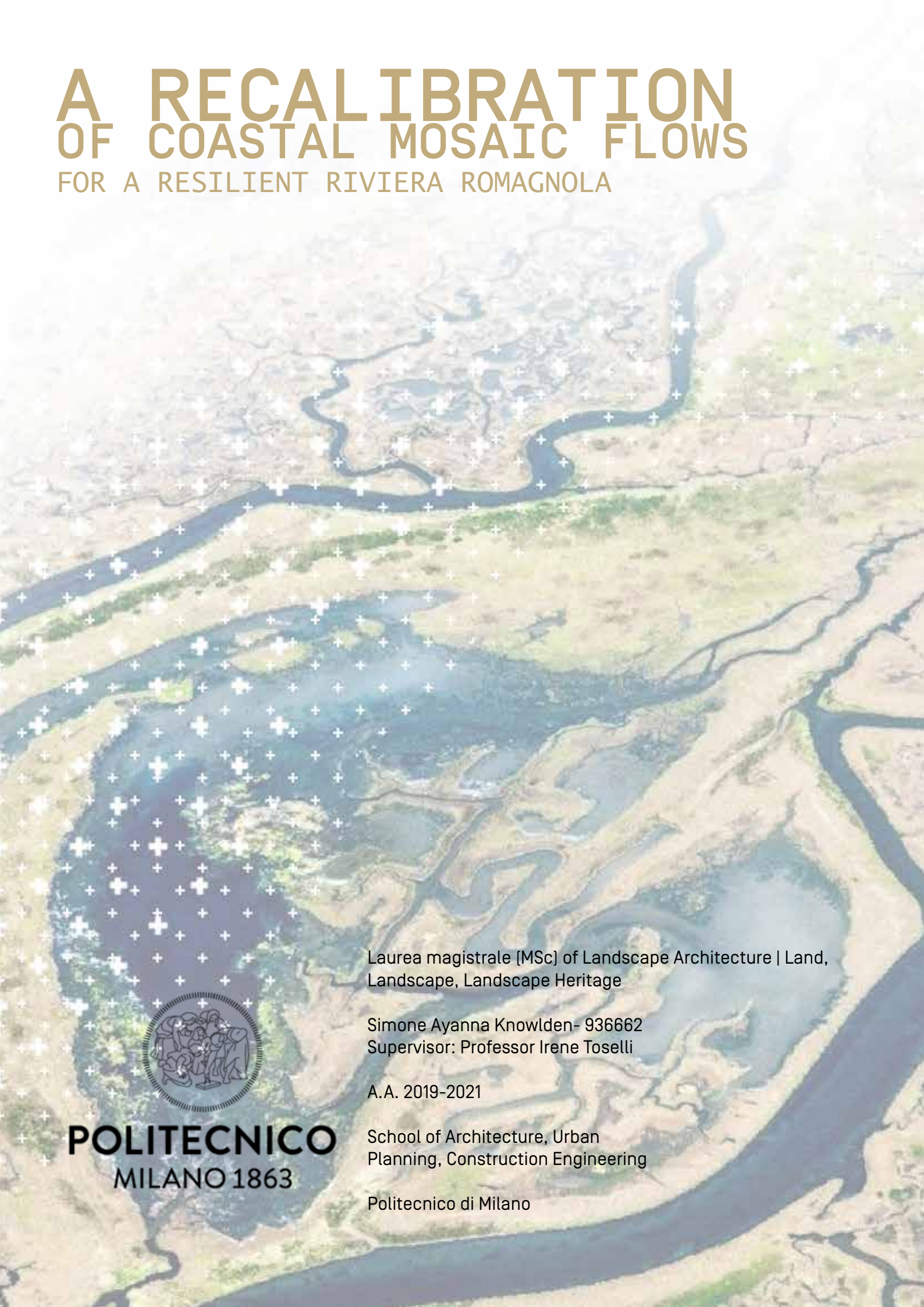
A RECALIBRATION OF COASTAL MOSAIC FLOWS

FOR A RESILIENT RIVIERA ROMAGNOLA



Laurea magistrale (MSc) of Landscape Architecture | Land, Landscape, Landscape Heritage

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ABSTRACT

A recalibration of Emilia Romagna coastal flows can begin through the lens of land mosaics. The term land mosaic comes from landscape ecology described by Forman as an assemblage of energetically open patches, corridors and matrices (the basic spatial elements) that form a pattern on the land at a human scale. In other words, a set of landscape elements that are connected by flows of energy and materials (1995). These flows can have both anthropic and natural origins and include anything from animal and human activities to water, sediment and pollutants. Through this lens we can visualize this dynamic landscape as a whole shaped by various networks of flows and alleviate conflicting and congested flows to improve spatial patterns. Such a framework has the potential to reconfigure a landscape of rigid control into a landscape of resilience that harmoniously accommodates both anthropic and natural flows.

Land mosaics are a result of two drivers, geology and culture (Forman, 1995). As man becomes an evermore powerful geological agent, we have seen a drastic transformation of mosaics from those dictated by natural phenomenon to those shaped by human actions. With pressing issues such as climate change we are beginning to feel the imbalance of these spatial transformations on communities world wide that live upon the mosaics and rely on them for all of life's necessities.

The Po River Delta, ancient and active, is an excellent example of a land mosaic formed by the converging forces of man and geology. It is an exceptionally dynamic waterscape that has been molded a multitude of times by water and man alike. Once a mosaic dominated primarily by rivers, wetlands, lagoons, salt marshes, and dunes, what remains today is a predominantly agrarian landscape with beachside tourist towns lining the coast and sparsely distributed patches of remnants to testify of a forgotten landscape. These patches are a critical stronghold for the native flora and fauna that are becoming more and more rare. The cohesive integration of these elements and subsequent flows, both anthropic and natural, is the key to a cohesive landscape mosaic that is resilient, functional and balanced.

Today after centuries of reclamation, channel diversion, dam building and sediment and gas extraction, the Emilia Romagna coast is suffering from battling spatial flows across the landscape. In addition, this stretch of coastline is experiencing an increase in frequency and intensity of storm surges that has the potential to cripple the region's coastal tourism based economy. Lido Degli Estensi is a coastal summer tourism town that has reportedly been dropping in visitorship while facing more coastal flooding. The fragmentation of the inland lagoons and coastal beaches and lack of cohesion in spatial qualities have likely contributed to the decline in their main economic driver.

The shifting of flows through the landscape give important insights to what can be done to mitigate these problems on a spatial scale. This proposal looks at the flow of water, sand, people and wildlife to improve a piece of a greater mosaic, Lido Degli Estensi by not only acknowledging changes in flows but by using them as opportunities to improve mosaic dynamics. Given the shifting of flows across and throughout the coastal mosaic, reevaluating how flows are managed to restore balance and improve economies, while integrating valuable habitat and ecosystems.

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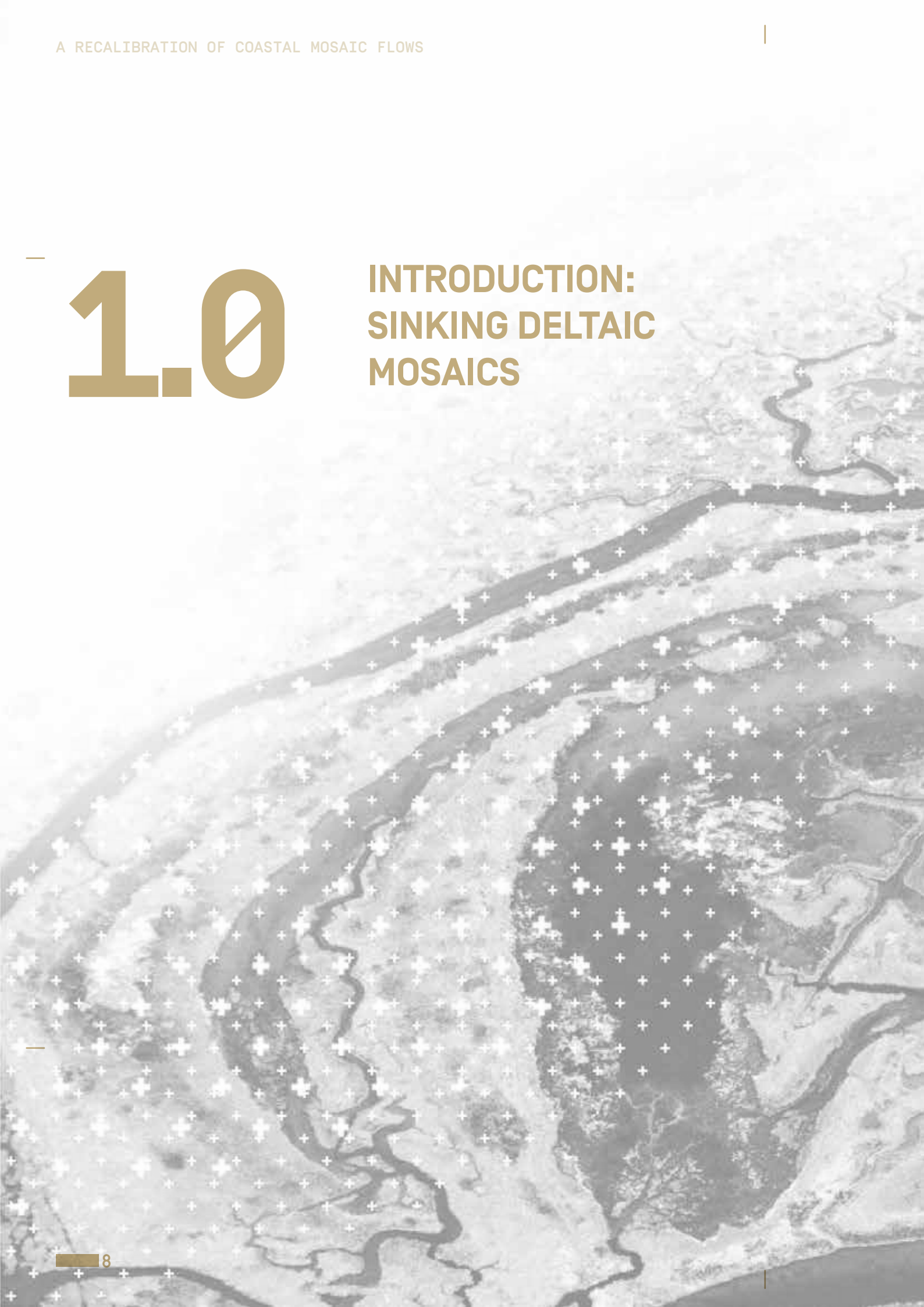
1.0 INTRODUCTION: SINKING DELTAIC MOSAICS



Intro

Observing from the window of an airplane or an orthographic aerial, one can begin to see emerging patterns of land covers that spread throughout a territory. Looking down at the Po River delta and the Emilia Romagna coast a dynamic land mosaic shaped by water and man is revealed. The term land mosaic comes from landscape ecology described by Forman (1995) as an assemblage of energetically open patches, corridors, and matrices (the basic spatial elements of landscapes) that form a pattern on the land at a human scale. In other words, a set of landscape elements that are interconnected by flows of energy and materials. These flows can have anthropic and natural origins and include anything from animal and human activities to water, sediment, and pollutants.

This territory has been molded and remolded by the changing fluxes and dynamics of the flows that have passed through it, such as the ebb and flow of the Po river and the rise and fall of the Port city of Spina. The resulting landscape is a composite of patches and corridors within a primarily agricultural matrix. Varying interests in agriculture, fishing, tourism, habitat, and heritage conservation have fragmented the landscape and transformed the structure-function feedback, each stakeholder fighting for the opportunities provided by the rich landscape of the Po River Delta. This wealth of landscape elements create a heterogenous fine-scale grid of horizontal and parallel flows to the coast (Forman, 2010). Amongst these elements and flows, there are undoubtedly numerous conflicting ecological and anthropic flows.

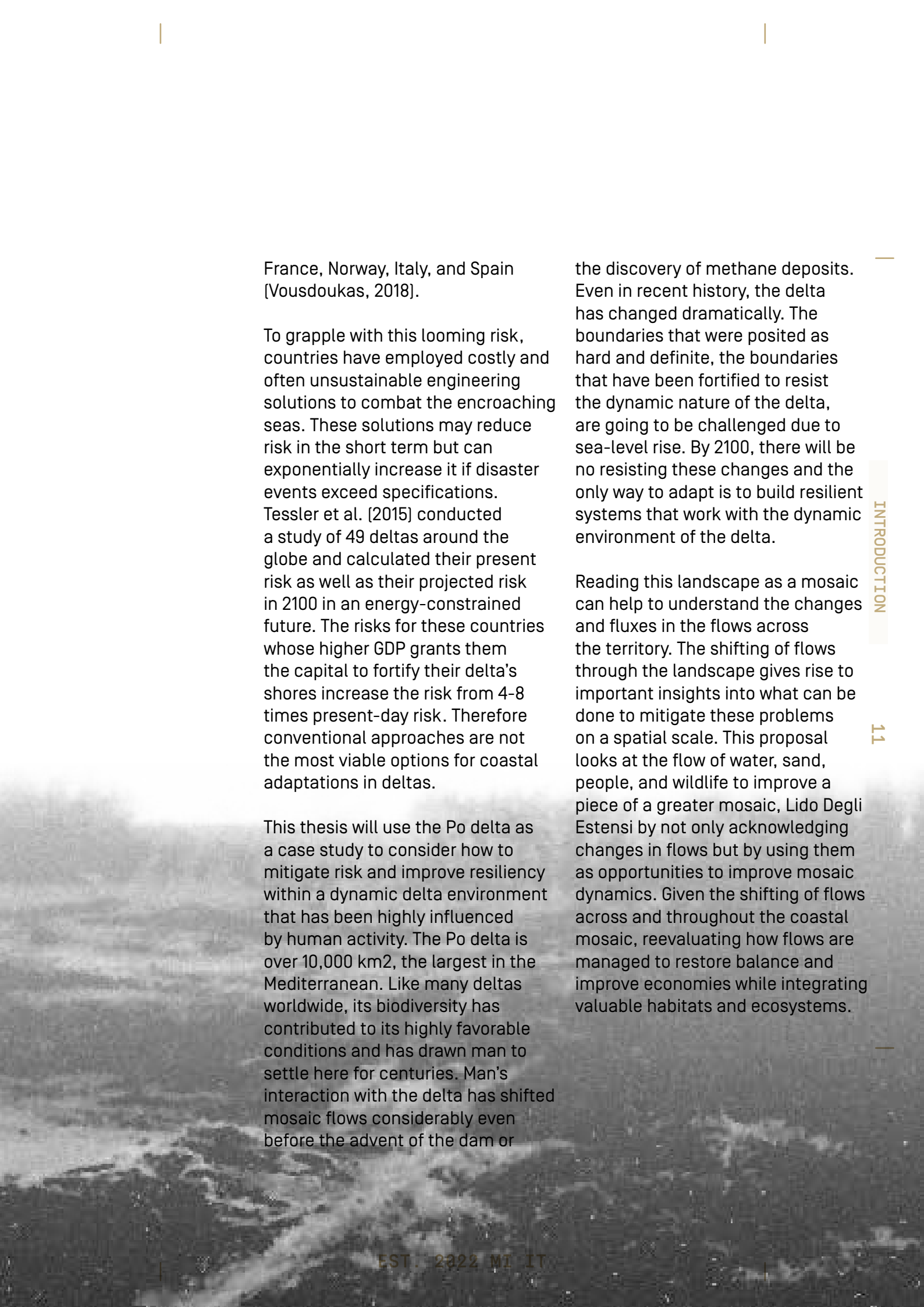
Coastal mosaics and specifically deltas are dynamic and highly resilient environments, however, human activity has severely weakened their capacity to recover. Human influences on the Po river delta range from the flow regulation by dams and sediment entrapment by reservoirs, deforestation, channelization, land cover change, groundwater, and hydrocarbon extraction, resulting in its present-day retreat (Bizzi & Surian, 2021). In addition, eustatic sea levels are rising at alarming rates due to climate change. Ultimately, deltas including that of the Po River will be disproportionately impacted by catastrophic flooding (Edmonds, 2020). At the forefront lies vulnerable habitats and highly profitable industries, like tourism in Emilia Romagna that boost economies. Projections are estimated that in the EU coastal flooding will cost nearly €1 billion annually and will impact over 3.5 million citizens. Countries, particularly at risk, are the UK,

France, Norway, Italy, and Spain (Vousdoukas, 2018).

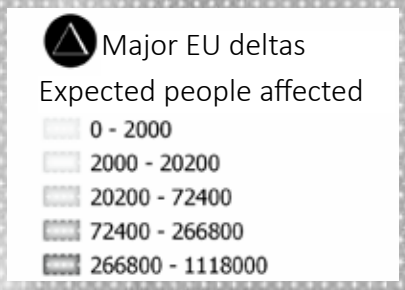
To grapple with this looming risk, countries have employed costly and often unsustainable engineering solutions to combat the encroaching seas. These solutions may reduce risk in the short term but can exponentially increase it if disaster events exceed specifications. Tessler et al. (2015) conducted a study of 49 deltas around the globe and calculated their present risk as well as their projected risk in 2100 in an energy-constrained future. The risks for these countries whose higher GDP grants them the capital to fortify their delta's shores increase the risk from 4-8 times present-day risk. Therefore conventional approaches are not the most viable options for coastal adaptations in deltas.

This thesis will use the Po delta as a case study to consider how to mitigate risk and improve resiliency within a dynamic delta environment that has been highly influenced by human activity. The Po delta is over 10,000 km2, the largest in the Mediterranean. Like many deltas worldwide, its biodiversity has contributed to its highly favorable conditions and has drawn man to settle here for centuries. Man's interaction with the delta has shifted mosaic flows considerably even before the advent of the dam or the discovery of methane deposits. Even in recent history, the delta has changed dramatically. The boundaries that were posited as hard and definite, the boundaries that have been fortified to resist the dynamic nature of the delta, are going to be challenged due to sea-level rise. By 2100, there will be no resisting these changes and the only way to adapt is to build resilient systems that work with the dynamic environment of the delta.

Reading this landscape as a mosaic can help to understand the changes and fluxes in the flows across the territory. The shifting of flows through the landscape gives rise to important insights into what can be done to mitigate these problems on a spatial scale. This proposal looks at the flow of water, sand, people, and wildlife to improve a piece of a greater mosaic, Lido Degli Estensi by not only acknowledging changes in flows but by using them as opportunities to improve mosaic dynamics. Given the shifting of flows across and throughout the coastal mosaic, reevaluating how flows are managed to restore balance and improve economies while integrating valuable habitats and ecosystems.



PROJECTED PEOPLE AFFECTED BY COASTAL FLOODING IN EUROPE



MAP-01: PEOPLE PROJECTED TO BE AFFECTED BY COASTAL FLOODING IN EUROPE SOURCE : TESSLER ET. AL., 2015

PO DELTA

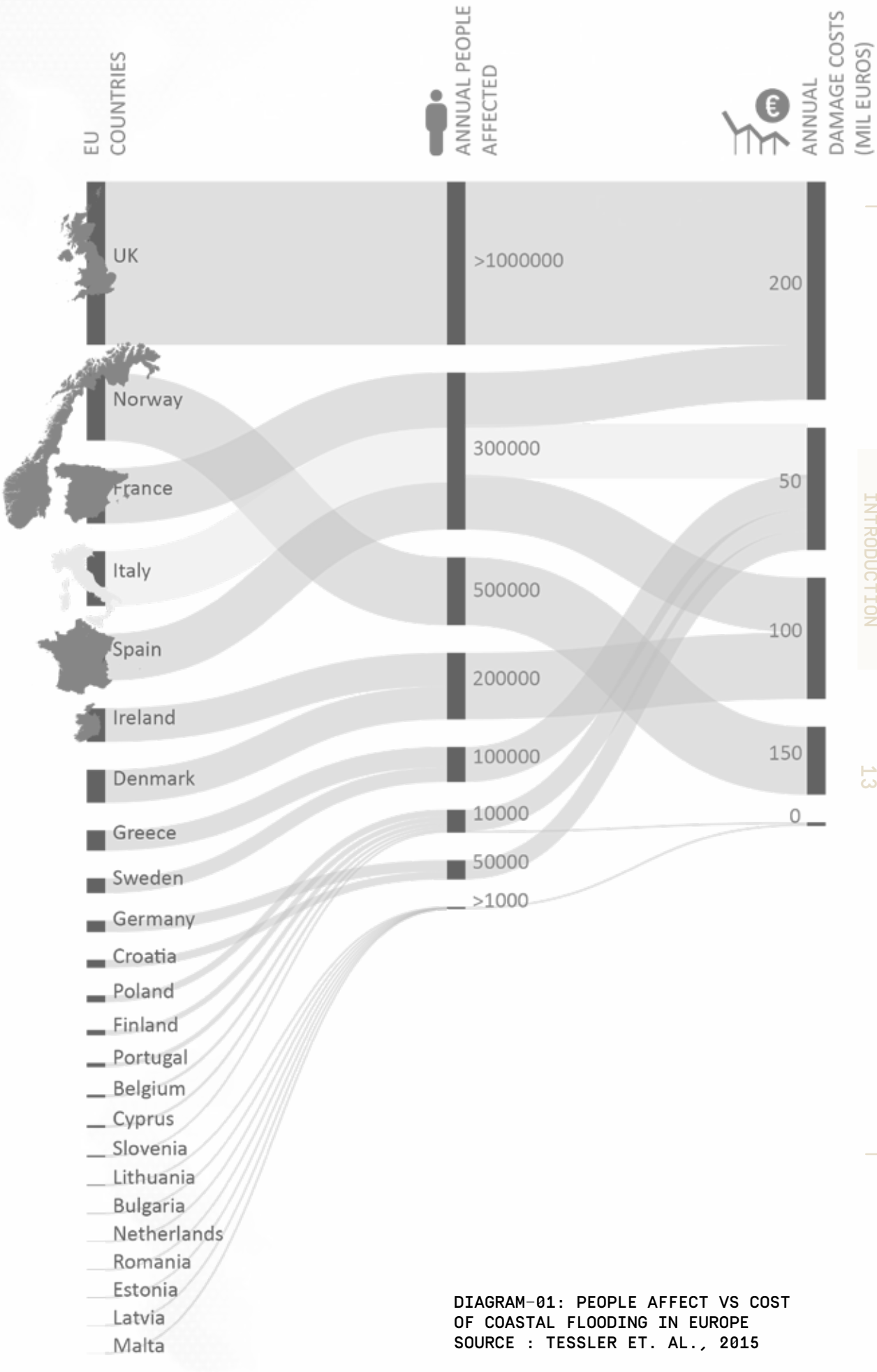
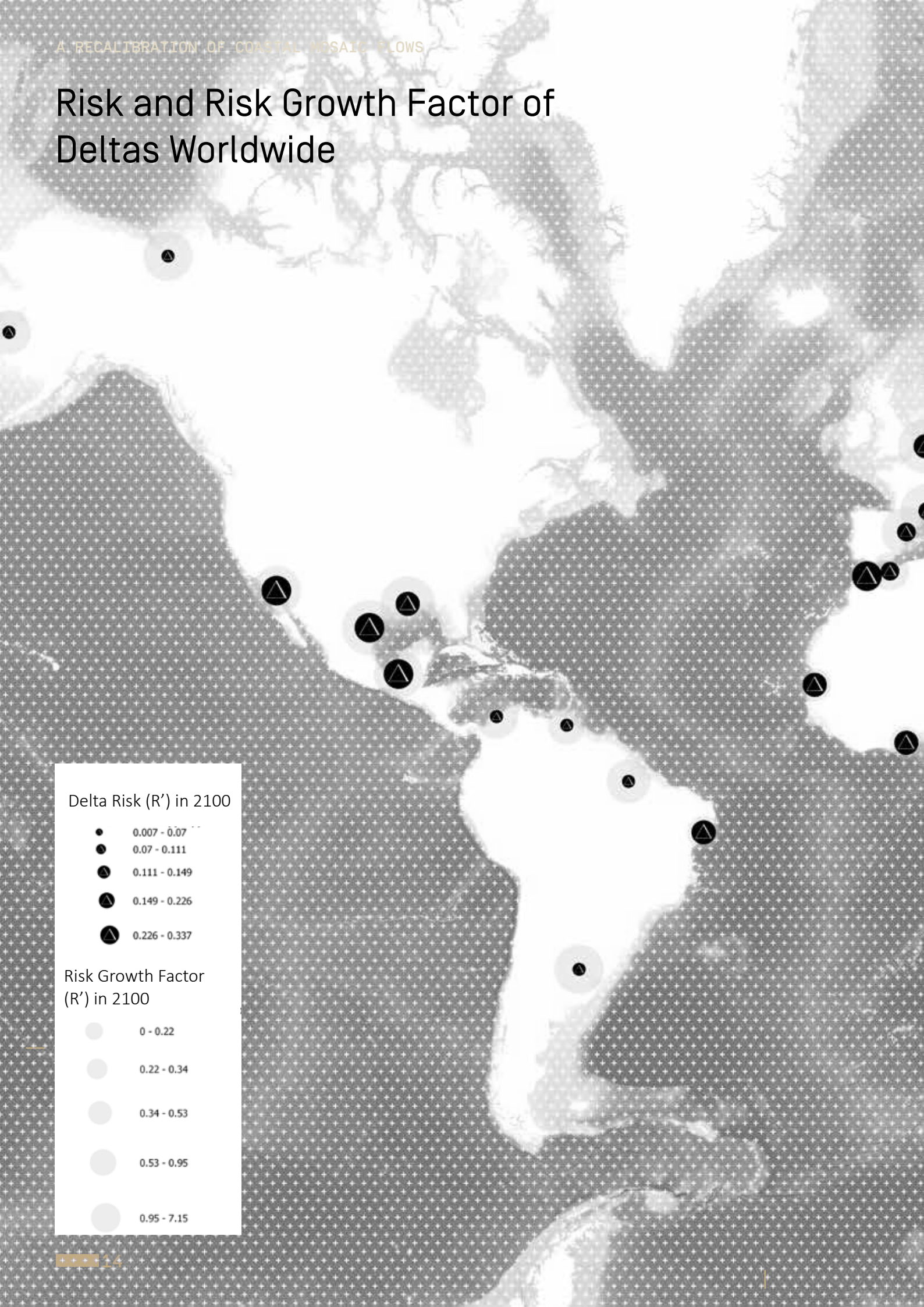
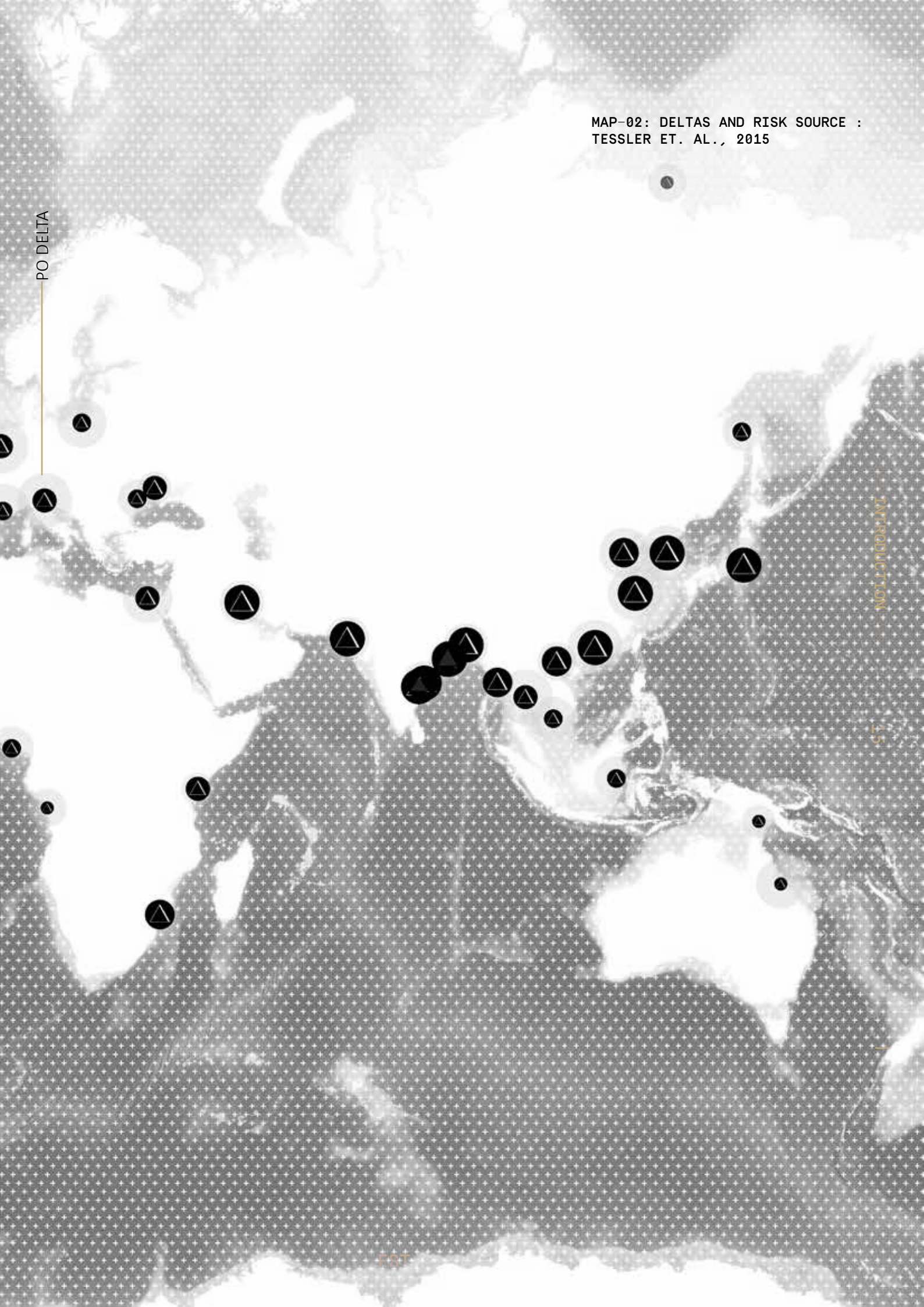


DIAGRAM-01: PEOPLE AFFECT VS COST OF COASTAL FLOODING IN EUROPE
SOURCE : TESSLER ET. AL., 2015

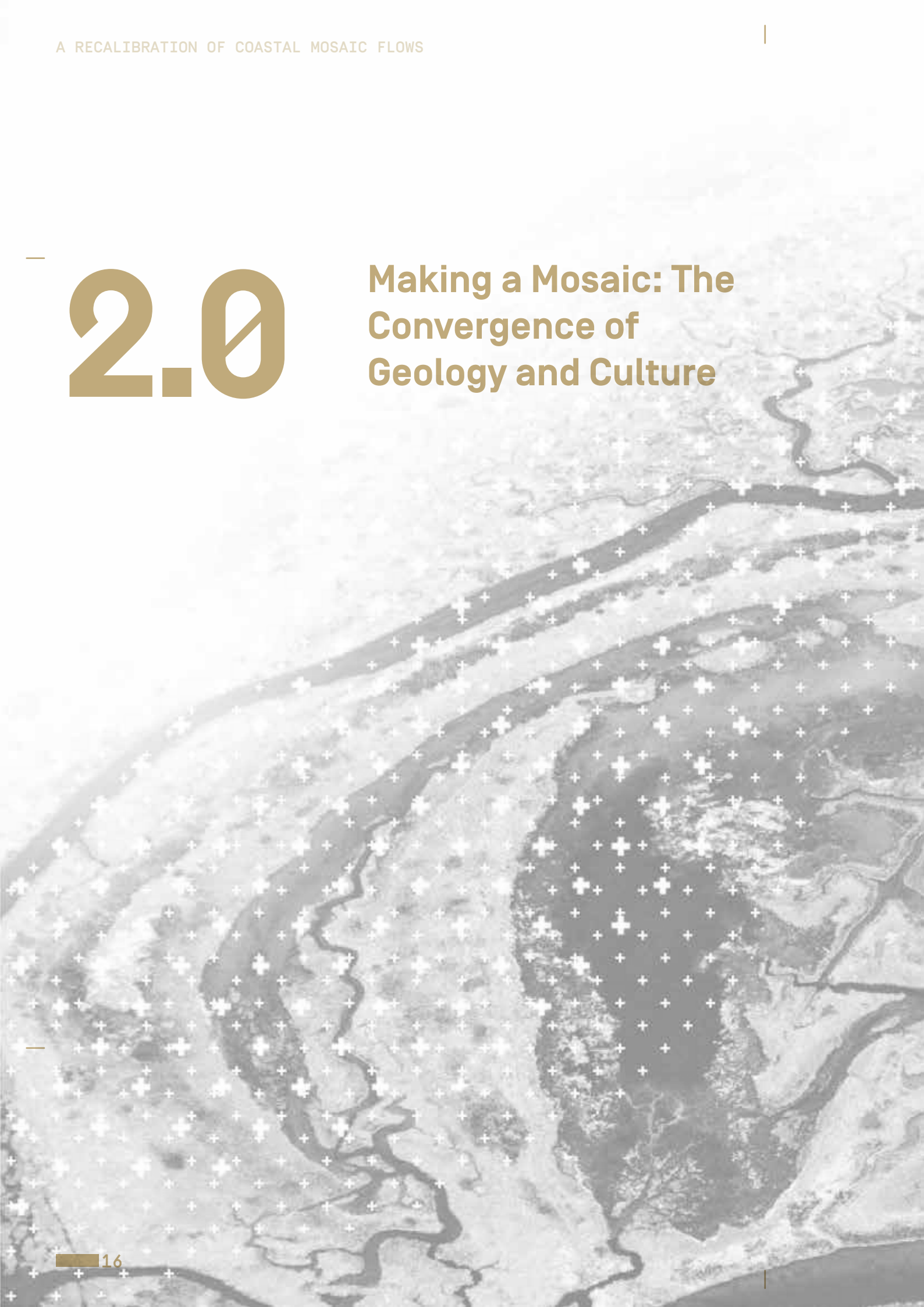
Risk and Risk Growth Factor of Deltas Worldwide





MAP-02: DELTAS AND RISK SOURCE :
TESSLER ET. AL., 2015

2.0 Making a Mosaic: The Convergence of Geology and Culture



Subchapters

INTRO

As previously mentioned, land mosaics are an assemblage of patches, corridors, and matrixes that form a pattern on the land at a human scale (kilometers to thousands of kilometers, i.e. landscapes, regions, and continents) (Forman, 1995). They are spatially heterogeneous/have structure due to being thermodynamically open, as the sun proves consistent energetic input, thus maintaining structure and heterogeneity across the land. The most prevalent type of land heterogeneity can be read as land mosaics.

Three main mechanisms create a mosaic which is then further modified by a plethora of biological processes. Those mechanisms are the following: natural disturbances (create heterogeneity), substrate heterogeneity (creates variation in vegetation cover), human activity (influences patches, corridors, boundaries, and mosaic patterns) (Forman, 1995).

Mosaics can also be understood through the structure-function feedback loop, where both structure and function influence the other in a continuous loop that is always subject to changes. Therefore, geomorphic processes at work transport organic and inorganic materials creating landforms. In our case, the Po River watershed weathers stone from the Alps and Apennines, and the transport of these materials over millennia has driven the development of the Po River Delta. The form of the delta was mainly driven by the frequent flooding of the river and the sea. The steady flow of water and sediment counteracted the subsidence that naturally occurs over geological periods. These flows also created a vast waterscape of lagoons, salt marshes, and brackish ponds.

However, in 1604 when the Venetians executed the Taglio di Porto Viro intervention (diversion of the course of the Po Grande) this initiated a change in flows and shifted the main geological agent of the delta from the Po to man (Bondesan 1989). This marked the beginning of the construction of the delta we see today. Later most of the wetlands were drained in 1870 and 1970 using mechanical reclamation techniques for agriculture while the remaining lagoons host a vibrant fishing culture (Bondesan 1989). Beach strands and dunes have also been occupied by a mass summer tourism industry

2.1 Po Delta Mosaic Process Flowweb

Modern deltas are relatively novel landforms on a geological timescale. They all began development under the conditions that arose between 9000 and 6000 years BP. When the eustatic sea-level change began to stabilize during the postglacial period, rivers that supplied abundant sediment grew seaward, driving some of the largest coastal landforms1 (Anthony, 2015). Thus, estuaries transformed into deltas, and shorelines prograded. In the subsequent millennia, civilizations flocked to their shores to receive the bountiful ecosystem services provided and nearly 400,000 people globally live within a delta7 (Edmonds, 2020).

