AMERICAN UNIVERSITY OF BEIRUT

RETREAT TO ADVANCE: LANDSCAPE AS COASTAL INFRASTRUCTURE IN A CHANGING CLIMATE, THE CASE OF DAMOUR, LEBANON

by
DANA REDA ALI

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Urban Design to the Department of Architecture and Design of the Maroun Semaan Faculty of Engineering and Architecture at the American University of Beirut

Beirut, Lebanon
January 2020

AMERICAN UNIVERSITY OF BEIRUT

RETREAT TO ADVANCE: LANDSCAPE AS COASTAL INFRASTRUCTURE IN A CHANGING CLIMATE, THE CASE OF DAMOUR, LEBANON

by
DANA REDA ALI

Approved by:

Dr. Maria Gabriella Trovato, Assistant Professor — Advisor
Department of Landscape Design and Ecosystem Management

Dr. Robert Saliba, Professor — Member of Committee
Department of Architecture and Design

~~Dr.~~ Aram Yeretzian, Assistant Professor — Member of Committee
Department of Architecture and Design

Dr. Nadim Farajalla, Director of Program — ~~Member of~~ Committee
Issam Fares Institute for Public Policy and International Affairs

Date of thesis/dissertation defense: February 12, 2020

AMERICAN UNIVERSITY OF BEIRUT

THESIS, DISSERTATION, PROJECT RELEASE FORM

Student Name:

Ali	Dana	Reda
Last	First	Middle

● Master's Thesis ○ Master's Project ○ Doctoral Dissertation

[x] I authorize the American University of Beirut to: (a) reproduce hard or electronic copies of my thesis, dissertation, or project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

[ ] I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of it; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes after:

One ---- year from the date of submission of my thesis, dissertation, or project.
Two ---- years from the date of submission of my thesis, dissertation, or project.
Three ---- years from the date of submission of my thesis, dissertation, or project.

[signature] February 20, 2020

Signature Date

ACKNOWLEDGEMENTS

To my family: Reda, Fatima, Ali, Nada, and Fayrouz, words cannot express how thankful I am for all that we have shared, for your continuous support, and unwavering love. I thank you for all that I am. To my mother, Fatima, thank you for giving me life, for being a source of warmth and love, for teaching me to see beauty and to have compassion, and for always standing by my decisions and pushing me to pursue higher learning. You have taught me many things far more important than what I could ever learn through schooling.

I want to thank my advisor, Prof. Maria Gabriella Trovato, for being my friend as well as mentor, for sharing many laughs, and for inspiring me to always achieve my best work. I thank you for your trust in me, your guidance, and for expanding my horizons both academically and personally. It has been a pleasure learning from you, working with you, and being your advisee.

To my committee readers, Prof's Robert Saliba, Nadim Farajallah, and Aram Yeretzian, thank you for all you have taught me, for your time, effort, and support in this process. I'd also like to thank Prof's Ramzi Farhat, Habib Basha, and Rami Zurayk, for sharing their knowledge and time with me. Many thanks to Patty Farah for assisting me in GIS, Public Works Studio for sharing their data of Damour with me, and Yasmina Choueiri for her guidance and advice .

And to all my previous and current professors, friends, and family, my sincere gratitude to you all.

AN ABSTRACT FOR THE THESIS OF

Dana Reda Ali for Master of Urban Design
Major: Urban Design

Title: Retreat to Advance: Landscape as Coastal Infrastructure in a Changing Climate, the case of Damour, Lebanon

Climate change and its impacts are currently threatening cities and landscapes all around the world; however, recent events and decades of observation show that the climate is already changing in the Mediterranean, terming the region a “hotspot” (Garcia et al., 2011). While mitigation efforts through global agreements have sought to reduce the causes of climate change, a more localized response is required to adapt to current and projected changes that are unevenly distributed. Therefore, there is a pressing need and challenge for municipalities, communities, planners, and designers to respond to climate and climate-related impacts, and provide resilient solutions that can reduce vulnerability of people, assets, and localities.

In line with this challenge, this research aims to integrate climate change and its impacts into design and planning, by taking the coastal town of Damour in Lebanon as a case study, where adaptation is seen as a necessary measure to adjust to and cope with current and future challenges. Other than direct impacts, climate change exacerbates risks and hazards Damour’s landscape is subject to, such as coastal erosion, salt-water intrusion, flooding, forest fires, and water pollution. Therefore, a resilient approach towards coastal development is proposed that works with dynamism and unpredictability as inherent qualities of coastal landscapes. Guided by a scalar and temporal approach through concepts of landscape urbanism, and situated in resilience theory, this thesis proposes design adaptation strategies throughout a timeline, where their compatibilites are studied in aims of imagining an alternative, dynamic, and resilient landscape. Here, infrastructure assumes a hybrid role capable of mediating between proposed programs and adapting to changes. Thus, risk becomes opportunity.

CONTENTS

ILLUSTRATIONS

Figure page

TABLES

CHAPTER I
INTRODUCTION

The relationship between man and sea has transformed in the past 300 years. Once feared and avoided for its unpredictable nature, the sea today is sought. This can be seen in popular artworks of the early-mid. 19th centuries, such as the 'Slave Ship' by Turner, or 'The Great Wave' by Hokusai (Fig. 1.1). In Turner's work, which is saturated with a political message, man is not only enslaved by his own kind but is also dominated by the sea, depicted as an endless entity (Kleiner, 2008). The sea in Hokusai's work, full of movement, is seemingly overpowering three ships on what seems to be a clear day. Mount Fuji is not striking in the image, but lurks firmly in the background and strongly contrasts the dynamic waves in character, however not in style. In some sense land becomes sea and sea becomes land.

As we become more invested in our coasts, the sea remains an element of unpredictability; however, we are ever encroaching upon it. A clearly preferred zone for urbanization, the coast now presents many resources and a range of activities essential to society (Hall, 2001). Nonetheless, the coast is a "risky" place, subject to many threats exacerbated by anthropogenic impacts and climate change.

Fig. 1.1. Left: "The Slave Ship" by J. M. W. Turner; Right: "The Great Wave" by Katsushika Hokusai
Source: amazaon.co.uk

A. Problem Definition

Climate change and its impacts are currently threatening cities and landscapes all around the world; however, recent events and decades of observation show that the climate is already changing in the Mediterranean, terming the region a "hotspot" (Garcia et al., 2011). While mitigation efforts through global agreements have sought to reduce the causes of climate change, a more localized response is required to adapt to current and projected changes that are unevenly distributed. Therefore, there is a pressing need and challenge for municipalities, communities, planners, and designers to respond to climate and climate-related impacts, and provide resilient solutions that can reduce vulnerability of people, assets, and localities.

The Mediterranean region is considered a "hotspot" or a reference lab for the global climate change community (Garcia et al., 2011; Doublas, 2015). Recent extreme events and decades of observation show that the Mediterranean climate is already changing, with increased heat waves, more intense storms, earlier spring seasons, drier winter seasons, increased droughts, and more (Santos et al., 2014). Very recently, on January 19th, 2020, Storm Gloria hit the Eastern Spanish coast on the Mediterranean, causing unprecedented damages and claiming 13 lives with 10 people reported missing. With winds traveling at 140km/hr and wave heights reaching 15m, many coastal towns flooded with sea water, the Ebro river delta was inundated, beaches lost almost 30% of the shore area, and many touristic and agricultural areas were compromised. The lack of preparedness to such an event was high, and the consequences were higher. This sheds light on the need for immediate action to mitigate and adapt to the effects of climate change in the Mediterranean, incoporating unpredictability as a factor that must be considered in coastal development.

1.Source:https://www.theolivepress.es/spain-news/2020/02/03/weve-never-seen-anything-like-it-beaches-in-eastern-spain-lose-average-of-11m-of-sand-following-storm-gloria.

In the case of Lebanon, the integration of climate and climate-related risks into planning and urban design has not yet materialized, and approaches to more adaptive systems that employ flexible structures is lacking. This is seen in the way cities and landscapes are designed through traditional engineering/infrastructure thinking that wishes to overcome the forces of nature rather than work with them. Consequentially, many areas, specifically the coast, are highly vulnerable to climate change and its impacts.

In the case of Damour, a coastal town South of Beirut experiencing increased development pressures, climate-related threats and climate change impacts include coastal erosion, sea level rise, flooding, desertification, forest fires, water pollution, and salt-water intrusion. Moreover, increased resorts and privatized shore lands have led to arbitrary, hard-engineering, shore protection measures, often increasing vulnerability of adjacent shores and inland areas to extreme events. The current municipal plan designates the entire shore as a tourism zone, however, this is an unsustainable approach that stresses the landscape, places resorts at risk themselves, and completely disregards the shore as a public space. Therefore, this predominantly agricultural town is currently attractive to resort and real-estate development, but it's actually highly vulnerable to many risks and must be planned and designed taking these factors into consideration.

B. Research Question and Aims

1. Research Question

In addressing the challenge of making landscapes and urban development more resilient and adaptive to climate change, the main questions tackled in this research are:

How can design respond to climate change threats?

How can climate and climate-related risks such as sea level rise and flooding turn into opportunity?

What strategies could be employed to decrease vulnerability and increase the resilience of coastal landscapes, in light of extreme events such as Storm Gloria that recently hit the Mediterranean?

2. Research Aims

The aims of this research are:

1. To integrate climate change into design and planning frameworks.

2. Establish a methodology to assess adaptation strategies and their possible application to a case study in the Eastern Mediterranean, and to technically explore how this can be done.

3. To perceive climate change as opportunity to orient development, planning, and design to ecological issues.

4. To question the norm that is currently adopted in Lebanon where urban development and associated infrastructures still rely on traditional and 'hard-engineering' approaches,

ruling out the potential of flexible and adaptive systems.

5. To push urbanism studies to a more proactive than reactive stance and role in theory and practice.

6. To rely on integrated and scalar approaches in designing with climate change, especially when there is limited data readily available at more local scales, as is the case for Lebanon.

C. Methodology & Research Structure

1. Methodology

The conceptual approach of this research (Fig. 1.2), operating under the framework of climate change, involved the process of 'Research through Designing,' (Lenzholzer et al., 2013) looking at different problems that arise under climate change, the multiple responses, and how different countries devised and employed different strategies to respond and cope with climate related changes. This also included researching advancements in technology and science, ecological engineering, adaptation to flooding and sea level rise, and seeing how they apply to the context of Damour.

Moreover, a main theme of landscape urbanism, *process over time,* was used, recognizing the need to shift attention away from studying and designing fixed patterns or states, towards the forces that condition or play a factor in shaping them (Corner, 2006). In this research, it's employed through a scalar and temporal approach, incorporating time as an active element in design, by looking at historical landscapes, current site conditions, global processes, and possible future trends, risks, and changes. The design intervention is also conceived in phases and in response to the analyzed changes and risks.

From an ideological point of view, the strength of the concept of landscape urbanism is realized, where urbanism can't be considered without landscape and vice versa. With this line of thinking, "landscape replaces architecture as the basic building block of contemporary urbanism" (Waldheim, 2006, pg. 11), through 'landscape infrastructures', where infrastructure is the "most important generative public space" (Mossop, 2006, pg. 171). Here, infrastructure becomes capable of "irrigating territories with potential," orienting urbanism towards a future that is "no longer obsessed with the city, but with the manipulation of infrastructure for endless intensifications and diversifications." (Koolhas, 1995, p. 969).

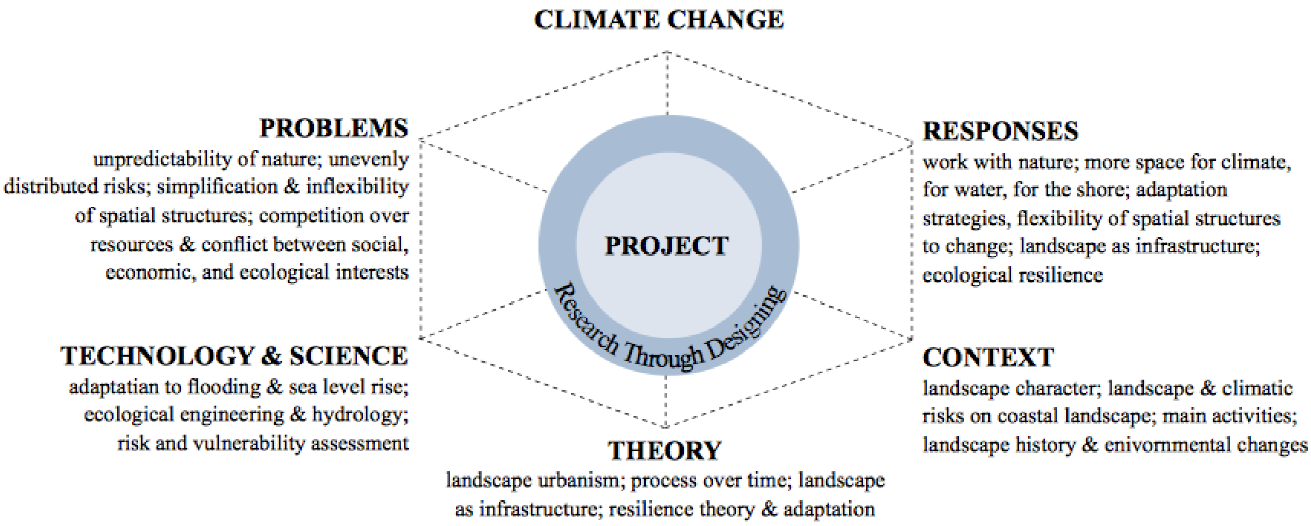


Fig. 1.2. Conceptual approach of this research project
Source:Author

2. Research Structure

The first chapter of this thesis introduced the main research topic, problematic, research content, methods, and the aims of the research. The second chapter attends to a literature review on the subject of climate change, its impacts, responses on global and national fronts, their limitation, and the possible linkages between adaptation responses with risk management efforts. The chapter culminates in a review of spatial adaptation strategies to flooding and sea level rise, relating them to practical examples and infrastructural approaches worldwide. The third chapter provides a background to the case study, moving from the scale of the Mediterranean to Lebanon's coast, and the fourth chapter delivers the case study of Damour. The fifth chapter includes the design intervention that delves into each pillar of the design strategy. The final chapter is reflects upon the presented work, describes the research limitations, and explores potentials for further research.

CHAPTER II
THEORETICAL FRAMEWORK

In its 4.5 billion years of recorded existence, earth's climate has always been changing (Burroughs, 2007; Flannery, 2008). Beginning as an anaerobic, cold, and life-less environment, earth evolved to include single-celled microbes and organisms photo-synthesizing and releasing oxygen as a by-product (Hetherington & Reid, 2010). With millions of years of volcanic eruptions releasing carbon dioxide into the atmosphere, the earth gradually got warmer as greenhouses gases trapped heat reflected off earth's surface, melting away a snow-covered landscape and replacing it with a vegetated one, which in turn trapped more heat from the sun (ibid.). Subsequent phases of cooling and heating followed, including extreme climate events that often triggered mass extinctions. These mass extinctions often gave way to colonization by new species, often marking new climatic periods (ibid.).

While climate change is a natural phenomenon, humans have been arguably accelerating this change (Gardoni et al., 2016). The period after the industrial revolution (labeled anthropogenic climate change) marks a sharp rise in global surface and ocean temperatures, and in carbon dioxide emissions and other greenhouse gases (IPCC, 2013). Between 1880 and 2012, the temperature of land and ocean surface increased by 0.85 °C, while emissions of greenhouse gases since 1990 have increased by 7% (IPCC, 2014). Today, climate change is posed as one of the most pressing challenges of the 21st century (Lawn, 2016; Gardoni et al., 2016; Hetherington & Reid, 2010).

The impacts of climate change are widespread, including sea level rise, ocean warming and acidification, severe weather events such as droughts, floods, heat waves, intense storms, and wildfires to name a few.

While these impacts threaten populations worldwide, they are often not experienced singularly, and exacerbate, or are exacerbated by anthropogenic influences or natural hazards (Gardoni et al., 2016). Moreover, climate change isn't globally uniform, and its effects vary based on the vulnerability and resilience of populations and localities (Zolnikov, 2019).

A. Defining Climate Change

Climate can be simply defined as the 'average weather' (Metz, 2009). However, Burroughs (2007, p. 2) makes a clear distinction between the two terms weather and climate, stating that "weather is what you get, and climate is what you expect". The IPCC (2013, p. 126) also distinguish between weather and climate, where:

> "Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system."

Therefore, climate change may cover broad spans of time such as millions of years or be limited to decades. The climate system is a result of both internal and external forcings (or exogenous shocks), and is driven by the energy of the sun (Stocker, 2014; Lawn, 2016).

It includes the land surface, atmosphere, oceans, and ice (Gardoni et al., 2016). It's a complex system with many interrelationships, where the concept of feedback is necessary to understand how the climate responds to change (Burroughs, 2007). Feedbacks are understood either as positive or negative, i.e. either they enforce the impact of a change, or they dampen it (ibid.). A popular example of a positive feedback is when warming causes the melting away of snow cover, leading to increased warming as more heat is absorbed at the surface. A negative feedback occurs when water vapor caused by warming of the ocean forms clouds, in turn dispersing sunlight and decreasing warming (ibid.).

B. Climate Change Impacts and Responses

1. Projected Climatic Variables And Impacts

The effects of climate change include extremes of atmospheric weather and climate variables (temperature, precipitation, and wind), and impacts on the natural environment, such as droughts, foods, extreme sea level and wave heights, coastal impacts, dust storms, and such, understood as 'compound events' (IPCC, 2012b). The IPCC (2012) uses climate models to predict future changes in climate; the projected changes by 2100 are summarized here:

- Temperature: decrease in unusually cold days and nights, and an increase in unusually warm days & nights, coupled with more intense and frequent warm spells or heat waves.
- Precipitation: an increase in frequency of heavy rainfall events around the globe but specifically in tropical and high latitude regions.
- Wind: insufficient data but presumably extreme wind patterns
- Droughts: Increased intensity and duration in some regions of the world, such as the Mediterranean, Central and Southern Europe, as well as Central America, Mexico etc.

- Floods: insufficient data for projections, but physical reasoning shows that heavy precipitation will contribute to flooding in some catchments, and it’s very likely that earlier spring flows will occur in snow-melt and glacier fed rivers.
- Extreme Sea Level & Coastal Impacts: it’s very likely that sea level rise will lead to extreme coastal high water levels; and areas experiencing coastal erosion and inundation will continue to do so in the absence of changes in other contributing factors.

Other than these direct impacts, both climate-related hazards and climate change affect multiple ecological systems, such as forests, grasslands, wetlands, rivers and marine environments, as well as agriculture, water & coastal resources, health, finance, and settlements (IPCC, 2001). Developing countries in particular are put at risk as they depend on agricultural sectors and fisheries, with low capacities to anticipate and respond to the effects of climate change (Thomalla et al., 2006).

2. Responses To Climate Change

Adaptation and mitigation are the two general policy responses to climate change (Zolnikov, 2019). Mitigation focuses on reducing or reversing the causes of anthropogenic climate change, through decreasing greenhouse gas emissions or increasing their sinks (Füssel & Klein, 2006; ACT, 2018). Adaptation refers to “adjustments in a system’s behavior and characteristics that enhance its ability to cope with external stress” (Brooks, 2003, p. 8). Mitigation efforts have been the focus of both scientific and policy related climate communities up until a decade ago (Füssel & Klein, 2006), with many climate conventions emphasizing the need for reducing or cutting down greenhouse gas emissions till this day (Lawn, 2016). The attention has however shifted to the need for placing more emphasis on adaptation. As outlined by Füssel & Klein (2006): 1. Mitigation alone can't respond to an already changing climate, 2. Mitigation operates over several decades before results can be seen, while adaptation is direct and can have immediate benefits, 3. Adaptations can be implemented on regional or local scales, and therefore are not solely reliant global cooperation (unlike mitigation efforts). Based on their timing, adaptations can be anticipatory or reactive, autonomous or planned (Fankhauser et al., 1999; Smit et al., 2000). This increased interest in the concept of adaptation to climate change is relevant to the evolution of the theory and practice of climate change vulnerability assessments (Füssel & Klein, 2006).

C. Intertwining Disaster Risk Reduction and Climate Change Adaptation

Disaster risk management is understood as the process of designing, implementing, and evaluating strategies and policies to increase knowledge of disaster risk, to reduce risk, and work to increase preparedness, response, and recovery practices, in aims of enhancing well-being, and sustaining development (IPCC, 2012a). The research communities in fields of disaster risk reduction (DRR) and climate change adaptation (CCA) are often intertwined in their common goals to decrease socio-economic vulnerability of populations and localities and enhancing resilience (Thomalla et al., 2006; Begum et al., 2014). Moreover, there is a general understanding that capitalizing on the synergies between disaster risk management and adaptation to climate change will help in the management of current and future risks (Thomalla et al., 2006). This is obvious in a changing attitude in DRR (as it became an important component in development planning), moving from reactive, post-impact responses to more proactive, prospective risk prevention ones

(UNISDR, 2009). Both CCA and DRR can therefore complement each other, where understanding current risks supports knowledge of future threats, and studying climate changes helps address future conditions effectively (ibid.). Moreover, climate change will likely increase the frequency of extreme events, and adds uncertainty to the assessment of hazards and vulnerability (Lavel et al., 2012).

Nevertheless, linking disaster risk reduction and adaptation to climate change has its limits, as the former works under UNDRR (United Nations Office for Disaster Risk Reduction), while the latter operates under the UNFCC (United Nations Framework Convention on Climate Change). Moreover, the scope and scales at which DRR operates are more local, while climate change studies are mostly global and regional (Begum et al., 2014).

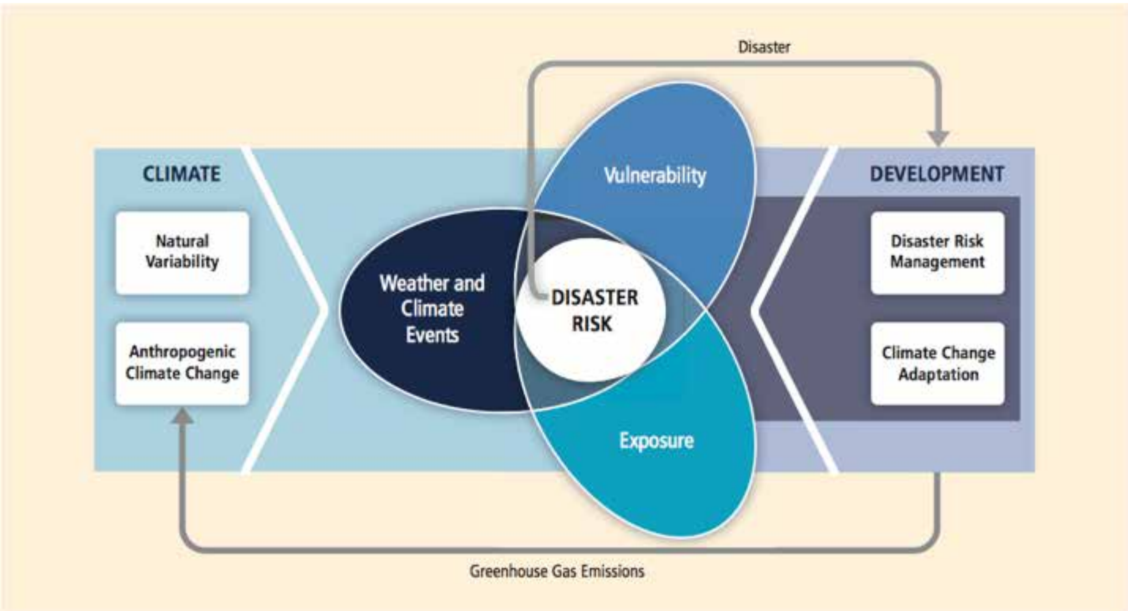


Fig. 2.1. Linking Climate Change Adaptation and Disaster Risk Reduction
Source: IPCC (2012): Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.

1. Risk And Vulnerability

Disaster risk reduction and climate change adaptation share many concepts, goals, and processes, such as such resilience, adaptation, exposure, vulnerability, and adaptive capacity, all widely used terms in global change science (Smit & Wandel, 2006; Lavel et al., 2012). While these definitions may vary from DRR which is embedded in engineering and natural sciences while CCA has a strong scientific basis (Thomalla et al., 2006).

Disaster risk is defined as the likelihood or probability of severe changes in the normal functioning of a society due to hazardous physical events (Lavel et al., 2012). Quantitatively, it's expressed as: risk = probability x consequence, where consequence includes hazards, vulnerability, and exposure (ibid.). The United Nations (2004) defines 'hazard' as ''a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.'' Examples of hazards may include floods, landslides, forest fires, erosion, and many more. Exposure is understood as the presence (location) of people, assets, and livelihoods that will be adversely affected by physical events, leading to potential loss, harm, or damage (Lavel et al., 2012).

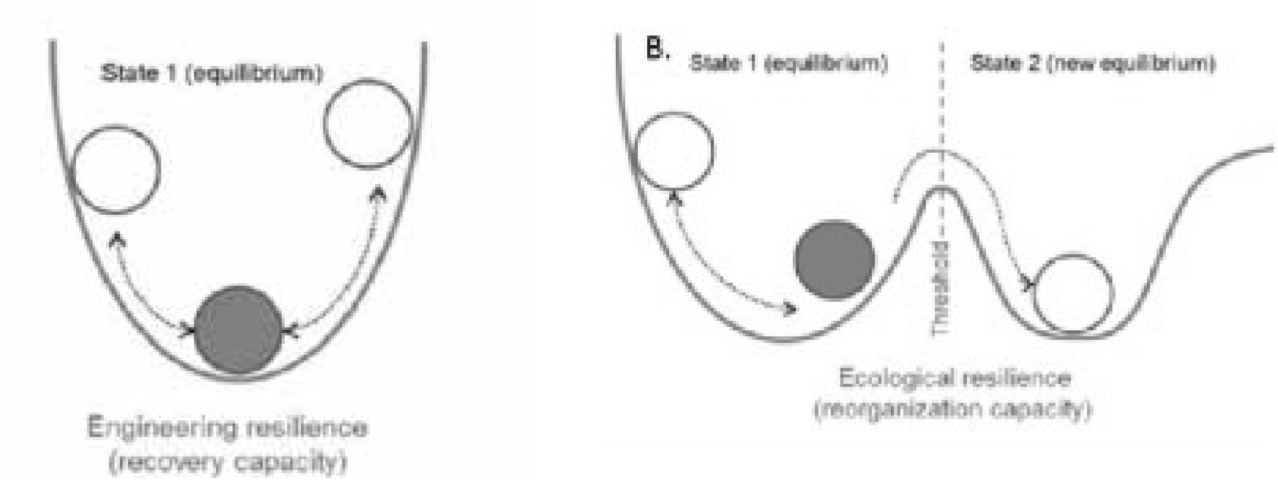
Vulnerability however has been used in many different contexts such as social, economic, physical, environmental and developmental studies, leading to many varying and often contradictory definitions of the term (Füssel, 2007). Most simply, vulnerability is understood is the degree to which a system is likely to experience harm due to exposure to a hazard or physical event (Turner II et al., 2003). In global change studies, it's defined by Smit & Wandel (2006, p. 286) as: "The vulnerability of any system (at any scale) is reflective of (or a function of) the exposure and sensitivity of that system to hazardous conditions and the ability or capacity or resilience of the system to cope, adapt or recover from the effects of those conditions."

This broad definition of vulnerability necessitates that it be narrowed down to be effective in a practical sense. Brooks (2003) states that it's useful to define vulnerability with reference to a specific system and to a specific hazard, and to differentiate between current and future vulnerabilities. Through Smit & Wandel's definition it's evident that increased adaptive capacity of a system to a certain risk event increases its resilience and thus decreases its vulnerability to exposed changes.

2. Adaptive Capacity And Resilience

Adaptive capacity is the common thread linking resilience and vulnerability. It's understood as "the ability of an individual, family, community, or other social group to adjust to changes in the environment guaranteeing survival and sustainability" (Lavell, 1999). IPCC (2012, p. 556) define it as the "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities." What is interesting in their definition is that they add an opportunistic lens to the concept of adaptive capacity. According to Cardona et al. (2012, p. 73) adaptive capacity is "the ability of a system or individual to adapt to climate change [or disaster risk]". These three definitions all include one element the other doesn't. For example, Cardona et al. consider it in reference to both abilities of individuals and systems, unlike the other two definitions, which only mention individuals or societal roles. Lavell's definition adds an important component of survival and sustainability, while IPCC's definition emphasizes a process of identifying vulnerabilities, employing resources, and strategies that can empower communities in responding to change.

These adaptations or responses to a changing set of conditions relate to the concept of resilience, or the capacity of a system to recover from changes in a 'timely manner'. While engineering resilience is understood as the return time of a system to its initial state – or steady state equilibrium – after disturbance(s), ecological resilience refers to the magnitude of disturbances a system absorbs before it moves into another stability domain (Gunderson, 2000). As such, the ecological viewpoint imagines multiple ecological systems and multiple equilibriums, each with their own sets of processes and structures (ibid.). In contrast to the engineering view, ecological resilience is interested in the persistence of a system, rather than the time it takes for this system to return to equilibrium.



single state equillibrium *new equillibriums, meta-state equillibria*

Fig. 2.2. Engineering vs. ecological resilience
Source: (Piegay, Chabot, & Lay, 2018)

D. Spatial Adaptation Measures

Since the United Nations Framework Convention on Climate Change in 1995, efforts in responding to climate change have been mostly through mitigation policies operating at global scales. Considering that the climate is already changing, and climate change impacts are not equally experienced throughout the world, action must be taken at local and national scales to decrease vulnerabilities of populations and localities. Therefore, while working on reducing the causes of accelerated climate change, measures to adapt to these changes are required as well. Spatial planning is now seen as a main instrument in adapting to climate change and its impacts in spatial contexts (Meyer et al., 2010).

Roggema (2009, p. 59) comments that the delayed inclusion of integrated designs and spatial plans in adaptation to climate change is strange, as "adaptation to climate change needs to be implemented and realized mainly through spatial patterns and lay out." The reasons for this may be attributed to the recent adoption of adaptation into political agendas, or that there is a general impression that adaptive strategies often employ more expensive measures than standardized ones, or that there is insufficient knowledge to carry out integrated responses to climate change (ibid.). This last point has been also viewed as an impediment or a limit to adaptation, as there is a clear incongruence between the way knowledge is produced by the scientific community and the type of information that serves useful for decision makers (Opdam et al., 2009). Nonetheless, countries such as Germany, Netherlands, Spain, certain states in the US, UK, China, and others, have successfully adopted adaptation policies and strategies in response to climate change and risks (Roggema, 2009).

1. Adaptation Policies And Design Strategies

The case of Netherlands is particular, as it has been combating sea level rise for centuries now. Since the publication of the first IPCC report in 2001, a climate agreement occured between the national governement and all other policy tiers (Vries & Wolsink, 2009). New paradigms such as making the country 'climate proof' were put forward, and existing paradigms of making space for water were strengthened, marking an increased integration of water management and spatial planning (ibid.)

For better communication between national and regional efforts, climate atlases have been produced that provide decision makers and planners within each province with essential information to carry out appropriate measures, in many cases to target risks of flooding (Roggema, 2009). Some of the design and planning concepts arising from Dutch experiences include: building at higher altitudes, while innovating in lower areas; creating coastal defences in front of existing ones, creating water buffers to keep water available during dry periods; creating vigorous ecological structures at lower areas which may be inundated periodically; and using water as a guiding principle in planning (ibid.).

UK's approach to shore management planning is noteworthy as it operates through a hierarchical system, where shoreline management units were delineated and subsequently grouped into shoreline behavioural units based on socio-economic characteristics and physiscal processes (Jennings, 2004; Nicholls et al., 2014). As greater attention was placed on processes in realization of the dynamism of the coast, this approach proved useful in responding to physical events and impacts. Another advancement in UK governance was through establishing public private partnerships to offset governmental under spending in infrastructure, which included maintaining coastal management measures (Jennings, 2004). In London, climate variables were projected for the years 2020, 2050, and

2080. These models were then put to use regarding energy generation, dam safety, and availability of drinking water (Roggema, 2009).

In Hamburg, Germany, an urban redevelopment design project for Hafencity works with flooding rather than limits it, resulting in a two-level city that responds to rising and receding water levels, possibly enhancing experiences in the city. Moreover, Rannow et al. (2010) developed a climate change impact assessment for the entire German territory, where multiple risks and vulnerabilities were delineated based on land-use, incorporating landscape sensitivity. This provides a very important base to approach planning and climate change adaptation efforts, and facilitates decision-making nationwide.

In China, the stream valley project in Shenzhen aimed at increasing water supplies in the dry season, while increasing water quality and decreasing heating in urban environments (ibid.). This included the halting of agricultural activities along river that resulted in better water quality, and creating many ponds along the river's watershed, which would store water and decrease water flow speeds. Moreover, construction efforts were highly sensitive to vulnerable and valuable landscapes, and buildings were raised and connected to the landscape through bridges (ibid.).

2. Coastal Landscapes And Changing Climates

Coastal zones, used synonymously with coastal landscapes in this research, represent the interface between land and sea (Ramanathan et. al, 2010; Masselink & Gehrels, 2015). This zone is defined as the landward limit of marine influence and the seaward limit of terrestrial influence (Carter, 1988). Today, coastal zones constitute 15% of the world's landmass, with approximately 60% of the global population residing within 60km of the coast (Dowling & Pforr, 2009). Other than being the preferred zone for urbanization, the coast presents a range of resources and activities essential to society, such as navigation, communication, resources, tourism and recreation, to name a few (Hall, 2001). Therefore, there has been widespread effort to establish increasingly resilient coastal landscapes to climate change and its impacts.

Sea-level rise raises significant concern due to the high concentration of natural and socio-economic assets in the coastal zone (Watson et al., 2001). While sea level rise is often the most fundamental driver of sea level change, other impacts such as intense storms, wave action, and run-off characteristics often implicate coastal zones further (Nicholls et al., 2014). Moreover, climate change and related impacts in coastal areas often include inundation and flooding, wetland loss or change, erosion, saltwater intrusion, and impeded drainage (Nicholls, 2010). We are now regularly hearing about the devastating results of storms or climate-related events from different corners of the world, flooding disasters in cities and along rivers, disappearing or inundated deltas, breaching of coastal defenses, infrastructural losses, and most threatening, the loss of human lives. As such the coast can be seen as a ‘risky place,’ threatened from accelerated human alteration of landscapes, and subject to extreme and unpredictable climate events, climate change impacts, and risks.

a. Adaptation Responses to Sea-Level Rise & Flooding

Mitigation and adaptation responses are of high importance in managing risks in the coastal landscape. Nicholls et al. (2014) clarify that mitigation addresses the causes of coastal change, whereas adaptation deals with the consequences. The authors distinguish between adaptation responses proposed by the IPCC and UK shore management planning. Through the IPCC, the following classifications of coastal adaptation were proposed: 1. (Planned) retreat: human impacts on the coast are minimized by withdrawing away from the sea, through land-use planning and development controls. 2. Accommodation: adjusting to conditions, where natural systems continue to function in much the same way but human impacts are lessened as more resilient measures are adopted.. 3. Protection: natural system effects are controlled by soft and hard coastal infrastructures, where human impacts are reduced as a result of protection. In shore management planning practiced in the UK, adaptation responses include: 1. Advancing the line: claiming land seaward, 2. Holding the line: protecting 3. Retreating the line: withdrawing, also understood as planned retreat, and 4. Limited intervention: doing nothing; monitoring changes. The first two options can be understood under the framework of protection, while the 3rd and 4th option relate more to retreat.

These adaptation measures have been widely adopted worldwide, where van Koningsveld et al. (2008) comments that the experience in the Netherlands has progressed from retreat and accommodation to hard protection and advancement. Often, it’s not clear whether these options should be employed separately or in conjunction, or should emphasize one approach over another (Nicholls et al., 2014).

In practice however, many hybrids may occur as a result of existing site conditions, programs and uses, and projected risks and changes. A collation of infrastructural approaches to sea level rise and flooding risks is presented in fig. 2.3, following Hill's (2015) classification of coastal infrastructural solutions based on two main axes: dyanmic vs. static, and walled vs. landscape designs.

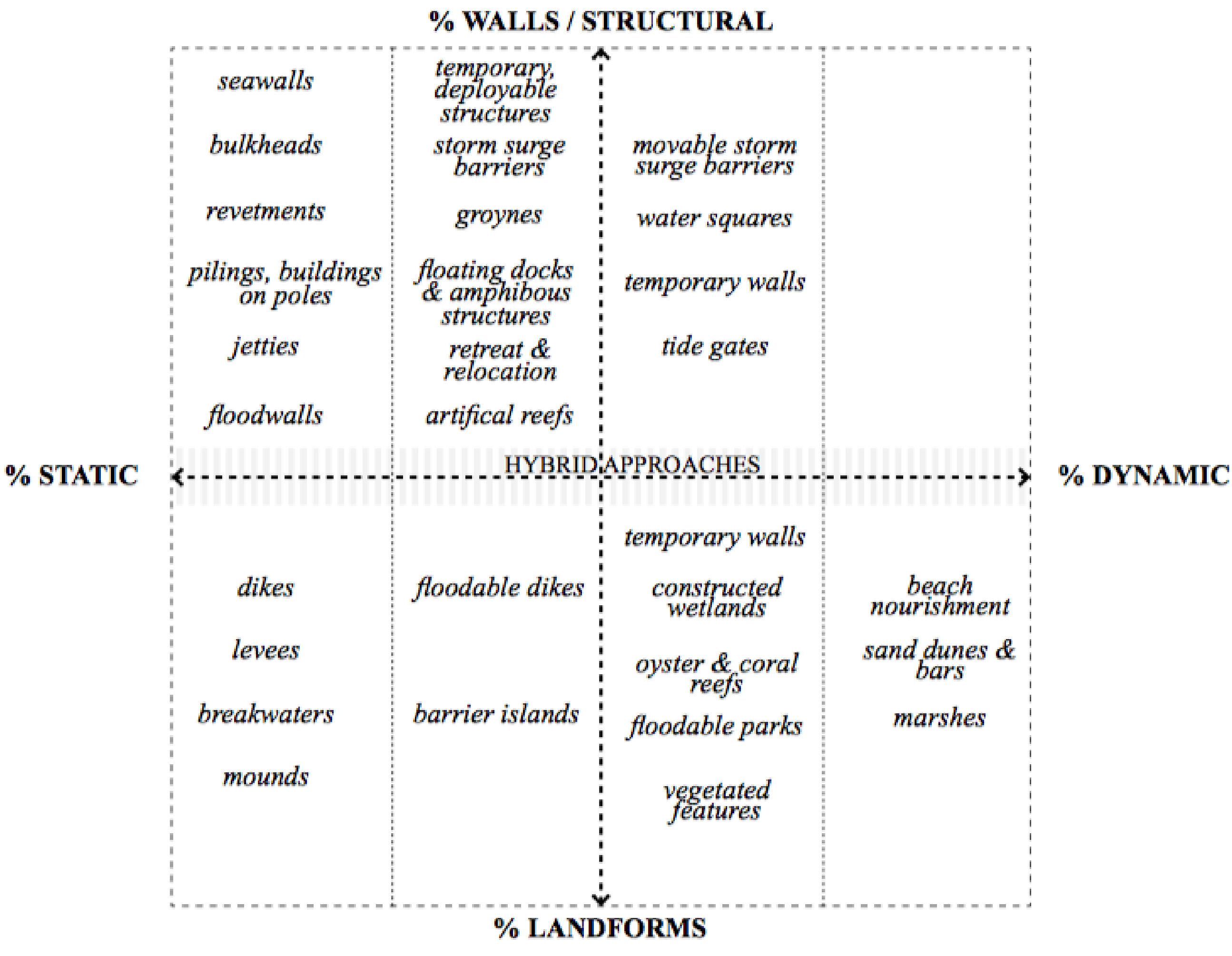


Fig. 2.3 Coastal infrastructure practices shown on a gradient of dynamic vs. static and landform vs. walled

Source: Adopted from Hill (2015) and added upon from O'donnell (2017), Hamin et al. (2018), Nordstrom (2014)

E. Limits To Adaptation

In view of the growing literature on adaptation strategies, Eriksen et al. (2015) remark that planning and policy responses to climate impacts are generally seen as beneficial. However, adaptation strategies have been strongly controlled by economic and technical capabilities under the notion of scientific uncertainty. Moreover, in their manifestation, adaptation policies and measures can disenfranchise certain groups of people, and may at certain instances decrease their vulnerability in coping with climatic effects, often as a result of politics (Eriksen et al., 2015). The separation of adaptation from societies and political economies in much climate change literature has distanced it from understanding and thus tackling the drivers of vulnerability (Eriksen et al., 2015). Efforts to extend the concept of adaptation call for surpassing the notion that it's achieved through singular decisions or measures, towards adaptation understood as a social process where social and political relationships drive the management of diverse changes (Pelling, 2011).

Through a review of successful case studies, Leal and Nalau (2018) contend that adaptation practices must take into consideration the issue of governance, the need for information, communication, and capacity building, and engaging stakeholders in design processes. It's therefore not enough to aim for incremental adaptation which modifies the current adaptation approach, but for a transformational adaptation, one that is more responsive to discerning the roots of vulnerability (Agard et al., 2014). While issues of power and empowerment of vulnerable groups have gained more attention in adaptation processes, vulnerability remains situated within analysis of climate change rather than in societies and political economies (Schipper et al., 2014; Eriksen et al., 2015). It's therefore suggested that understanding the social dynamics of vulnerability should serve as a starting point in addressing the political nature of climate change in adaptation (Thomalla et al., 2005; Eriksen et al., 2015).

F. Case Study Exploration

A more integrated approach between disciplines has become integral to the design process, where collaboration between designers, scientific experts, engineers, economists, ecosystem managers, and local populations is a method that is gaining popularity. With the advent of climatic changes, projected sea level rise, extreme weather events, urban heat island effects, and water scarcity, not to mention ongoing problems of pollution and the effects of mass urbanization, a change in attitude is necessary. It's not enough to rely on one sector or institution to tackle these problems, nor is it sufficient to advocate either a bottom-up or top-down approach, since both approaches are fundamental.

