○
Income: ●●○○○
Diversity of jobs: ●●●○○
Investments innovation: ●●●●○
Adaptation Costs: ●●●●○
External Funding: ●●●○○

64/100

SSP3
Stormy Waters

Environmental
Flood safety: ●○○○○
Erosion protection: ●●○○○
Waste Removal: ●○○○○
Clean Water: ●●○○○
Renewable Energy: ●●○○○
Land Consumption: ●●●●○

Social
Social Cohesion: ●●●●●
Safety: ●●○○○
Education: ●○○○○
Equality: ●●○○○
Political power: ●○○○○
Migration: ●●●●○
Connection to mainland: ●●○○○
Well-being: ●○○○○

Economical
Employment opportunities: ●○○○○
Income: ●○○○○
Diversity of jobs: ●○○○○
Investments innovation: ●●○○○
Adaptation Costs: ●●●●●
External Funding: ●●●●●

45/100

SSP4
Oceans Apart

Environmental
Flood safety: ●●●○○
Erosion protection: ●●●○○
Waste Removal: ●●○○○
Clean Water: ●○○○○
Renewable Energy: ●○○○○
Land Consumption: ●●○○○

Social
Social Cohesion: ●○○○○
Safety: ●○○○○
Education: ●●○○○
Equality: ●○○○○
Political power: ●●○○○
Migration: ●●●○○
Connection to mainland: ●○○○○
Well-being: ●●○○○

Economical
Employment opportunities: ●●○○○
Income: ●●●○○
Diversity of jobs: ●●○○○
Investments innovation: ●○○○○
Adaptation Costs: ●●●○○
External Funding: ●●○○○

38/100

SSP5
High Waves

Environmental
Flood safety: ●●●●○
Erosion protection: ●●●●●
Waste Removal: ●●●●○
Clean Water: ●●●●○
Renewable Energy: ●●●○○
Land Consumption: ●○○○○

Social
Social Cohesion: ●●●○○
Safety: ●●●●●
Education: ●●●●●
Equality: ●●●○○
Political power: ●●●●○
Migration: ●●●●●
Connection to mainland: ●●●●●
Well-being: ●●●●○

Economical
Employment opportunities: ●●●●●
Income: ●●●●●
Diversity of jobs: ●●●●●
Investments innovation: ●●●○○
Adaptation Costs: ●○○○○
External Funding: ●●●●○

78/100

Comparison of Resilience
Explanations

Environmental

1. Flood safety:
   The vulnerability of people towards coastal flood events.

2. Erosion protection:
   Measures the stabilization of the coast and the position of the barrier island.

3. Waste Removal:
   Demonstrates the efficiency of waste removal and beach cleanups. A high score indicates low plastic and debris pollution.

4. Clean Water:
   Looks at a variety of pollutants in the coastal and lagoon waters, which could affect human health or natural ecosystems.

5. Renewable Energy:
   Considers the % of consumed energy, which is produced by local renewable energy sources, indicating self-sufficiency. A high energy consumption of non-renewables points towards environmental degradation elsewhere and air pollution. A high consumption of non-local sources indicates an energy-intensive lifestyle and potentially an overuse of natural resources.

6. Land Consumption:
   Calculates the area occupied by human use, incl. buildings, paths, harbours, piers, cultivation of edible/ornamental plants, energy production, and others.

Social

1. Social Cohesion:
   Considers citizen engagement, the number of community events, the representation of all residents by political leaders and more.

2. Safety:
   Includes crime, marine accidents, perceived safety, disaster warning/effectiveness of response, among others.

3. Education:
   This can be calculated by comparing the highest levels of education achieved by all residents.

4. Equality:
   Includes gender equality, as well as the political power shared among residents and between the island villages and higher institutions.

5. Political Power:
   Looks at the political representation of community members in institutions and public offices, whose decisions affect them.

6. Migration:
   A resilient community could be characterised by a manageable slow increase in population or a stable population. Emigration could indicate a lack of economic opportunities or low living standards, while high immigration could destabilise social cohesion and cultural identity.

7. Connection to the mainland:
   A high mobility to the mainland could be indicative of the sharing of products and knowledge, collaboration and reduced isolation of the island villages.

8. Well-being:
   Compares the physical and mental well-being of all residents and is connected to available health care, education, and perceived risk, among others.

Economical

1. Employment opportunities:
   This could be measured by the number of jobs available or the average time to find new employment in the area. It does not account for unfilled opportunities, which could hurt local businesses.

2. Income:
   Accounts for the gross income of the residents. For simplicity, a general average is assumed, which would not account for societal stratification.

3. Diversity of jobs:
   A high diversity allows for the continuation of economic production even if one industry is disrupted. Specifically in the Ria Formosa, it would indicate greater stability throughout the seasons.