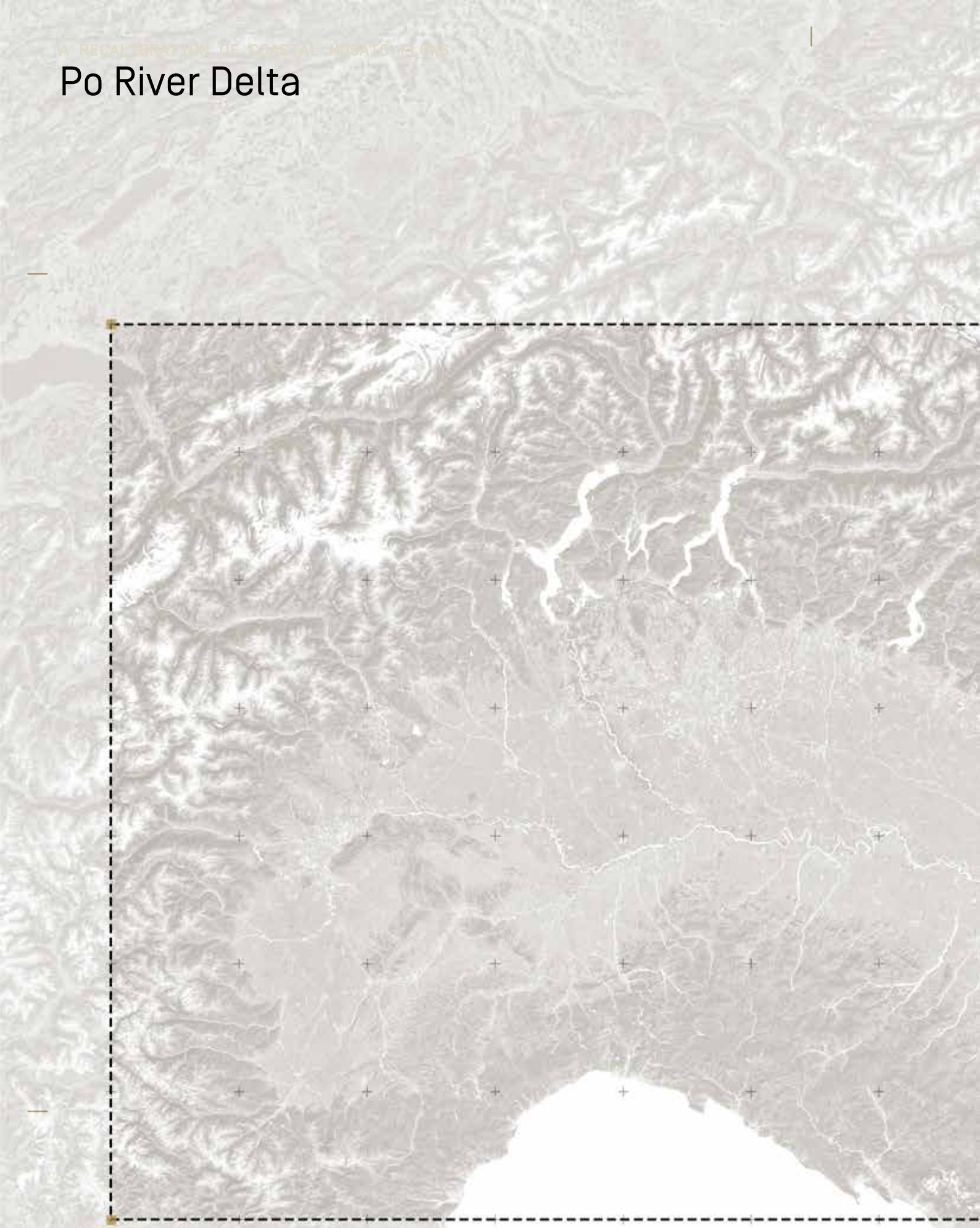
It is now recognized that Eustatic sea-level change is the primary contributor that influences the development of deltas. However, climate change is shifting the delicate balance in which deltas and those who inhabit them have been able to flourish. Sea-level rise is outpacing the accumulation of sediment, resulting in deltas retreating landwards, also known as retrogradation. These low-lying landforms are consequently, more vulnerable to coastal flooding7 (Edmonds, 2020).

Delta's were ascribed their name when the Greek historian, Herodotus, in the 5th century compared the triangular shape of the Nile's subaerial delta to the greek letter for D. The geologist L.D. Wright (1985) defined deltas as "coastal accumulations, both subaqueous and subaerial, of river-derived sediments adjacent to, or in close proximity to, the source stream, including the deposits that have been secondarily molded by waves, currents, or tides" (Wright, 1985).
Not all rivers form deltas, however, the sediment input over geological time scales is paramount for the progradation of coasts. An interplay of factors determines whether a delta will form, such as the sediment supply, grain size, geomorphology, and the oceanographic conditions of the receiving basin.

What emerges is a diversified composite of sub-environments. The part of the delta above water is called the subaerial delta plain, which is divided further into the lower and upper parts depending on the dominant force acting upon its morphology. (river vs. estuarine or marine processes). These segments can be distinguished by the transition of vegetation from mangrove or salt marsh to brackish-freshwater marshes and marshy forests. The presence of active and abandoned sections of the delta plain can be noted as well.

The subaqueous delta plain is the submerged part fronting the subaerial plain. It consists of the shallow delta front and a prodelta made of finer-grained sediments. Depending on the sediment load, the subaqueous delta plains can carve canyons with deep-sea fans which can accrue massive quantities of sediment. Deltas can be classified by their morphodynamics. Galloway (1975) developed the ternary diagram which classifies deltas in terms of their dominant driver: river-, wave-, tide-dominated. The predominant force dictates the morphodynamics and associated sub-environments, such as strand plain beach ridges or tidal flats.

Po River Delta



MAP-03: PO RIVRE DELTA

Fluid flows

Water and wind flow throughout the mosaic to form what we see today as the delta

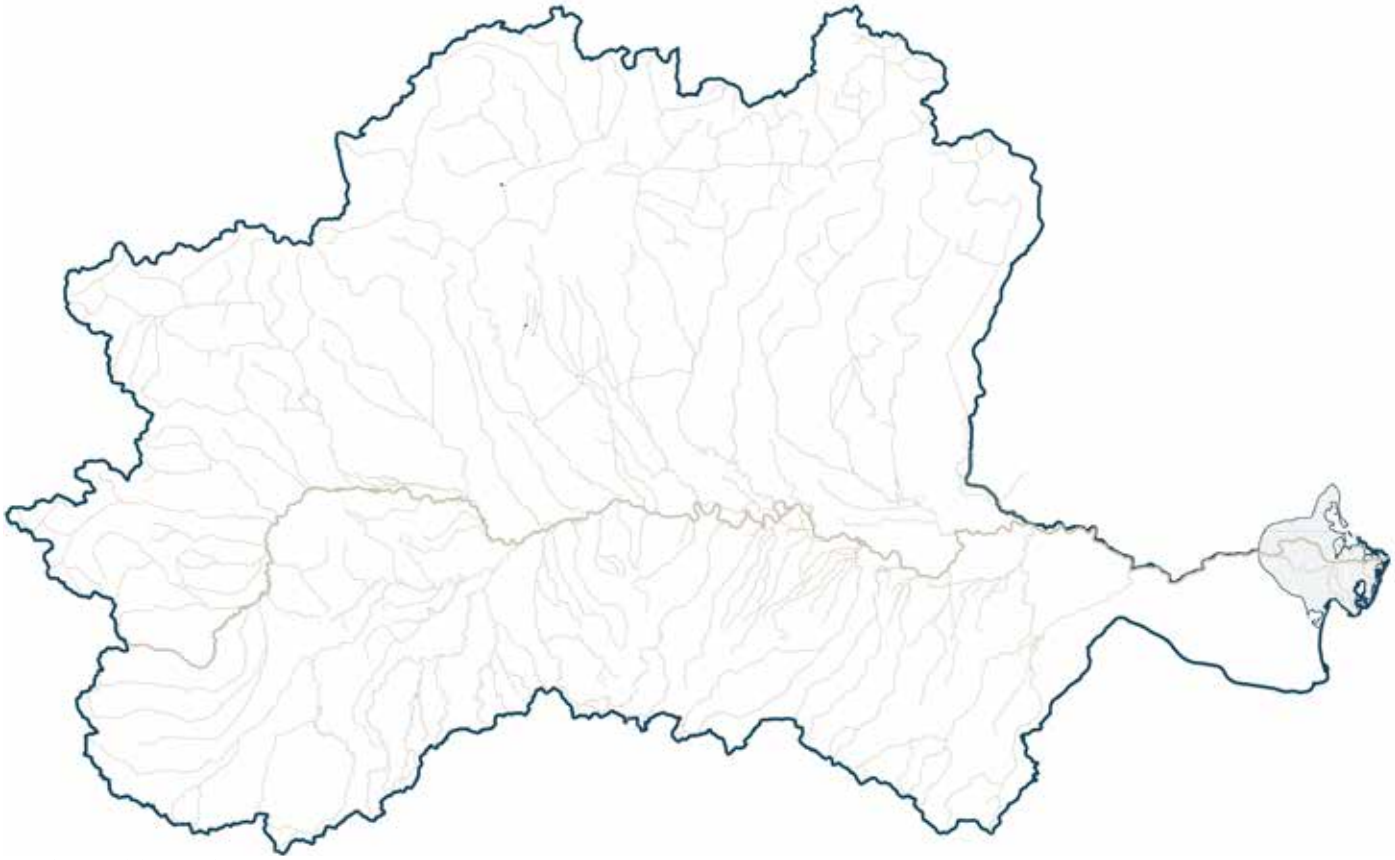


DIAGRAM-02: PO RIVER WATERSHED

This map shows the watershed of the Po river. The delta area is highlighted on the right. In this map you can see the vast area of tributary streams and rivers which flow into the Po river and exit in the area of Lido degli Estensi to the sea. Over the course of the history of the Po river, its streams and tributaries are in constant flux. This can cause dramatic changes in the course of the river and effect the overall dispersal of the watershed of the area.

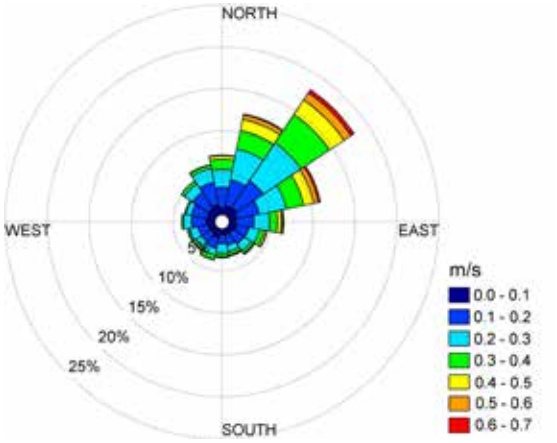


FIGURE 02: CURRENT ROSE PRODUCED BY THEADRIAROMS OCEANOGRAPHIC MODEL OPERATED AT THE HYDR-METEOROLOGICAL SERVICE OF THE ARPA EMILIA-ROMAGNA

This diagram shows the speed, intensity and direction of the mos prevalent currents in the delta region around Ravenna and Comacchio. As you can see, the strongest currents come from a northeasterly direction.

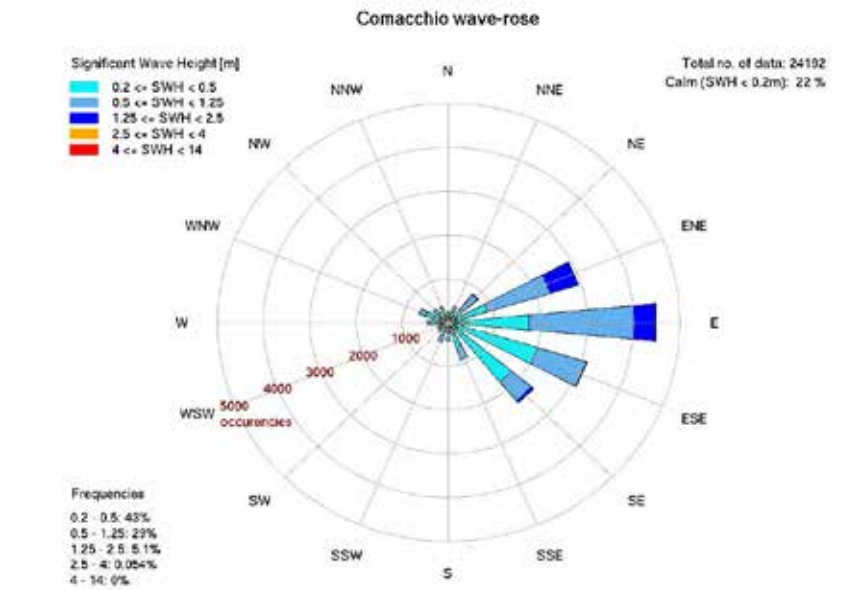


FIGURE 03: WAVE ROSE PRODUCED BY THE SWAN SEA STATE MODEL OPERATED AT THE HYDR-METEOROLOGICAL SERVICE OF THE ARPA EMILIA-ROMAGNA

This diagram shows the amplitude, frequency and direction of waves in Comacchio. With a sample of 24192 waves in taken in a relatively normal period the diagram shows a distinct pattern of east facing waves.

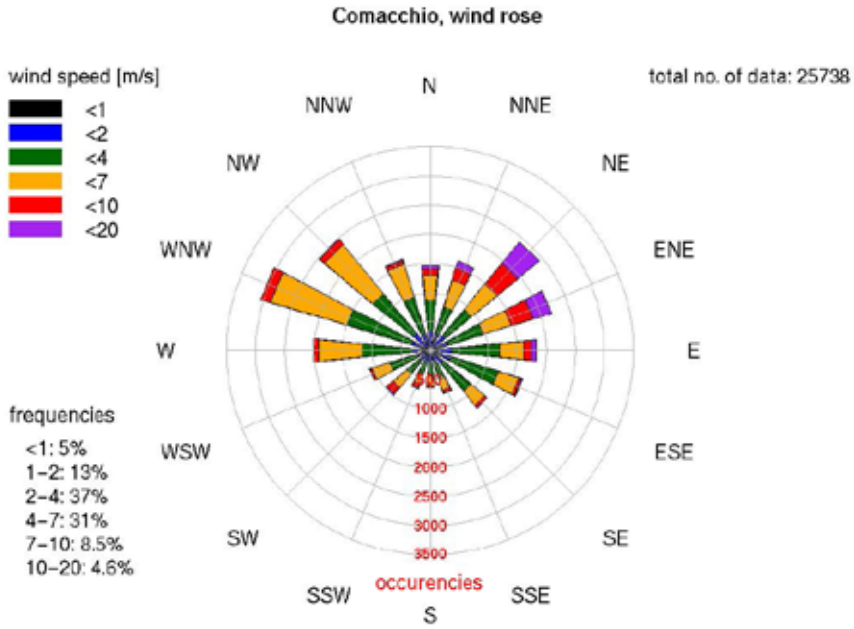
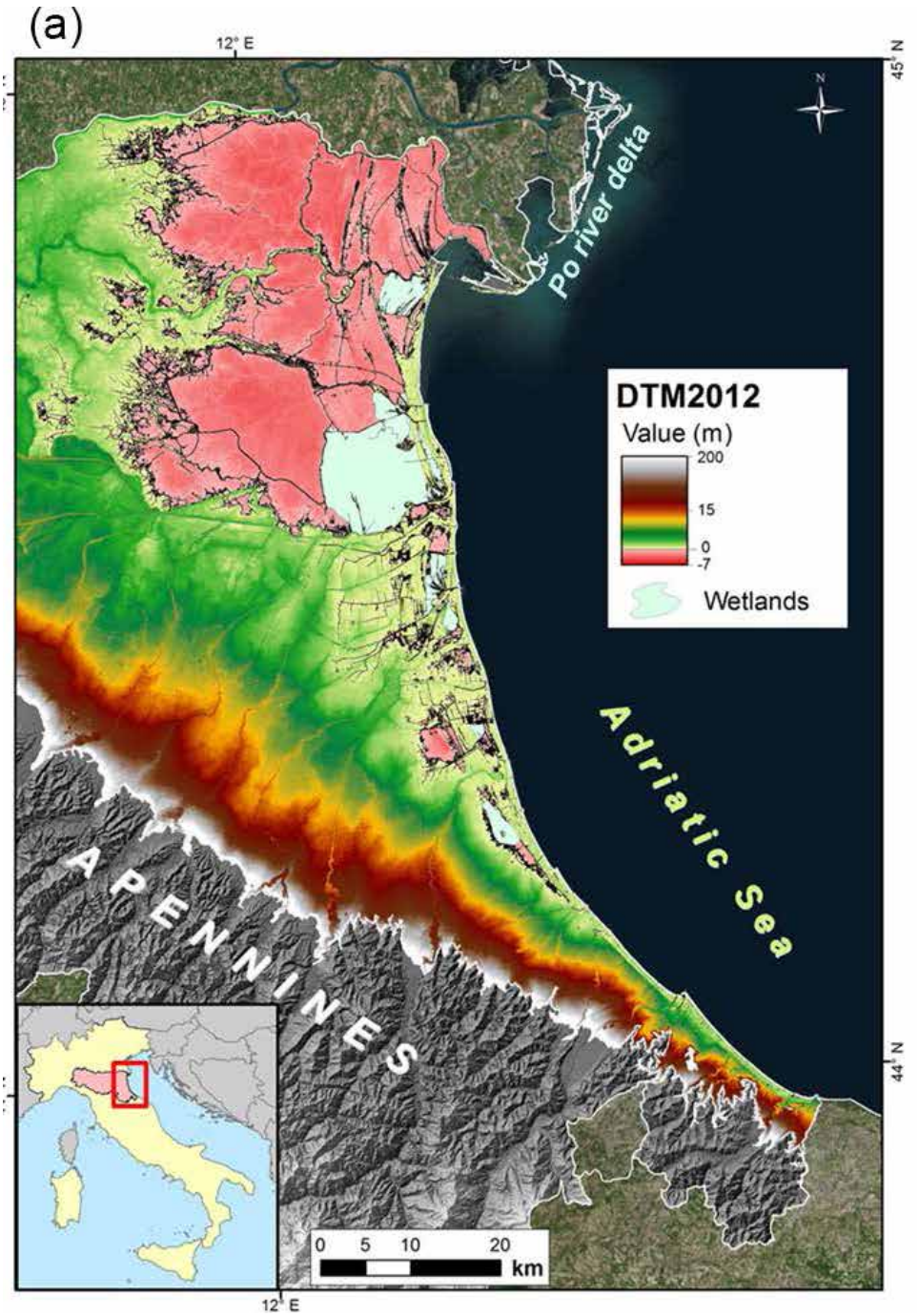


FIGURE 01: WIND ROSE PRODUCED BY THE LAMA METEOROLICAL MODEL OPERATED AT THE HYDR-METEOROLOGICAL SERVICE OF THE ARPA EMILIA-ROMAGNA

The corresponding wind rose depictied here shows the speed, frequency and direction of wind in the Comacchio region. The wind is predominantly North facing. With the most occurences occuring in the Northwest and the West Northwest regionions. However the most severe winds (greater than 20m/s) occurred most frequently in the Northeast direction in correlation with the currents.

Subsidence


(a)
12° E
45° N
44° N
12° E
Po river delta
DTM2012
Value (m)
200
15
0
-7
Wetlands
Adriatic Sea
APENNINES
0 5 10 20
km

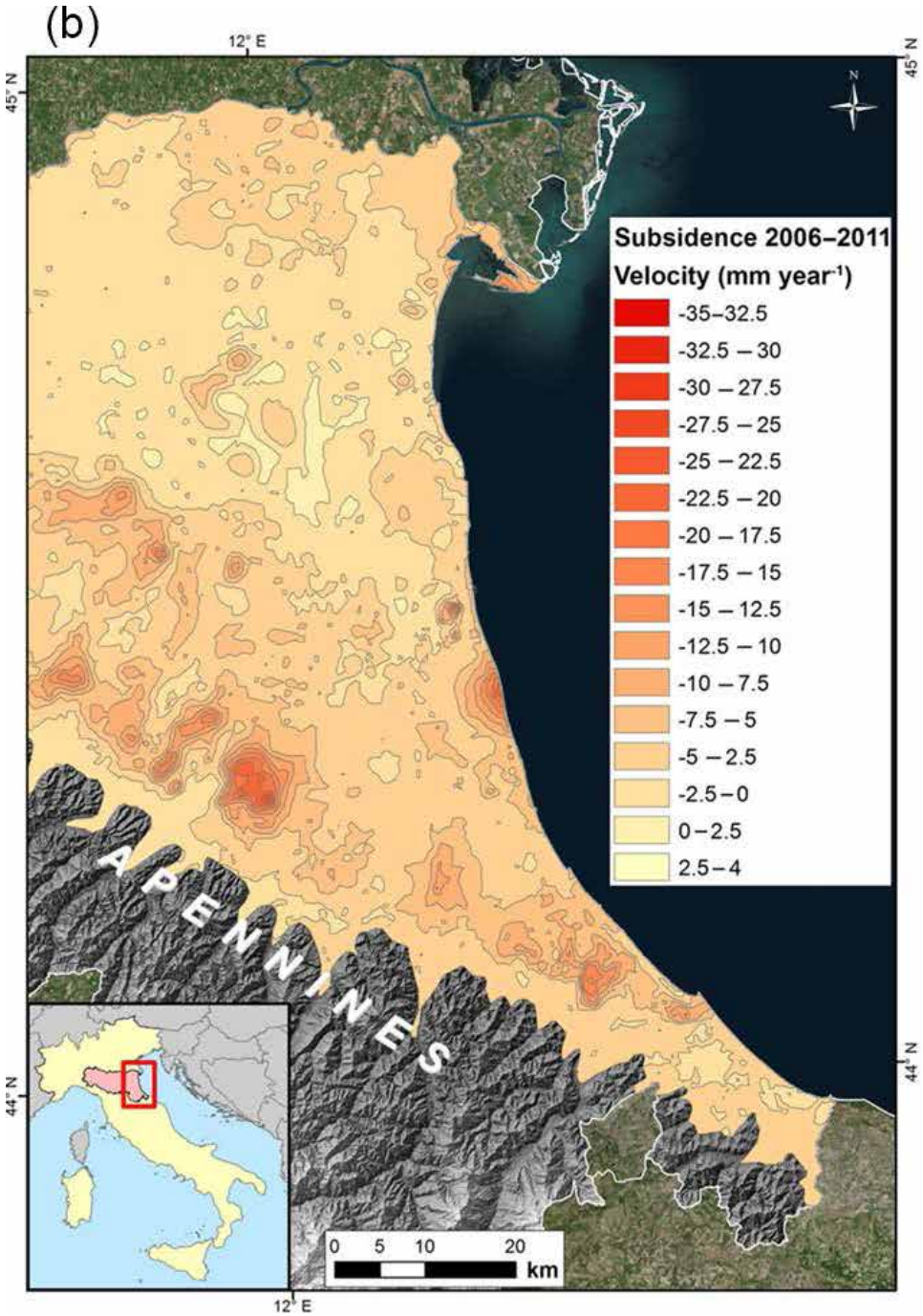
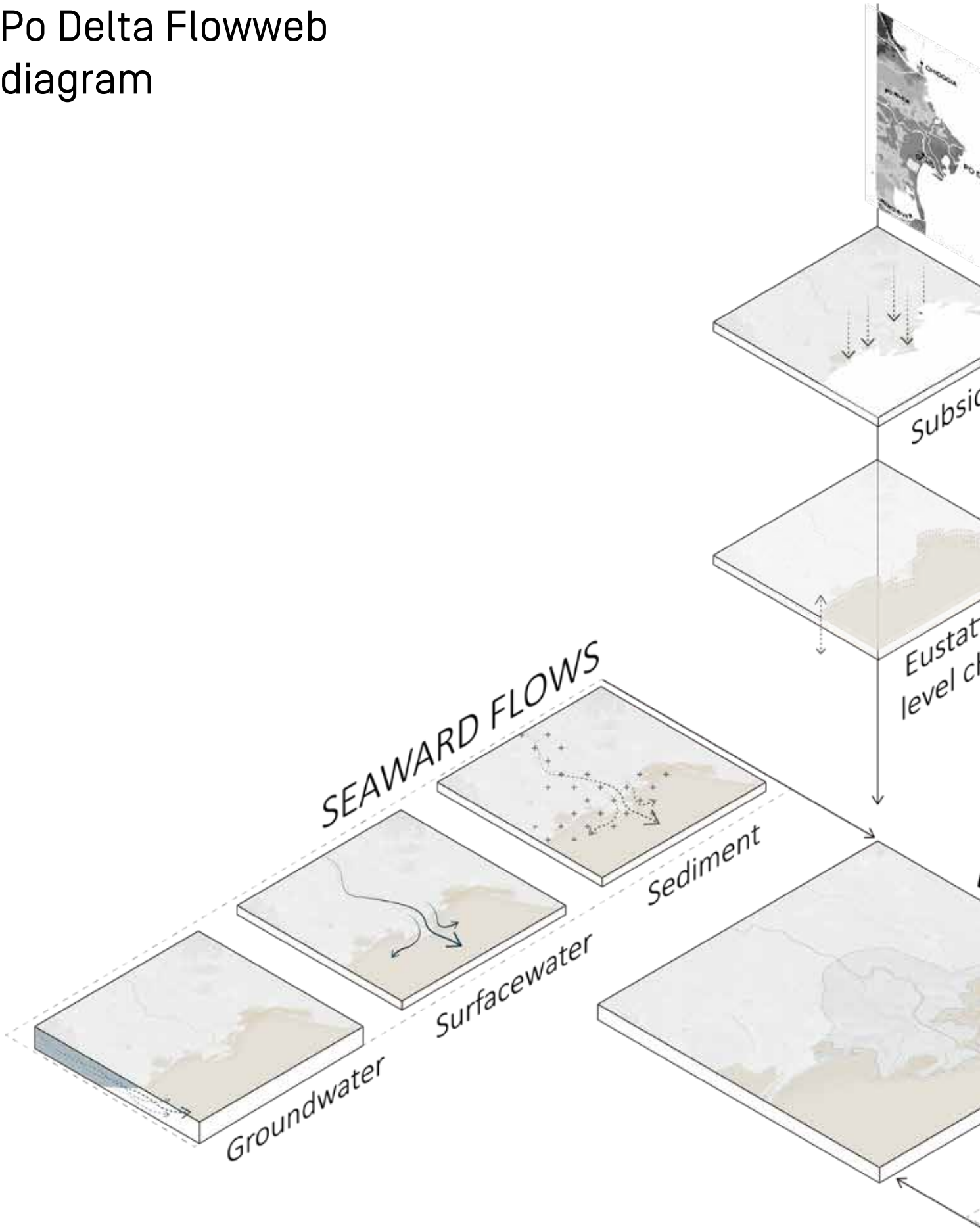


FIGURE 04: DTM AND SUBSIDENCE 2008-2011 FROM PERINI [2017]

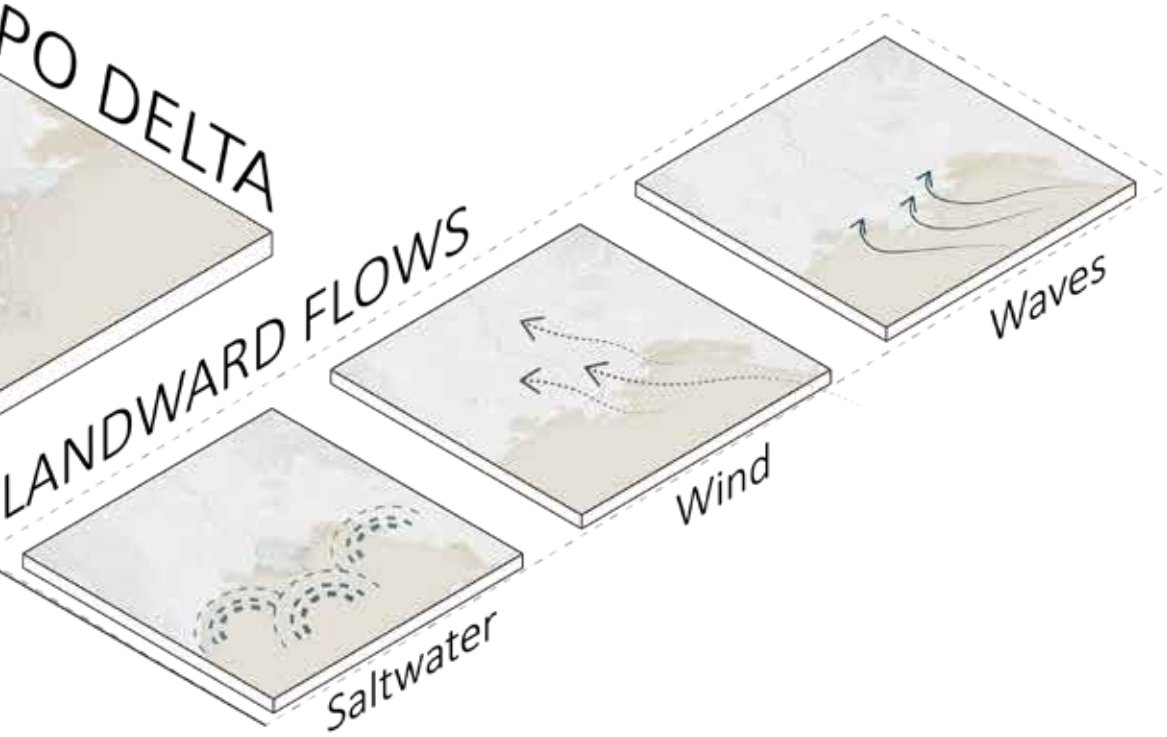
This diagram shows the levels of subsidence occuring in the Po River Delta region. You can see that the river has a big influence on subsidence where the main outflows of the river appear to be showing the highest levels of subsidence.

Po Delta Flowweb diagram



DIAGRAM–03: PROCESS

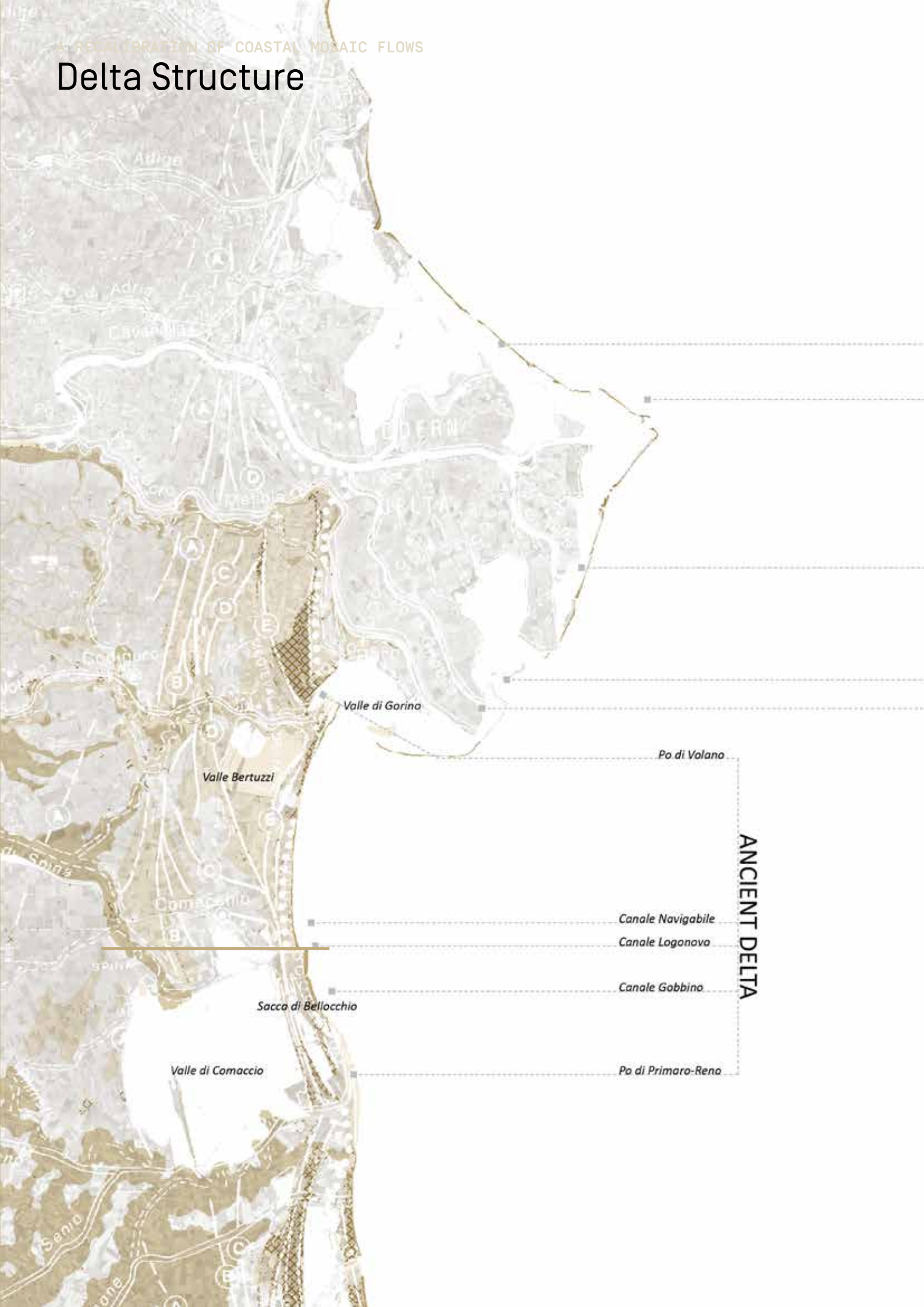
This diagram demonstrates some of the main process flows that drive the development of the Po River Delta. They can be divided into three main forces, seaward flows, landward flows, and coastal changes. The seaward flows show the effect of three main forces of flow from the Po river and its watershed, the groundwater, surfacewater, and sediment. The landward flows are defined by the forces of the sea, which are the currents of the sea, the wind, and the waves. Lastly there are the coastal changes, which are defined by subsidence and eustatic sea level change. Seaward flows create groundwater discharge zones, drainage basin divides, and sediment plumes. While, landward flows influence coastal microclimate zones, vegetation zonation, and saltwater intrusion (Forman, 2010)



2.2 Ancient Po Delta Mosaic Structure Through Time

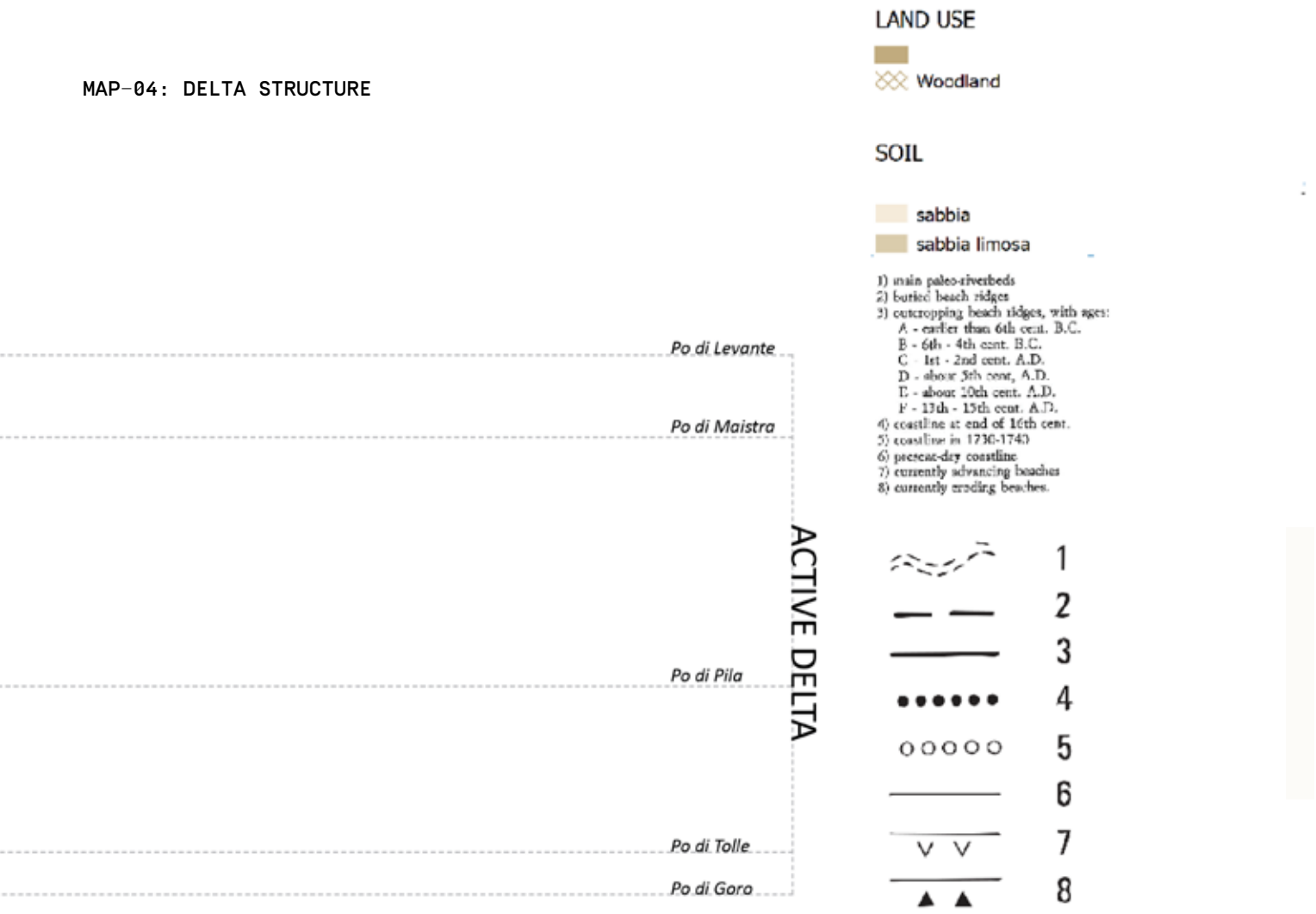
As the proccess flows transfer energy and materials across the Po Delta, the resulting structure is evident over time and space. Different spatial patterns presented over times as flows ebbed and flows. The delta mosaic today consists of gradients of wetness from salt marshes, lagoons and beach ridges, ancient and modern.