Design firms often have limited opportunities and budgets to explore design alternatives that stray away from clients' expectations. However, some exceptions do exist, and they will be tackled in this section. Whether made possible through competitions or student projects, which allow unconstrained imaginative landscapes to come to life, or radical design firms standing strong with their vision, or even through public / private interest to plan and manage responsibly, these projects are forward looking and worth learning from. The aim of studying these projects is threefold: first, to learn from the aims, approaches, methods, and tools used; second: to understand how scientific understanding is translated into design and the impediments faced in such an undertaking; and third: to highlight any paradigms that act as a methodological basis for integrated design studies, in aims to guide the development of this research and the design intervention.

1. Public Sediment for Alameda Creek

This project was developed for the Resilient by Design Bay Area Challenge, launched in May, 2017 - May, 2018, in San Francisco, California, through a collaboration between CCA Architectural Ecologies Lab, SCAPE Landscape Architecture, Dredge Research Collaborative, UC Davis, Arcadis, Cy Keener, and TLS Studio. The collaborators realized that one key instrument to tackle coastal problems in the face of climate change was through looking upstream. The presence of dams in the creek had affected sediment flows, leading to excess sediment at the dam and deprivation at the coast. The team realized the potentials in 'unlocking the creek', where sediment flows would restore tidal ecosystems, through re-establishing estuaries, marshes, and protective mud mounds along the shore. Looking at sediment as a resource, 'designing with mud' enables sustainable alternatives and opens potentials for risk reduction, educational and research opportunities, as well as increased access for humans and aquatic organisms. The proposal unlocks sediment traps, makes more room for water gathering and flow, installs flood control mechanisms, and transports sediments to the bay area. The locked sediment is to be transported to the baylands using sediment diversion channels and truck transport, and a fish channel will ensure the migration of fish both upstream and downstream (Fig. 2.4). The steelhead trout fish is used as an indicator species, as their lifecycles depend on the connectivity of the bay and the uplands.

Fig. 2.4. A section showing upstream and bay area relations, and highlighted in pink are community-involvement areas, connecting people to the area and to climate change effects.

Source: http://www.variableprojects.com/public-sediment-for-alameda-creek

The design-science collaboration efforts show that a similar approach can be adopted along all San Fransisco baylands, and in large Californian rivers. This tributary approach is made possible through adaptive management, involvement of locals, and ecological enhancement. Previous flows and land-uses using historical satellite imagery show tidal marshes and fluvial flans constituting the transition from land to seawater. A channel morphology study identified the main types of sediment in the channel, and the rate of sedimentation, while projections of the future sea level rise visibly show the impacts on the area. The sediment types identified are both fine and coarse in nature, thus the proposal works to move finer sediments to establish marshy baylands, while coarser and mixed sediments would constitute the envisioned pebble dunes. Making sediment public is also an aim, where terrace trails and seasonal bridges would connect people to the water, and floodrooms and mudrooms would serve as educational and recreational spaces. At a finer scale, the living levee proposal complements the teams efforts to re-establish ecological habitats for fish, plants, and people along the river. This multi-functional, and multi-scalar module (Fig. 2.5) also works to diminish erosive processes along the shore.

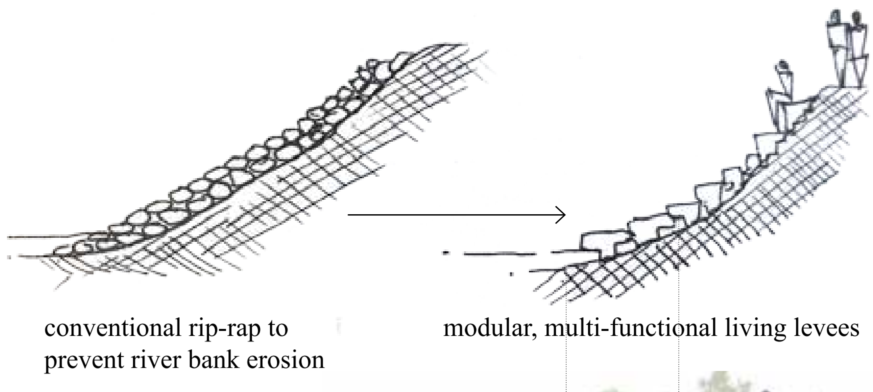


Fig. 2.5. Conventional rip-rap armor vs. living levee as habitat for fish, plants, and people

Source::Top: by author; bottom image from http://www.variableprojects.com/public-sediment-for-alameda-creek

2. Living Breakwaters

One of the winners of the Rebuild by Design competition in Staten Island New York (June 2014), 'Living Breakwaters' tackled coastal resiliency with a multitude of interventions. Led by Scape Studio, the project's aims are threefold: 1. Risk reduction; 2. Ecological enhancement; and 3. Social Resiliency. Historically, bays acted as 'ecological infrastructure,' cushioning the land and providing habitats for oysters. Dredging and the eventual collapse of the oyster populations altered the marine ecosystem, increasing the vulnerability of the coastal zone to climae change impacts and extreme events. The team worked to revive the shoreline and studied patterns of erosion, accretion, and inundation in the face of projected climate changes. Most notable perhaps is re-conceptualizing the role and potential of offshore breakwaters in wave reduction, decreasing water pollution, and providing spaces for habitat (Fig. 2.6). Moreover, by letting nature do its work and privding space for habitat, oysters will act as water filtration organisms, and as reef builders, strengthening coastal defenses. Onshore strategies included increasing sediment areas of eroded beaches, which would complement breakwater interventions.

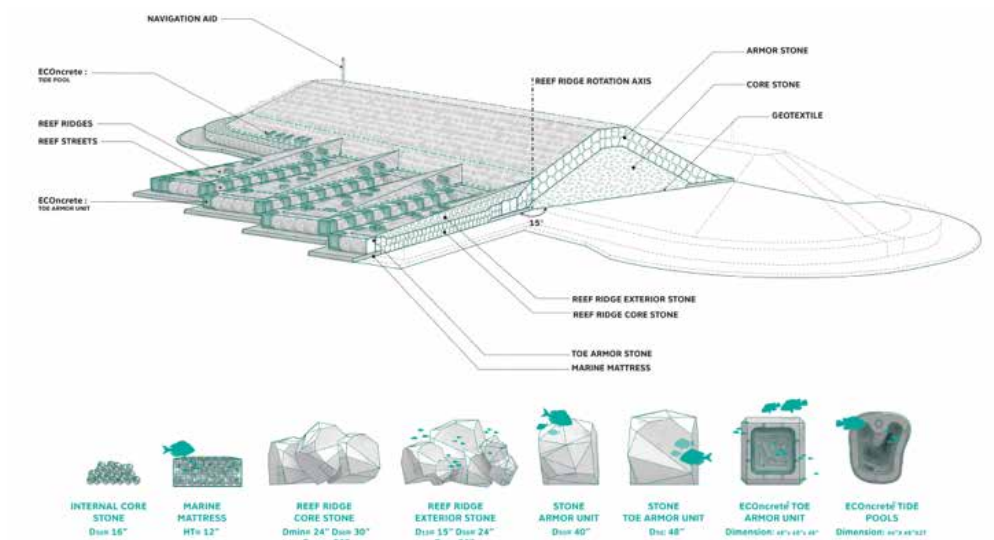


Fig. 2.6. Cross-section of the living breakwater, with prototypes of concrete blocks as habitat
Source: Data and images retrieved from Living Breakwaters IP Edition Staten Island and Raritan Bay (Rep.). (n.d.). Retrieved from https://www.scapestudio.com

The project is sensitive to aquatic organisms, where the plan for project implementation avoids critical breeding months. Moreover, Figure 2.7 shows how scale was used to make habitats available for multiple sizes of fish, where recycled concrete structures are available in multiple shapes and sizes to suit diverse organism niches.

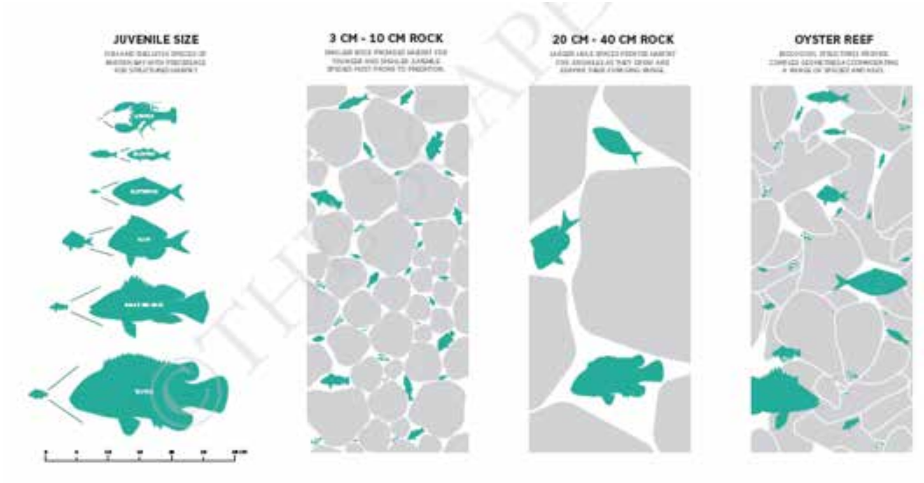


Fig. 2.7. Relationship between scale and habitat

Source: data and images retrieved from Living Breakwaters IP Edition Staten Island and Raritan Bay (Rep.). (n.d.). Retrieved from https://www.scapestudio.com

3. Sand Motor

The Sand Motor project, developed by H+N+S Landscape Architects in collaboration with DHV and Deltares, is a coastal scientific experiment in the Netherlands. Located on the Western edge of Holland, the coast faces powerful forces of erosion, needing to be replaced and managed on a yearly basis, and replenished with sand every 5 years. The Ministry of Infrastructure and Environment and the Province of South Holland have looked into alternative solutions and integrated approaches to coastal development. The main idea in this experiment is to ‘work with nature, not against it’. 2.5 million m3 of sand were added along a 1 km long and 2km wide extension of the coast (Figure 2.6), and calculated assumptions of an increase of 35 hectares of coastal sandy areas along the Northern and Southern coasts are envisioned as an outcome.

The main goals of the project are to: 1. Establish coastal safety; 2. Offer space for leisure and nature; 3. Stimulate knowledge about coastal development. After 5 years of project implementation and monitoring (Fig. 2.8), the research team evaluated the project, finding that it's doing its job of spreading sand along the coast. Winds have spread sand in the Northeastern direction towards the beach and the dunes, along with cliffs appearing, and the formation of a lagoon, which became shallower with time. The idea in this experiment is to let nature do its job, through changing morphologies, structures, and establishing new flora and fauna through succession. Plants have started to colonize sand dunes, although at a slower rate than expected, and some endangered species are found on site. New habitats hosting birds, seals, and other seabed organisms are colonizing the site.

Sand motor has gained popularity as a serene and quiet space, where multiple leisure and recreational activities are taking place, such as horseback riding, windsurfing, jogging, and hiking. Safety measures are of high importance, and a downloaded application tells users of current strengths and winds, as well as a safety team that is always in operation.

Fig. 2.8. Implementation of sand motor in 2011 and progression till 2016.
Source: images retreived from www.businessinsider.com

Moreover, people have an integral role in data collection, such as the spotting of seals and recording of this information on an application, with time and location to aid researchers in understanding and mapping coastal dynamics. Current strengths have considerably decreased in the past 5 years, and this pilot project is gaining acclamation worldwide.

4. Farmhouse

Moving in scale to architecture, Studio Precht has designed a high rise building "Farmhouse," as a modular and environmentally-conscious building that uses carbon-sequestering materials (wood), and allows inhabitants to grow their own food. The designers comment on the disconnection between people in the city with nature, and with food, stating the benefits of being closer to production, decreasing transport time and costs, and literally knowing where your food comes from. With that in mind, they designed modular spaces that could be selected based on the inhabitants' preferences, supporting vertical farm spaces (Fig. 2.9). These stacked spaces also decrease the area needed to produce food, and protect crops from harsh weather. The building collects rainwater and recycles greywater, and encourages reuse of wastes for the production of compost, which can be recycled in farming practices that thrive on the heat generated by the building. Prefabricated A-frames are delivered to the site, which decreases installation time and negative effects on surroundings. The building also includes an educational space, as well as a food market for selling surplus produce.

Fig. 2.9. The farmhouse, by Studio Precht
Source: images retreived from www.precht.at

5. Discussion And Lessons Learned

All these projects are forward looking. As an interest in this section is highlight paradigms that act as a methodological basis for integrated design studies, a few recurring concepts, methods, and lessons learned will be highlighted:

1. *The experimental nature of the design proposals*, which give chance for the transformation of proposals and management through time, with the help of the public. Perhaps this also touches upon the idea of "designed experiments" put forth by Felson & Pickett (2005), as a design strategy to tackle urban ecosystems.

2. *The simplicity of the proposals and their direct goals*, which can often be summarized into two or three main issues tackled. This however doesn't denounce the complexity to reach such goals, but prioritizes certain aspects over others and directs research efforts.

3. *Researching history when dealing with large-scale interventions;* as designers we are sometimes nostalgic to what was, and many theories throughout time have tried to disregard this. Whether nostalgia should be avoided or not, understanding the evolution of spaces and their relations with humans through time is important on many levels, especially in deciding what aspects are important to revive and which are outdated and not applicable.

4. '*Research by Design'; 'Work with nature | water'* are recurrent themes, and really put emphasis on process. The end result doesn't exist; it is always shaped and reshaped through time, and it's far more interesting to understand the evolution of these processes than to talk about a finished product or form.

5. *Often, a scalar approach is coupled with flexibility and thus modularity*, where designers innovate through creations of prototypes with multiple functions and adaptability to integrated designed programs.

G. Conclusion

While climate change is arguably the most pressing challenge of the 21st century, responses and plans to enhance preparedness and increase resilience of populations and localities hasn't been widely adopted, save for a few countries that have a strong public planning sector that capitalizes on private sector partnerships, as the case of the UK or Netherlands. Moreover, it's interesting to note that both UK and Netherlands have adopted an integral, rather than a sectoral approach to planning and management in the public sector. This enhances potentials for a hierarchical approach in research, planning, and execution, responding to general trends but also paying attention to site dynamics.

On the global front, mitigation has been the mainstream response to climate change, however this balance is currently shifting towards adaptation measures that are more robust at national and local scales. As adaptation becomes more mainstream, it should not remain a technical and scientific 'response' mechanism but should be understood as a 'process' that aims to discern the causes of vulnerabilities of societies and reduce them (Eriksen et al., 2015). On a practical level, it's widely accepted that successful adaptation strategies rarely respond to climate change effects alone, but incorporate them into existing decision structures relating to risk management, land use planning, livelihood and development initiatives, and the like (Smit & Wandel, 2006).

The recent coupling of climate change adaptation and disaster risk reduction has strengthened approaches to both fields, capitalizing on the concepts and goals shared between the two communities. Identifying socio-vulnerable areas and populations as a sort of basis for further inquiry, and determining risks, has solidified both communities of DRR and CCA. However, limitations exist in linking these two communities due to the fact that they operate under separate policy spheres and generally at different scales, resulting in limited coordination between different stakeholders (Smit & Wandel, 2006).

While adaptation strategies have materialized in the arenas of policy and planning, they have seen limited progress in design fields and in spatial manifestations, rest for design at the building scale. In the design of cities and landscapes, climate change is not well integrated, yet it has much potential to increase the resiliency and decrease the exposure of vulnerable communities to risks, and orient planning towards more sustainable goals. However, under economic recession, it's easy to set aside sustainability goals for economic growth (Davoudi et al., 2009).

Coastal areas are highly subjected to climate change and its impacts, and adaptation strategies have been expressed spatially with a diversity of infrastructural approaches to shoreline management in the face of sea level rise and flooding risks. These approaches where explored before and during the design intervention phase, to guide and ground the design intervention.

CHAPTER III
BACKGROUND

A. Climate Change Impacts In The Mediterranean

The Mediterranean region is a highly diverse and complex area, as it is the birthplace of many civilizations that have had strong impacts on shaping what it is today (Blondel, 2006). The term Mediterranean means inland, derived from mid 16th century mediterraneus: medius 'middle' and terra 'land', referring to a sea basin bordered by land. It's divided into the Western and Eastern basins, bordered by three continents, and 22 countries, making it a meeting point of multiple cultures and microclimates. The Med. (Mediterranean) climate is defined as a transitional zone situated between hyper-arid and temperate climates, and can be divided into 3 zones based on climatic differences: the Northern humid zone, the semi-arid Eastern zone, and the arid to hyper-arid Southern zone (Makhzoumi & Pungetti, 1999).

1. Climate Change Impacts

The Mediterranean region serves as a global reference lab for climate change, due to a high variation of environmental conditions and the high biodiversity of its lands and seas (Doublas, 2015). The fact that its almost a closed basin leads to a strong reaction to climatic changes, where it's been observed that most climate change variables often exceed global rates of change (Cramer et al., 2018). Table 3.1 summarizes IPCC's 5th assessment report (2013) on global climate change trends and the article by Cramer et al. (2018), listing climate change variables and impacts on the Med. and specifically the Eastern Med. region. The types of changes listed follow the RCP 8.5 scenario, or the 'baseline' scenario, with no mitigation efforts to reduce greenhouse gas emissions.

Type of Change	Past change in the Mediterraean		Projected Change in the Mediterranean					Projected Impact	Projected Impact on the Eastern Mediterranean
	1990-2000	2000-2010	2035	2050*	2065	2100			
						IPCC	Semi-empirical		
Sea Surface Temperature	0.4°C	0.4°C						Acidification: organisms with carbonate shells Marine mortality Shifts in geographic distribution of marine species	Extinction of >20% of fish by 2050 Fisheries most impacted Region with most severe effects from invasive species
Sea Level Rise	3 cm	3 cm		15-30cm above current levels		52-98cm above current levels	75-190 cm above current levels	Risks to coastal populations Reduction in land for agriculture	
Sea Water pH	0.018-0.028 units per decade	0.018-0.028 units per decade							
Surface Temperature Warming			Min. - Max. 0.3 - 2 °C		Min. - Max. 0.7 - 3.1 °C	Min. - Max. 0.6 - 4 °C		Increased aridity	Pest and disease outbreaks Olive production will require increased irrigation Food, vector, and water-borne diseases
Heatwaves	Return period = once/2yrs							Higher fire risk Crop diseases, less agricultural yield Heat-related illness	Return period = multiple occurences/yr negatively influences olive production
Precipitation			For each 1°C of warming, mean rainfall will decrease by 4%					Increased aridity Higher fire risk Decrease in freshwater wildlife	
Freshwater availability			2-15% decrease for every 2°C of warming					Freshwater wildlife	Satlwater intrusion intensification in coastal areas Increased water pollution Decreased groundwater recharge
Stream Flows			Earlier declines of high flows due to earlier snowmelt Intensification of low flows in summer Greater Discharge in winter						
Irrigation demands						Increase between 4 - 18%, which may be further increased to 22 - 74% by increased demand			
Flash floods			General increase in flash floods, especially in densely populated coastal areas					High rate of surface run-off and erosion Crop diseases, less agricultural yield	

Table3.1. Climate change impacts on the Mediterranean; and specifically on the Eastern Mediterranean

Data tabulated by author from Cramer et al., (2018); and IPCC (2013)

The pronounced impacts of climate change may determine the future of the region, especially with increased urbanization and anthropogenic influences in coastal areas. The Southern and Eastern regions of the basin currently suffer from increasing shortages in water resources (see Appendix I), and this will be exacerbated by climate change and cause increased lengths of droughts and salt-water intrusion in coastal regions (Cramer et al., 2018).

a. Coastal Landscapes and Climate Change

Almost 17% of the Mediterranean population live on the coast, which is 46,000 km long including the Med. islands (Poulos & Collins, 2002; Stewart & Morhange, 2009). Since Neolithic ages, Mediterranean coasts have harboured civilizations that have played major roles in reshaping and altering coastal dynamics and coastal geomorphology especially as sea-faring and trade became a prime avenue for development. These transformations can be seen in examples of creation of tomobolo's that link coastal islands to main lands through feats of coastal engineering during the time of Alexander the great, such as the coastal city of Tyre, Lebanon; and through river diversion and water storage systems used by the Romans and the Nabateans in areas receiving very little rainfall, ultimately influencing patterns of sediment budgets, some of which are still in use throughout the Med. basin (Anthony, Marriner & Morhange, 2014).

i. Coastal Erosion: A Pressing Issue

Around 46% of Med. shores are depositional, and the remaining are rocky coasts or cliffs (Anthony, Marriner & Morhange, 2014). While the rocky coasts have remained somewhat intact in the face of human pressures such as settlement, sandy or gravel beaches have been subject to continuous changes due to human interventions directly on the coast and along river streams (ibid.). While this helps the preservation of rocky coasts, it has greatly stressed depositional coasts.

Coastal erosion is experienced mostly in the Northern, humid portion of the Mediterranean, where it's two times more pronounced than the Southern arid and Eastern semi-arid zones (Fig.3.1) (Emelʹi͡anov & Shimkus, 1986). Along the Western Mediterranean, coastal engineering has almost completely transformed shores (Di Pippo et al., 2008), due to a concentration of commercial and industrial ports, touristic facilities, and land reclamation projects that gained popularity during the 1980's.

Fig. 3.1. Coastal erosion of depositional shores, and coastal ecosystems including lagoons, wetlands, barrier reefs, and dunes.
Source: Map adapted from Blue Plan, A Sustainable Future for The Mediterranean (2005).

ii. Coastal Tourism Impacts & Climate Change

The unique Mediterranean climate, history, and culture have attracted tourism to its coastal landscape resulting in a tourist boom experienced during the 1960's. This boom can also be attributed to Italy attracting tourists recorded since the 1890's, acting as a sort of catalyst to the touristification of its neighbouring countries, mostly Spain

(Anastasopoulos, 1989). Today, the Mediterranean region is the principal tourist destination in the world, playing a very important role in the economy of these regions (Aston Centre for Europe, 2013).

Indirect climate change impacts such as water scarcity, biodiversity loss, coastal erosion, desertification and a higher energy demand and expenses will negatively affect tourism in the Med. (IPCC, 2007). Direct impacts (mentioned in table 3.1) show variations in summer-based tourism to include tourism during spring and autumn (Amengual et al., 2014). This may offset negative impacts associated with seasonal employment and decrease the stress experienced by beach ecosystems due to concentrated tourism times (ibid). Ultimately, the "de-seasonalization" of the Mediterranean tourism industry is expected (ibid., pg. 3497), which can be supported by other cultural and off-season activities such as sightseeing, eco-tourism, and the like (Amelung & Moreno, 2012). Moreover, the projected increase in tourists in the Mediterranean will increase income and welfare, but will lead to a decline in agriculture and manufacturing, which will be somewhat reimbursed by the increase in service sector (Roson & Sartori, 2014). The decline in agriculture seems to counteract the additional demand for water by tourism, and lead to less water need overall (ibid.).

B. The Lebanese Coast

The Lebanese coastal plain is relatively wide in the Northern and Southern part of the country, and narrower at the centre. The coastal plain width is reflected in the width of the continental shelf. Cliff regions are most pronounced in Beirut, Jounieh, and Chekka, and are important ecological areas. Protected nature reserves along the coast are Tyre, Chekka, and Tripoli's Rabbit Island. Peninsulas occur in the large coastal plains, and are proximal to the sites where coastal dunes are still present, namely in Tyre and in Akkar.

Around 15 rivers flow East to West unto the Mediterranean Sea, including Nahr El Kebir, which defines the Lebanese-Syrian border. The rivers have been the main attractors of settlements throughout history, and today harbour the four major coastal cities: Beirut, Saida, Tyre, and Tripoli. Moreover, agricultural fields, mainly as fruit orchards, have been established on the soft sloping coastal plains adjacent to streams (see Appendix II).

1. Defining The Coastal Region Through Landscape Character Assessment (LCA)

[as part of the MedScapes (2013-2015) and FLRM (2016-2017) projects]

Landscape Character Assessment (LCA) is the process of characterizing and evaluating the landscape, to aid in the process of decision-making (Swanwick, 2002). It aims to understand the landscape as it is today, and how it will be in the future through analysing past trends. LCA is a useful tool that can be used to delineate boundaries based on landscape qualities and characteristics, and can be applied through scales. In regards to the fact that the Lebanese coastal region remains ill-defined (see planning and policy section), I propose the delineation of the coast based on the LCA conducted in MedScapes-ENPI project and developed during FLRM (Forest and Landscape Restoration Mechanisms) project,through selecting Landscape Descriptive Units (LDU) with coastal and adjacent coastal hill and valley landforms (Fig.3.2). LDU are the basic unit of assessment used in both MedScapes and FLRM, based on the overlay of four main attributes: landform, geology, settlement, and landuse. This is followed by the classification of LDU with similar characteristics into Landscape Character Types (LCT). The LCT's reflect general patterns of development, focusing on landform and landuse, and settlement secondarily as it's inherent in landuse.

The methodology and outcome of the MedScapes project were further developed during the FLRM experience, where LCA was carried out for the entire Lebanese region at the study scale of 1:250,000. Being part of the research team in MedScapes and FLRM, led by Dr. Maria Gabriella Trovato and co-led by Dr. Abunasser and Dr. Zurayk, respectively, my roles included fieldwork mapping and validation, supporting the GIS experts during the LCA process, preparation of reports, and developing a Risk Assessment (RA) model which aimed at evaluating the loss of landscape value using LCA as a tool.

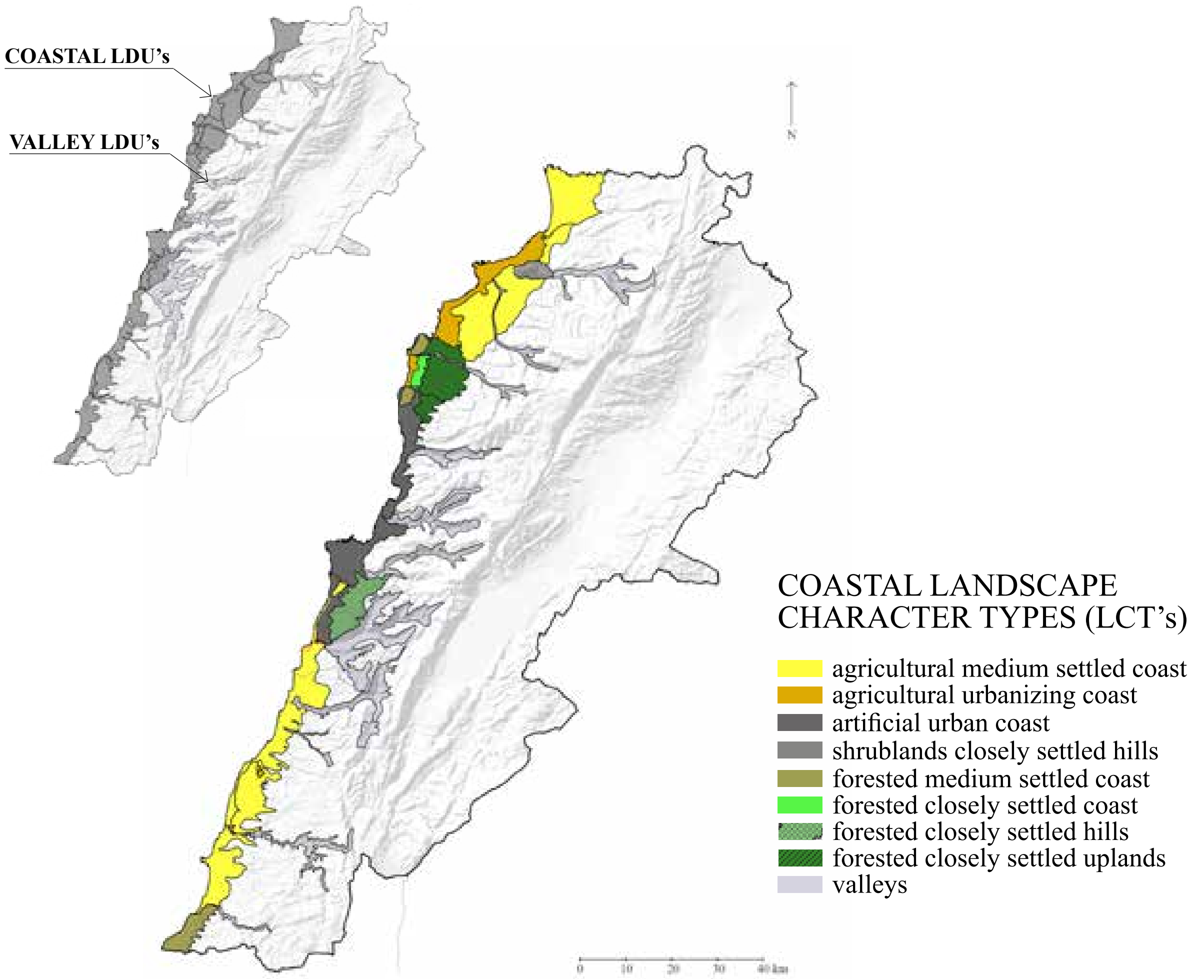


Fig. 3.2. Top left: coastal region based on coastal and adjacent valley LDUs; bottom right: LCT's of the coastal LDU's.
Source: By author, based on the work conducted during MedScapes (2013-2015, and FLRM (2016-2017).

2. Coastal Landuse

The coastal landscape in Lebanon hosts the most lucrative sectors in the country. Figure 3.4 shows urban areas, grasslands, agricultural areas, and forests along the coastal region defined through LCA. Urban areas are mostly concentrated in the Metropolitan area of Beirut, and along other cities of Tyre, Sidon, and Tripoli. Much of the remnant areas are agricultural, mostly pronounced in the Northern and Southern coastal plains, and along the Chouf valley where the Damour River flows. Grasslands are scattered along the coast, while forests are concentrated in Mount Lebanon, Chouf, Northern districts starting from Nahr El-Kalb towards Batroun, and along river valleys.

Fig. 3.3. Images depicting Landuse/Cover and associated landscape character along the Southern part of Lebanon's coast.
Source: Images by author

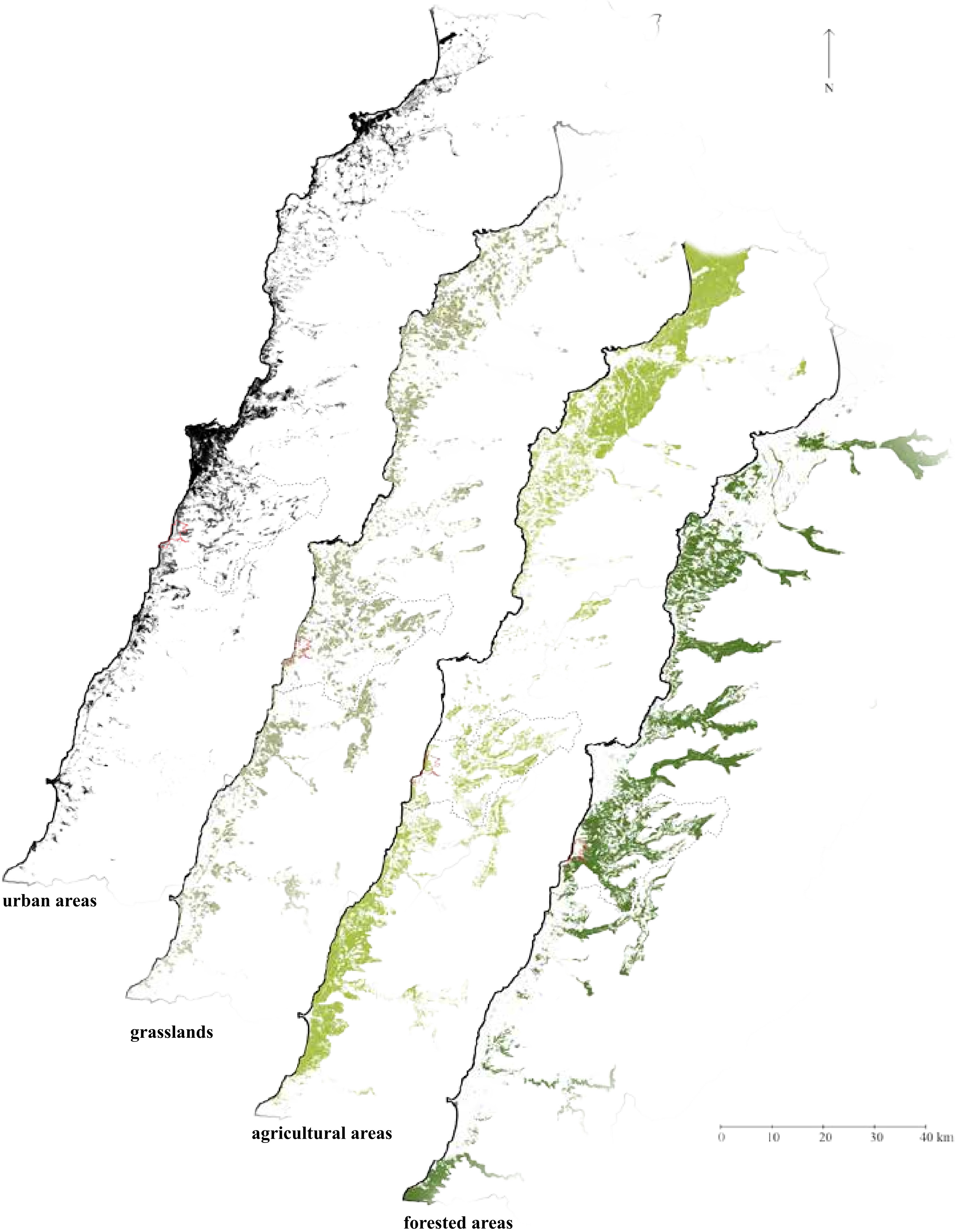


Fig. 3.4. Landuse/Cover along the Lebanese coastline, superimposed on coastal LDUs and adjacent valleys.
Source: By author, data retreived from LULC maps by CNRS (2005)

a. Urban Centers and Sprawl

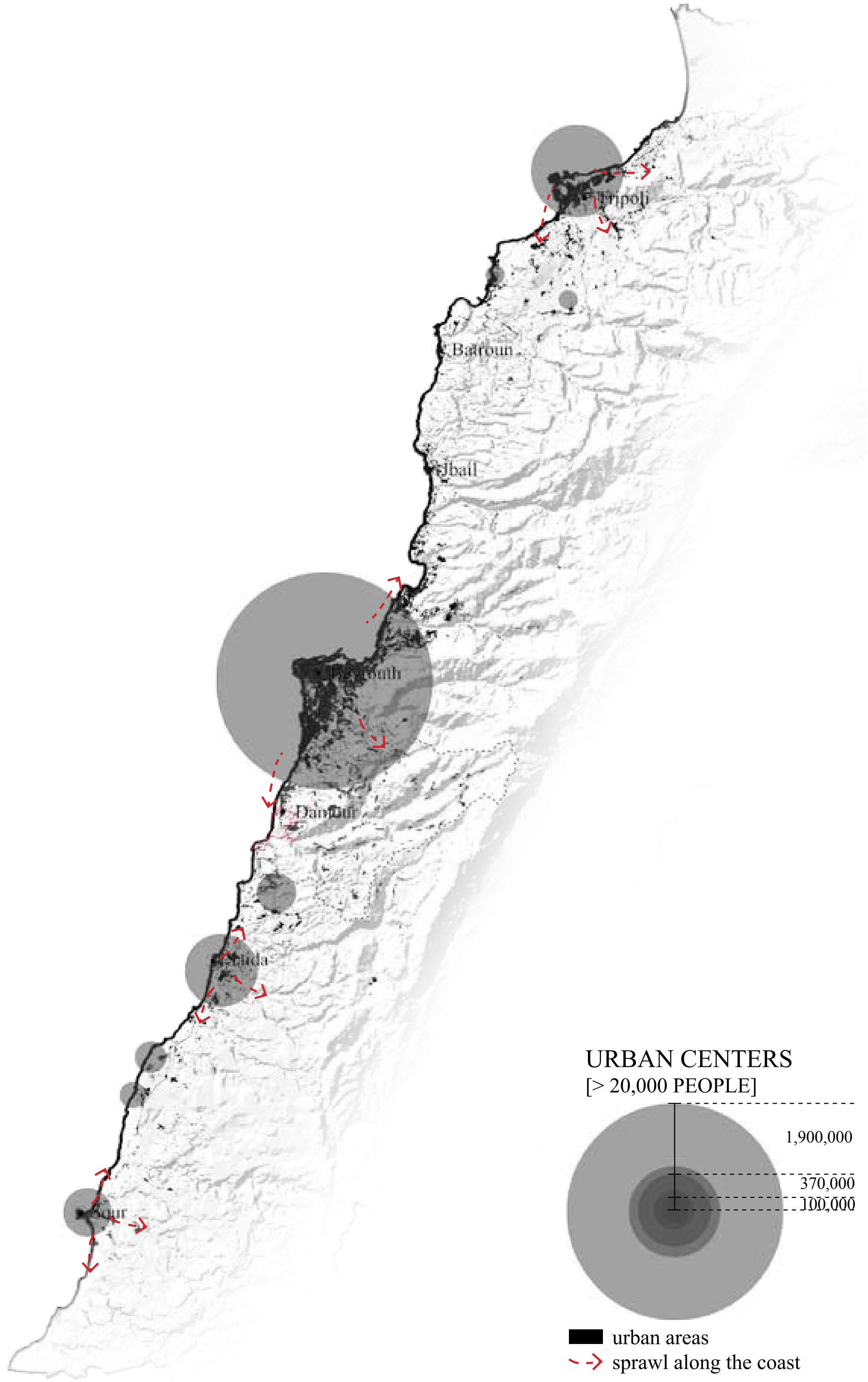


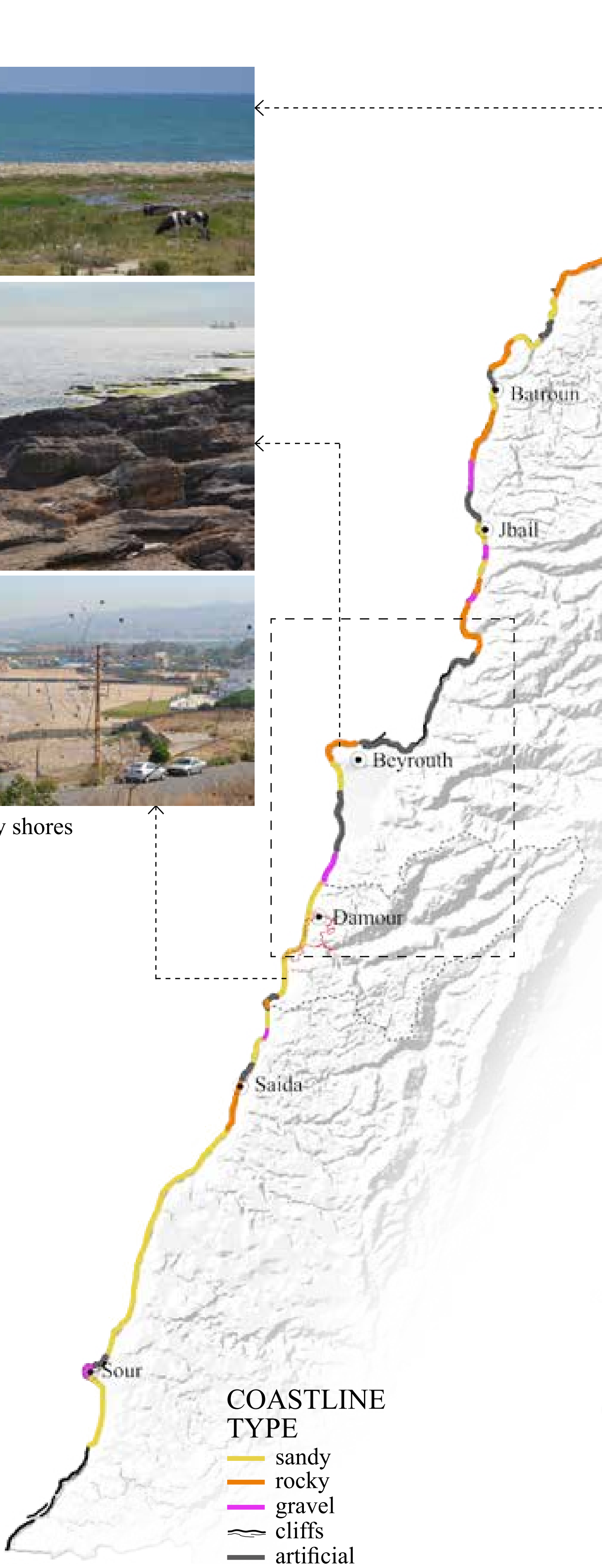
Fig. 3.5.Urban centres and sprawl along the coast

Source: By author, adapted from Verdeil et al. (2019)

b. Coastline Types

Fig. 3.6. Gravel, rocky, and sandy shores

Source: Images by author



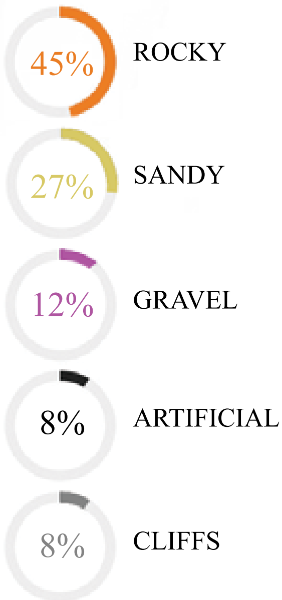


Fig. 3.8. Percentage of shore type along Lebanon's coast

Source: By author

Fig. 3.7. Coastline type along the Lebanese coast.

Source: data reworked by author, retreived from CDR (2005)

The Lebanese shore includes around 15 sandy beaches in total, and the rest are rocky, and gravel beaches, as well as many artificial defence structures densely occupying shore space in Greater Beirut reaching the bay of Jounieh (Fig. 3.10). Solid waste management in Lebanon has been inadequate in establishing a proper national plan to dispose of waste. Currently, about 84% of solid waste ends up in landfills and open, unregulated dumps. Many of these landfills are situated on the coast, such as the Bourj Hammoud landfill, the Costa Brava landfill by the Airport, and the Naameh landfill situated in coastal hills. Lebanon has been transforming landfills on the coast into land reclamation sites, after leachates have dissolved and high levels of methane have subsided (Azhari, 2017). These reclaimed sites are often transformed into lucrative real estate projects, such as Beirut's waterfront (Fig.3.9), previously known as the Normandy landfill.

i. Altered Coastlines: A 'Hard Engineering' Approach

Coastal defence infrastructures constitute hard-engineering methods, usually including sea-walls, rip-rap armoring, or a combination of those two. In the case of Beirut's Waterfront, a cell and arc structure was designed to protect the coast from wave heights reaching 10m. However, it was a highly expensive project that also required grading of off-shore slopes several kilometres into the sea.