4. Investment innovation
   Higher numbers suggest the capital available to support innovation in sustainable technologies as well as the economic valuation of development.

5. Adaptation Costs:
   Combines the private and public costs of adapting and mitigating the effects of climate change, such as coastal protections, renewable energy systems, and insulation of homes, among others. A high score would indicate a low price tag on needed adaptation measures.

6. External Funding:
   Evaluates the ability of the community to afford its own infrastructure adjustments and its reliance on external financial support, from the municipality, region, country, EU or private sponsors.

Comparison of Resilience
Evaluation

The idea for developing a scoring system to compare the scenarios derived from similar approaches regarding sustainability. One example is the international LEED framework, which includes a specific rating system for cities and communities (U.S. Green Building Council, 2022). Like this study's approach, the LEED score looks at environmental, social and economic performance indicators. With 38 quantified categories, it is more detailed than the proposed version here, even including points for resilience planning (U.S. Green Building Council, 2022). Other indicators, such as transport or smart waste, become less applicable to the island setting. As previously mentioned in the theory, urban and rural systems function widely differently and shouldn't be treated compared with the same scoring card.

The scoring system has been newly developed for this study and has not been tested on another project. It is difficult to say whether it only applies to Farol or can be used more universally for rural coastal communities. Given the scope of this project, it is based only on personal assessment. The chosen score for each indicator might vary greatly depending on someone's values and perspectives. Similarly, the indicators and their interpretations could be revised and modified by a panel of experts and stakeholders. The explanations themselves would need to become more precise to make a comparison between different sites possible and unbiased.

The distribution of the points can be modified depending on the application. To keep the scenarios in this example distinct, the scores were split up across one indicator. In reality, two scenarios could, at times, deserve the same score. Additionally, no 0 score was given, which could be a possibility in future evaluations, if the need for it becomes evident. The used approach was selected to be appropriate for the comparison of the scenarios of the same location with each other. If this evaluation system were developed further, one could aim to create a score, which ranks a scenario or project to a defined standard.

For example, one could say that any plans which score below 40 points put a community at severe risk and need to be revised to improve resilience. The scoring system would then act as a guide, which areas need most work. In the example of Farol, the scoring system might be useful in discussing the most desirable future and what features would contribute the most to resilience from each SSP.

In the proposed scheme, all indicators are equally weighed. When further developing and applying this scoring system, one can consider which indicators are more important to resilience and multiplying these scores by a selected factor. For example, flood safety could be thought to have a greater impact on resilience than the provision of renewable energy; or income might be a stronger indicator than job diversity. However, as the scoring was not the focal point of this study and there are already too many uncertainties with the scoring system, there seemed little value in assigning arbitrary values at this stage.

In the scoring of the Farol SSPs, the scenarios tended to either score generally well or generally poor. In reality, high ecological resilience doesn't always coincide with social or economic resilience. Ideally, a community would build resilience in all three categories to achieve the highest sustainability, but finding measures, which do so, are often tricky to find. Environmental protections at times may hinder economic developments, and economic growth, especially when not distributed evenly, can be detrimental to the social well-being of a society. Therefore, individual projects should be evaluated holistically, but also put into a wider context spatially and temporally.

The proposed scoring system is far from perfect, and some optimisations have been discussed here. However, it is a first attempt at standardising and comparing the resilience of imagined future communities, and has the potential of becoming a credible, transparent and replicable approach of evaluating the resilience of island communities.

Graphic 112- LEED Concepts
produced by Zemanta (2010)

SSP Evaluation
Consistency with Global SSP

SSP1
Green Waves

The scenario strives for the most effective sustainable solutions - in some cases this would mean localised decentralised systems (ie. food or energy); in other cases, centralised (ie. sewage system from Faro).

Redundancies can help with resilience by ensuring an alternative in case of system failure. Too many would put a strain on resources. Therefore a good balance would be sought after in this scenario.

The most extreme version, where the whole community would move to the mainland and only absolutely necessary infrastructure (lighthouse, weather tower) would remain, was not explored in this study, as it reduce the exploration of adaptation strategies on the island. But of course, from an environmental viewpoint, relocation would be the most resilient alternative.

SSP2
Calm Waters

This scenario assumes that current strategies of simply maintaining infrastructure will be kept in the near future. After the political heat surrounding the Polis Litoral Society, this strategy is understandable.

However, by doing nothing, the community risks missing its opportunity to adapt slowly to climate change. Here, it is assumed that one day the environmental pressures will force rapid, intrusive mitigation efforts, and that such spontaneous actions will not be the most suitable or cost-effective. The global SSP does not address this.