Delta Structure

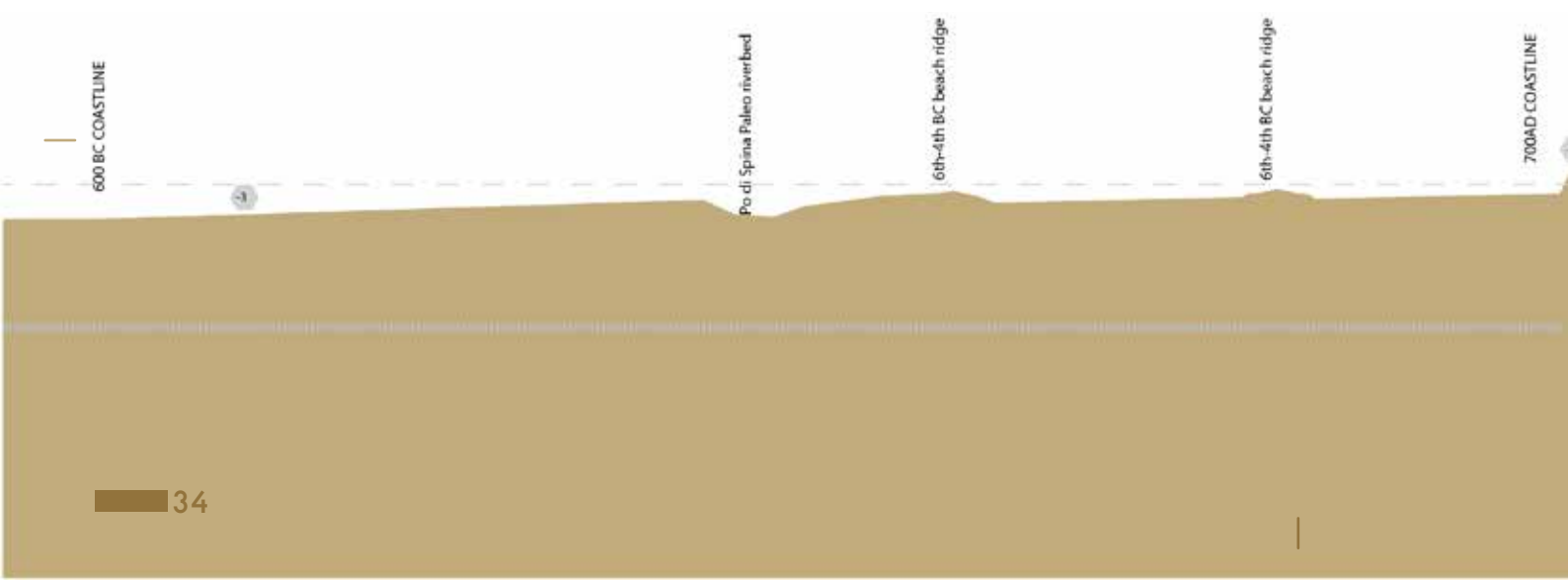


Structure Map

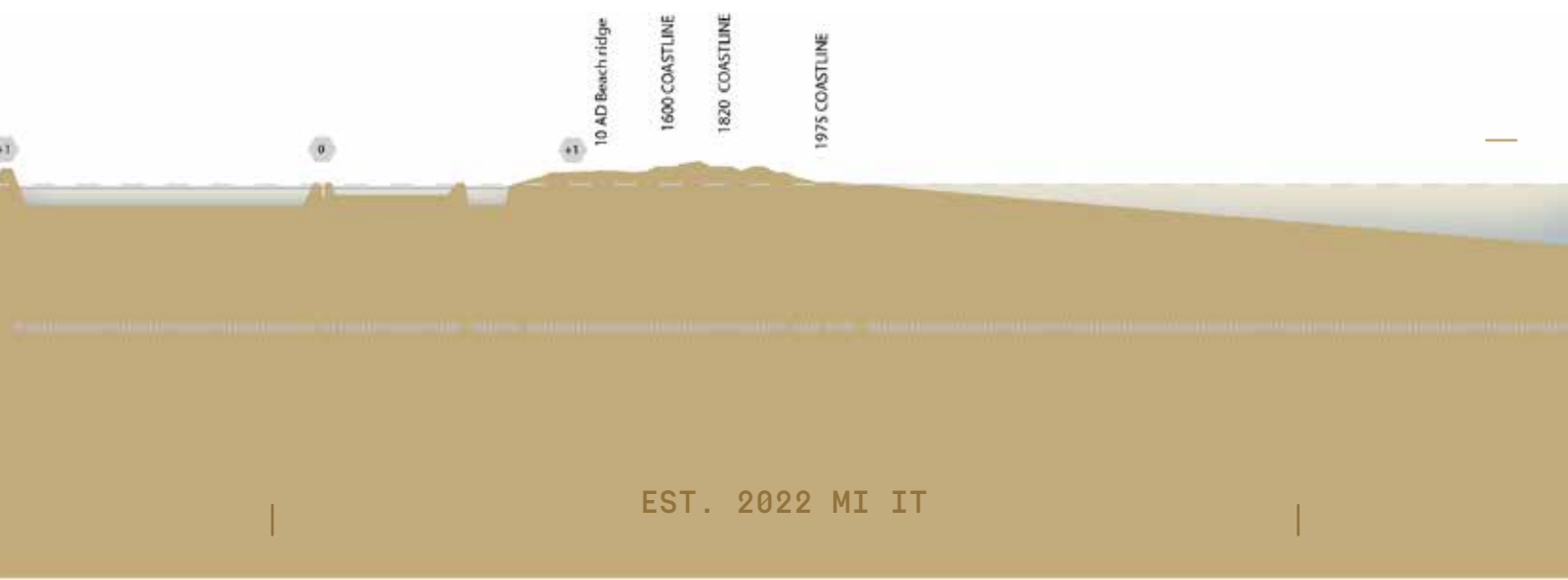
MAP–04: DELTA STRUCTURE



Section


600 BC COASTLINE
Po di Spina Paleo riverbed
6th-4th BC beach ridge
6th-4th BC beach ridge
700AD COASTLINE

DIAGRAM–04: SECTION



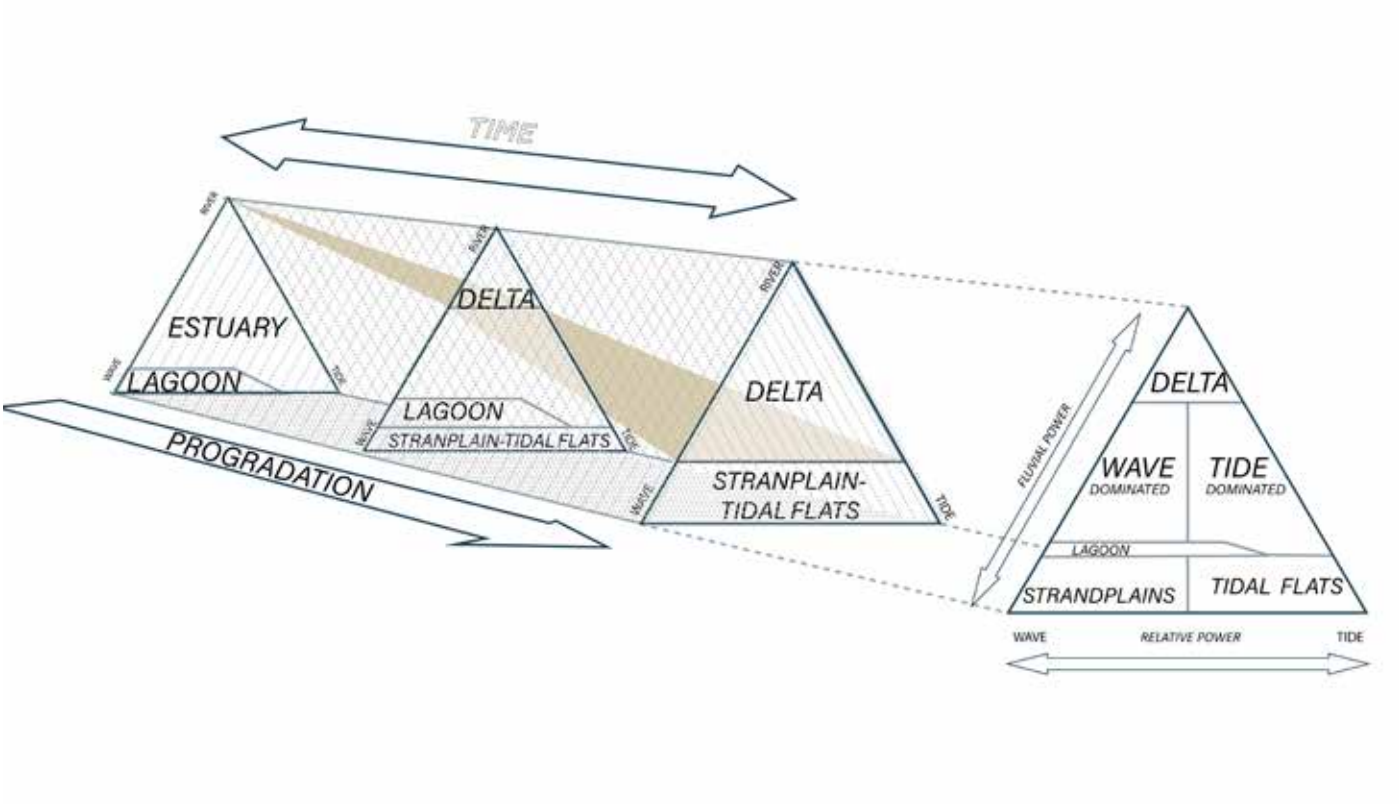
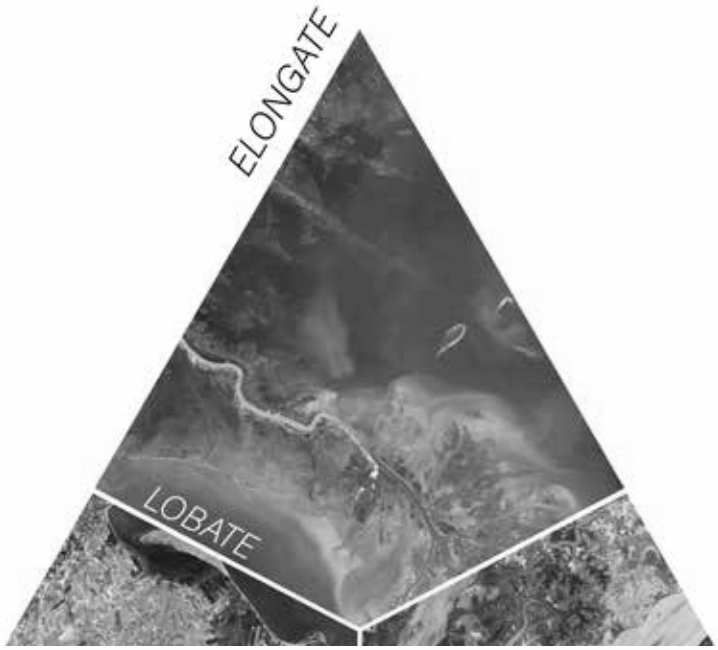
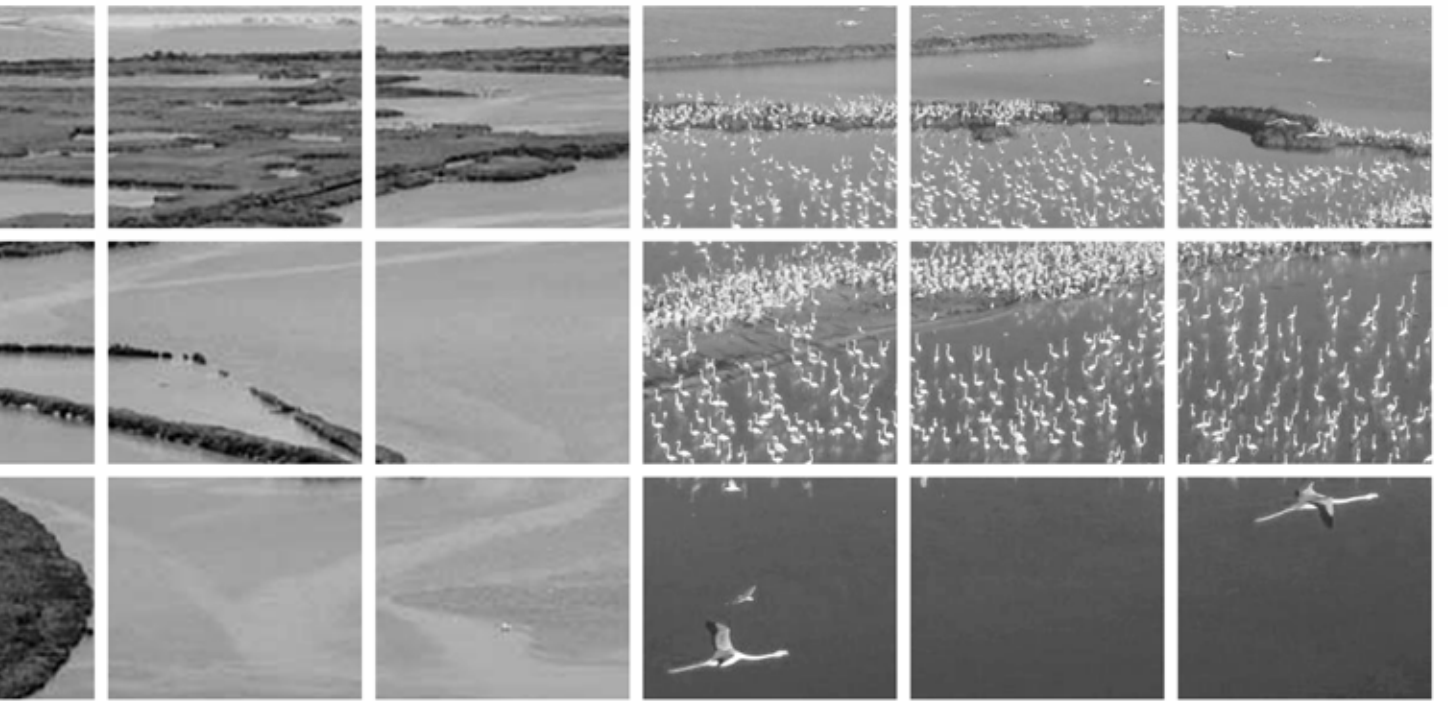

TIME
ESTUARY
LAGOON
DELTA
LAGOON
STRANPLAIN-TIDAL FLATS
DELTA
STRANPLAIN-
TIDAL FLATS
PROGRADATION
DELTA
WAVE
DOMINATED
TIDE
DOMINATED
LAGOON
STRANDPLAINS
TIDAL FLATS
FLUVIAL POWER
WAVE
RELATIVE POWER
TIDE

DIAGRAM-05: DELTA FORMATION TERNARY DIAGRMAS





Historical Development

DIAGRAM–06: TERNARY

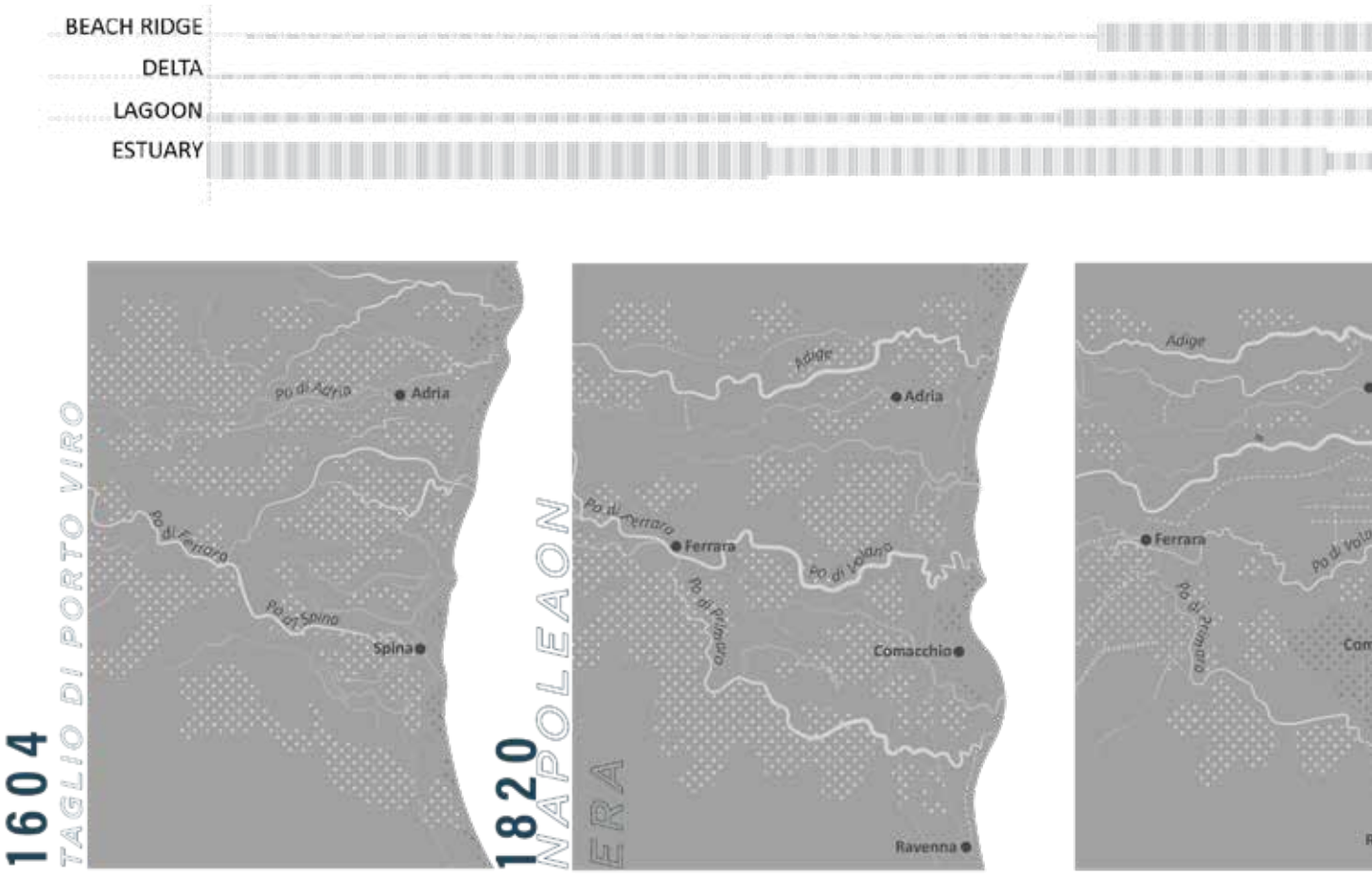
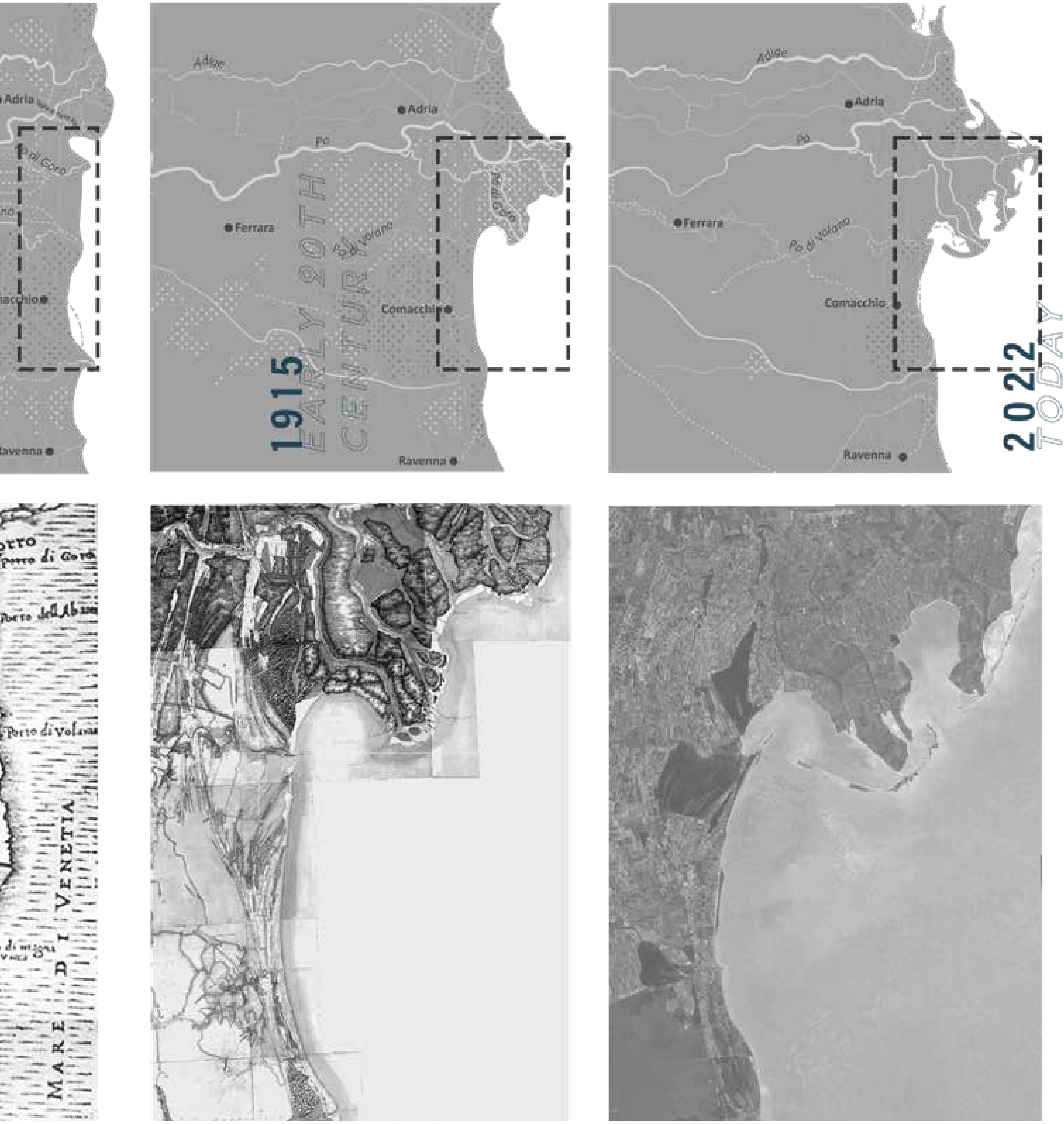


FIGURE 05: HISTORICAL DEVELOPMENT OF THE PO RIVER DELTA. SOURCE: CONSORZIO DI BONIFICA DELLA PIANURA DI FERRARA AND EMILIA-ROMAGNA REGION LUIGI COLÒ


1915
EARLY 20TH CENTURY
2022
TODAY
Adige
Adria
Po
Ferrara
Po di Volano
Po di Goro
Comacchio
Ravenna
MARE DI VENETIA
Porto di Volano

Landscapes shaped by man and water

FIGURE 06: SACCA DI GORO, RAMSAR WETLAND AND MPA SOURCE: FERRARA TERRA E ACQUA

1,300 Ha of isolated stretch of active dunes formed by sedimentation from the Po di Goro. The mouth of which mouth holds lots of biodiversity several endemic species and some threatened species.

FIGURE 07: LIDO DI VOLANO. SOURCE: TROVASPIAGGE

This recently deposited stretch of beach has a modern port and is near the mouth of, Volano, the oldest branch of the Po and surrounded by Foce di volcano Nature reserve (Pineta di volano).

FIGURE 08: PINETA DI VOLANO SOURCE: ERREPI IMMOBILIARE

120 ha of newly formed beaches from marine deposits. The formation of typical dune landscape is possible here. In the mid-1930's afforestation was carried out with pine species.

FIGURE 09: VALLE BERTUZZI SOURCE: FERRARA TERRE E ACQUA

3100 ha of partially man made large brackish wetland with a system of emergent and submerged banks (remains of dunes) with halophile vegetation and Quercus ilex forests and a hub for biodiversity.

FIGURE 010: PORTO GARIBALDI SOURCE: AGENZA DANILO

Seaside village with small ancient fishing port, boasting the first beach resort on the coast. Main economic drivers are fishing and tourism as one of the most important port in the upper adriatic. Tours to the delta leave from here.

FIGURE 011: RAMSAR WETLAND, VALLE DI COMACCHIO SOURCE: DELTA DUEMILA

13,500 ha and the most extensive palustrine wetland (inland brackish nontidal wetland) in Italy. From fresh to brackish to hypersaline water and a vast diversity of habitats thats been highly modified by man.

FIGURE 012: RAMSAR WETLAND, BELLECCHIO SAC SOURCE: ARPA EMILIA ROMAGNA

223 ha of brackish lagoon separated from adriatic sea by dune ridges. It is vegetated by typical mediterranean scrub and shrubs to west.

FIGURE 013: PINETA DI VOLANO SOURCE: ERREPI IMMOBILIARE

120 ha of newly formed beaches from marine deposits. The formation of typical dune landscape is possible here. In the mid-1930's afforestation was carried out with pine species.

FIGURE 014: PIALASSE DELLA BAIONA SOURCE: RAVENNA TURISMO

1,630 ha of open countryside with brackish wet meadows, artificial canals and intertidal wetlands that accept water from the Lamone river. Widely used by citizens of Ravenna for recreational activities such as mussle harvesting, hunting and fishing.

FIGURE 015: PINETA SAN VITALE SOURCE: ARPA EMILIA ROMAGNA

Ancient pine forests upon fossil dunes from planted by monks in the middle ages. It is the quintessential forest archetype of Ravenna and one of the last remnants of such a forest.

FIGURE 016: RAMSAR WETLAND, ORTAZZO E ORTAZZINA SOURCE: RAVENNA AND SURROUNDINGS.IT

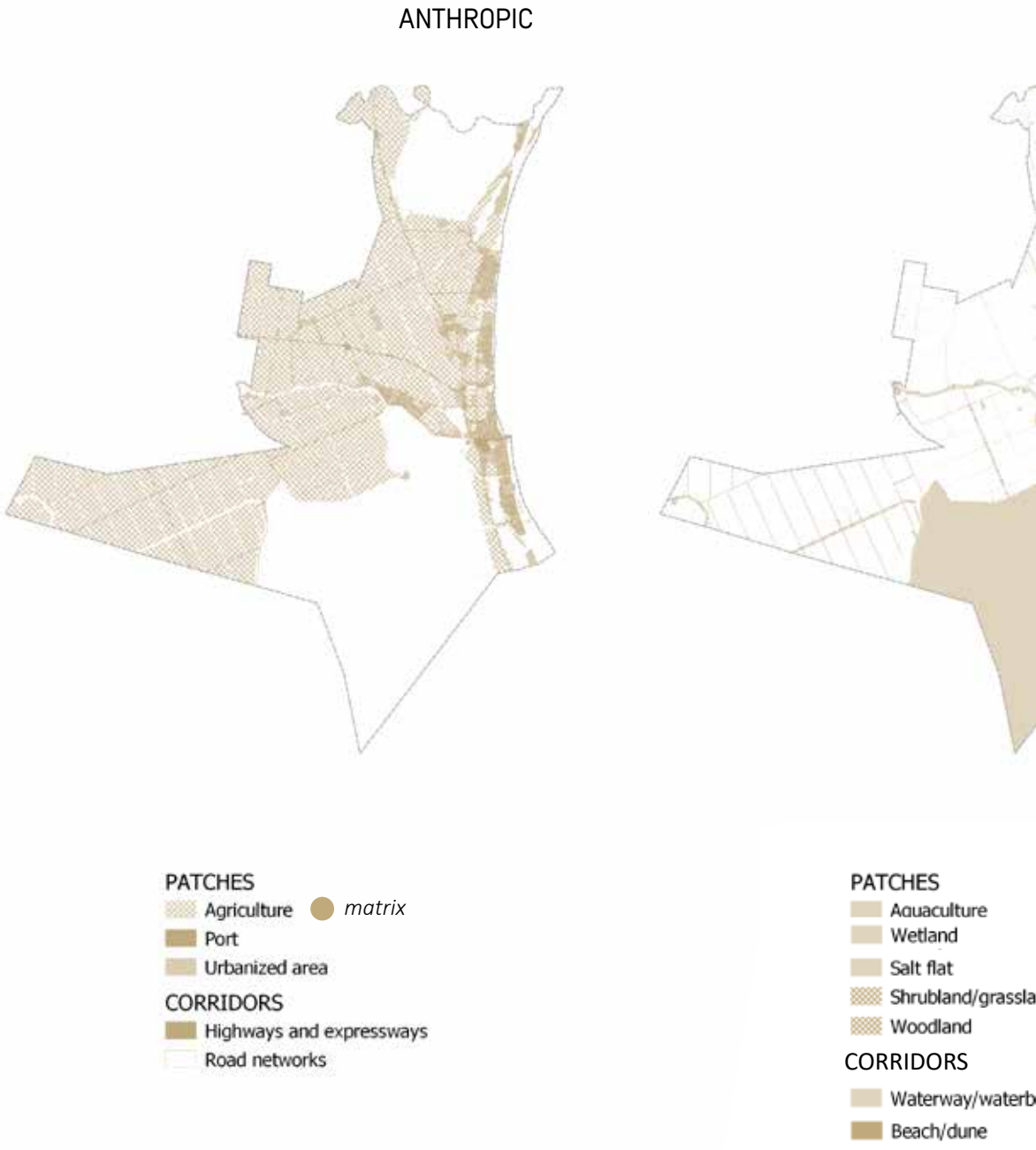
440 ha of diverse coastal system with stretches of active dunes and shrubs and oxbow lake at the mouth of the Bevano stream.

2.3 Flows And Functions Across The Mosaic

As we've seen, the arrangement of todays spatial elements (patches, corridors, edges) can be influence flows. However flows are also determined by the spatial structure and form of a place.

The regular grid of spatial elements created by man creates a predictable pattern that is repeated throughout the mosaic.
- in coastal zones spatial patterns are predictable and repeated within a given mosaic. in fact, a mosaic boundary can be determined by the [change in the sequence of ecosystem clusters or land uses
- these flows create clusters of ecosystems or configurations which are energetically connected.

Patch, Corridor, and Protected Areas



DIAGRAM–07: PATCHES, CORRIDORS AND PROTECTED AREAS FOR BOTH ANTHROPIC AND ECOLOGICAL PURPOSES

Spatial elements that make up the mosaic within the Comacchio municipality. We can see a highly fragmented mosaic composed of an agricultural matrix. Much of the wildlife patches and corridors have been protected since the 1990's.

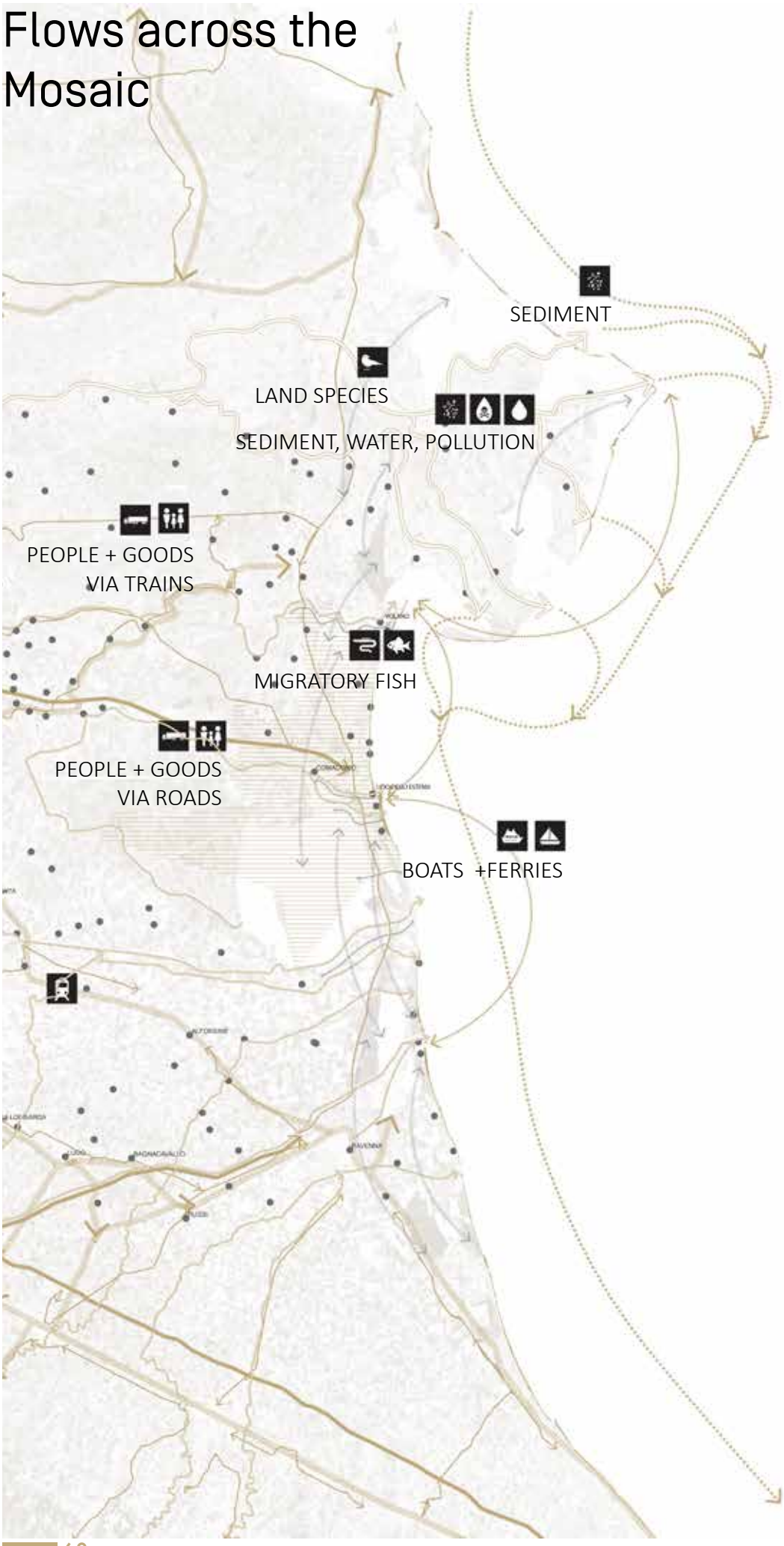
NATURAL

PROTECTED
AREAS

nd

ody

Flows across the Mosaic



MAP–05: FLOWS ACROSS THE MOSAIC

This map demonstrates the network of flows and their subsequent synergies and conflicts created by the regular grid of the coastal mosaic (Forman, 2010). Road infrastructure and access to public transfort determines the patterns of tourist concentrations. We can see that there is a large gap in accessibility by train. Most main roads flow perpendicular and their intersected by fewer parallel roads. These intersecting lines create a regular grid that can inhibit access to wildlife and impede movement.