Fig. 3.9. Section showing the original land profile and the reclaimed land of Beirut's Waterfront
Source: Drawn by author

HARD EDGE RECLAMATION

NORTHERN EDGE COASTAL DEFENSE:

-Sea base re-levelling;
-Cell and arc structure to slow down water flow and prevent erosion of construction material.

Fig. 3.10. Artificial coastline type, showing coastal defense infrastructure used in Beirut's Waterfront.
Source: By author

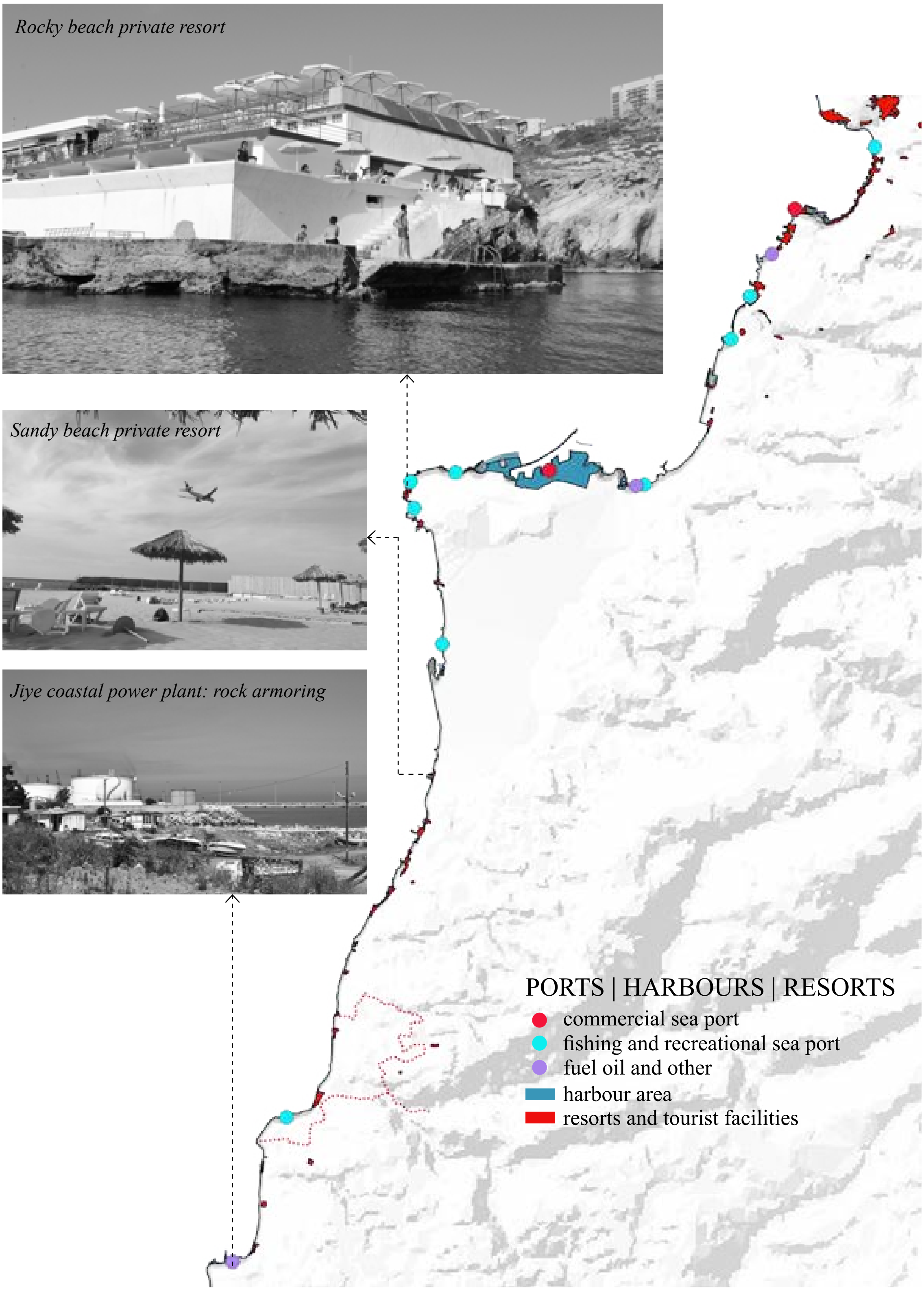


Fig. 3.11. Map of main coastal activities along the strip from Jiye to Jounieh
Source: Drawn by author, data retreived from CDR (2005), and LULC by CNRS (2005)
Images by author

c. Terrestrial Ecosystems: Beirut to Jiye Stretch As Key Biodiversity Area

The coastal stretch from Beirut - Jiye hosts a range of species endemic to Lebanon and to the Levant region in general (Valderrábano & Gil, 2018). Situated on a narrow strip, this zone is one of the last remaining sandstone outcrops in the country, and hosts some species not found elsewhere on the Lebanese coast, such as *Thymetea hirsuta* and *Retama raetam* (ibid.). In the case of urbanized Beirut, a few remnant biodiversity areas remain, such as the Hariri International Airport hosts a range of species on its inaccessible, stabilized, sand dunes (ibid.).

d. Marine Ecosystems

Marine diversity in the Eastern Mediterranean has been found to be lower than the Western Mediterranean, and this can and has resulted in more invasions of species from the Suez canal; mostly attributed to the lack of saturated niches, which opens up potentials for a wider range of organisms to colonize (Harmelin-Vivien et al., 2005). Figure 3.12 summarizes the findings from the previous section on the Mediterranean basin in the context of the Eastern Mediterranean in addition to the dominant climatic conditions. In Lebanon, four main marine ecosystems are preseent: Vermetid reefs, Cystoseira forests, Seagrass meadows, and seagrass beds Badreddine (2018) (see Appendix III).

Fig. 3.12.The main marine influences at the Eastern Mediteranean
Source: Drawn by author

3. Climate Change Impacts And Landscape Hazards

Climate change impacts will be highly exacerbated in the Mediterranean and especially in the Eastern Med. as waters will warm changing the diversity of marine fauna, salinity, and acidity of the sea. Moreover, as coastal cities along the basin continue to sprawl, pressures will increase from many fronts such as increases in heat-waves, water scarcity, forest fires, and agricultural land abandonment due to desertification especially in areas where salt-water intrusion is likely (Galil, 2007). Moreover, more intense rain events leading to more flooding and inundation of coastal areas especially where runoff coefficients are high is highly likely, and longer periods of drought, lesser rainfall with increasing temperatures are expected (refer to Table 3.1). Currently, seasonal variations of intense out-of-season storms are being experienced in Lebanon. This is having a great toll on agricultural yields often throughout the year, and farmers are already beginning to adjust to these seasonal variations by planting crops earlier so that earlier springs don't damage their crops. Increased heat waves aren't only detrimental to crops, but also to freshwater levels of storage basins and human health. People who are economically disadvantaged are often the most affected and exposed to such threats.

Figures 3.13 and 3.14 show the spatial extent of risk of coastal flood, erosion, forest fires, and desertification, acquired through my involvement in MedScapes (2013-2015) project during research work. Coastal flood risk is highest in low lying coastal plains such as Damour, Akkar's plain, Jiye, and Southern coastal plains, as well as highly urbanized coastal cities due to high run-off rates coupled with intense storms typical to the region. Desertification is most pronounced in cultivated areas, in North of Tripoli, the suburbs of Beirut, the coastal plain of Damour and the Southern coastal stretch starting from Saida reaching Naqoura.

Erosion is most pronounced along the coastal hills of Mount Lebanon, Tripoli, and the stretch of low lying hills East of Saida reaching till South of Tyre. Erosion has been exacerbated by cultivation practices and urban sprawl. Forest fires pose a threat to forested valleys of the Chouf and to the forested coastal areas occurring between Jbayl and Batroun.

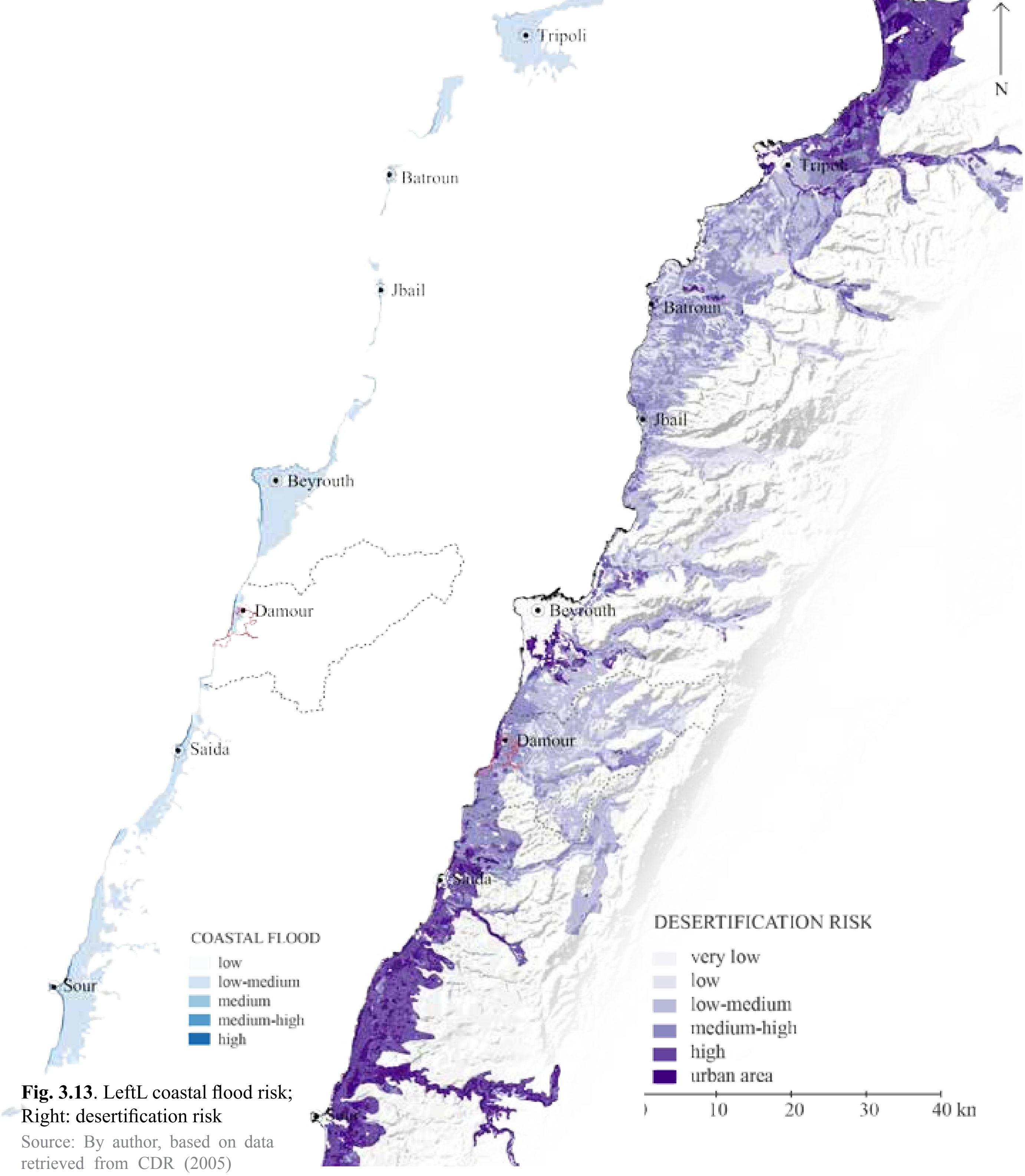


Fig. 3.13. LeftL coastal flood risk; Right: desertification risk

Source: By author, based on data retrieved from CDR (2005)

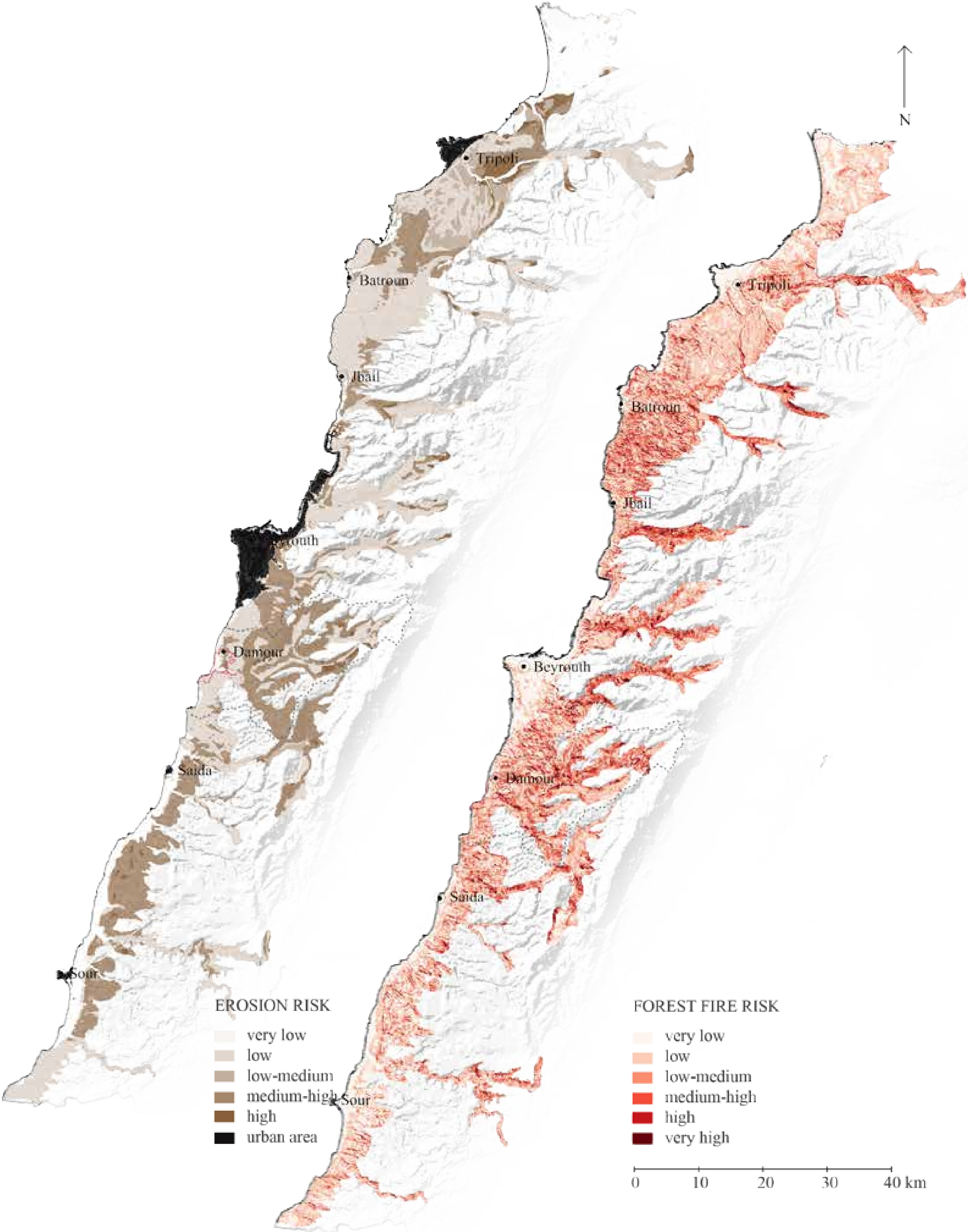


Fig. 3.14. Left: Erosion risk; Right: forest fire risk

Source: By author, based on data retrieved from CDR (2005)

4. Planning And Policy: Current Unsustainable Practices

The lack of a properly defined coastal region is problematic as it retards efforts to properly plan, research issues present along the coast, and create a vision or strategy for the most rapidly urbanizing region in Lebanon. This is further implicated by the lack of population data, which is based on estimates since the last consensus in 1932 (Verdeil et al., 2019).

Transgressions unto public maritime domain, whether authorized or not, often don't abide by laws specifying that access must be maintained to the shore even if construction on the maritime domain is permitted. The maritime public domain is delimited by the high-water mark and includes sandy and gravel beaches (Decree law No 144/S, 10/6/1925). As the high-water mark is temporary, this law has been argued as being ambiguous in its nature, subject to change and thus subject to exploitation. (see Appendix IV)

Pollution of the marine environment by high levels of fecal coliform is becoming a pressing issue especially along more urbanized areas along the coast, affecting swimming and fishing activities. While 52 waste water treatment plants are planned in Lebanon, to date only 11 are operational, 3 of which are located on the coast (See Appendix IV).

There are 40 dams are planned to solve the issue of water shortage in Lebanon, however not enough research is being conducted to assess their benefits, impacts, and alternative solutions. The effect of dams not only affects the river ecosystem, but highly implicates towns downstream and coastal dynamics (See Appendix IV).

C. Conclusion

This chapter aimed at framing the many sides and challenges in approaching coastal landscapes through the lens of climatic and increased anthropogenic changes, starting with the Mediterranean and zooming to the Lebanese coast. The rapid transformation and urbanization of the coastal landscape in Lebanon is not matched with the planning and management of infrastructural networks and capacities, and doesn't consider areas of increased vulnerability and the impacts of such practices on the sensitive littoral landscape. Lebanon faces increased difficulties in responding to climate and climate-related impacts as the public sector is generally perceived as a weak body, incapable of supplying even basic needs (energy & water) to its people. This hinders potentials of responding to pressing challenges, such as high pollution of resources, desertification of agricultural areas, coastal flooding of urbanized areas and coastal plains, forest fires in forested areas, and future risks and extreme events that will probably highly impact the most vulnerable communities.

CHAPTER IV

CASE STUDY ANALYSIS: DAMOUR

Damour is a semi-rural coastal suburb of Metropolitan Beirut, that is predominantly agricultural and is facing developmental pressures exacerbated on its sandy shore. It's unique character is contrasting with highly urbanized coastal areas adjacent to it, sprawling radially from coastal cities (Fig. 4.3). Damour's plain has been continuously cultivated since the 1830's, due to the richness of its soil and the availability of water from the Damour River, marking the agricultural heritage of the area. More recently, the shore has been attracting beach resorts, leading to an expected 'touristification' of the area based on the municipal master-plan released in 2008.

This chapter studies the evolution of Damour's landscape and its character through the use of a time-line of events. Existing site conditions & processes, patterns of development, future plans and projected climatic and landscape threats are mapped and discussed. The end of the chapter focuses on shore accessibility, public beach spaces, coastal processes, shore condition, effects of resorts, and a synthesis of the relationship between multiple land-uses, the shore, and the sea. A scalar approach is followed, starting with the Lebanese coast covered in the background chapter, followed by the Damour river watershed, reaching to the scale of Damour's municipal area (Fig. 4.1).

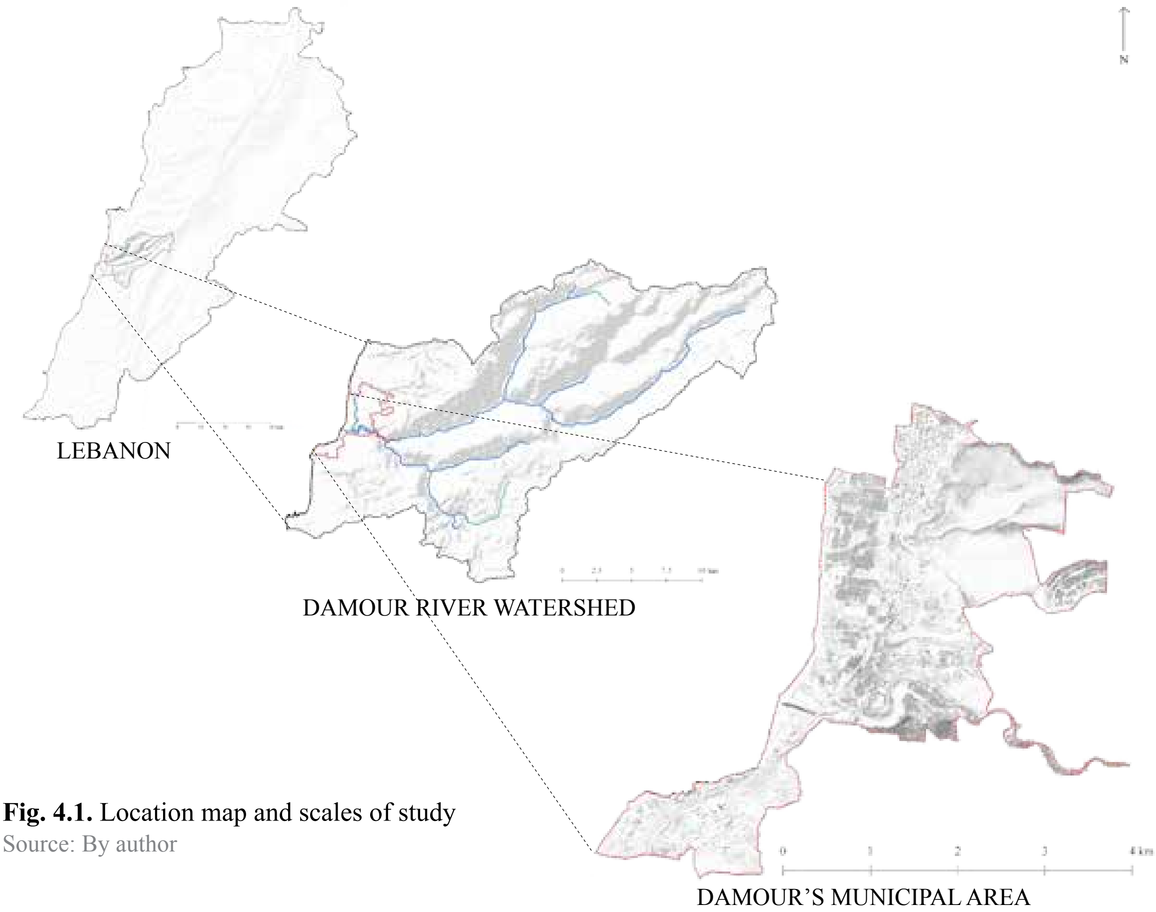


Fig. 4.1. Location map and scales of study
Source: By author

Damour's population

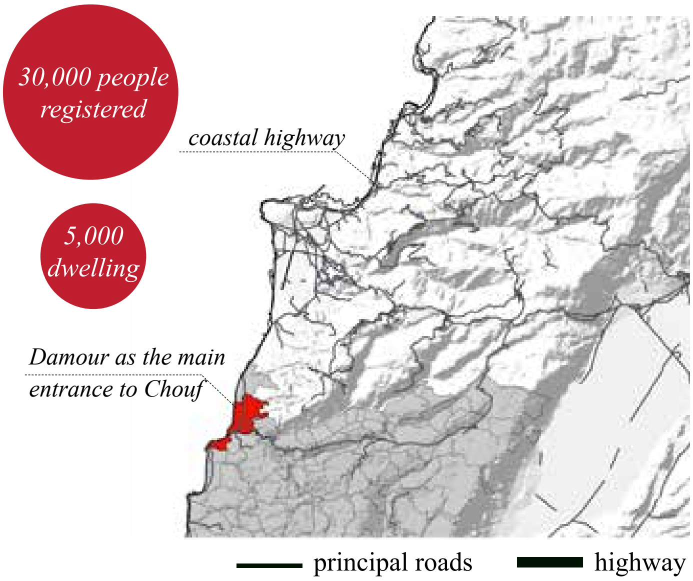


Fig. 4.2. Main road network
Source: By author, based on data from CDR (2005)

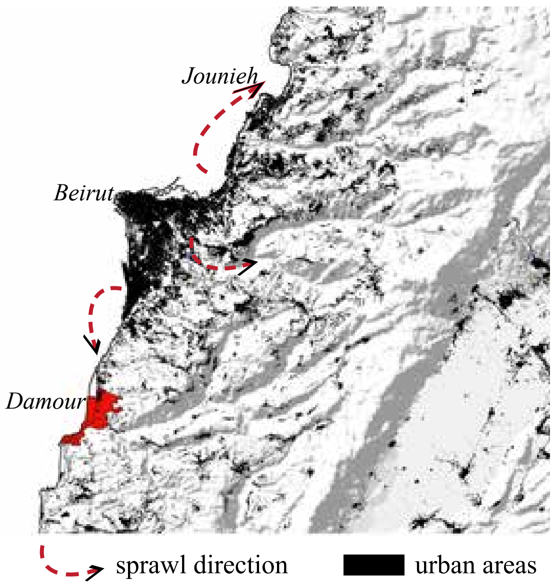


Fig. 4.3. Coastal urbanization
Source: By author, based on data from CDR (2005) and Landuse/Cover maps by CNRS (2005)

A. Context

Damour is located 24km South of Beirut, Lebanon's capital city, and includes the localities of Mechref and Saadiyat. It is part of the Chouf district of the Mount Lebanon Governate, whose administrative capital is Beit Eddine, capital of the Emirs of Mount Lebanon, also identified as the historic core of the Republic of Lebanon.

Four federations of municipalities exist in the region; North and South Iqlim El Kharroub, Chouf el Soujayne, and Chouf El-Alaa (Fig. 4.5). These federations facilitate communication and decision-making between the municipalities in the region, however, the coastal town of Damour isn't within any federation.

Chouf is popular for its forested mountainous landscape, ranging from Oak, Pine, and Cedars at high elevations, as well as mixed forests with many native species such as Judas trees, Pistachia shrubs, Cedars, and Carob trees, which are highly popular in Iklim el Kharroub (Kharroub means carob). The head of the Damour River reaches the areas of Ain Zhalta and Ain Dara, and throughout the river there are many recreational areas and restaurants. The main historic core of Chouf, Beit Eddine and Deir El-Amar, are highly touristic areas that still retain their traditional character.

Fig. 4.4. Top: Chouf Cedar Reserve; Middle: River passing through Barouk; Bottom: River passing through Damour

Source: By author

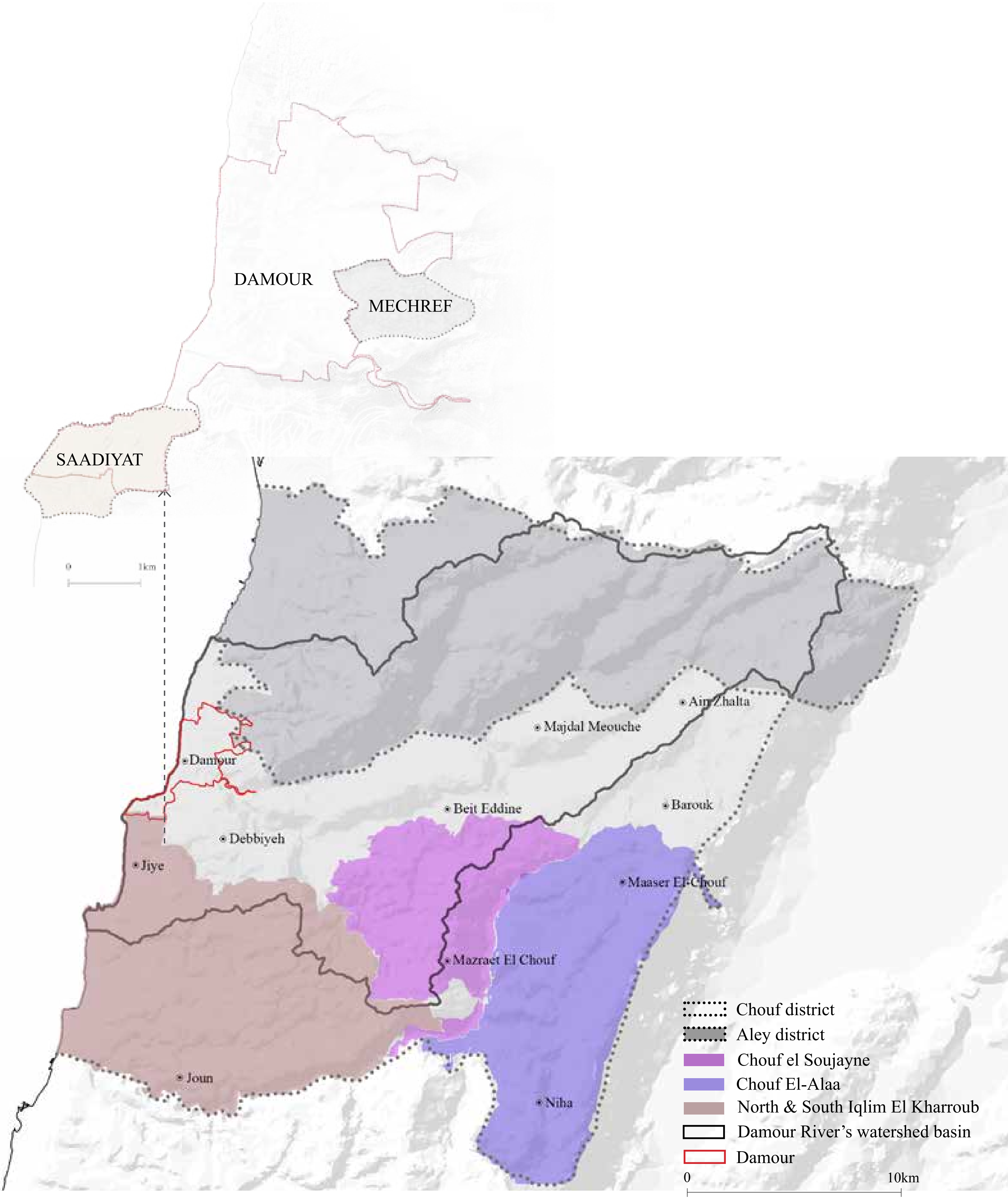


Fig. 4.5. Location of Damour with respect to the district of Chouf, highlighting the federations in the district.
Source: By author, based on data from CDR (2005)

B. Timeline | Landscape History

Damour's historical landscape is mapped and described using a timeline, spanning the time from the 1800's till the present. Agriculture has been a continuous activity in the area, establishing a unique identity through time. In Robinson's book "Travels in Palestine and Syria" (1837), he travels from Tyre to Beirut and describes the "straggling village of Damour" which was inhabited by Druze, where vines were planted throughout the village, being "the finest he had seen, with each grape as large as a prune" (Robinson, 1837, p. 286).

In the late 1800s, the area became famous for its silk production and mulberry plantations, where people from the Chouf region would assist Damour farmers in the collection of silk cocoons in harvesting season[1]. Today, two silk factories still exist in the area (out of a total of 5 factories previously), and serve touristic purposes. In the 1930's, with the onset of synthetic silks, Damour experienced a decline in its agricultural heritage and the prosperity of the town and its people (Makhzoumi, Chmaitelly & Lteif, 2012).

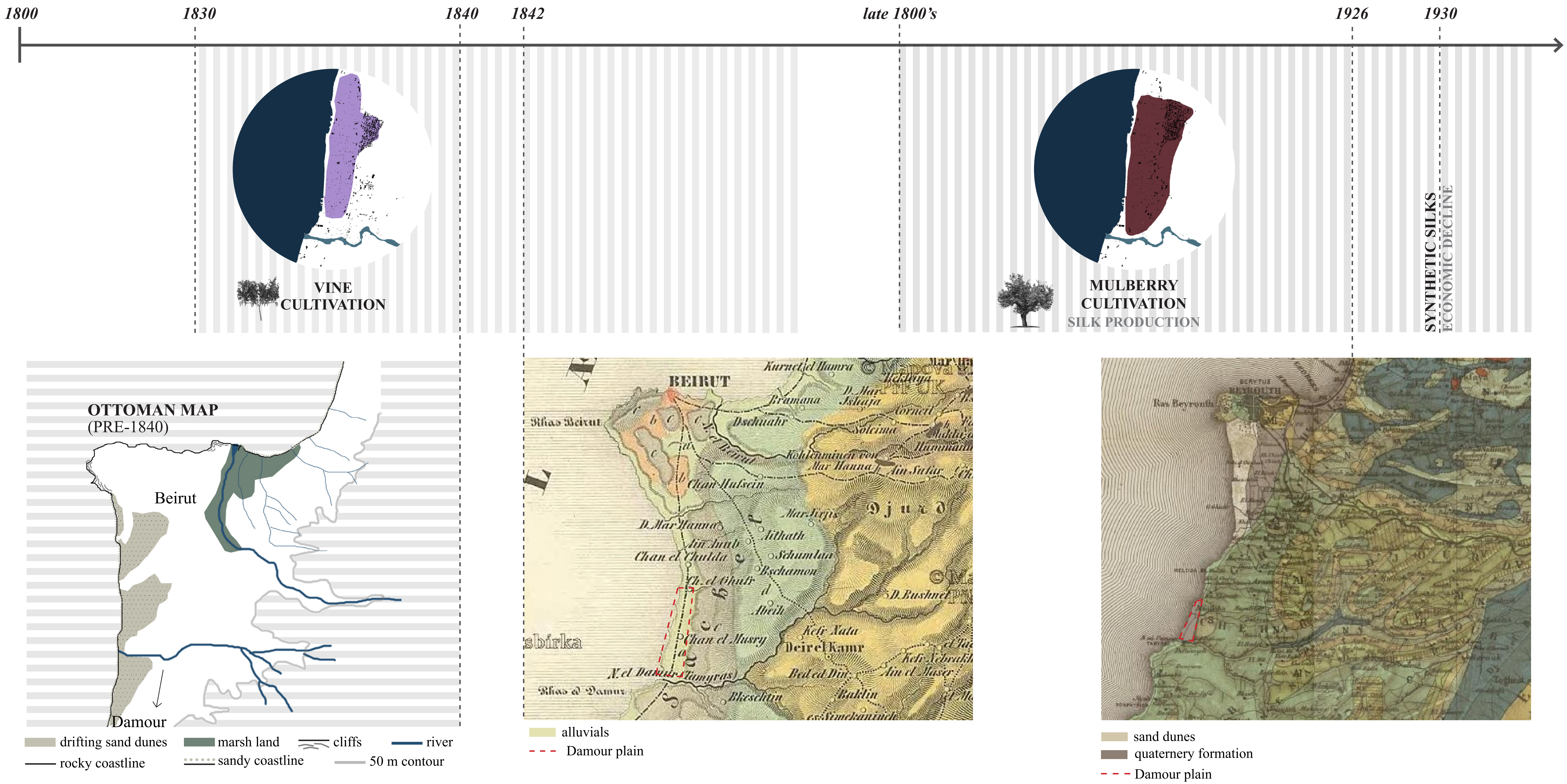


Fig. 4.6. Historical timeline of Damour, 1800-1930

Source: Ottoman map (left): redrawn by author, source of data: al-mashriq.hiof.no.
Geology maps (center & right): oldmapsonline.org/lebanon

Mulberry plantations were replaced with citrus trees, lasting 20 years until they were replaced again with banana plantations, which still survive till today (Makhzoumi, Chmaitelly & Lteif, 2012). The area is widely known for its agricultural heritage, but has also been the place of wars and clashes between religious sects. In 1941, Damour became the capital of the French administration, and experienced conquest by Australian forces during WWII, who had to cross the river to take siege of French headquarters.

In 1975, Damour experienced severe sectarian clashes by the Islamic Palestinian Liberation Organization, known as the Damour massacre. The people fled to Saadiyat, only to find it also under attack, and finally escaped on small boats and cattle ships to Jounieh. Around 25,000 Christians fled the area, 500 people were killed, and 620 buildings destroyed (Mehdi, 2004). During the period of the civil war, the agricultural plain was abandoned, and sind mining and dredging activities took place on the shore.

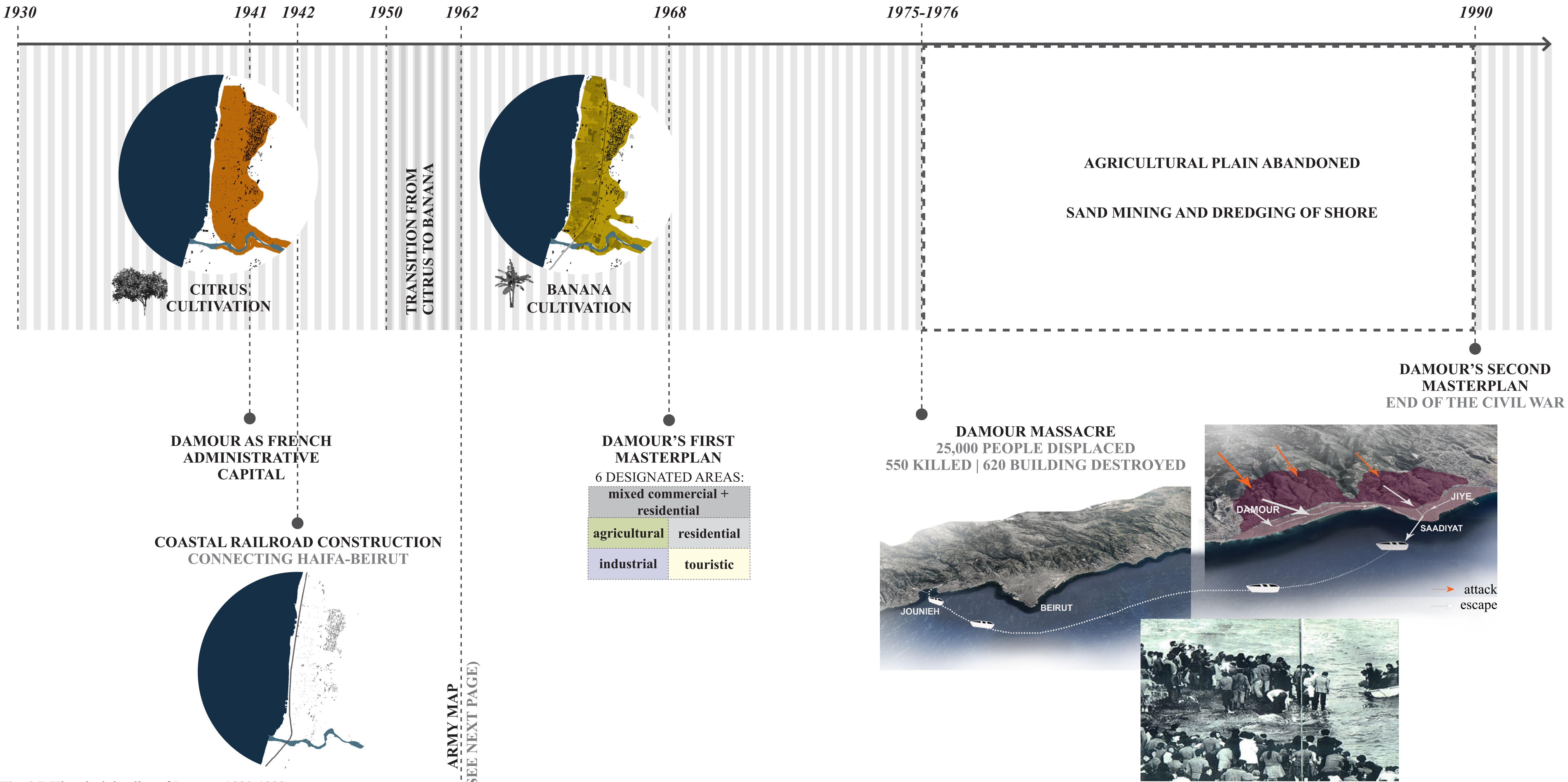


Fig. 4.7. Historical timeline of Damour, 1930-1990

Source: Top: drawn by author;
Bottom: image retreived from skyrock.com

In 1962, Damour's plain was almost fully agricultural, cultivated mostly by banana and secondarily by citrus trees. The agricultural plain is defined by the railroad and the shore to the West, and the coastal road to the East.

The Damour River is bound by floodplains and agricultural lands, where water diverted from the river is used to feed the plain through canals. A remnant coastal marsh is located North of the river mouth, that was perhaps too shallow for cultivation, or was needed as a floodable area by the river amidst agricultural land.

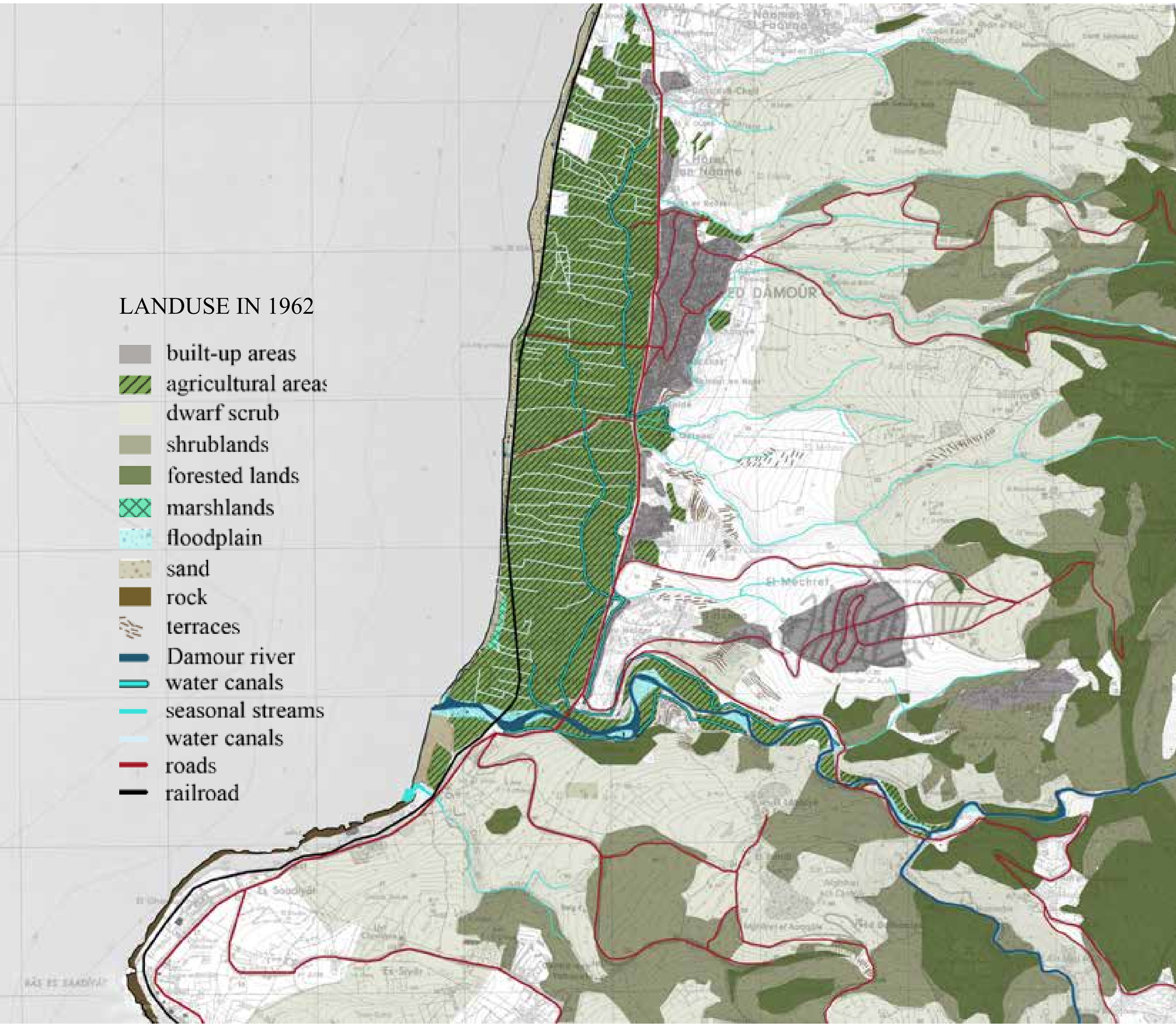


Fig. 4.8. Map of Damour, 1962

Source: Redrawn by author, from Lebanese Army maps (1962)

Damour's municipality has issued three masterplans to date, the first in 1968, the second in 1990, and the most recent in 2008. A municipal representative shares that an aim of the most recent masterplan is to keep the image of Damour intact, prohibitting vertical densification of the area, in fears that it may turn into a "Shaabi" area, which almost translates into a "communal" area. Below are the details of the latest masterplan with zoning regulation [In an interview conducted between Public Works Studio and the municipality, 2017].