SSP3
Stormy Waters

The global SSP centers on nationalism and regionalism, which was translated into localisation for the extended SSP. While in some ways the community is dependent on Faro, recent tensions with the Polis Litoral could hint at potential future political conflicts between the island and Faro. On the other hand, under this scenario, the region might grow stronger bonds against outsiders and inspire Farol to lean more on Faro. More research would be needed here to reduce ambiguities.

The scenario explores different options to increase the importance of fishing and aquaculture as a mean to compensate the decline in foreign tourism and allows for both community initiatives, as well as regional investments. The global SSP suggests more authoritarian forms of governance, which could suggest Faro implementing strict rules and enforce development plans most suitable to the municipality.

SSP4
Oceans Apart

The environmental policies focus on high income areas in the global SSP. However the community was considered too small to segregate by different policies.

Instead the new environmental regulations could be designed to favour the wealthy tourists and diminish the opportunities of the local fishermen, leading to increased poverty.

The global SSP does not concern itself with the relationship between locals and political institutions, hence for the local scenario, it was assumed that organisations and institutions would support the elite the most and mainly ignore the voices of those with less political and financial power.

SSP5
High Waves

This SSP maximises the development potential of Farol, which exaggerates even what is alluded to in the global SSP. The boundary of the military site is maintained (even though this might also be removed in the future), but every other piece of open land is offered up to new constructions.

Different floating homes today already demonstrate that future housing would not necessarily be restricted to land but could expand into the channels as well. This highlights the mentality of men over nature, which can be one interpretation of the global SSP.

Overall, the scenarios lack detail to make them realistic, which can either only be filled in by local stakeholders or experts in a given field, such as coastal engineering or sociology. But they are the best possible attempt by a singular perspective of a landscape architect. By combining a wide range of trends and issues in a single study, such as this one, it becomes more clear, which questions to ask in the future and to whom.

Conclusion

Summary

This project analysed the community of Farol by investigating the forces that play a central role in its development. The thesis first presents spatial factors through the Ria Formosa and Culatra and then proceeds with temporal ones through the extended SSP scenarios. Each showcases different possibilities for the future, what might lead there and offers suggestions how one can react to any potentially negative trends. This study was never conceived to find the best development solution for Farol (based on what criteria?) or most likely future (never happens how you plan it anyway).

Purpose

On their own, no scenario is designed to be an accurate prediction of the future or even a worthwhile masterplan. For example, favouring ecological resilience, as suggested in one scenario, could go hand-in-hand with reduced economic growth or as shown in another scenario, not all economic developments promote social resilience of the whole community. But as a set, the scenarios allow for a discussion of desirable trends and a catalogue of potential interventions.

The purpose of this thesis is to generate knowledge surrounding the possible impacts of socio-economic trends and to brainstorm mitigation measures for any threats to the community. This knowledge could then be used to start community-driven planning for Farol and to better inform the local residents of potential effects of their choices. The viability of any of these suggestions would need verification by local stakeholders, as well as an interdisciplinary team of experts. The insights from this thesis could likewise be used by the academic community to continue developing the method of creating extended SSPs and expand on its applications.

This project aims to show how landscape architecture can contribute to 'future' research and its communication. The SSPs are often combined with other numerical models to predict trends in the environment. To function, these typically reduce complexity to a few indicators and then produce abstract results. In contrast, this project looked at environmental, social and economic aspects in parallel and summarised the ideas in comprehensible graphical depictions of development responses. This could allow for more stakeholders to join in the conversation about their local area and for the ramifications of other calculated results to be understood.

The SSPs and Resilience

Through five extended SSP scenarios, potential future developments in Farol have been explored.

In the first scenario, (Green Waves), the natural environment and people's well-being would be prioritised. It considered removing or adapting infrastructure to not impede natural processes and habitats, while still allowing for human uses of the spaces. This would greatly aid environmental resilience but would come with its own challenges of social acceptance and high costs.

The second scenario (Calm Waters) continues business as usual, risking more dramatic threats in the future.

Thirdly (Stormy Waters) imagines a future with more social conflict, locally and internationally. On one hand, localisation trends can positively contribute to preserving culture and self-sufficiency, as well as reducing carbon footprints from international travel, on the other, a lack of cooperation can seriously hinder adaptation developments.

The fourth scenario (Oceans Apart), exaggerates social stratification and separates Farol into wealthy tourist resorts and impoverished fishermen. While a structural division in such a small community is uncommon, a similar development can already be observed on Praia do Faro.

The fifth and last scenario (High Waves) is the most successful in generating wealth and progress and assumes all locals to be profiting from these developments. The disregard for the environment and worst climate scenario would make nature the biggest threat to people's livelihoods.