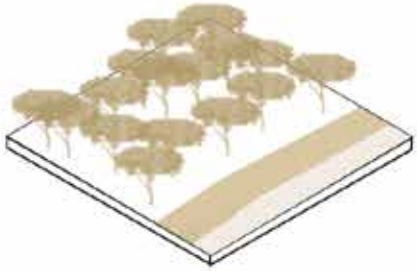
Ecosystem Clusters: flows at a spatial scale

LINEAR

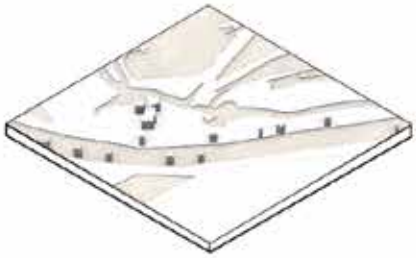
PARALLEL

COASTAL SETTLEMENT > BEACH > SEA >

PINE FOREST > BEACH > SEA >



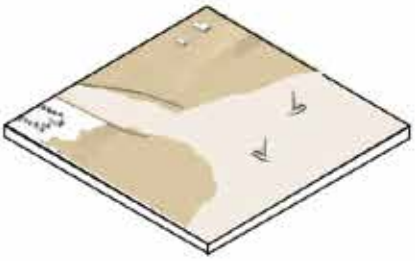
BILANCIONI (FISHING HUT) > CANAL >



WETLAND > FOREST >

PERPENDICULAR

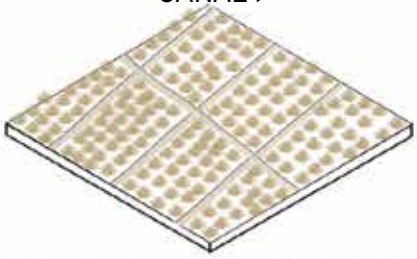
BILANCIONI (FISHING HUT) > CANAL >



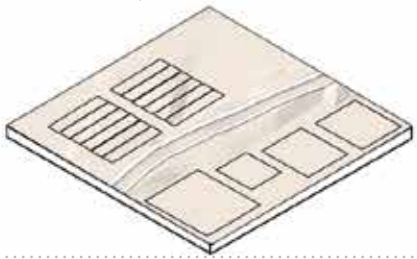
BILANCIONI (FISHING HUT) > CANAL >

REGULAR

AGRICULTURAL FIELD > CANAL >

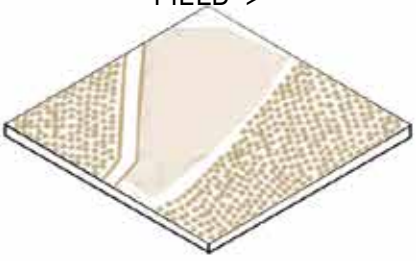


SALT FLAT > AQUACULTURE >

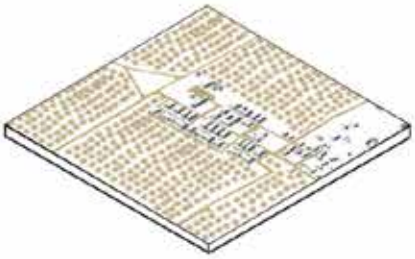


AGGREGATED

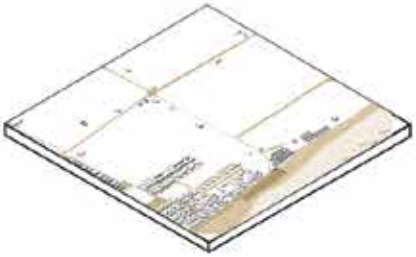
LAGOON > CANAL > FIELD >



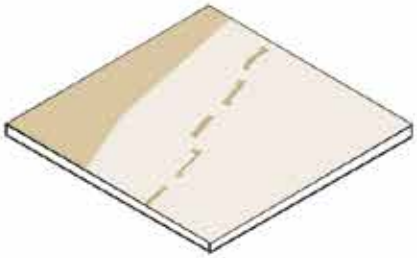
SETTLEMENT > FIELD



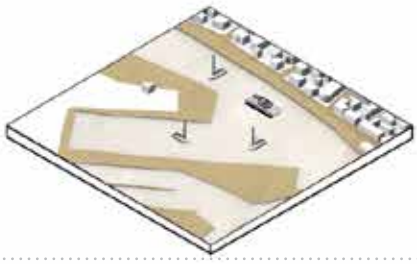
ROADS> SETTLEMENT > SEA >



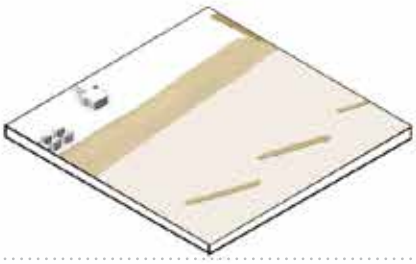
COASTAL BARRIERS > BEACH > SEA >



TOURIST PORT > CANAL >



WASTEWATER DISCHARGE > SEA >



BEACH RESORT > BEACH > SEA >

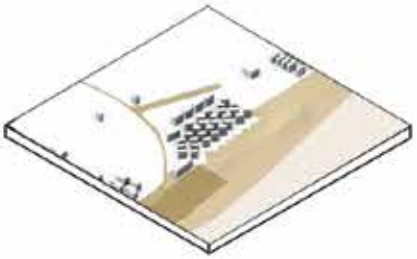


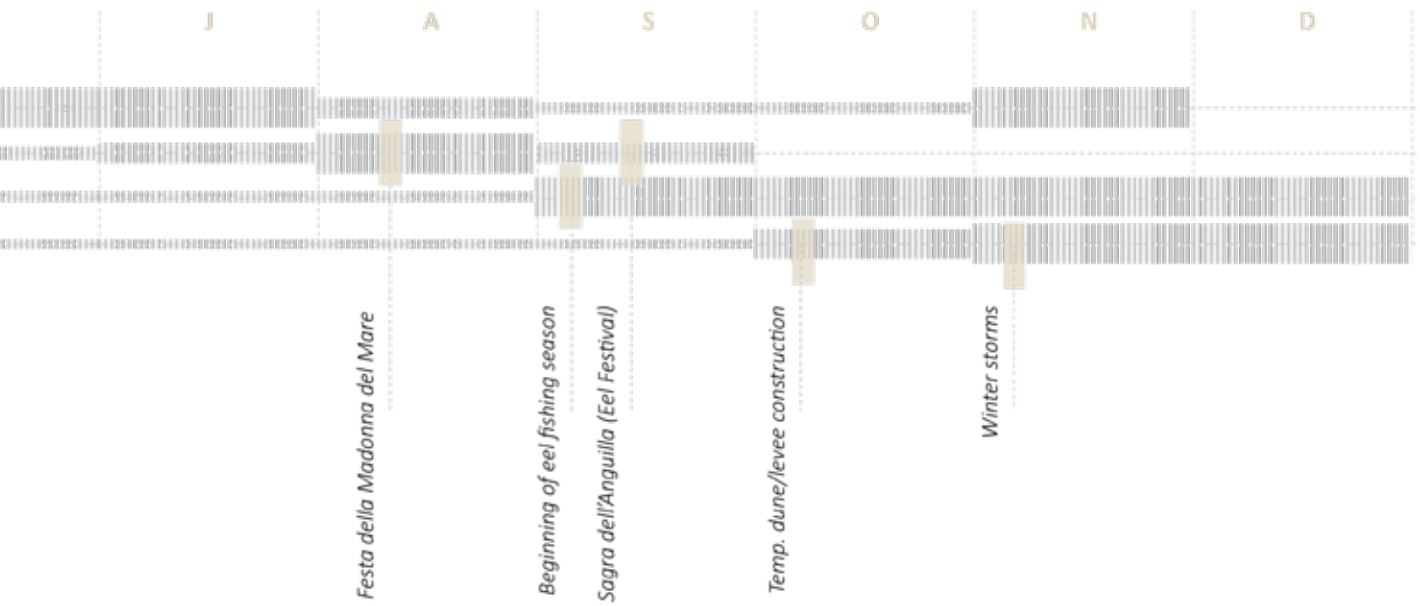
DIAGRAM-08: ECOSYSTEM CLUSTERS

Ecosystem clusters are a collection of landscape elements that share a significant amount of flows at a scale smaller than a landscape and larger than an ecosystem. These ecosystem clusters exhibit typical spatial patterns that are repeated through out the Emilia-Romagna coast and are characteristic of this particular mosaic. They share flows of energy and materials from both man and wildlife/nature.

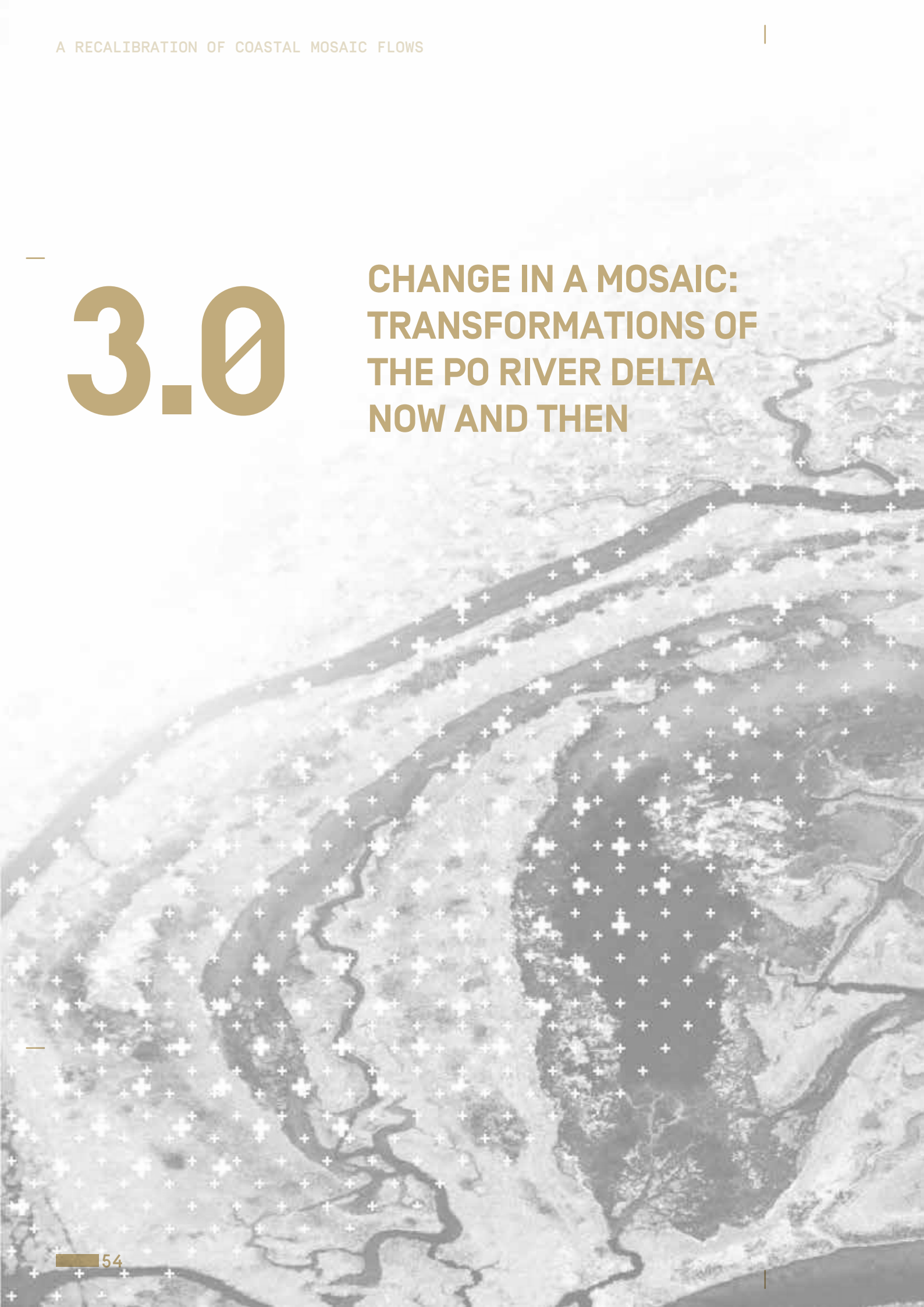
Flows working on a temporal scale

DIAGRAM–09:
FLOW/FUNCTION CALENDAR

Flows work not only on a spatial scale but also a temporal scale. we can see cyclical diurnal and seasonal variations very evidently on the coast as sunlight, atmospheric and oceanic conditions determine aquatic and human activities. Many traditions and cultures are centered aound the migration of fish inland through canals and lagoons and seasonal tourism booms during the summer periods while winter storms can ravage infrastructure.



3.0 CHANGE IN A MOSAIC: TRANSFORMATIONS OF THE PO RIVER DELTA NOW AND THEN



Subchapters

INTRO

In the structure-function feedback principle, it is necessary to factor in change. Two of the most influential drivers of mosaic patterns are natural disturbances that often create heterogeneity, while human activity is instrumental in delineating patches, corridors, and boundaries.

In the Po River Delta, the implications of these two mechanisms at play will impact the way planners make decisions and design in the future. Forman stated, "What we see today was produced by flows yesterday" (1995). Though flow alterations across this mosaic boosted the regions economy, the imbalance created has now reduced the resiliency of its natural coastal defenses that are both the backbone of the economy and the frontlines against a rising sea. As climate change brings greater frequency and intensity of storms, urban areas and unique natural habitats are threatened by inundation and destabilization.

This chapter will explain the significant changes of the past, present, and future that have and will ultimately transform the structure of the mosaic. We'll see how human activities have reduced heterogeneity of the mosaic and imposed controls to tame the waterscape of the delta. Additionally, we'll see how the consequences of such imbalances will be tested during the Anthropocene and climate change-induced sea level rise.

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3.1 Human Actions and a Mosaic of Control

Man has been recorded on the Po river delta since the 10th century BC. Most noteably, the ancient Etruscan port city of Spina, located at the mouth of the ancient delta, was an important hub of the ancient amber trade from the 6th -the 3rd centuries BC. The city colonized emergent isles among dunes with an urban fabric of wood-bounded channels and regular orthogonal axes of waterlogged settlements (Museo Delta Antico, 2022).

During the Roman era, mass deforestation encouraged the development of agriculture in this region although no centuriation was carried out in the Ferrara Province. Comacchio emerged during the 7th century as another trade post and fishing village on an island amongst the great marshes of the delta (Museo Delta Antico, 20022). However, it wasn't until the 15th century AD that the modern delta was constructed when Venetianhydraulic engineers diverted the Po southwards towards Ferrara. The Taglio di Porto Viro was executed in hopes to prevent the sediment deposits of the Po and the Adige from blocking the mouth of Venice Lagoon, thus cutting off the 'renaissance delta' from the Po watershed entirely (Bondesan, 1989). The delta we see today, south of the abandoned one, was formed with the consistent intervention of the Venetians and the branching of several new streams.

Due to an improvement in reclamation techniques, agriculture grew exponentially in Ferrara and the Po River Delta, making the region one of

Evidence of Ancient civilizations

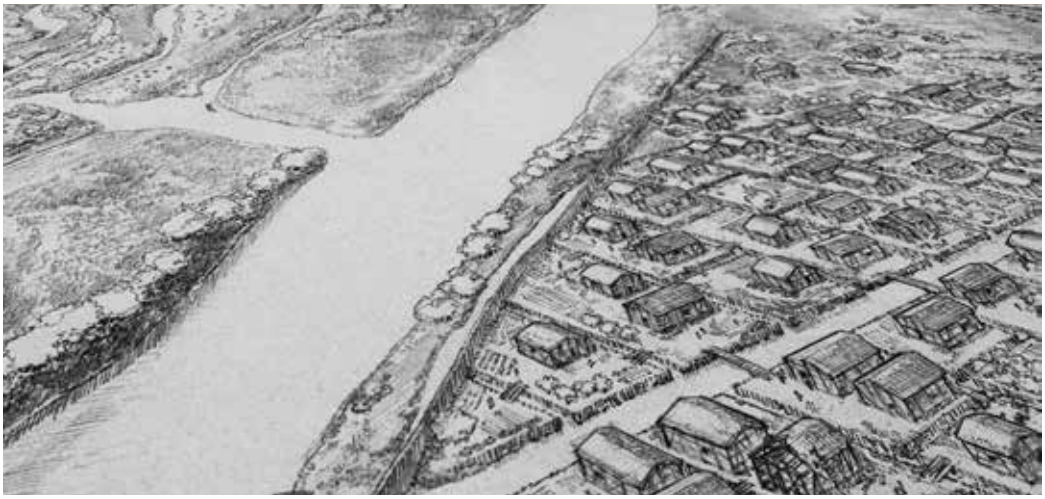


FIGURE 017:
REPRESENTATION OF THE CITY OF SPINA SOURCE: MUSEO DELTA ANTICO [2022]

FIGURE 018:
REPLICA OF TOMB EXCAVATION SITE
SOURCE: MUSEO DELTA ANTICO [2022]

FIGURE 019:
AMBER TRADE MAP
SOURCE:MUSEO DELTA ANTICO [2022]

FIGURE 020:
ETRUSCAN ARTIFACT FROM SPINA SOURCE: MUSEO DELTA ANTICO [2022]

FIGURE 021:
ROMAN EMPIRE AND TRADE
MAP SOURCE: MUSEO
DELTA ANTICO [2022]

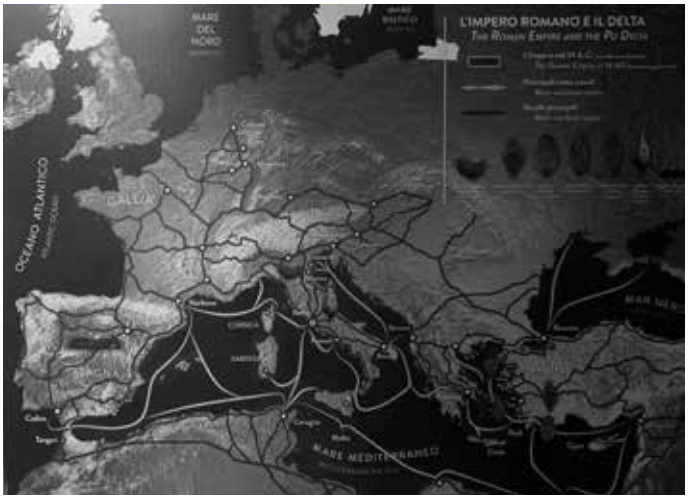


FIGURE 022:
ROMAN AMPHORAE SOURCE:
MUSEO DELTA ANTICO
[2022]

FIGURE 023:
REPRESENTATION OF
ANCIENT COMACCHIO
SOURCE: MUSEO DELTA
ANTICO [2022]

FIGURE 024:
TRADE MAP OF COMACCHIO
SOURCE: MUSEO DELTA
ANTICO [2022]

the leading producers in the country. Thus, transforming an organic waterscape of lagoons and wetlands into a regular grid of rectangular fields border embankments with trees and vines of the 'baulatura piantata' (Sereni, 2014). From 1870 the area of marshlands reduced from 89,000 ha to 56,000 in 1950, while cultivated lands grew from 120,000ha to 190,000 ha respectively (Sereni, 2014). Since the 1870's mechanized pumps (still in use today) were utilized when traditional landfill techniques were too difficult to employ, which led to an "agricultural revolution" that profoundly transformed the physical and social structures across the mosaic. For example, the proliferation of the 'larga' or open plain which is characterized by a large expanse of land that had recently been reclaimed by a large hydraulic network (Sereni, 2014).

In the remaining coastal marshes, ingenious solutions for trapping migratory fish and eels were devised that also imposed a more controlled and regular structure to the dynamic amorphous forms of the waterscapes. A vibrant fishing culture developed along the shores of these landforms that seemed to develop more in harmony with nature than in opposition to it. In the 1930s an afforestation initiative was carried out to protect coastal croplands from strong winds. Pine forests reminiscent of the ancient forests planted by monks were planted along the upper Emilia-Romagna coast.

Two decades later another transformation made way as a result of the new interest in the coast as a tourist destination. Housing, hotels, and tourism infrastructure were developed, often by large development corporations, to accept the growing flow of tourists to the coast. The following decades ('60s-'90s) marked the most intensive period of tourist development. Stretches of beach ridges are no longer populated by a succession of dunes and pine forests but are now lined by resort towns, camping sites, and bagni that need to be protected by winter storms with temporary 'dunes'. A fine grid of roads and buildings have been etched into the mosaic. These spatial transformations have bolstered coastal tourism, as it now represents 10% of the region's GDP (Barbanti et. al., 2018)

To conclude, man has played an integral part in the shaping of the structures of the delta mosaic since the 17th century. The reclaiming of land for agriculture and development of the coast for tourism have structurally transformed the mosaic and consequently altered the flow of water and the sediment it carries, as well as the people it sustains across the landscape. With higher embankments, a mosaic that once flooded can no longer expand beyond the boundaries of its river beds and fill the plain with sediment to combat subsidence. The flux in investment in agriculture resulted in the flux in working-class laborers from all regions to capitalize on the growing job market (Sereni, 2014). Finally, the sand trapping and storm surge buffering power of dunes and forests were replaced by tourist settlements that attract hundreds of thousands of visitors every summer and hardened coastal defenses.

FIGURE 026:
EMILIAN RICE FIELD IN MONDINE 1940 BY ALDO BORGONZONI. SOURCE: SERENI 2014

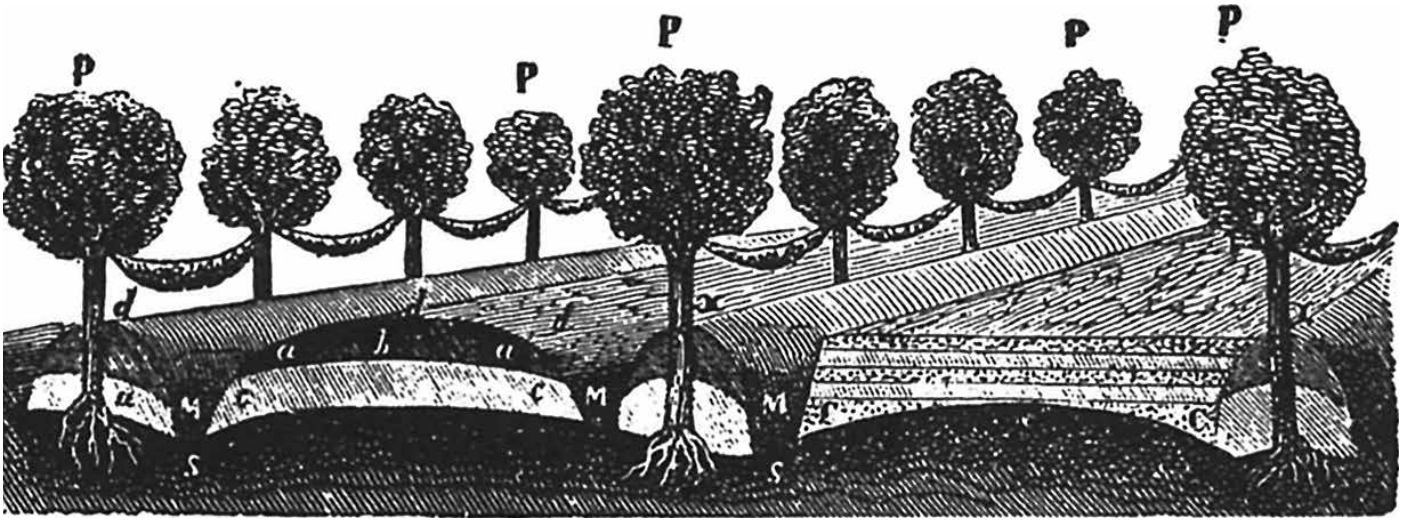
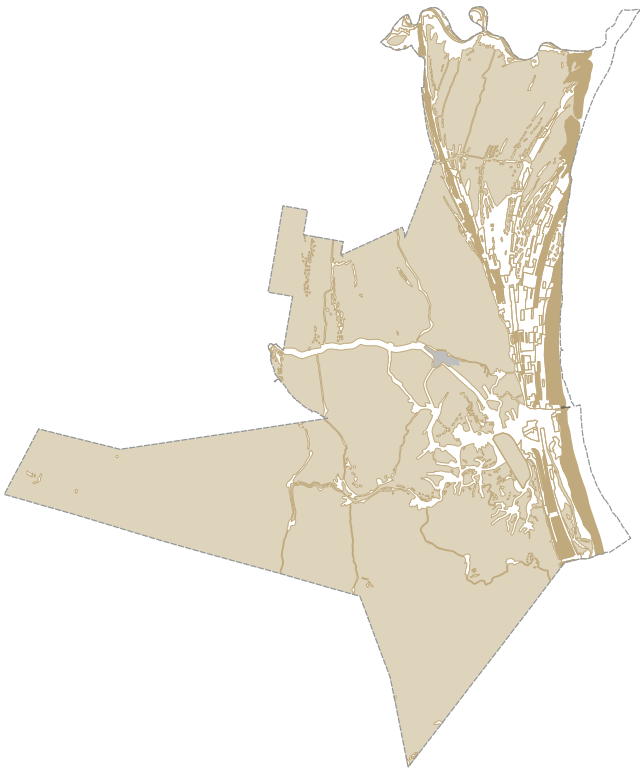


FIGURE 025:
BOLOGNESE PIANTATA IN THE EARLY NINETEENTH CENTURY FROM THE ISTITUZIONI DI AGRICOLTURA BY BERTI-PICHAT SOURCE: SERENI, 2014

Reclamation and Development from the 19th to 21st Century

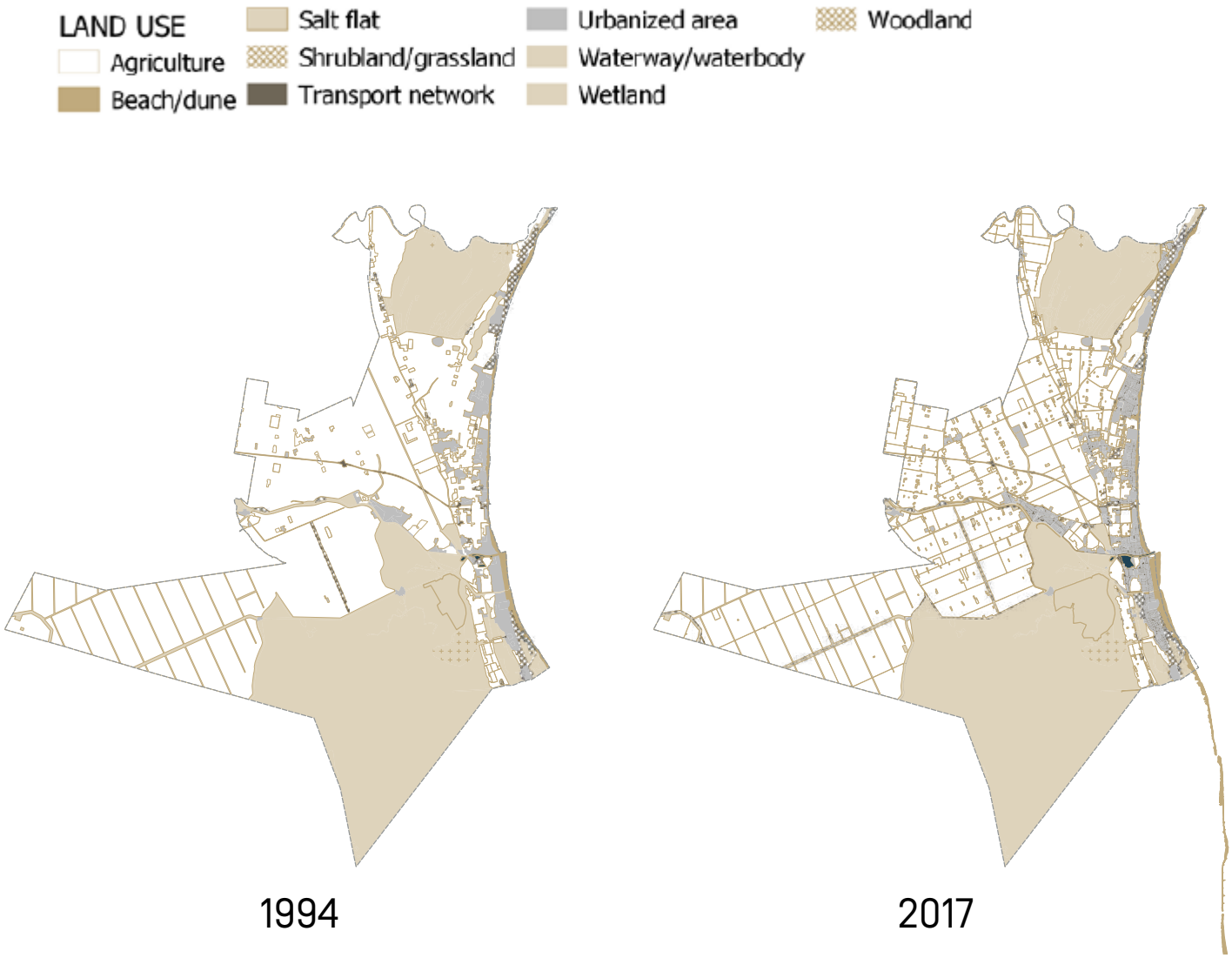


1853

1976

DIAGRAM–010:
RECLAMATION AND
DEVELOPMENT OF
COMACCHIO COMMUNE
DIAGRAM

This diagram demonstrates the land use changes over the last two centuries. We can see that as agriculture and urban development increased the mosaic became more regular and fine scaled. The area of wetlands, forests and beaches saw a drastic decline.