The designated touristic zone (E) starts from shore and stretches almost 200m inland, reducing the area of the agricultural plain by almost a 1/4 of what it is today and fully encroaches unto the shore. A commercial stip is imagined along the highway, and private housing in the form of gated communities are proposed along the hills. One particular oddity is the designation of an entire area (zone M) to 'one family only'. Also, municipally owned barren coastal hills (Zone H), which embody the current character of Damour, are designated as a future sprawl zone.

LAW NO. 332
PLAN TO RETURN DISPLACED PEOPLE

DAMOUR'S THIRD MASTERPLAN

Source: Redrawn by author, data retreived from Public Works Studio, Lebanon.

Zone Code	Zone	FAR (%)	Maximum # of floors
A	Residential and commercial	40	4
B	Medium rise residential and commercial	40	3
C	Medium rise residential	30	3
C1		30	2
D	Low density residential and commercial	30	2
D1		10	2
D2		15	1
E	Touristic: restaurants, pools, resorts	20	2
E1	Touristic: restaurants, pools, resorts, private housing	15	2
F	Agriculture and semi-natural areas	5	1
G	Private housing	15	2
H	Future sprawl area	5	1
M	Private housing: one family only	30	2
MB	Commercial	30	3
N	Residential	30	3
S	Historic Character	25	2
S1	Protected historic area	20	2

Fig. 4.9. Historical timeline of Damour, 1990 - present

C. The Present | Damour's Coastal Landscape

1. Landscape Character

The character of Damour is an amalgamation of the wide agricultural plain, barren, settled coastal hills, Damour river, and the sandy shore that is generally narrow and widens at the estuary (Fig. 4.10). Damour is distinct from its coastal surroundings that are more urbanized, mostly because of its wide agriclutural plain that remains intact and is visible from the highway and the coastal hills. The sandy shore isn't saturated with tourist resorts / facilities, as well as its dense village that hasn't sprawled at a very fast rate. South of the main village, settlement is dispersed and interlinked with terraces of agricultural cultivation.

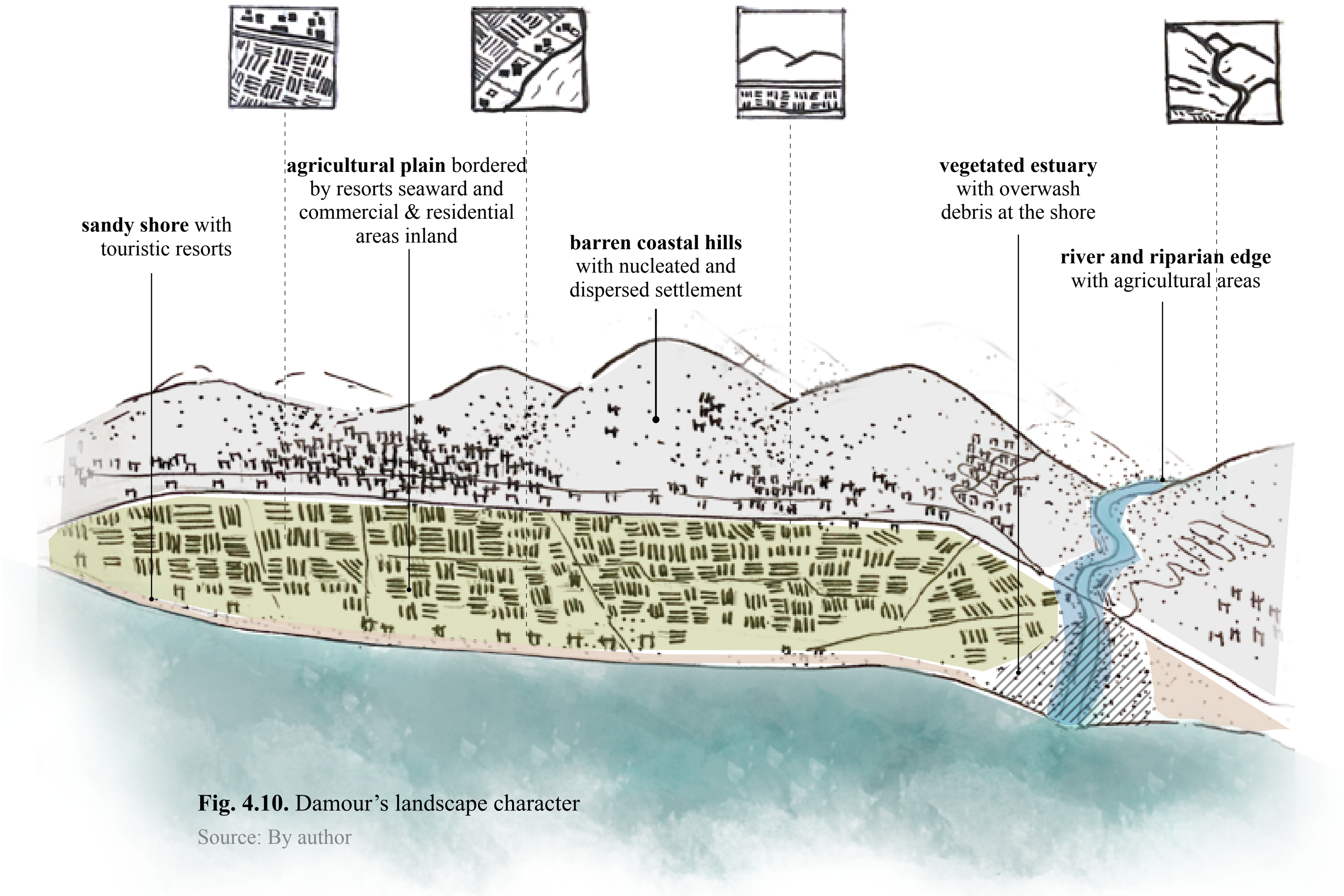


Fig. 4.10. Damour's landscape character
Source: By author

Fig. 4.11. Images along the coastal plain of Damour
Source: By author

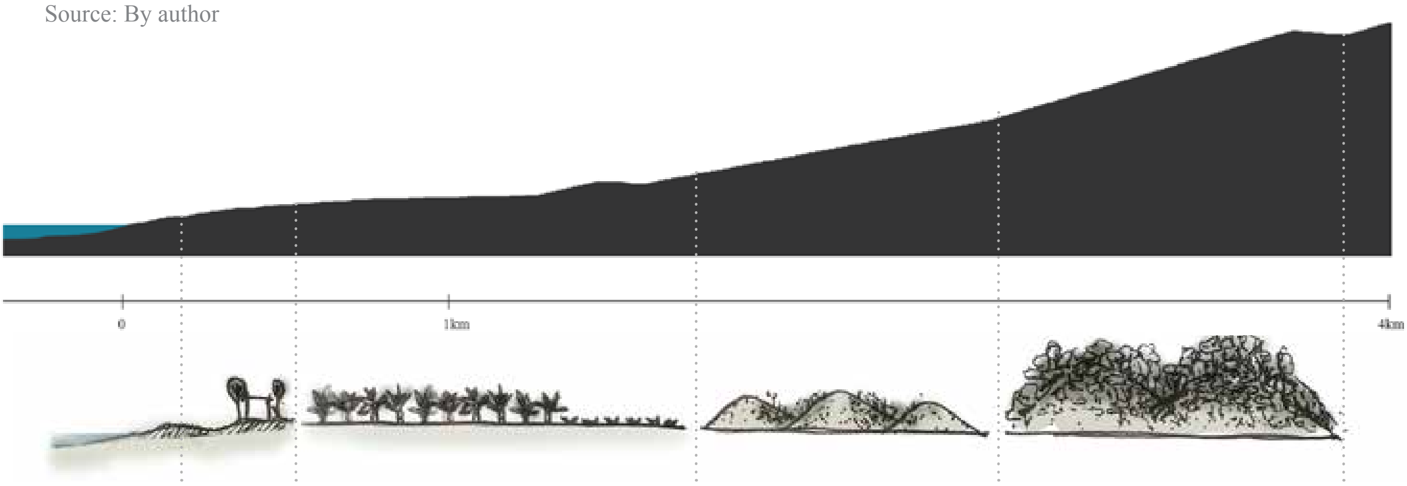


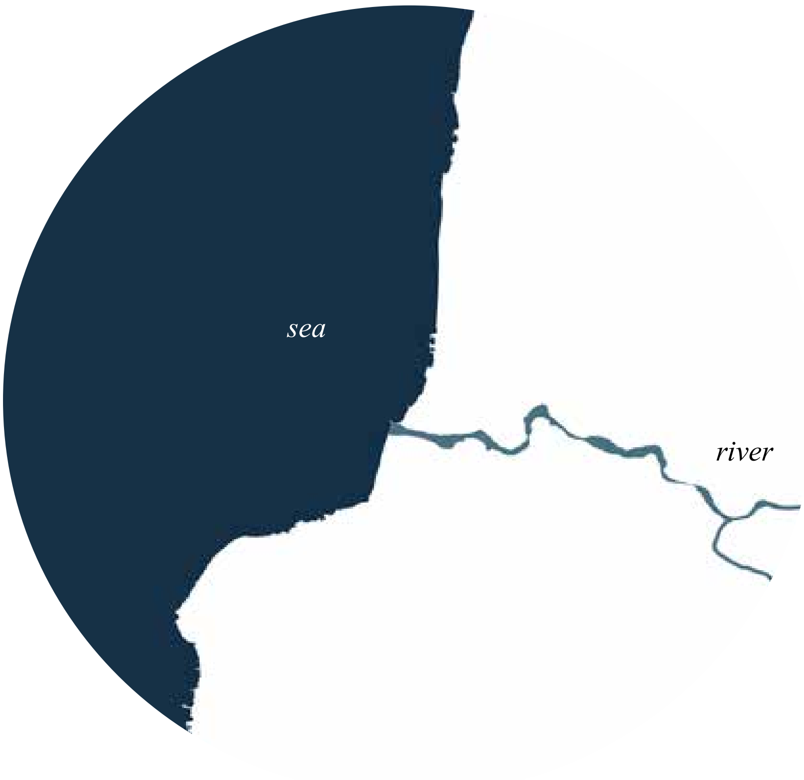
Fig. 4.12. General section and dominant character from the sea towards the coastal hills
Source: By author

a. Edges as a Defining Feature of Damour's Landscape

Edges are created as a result of the proximity of two elements / congregate of elements that are contrasting in type, nature, or form (Pickett et al., 2013). Each person perceives edges uniquely, and edges can be imaginary or fixed elements. In this sense, borders can be thought of as imaginary lines, while boundaries are often fixed limits that define the bounded subject/object. As a result, edges are often areas of interest because first, they help in defining/bounding a subject into a comprehensible part of a whole; second, they are infinite and repeatable, thus they create patterns which visually aid in decoding, understanding, and relating elements or congregates of elements; and third, and perhaps most importantly, they are spaces of interaction, where mixing can occur at fast rates or is strictly resisted. Moreover, edges often seperate entities, but can also connect others (Batty & Longley, 1994), take rivers, or highways for example. In nature, edges are often areas of increased variety and diversity (Odum, 1971); where the morphology of the edge is a defining factor in the levels of interaction between entities.

In Damour, fluid, natural, and hard edges define the landscape. The main hard, linear edge is the highway, which defines the limits of the village and the agricultural plain, and acts as a seperator due to fast mobility (Fig. 4.14). The fluid edges in the landscape are the sea and the river. The morphology of the river is meandering, while the sea edge is mostly linear (Fig. 4.13). Both the river and the sea are fluid, dynamic boundaries, however the river acts as a corridor while the sea a sink, thus differing in experience and character (Fig. 4.15). The sea is grand, bounded by one edge, and is usually visible from a distance, while the river is bounded by two sides, and seeks discovery. Living edges such as forests and scrublands are mostly static edges, and in many instances cannot be defined as easily as rivers or the sea.

FLUID EDGES | THE RIVER AND THE SEA



HARD EDGE | THE HIGHWAY

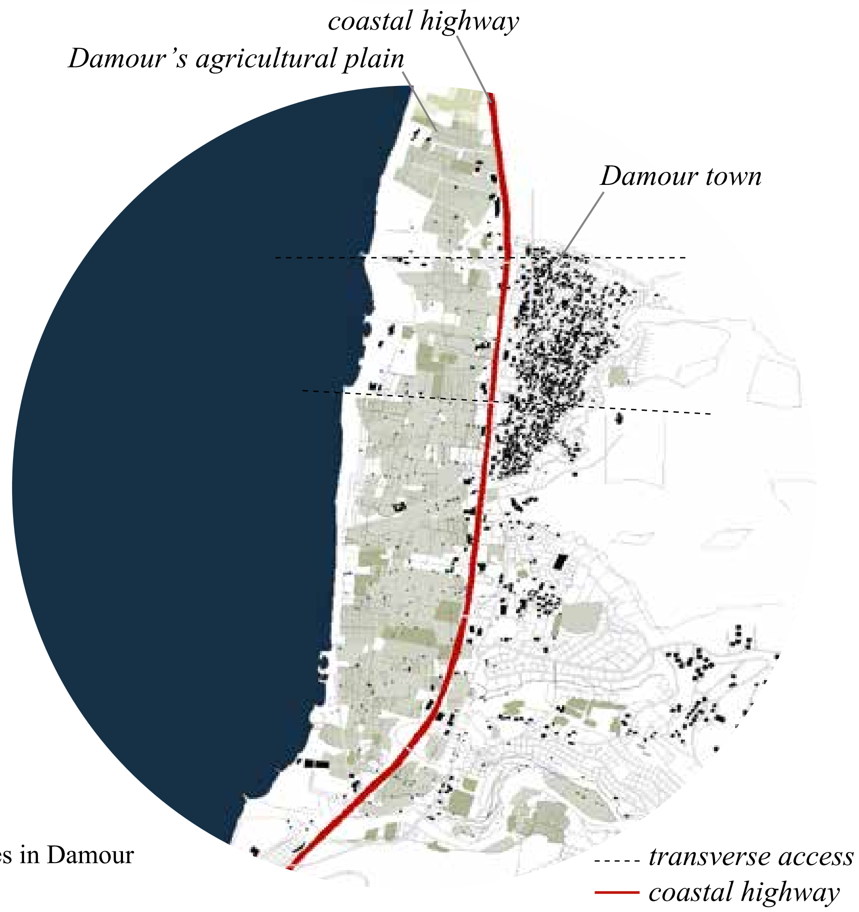
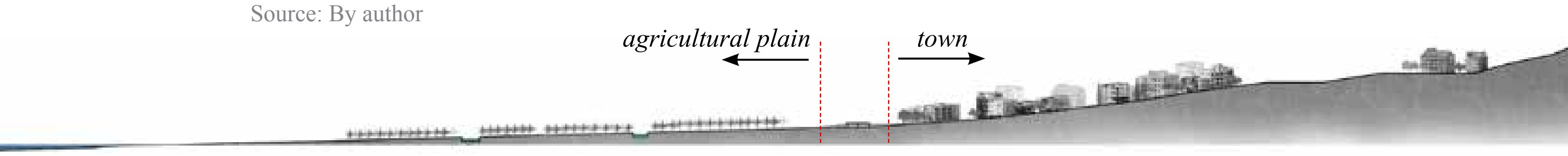


Fig. 4.13. Fluid and hard edges in Damour
Source: By author

Fig. 4.14. Highway defines and seperates town and plain.
Source: By author



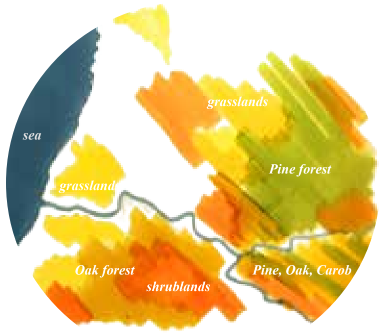
PATTERNS

DAMOUR TOWN
DENSE - IRREGULAR

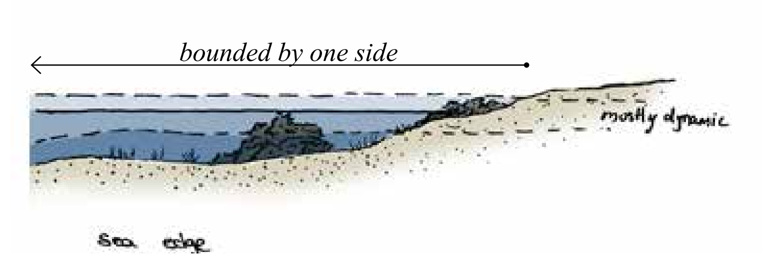
MECHREF TOWN
DISPESRSED - UNIFORM,

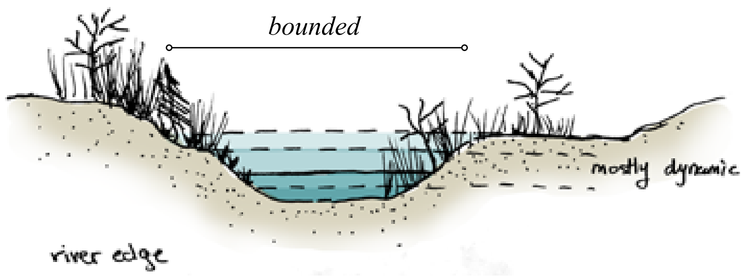
AGRICULTURAL PLAIN
MOSTLY REGULAR

SEMI-NATURAL AREAS
DISPERSED ⟶ DENSE



EDGE QUALITIES





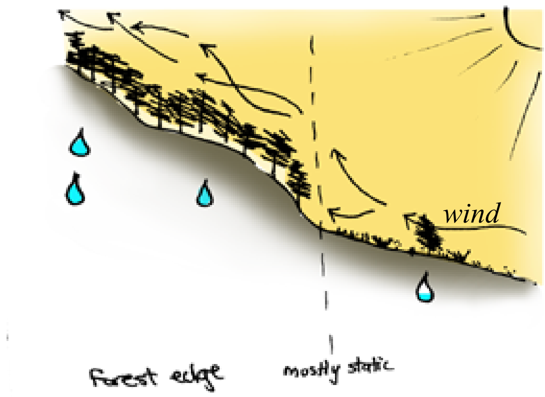


Fig. 4.15. Edge type and qualities, and patterns in Damour's landscape
Source: By author

2. Landuse

a. Landuse Change | Damour River Watershed

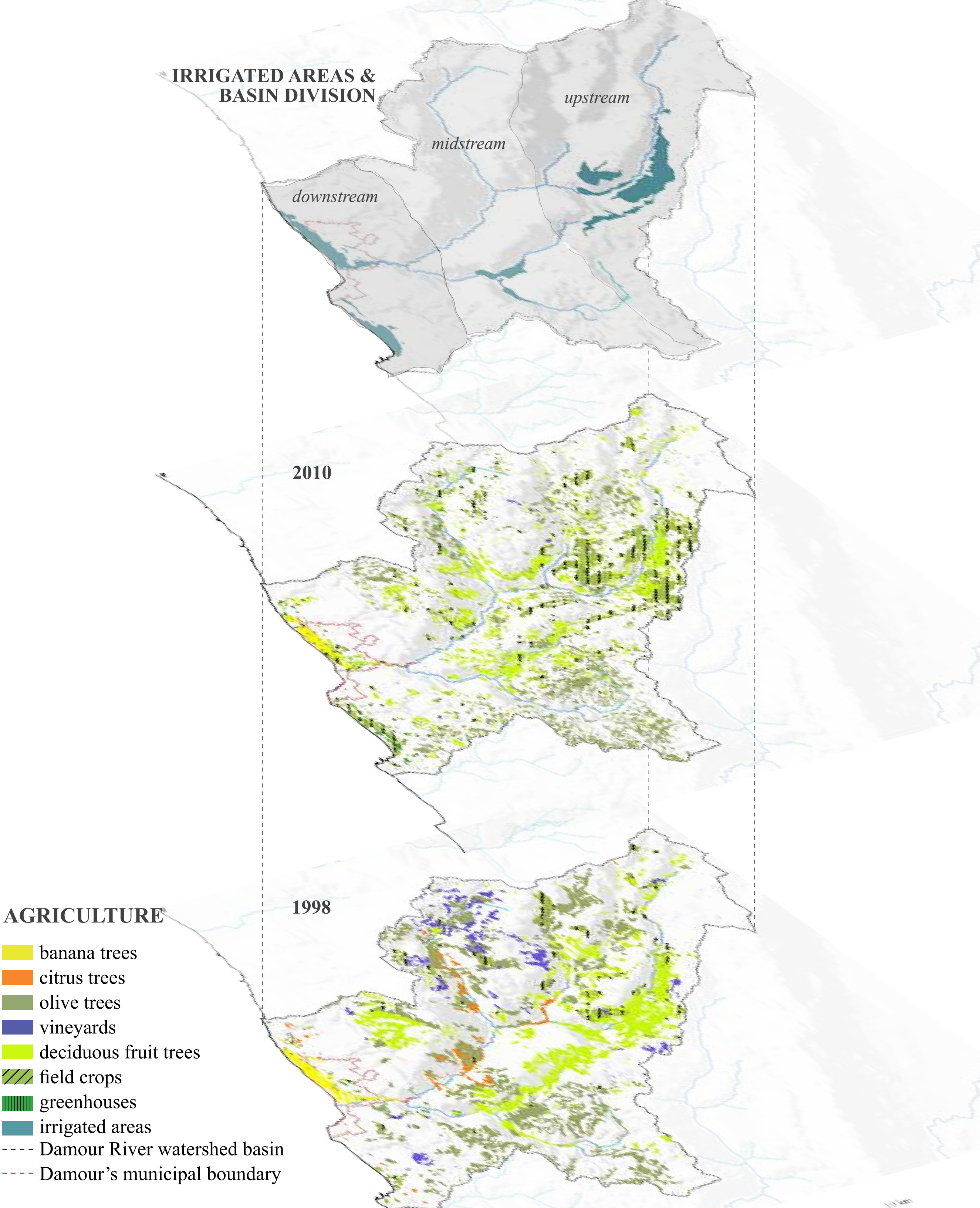


Fig. 4.16. Evolution of agriculture along Damour River's watershed from 1998-2010
Source: By author, data from LULC by CNRS (1998, 2005), and CDR(2005)

Agricultural change generally shows the fragmentation of cultivated Areas. In 1998 in the upstream portion of the watershed, mostly deciduous trees were cultivated, along with some field crops and vineyards, whereas in 2010, most of the deciduous trees are replaced by fieldcrops, and vineyards almost disappear. Changes in the midstream portion show a decrease in cultivation of citrus, especially along Damour river, and an increase of olive groves in the Southern part of the watershed. Downstream changes are most notably the introduction of agricultural cultivation South of Damour in Jiye's plain. A greater diversity of planted crop types is noticable in Damour, shifting from banana trees only in 1998 to incorporate field crops by 2010. The transition from deciduous trees to field crops upstream and the cultivation of coastal Jiye by 2010 increases irrigation demands.

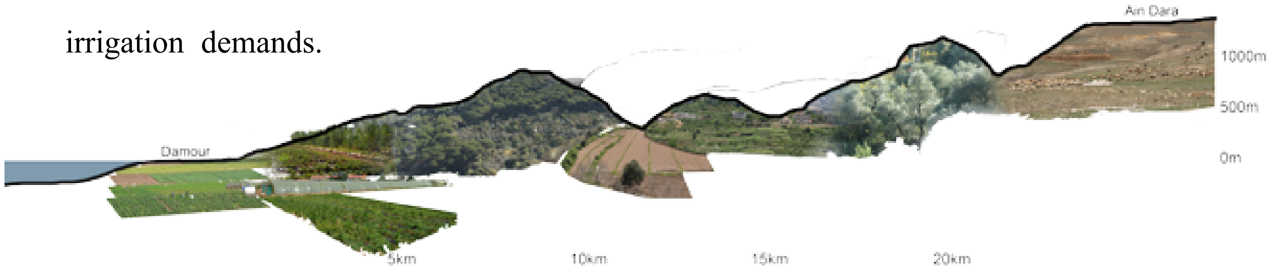


Fig. 4.17. Section accross watershed showing cultivation practices from Damour to Ain Dara
Source: By author

Fig. 4.18. Images of landuse along watershed area
Source: By author

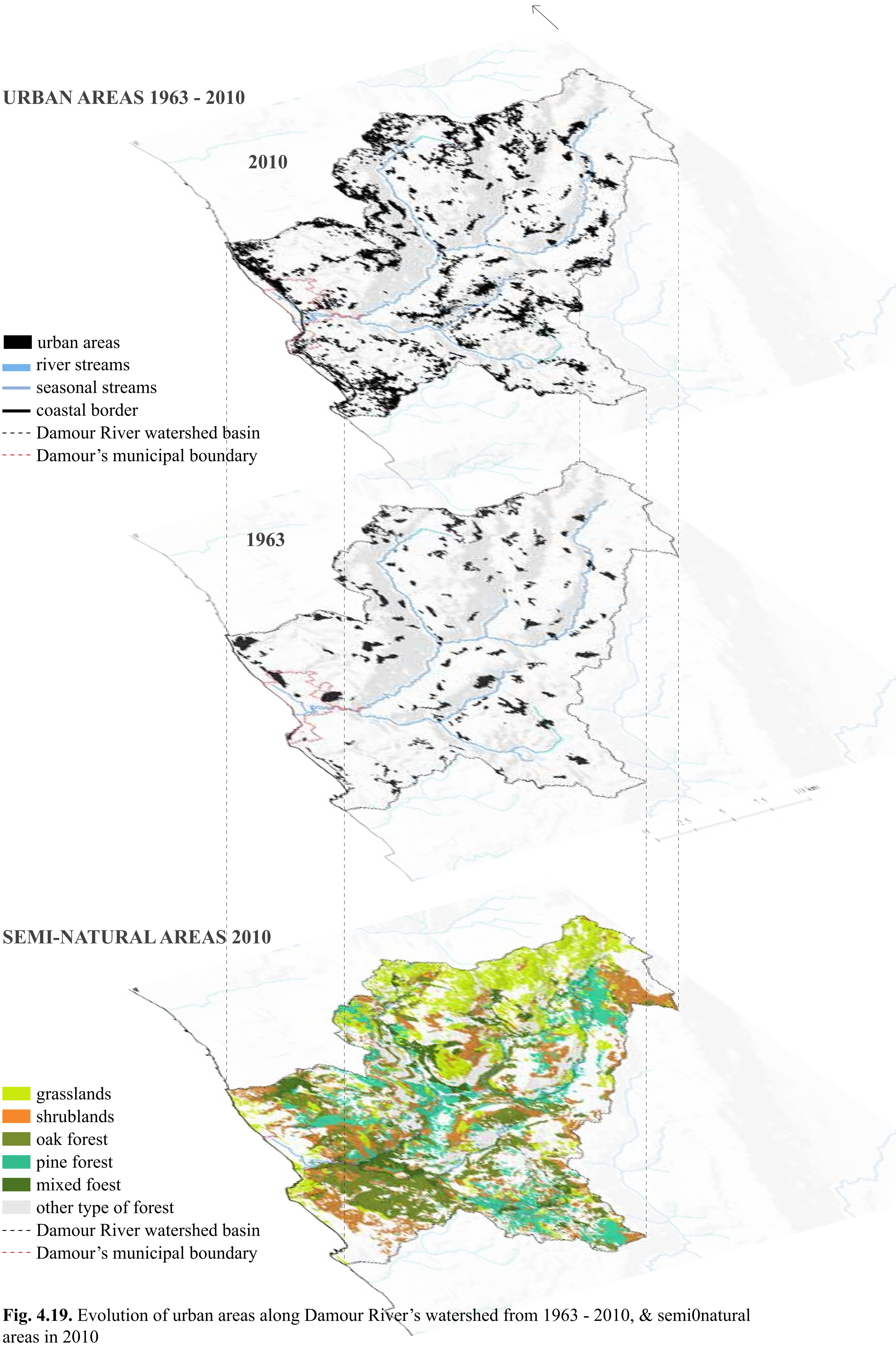


Fig. 4.19. Evolution of urban areas along Damour River's watershed from 1963 - 2010, & semi0natural areas in 2010

Source: By author, data from LULC by CNRS (2005), and CDR(2005)

b. Landuse | Damour

Fig. 4.20. Landuse 2010
Source: By author based on fieldwork and LULC (2010) by CNRS

Comparison of landuse in 1962 with current landuse shows the retreat of the coastline as a result of coastal erosion, and the construction of breakwaters. The agricultural plain has decreased in size, as a result of the construction of the highway, which slowly transform cultivated lands East of the highway into a commercial/ residential strip. Agricultural lands have also retreated away from the shore, due to the attractiveness of those areas to touristic resorts and private development, as well as the decreasing suitability of these lands for cultivation.

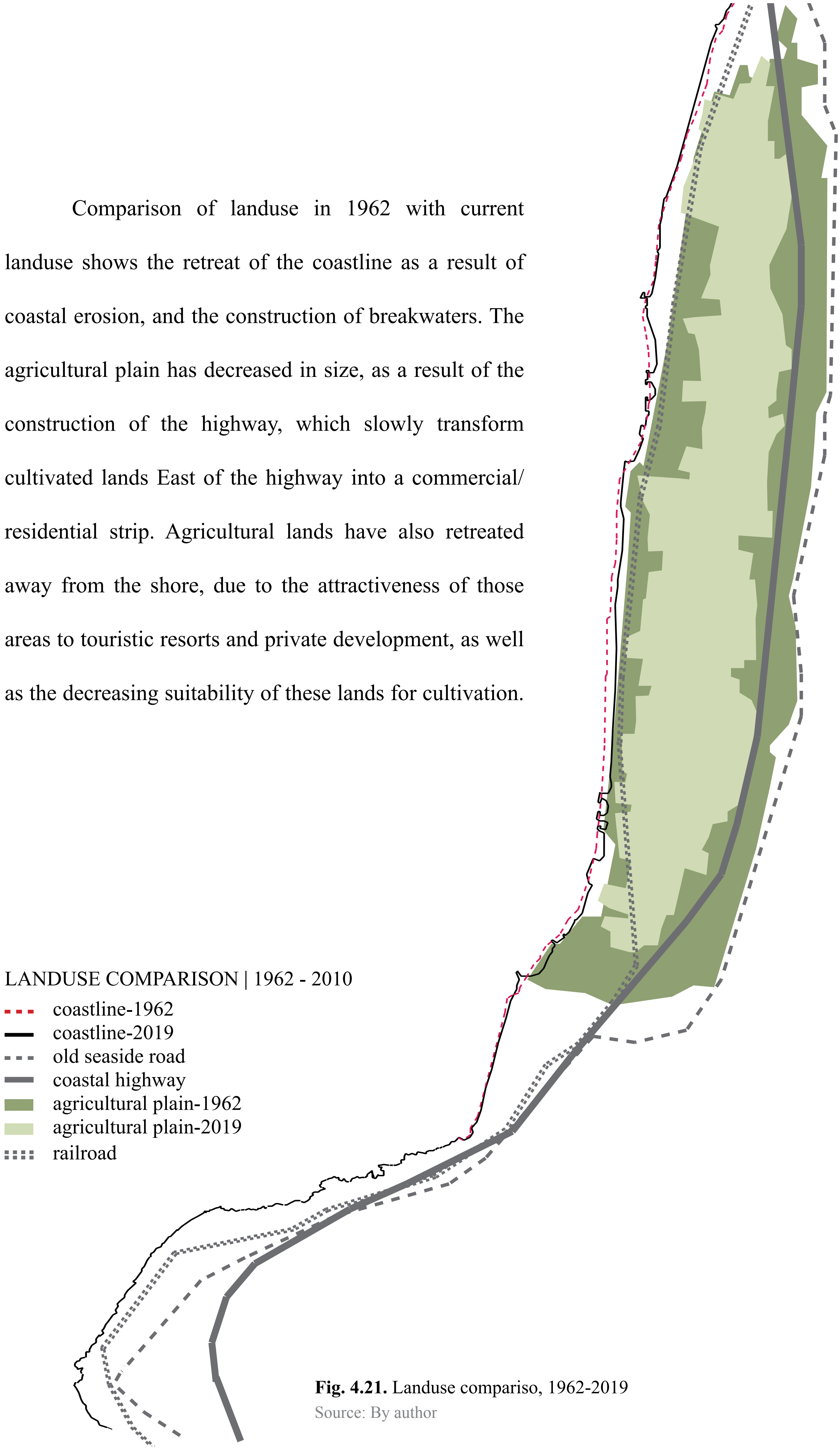


Fig. 4.21. Landuse compariso, 1962-2019
Source: By author

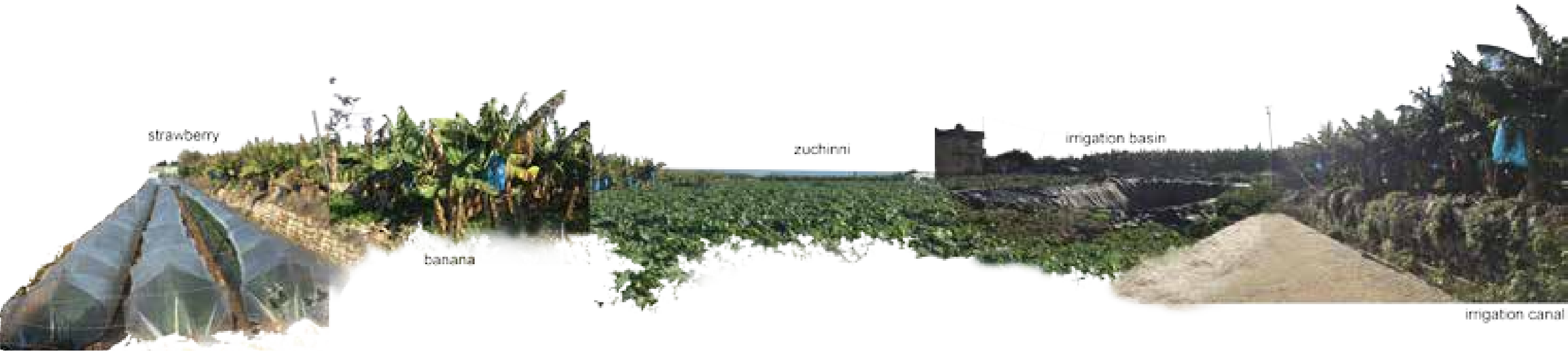


Fig. 4.22. Main agricultural cultivation through Damour's plain
Source: By author

Fig. 4.23. Diversity of semi-natural areas throughout Damour
Source: By author

c. Flora and Fauna

FLORA	SURVEYED SPECIES		
AREA / HABITAT TYPE			
COASTAL DUNES	RIPARIAN EDGE	GRASSLANDS / SHRUBLANDS	FORESTS
Xanthium strumarium	*Arundo Donax*	*Phlomis viscosa*	*Pinus Pinea*
Echium Plantagineum	*Phragmites Australis*	*Crysanthemum coronarium*	*Quercus calliprinos*
Capparis Spinosa	*Eucalyptus spp.*	*Pancratium maritimum*	*Quercus ilex*
Pancratium maritimum	*Acer spp.*	*Calictome vilosa*	*Cercis silliquastrum*
			Pistacia lentiscus
			Ceratonia siliqua

FAUNA	INVENTORIED SPECIES	
BIRDS	HABITAT	BUTTERFLIES
Botaurus stellaris	*winters in marshes and reedbeds*	*Strymonidia (satyrium)*
Ciconia ciconia	*fields & meadows (migrant)*	*Spini melantho*
Falco columalorius	*estuaries and marshes (winter visitor)*	*Spialia orbifer hilaris*
Streptpelia turtur	*young woodlands (summer breeder & migrant)*	*Lasiommata maera orientalis*
Acrocephalus arundinaceus	*marshy areas, ditches, and dikes near coast (summer breeder & winters)*	

Table 4.1. Surveyed and inventoried flora and fauna in Damour
Source: By author

Fig. 4.24. Habitats in Damour
Source: By author

3. Water

Damour River is perennial, flowing East to West into the Mediterranean Sea. It's watershed is 305km^2, fed by El Safa and Barouk springs, and its length is 38 km (Daou et al., 2018). In its high water flow period, flow rate reaches 68 m^3/s that drops to 0m^3/s in dry summer months downstream.

Two dams are proposed along Damour River (Fig. 4.25). If completed, these dams may have a negative ecological impact on the whole river ecosystem, and the coast due to sediment starvation downstream, limiting natural beach formation, and accelerating coastal erosion. Increased groundwater extraction throughout the river profile has caused salt-water intrusion in the coastal landscape, where subsidence has been reported (Mehdi, 2004).

Many restaurants and industrial facilities support tourism, recreation, and production. However, their actions are unregulated whereby wastewater, sewage, and effluents are dumped into the Damour river (Massoud, 2012). Moreover, sewer outlets of some towns flow directly into the river stream.

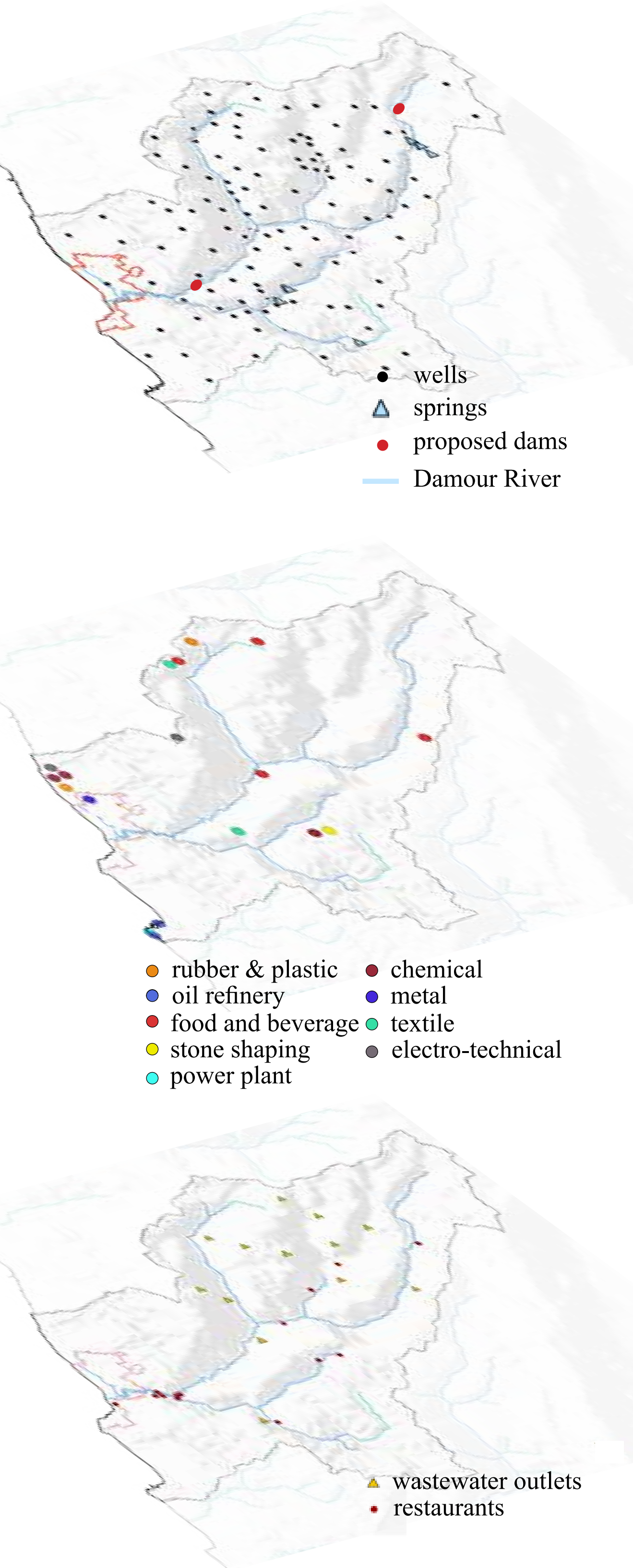


Fig. 4.25. Profiling Damour River: wells, springs, industries, wastewater outlets, restaurants, and proposed dams.

Source: By author, based on data from CDR (2005), and google earth

a. Water Quality | Damour River

A study by Daou et al. (2018) conducted five sampling sites along the river, shown in Fig. 4.26., starting from El Safa spring (S1), downstream to Ain Zhalta (S2), Barouk spring (S3), with a sampling point just upstream of the meeting of the two tributaries (S4), and finally near the river mouth (S5). Results show that water at S1 & S3 have a good water quality and high dissolved oxygen content, due to the strong slopes of the riverbed (Daou et al., 2018). S2 near El Safa source has a slightly lower water quality than the two springs that feed the river (ibid.).