No scenario is aiming to depict a utopia, but rather is a tool to understanding the bigger context, of what drives developments in our built environment. Accepting that there is no perfect world with zero threats, the scenarios look for improvements and mitigation strategies regardless of what actually happens.

Evaluating External Trends

Each scenario is established on current trends, which hint at the real possibility of these coming true. In addition, the development matrix explores past events, which heavily impact the PNRF and in turn, Farol. Tourism is by large, the biggest driver of change today, bringing in people and income, requiring infrastructure and new regulations. How natural resources are extracted through fishing, agriculture or salt harvests, has dramatically changed in the past 50 years with visible impacts on the landscape. The environmental regulations of the PNRF aim to minimise these and their effects on the ecosystem of the lagoon.

Reflection on Method

The thesis was created by a singular landscape architecture student within a few months time, and therefore naturally comes with flaws and untested ideas. Distant planning such as this can't and shouldn't be used to make changes in the built environment. It's a conversation starter on an academic level to discuss coastal community adaptations or as a first step to community discussions.

Locals will be much more sensitive to local trends and mindsets, which should form the backbone of scenario-based planning, which is intended to translate into master plans. "Given the context of policy fragmentation, economic vulnerability and increasing need for cooperative financing in coastal areas, genuine participation by local stakeholders and the public is crucial, building on existing and potential social capital" (Schmidt, 2014)

Within the landscape architecture profession, one designs an area based on current or near-future needs. The background research is also often limited spatially. Yet, the projects are expected to endure for long periods of time and therefore impact many more people than considered during the design phase. The SSPs provide a structured template that can help to bridge this gap and make the landscape architect aware of future impacts on his landscape design.

Future Outlook

We can't predict the future, but we can map out eventualities. Considering the rapid changes in the world, including climate change, anticipating different trends allows for better capacities to adapt and increase resiliency. We should plan with contingencies and embrace changes.

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Text

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List of Graphics

1 - Barrier Island Typology
adapted from: Carrasco, A. R., & Matias, A. (2019). Backbarrier shores along the Ria Formosa lagoon. In: Aníbal, J., Gomes, A., Mendes, I. & Moura, D. (Eds.), Ria Formosa: Challenges of a Coastal Lagoon in a Changing Environment, 1st edition. University of Algarve, Faro. (978-989-8859-72-3), 17–28. https://sapientia.ualg.pt/handle/10400.1/12475

2 - Flood Risk Portugal
adapted from: Muis, S., Verlaan, M., Winsemius, H. C., Aerts, J. C. J. H., & Ward, P. J. (2016). A global reanalysis of storm surges and extreme sea levels. Nature Communications, 7(1), 1–11. https://doi.org/10.1038/ncomms11969Map "SS-GLOBAL-MUIS-50" found on ThinkHazard

3 - Coastal Erosion
collage based on personal photograph

4 - Resilience Perspectives
adapted from: Kombiadou, K., Matias, A., Costas, S., Carrasco, A. R., Plomaritis, T. A., & Ferreira, Ó. (2020). Barrier island resilience assessment: Applying the ecological principles to geomorphological data. CATENA, 194(0341-8162), 104755. ScienceDirect. https://doi.org/10.1016/j.catena.2020.104755

5- SSP Representations
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6 - Sea2City Catalogue
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7 - SSPs Flensburg
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8 - Site Visit
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9 - Line Drawing Farol
cadmapper.com

10 - Scheme of Solution Ideas
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11- Working Board
personal photograph

12- Scheme of Design Process
personal drawing

13 - Map Portugal
adapted from: World Atlas. "Districts of Portugal Map," Worldatlas.com, Feb. 2021, www.worldatlas.com/maps/portugal. Accessed May 2024.

14 - Map Algarve
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15 - Overview PNRF
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16 - Section PNRF
collage created from personal photographs and publicly available images (ecosia.org)

17 - Park Limits
adapted from: DGT - Direção-Geral do Território. "Sentinel - 2," SMOS, July 2021, smos.dgterritorio.gov.pt/coscid/. Accessed May 2024.

18 - Place Names
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19 - Sediment Movement
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20 - Landcover
Generated using European Union's Copernicus Land Monitoring Service information; https://doi.org/10.2909/205e2db2-4e35-4b1b-bf84-271c4a82248c

21- Barrier Islands
personal photograph

22- Lagoon
personal photograph

23- Forest
personal photograph

24- Birds Ria Formosa
collage created from publicly available images (ecosia.org)

25- Mammals Ria Formosa
collage created from publicly available images (ecosia.org)

26- Aquatic Species Ria Formosa
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personal photograph

62- Concrete
personal photograph

63- Hollow Clay Brick
personal photograph

64- Insulated Roof Panels
personal photograph

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personal drawing

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