LAND USE
Agriculture
Beach/dune
Salt flat
Shrubland/grassland
Transport network
Urbanized area
Waterway/waterbody
Wetland
Woodland
1994
2017

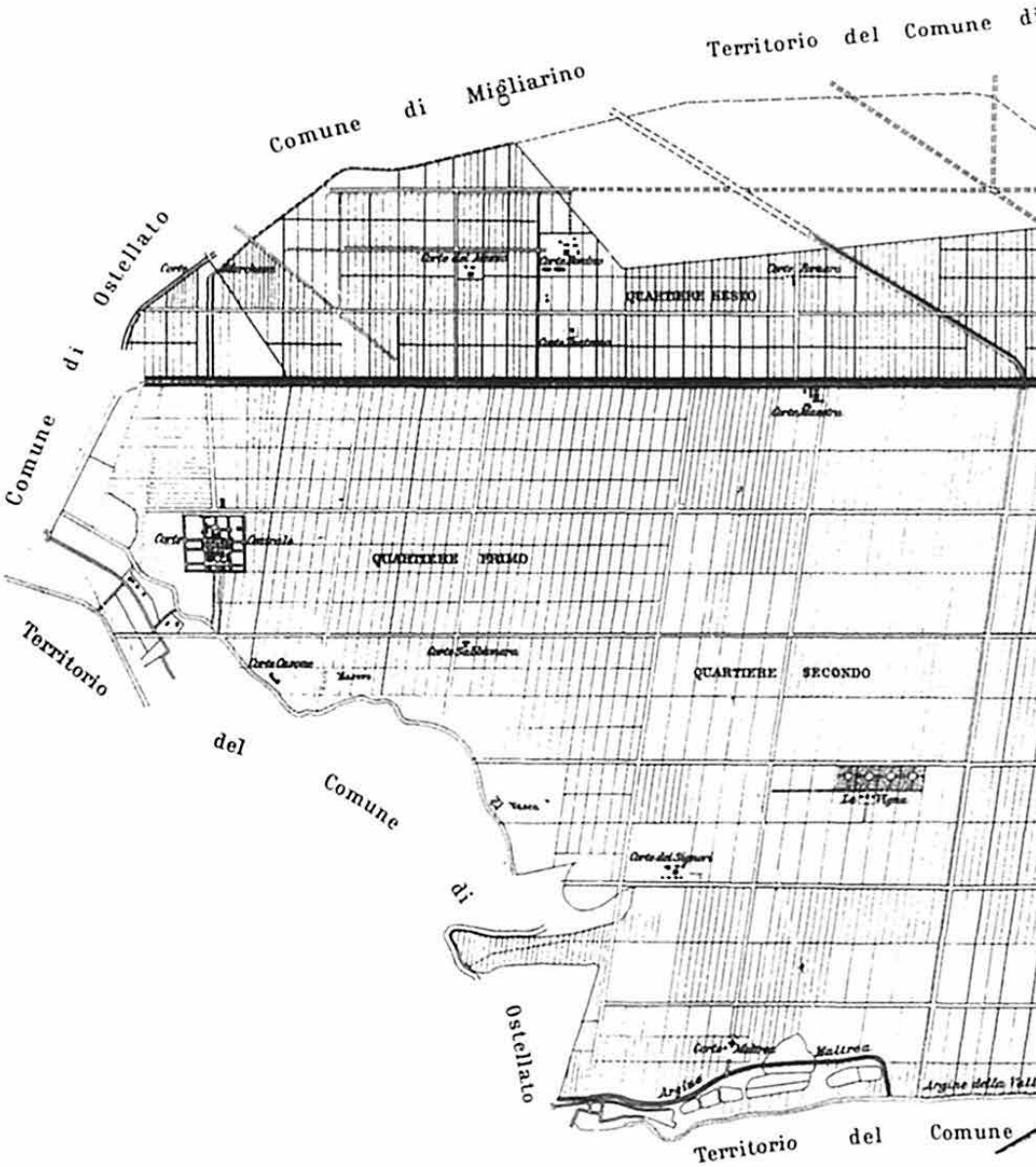
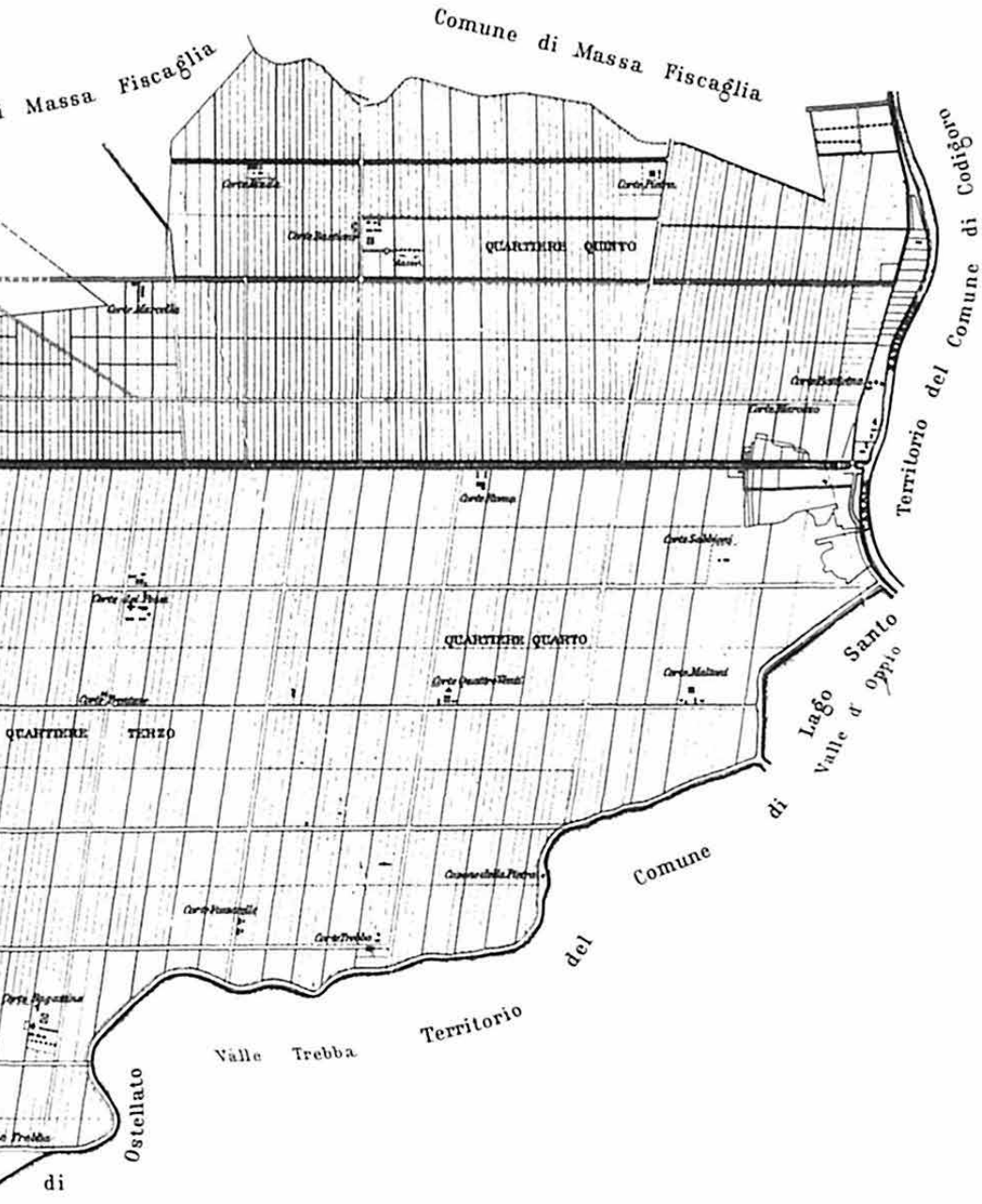


Plate 74. The landscape of the *larga* in the early tw
of the Istituto d

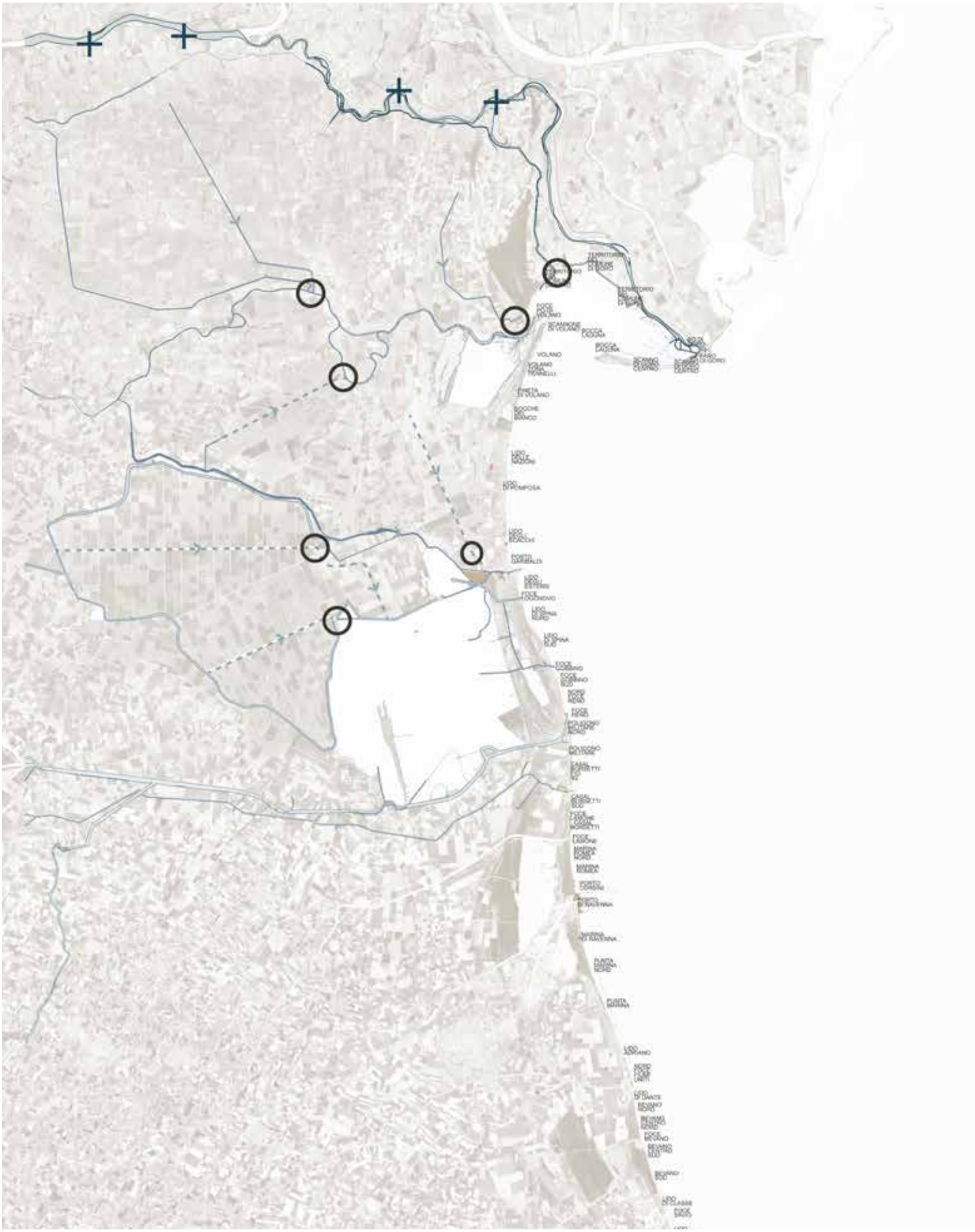
FIGURE 027:
MAP OF GALLARE LARGA
SOURCE: SERENI, 2014

Sereni (2014)



ventieth century, in a map of the Gallare holding
i fondi rustici.

Bonifica water managment



MAP-06: MOSAIC OF CONTROL: RECLAMATION AND TOURISM INFRASTRUCTURE SOURCE: BONDESAN, CONSORZIO DI BONIFICA PIANURA DI FERRARA [2015]

A complex system of irrigation and drainage canals flow perpendicular to the coastline from the Po River to the Adriatic Sea. Mechanical pumps that regulate the water flow are managed by the Reclamation Consortium. The coastline is densley populated by beach settlements and ports.

Main irrigation systems

Main drainage systems

Coastal defense infrastructure

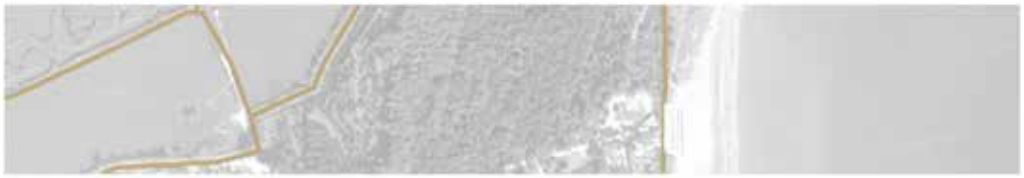
Irrigation and drainage canals

Navigable canals

Beach

Coastal Defense typologies

INTERNAL EMBANKMENTS



INTERNAL EMBANKMENT + JETTY

ARMOURED DUNES + WOODEN JETTIES

BREAKWATERS + INTERNAL EMBANKMENT

PORT AREA WITH JETTIES

INTERNAL EMBANKMENTS AND GROYNES

DIAGRAM-011: COASTAL DEFENSIVE TYPOLOGIES

The historic flood of 1966 prompted the constructing of the artificial defenses seen througout the adriatic coast of Emilia-Romagna (Perini, 2017)

INTERNAL EMBANKMENTS

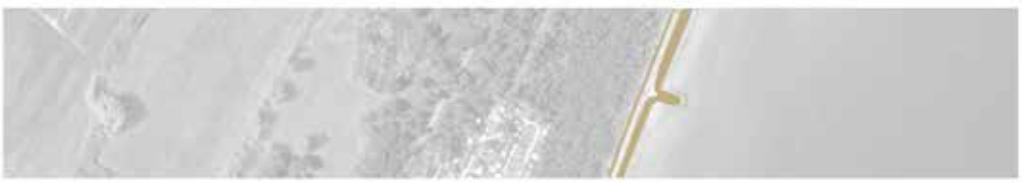
INTERNAL EMBANKMENTS

PORT + BREAKWATERS

ARMOURED RIVER MOUTH

PORT AREA WITH JETTIES

ATTACHED LONGITUDINAL DEFENSES

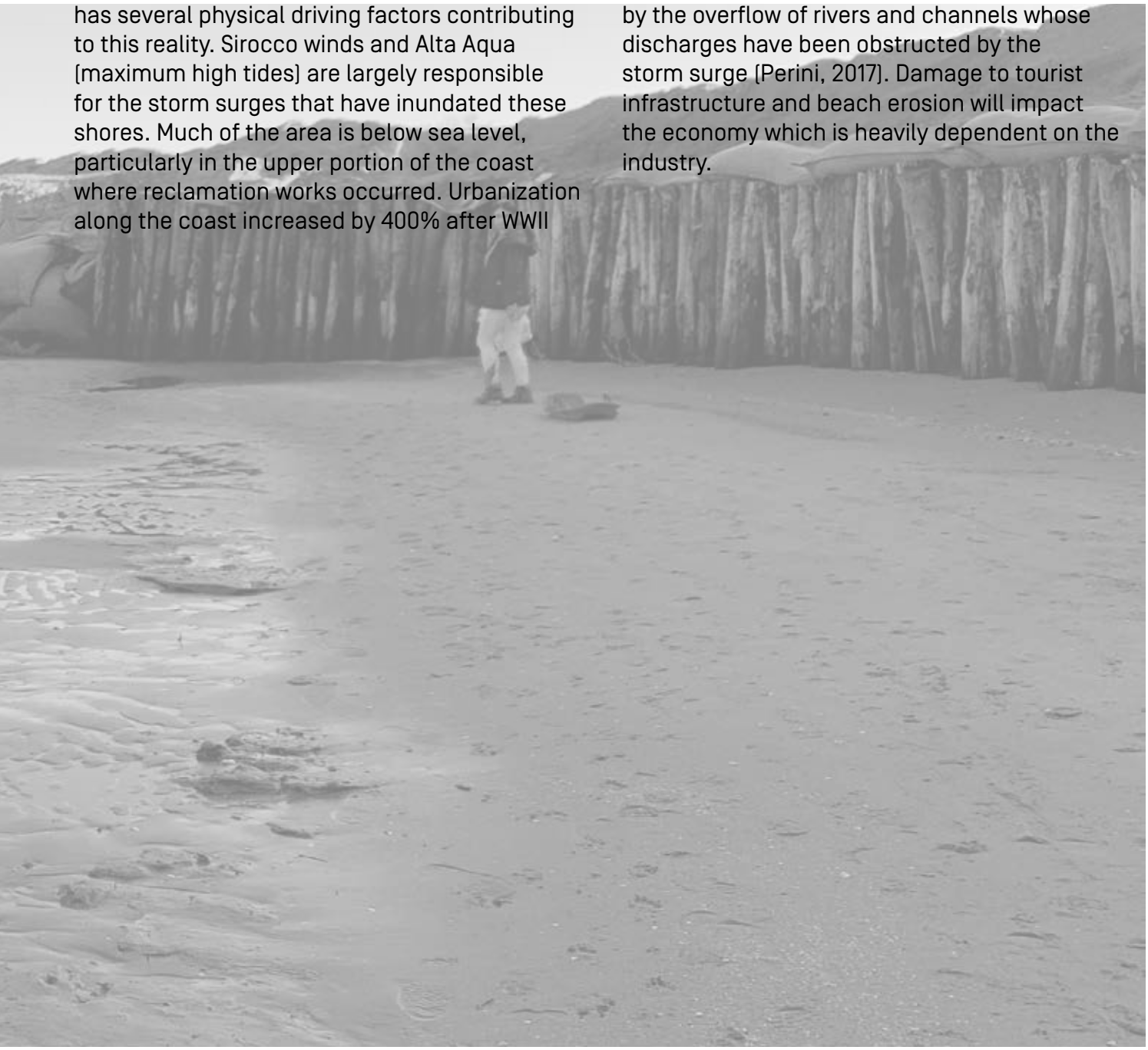


3.2 Natural Disturbances and a Flux in Sea level

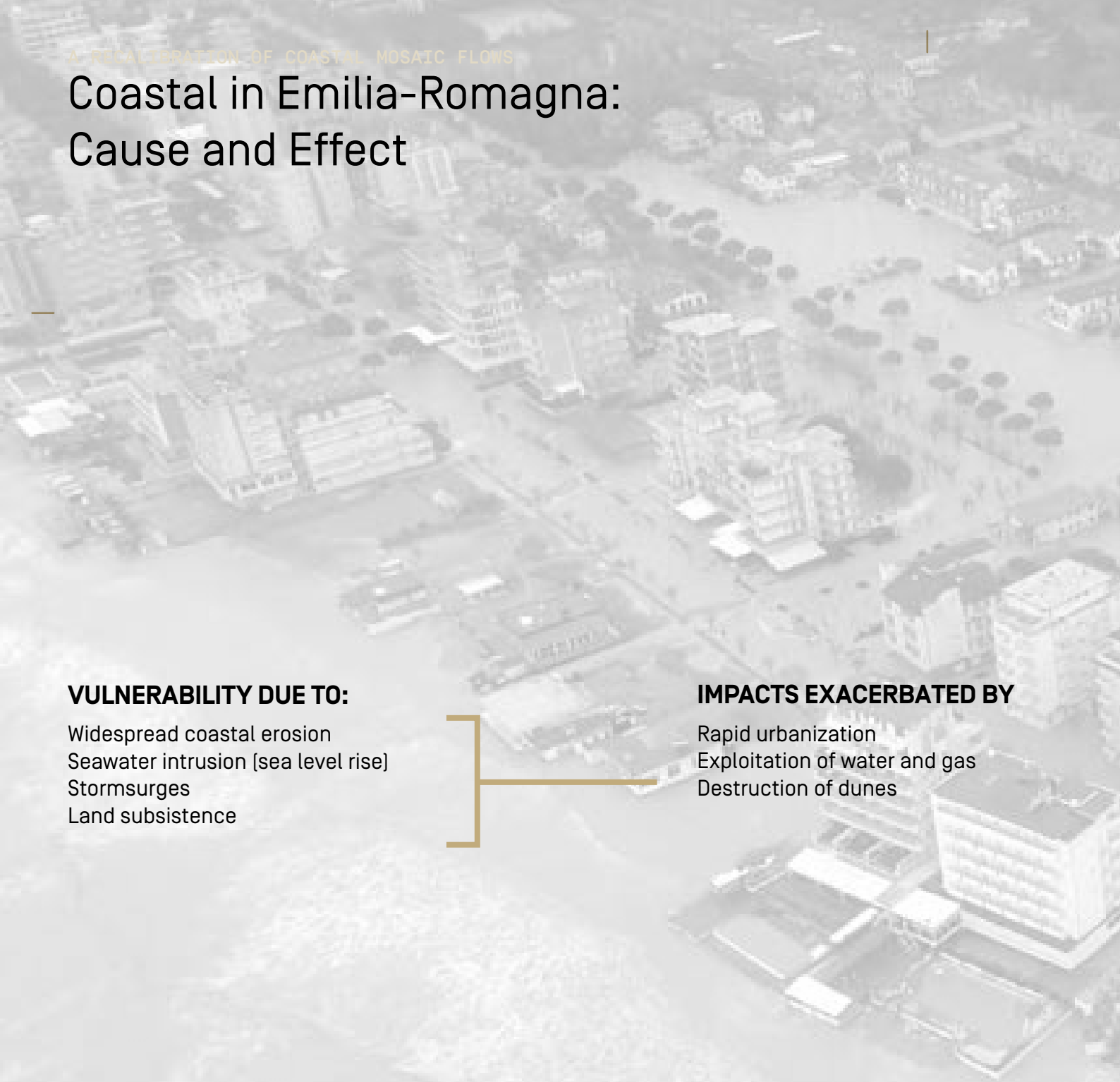
Natural disturbances are often instrumental in introducing heterogeneity into a mosaic. The delta is no stranger to flooding as was once characterized by frequent events of flooding, however, unprecedented change is impacting the rhythm of storms and flooding events. The historical flood season has been late autumn from November to December. In recent years extreme floods have been recorded until February. These increasingly frequent storms and rise in sea level will eventually blanket important coastal features, such as beaches, wetlands, and dunes in addition to the urbanized areas built along them.

Perini et al. determined that the Emilia-Romagna coast will become increasingly vulnerable to storm surges by 2100 (2017). The 130km shoreline has several physical driving factors contributing to this reality. Sirocco winds and Alta Aqua (maximum high tides) are largely responsible for the storm surges that have inundated these shores. Much of the area is below sea level, particularly in the upper portion of the coast where reclamation works occurred. Urbanization along the coast increased by 400% after WWII which has dramatically increased the risk of coastal flooding in urbanized areas. The combined effects of land subsidence (natural and anthropically induced) and natural shoreline retreat (anthropically induced reduction in sediment discharge (Bizzi & Surian, 2021)) are causing widespread coastal erosion. With much of the natural coastal defenses destroyed, the coastline is highly fortified with hardened coastal infrastructure that will require retrofitting to combat future flood scenarios (Perini, 2017).

The study attributes much of the coasts vulnerability to the absence and discontinuity of dune systems along the shore. Historic transformations of this coastal ecosystem cluster shifted the flow of water into low permeability urbanized areas. Flooding is then exacerbated by the overflow of rivers and channels whose discharges have been obstructed by the storm surge (Perini, 2017). Damage to tourist infrastructure and beach erosion will impact the economy which is heavily dependent on the industry.



Coastal in Emilia-Romagna: Cause and Effect



VULNERABILITY DUE TO:

Widespread coastal erosion
Seawater intrusion (sea level rise)
Stormsurges
Land subsistence

IMPACTS EXACERBATED BY

Rapid urbanization
Exploitation of water and gas
Destruction of dunes

FIGURE 028: FEBRUARY 2015 FLOODING EVENT IN LIDO DI SAVIO
SOURCE: BARBANTI ET AL., 2018

IMPACTED ECOSYSTEMS/LAND USES

Beaches/coastlines (economy drivers)
Wetlands and dunes
Urban areas

Sea level rise projections and land subsidence

RCP	E-R coast (m)	Adriatic (m)	Mediterranean (m)	Global (m)
2.6	0.30 ± 0.07	0.31 ± 0.01	0.36 ± 0.02	0.38 ± 0.15
4.5	0.34 ± 0.09	0.37 ± 0.01	0.42 ± 0.03	0.45 ± 0.16
6.0	0.33 ± 0.08	0.36 ± 0.02	0.42 ± 0.03	0.47 ± 0.16
8.5	0.45 ± 0.12	0.48 ± 0.02	0.57 ± 0.03	0.60 ± 0.19

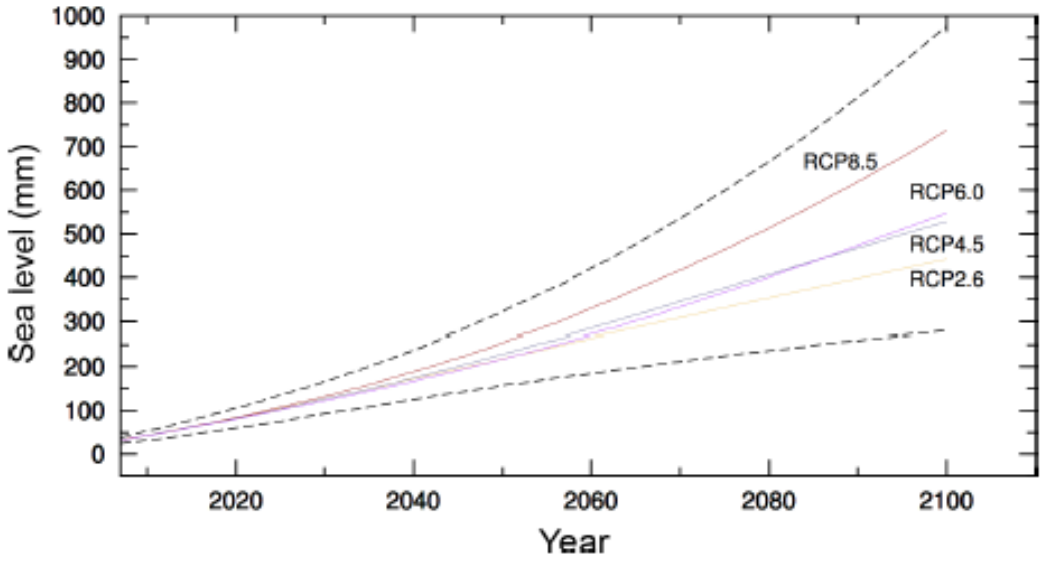


FIGURE 029: SEA LEVEL CHANGE BY 2100 SOURCE: PERINI, 2017

Sea level rise predictions from 2081-2100 and sea level pathways according to IPCC AR5 RCP's. Dashed lines represent upper limit of RCP 8.5 and lower limit of RCP 2.6

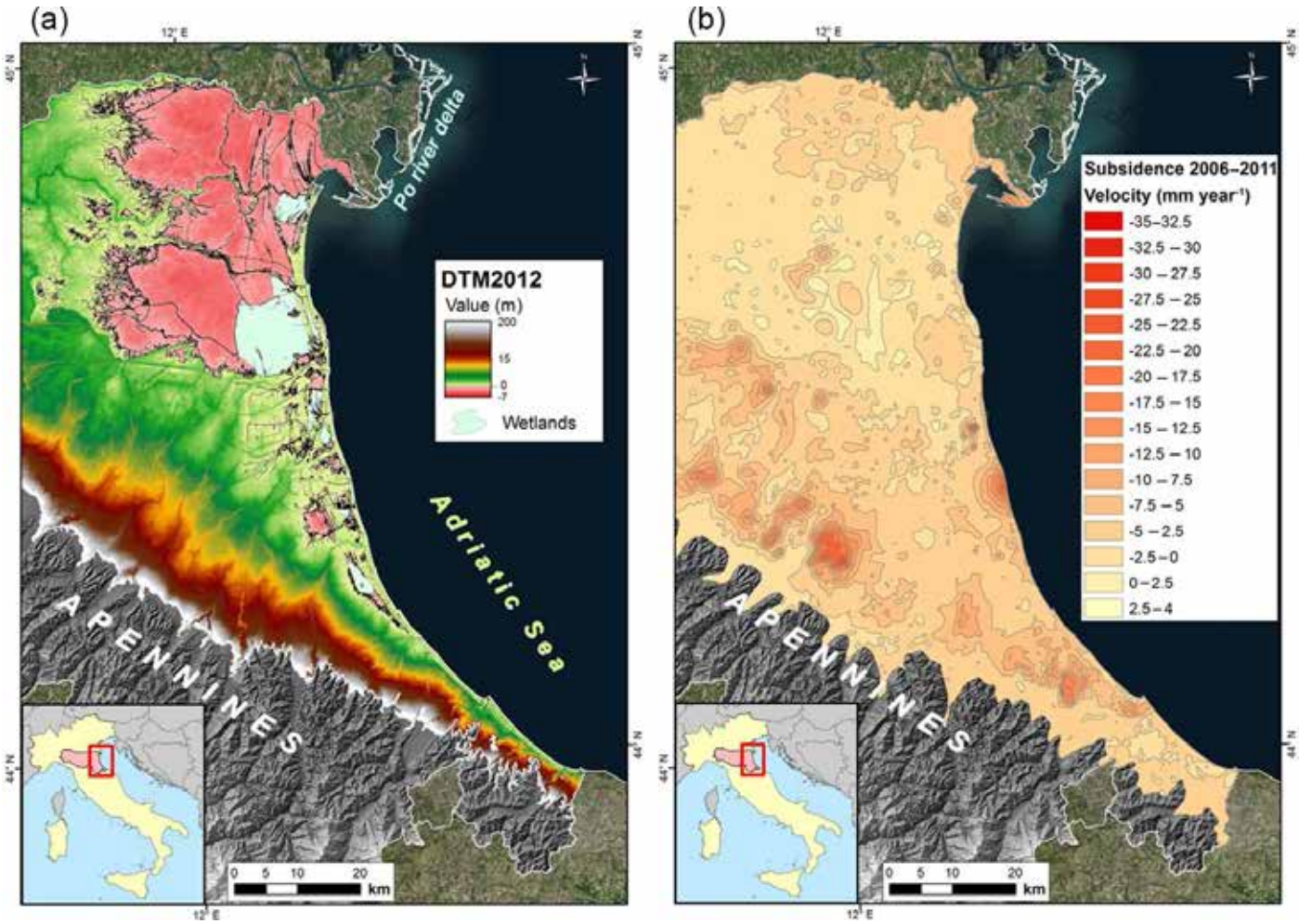
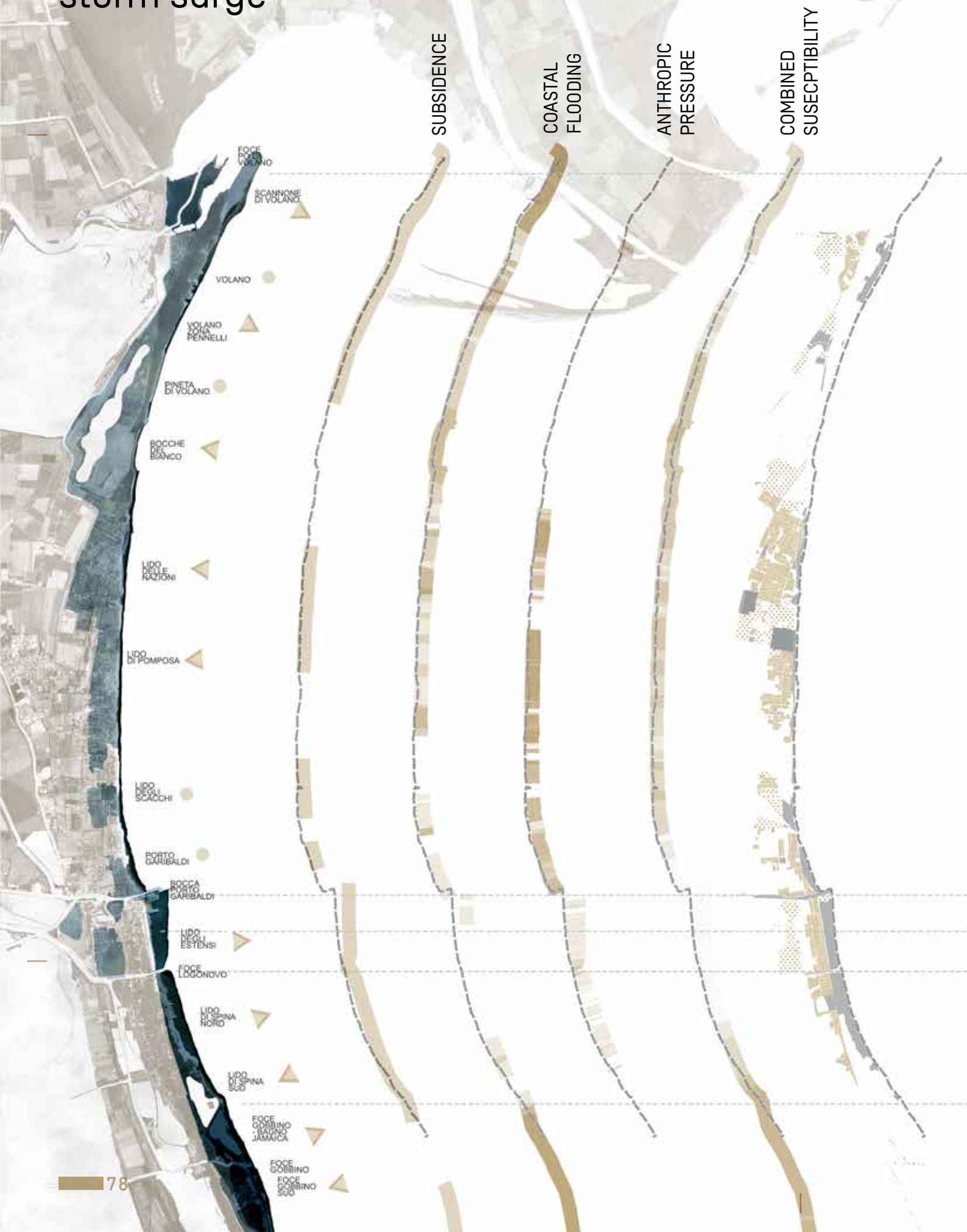


FIGURE 030:
DTM AND SUBSIDENCE
SOURCE: [PERINI, 2017]

Land subsidence is both naturally occuring and excacerbated by man. Gas and water extraction in the 20th century has greatly contributed to the increasing rate of subsidence along the coast and the delta. With lower rates in sediment discharge and distribution from rivers, rates of subsidence can not be counter balanced as they would naturally.

Cummulative effects on vulnerability to storm surge



SAND W/DRAWAL * for nourishment (m3 06-10)

- +59% floodable area only due to subsistance (primarily natural causes and rates not expected to reduce)
- +102-214% floodable area taking into account sea level rise
- most floodable areas currently protected by embankments (however considered to be useless by 2100)
- +2km floodable area inland
- Main problems will occur at weak points or low points in embankments therefore consistent maintenance required

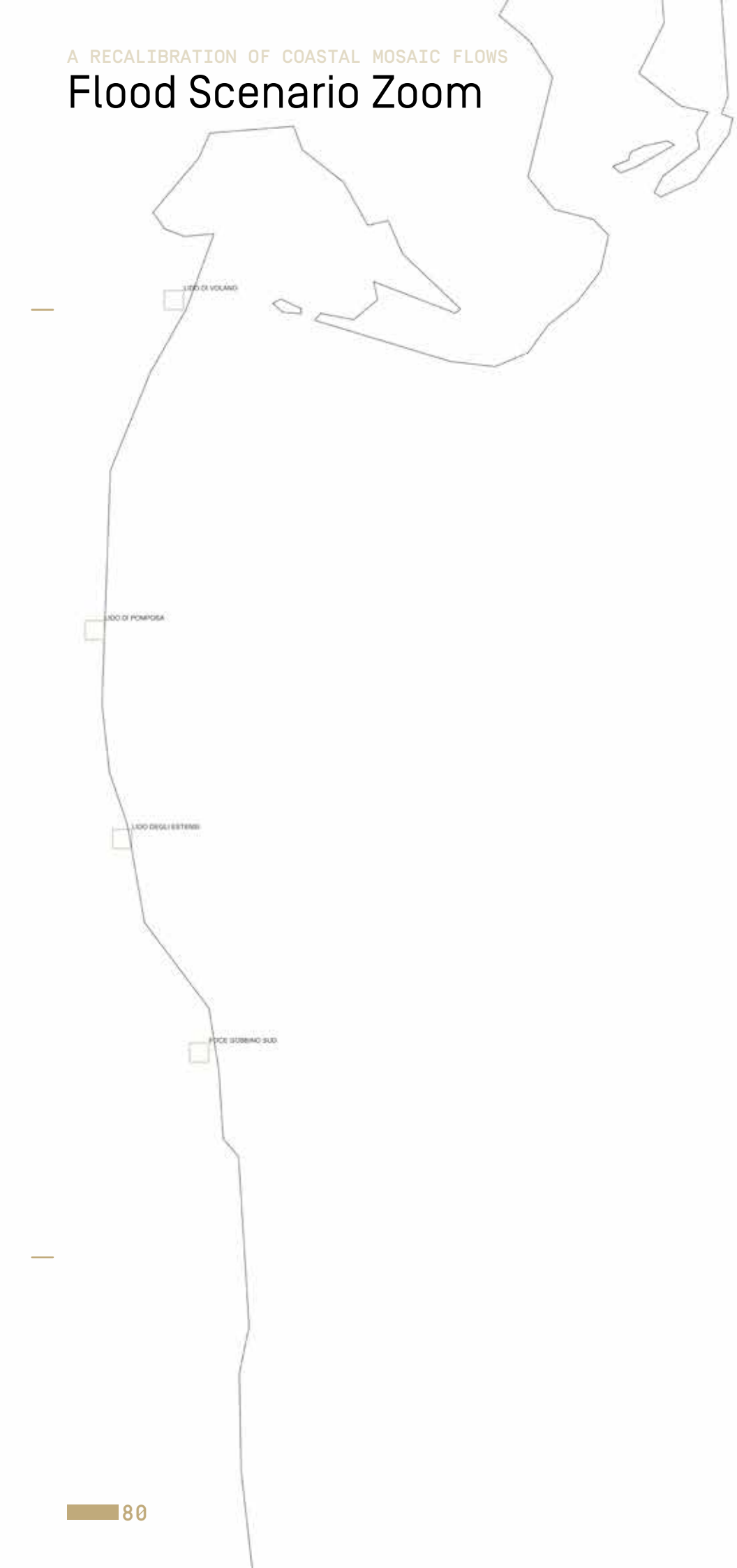
Already lowlying areas increase vulnerability especially due to lack of dunes and embankments and a greater rate of subsistence (15-20 mm/year $^{-1}$)

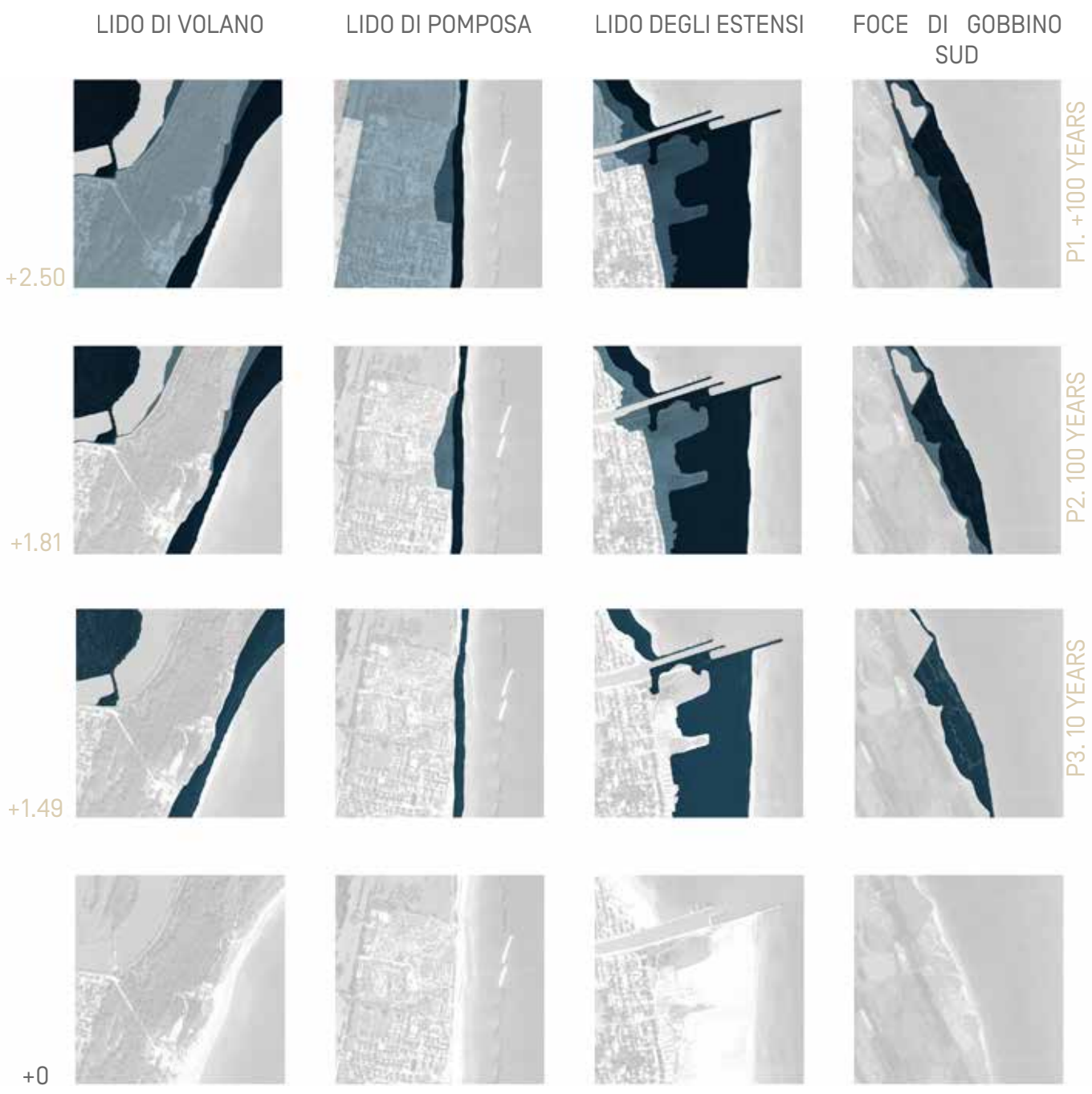
- INgression impacts whole coast including urban and nature reserves up to 1 km inland (however strong decrease in subsistance projected in other studies)

Table 4. Total water elevation for the different types of sea storms considered in the FD and corresponding return periods (Perini et al., 2012, 2016; Salerno et al., 2012).