Both S4 and S5 downstream sites show high pollution and contaminants in their samples (ibid.). The presence of restaurants along the river in S4 and the high agricultural effluents in S5 explain these results (ibid.). Both sites show high bacterial indicators, total coliforms, total fecal matter, as well as high mineral indicators, where high levels of Sulfate have been recorded in Damour's estuary (Houri, & Jeblawi, 2007; Daou et al., 2018). Finally, the soft slopes near Damour's estuary (S5) contribute to high temperatures recorded in the dry season and possibly expose the river to increased pollutants in its stream (Houri, & Jeblawi, 2007).

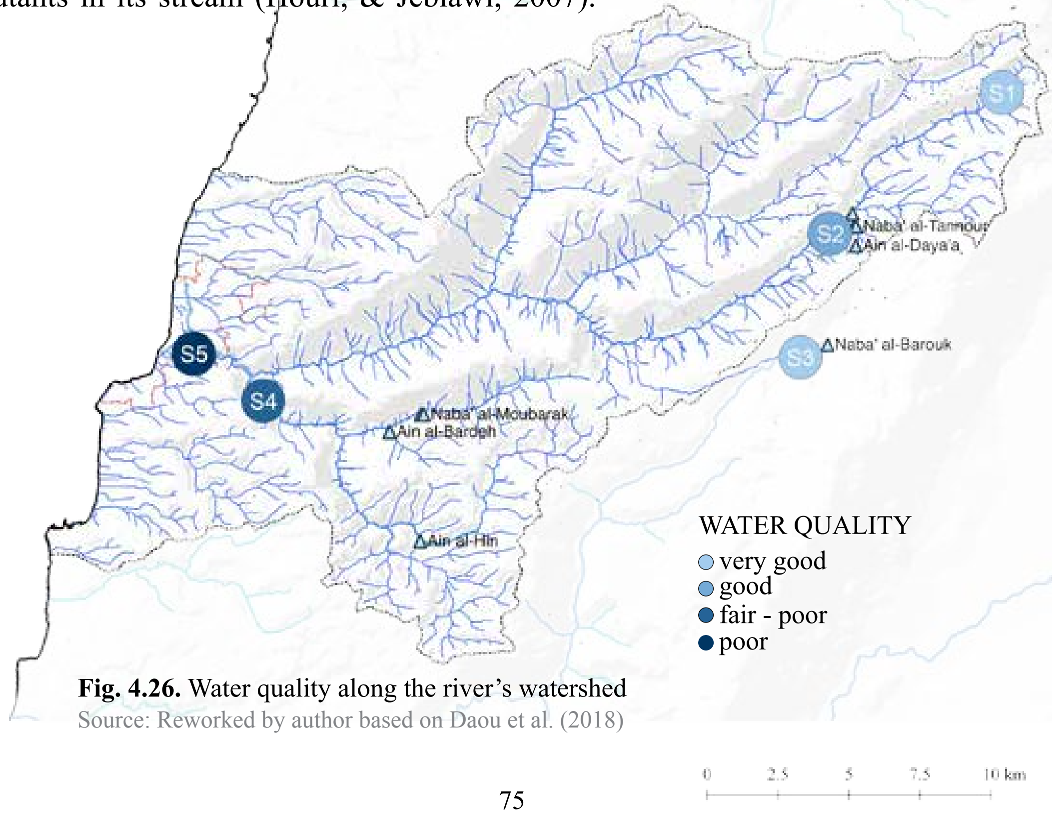


Fig. 4.26. Water quality along the river's watershed
Source: Reworked by author based on Daou et al. (2018)

b. Water Infrastructure | Damour

Damour's water infrastructure is divided into two main categories in terms of use: domestic and agricultural. Domestic use is provided through municipal and private wells, while agricultural use is supplemented through the diversion of the river stream into irrigation canals (Fig. 4.27). A third end-use of Damour's water is to supply Greater Beirut with it's water needs, whereby it was estimated that 80% of Damour's water serves this purpose only (Mehdi, 2004). This increased extraction of water from the landscape contributes to an earlier drying of the river stream in the late summer months, halting cultivation practices in that period. Farmers have also been experiencing increased salt-water intrusion, crippling agricultural yields.

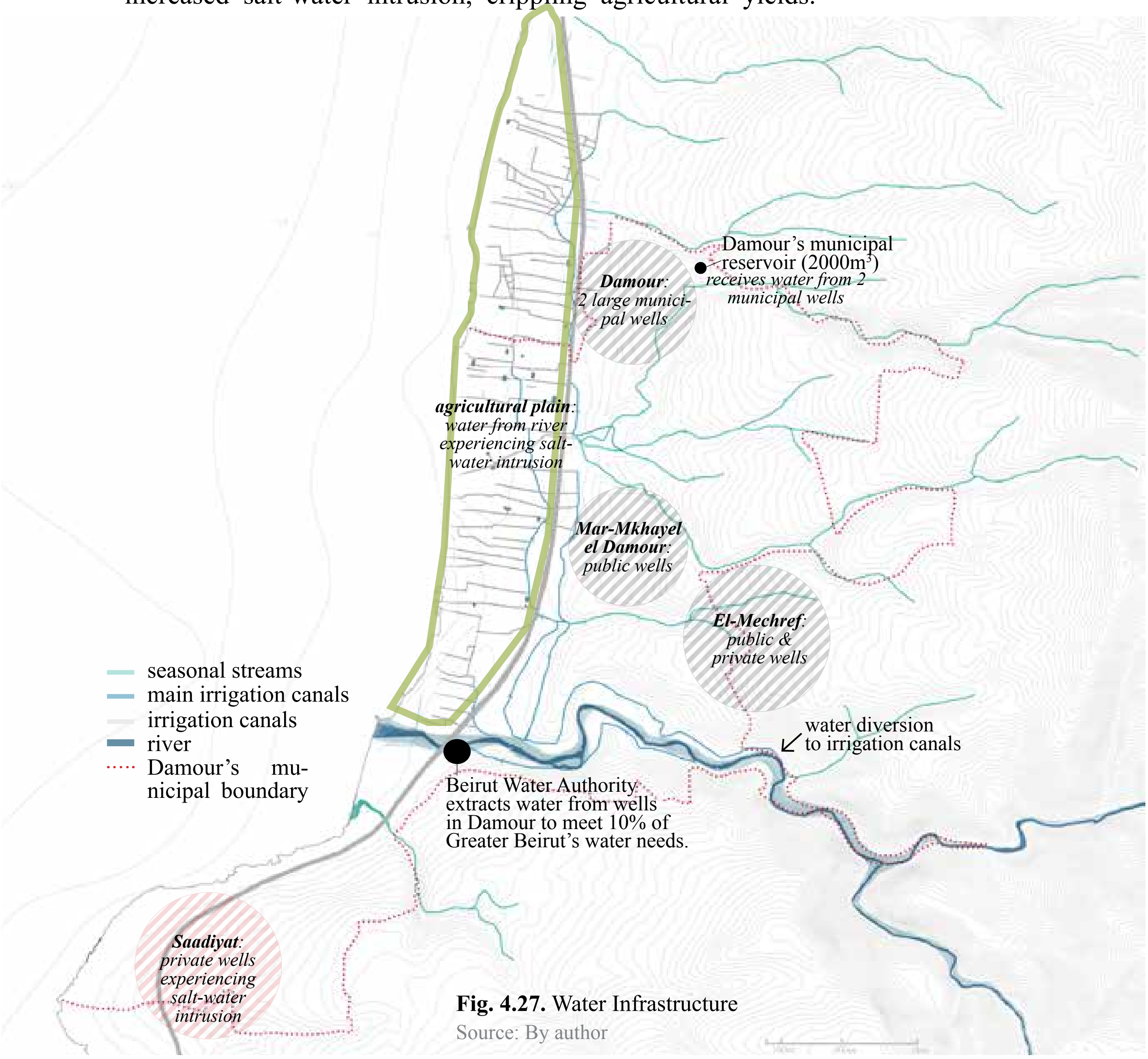


Fig. 4.27. Water Infrastructure
Source: By author

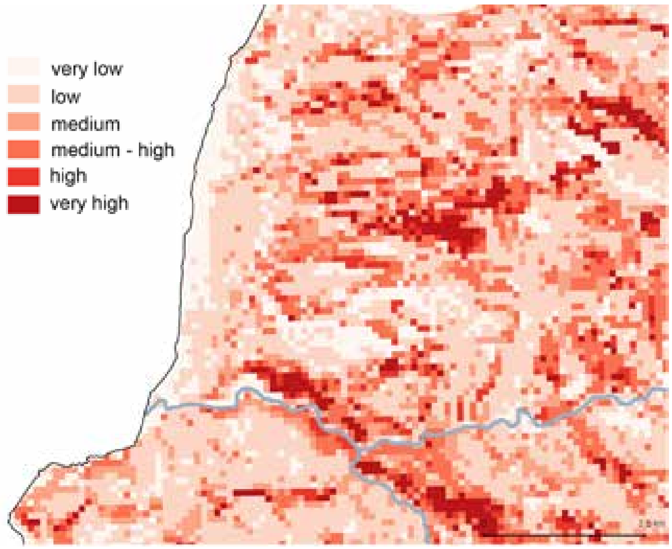
D. Climatic Processes, Impacts, & Anthropogenic Influences

1. Climate Impacts & Landscape Hazards

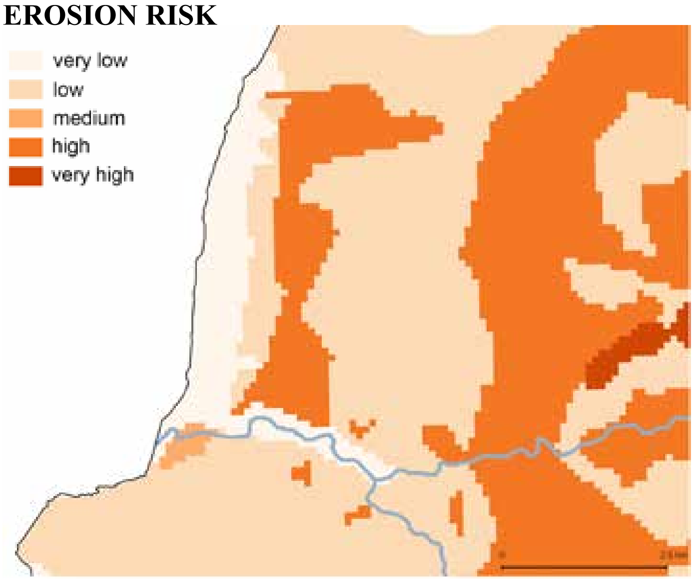
Damour’s unique landscape is threatened on several fronts. Landscape threats are mapped based on data retreived from CNRS and SDATL through my involvement in previous projects tackling landscape risks (Trovato et al., 2017). Saltwater intrusion and sea level changes are also mapped in accordance to published reports by the IPCC and the MOE (Ministry of Environment), using the RCP 8.5 scenario. All landscape hazards shown are studied at a 100 x 100m raster cell size.

Coastal Floods are highly pronounced along the Damour plain, along with desertification risk reflective of the continuous agricultural activity and monoculture agriculture which decreases soil productivity (Fig. 4.28). Erosion occurs at steeper slopes above the Damour plain, however it’s not very pronounced. Forest fires are highest risk near the riparian corridor of Damour’s River, along Mechref, and Damour’s village (Fig. 4.29). In October 2019, forest fires ravaged through the Chouf district, concentrated in the areas of Damour, Mechref, neighbouring Debbieh, Naameh, and many more. Many homes burnt down, forests destroyed, and people were put in danger with many reported injuries and one death. The incapacity of the state to deal with such a problem required foreign assistance to stop the fires that went on for days, which were hard to control due to high wind speeds. Through the addition of desertification, erosion, and forest fire risk (each weighed equally at 33.33%), the multi-hazard analysis is computed and shows that slopes above the plain are most prone to one or more risks, and the plain is at medium threat from compound risks. Finally, sea level rise threatens the shore space and the agricultural plain especially in the case of strong storm surges, and salt-water intrusion affects Damour’s entire area.

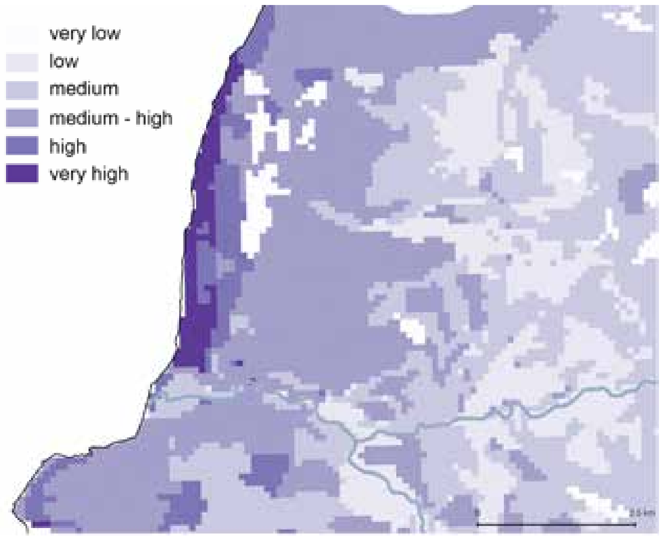
FOREST FIRE RISK



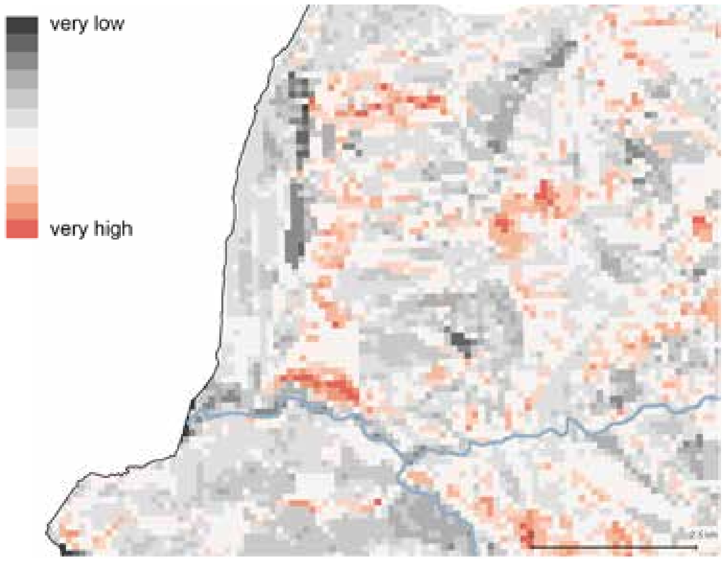
EROSION RISK



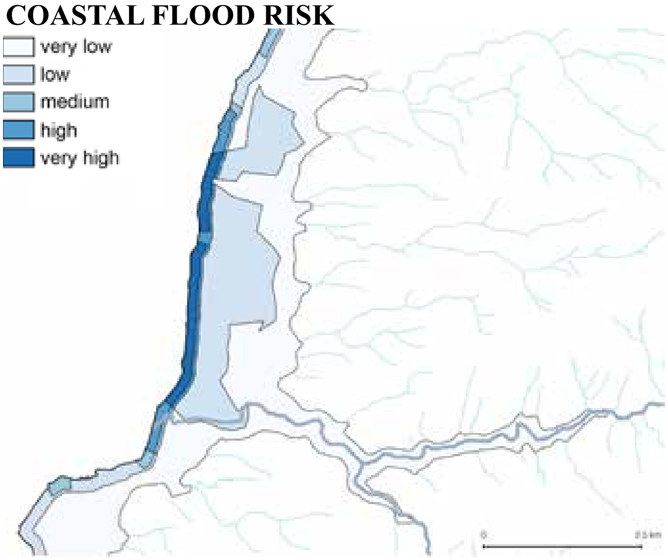
DESERTIFICATION RISK



MULTI-HAZARD RISK



COASTAL FLOOD RISK



SEA-LEVEL RISE & SALTWATER INTRUSION

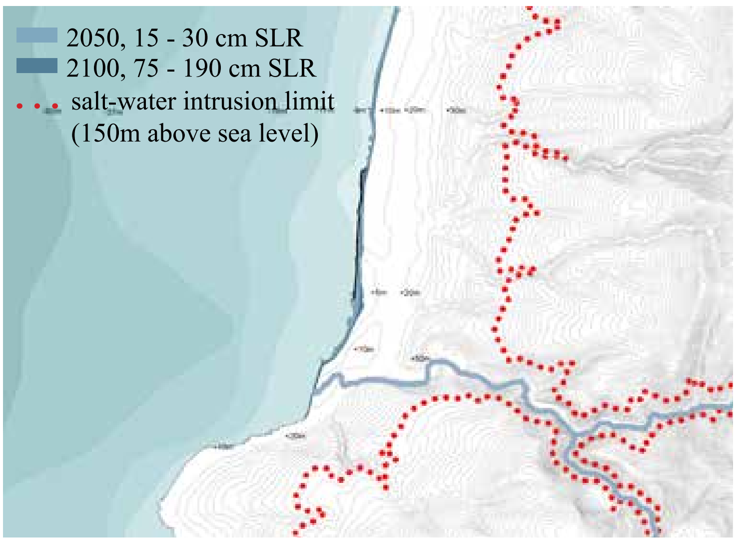


Fig. 4.28. Coastal flood, desertification, and forest fire risks.
Source: By author, based on CDR (2005); and Trovato et al. (2017)

Fig. 4.29. Erosion, multi-hazard risk, SLR & saltwater intrusion.
Source: By author, data from Trovato et al., (2017); SLR based on IPCC; salt-water intrusion data retreived from Assessment of Groundwater Resources of Lebanon (Rep.). (2014).

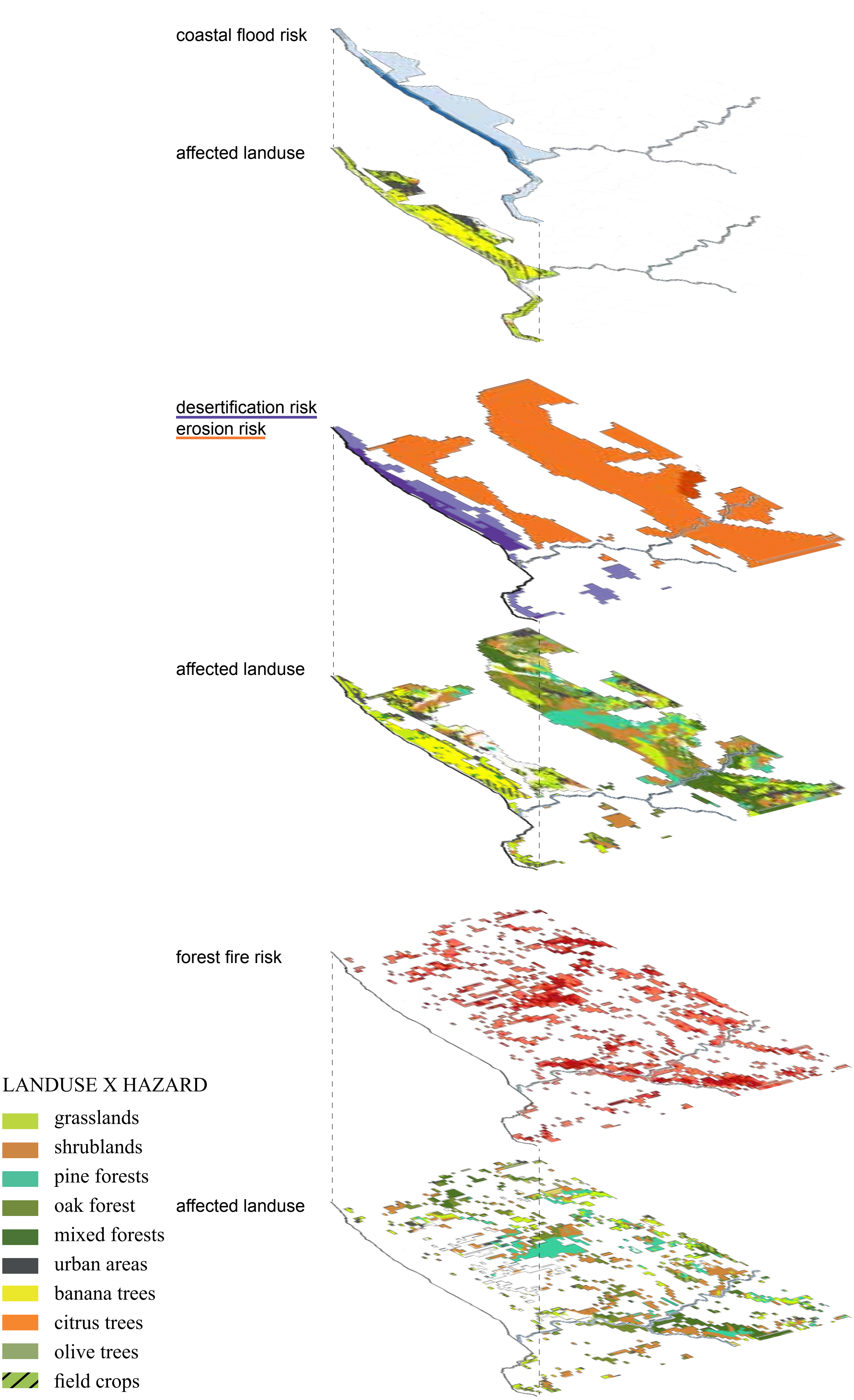


Fig. 4.30. High & very high landscape risk values overlain with landusse
Source: By author, based on CDR(2005); Trovato et al. (2017); and LULC data by CNRS (2010)

2. ANTHROPOGENIC IMPACTS AND PROCESSES

a. Circulation and Shore Accessibility

As Damour's plain has been continuously cultivated since the 1800's, its shore hasn't been the centre of interest for any other kind of development until recently. Three beach resorts existed prior 2004, while today there are 10 beach resorts. While these beach resorts limit the amount of public beach area, they are not the only type of transgression on maritime domain, with some privatized lands directly occupying the shore for leisure or residential purposes (Fig. 4.32 - 4.33). Roads reaching the shore have been mostly in service of resorts, which lead to dead ends unless one enters the resort. There is only one road that reaches the edge of the public beach, where vehicular access directly on the sandy beach occurs due to a lack of shore management or control put in place to limit such activity (Fig. 4.31).

Fig. 4.31. Shore accessibility
Source: By author

Fig. 4.32. Dead ends and privatized, inaccessible shore lands
Source: By author

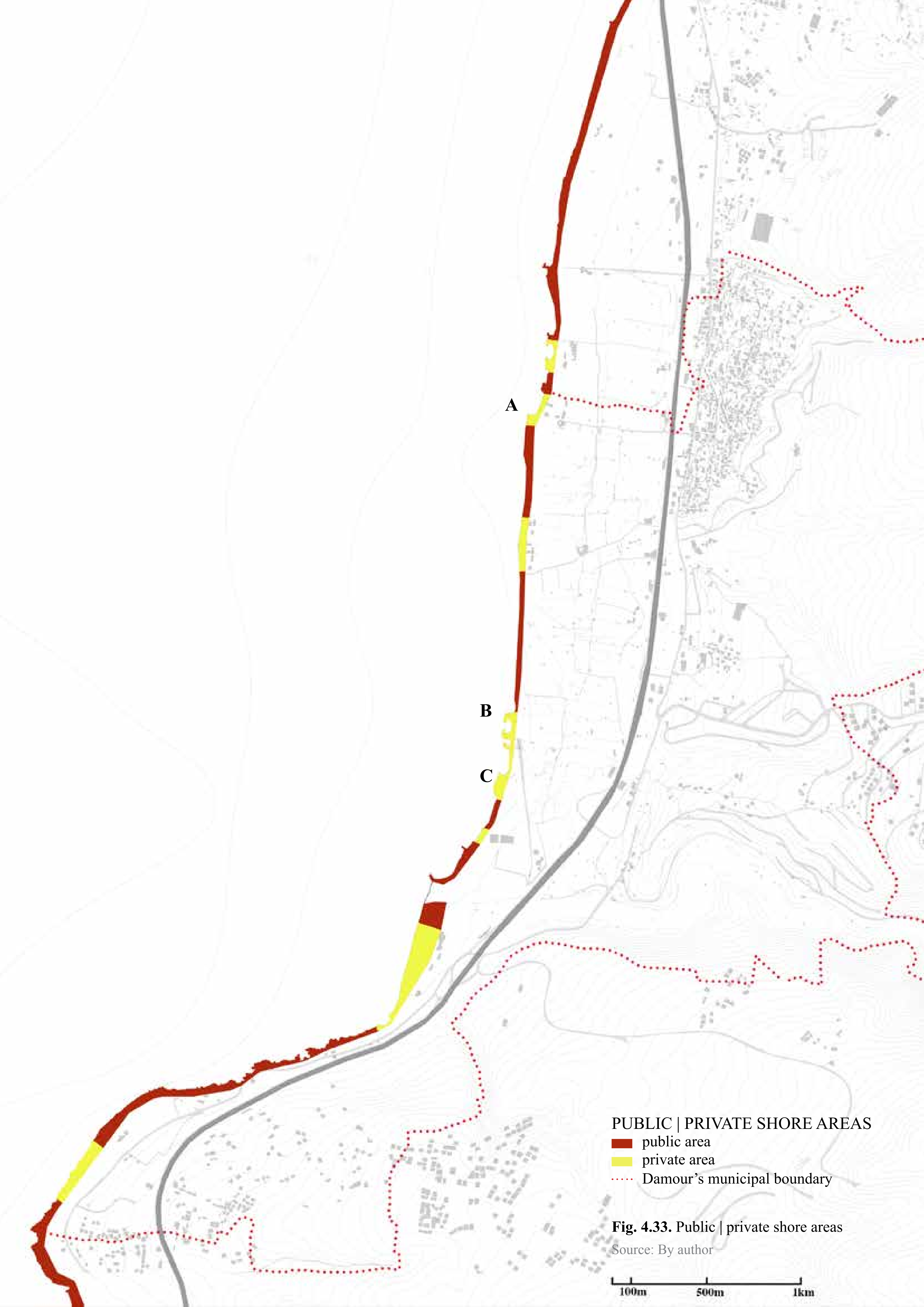
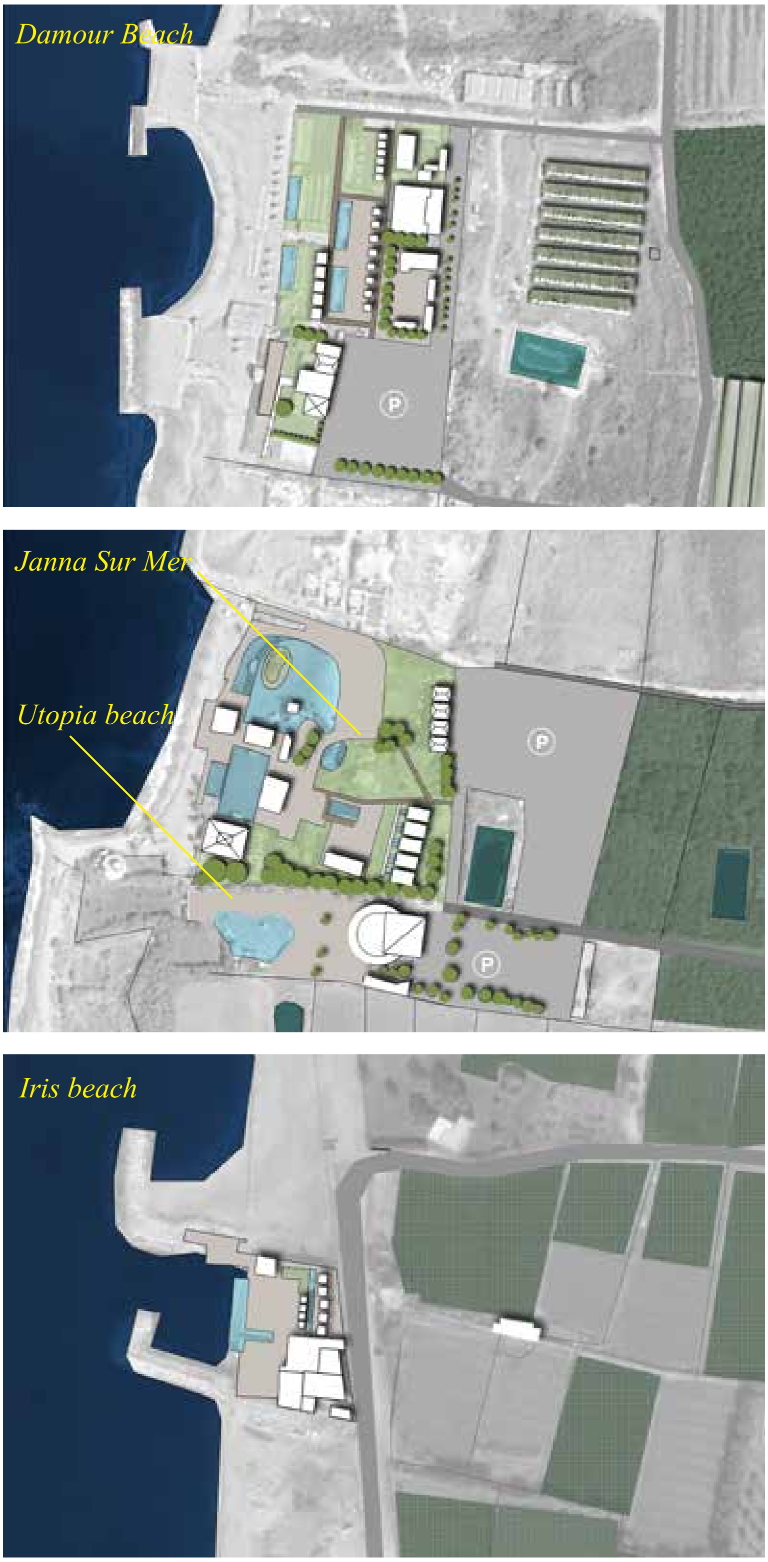


Fig. 4.33. Public | private shore areas

Source: By author

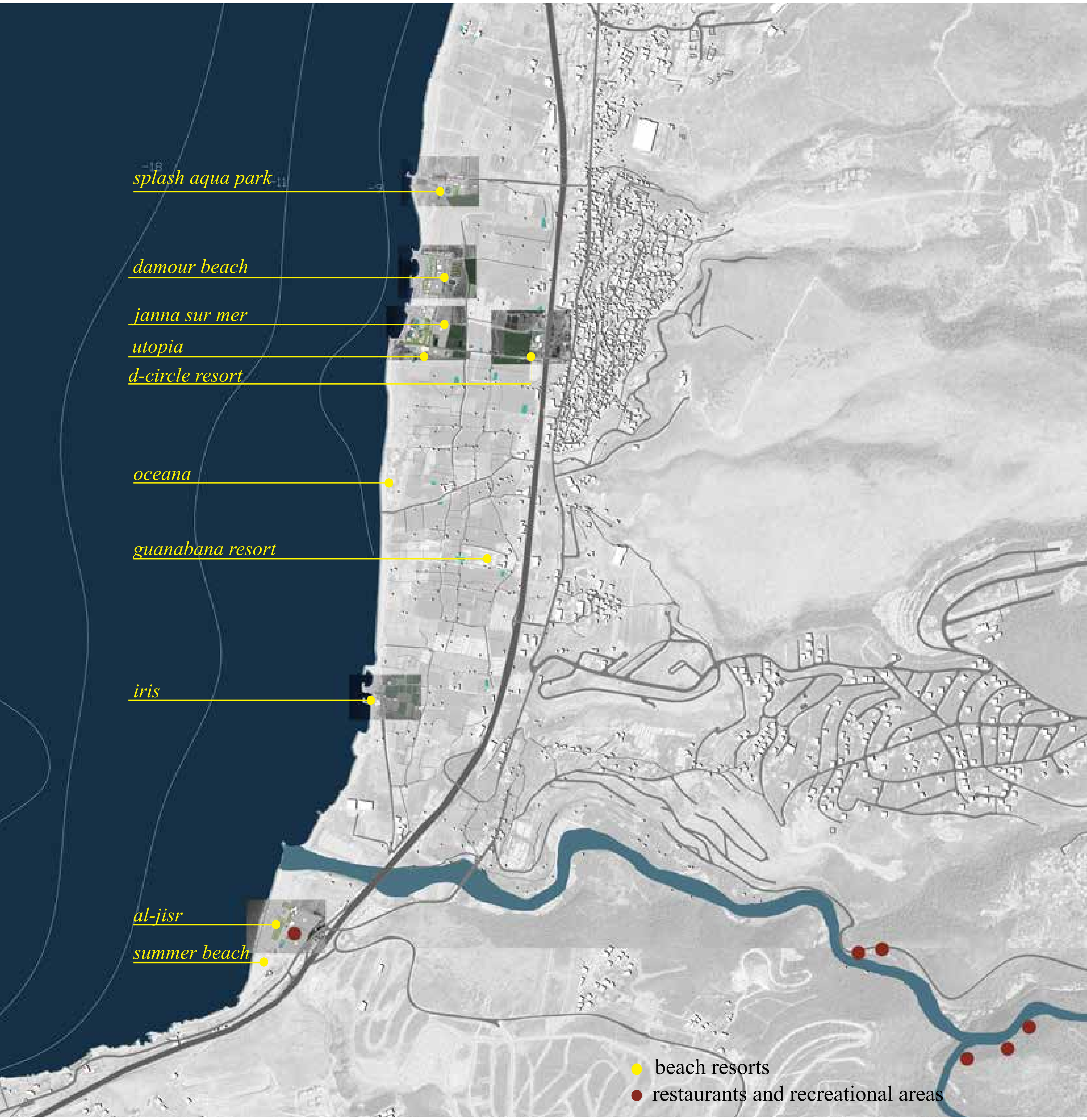
b. Resorts



SELECTED RESORTS PLAN VIEW

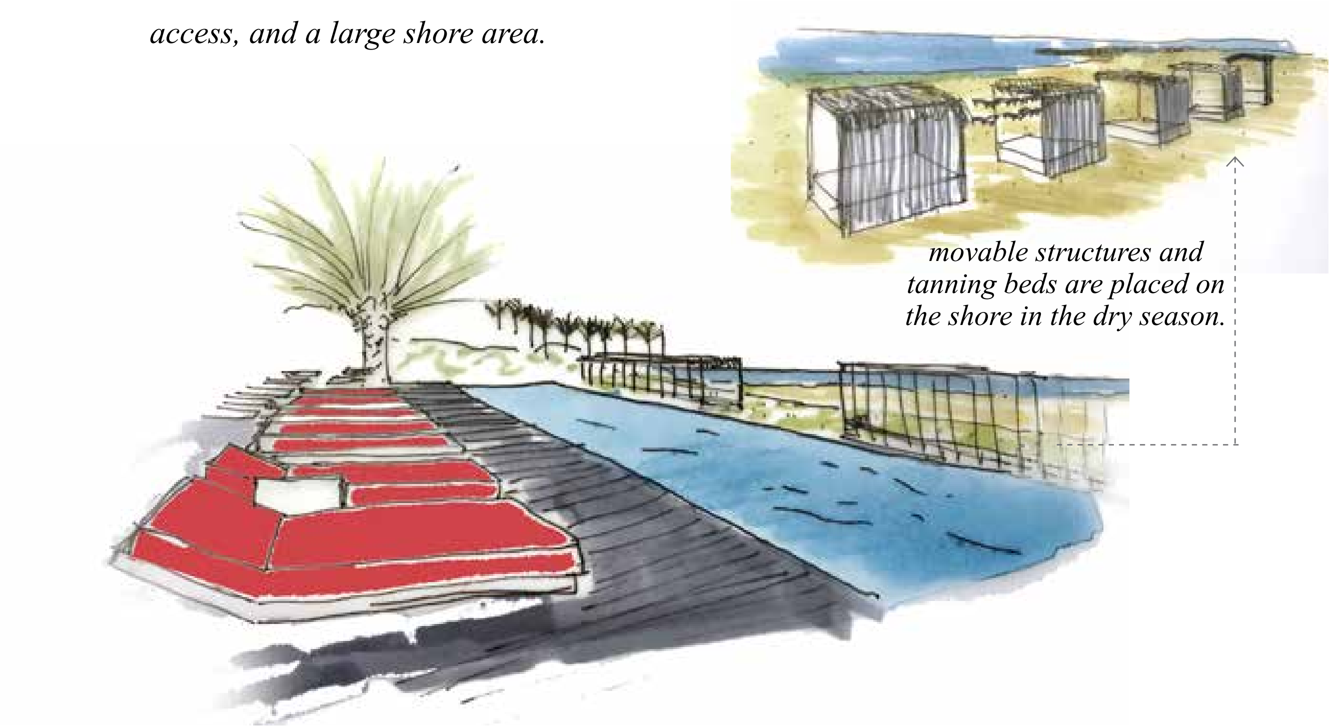
- paved surface
- parking
- grassy area
- swimming pools
- building | structure
- vehicular circulation
- irrigation basins
- trees
- greenhouses
- banana cultivation
- field crop cultivation

Fig. 4.34. Resort and restaurants, with zoom ins on selected resorts.
Source: By author


splash aqua park
damour beach
janna sur mer
utopia
d-circle resort
oceana
guanabana resort
iris
al-jisr
summer beach
beach resorts
restaurants and recreational areas

DAMOUR BEACH RESORT

The sea is emphasized in Damour beach, with multiple terraces with an open visual access, and a large shore area.



JANNA & UTOPIA ADJACENT BEACH RESORTS

The sea is de-emphasized in both Janna and Utopia resorts. Utopia's users do not have access to the coast, while Janna resort has a very narrow beach area, prioritizing paved areas over sandy ones.