Type of surge	Return period (years)	Sea surface elevation (m)
Frequent (P3)	10	1.49
Less Frequent (P2)	100	1.81
Rare (P1)	$\gg 100$	2.50

Flood Scenario Zoom





MAP-08: FLOOD SCENARIO ZOOMS AT REGIONAL SCALE [1:30000]

Vel iusdaerunt el et alis et estiberum quis repe de cor alitiis sedis nonemquasi reribusam, voluptatet voluptaquiam estem harum duntotatur, occus eaqui coris ipsae prat.
Offictur, idem eosae vel mos ipic te vero experum volor aligenimet

Storm Surge Calender

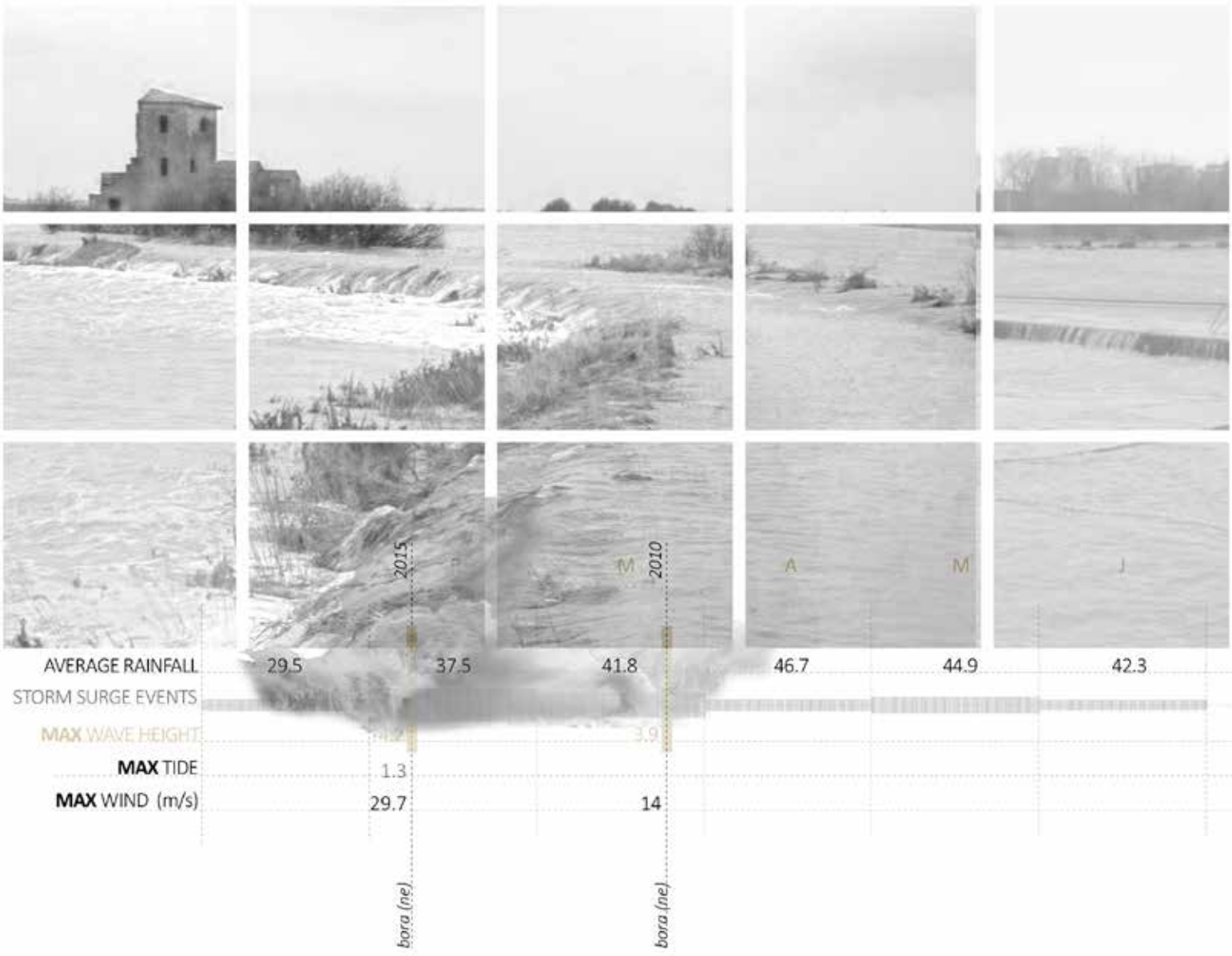
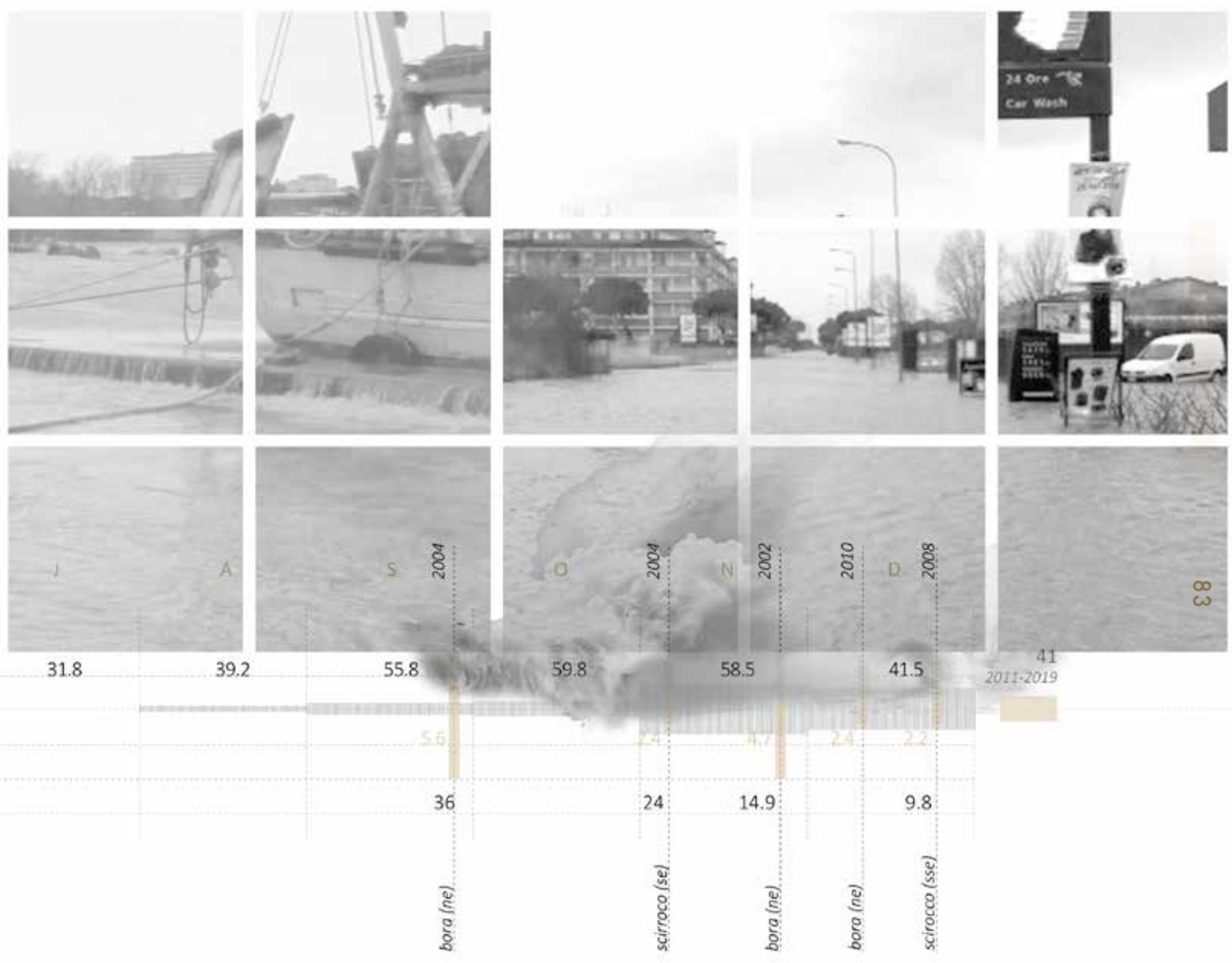


DIAGRAM-012: STORM SURGE + METEOROLOGICAL CALENDER


24 Ore
Car Wash
J
A
S
2004
O
2004
N
2002
2010
D
2008
31.8
39.2
55.8
59.8
58.5
41.5
41
2011-2019
36
24
14.9
9.8
bora (ne)
scirroco (se)
bora (ne)
bora (ne)
scirocco (sse)

Ortazzo e Ortazzino:
A case study for change in a mosaic

FIGURE 031: BEZZANO RIVER SOURCE: GOOGLE EARTH

Ortazzo e Ortazzino is a 440ha RAMSAR protected wetland is an interesting example of a diverse coastal ecosystem that has developed due to subsidence and sea water intrusion. The system is driven by the brackish water delivered by the Bevano torrente and the sea. The Bevano is allowed to evolve naturally and exhibits interesting hydromorphological characteristics such as an oxbow lake and slack dunes which periodically flood. There are also wet pastures and consolidated dunes with shrubs. Active dunes are present around the mouth. This system is the best representation of an estuary system on entire adriatic coast because it demonstrates all aspects of the natural evolution of the river mouth and is an important habitat for birds.

Its transformation began from subsistence and invasion of water from saline aquifers in lagoons which were once used for rice paddies (separated by embankments) with mainly muddy beds and low water levels maintained by the inflow of fresh water (Acquara canal) and brackish water (fosso ghiaia aquifer) (RAMSAR)

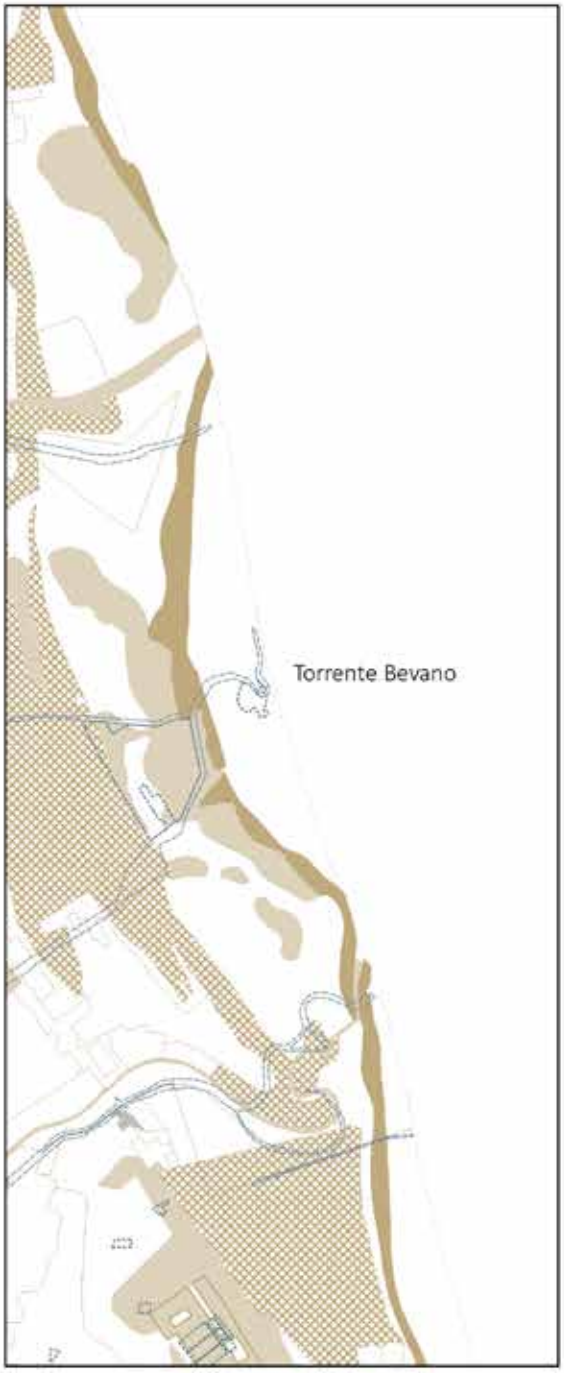
Hydrological value

Coastal erosion mitiagation at the mouth where sediment is continuously deposited

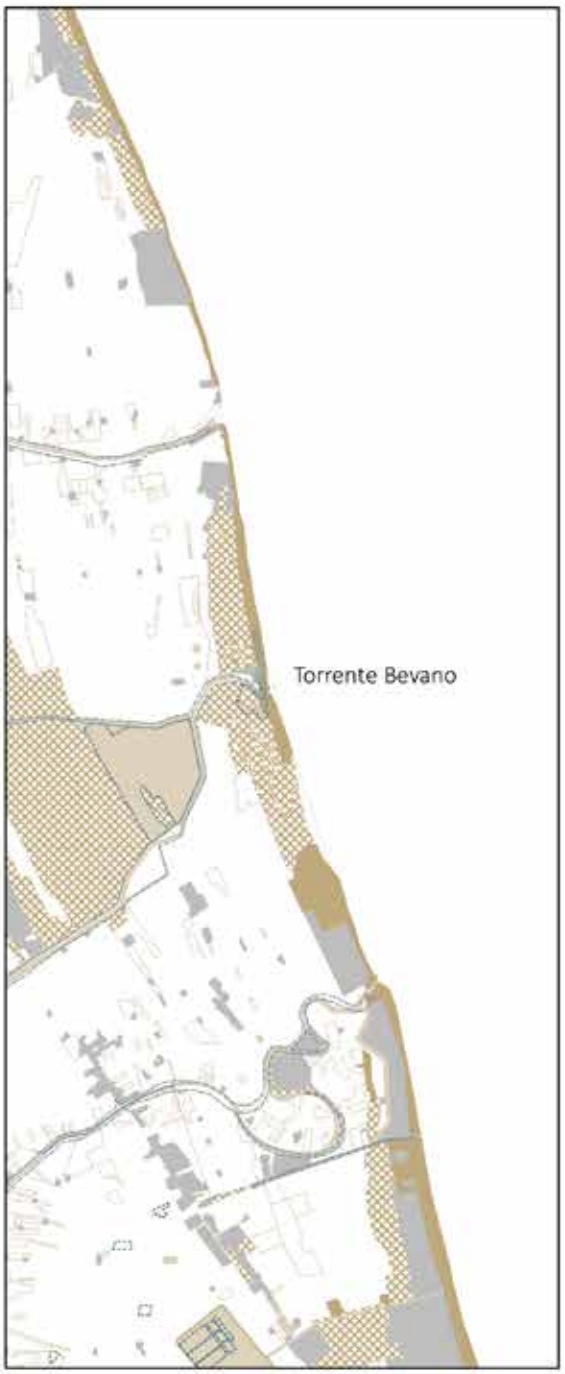
Sociocultural values
nature conservation and wildlife observation

Ortazzo e Ortazzino: Land use changes

1853



1976



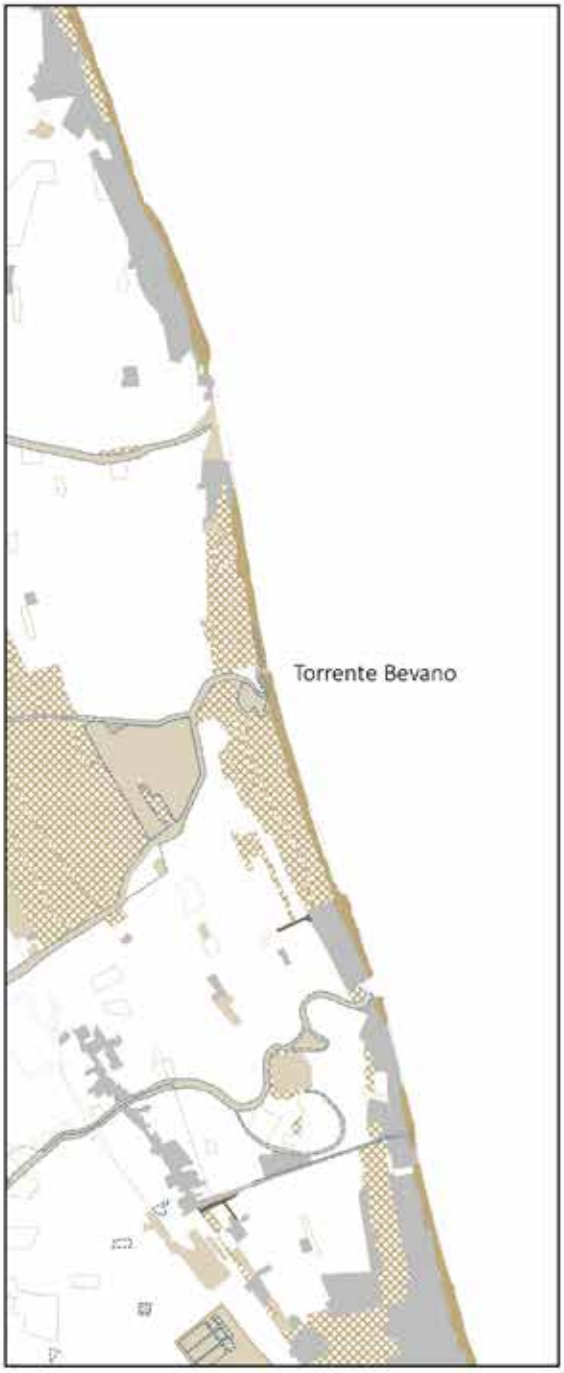
LEGEND

current river course
wetland
current coastline

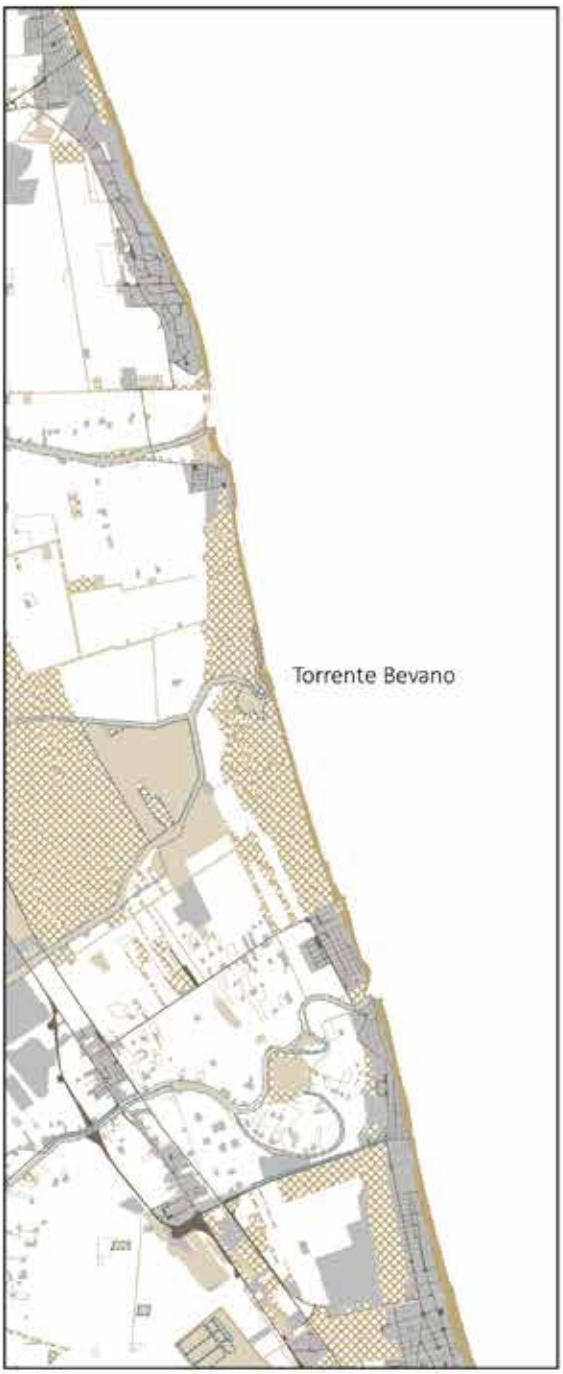
LAND USE

Agriculture
Beach/dune
Salt flat
Shrubland/grassland
Transport network
Urbanized area
Waterway/waterbody
Wetland
Woodland

1994

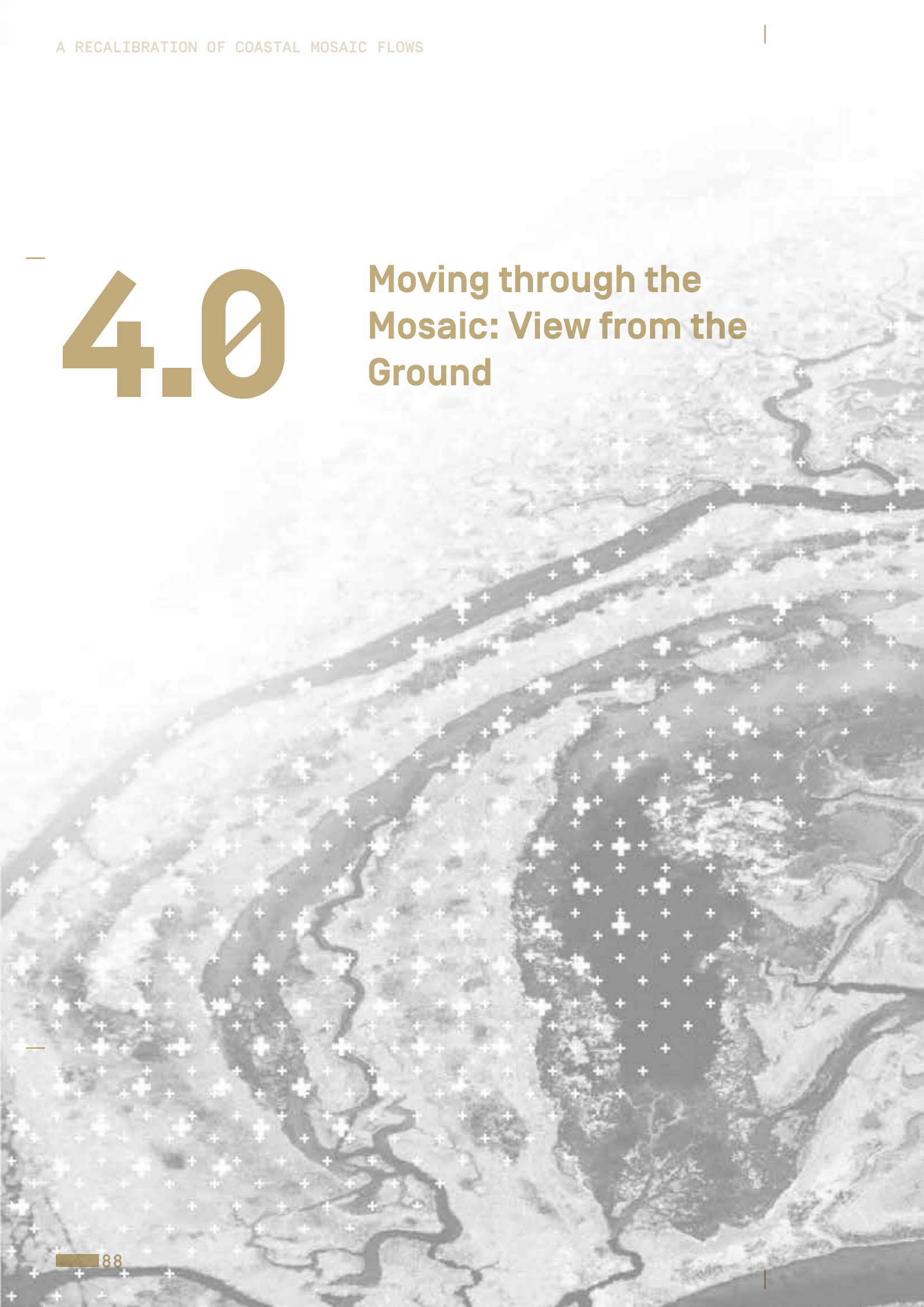


2017



MAP-09: BEZZANO RIVER
SCALE: 1,100,000

4.0 Moving through the Mosaic: View from the Ground



Subchapters

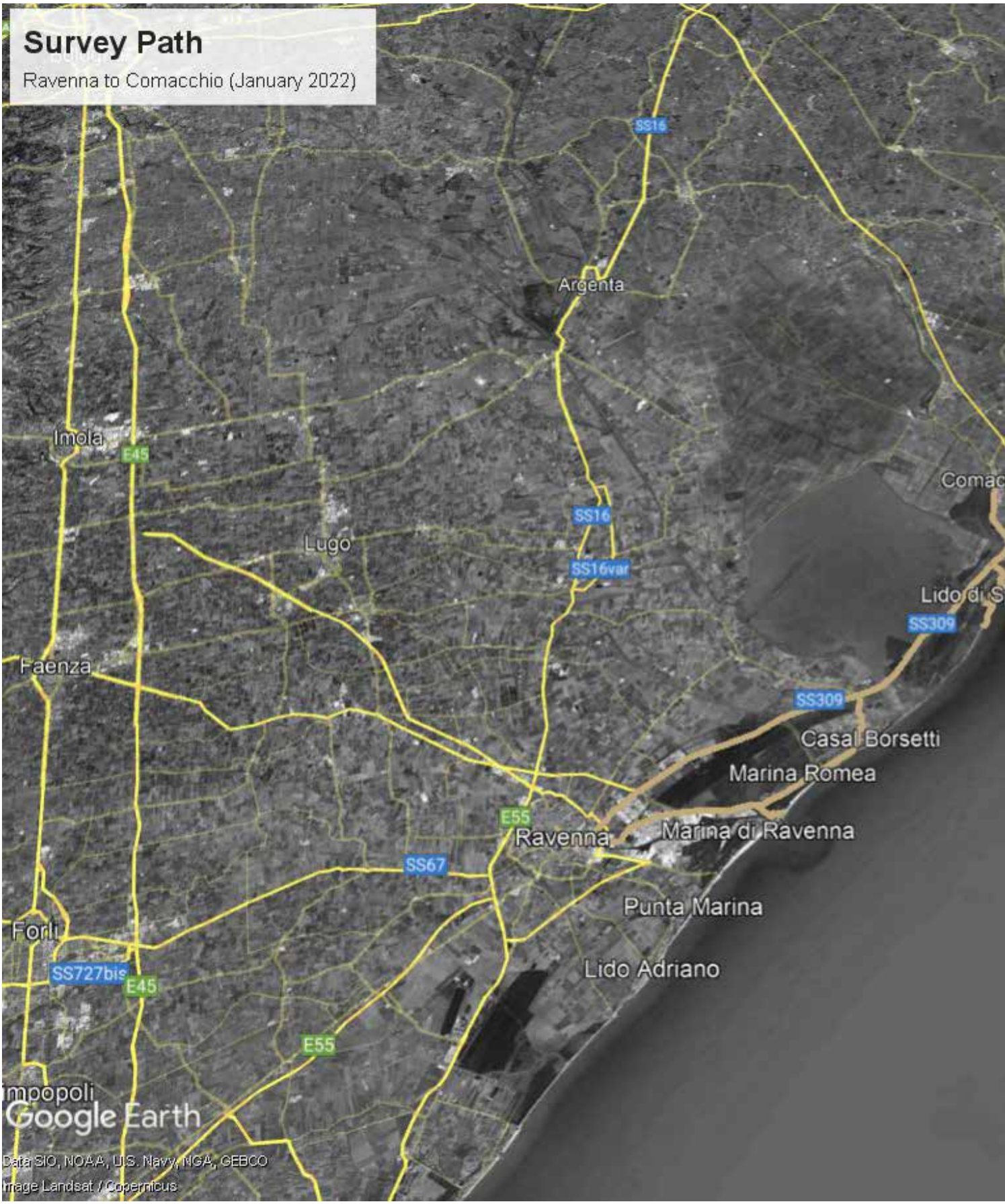
INTRO

The following is a brief survey of the coast between Ravenna and Comacchio. We biked the distance on a cool winter day during the low season, following Via Romea north towards Comacchio.

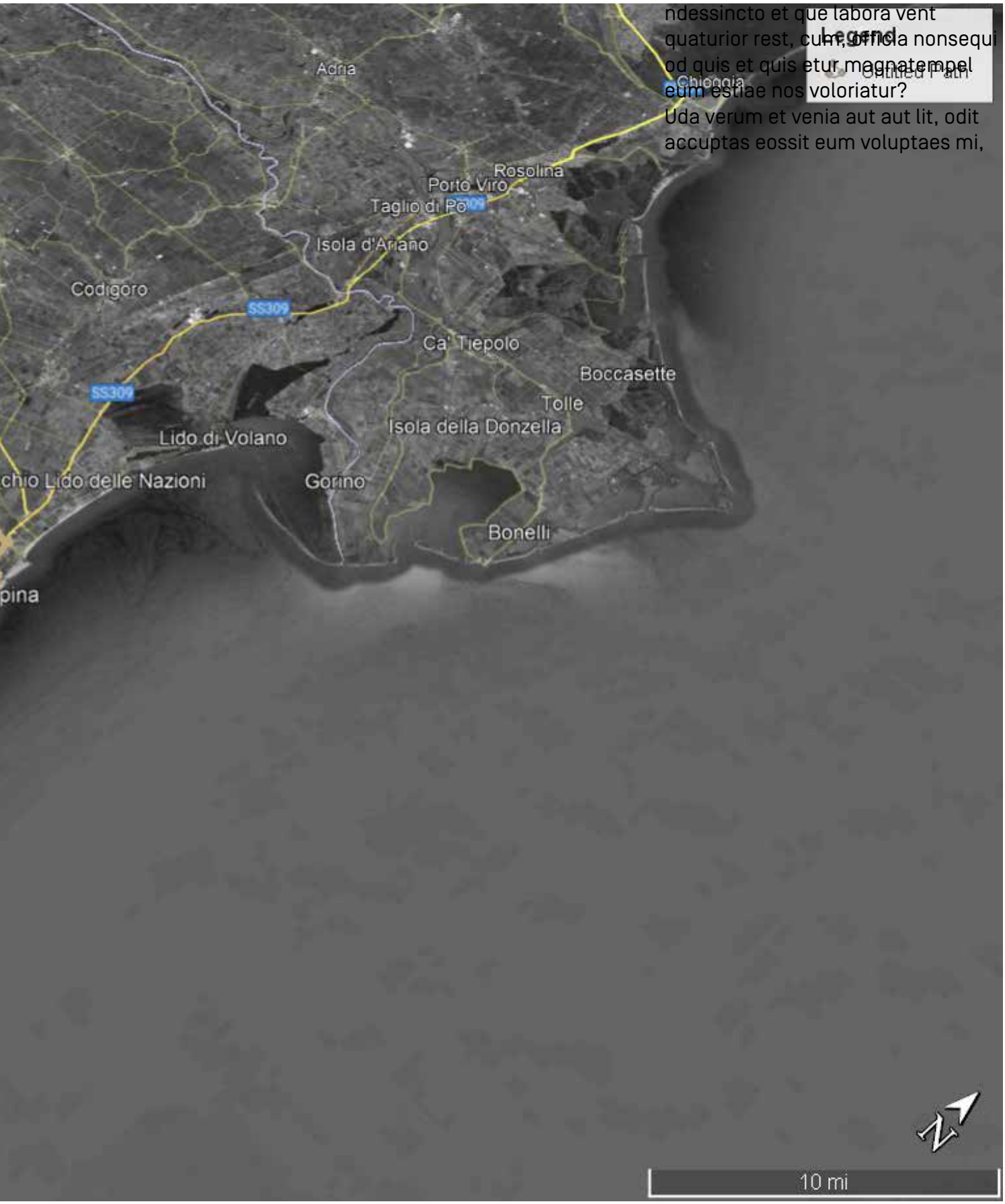
The landscape offered up stark contrasts between its different zones, from quaint and historic towns to industrial parks, fishing shacks to beachside resorts, and from pine forests to agricultural zones. Along the way we encountered very few people as this was a low season for tourism. However people local to the area were surprised that we would bike the distance, which maybe due to the lack of slow mobility connectivity. We shared the road with a variety of birds, a few cars, and even some large eighteen wheeler trucks.

The following pages offer a glimpse into the site highlighting some of the main pros and cons of the area. Something that is immediately apparent travelling through the delta is that it is a land of constant change, where some areas adapt and others fall behind.


EST. 2022 MI IT


Survey Path
Ravenna to Comacchio (January 2022)
SS16
Argenta
Imola
E45
SS16
Lugo
SS16var
Lido di S
SS309
Faenza
SS309
Casal Borsetti
Marina Romea
E55
Ravenna
Marina di Ravenna
SS67
Punta Marina
Forlì
SS727bis
E45
Lido Adriano
E55
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus

Gitia autas acepuda nduntium quid quibus ne et et aut od que aut etur, ut od quae viti dit elloratur atem eriorem haris qui dendelest exere ea volor restioriat ut ommolo et expliquis quam vero blam, consequiatur solest destore ndessincto et que labora vent quaturior rest, cum, officia nonsequi od quis et quis etur magnatempel eum estiae nos voloriatur? Uda verum et venia aut aut lit, odit accuptas eossit eum voluptaes mi,



“twixt either gilden horn, Eridanus
the laughing plains more furious p
-Virgil, Georgics, I, 481-83

s, Than whole none other through
bours into the purple sea.

View from the Ground

FIGURE 032: VIA ROMEA, RAVENNA
JANUARY, 2022

FIGURE 033: RAVENNA, JANUARY, 2022

FIGURE 034: RAVENNA, JANUARY, 2022

FIGURE 035: LIDO DI SPINA, COMACCHIO, JANUARY, 2022

FIGURE 036: LIDO DI SPINA, COMACCHIO, JANUARY, 2022

FIGURE 037: BAGNO CORALLO, COMACCHIO, JANUARY, 2022

FIGURE 038: RAVENNA, JANUARY, 2022

FIGURE 039: PORTO DI RAVENNA, JANUARY 2022

FIGURE 040: PORTO DI RAVENNA, JANUARY 2022

FIGURE 041: PORTO DI RAVENNA, JANUARY 2022

FIGURE 042: PORTO DI RAVENNA, JANUARY 2022

FIGURE 043: PORTO DI RAVENNA, JANUARY 2022

FIGURE 044: PORTO DI RAVENNA, JANUARY 2022

FIGURE 045: PORTO DI RAVENNA, JANUARY 2022

FIGURE 046: PORTO DI RAVENNA, JANUARY 2022

FIGURE 047: PORTO DI RAVENNA, JANUARY 2022

FIGURE 048: PORTO DI RAVENNA, JANUARY 2022

FIGURE 049: PORTO DI RAVENNA, JANUARY 2022

FIGURE 050: MARINA ROMEA, JANUARY 2022

FIGURE 051: VIA ROMEA NORD, TORRE DI AVVISTAMENTO, RAVENNA, JANUARY 2022

FIGURE 052: VIA ROMEA NORD, RAVENNA, JANUARY 2022

FIGURE 053: VIA ROMEA NORD, CANALI MAGNI, RAVENNA, JANUARY 2022

FIGURE 054: VIA GIOVANNI SPALLAZZI, RAVENNA, JANUARY 2022

FIGURE 055: VIA ROMEA NORD, OASI DI PUNTE ALBERETE, RAVENNA, JANUARY 2022

FIGURE 056: PISCINA MARE PINETA,LIDO DI SPINA, JANUARY 2022

FIGURE 057: VIA ROMEA NORD, RAVENNA, JANUARY 2022

FIGURE 058: VIA ROMEA NORD, CANALI MAGNI, RAVENNA, JANUARY 2022

FIGURE 059: VIA ROMEA NORD, RAVENNA, JANUARY 2022

FIGURE 060: VIA ROMEA NORD, RAVENNA, JANUARY 2022

FIGURE 061: COMACCHIO, JANUARY 2022

FIGURE 062: COMACCHIO, JANUARY 2022

FIGURE 063: COMACCHIO, JANUARY 2022

FIGURE 064: COMACCHIO, JANUARY 2022

FIGURE 065: VIA ROMEA, RAVENNA, JANUARY 2022

FIGURE 066: VIA ROMEA, RAVENNA, JANUARY 2022

FIGURE 067: VIA ROMEA, RAVENNA, JANUARY 2022

FIGURE 068: VIA ROMEA, RAVENNA, JANUARY 2022

FIGURE 069: COMACCHIO, JANUARY 2022

FIGURE 070: LIDO DI SPINA, JANUARY 2022

FIGURE 071: LIDO DI SPINA, JANUARY 2022

FIGURE 072: LIDO DI SPINA, JANUARY 2022

FIGURE 073: LIDO DI SPINA, JANUARY 2022

FIGURE 074: LIDO DI SPINA, JANUARY 2022

FIGURE 075: LIDO DI SPINA, JANUARY 2022

FIGURE 076: LIDO DI SPINA, JANUARY 2022

FIGURE 077: LIDO DI SPINA, JANUARY 2022

FIGURE 078: LIDO DI SPINA, JANUARY 2022

FIGURE 079: LIDO DI SPINA, JANUARY 2022

FIGURE 080: LIDO DI SPINA, JANUARY 2022

FIGURE 081: LIDO DI SPINA, JANUARY 2022

FIGURE 082: LIDO DI SPINA, JANUARY 2022

FIGURE 083: LIDO DI SPINA, JANUARY 2022

FIGURE 084: LIDO DI SPINA, JANUARY 2022

FIGURE 085: LIDO DI SPINA, JANUARY 2022

FIGURE 086: LIDO DI SPINA, JANUARY 2022

5.0 RECALIBRATING MOSAIC FLOWS IN SPACE

Subchapters

5.1 Lido delle Estensi
5.3 Name of the Project

5.1 Lido Degli Estensi

Lido Degli Estensi is a 134.0ha area with a small population that is characterized by its contrasting zones. Situated on the sea-side, it has urban areas as well as a mixture of natural settings comprising of a wide variety of vegetation.

These contrasting zones are a result of historical developments in the thirties and fifties. In the thirties, Lido degli Estensi and Lido di Spina underwent a large scale pine afforestation project as an extension of the Pineta di Classe of Ravenna. While in the fifties, the area began to transform again to prioritize tourism and residential development while keeping the environmental character of the area.
The results are contrasting pockets of urbanization as well as residual greenery that need to be integrated and connected to create a cohesive landscape.

Today, Lido degli Estensi is facing several problems due in part to the historical developments of the area and the threats of climate change. Infrastructure such as sewage treatment plants and rainwater sewerage

Historical Maps/Aerials

FIGURE 087:
HISTORICAL MAP 1814

Carte storiche in Emilia-Romagna

FIGURE 088:
HISTORICAL MAP 1931

Volo IGM 1931-1937

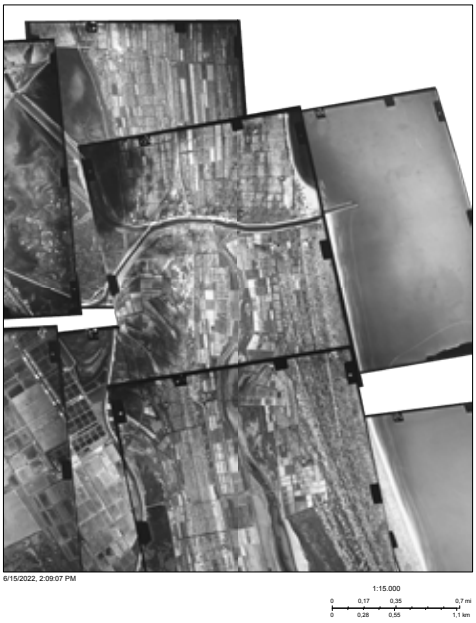


FIGURE 089:
HISTORICAL MAP 1943

Le foto della Royal Air Force nel 1943 e 1944

FIGURE 090: AERIAL 2010

FIGURE 091: AERIAL 2015

FIGURE 092: AERIAL 2018

FIGURE 093: AERIAL TODAY

Description

FIGURE 094:
PHOTOGRAPHIC OFFICE
MONTECATINI 1957/85

FIGURE 095:
PHOTOGRAPHIC OFFICE
MONTECATINI

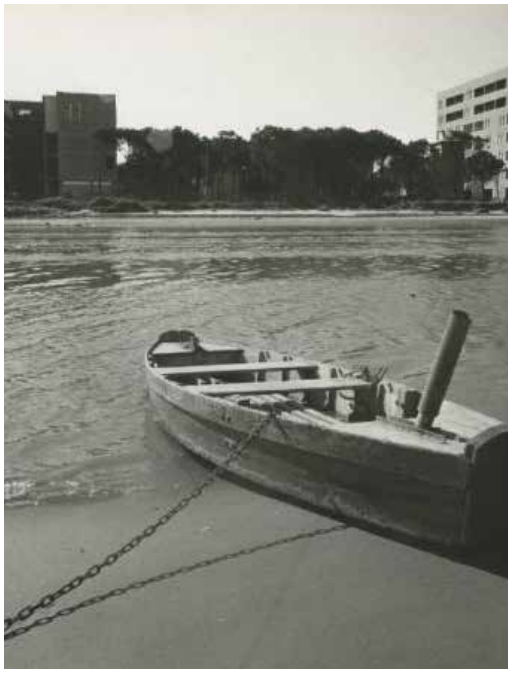


FIGURE 096:
PHOTOGRAPHIC OFFICE
MONTECATINI 1957/85

FIGURE 097:
PHOTOGRAPHIC OFFICE
MONTECATINI

networks are undersized and thus vulnerable to weather events. This fact is compounded by an absence of detention basins/floodable areas that could help mitigate the risks of the sewer network by integrating the landscape and urban infrastructure of the area.

There is also a lack of organized public spaces in favor of linear commercial avenues like Viale Carducci. Green areas tend to be used as traffic dividers or makeshift parking lots with a few minor exceptions. This means that the quality of green areas is much lower than its potential.

With general tourism declining and ecotourism on the rise, the lack of quality green areas is a substantial deficiency that effects tourism and resiliency.

Lastly, there is a general lack of connectivity within the area. Romeo road fragments the territory and a lack of slow mobility infrastructure make the area less hospitable to most users.

FIGURE 098:
PHOTOGRAPHIC OFFICE
MONTECATINI 1957/85

FIGURE 099:
PHOTOGRAPHIC OFFICE
MONTECATINI 1957/85

Other Historical Images

FIGURE 0100: POSTCARD

FIGURE 0101: POSTCARD

FIGURE 0102: POSTCARD

FIGURE 0103: POSTCARD

FIGURE 0104: POSTCARD

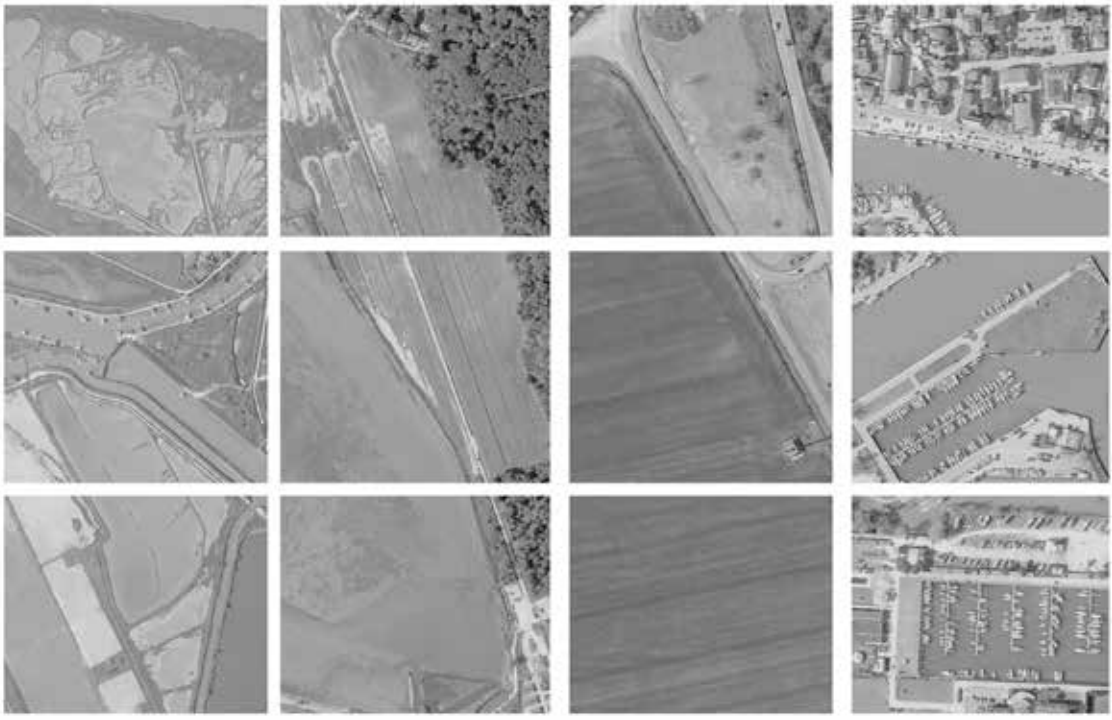
FIGURE 0105: POSTCARD

Lido Degli estensi site analysis

MAP-011: SITE ANALYSIS

Vel iusdaerunt el et alis et estiberum quis repe de cor alitiis sedis nonemquasi reribusam, voluptatet voluptaquiam estem harum duntotatur, occus eaqui coris ipsae prat.
Offictur, idem eosae vel mos ipic te vero experum volor aligenimet

Ecosystem Clusters of Lido Degli Estensi



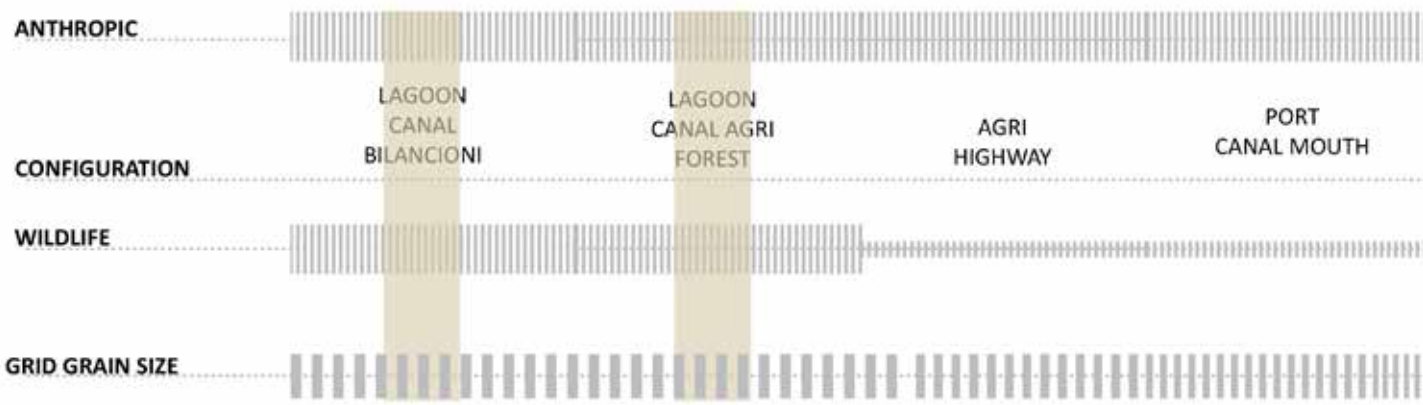
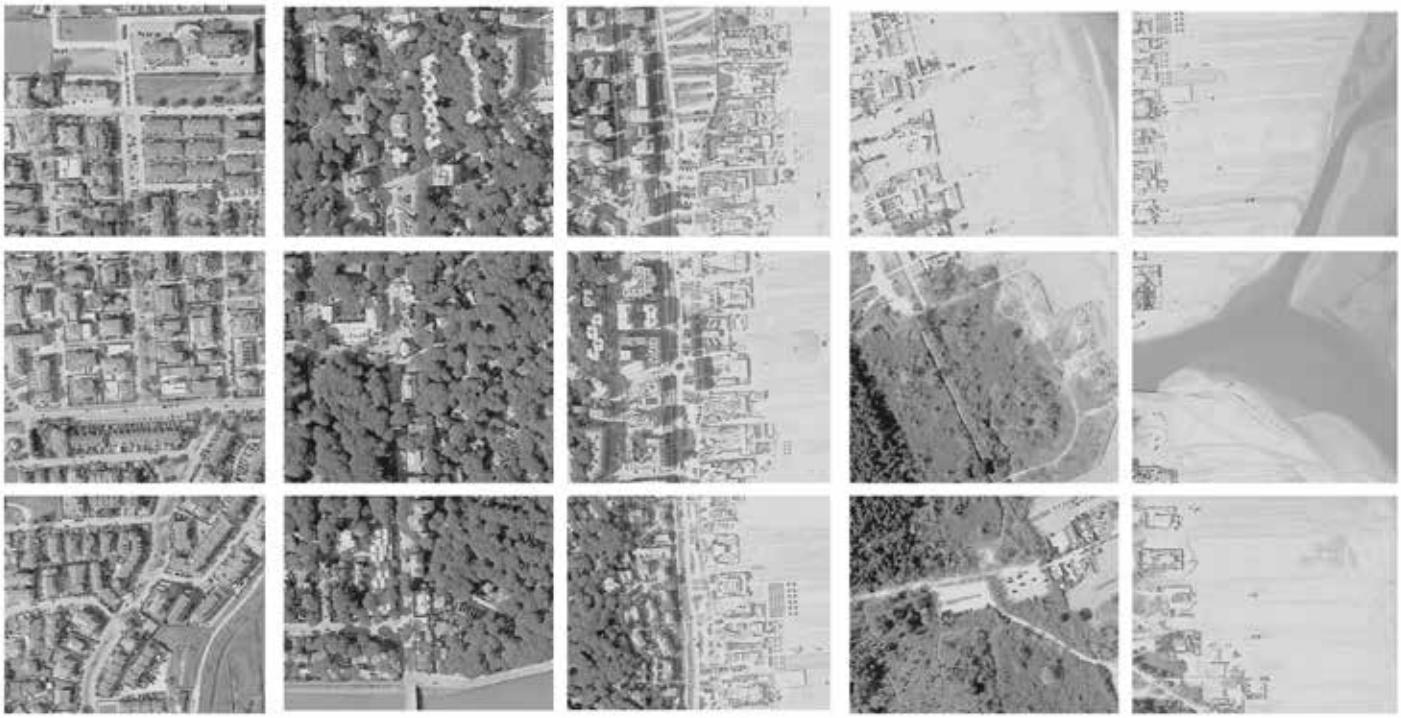
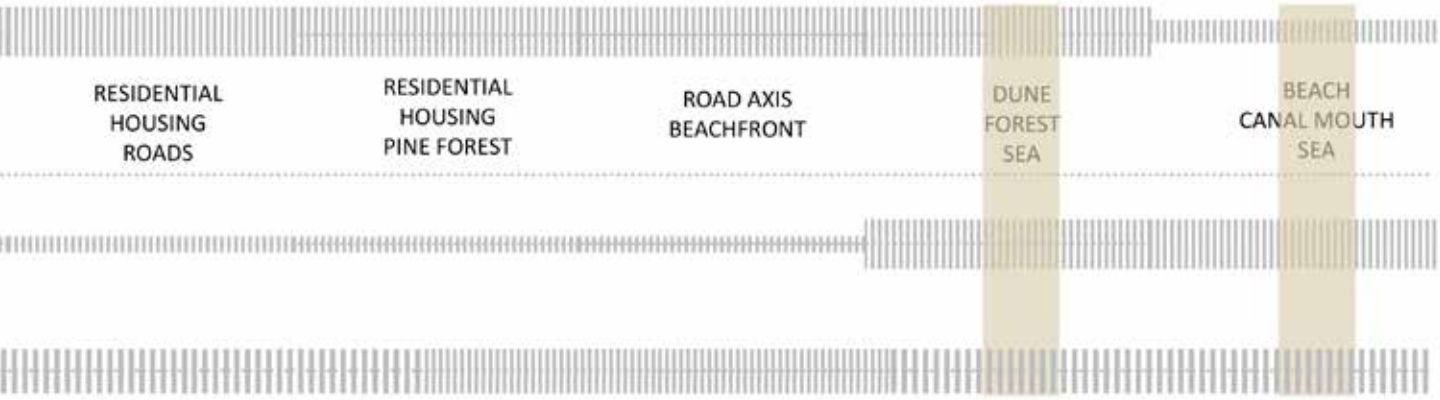


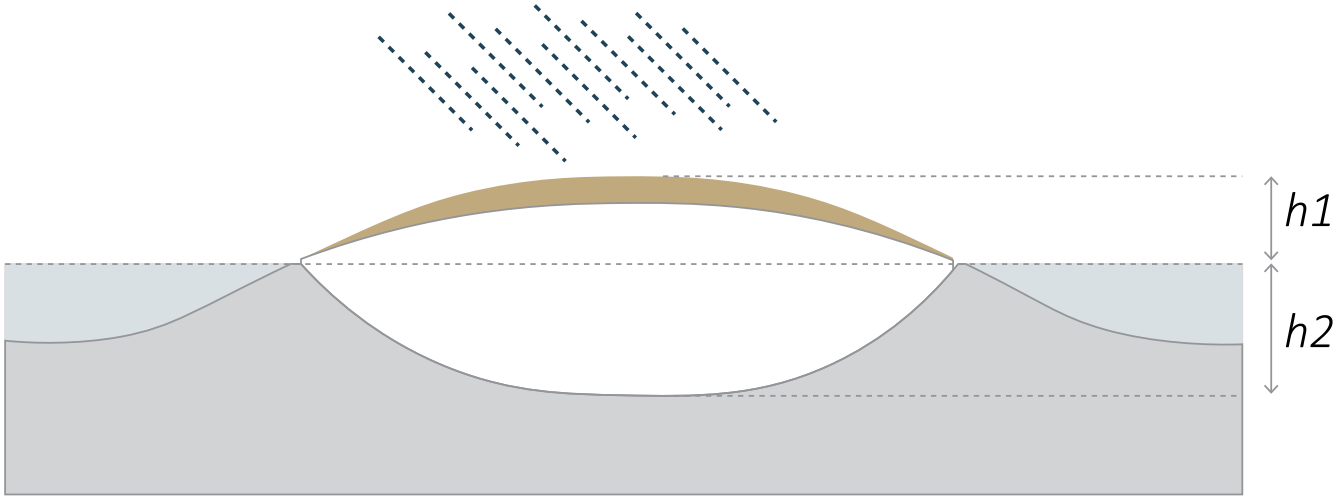
DIAGRAM-013: CLUSTERS




RESIDENTIAL
HOUSING
ROADS
RESIDENTIAL
HOUSING
PINE FOREST
ROAD AXIS
BEACHFRONT
DUNE
FOREST
SEA
BEACH
CANAL MOUTH
SEA

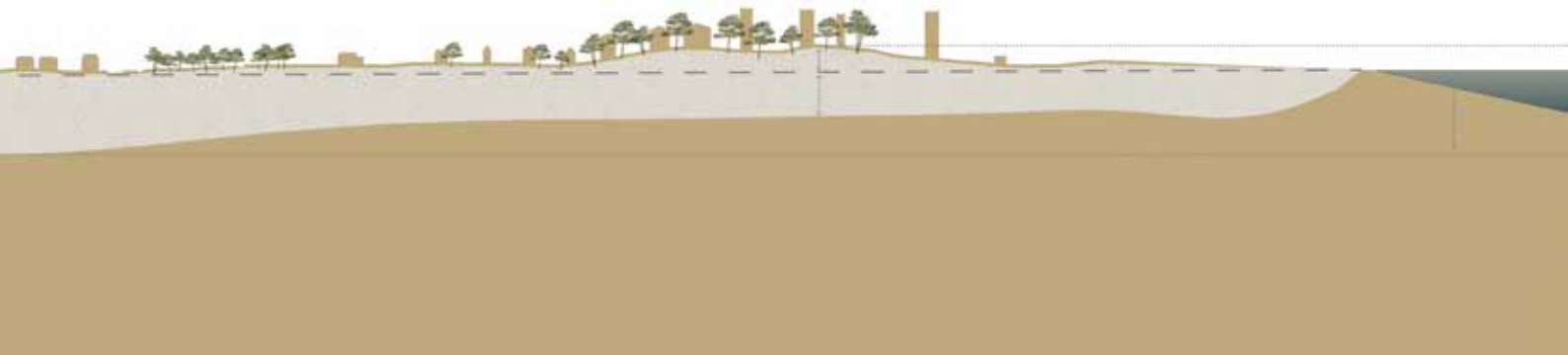
Lido Degli Estensi as Island

DIAGRAM–014: LIDO DEGLI ESTENSI AS ISLAND SECTION



DIAGRAM–015: SALT WEDGE DIAGRAM

The amount of freshwater stored in the aquifer depends on the sea level and land elevation. In order to combat salt water from intruding the ground water aquifers the thin layer of freshwater must be maintained



Flood Scenario Zoom

FLOOD EVENT
(PERINI, 2017)

P3 (10 YEARS)

P2 (100 YEARS)

P1 (+100 YEARS

MAP-012: LIDO DEGLI ESTENSI FLOOD SCENARIOS SOURCE: PERENI, 2017

+2.50

P1. +100 YEARS

+1.81

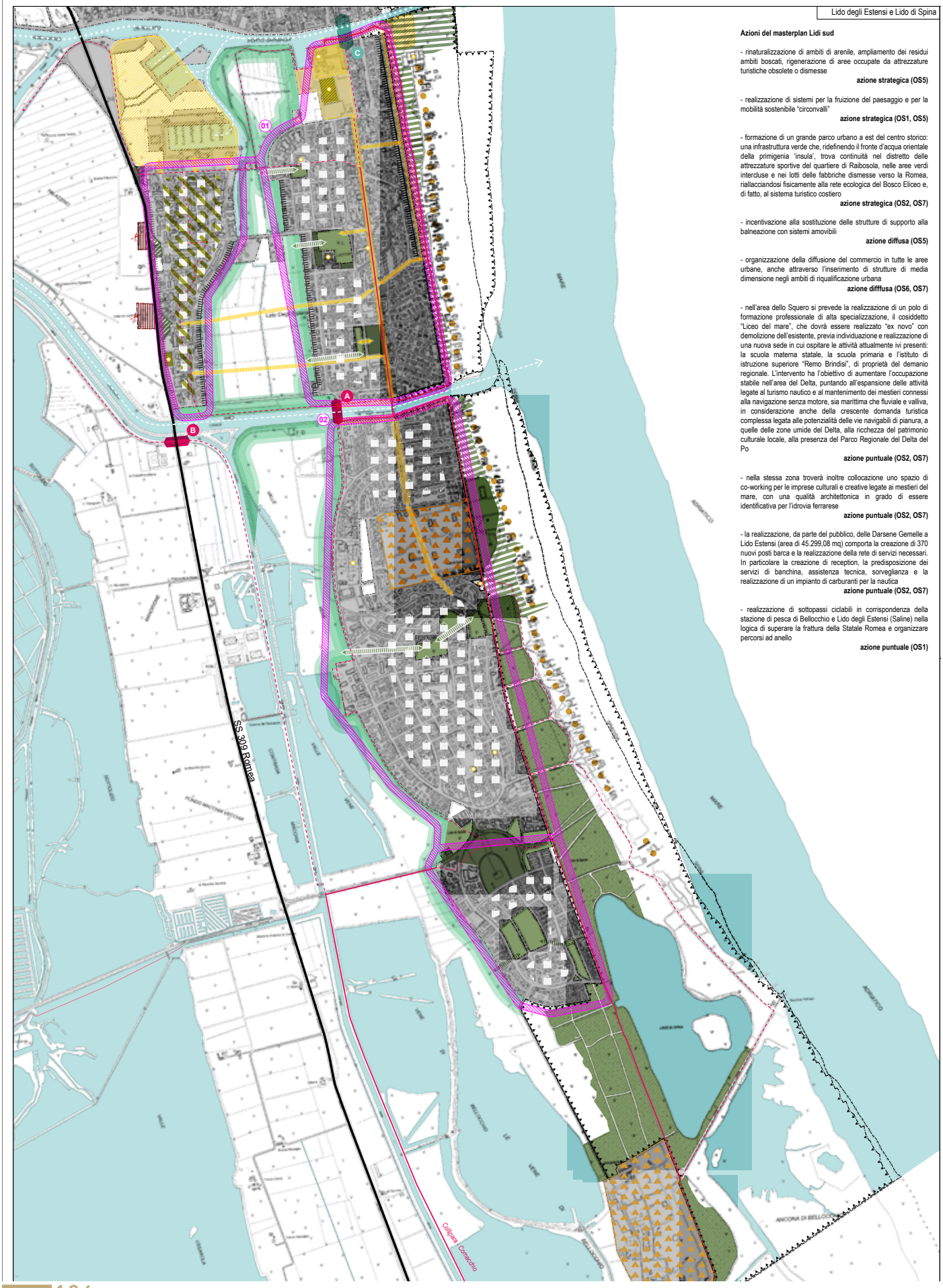
P2. 100 YEARS

+1.49

P3. 10 YEARS

+0

PUG



Lido degli Estensi e Lido di Spina

Azioni del masterplan Lidi sud

- rinaturalizzazione di ambiti di arenile, ampliamento dei residui ambiti boscati, rigenerazione di aree occupate da attrezzature turistiche obsolete o dismesse

azione strategica (OS5)

- realizzazione di sistemi per la fruizione del paesaggio e per la mobilità sostenibile "circonvalli"

azione strategica (OS1, OS5)

- formazione di un grande parco urbano a est del centro storico: una infrastruttura verde che, ridefinendo il fronte d'acqua orientale della primigenia 'insula', trova continuità nel distretto delle attrezzature sportive del quartiere di Raibosola, nelle aree verdi intercluse e nei lotti delle fabbriche dismesse verso la Romea, riallacciandosi fisicamente alla rete ecologica del Bosco Eliceo e, di fatto, al sistema turistico costiero

azione strategica (OS2, OS7)

- incentivazione alla sostituzione delle strutture di supporto alla balneazione con sistemi amovibili

azione diffusa (OS5)

- organizzazione della diffusione del commercio in tutte le aree urbane, anche attraverso l'inserimento di strutture di media dimensione negli ambiti di riqualificazione urbana

azione difffusa (OS6, OS7)

- nell'area dello Squero si prevede la realizzazione di un polo di formazione professionale di alta specializzazione, il cosiddetto "Liceo del mare", che dovrà essere realizzato "ex novo" con demolizione dell'esistente, previa individuazione e realizzazione di una nuova sede in cui ospitare le attività attualmente ivi presenti: la scuola materna statale, la scuola primaria e l'istituto di istruzione superiore "Remo Brindisi", di proprietà del demanio regionale. L'intervento ha l'obiettivo di aumentare l'occupazione stabile nell'area del Delta, puntando all'espansione delle attività legate al turismo nautico e al mantenimento dei mestieri connessi alla navigazione senza motore, sia marittima che fluviale e vallliva, in considerazione anche della crescente domanda turistica complessa legata alle potenzialità delle vie navigabili di pianura, a quelle delle zone umide del Delta, alla ricchezza del patrimonio culturale locale, alla presenza del Parco Regionale del Delta del Po

azione puntuale (OS2, OS7)

- nella stessa zona troverà inoltre collocazione uno spazio di co-working per le imprese culturali e creative legate ai mestieri del mare, con una qualità architettonica in grado di essere identificativa per l'idrovia ferrarese

azione puntuale (OS2, OS7)

- la realizzazione, da parte del pubblico, delle Darsene Gemelle a Lido Estensi (area di 45.299,08 mq) comporta la creazione di 370 nuovi posti barca e la realizzazione della rete di servizi necessari. In particolare la creazione di reception, la predisposizione dei servizi di banchina, assistenza tecnica, sorveglianza e la realizzazione di un impianto di carburanti per la nautica

azione puntuale (OS2, OS7)

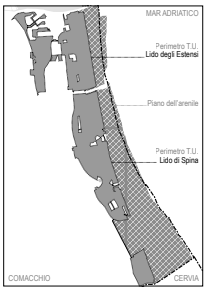
- realizzazione di sottopassi ciclabili in corrispondenza della stazione di pesca di Bellocchio e Lido degli Estensi (Saline) nella logica di superare la frattura della Statale Romea e organizzare percorsi ad anello

azione puntuale (OS1)

FIGURE 0106: PUG

LEGENDA

- Perimetro del Territorio Urbanizzato (art. 32, L.R.24/2017)
- Confini del Territorio Comunale
- Perimetro del Piano dell'Arenile
- Canali - infrastruttura blu esistente
- Aree boscate da preservare, valorizzare e connettere
- Infrastruttura verde di progetto
- Connessioni ecologiche
- Margini dei paesaggi anfibi
- Riconfigurazione del fronte del fronte sui 'paesaggi anfibi'
- Ricomposizione del fronte mare
- Riqualificazione del fronte canale
- Fascia verde di mitigazione della SS 309 Romea
- Riorganizzazione del commercio diffuso
- Incremento del verde in ambito urbano
- Verde attrezzato
- Attrezzature collettive
- Polarità urbane esistenti
- Polarità di progetto o oggetto di riqualificazione/valorizzazione
- Connessioni con e tra polarità
- Fronti permeabili
- Campeggi esistenti
- Sostituzione di stabilimenti balneari con sistemi rimovibili
- Insediamenti giudicati incongrui dal punto di vista paesaggistico, ambientale o della compattezza del costruito
- Canali navigabili
- Canali navigabili - Progetto Idrovia ferrarese
- Viabilità carrabile principale
- Percorsi ciclabili in sicurezza (piste e/o aree ciclopedonali)
- Percorsi ciclabili di progetto
- **A** Riqualificazione/ricostruzione ponte sul canale Logonovo
  B Realizzazione di sottopasso ciclopedonale sotto la SS 309 Romea
- **C** Potenziamento traghetto di attraversamento del canale Navigabile
- Progetti specifici
  01 Sistemi per la fruizione del paesaggio e per la mobilità ostenibile ("circonvalli") integrati a opere di contrasto al fenomeno dell'ingressione marina da realizzare al Lido degli Estensi
  02 Sistemi per la fruizione del paesaggio e per la mobilità ostenibile ("circonvalli") da realizzare al Lifo di Spina



CITTÀ DI COMACCHIO
PROVINCIA DI FERRARA

PUG

TAVOLA **04**
SCALA 1:10.000

OBIETTIVI STRATEGICI E SCELTE GENERALI DI ASSETTO DEL TERRITORIO
MASTERPLAN "LIDI SUD"

DATA febbraio 2021

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Adottato
Del. C.C. n. del

5.2 A Recalibration of Coastal Mosaic Flows on the Riveria Romagnola

Concept Diagrams

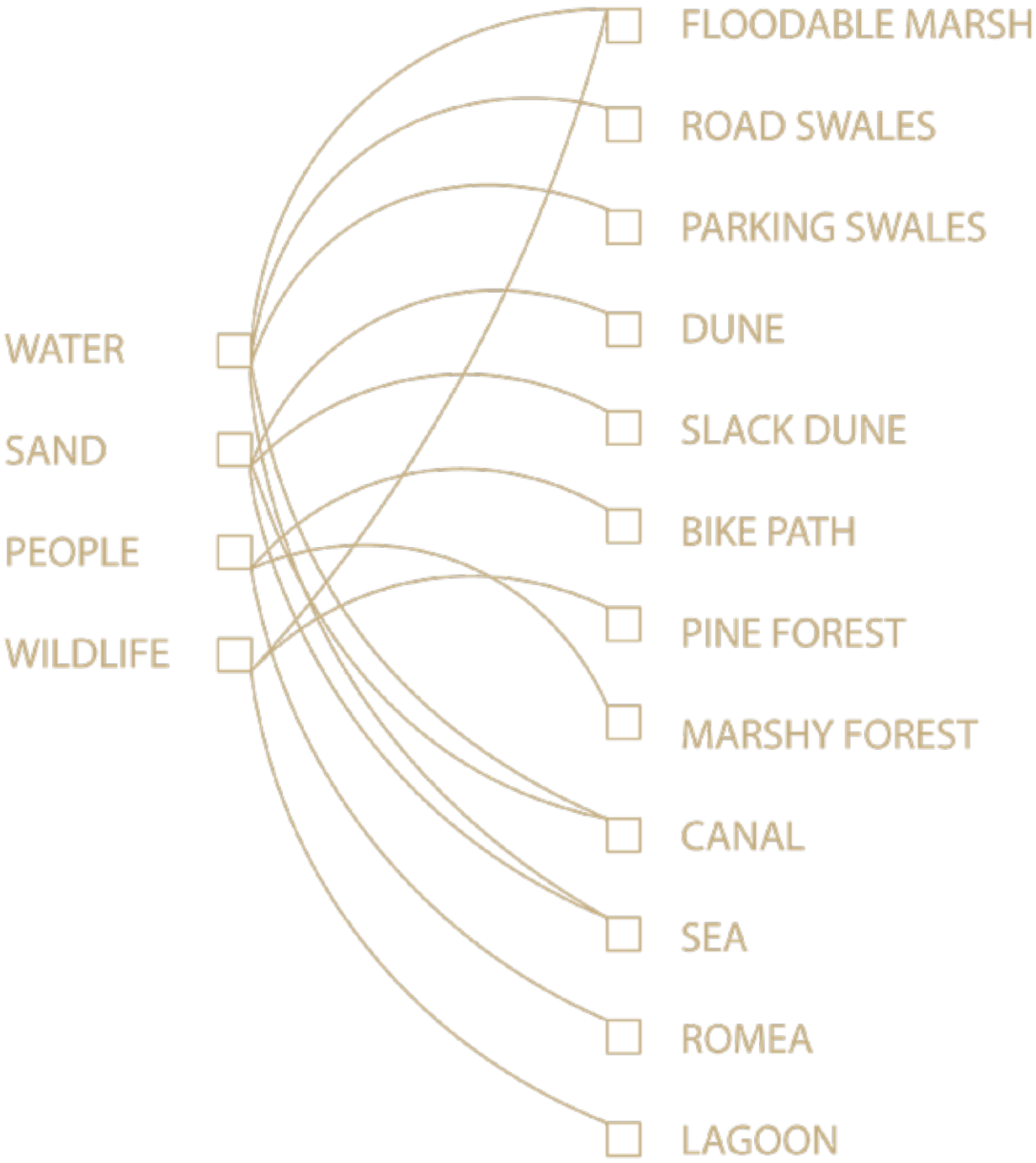
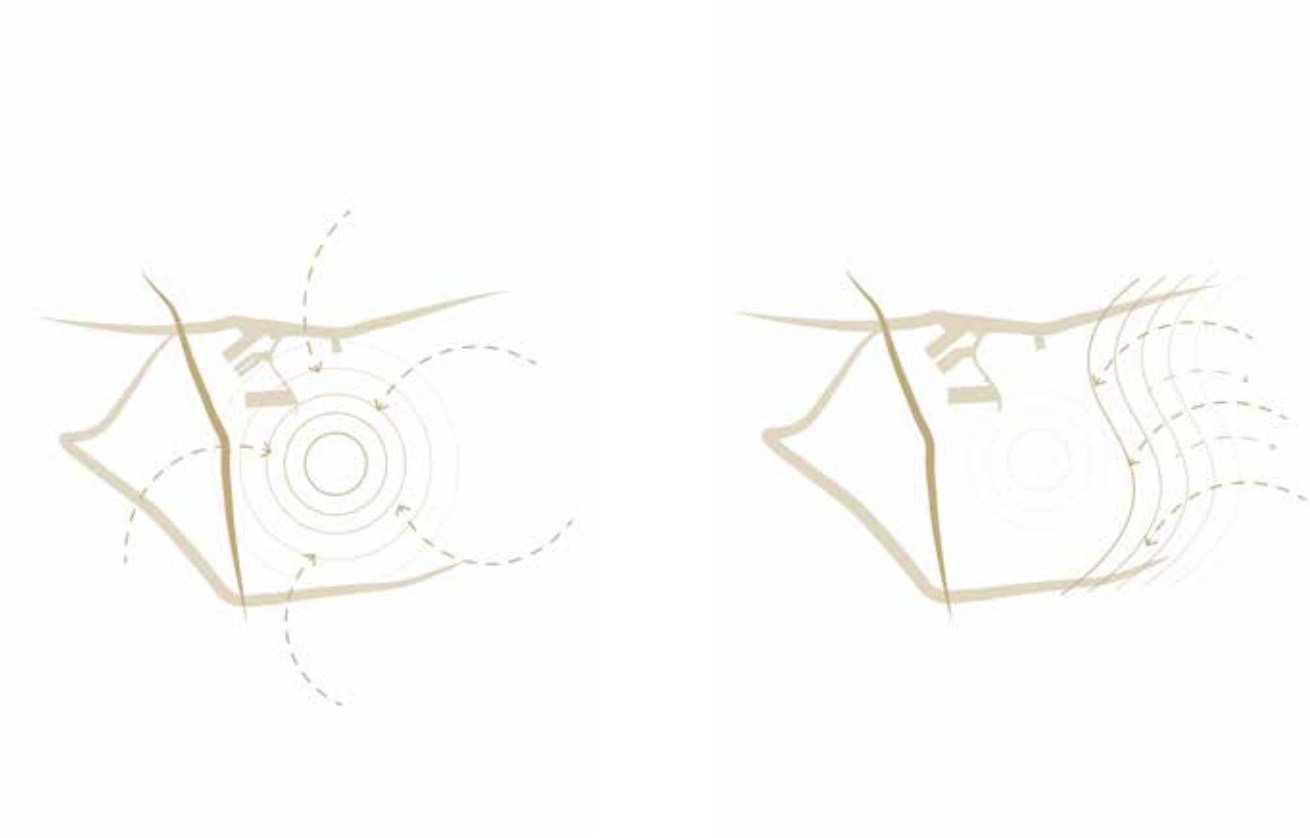