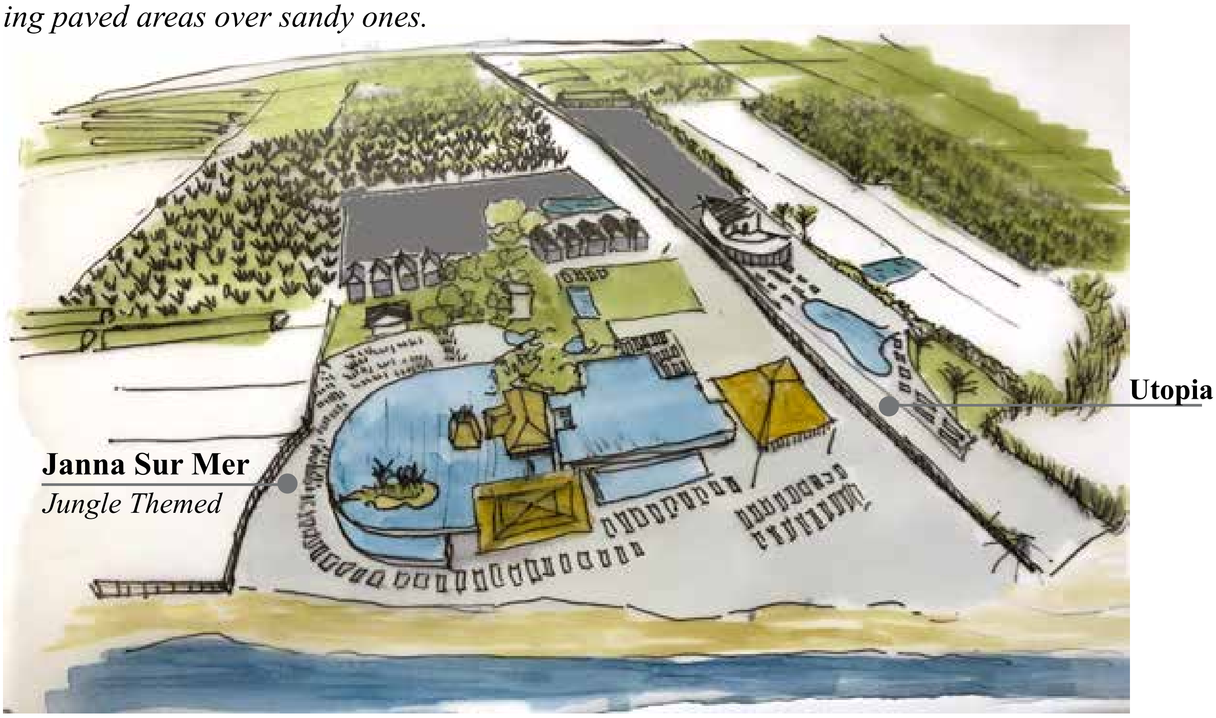


Fig. 4.35. Damour, Janna Sur Mer, and utopia beach resorts themes and relation with the sea.
Source: By author

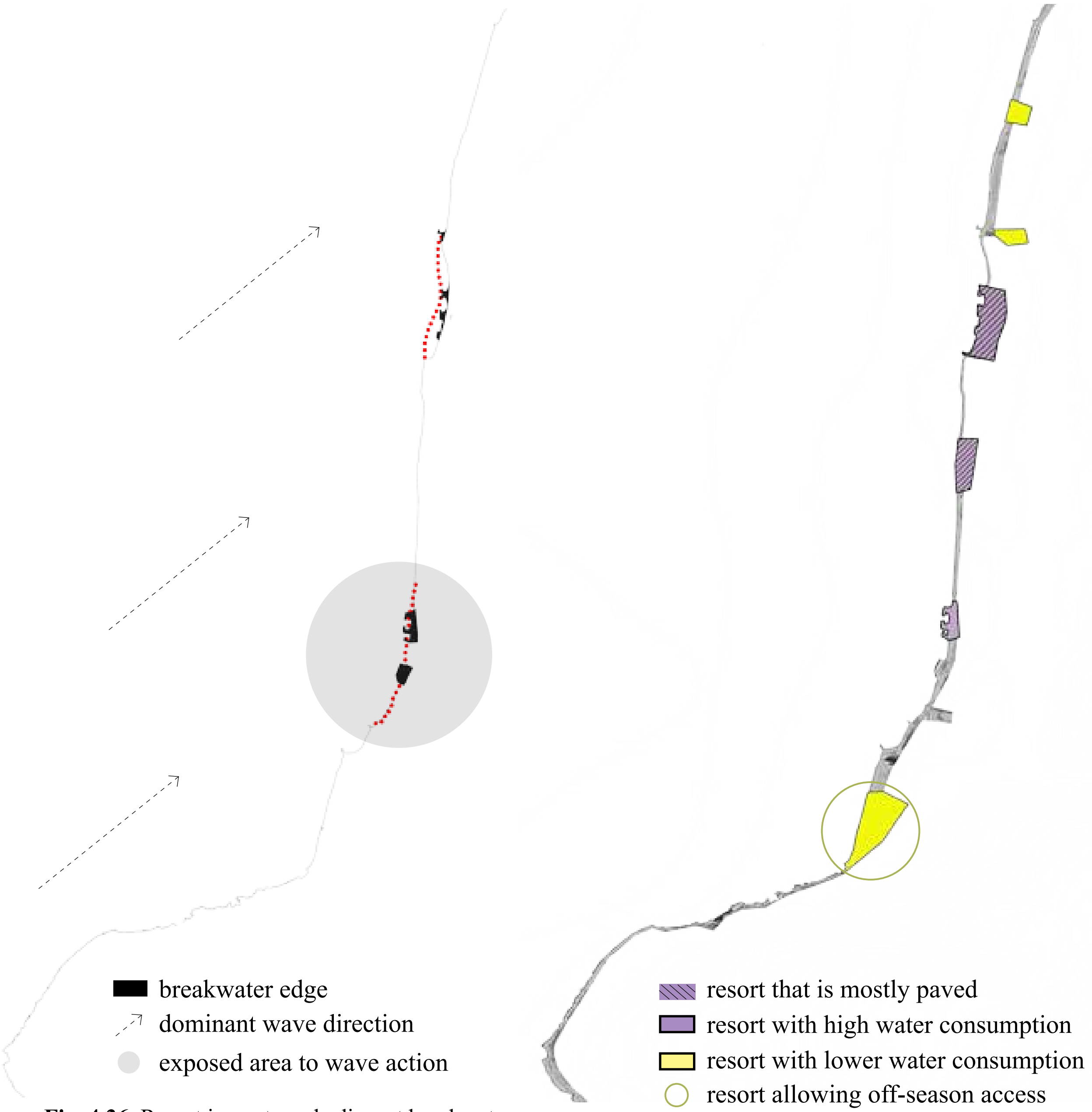


Fig. 4.36. Resort impacts and adjacent breakwaters
Source: By author

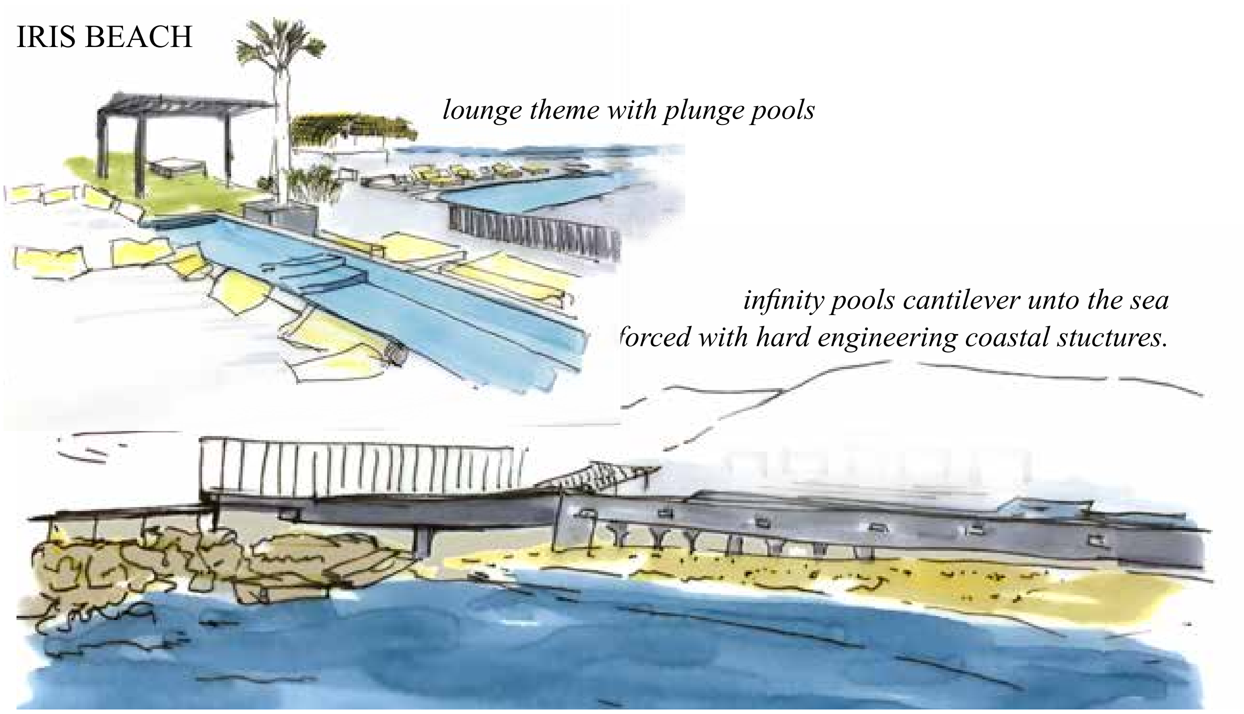


Fig. 4.37. Iris beach theme and relation with the sea.
Source: By author

The highest usage of beach resorts is during May-September. Only two resorts are accessible during the winter months, namely Summer Beach and Jisr beach South of the river estuary, as they are used by a surfing community establish in Jiye, a town located South of Damour. In intermediary months such as March and April, these resorts may charge minimal entrance fees based on the presence of employees at the door. Resorts are also often used as wedding venues in the summer season, and as musical event spaces such as Iris beach. Some resorts don't have a shore access, such as Splash Aqua Park, Utopia Beach, and two resorts located within the agricultural field. Most resorts have constructed breakwaters to limit sand loss from their shores and create safe swimming bays for their users (Fig. 4.36). Iris beach have constructed large breakwaters to deter strong wave action, leading to a very limited shore space (Fig. 4.37). Resorts such as Janna Sur Mer and Oceana have many large pools leading to increased water consumption (Fig. 4.35).

c. Coastal Processes and Shore Management

Damour's shore is considered a "neutral" beach, one formed by the interaction of coastal and river processes. Therefore, it's sediment input should equal that of relative sea level change, meaning that it ideally shouldn't propagade nor retreat (Finkl et al., 2019) . However, Damour's coastline has retreated significantly over time (Fig. 4.39), documented by (Mehdi, 2004) as 25 m during the period of the civil war. The situation today includes a severely eroded foredune ridge, and an eroded backshore that has lost much of its sand, exposing previous alluvial cobble stone deposits. This loss is attributed to sand mining of the area initiated during the 1970's, increasing anthropogenic disturbances and coastline alterations, and increased groundwater extraction causing land subsidence.

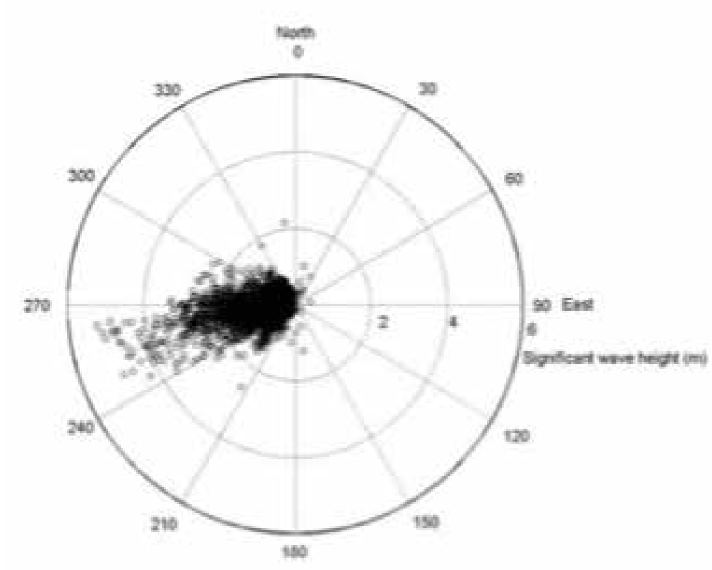


Fig. 4.38. Significant wave height (m) vs. mean wave direction (location of study: Beirut)
Source: Kabbara (2005)

1. ERODED FOREDUNE RIDGE AND BEACH FACE

2. ERODED BLUFF AND DISINTEGRATED ROCK ARMORING

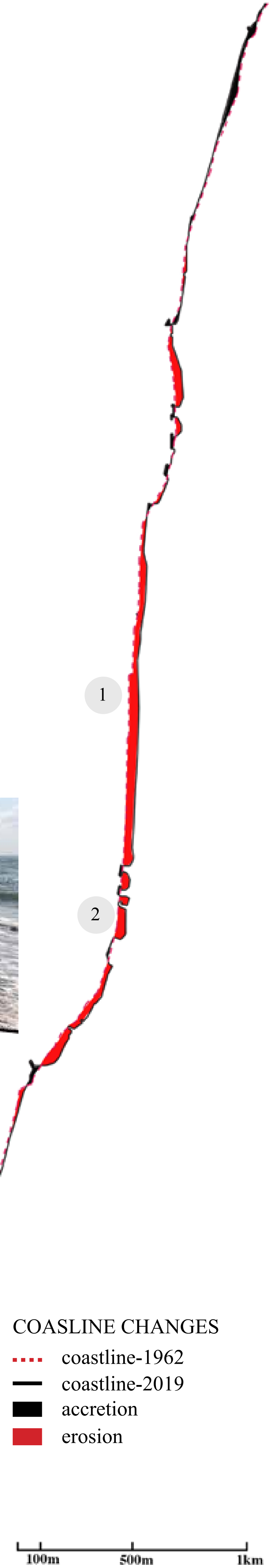
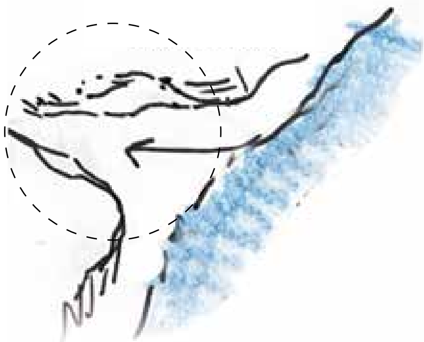


Fig. 4.39. Coastal erosion 1962-3019
Source: By author

Although the beach condition is highly dynamic, a sign of high interaction between the sea and the land, erosion is severe leading to blowouts and eroded foredunes (Fig. 4.40). This limits the potential of shore usage due to a diminishing shore area, and increases the probability that breakwaters will be built by resorts to protect existing and added sand to their shore area.

SUMMER CONDITION

BLOWOUT DUNE



ESCARPMENT /
ERODED FOREDUNE

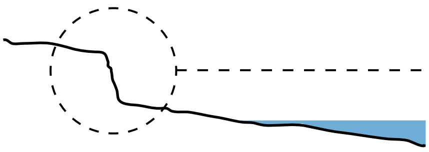


Fig. 4.40 Beach condition is highly dynamic with blowouts and eroded foredunes, leading to a loss of sandy shore area.
Source: By author

Due to extreme wave action in the winter months, most resorts in the study area use heavy machinery to push back sand to form a dune barrier that deters strong waves. Such a maintenance measure is low cost, however it damages the littoral ecosystem due to compaction of the sand berm and movement of sand inland (Fig. 4.41).

Fig. 4.41. Resorts create temporary dunes as a precautionary coastal defense mechanism against strong winter storm surges.

Source: By author

d. Coastal Infrastructure

Breakwaters are used in areas where waves crash at high intensities, namely North of the rocky shore and the mini-bay as shown in Fig. 4.42. Sea walls are the dominant type of breakwater used, and are either perpendicular to the coast, with added rock armor, or forming an L shape for increased protection of the sandy area. Type 4, the encroaching platform - which is reclaimed land - is constructed on private property rather than a resort, unlike other breakwaters which are mostly constructed adjacent to resorts.

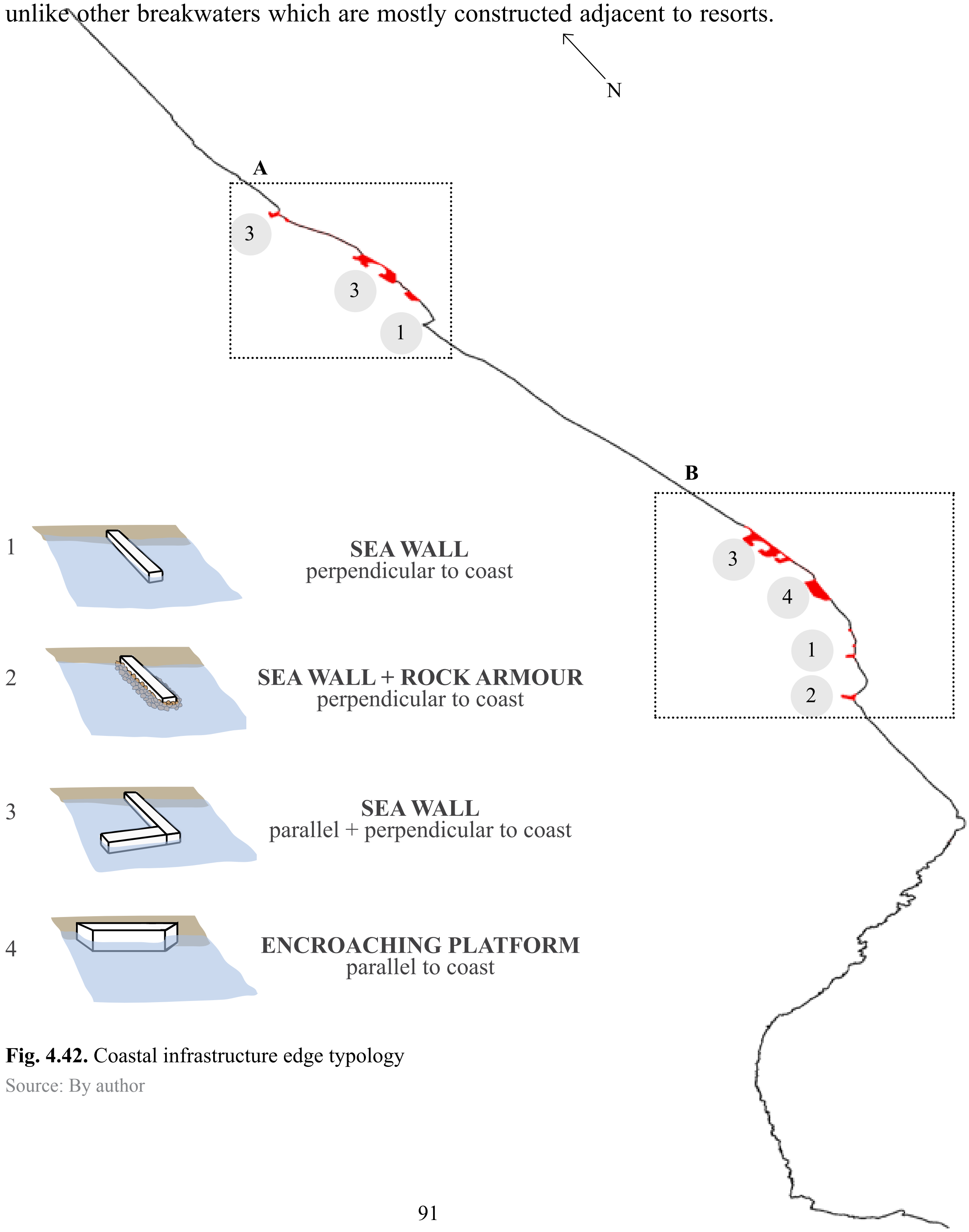


Fig. 4.42. Coastal infrastructure edge typology

Source: By author

e. Analysis of Landuse Transformation & Edge Relations

The areas adjacent to the shore have been experiencing the most landuse changes in the past decade. There is a noticeable trend of agricultural land abandonment in areas by the sea, as well as replacement of agriculture by greenhouses or resorts (Fig. 4.43). This is related to both the scarcity of water and the strong salt spray seaward, as well as the higher economic revenue owners yield from selling their lands vs. cultivating them.

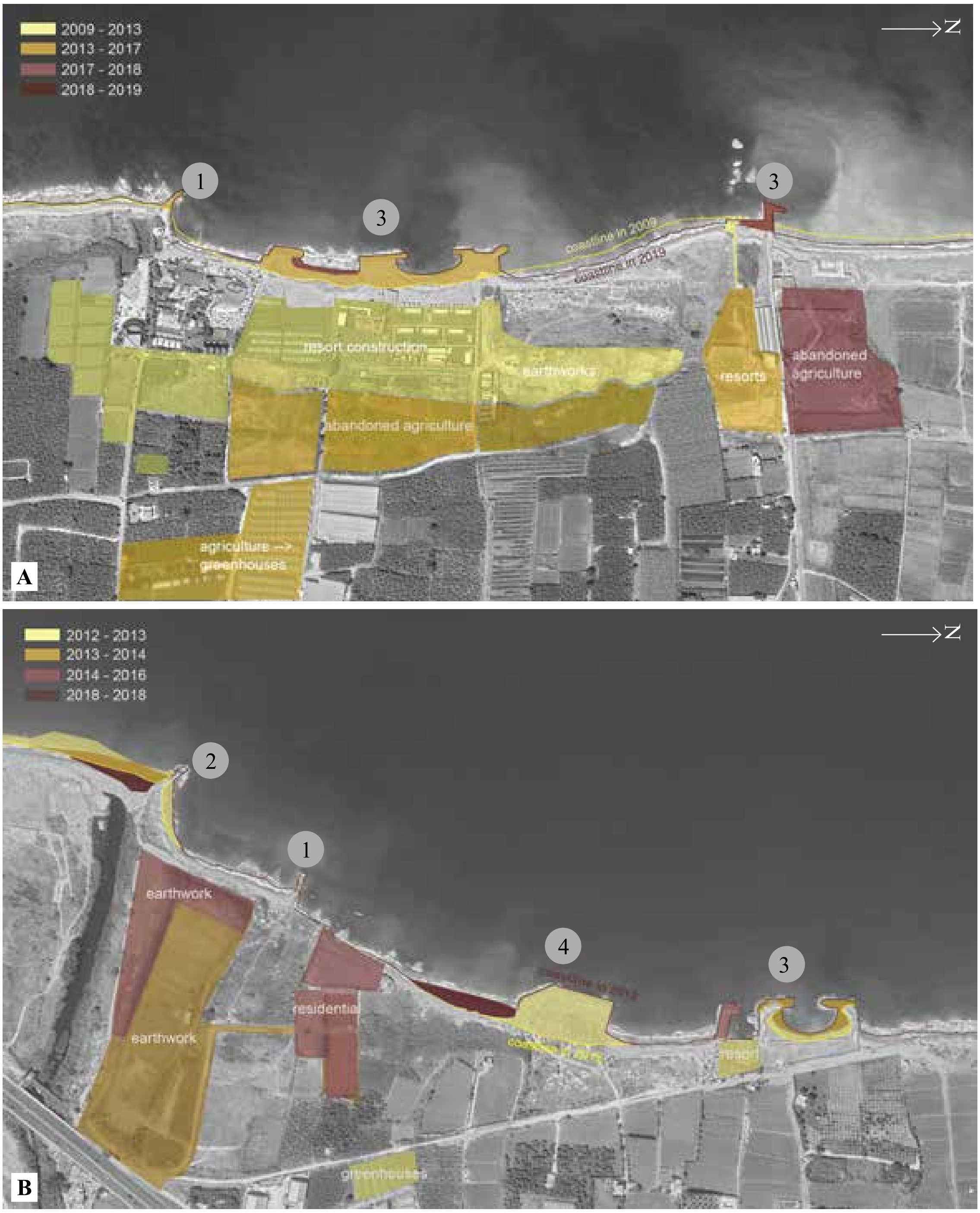


Fig. 4.43. Coastal landuse change and associated edge transformation
Source: By author, from Google Earth

Analysis of landuse transformation through time yields a repetitive trend, as shown in Fig. 4.44. Agricultural lands are retreating away from the sea, often as a result of acquisition of lands be developers, and due to the increased salt-water intrusion at the edge rendering these lands agriculturally non-productive. Beach resorts and private residential development are encroaching unto the shore, transforming soft edges into impermeable hard edges. often affecting sedimentation processes along the coast at a larger scale, and limit the movement of organisms and people along the coast.

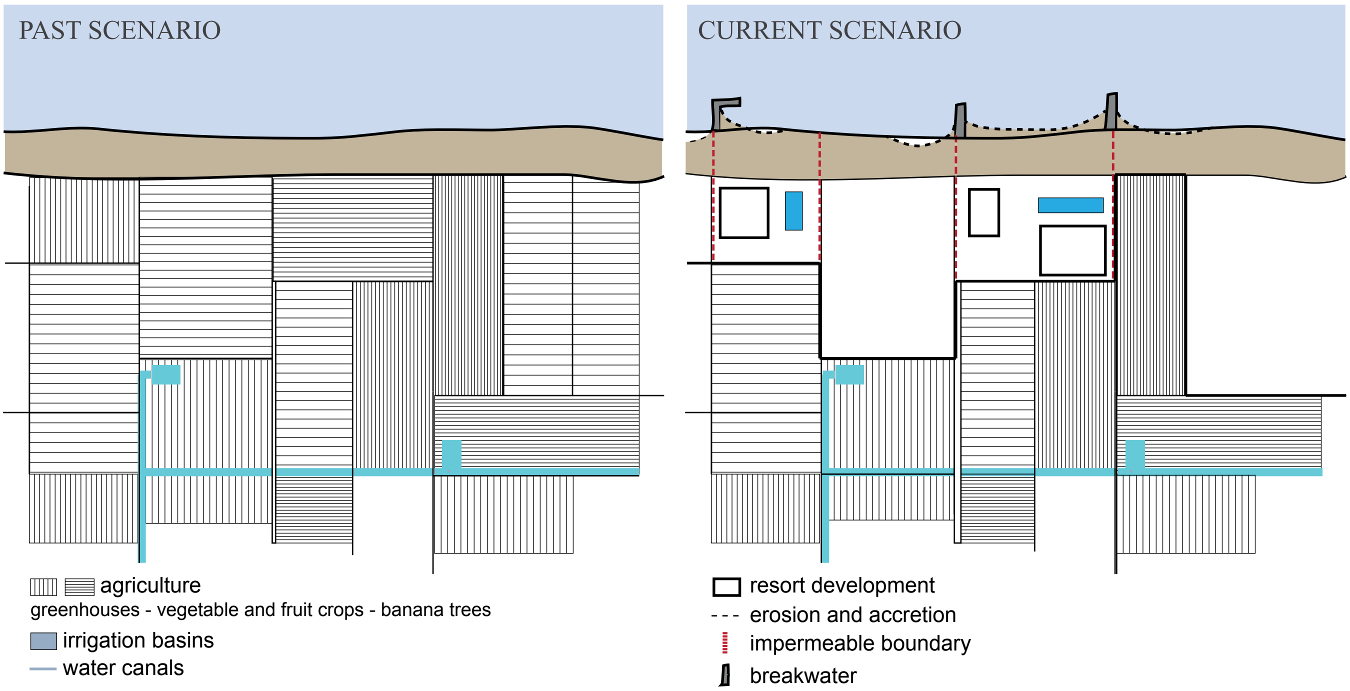


Fig. 4.44. Schematic comparison of past and current situation based on analysis.
Source: By author

E. Conclusion

Damour's landscape is unique and stands out with respect to its urbanized surroundings, and its character is strengthened by the presence of a vast agricultural plain leading to a sandy shore, giving it a natural quality. In some sense, Damour is the first town traveling Southwards from Beirut that reflects the character of the Southern Lebanese coast, of vast agricultural (mostly banana) fields and sandy coasts.

Analysis shows that Damour has been attracting more commercial and residential development to its shore and its coastal hills, while the agricultural plain has been shrinking from both seaward and landward directions. However, there is a noticeable disconnect between the plain and the town, and between the residents and their shore. The usage of the shore is limited by access, lack of managed public beach space, and privatization by resorts and residential development. It's also eroding leading to a loss of sandy shore, and threatening agricultural and residential & commercial areas inland.

The municipal masterplan designates complete privatization of the shore, and sprawl unto municipally owned coastal hills. While this model perhaps reaps direct economic revenue as public lands are leased or sold to investors, it threatens the limited resources of the area and its general character. It also disregards vulnerabilities to landscape threats and climatic changes, wherein coastal erosion, flooding, salt-water intrusion, water pollution, and desertification risks are highly pronounced along the plain. These implicate the agricultural community, where many farmers are settled within their fields, resorts built very close to the sea, and residential & commercial development concentrated near the highway but also at the shore. Moreover, resorts often require coastal defence structures to ensure safety of people and properties, and are usually hard-engineering structures including sea walls and rock armouring. Forest fire risk is very likely to occur along the coastal hills of Damour and Mechref, and flooding is likely to occur in Damour's town.

CHAPTER V
DESIGN INTERVENTION | RETREAT TO ADVANCE

retreat
/rɪˈtriːt/

noun

1. an act of moving back or withdrawing.

2. a quiet or secluded place in which one can rest and relax.

advance
/ədˈvɑːns/

verb

1. move forwards in a purposeful way.

2. make or cause to make progress.

Fig. 5.1. Current and expected scenario based on analysis
Source: By author

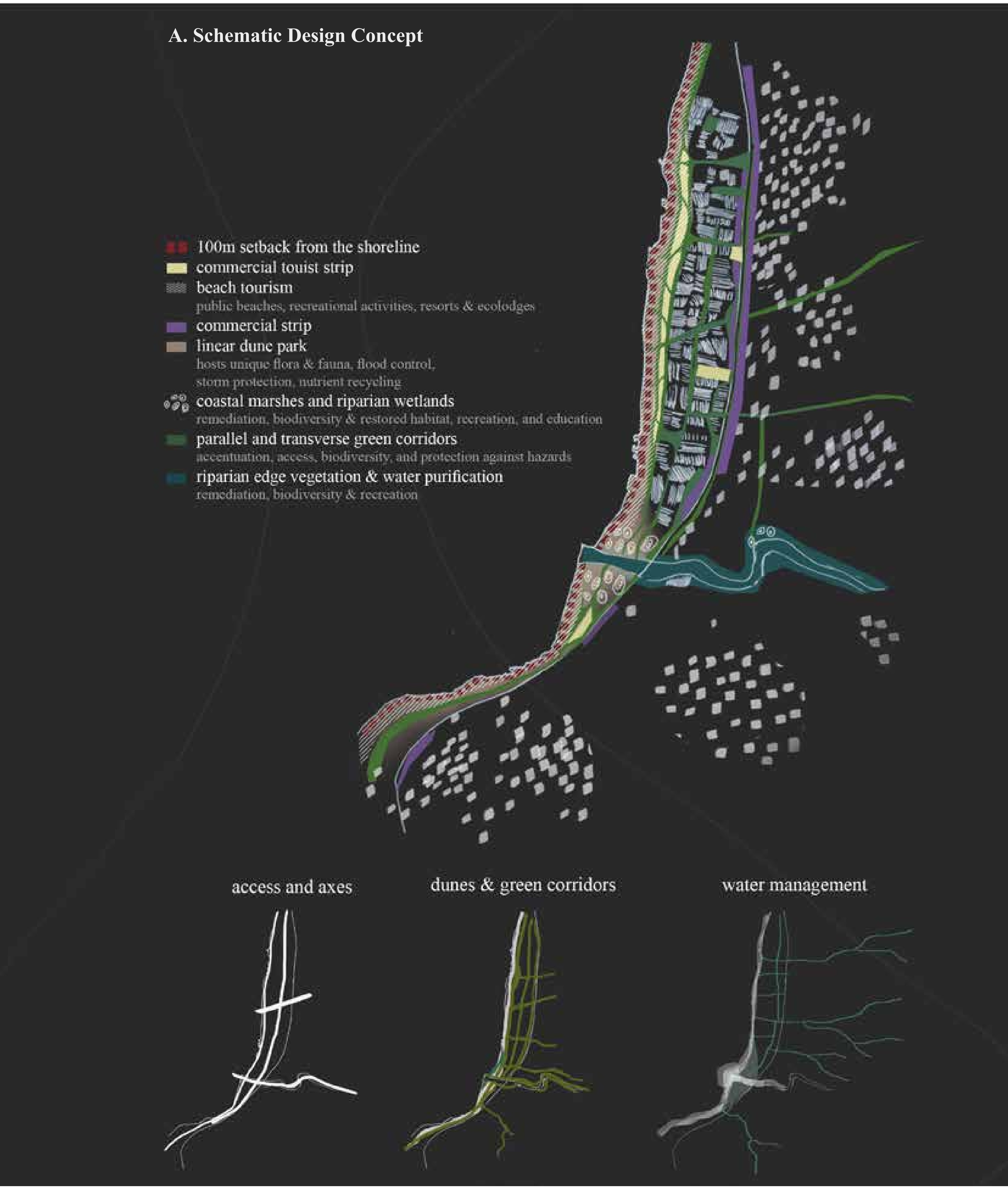


Fig. 5.2. Schematic Design Concept
Source: By author

B. Design Masterplan

Fig. 5.3. Design Masterplan
Source: By author

The design intervention aims to preserve the identity of Damour and enhance its character, through establishing a resilient and adaptive landscape that can respond to risks, but also capitalize on their potential to gear development in a more sustainable direction. Fundamental to this intervention is the ideology of ‘giving more space’ to the climate, to the shore, to water, or to an ‘edge condition’, following the popular Dutch approach of giving ‘more room for the river’ (Vries & Wolsink, 2018). This is made possible as Damour is somewhat underdeveloped at this stage, with more landuse flexibility than in settings like dense cities.

The intervention is conceived through phases to establish an accessible, dynamic border between the sea and the land, create a connected network of green spaces through which water is made visible, which sets the framework that spatially defines future development and economic avenues for growth. Starting with the shore, the most dynamic edge, a reformulation of the relationship between land and sea is imagined. Instead of using hard engineering structures to establish the necessary level of safety that is usually a precursor to development, or to ‘control’ the sea, the land is imagined to mimic the sea. In much the same way the sea retreats and advances, or pushes and pulls, the land will do the same. Here, landuse retreats inland, and beach nourishment advances the shore seaward. As the sea rises, dunes are imagined to increase in height, responding to sea level rise over time. This edge landscape expands in space, changes in time, and works with coastal processes not against them. By giving more space, the shore becomes a space of leisure, serving as a ‘retreat’. Most importantly, the shore is a shared, public space, accessible to all.

Water management compliments shore management, and works through establishing a network of green spaces. Floodable landscapes along the river act as sponges that absorb and recharge groundwater, protect the plain from flooding, and serve ecological functions. Agriculture along the river is replaced with floodplains and wetlands to reduce the direct pollution of river water especially near its mouth, and restaurants are setback 20m. The historic coastal marsh landscape is re-introduced, serving a large role between accumulating sediment and letting it go, forming a symbiotic relationship with the dune landscape. Water becomes an emphasized, visible element in the landscape, sometimes leading users to the sea while at other times serving as spaces of leisure and gathering.

More conscious development include strategies that accommodate to and retreat from changes, based on different vulnerabilities assessed. The intervention accepts that a trend of landward agricultural retreat is occurring, and sees potential in retreating resorts too. Setback 100m from the coastline, resort design abides by design guidelines, such as climate-responsive, energy saving design, and lightweight materials. Raising resorts on piles and creating a multi-level experience increases resilience of these spaces and allows for new experiences, secluded and surrounded by green spaces. Existing and introduced site attractions will connect with the shore and the river, creating continuity and enhancing the potential of the plain to become a park of a multitude of experiences.

The proposal is conceived through phases, sectioned into 5 year intervals, in which different adaptation strategies are selected based on their complementarity. The title of the intervention 'Retreat to Advance' does not denote a linear relationship as the title suggests but a cyclical one. Retreat is understood in both its meanings, to move back or withdraw, as well as to find an escape in a remote landscape by the sea. This makes advancing possible, both by moving seaward, and by making progress, ecologically, socially, and economically.

C. Strategic Intervention

The three main pillars of the intervention are:

1. A dynamic edge | Shore management and accessibility

2. Ecological connectivity | Water management, and green spaces

3. Conscious development | Protection of people, assets, and landscapes

The intervention considers the mutual benefits arising from each pillar and the interrelations between the multiple management measures, programs & objectives. For example, establishing a dynamic border between the sea and land not ony helps it adapt to rising sea levels and increases the protection of people and assets, but also reformulates the usage of this liminal landscape by people. Water management is interlinked with green spaces, but also sustains shore management strategies through floodable landscapes, groundwater recharge, and marshes, which act as sediment sinks and sources. Green spaces not only serve as an aesthetic element, but complement water channeling, storage, and purification. Agriculture and commercial development benefit from these systems, where native green corridors increase biodiversity and aid in purifying water, possibly enhancing yields. Shore protection acts as a sort of foundation over which other programs are imagined, as many are compromised by coastal erosion or extreme overwash which are probable events as climate change is causing more intense and severe storms. The strategies are outlined in more detail in this chapter.

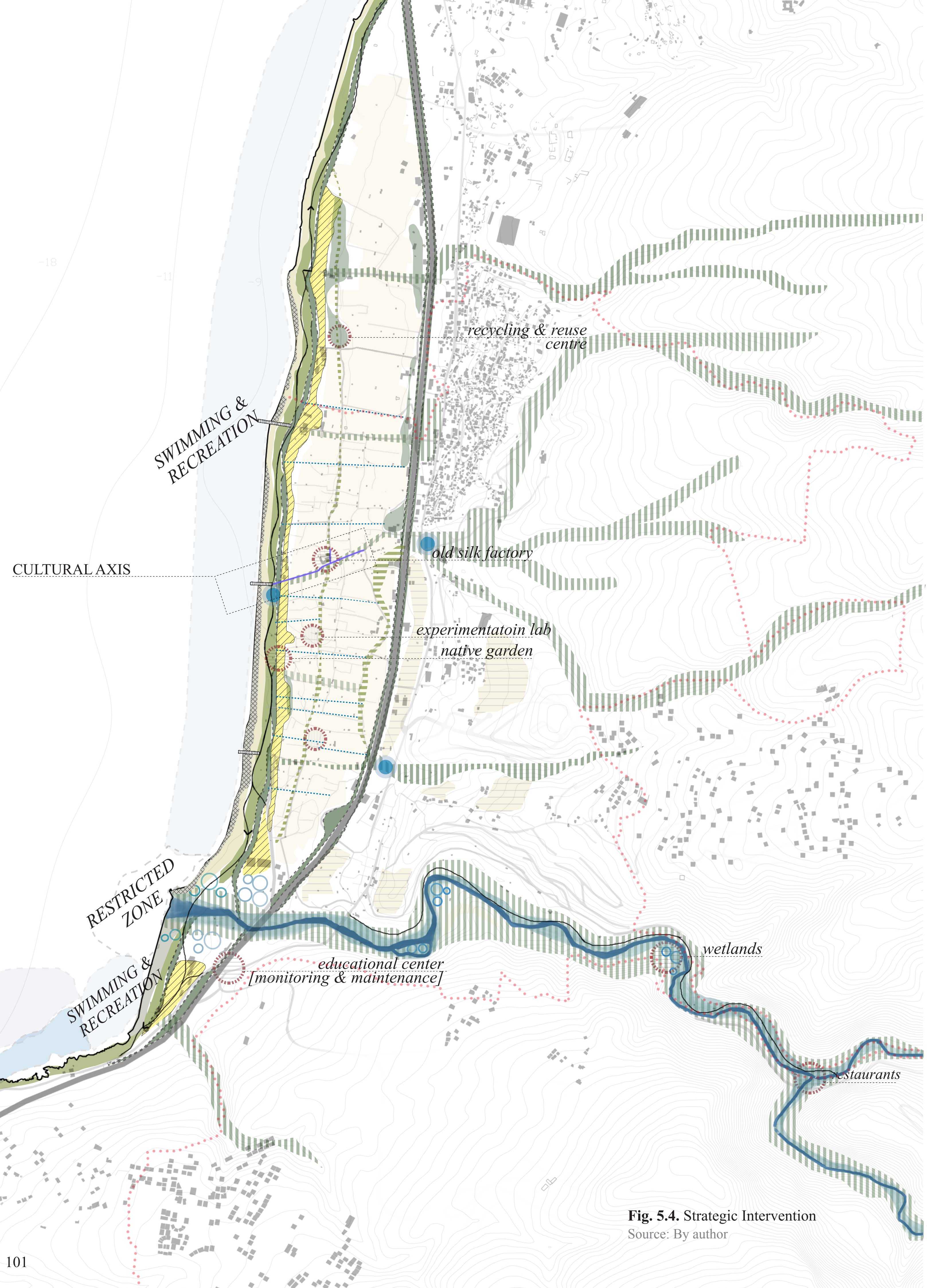


Fig. 5.4. Strategic Intervention
Source: By author

1. A Dynamic Edge | Shore Management & Accessibility

OBJECTIVES

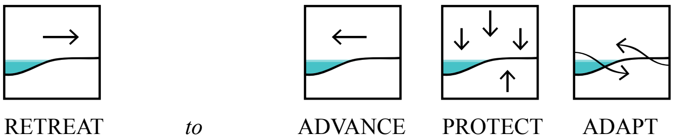
Erosion and flood management

Protection of people and properties

Physically and economically accessible

Aesthetic and novel landscape

MANAGEMENT SCENARIO



SELECTED STRATEGIES

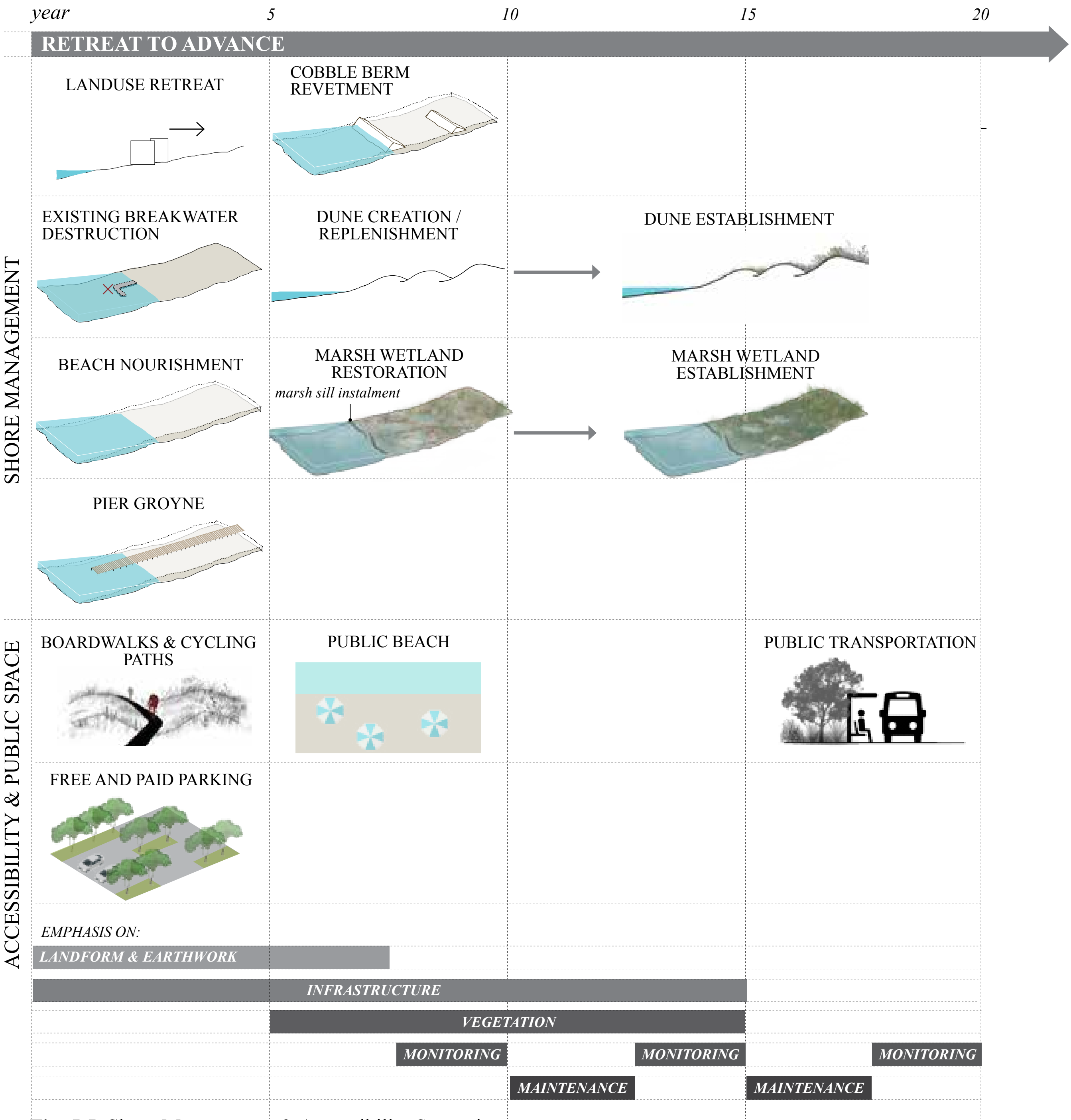


Fig. 5.5. Shore Management & Accessibility Strategies

Source: By author

The selected strategies for shore management in the first 5 year phase of the intervention include a concentration of infrastructural works, through the setback of resorts 100m from the sea, the removal of existing breakwaters, laying out site circulation through boardwalks and piers, and advancing the shore seaward through beach nourishment.

After the foundations are laid out, dune replenishment and creation will begin at year 5 and continue until establishment, which will take an average of 10-15 years. Marsh wetland restoration also begins at year 5, however site grading will have to occur at year 4 to reuse excavated sand for beach nourishment purposes which end at year 5. Marsh sills are installed using the rubble from breakwater removal, and vegetation of the coastal wetland begins. Selected strategies are expanded upon more thoroughly in this section.