DIAGRAM-016: CONCEPT
DIAGRAMS



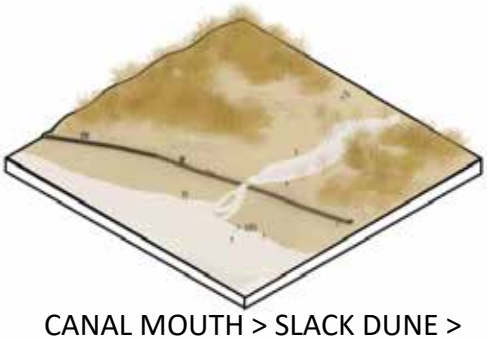
Project aims

DIAGRAM–017:
RECALIBRATING TRAFFIC

DIAGRAM–018:
RECALIBRATING WATER

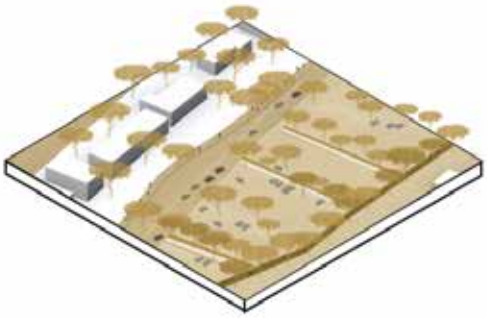
DIAGRAM–019:
RECALIBRATING WILDLIFE

Introduced clusters

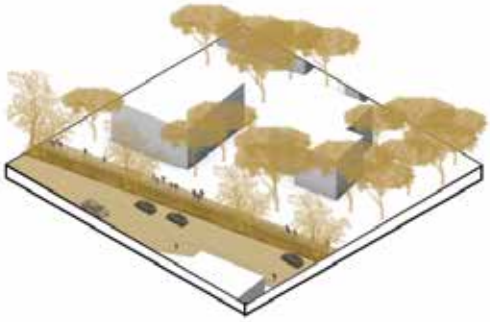


CANAL MOUTH > SLACK DUNE > JETTY

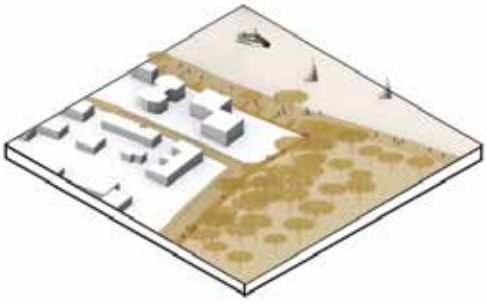
DUNE > BOARDWALK > BEACH



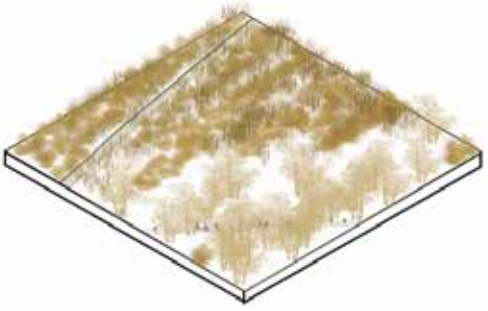
PINE FOREST > BIOSWALE > PARKING > SEA



STREET > BIOSWALE > MARSH PARKLAND

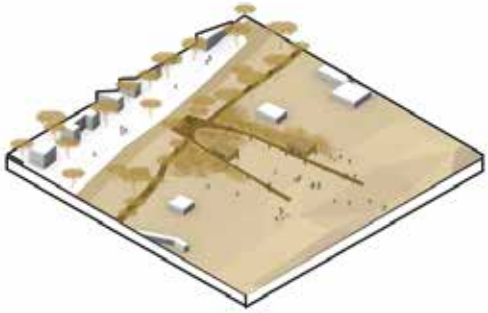


CANAL > BIOSWALES > DUNES > LUNGO MARE

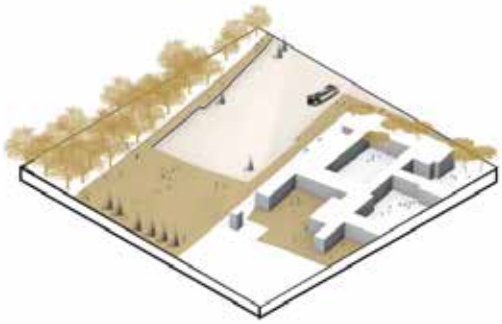


MARSH > MARSHY FOREST > SLOW MOBILITY

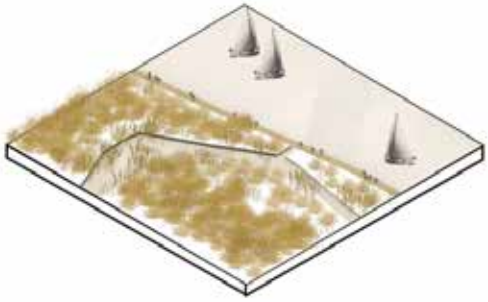
DIAGRAM-020: INTRODUCED CLUSTERS



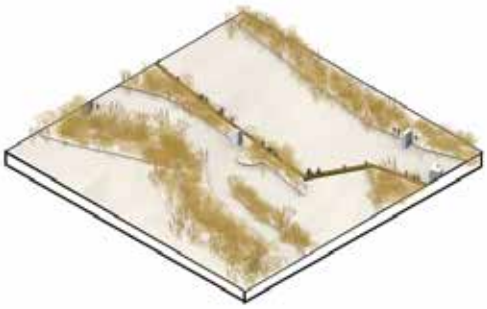
DUNE > BOARDWALK >RAISED BAGNI > BEACH



CANAL > LICEO AL MARE > MARSH



MARSH > CANAL > PEDESTRIAN PATH



LAGOON > SLOW MOBILITY PATHWAYS

MARSH > CANAL > OUTDOOR CLASSROOM

Design Precendents Responding to RSLR in Urbanized Delta's

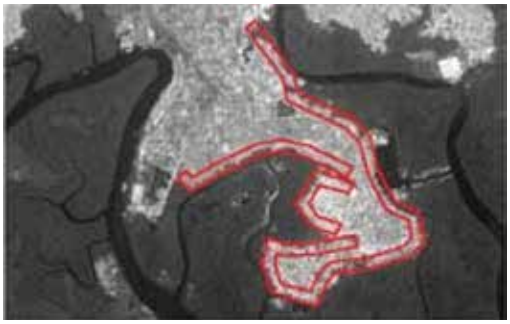
FIGURE 0107: INNOVATIVE SOLUTIONS FOR THE DELTA

World Deltas "Innovative Solutions for the Delta". Delta Alliance, 2nd Edition of competition. 2008-2010 Research Project. http://www.climatedeltaconference.org

Resistence | | | | ● | | | | | Resilience

FIGURE 0108: DELTA CITY OF THE FUTURE

World Deltas "Delta City of the Future" Unesco Competition 2010 www.unesco-ihe.org/delta-city-of-the-future



Resistence | | | | ● | | | | | Resilience

FIGURE 0109: AERATED LAGOON PARK

Vietnam, Ho Chi Minh City "Aerated Lagoon Park". Black & Veatchetal. 200.

Resistence | | | | ● | | | | | Resilience

FIGURE 0110: ZHIANGIJAWO NEW TOWN

China, Tianjin. "Zhiangijawo New Town" Atelier Dreiseitl. 2006-2009

Resistence | | | | ● | | | | | Resilience

FIGURE 0111: SOAK MUMBAI IN AN ESTUARY

India, Mumbai. "Soak, Mumbai in an Estuary".Mathar Da Cunha, 2009. Research Project and Exhibition

Resistence | | | | ● | | | | | Resilience

FIGURE 0112: SUPERLEVEES Japan, “Super Levees”. Nation Program. 1985

Resistence | | | | ● | | | | | Resilience

FIGURE 0113: BOTANICAL GARDEN AND RIO PIEDRAS RESTORATION PROJECT Puerto Rico, San Juan. “Botanical Garden and Rio Piedras Restoration Project”. Field Operation et al. 2006.

Resistence | | | | ● | | | | | Resilience

FIGURE 0114: OLYMPIC GAMES PLACE Australia, Sydney. “Olympic Games Place”. Hargreaves Associates. 2000.

Resistence | | | | ● | | | | | Resilience

FIGURE 0115: SEA CHANGE 2030+ Australia Sydney Harbour. “Sea Change 2030+”. Competition. 2009.

Resistence | | | | ● | | | | | Resilience

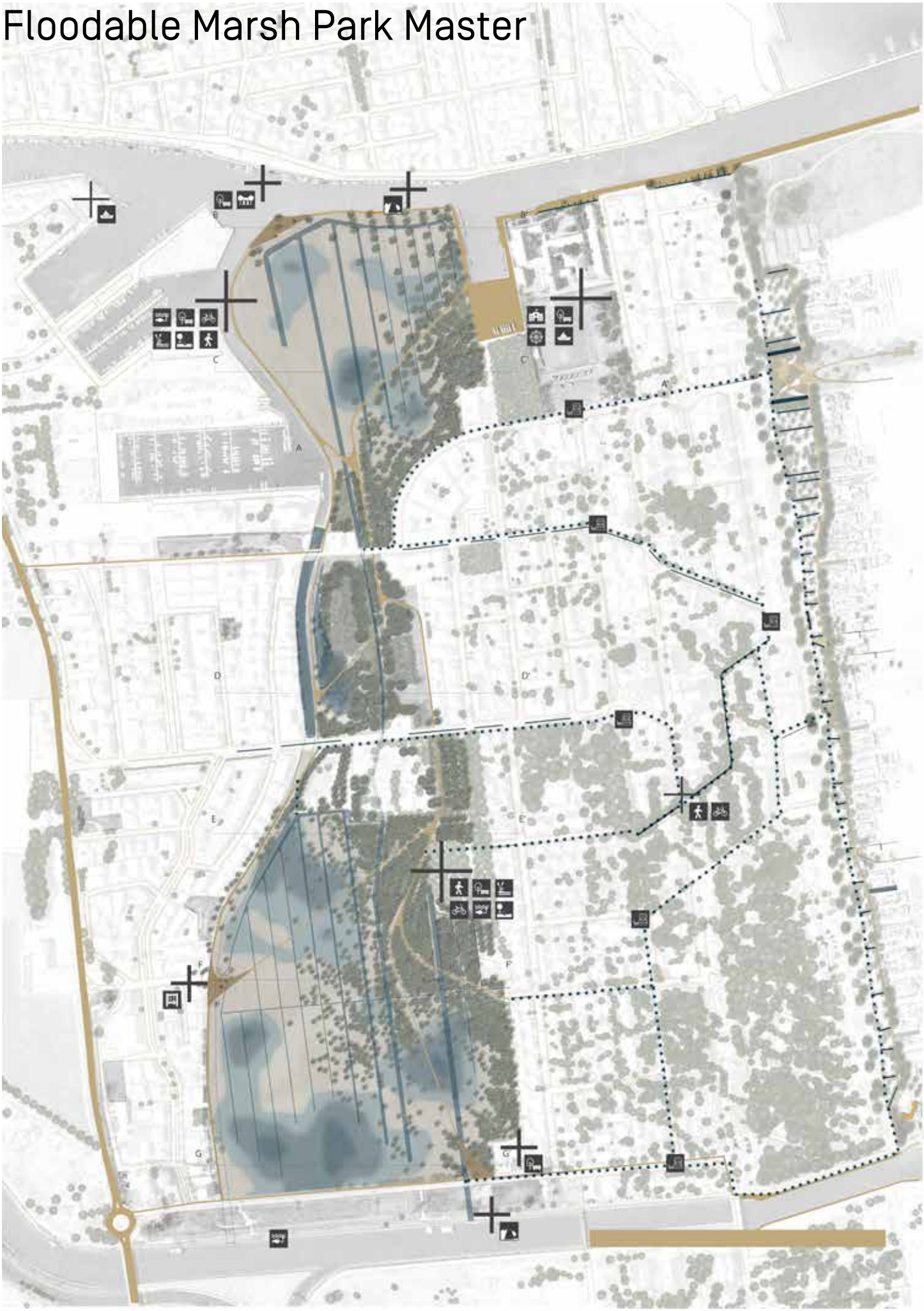
FIGURE 0116: NEWPLYMOUTH FORESHORE New Zealand, New Plymouth. “New Plymouth Foreshore”. Isthmus sdt. 2005

Resistence | | | | ● | | | | | Resilience

Masterplan

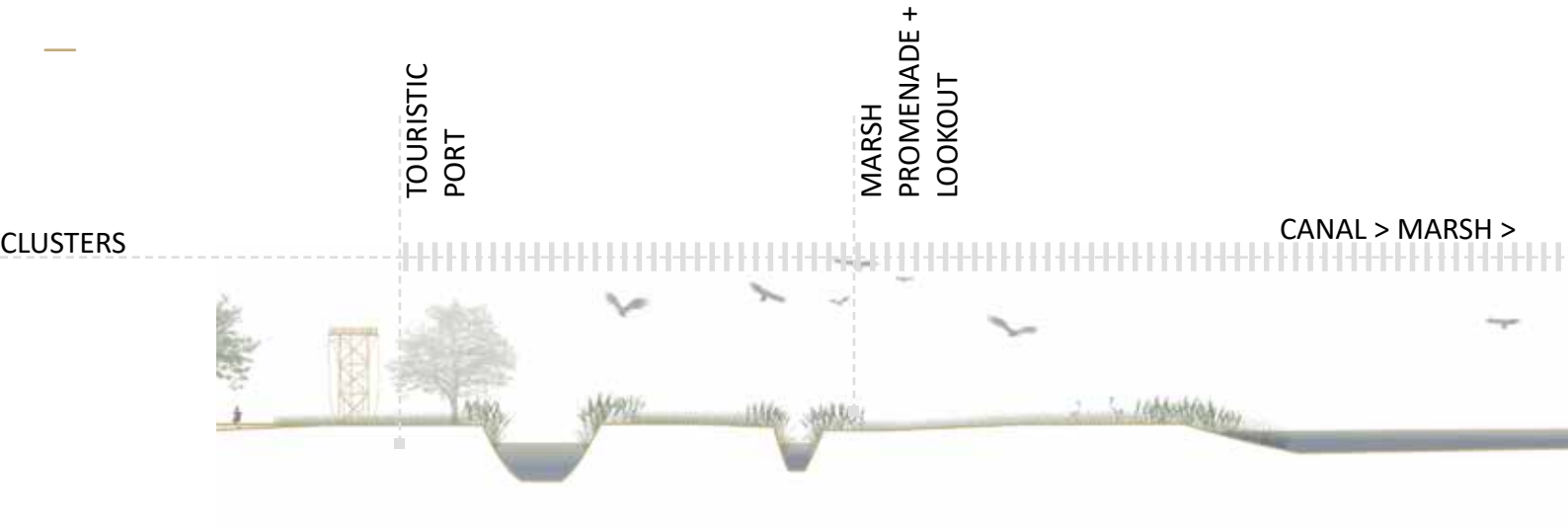
DIAGRAM–021: MASTER PLAN

Floodable Marsh Park Master

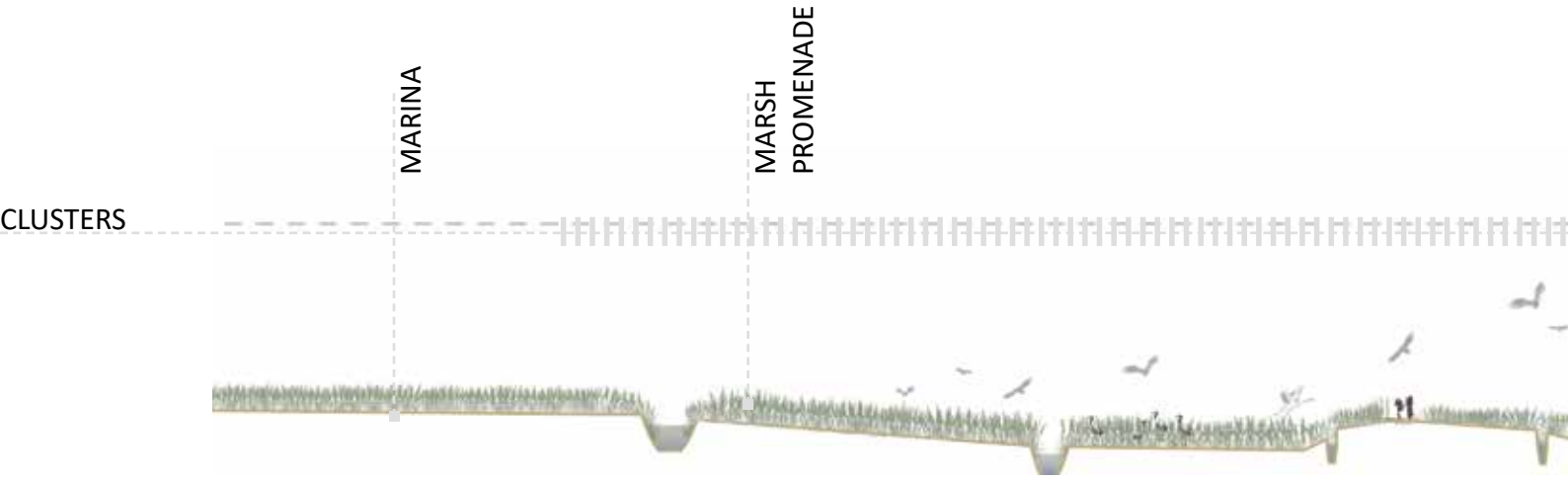


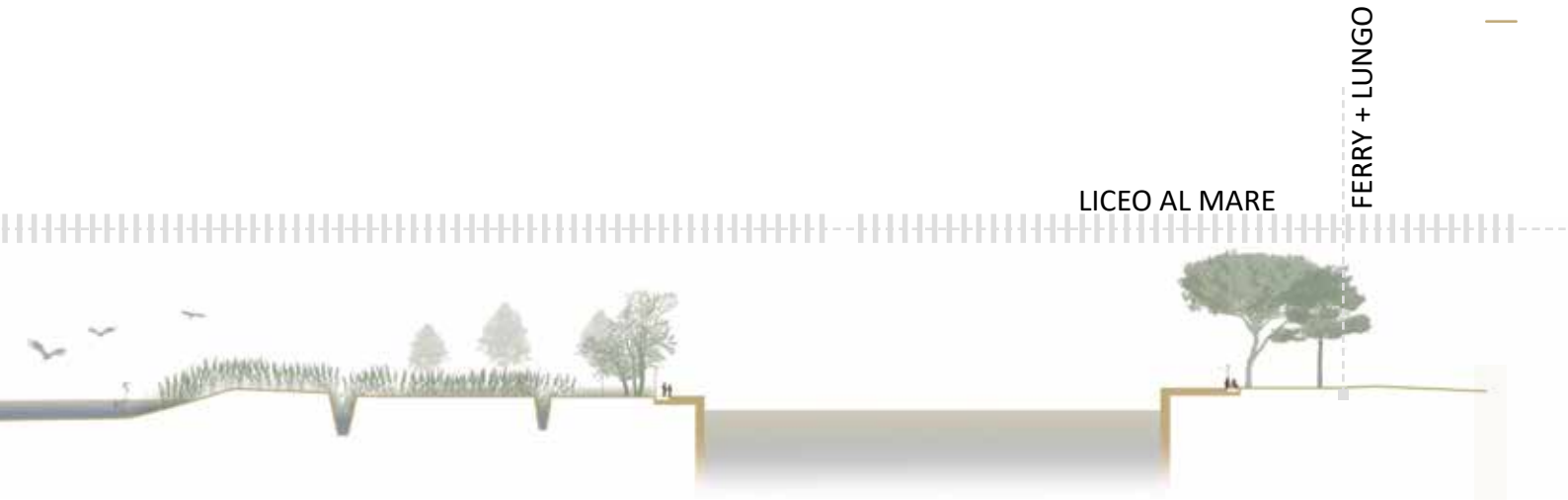
MAP-013: MARSH PARK
MASTERPLAN

SECTION B-B'
1:1,000



SECTION C-C'
1:1,000




FERRY + LUNGO
LICEO AL MARE


FLOOD PATH
CANAL > MARSH > MARSHY FOREST

Marsh Park

SECTION D-D'
1:1,000

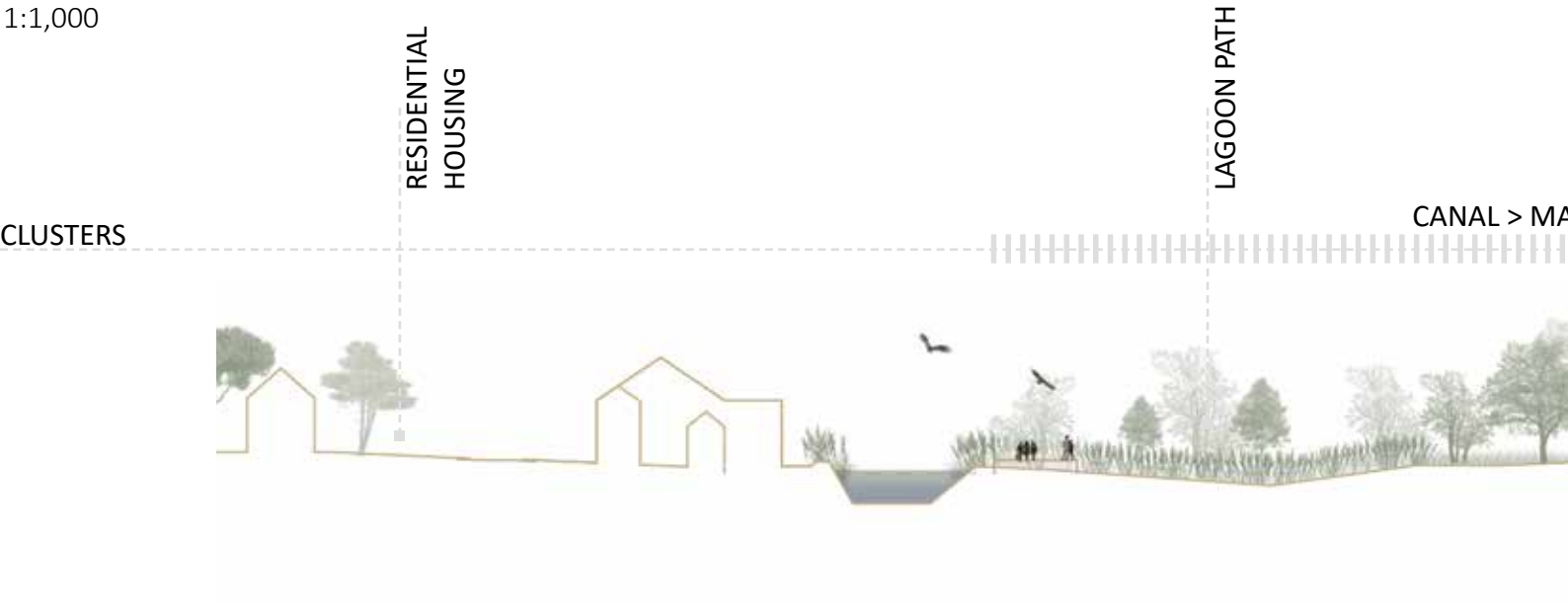
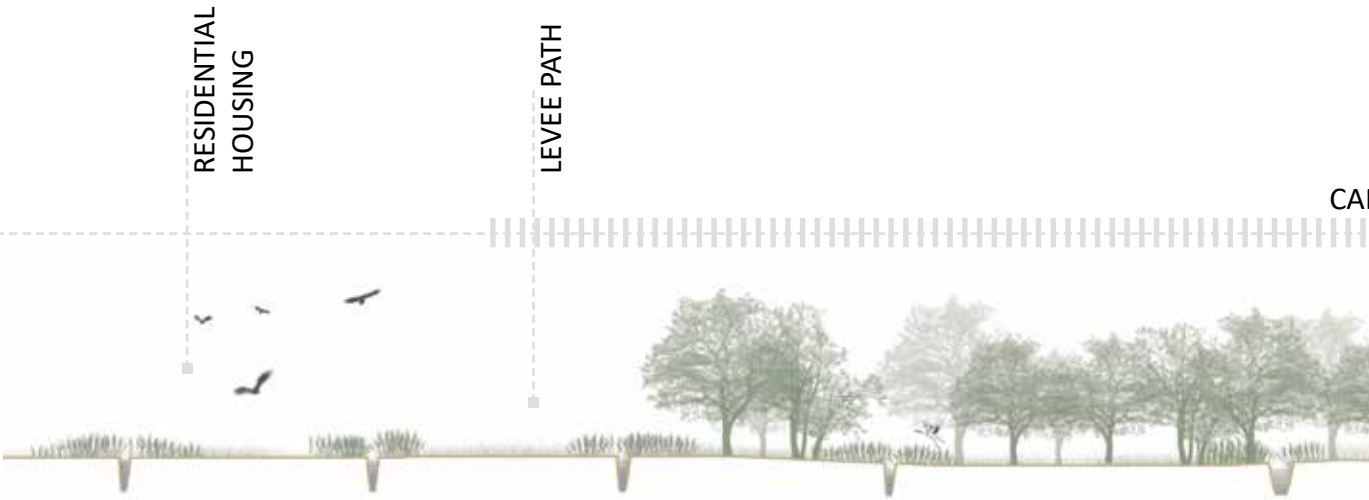


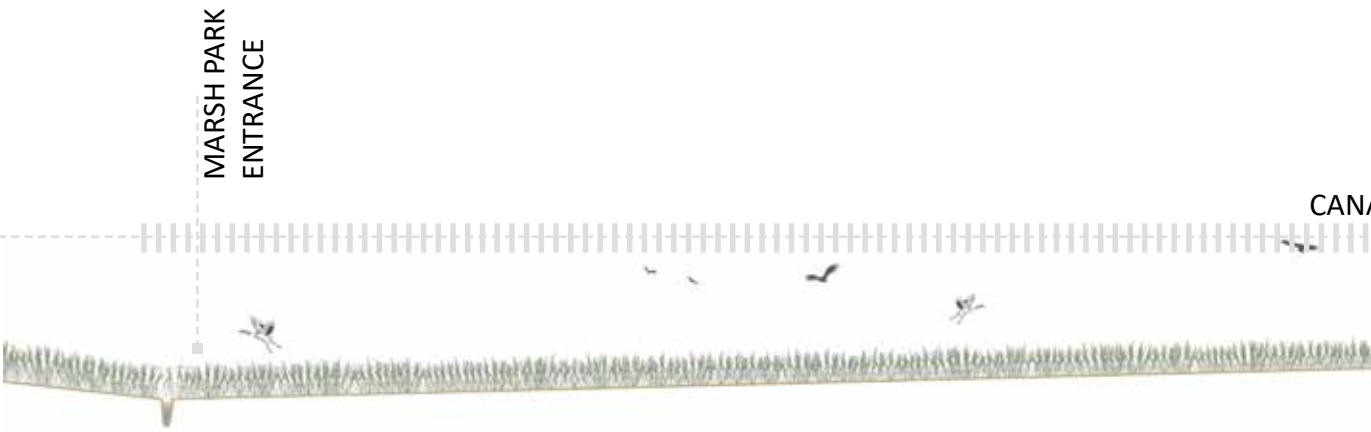
DIAGRAM-022: MARSH LONG SECTION

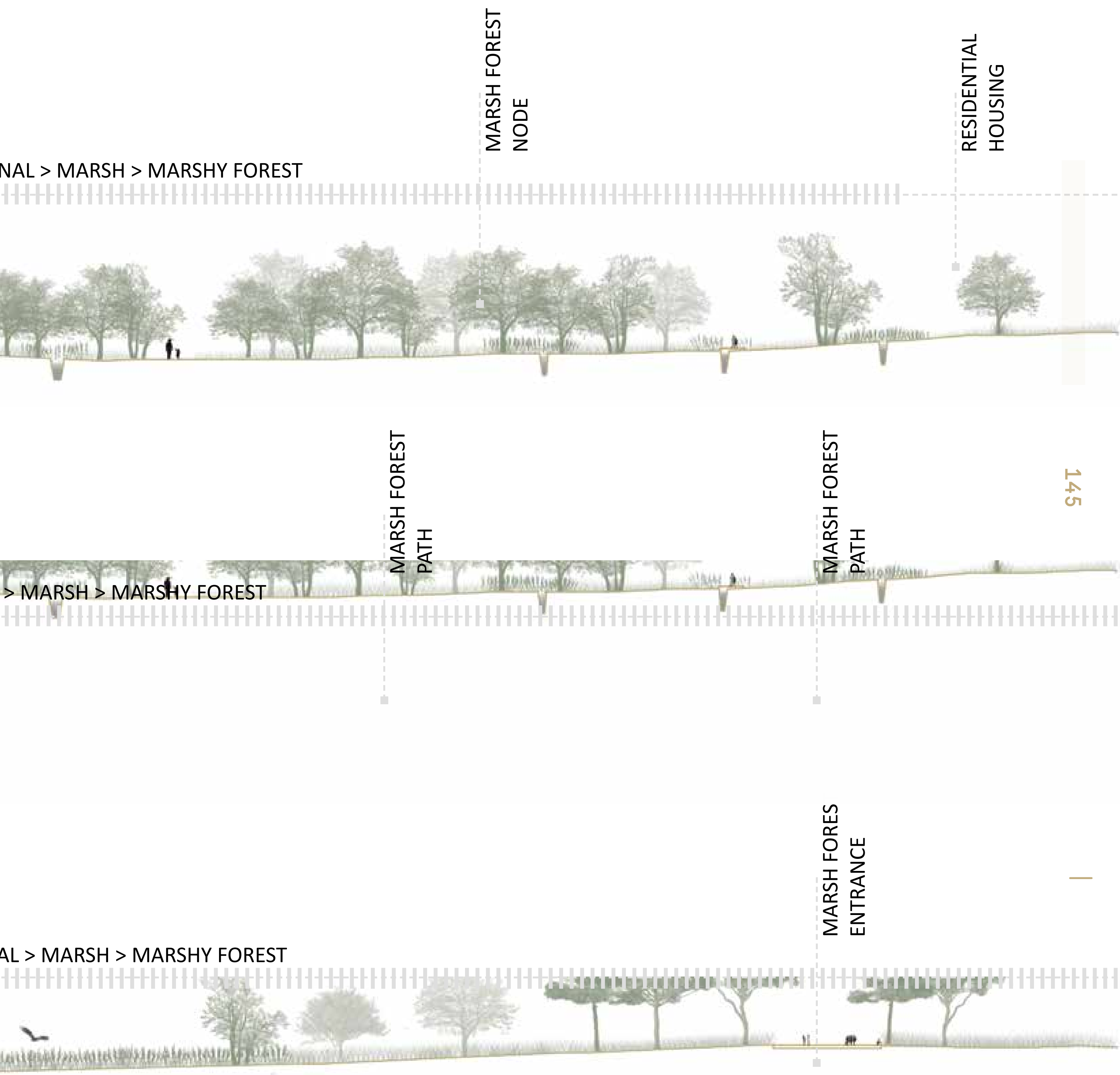
SECTION E-E'
1:1,000



SECTION F-F'
1:1,000

SECTION G-G'
1:1,000



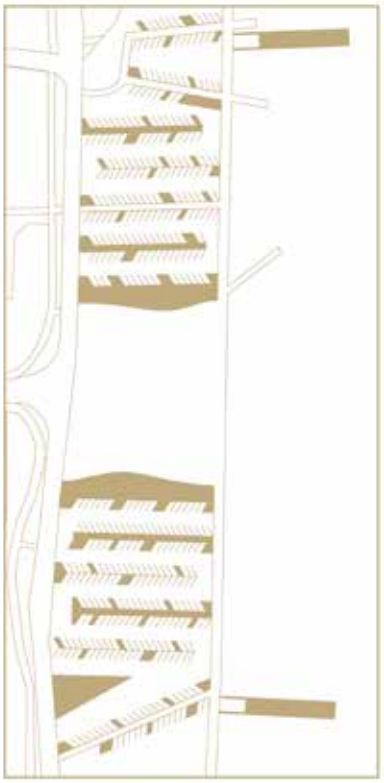


MARSH FOREST
NODE
RESIDENTIAL
HOUSING
NAL > MARSH > MARSHY FOREST
MARSH FOREST
PATH
MARSH FOREST
PATH
> MARSH > MARSHY FOREST
MARSH FORES
ENTRANCE
AL > MARSH > MARSHY FOREST

Lungo Mare Plan

MAP-014: LUNGO MARE
PLAN

DIAGRAM-023: PARKING DIAGRAM



Lungo Mare Long Section

DIAGRAM-024: MARSH LONG SECTION

DIAGRAM-025: BEACH FRONT

DIAGRAM-026: BEACH FRONT
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