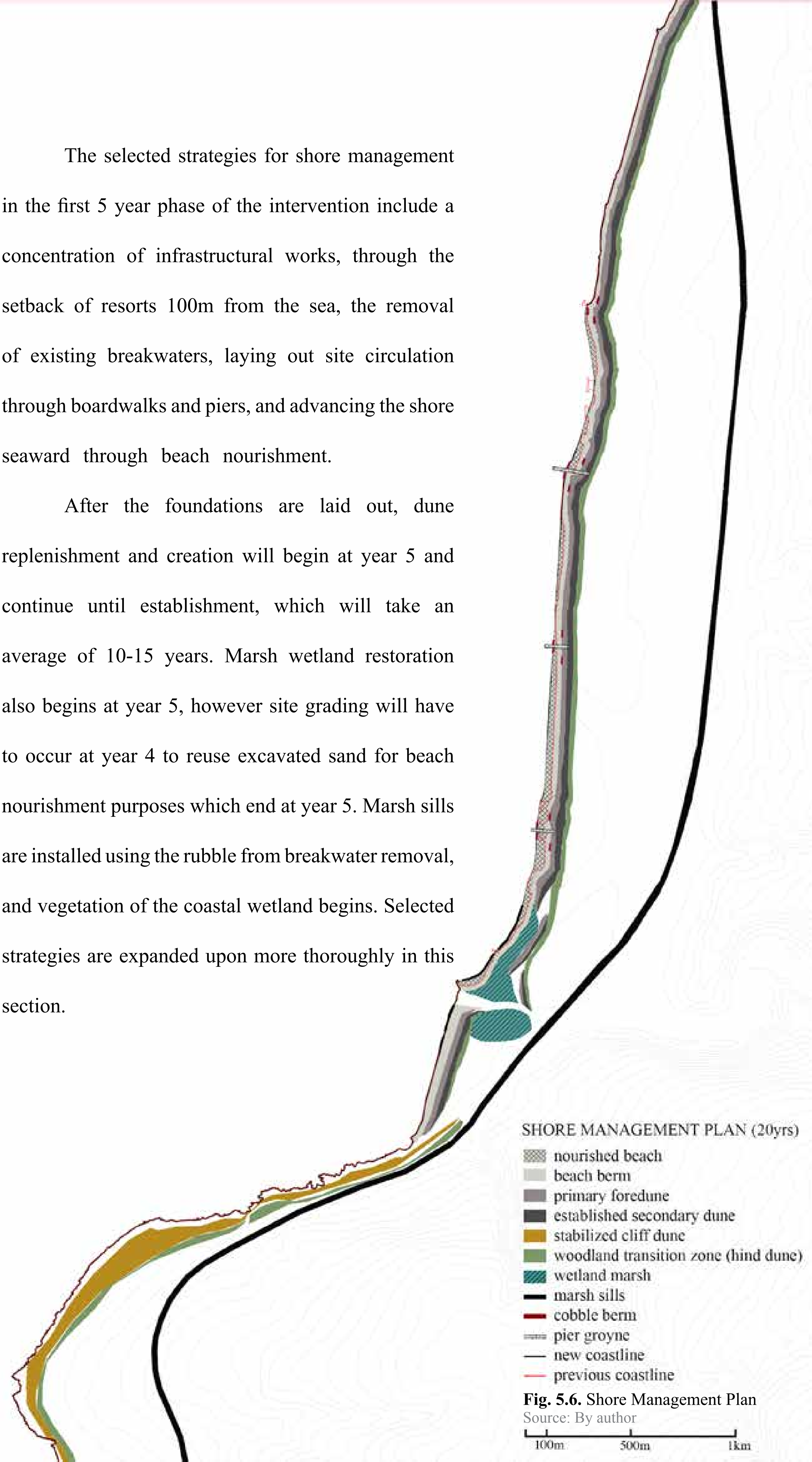
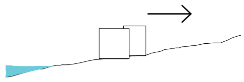


Fig. 5.6. Shore Management Plan
Source: By author

a. Shore Management Strategies

i. Landuse Retreat



The most guaranteed form of coastal protection is retreating away from the coastline. While in urban areas this option may not prove feasible or even possible, in more rural settings such as Damour it's most advisable as it guarantees the protection of coastal assets, properties, and people. Historic site analysis shows the gradual retreat of agriculture away from the coastline, and the encroachment of resorts towards the coastline. Such a trend accelerates negative impacts on the coast, through diminishing the sandy shore area due to erosion, depleting water resources through unregulated water extraction and usage, and altering ecosystem dynamics.

Unregulated touristification can lead to the complete privatization of the sandy shore, which is by law within the public domain (see Appendix V). Therefore, a retreat of 100m away from the existing coastline is proposed abiding by Article 8 of the Madrid protocol. In this model, resorts will be built on the actual parcels acquired, rather than on adjacent shore areas, abiding by a 100m offset from the shore (Fig. 5.7). Shore area is then a shared space between resort users and the public, and resort developers will be responsible for management of the shoreline through Public Private Partnerships.

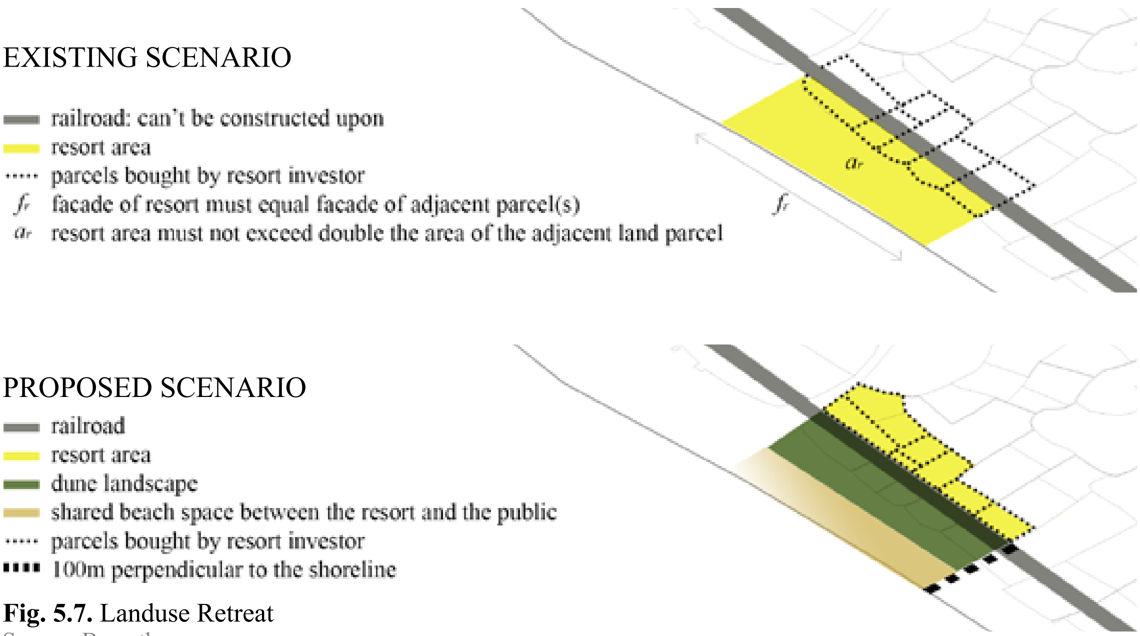
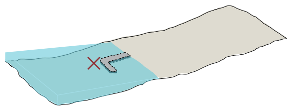


Fig. 5.7. Landuse Retreat
Source: By author

The relocation of resorts shouldn't require more than 2-5 years for completion. Owners will not be compensated for any losses endured, as any structure currently occupying the shore should technically be temporary. Moreover, resorts must abide by updated guidelines for permitted construction materials, use of vegetation, transitional zones, which is outlined in more detail in the zoning regulations section.

ii. Impermeable Breakwater Removal



Impermeable breakwaters have been constructed as an extension of resorts and private development on the shore to limit beach loss and create safe zones for swimming. While impacts such as sediment trapping may be positive for a small area of the beach (such as areas occupied by resorts), impermeable breakwaters limit sediment flows and effect coastal processes such as accelerating erosion downdrift due to sediment starvation beaches. After breakwater removal, resultant rubble will be used to create marsh sills (Fig.5.8), as the material has been weathered over time and can serve as a partially submerged coastal defence structure.

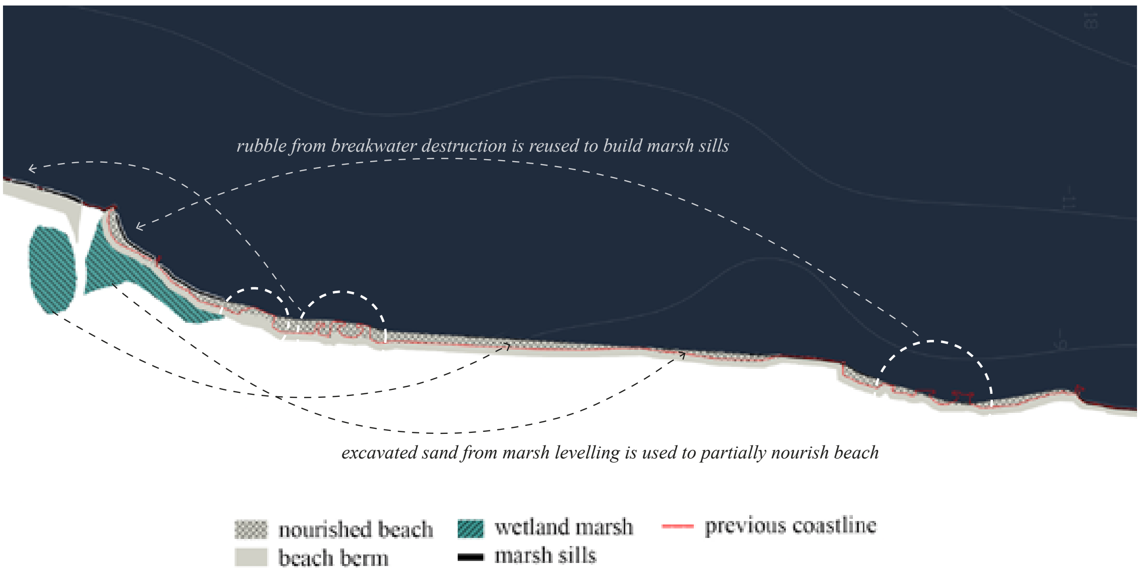
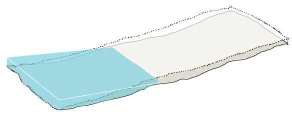


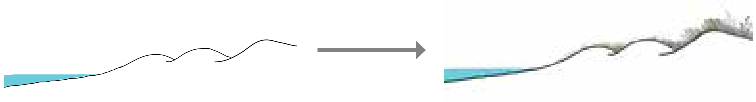
Fig. 5.8. Reuse of breakwater rubble for marsh sills, and excavated marsh sand for beach nourishment.
Source: By author

iii. Beach Nourishment



Nourishment is a strategy that complements dune building, as it makes sand available for transport and deposition. Compared with “hard” coastal engineering approaches, beach nourishment proves both cost-effective and has less negative environmental impacts on beach ecosystems (Odonnell, 2017). Beach nourishment will occur simultaneously with the relocation of existing resorts. It will start at year 3 of the proposed plan, and will take around 2 years of work. The total nourished area requires approximately 65,000 m^3 of sand (area x 1m depth). This sand must be similar in nature and quality to the sand of Damour’s beach. A possible source of this sand can be obtained from Damour’s estuary, which will be levelled to allow for marshlands (Fig. 5.8). Some of the nourished beach will be lost to the formation of long-shore bars in the offshore and near-shore, especially during severe winter storms. While this may reduce dune heights, it should be noted that offshore sand bars work as primary coastal defence structures by obstructing high incoming waves.

iv. Dune Landscape



The historic dune landscape that existed has become a flat plain with a severely eroded foredune ridge and beach face, serving as the only coastal defense measure against high storm surges in under developed sections of the coast. Therefore, dunes will serve as the main shore protection strategy along Damour’s coast, due to their capacity to absorb wind and wave energy and adjust to tidal action. Combined with beach nourishment, coastal sand dunes can prove to be the most cost-effective shore protection strategy that allows for recreational beach use (Schwartz, 2005).

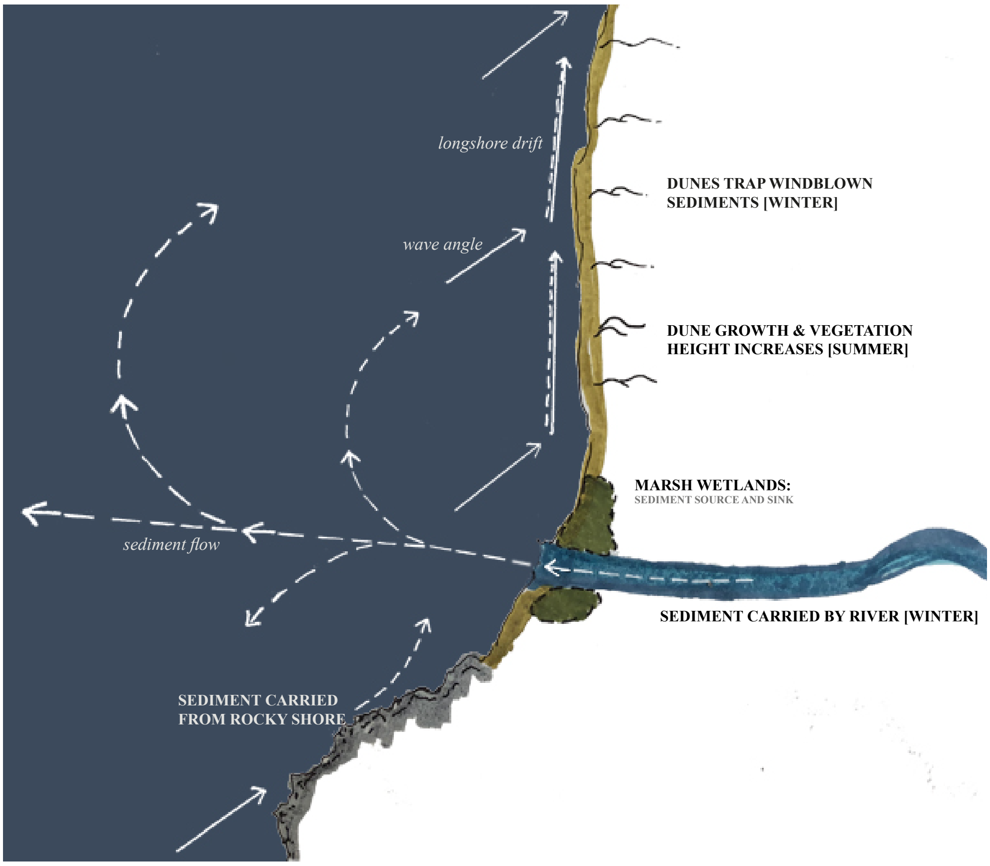


Fig. 5.9. Coastal processes and relations between proposed dune landscape and marsh wetlands.
Source: By author

Figure 5.9 shows the cycle of flows and the driving forces that will supplement the natural evolution of the dune landscape. Following beach nourishment of the shore, dune growth will be fed by cycles of sediment transported during the wet season through long-shore drift. Marsh wetlands along the river's estuary act as sediment sinks and sources, slowly releasing sediments and nutrients on the coast. Rocky outcrops supply calcareous sediment which is vital to composition of sand dunes. During periods of growth, sand dunes function as obstacles that trap sediment through aeolian forces. Consequentially, during storm surges, dunes act as coastal defence structures, and in the process lose sand that is transported to offshore bars. This cycle is not linear and depends on many factors, such as beach configuration, sediment budget, aeolian forces, morphology of dune systems, presence and type of vegetation, and anthropogenic disturbances to name a few.

There are two possible scenarios for dune building; the first where dunes will be replenished and expanded where they already exist; and the second where artificial dunes will be created where they have been destroyed by coastal development (figures 5.10 and 5.11).

• Scenario 1: Replenishment of Eroded Foredune

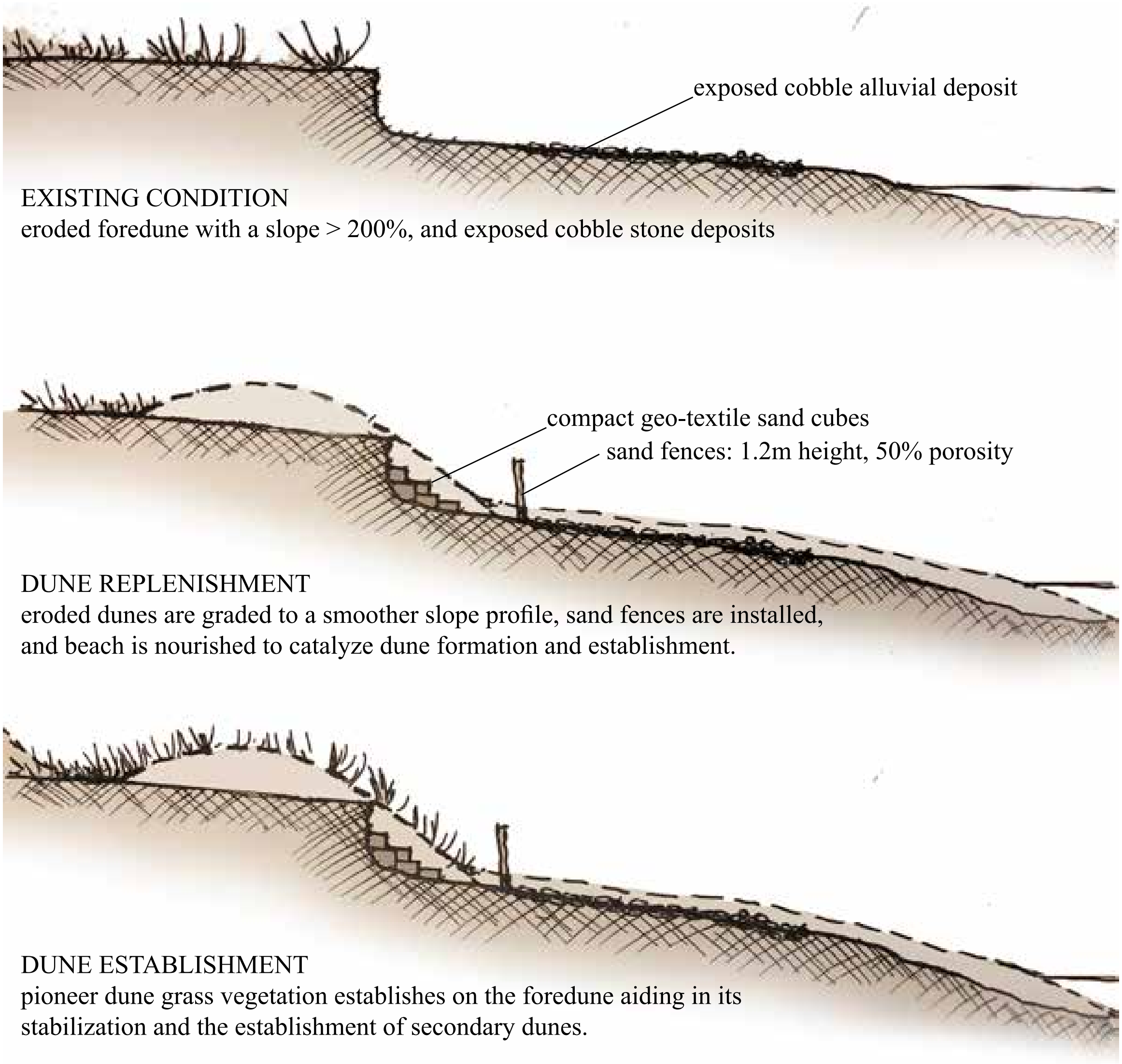
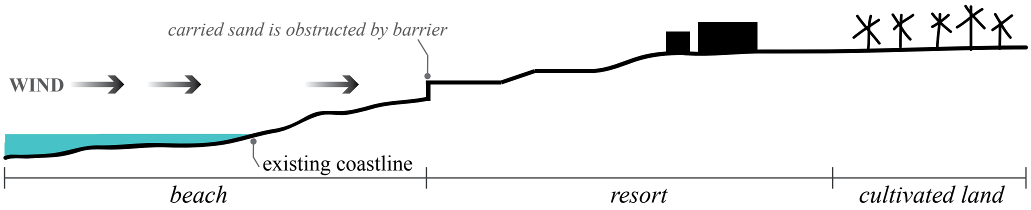


Fig. 5.10. Replenishment of Eroded Foredune
Source: By author

• Scenario 2: Landuse Retreat & Artificial Dune Creation

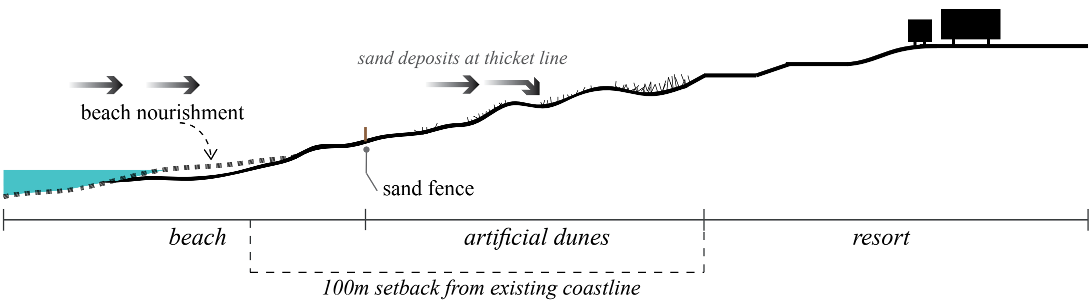
CURRENT SITUATION

Beach is limited by resort construction and is off-limits to the public. Coastal erosion is severe leading to a loss of sandy shore area.



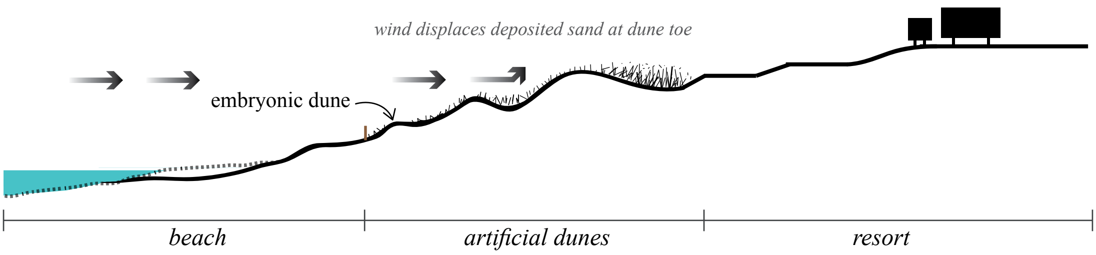
5 YEAR PLAN

A model of managed retreat is proposed whereby resorts are setback 100m from the existing coastline. Aritifical dunes are created after beach is nourished, with pioneer vegetation planted at the secondary dune and dune grasses at the foredune.



10 YEAR PLAN

Dunes prograde seaward as embryonic dunes due to dune grasses and sand fences trapping windblown sand. Nourished beach equilibrates as a result of wind and wave action and is further compacted due to trampling.



15 YEAR PLAN

Secondary dune stabilizes and the primary dune formation accelerates as mesic communities spread seaward. Shrubs and woodland species replace dune grasses behind the secondary dune.

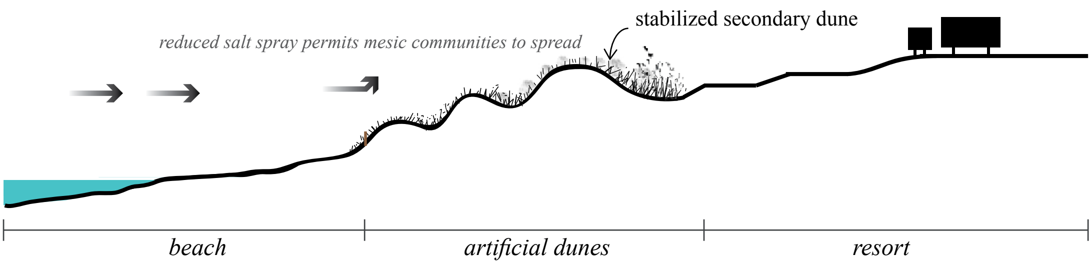


Fig. 5.11. Landuse retreat and artificial dune creation.

Source: By author

• Dune Building Methods | Sand Fences & Boardwalks

Dune building will begin at year 5, following the main infrastructural works of beach nourishment, board-walk, and sand fence instalment. This ensures that site users will not trample dunes early on in the project, which is a main threat to the success of the proposed dune landscape.

Sand fences and board-walks will also act as obstacles that will aid in sand trapping and stimulate dune growth. The layout of obstacles affects the morphology and configuration of dunes. Here, serpentine pathways increase topographic variability, and enhance edge porosity, potentially creating a more dynamic, aesthetic, and biodiverse edge landscape.

Sand fences should have a porosity of 50%, with a height of 1.2m and thickness of 5cm. Boardwalks are elevated approximately one meter above the ground and slope downwards as they reach the beach berm.

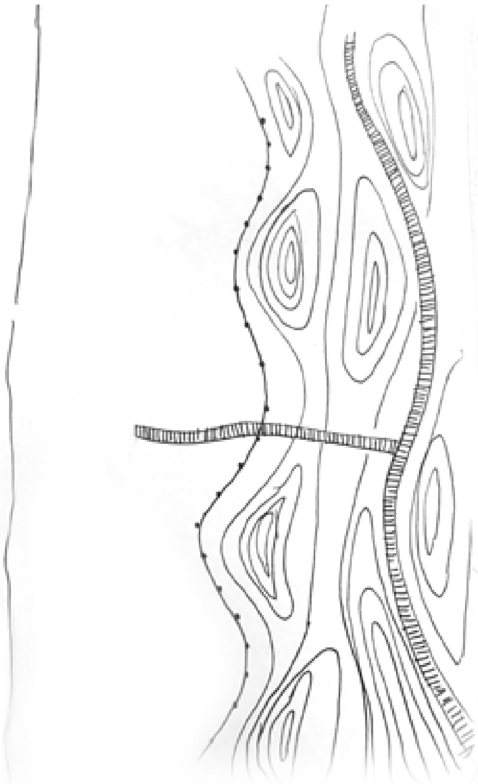


Fig. 5.12. Plan view showing sand fences, board-walks, and their influence on dune morphology.
Source: By author

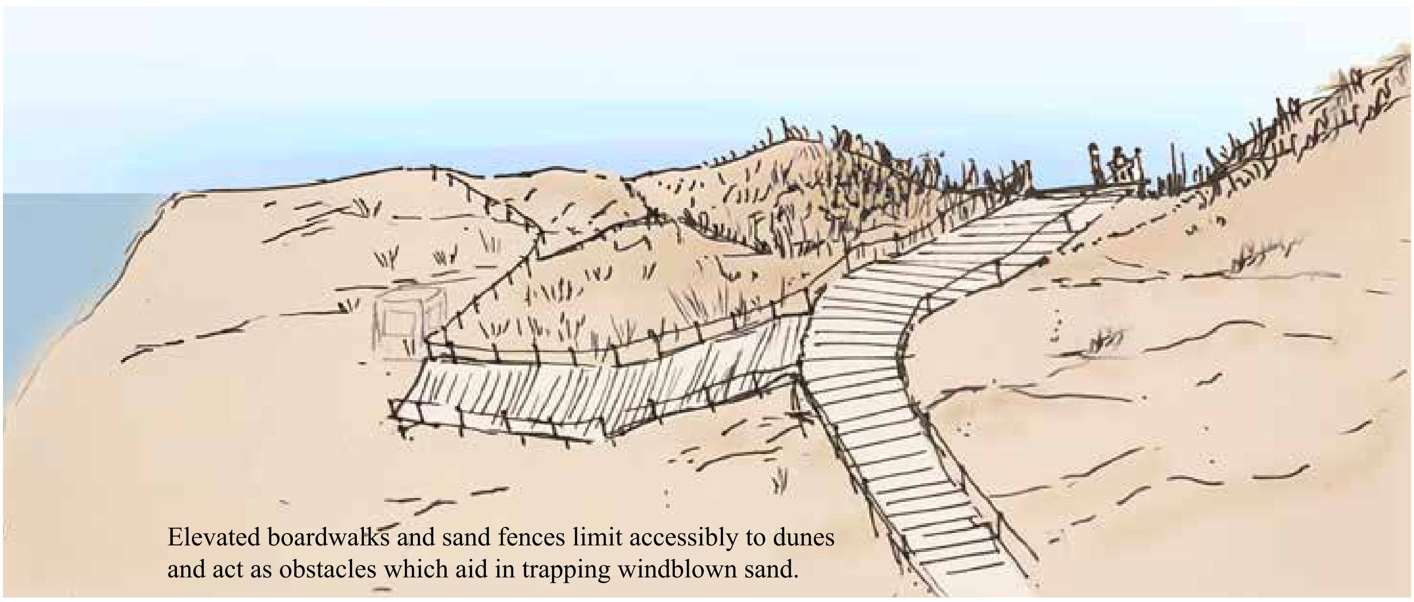
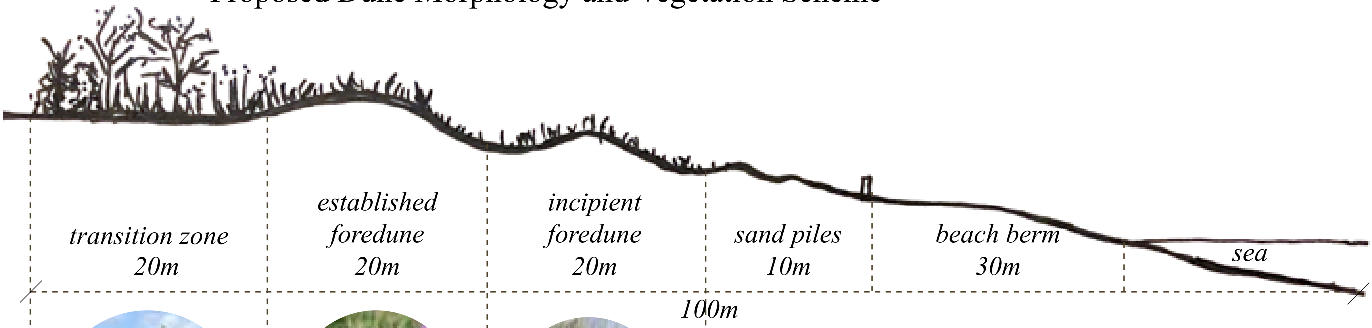


Fig. 5.13. Dune landscape and accessibility.
Source: By author

• Proposed Dune Morphology and Vegetation Scheme

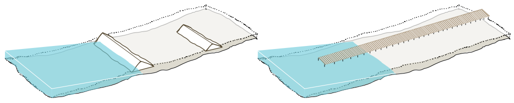


The littoral edge is divided into three main zones: the transition zone, the dune zone, and the beach zone. The transition zone (20m) creates a buffer between agricultural/touristic land and the sensitive dune system. Native plants are chosen to establish continuity between plants found along the coastal hills towards the shore.

The dune zone includes the incipient(20m) and established foredunes (20m). The incipient foredune is planted with sand building foundation species - mostly grasses. The established foredune is planted with both sand binding and sand burying plants. This enhances dune growth potential. The remaining 10m are allocated to sand piles placed seaward of the foredunes, which will stimulate embryo dune development resulting in an organic progradation of the dune ecosystem to encompass the entire 50m stretch. Plant selection is guided by existing species on site, Hegazy & Doust (2016), Sabra et al. (2017), and Valderrábano & Gil (2018).

Fig. 5.14. Dune landscape and accessibility.
Source: By author

v. Berm Revetments & Permeable Pier Groynes



Cobble berms are devised to limit erosion of the beach face, and are situated parallel to the shoreline. They are specifically designed to deter strong wave action that will result from piers, which are permeable groynes perpendicular to the shore (Fig. 5.15). Permeable peir groynes deter strong wave action, limit long shore drift aiding in the trapping of sediments, and contribute to dune building processes. Piers are also recreational and add an aesthetic component to the landscape unlike other hard engineering coastal structures.

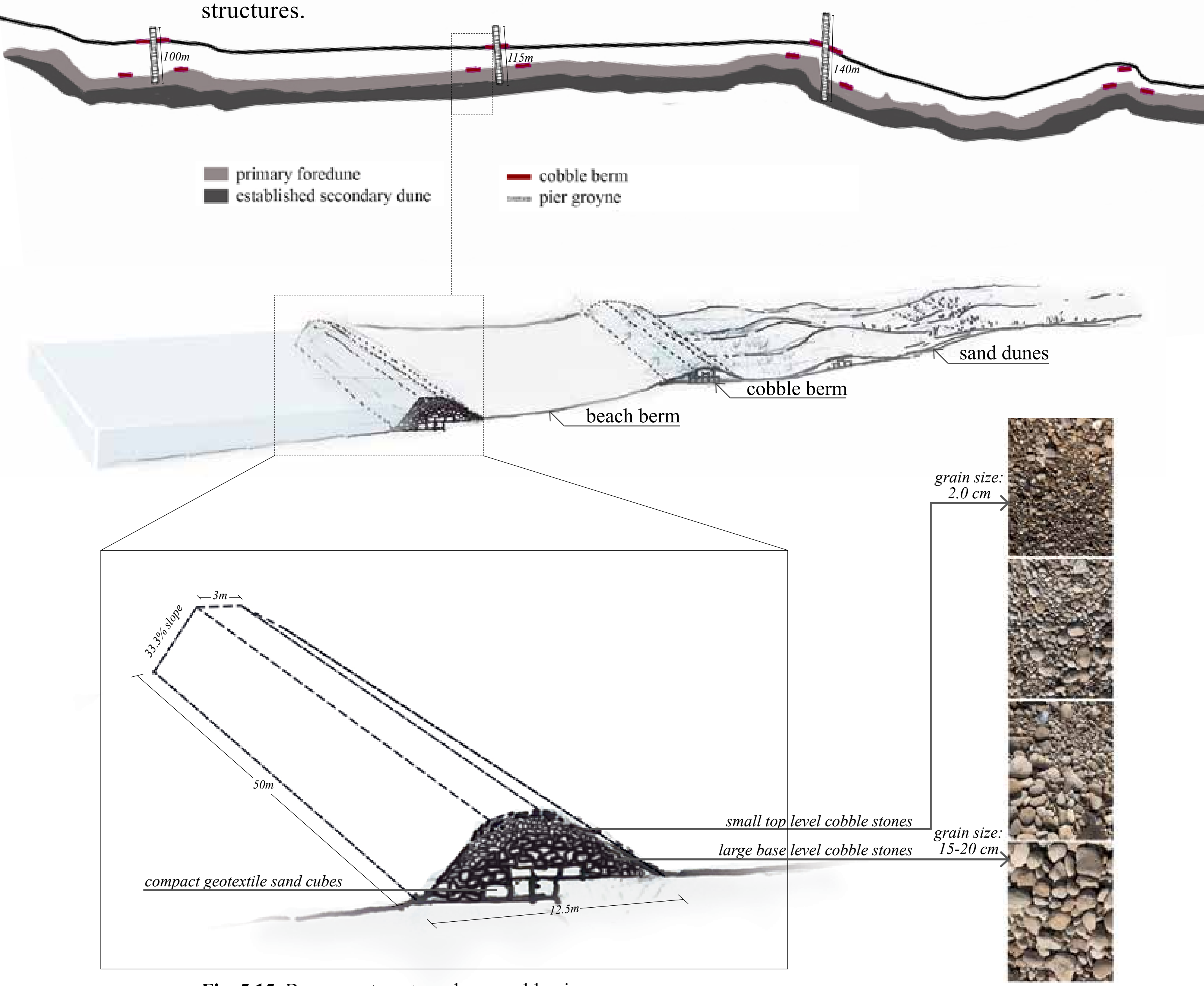


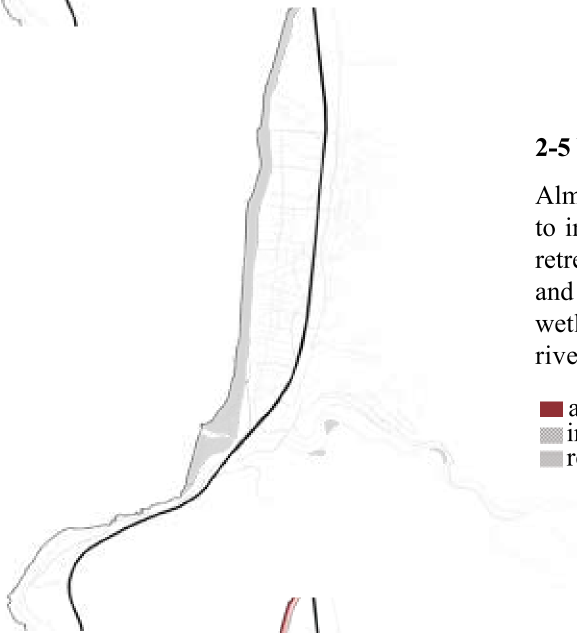
Fig. 5.15. Berm revetments and permeable pier groynes
Source: By author

b. Accessibility and Circulation

1-2 YEARS | ACCESSIBLE

The shoreline is accessible to users during this time as private development and resorts retreat backwards. Accesibility to the shore remains a challenge as there is no infrastructural networks leading to the shore yet.

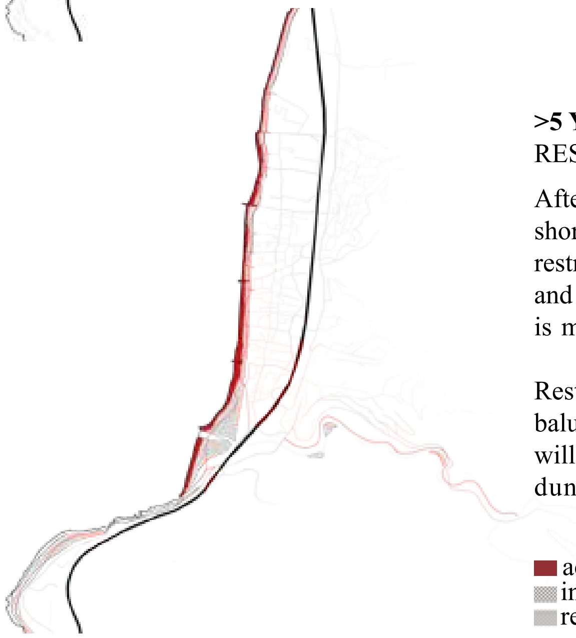
accessible
inaccessible
restricted



2-5 YEARS | INACCESSIBLE

Almost all the shore is inaccessible due to infrastructural works such as landuse retreat, beach nourishment, boardwalk and pier building, followed by dune and wetland creation along the shore and river.

accessible
inaccessible
restricted



>5 YEARS | ACCESSIBLE AND RESTRICTED

After a period of 5 years, access to the shore becomes possible. It's however restricted and will remain so, to protect and enhance the dune ecosystem which is most often stressed due to trampling.

Restrictions are enforced with boardwalk balustrades and sand fences which will limit people's movement in the dunescape.

accessible
inaccessible
restricted

Fig. 5.16. Accessibiliy to the shore.
Source: By author

Two main pedestrian circulation arteries are designed: the boardwalk which links the shore in the North-South direction and makes the riparian river edge accessible, and the pedestrianized paved road which constitutes the cultural axis. Together, these are imagined to activate the site, and attract people through activities such as strolling alongside the sea and biking throughout the site. Markets and other events could be held along the cultural axis in congruence with the historic silk factory.

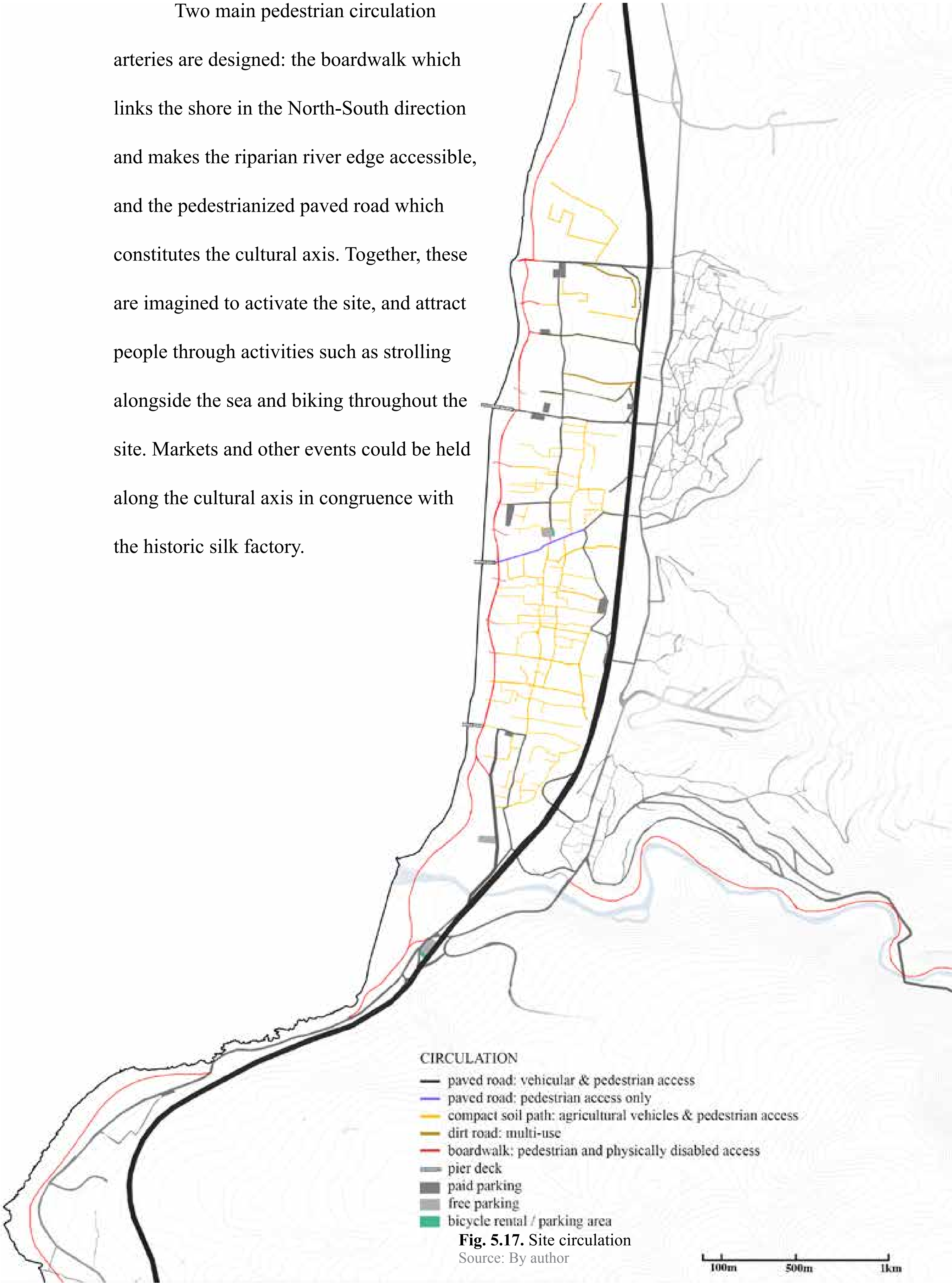


Fig. 5.17. Site circulation
Source: By author

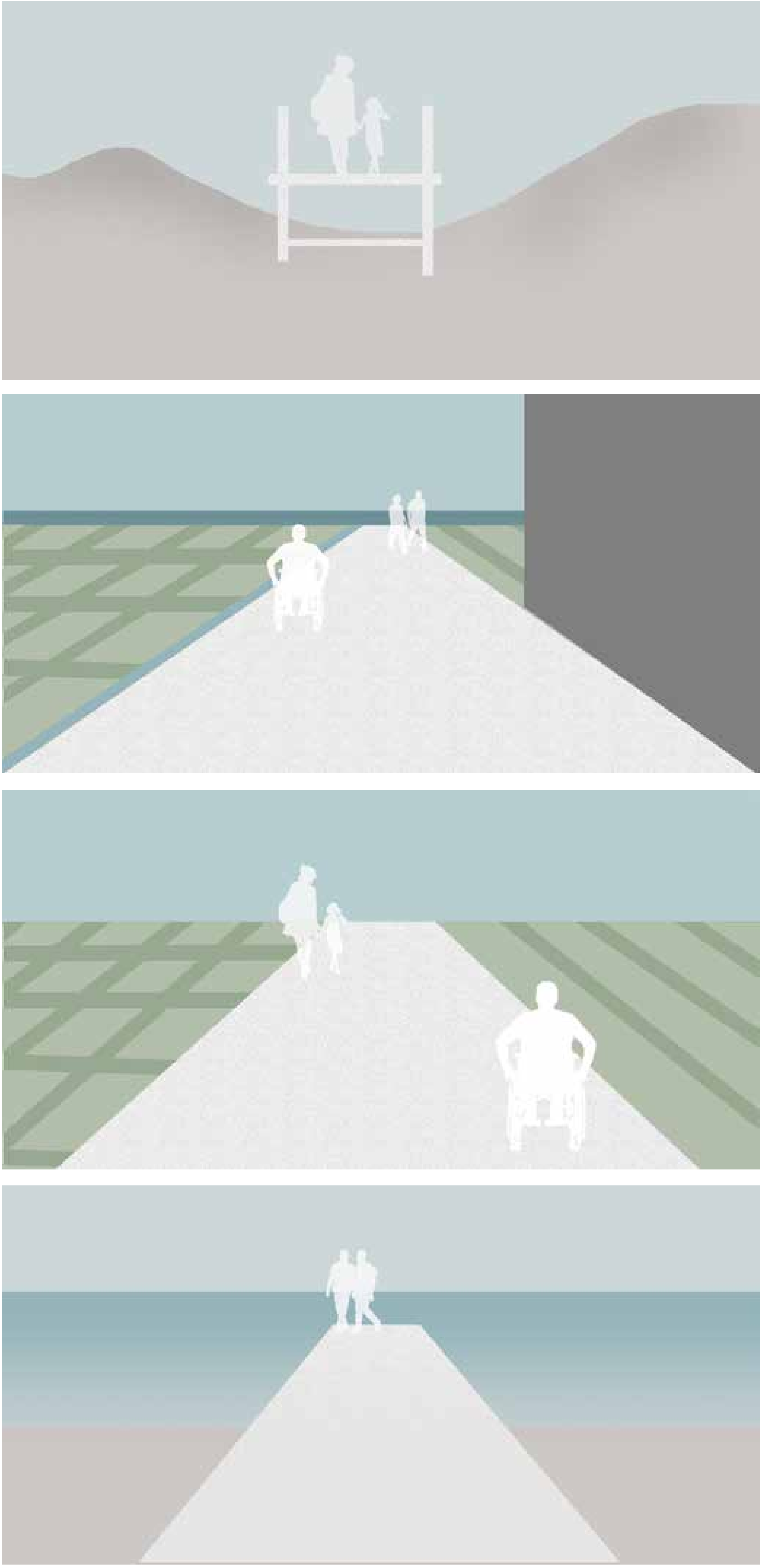


Fig. 5.18. Experiences along circulation infrastructure
Source: By author

2. Ecological Connectivity | Water Management & Green Spaces

OBJECTIVES

Establish continuity between elements | *Enhance water quality*

Biodiversity and habitat | *Flood management*

SELECTED STRATEGIES

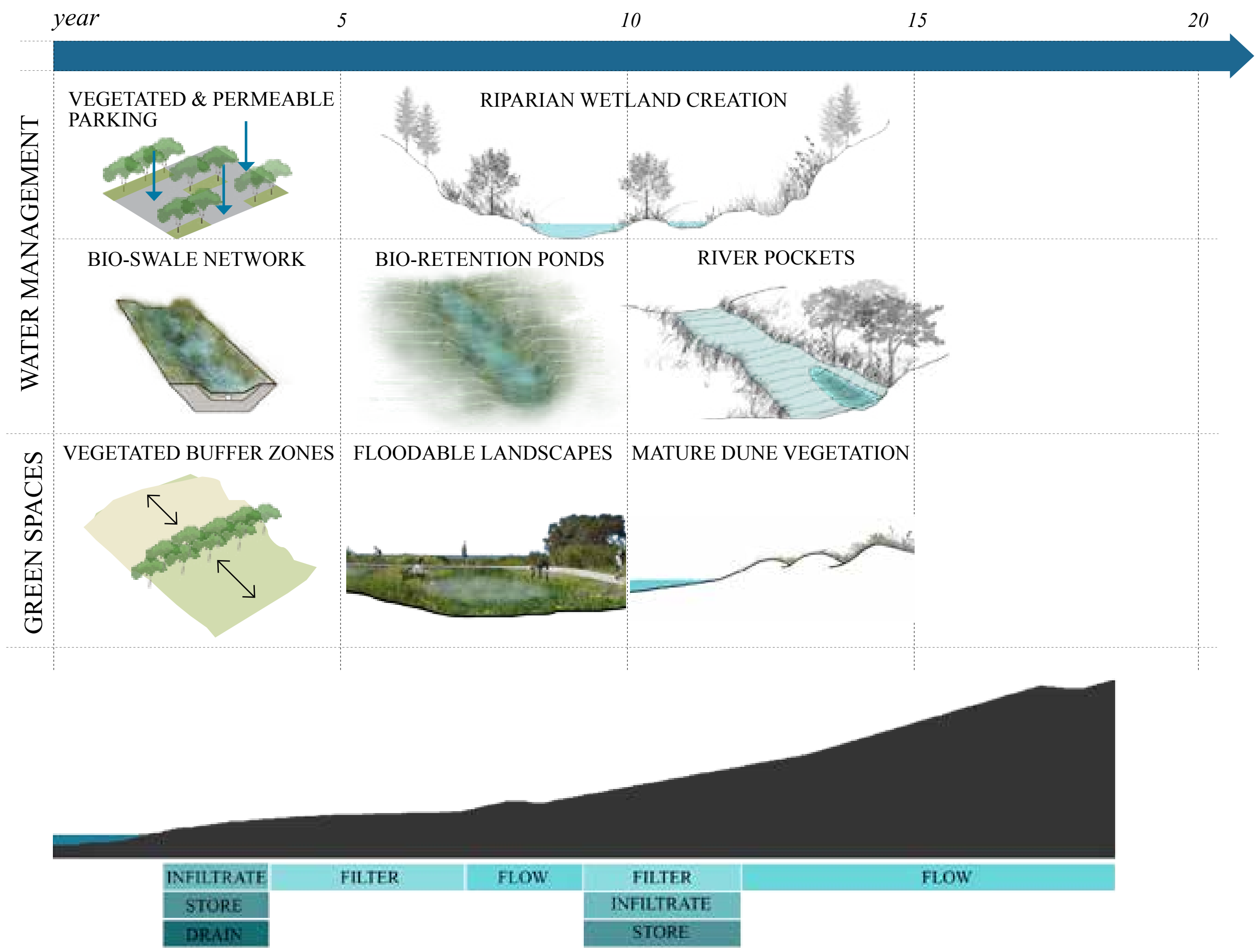


Fig. 5.19. Water management and green space strategies
Source: By author

Water management includes water channelling, filtration, infiltration, storage, and drainage. A network of bio-swales is proposed to replace irrigation canals to increase water quality through filtration, and add an aesthetic and recreational value to the landscape. The confluence of seasonal streams along coastal hills is a pivotal point, where bio-retention ponds are designed to act as large filtration and infiltration pools, and as public spaces that can be seasonally used.

Riparian wetlands along the river and marshes on the coast are important sites of refuge and habitat for organisms, and reverse eutrophication resultant from agricultural effluents. They also act as sediment sinks and sources that are necessary for the proposed natural evolution of the dune landscape. Pocket rivers act as miniature water basins that remain wet throughout the year through increased shading and channel deepening, and host aquatic life.

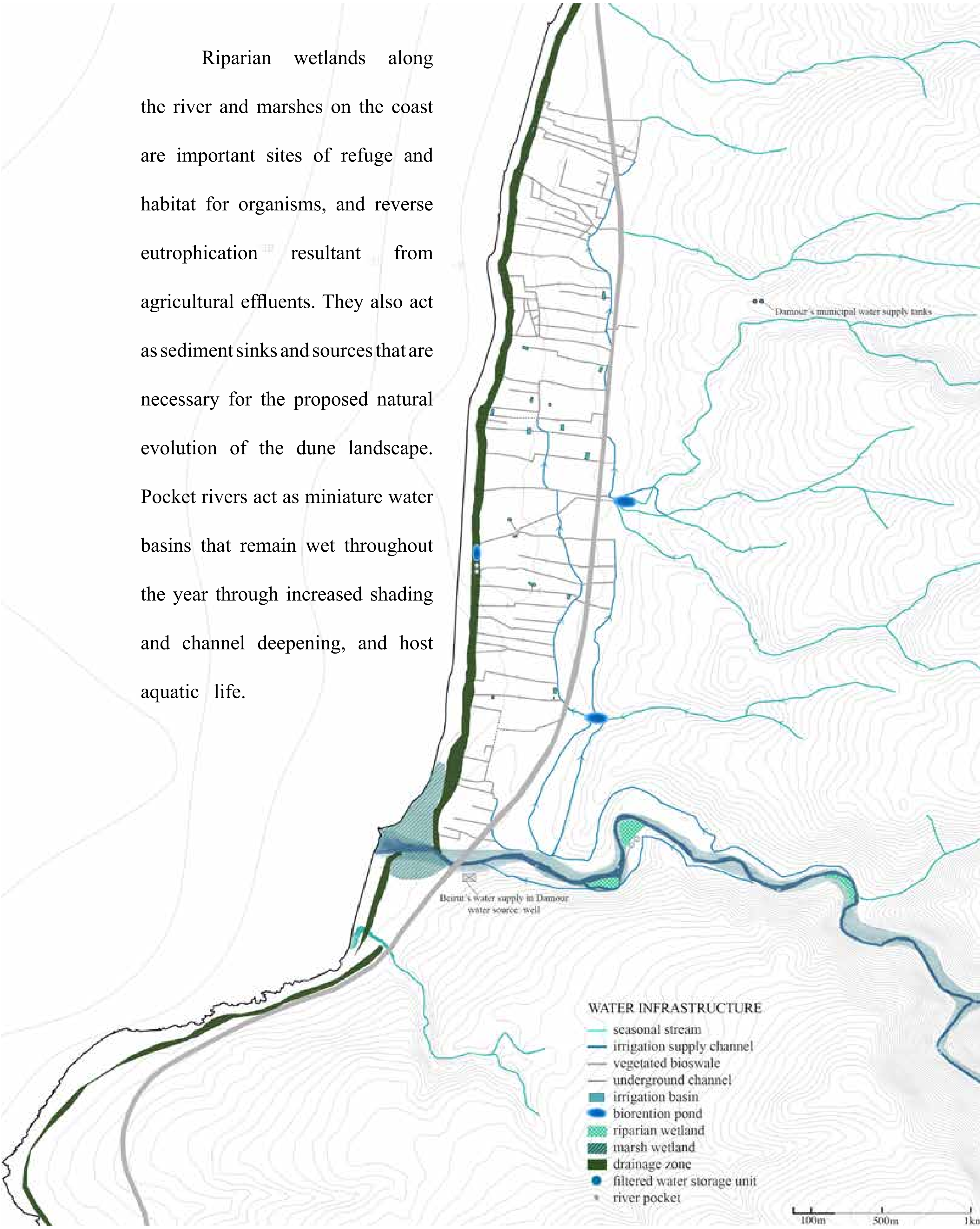
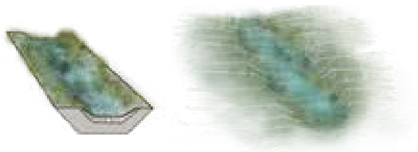


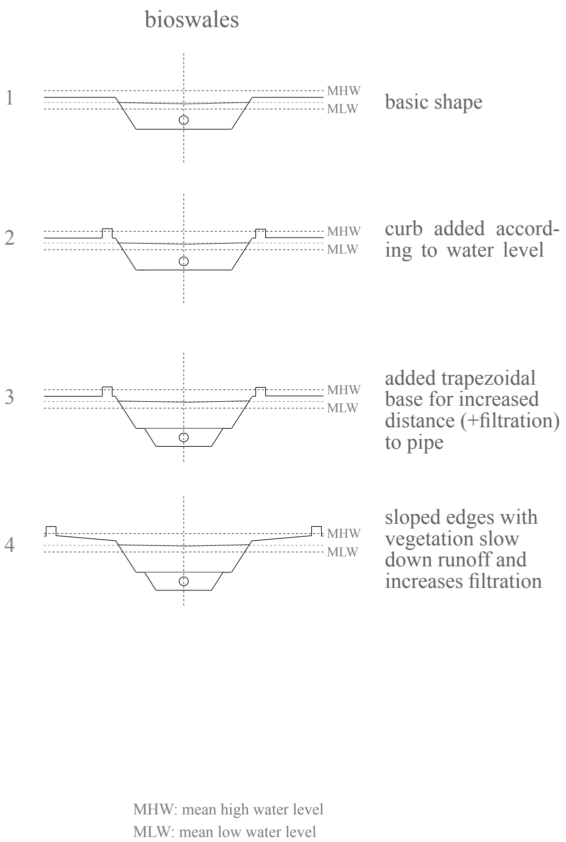
Fig. 5.20. Water Management Plan
Source: By author

a. Water Management Strategies

i. Bio-swales and Bio-retention Ponds



Bio-swales and retention ponds increase water quality by filtration through a soft medium that supports vegetation. Design alternatives are explored through scales, starting with the basic trapezoidal shape (Fig. 5.21). This yields several typologies that can be chosen according to each scenario. For example, as bio-swale channels are widened, water slows down, allowing for greater filtration but also decreasing the total volume of water channelled. While this can be beneficial for drainage systems, narrower channels would suit water distribution systems better (such as irrigation canals. Bioretention ponds follow the same logic, except instead of flowing from a source to a point like swales, they retain water that undergoes deep filtration. Bio-swales are constructed in the first 5 years of the intervention, while bio-retention ponds are implemented at year 5.



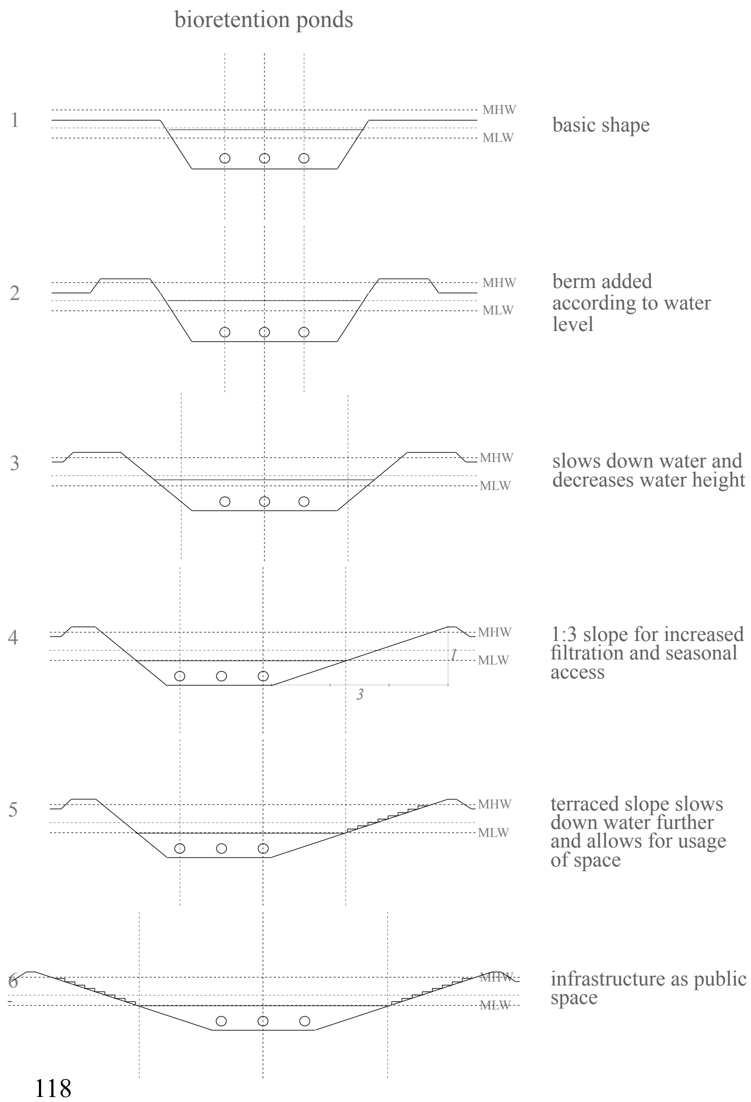


Fig. 5.21. Bioswale and retention pond morphology.
Source: By author

Fig. 5.22. Bioswale section and photomontage.
Source: By author

The process of filtration includes phytoremediation, where heavy metals and nutrients adsorb to the filtration soil medium. This high quality water is then stored underground and can be re-used as management sees fit. Bio-retention ponds serve dual purposes of purification and recreation based on pond design and season. Plant selection is based on a literature review of hydrophytic species endemic to Lebanon or the wider Mediterranean basin. Those plants have the potential to phytoremediate soils, and remove nutrients such as Nitrogen and Phosphorus from eutrophic water bodies resultant from agricultural runoff.

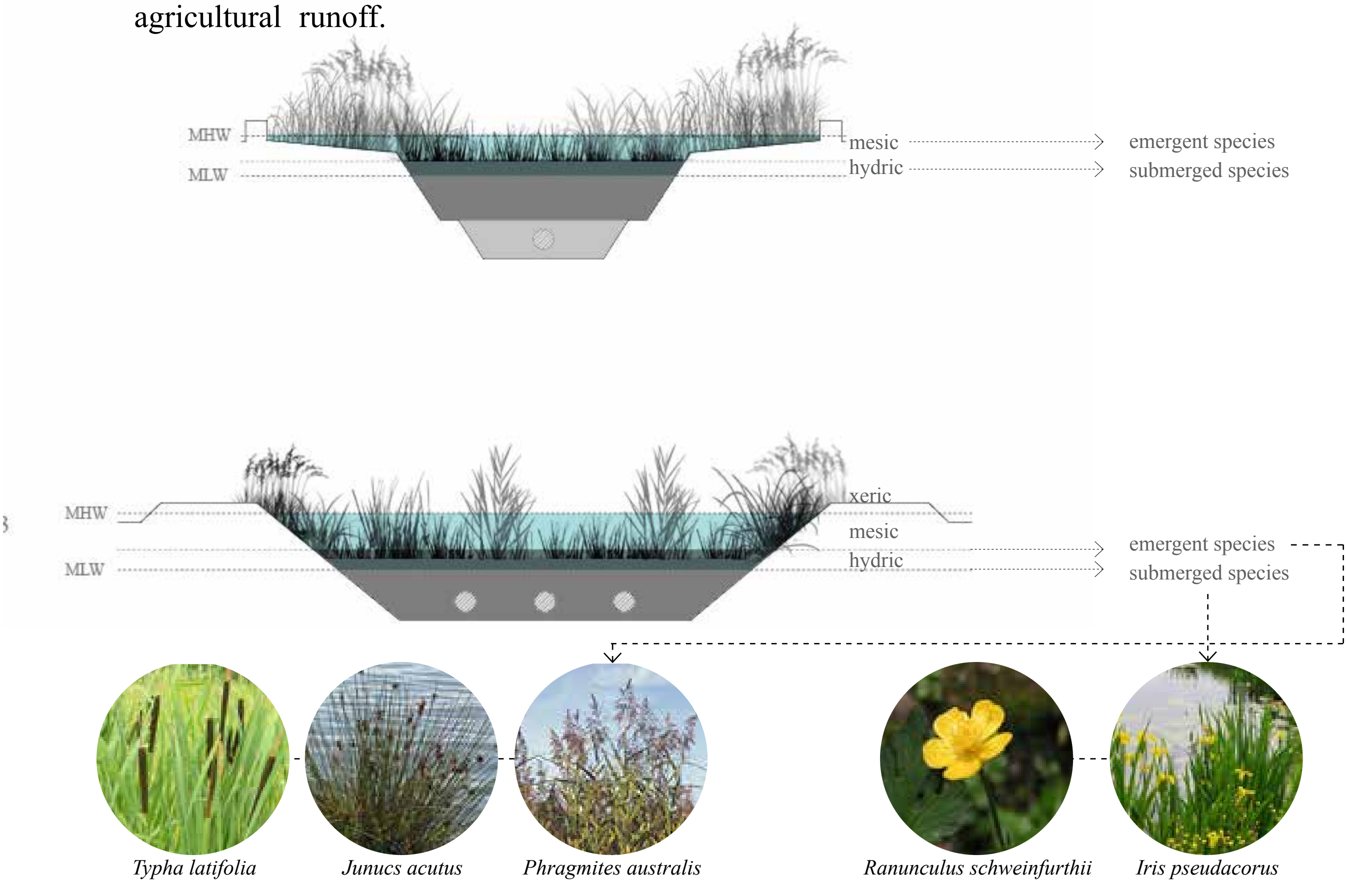


Fig. 5.23. Bioswale and bio-retention ponds plant selection
Source: By author

ii. Marsh, Seasonal & Riparian Wetlands

The intervention seeks to re-establish lost ecosystems such as coastal marshes along Damour’s plain, and to re-identify with concepts of “floodable landscapes” that are pivotal for increased ecological functioning of the river ecosystem (Fig. 5.24). Here, agriculture along the river bed is removed and replaced with floodlplains, wetlands, or riparian vegetation. Seasonal wetlands are proposed along the river mouth, and are ecosystems unique to a semi-arid climate. Marsh wetlands include seagrass communities that have yielded positive results in decreasing eutrophication of water bodies. By creating public paths along these riverine landcsapes, people get to enjoy, learn, and interact with ecosystems that have been long forgotten.

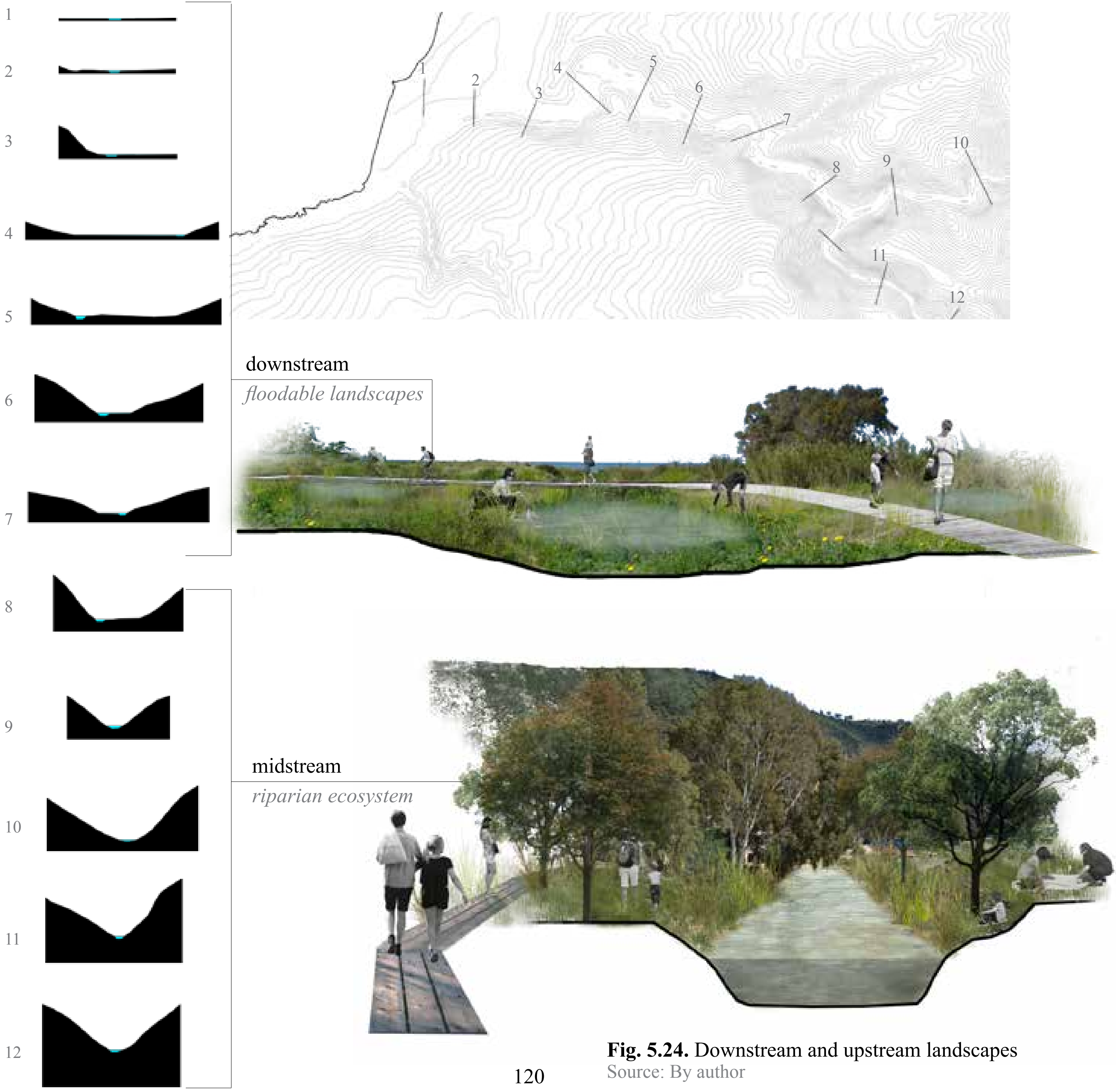


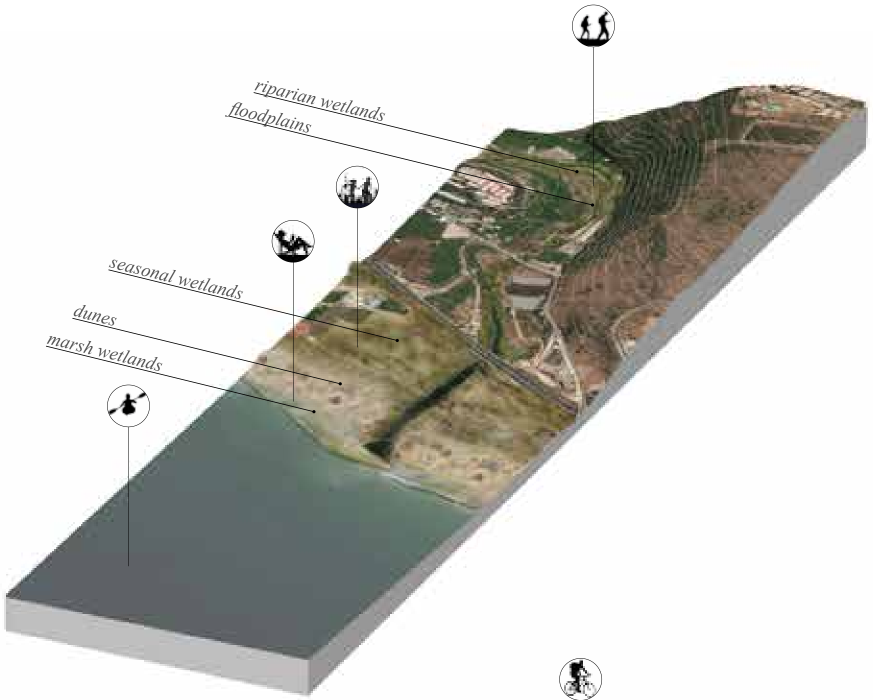
Fig. 5.24. Downstream and upstream landscapes
Source: By author

• Floodable Landscapes

LOW WATER FLOW

Low water levels are experienced during the dry season, marked by little or no rainfall. Here, the last portion of Damour River completely dries out, inviting seawater into the river channel. Marsh wetlands are most productive during the dry season, while seasonal wetlands gradually lose their source of freshwater as conditions get drier. The water level of riparian wetlands is minimal and sustains aquatic life, through the storage of water during the wet season.

J	F	M	A	M	J	J	A	S	O	N	D



AVERAGE WATER FLOW

Average flows are experienced prior to and post the wet season, marking a dynamic period moving from dryness to wetness and vice versa. During the first rains, high rainfall intensity causes a flush of sediments and pollutants that are carried towards the coast, potentially adsorbing to coastal mudflats and marshes. Seasonal wetlands host aquatic life and migration through the river channel becomes possible allowing for breeding cycles to begin.

J	F	M	A	M	J	J	A	S	O	N	D

HIGH WATER FLOW

High water flows are experienced during the wet season, marked by high rainfall. This period transports sediment to the coast, and recharges groundwater levels, decreasing salt water intrusion unto the littoral landscape. Coastal marshes experience erosion due to high wave action during this time, while seasonal wetlands act as flood attentuation and breeding sites for migratory birds. Riparian wetlands experience extended levels of inundation and serve as productive sites for aquatic life.

J	F	M	A	M	J	J	A	S	O	N	D

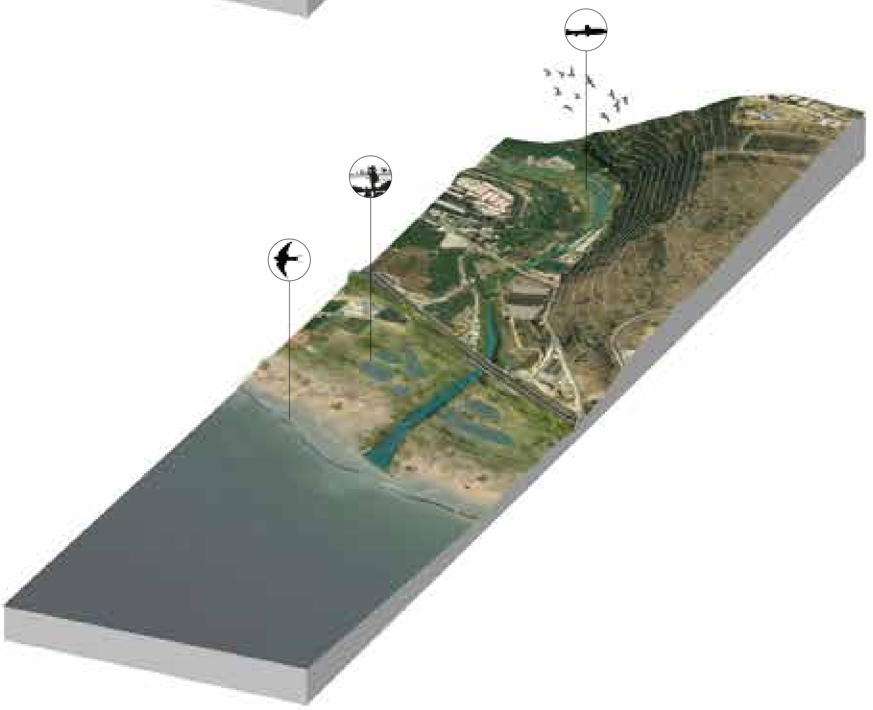
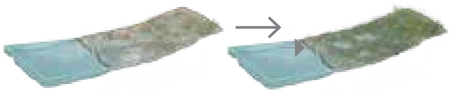


Fig. 5.25. Photomontage showing ammalgamation of strategies along the river, and seasonal changes.
Source: By author

• Coastal Marsh Morphology and Vegetation Scheme 

Zonation along the wetland marsh is based on plant tolerance of inundation and salinity as influenced by tidal action. In Lebanon, the high neap and spring tides vary approximately 30cm in height. In order to have an expansive plain that is partially wet, sand is levelled and extra sand is removed to recreate a marsh wetland ecosystem. Damour’s river has shown to contain high quantities of TDS (Total Dissolved Solids) and low DO (Dissolved Oxygen) especially at its estuary. Therefore plant selection reflects species that are capable of cycling of nutrients and dissolving them. Selection is also based on research of halophytes along the Eastern Mediterranean, as any invasive intrusion can create a monoculture, greatly reducing diversity of the ecosystem. Seagrasses are reintroduced along the mudflats, as they are endangered marine ecosystem on sandy Lebanese shores. They serve as important nesting and breeding sites for many aquatic and avian organisms, and they have shown to decrease nitrification of water bodies.

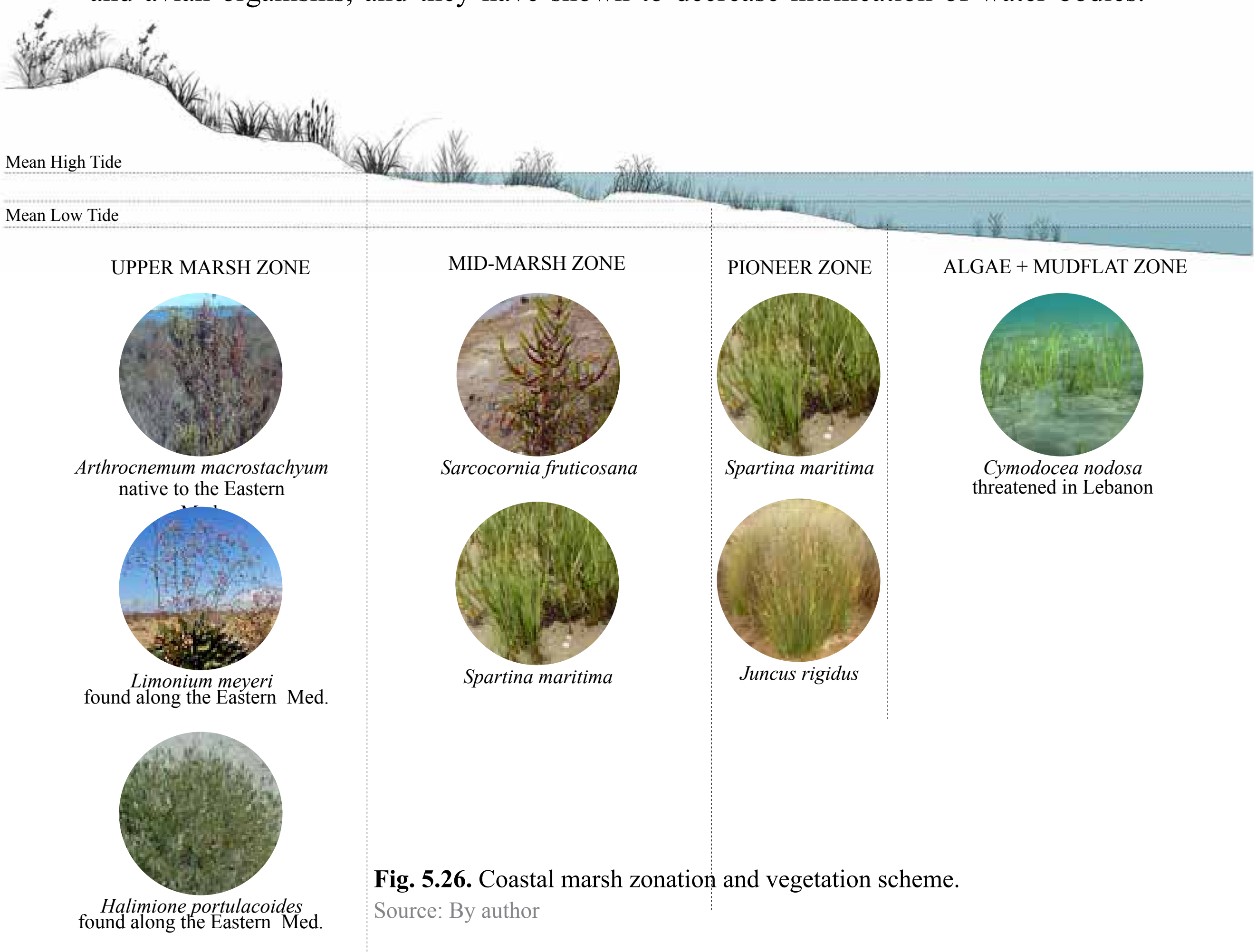


Fig. 5.26. Coastal marsh zonation and vegetation scheme.
Source: By author

3. Conscious Development | Protection of People, Assets, and Landscapes

OBJECTIVES

Paced development
Energy efficient & climate responsive design
Sustainable agriculture
Landscape-centered Tourism

The combined shore and water management strategies guide future commercial, residential, and agricultural development of the coast. Increased accessibility, more shore space and landscape attractions open up the potential for multiple programs to take place and economically drive, sustain, and benefit from a more resilient landscape. Development follows the spatial allocations determined shore and water management, incorporates green spaces, and respects access and public space.

PROGRAMS & STRATEGIES

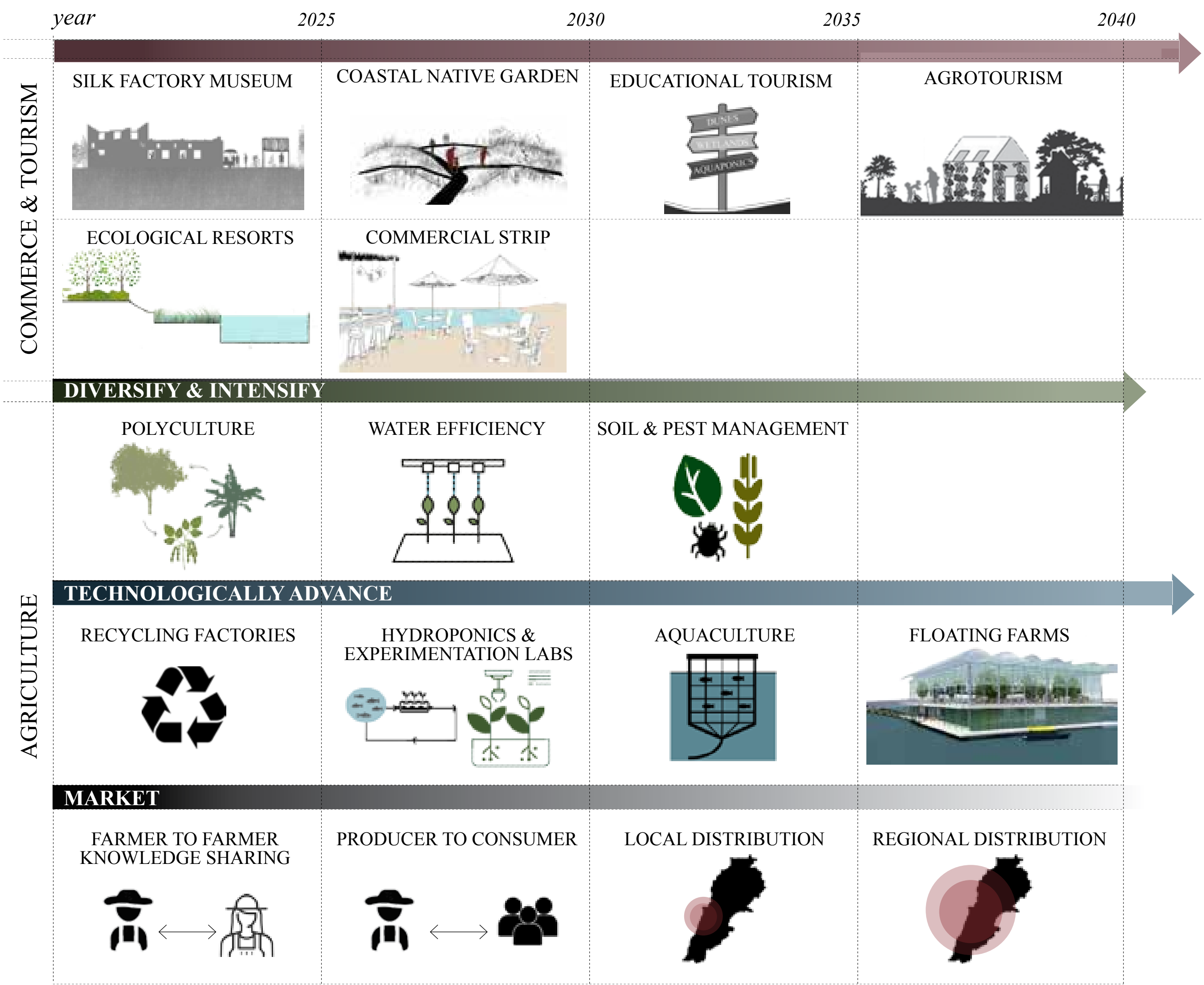


Fig. 5.27. Commercial and agricultural development strategies.
Source: By author

a. Zoning Plan and General Guidelines | 20 Years

The zoning plan is conceived to reconcile the multiple landuses and activities in Damour, to give more space for the shore and the river, and avoids building along seasonal streams and waterways. The public beach is bordered by a green buffer zone inland, and a resort/commercial strip is proposed between the buffer and the agricultural plain. Resorts and commercial stores that exist on both sides of the highway are maintained, and the highway is buffered by vegetation. Low-rise, mixed use commercial and residential zones are proposed in Saadiyat and West of Damour's main town, while a mixed use residential and cultivation zone is proposed South of Damour's town. Coastal hills are public municipal lands and are preserved. A riparian zone widens as the river nears the sea, culminating in estuary and marsh zones.

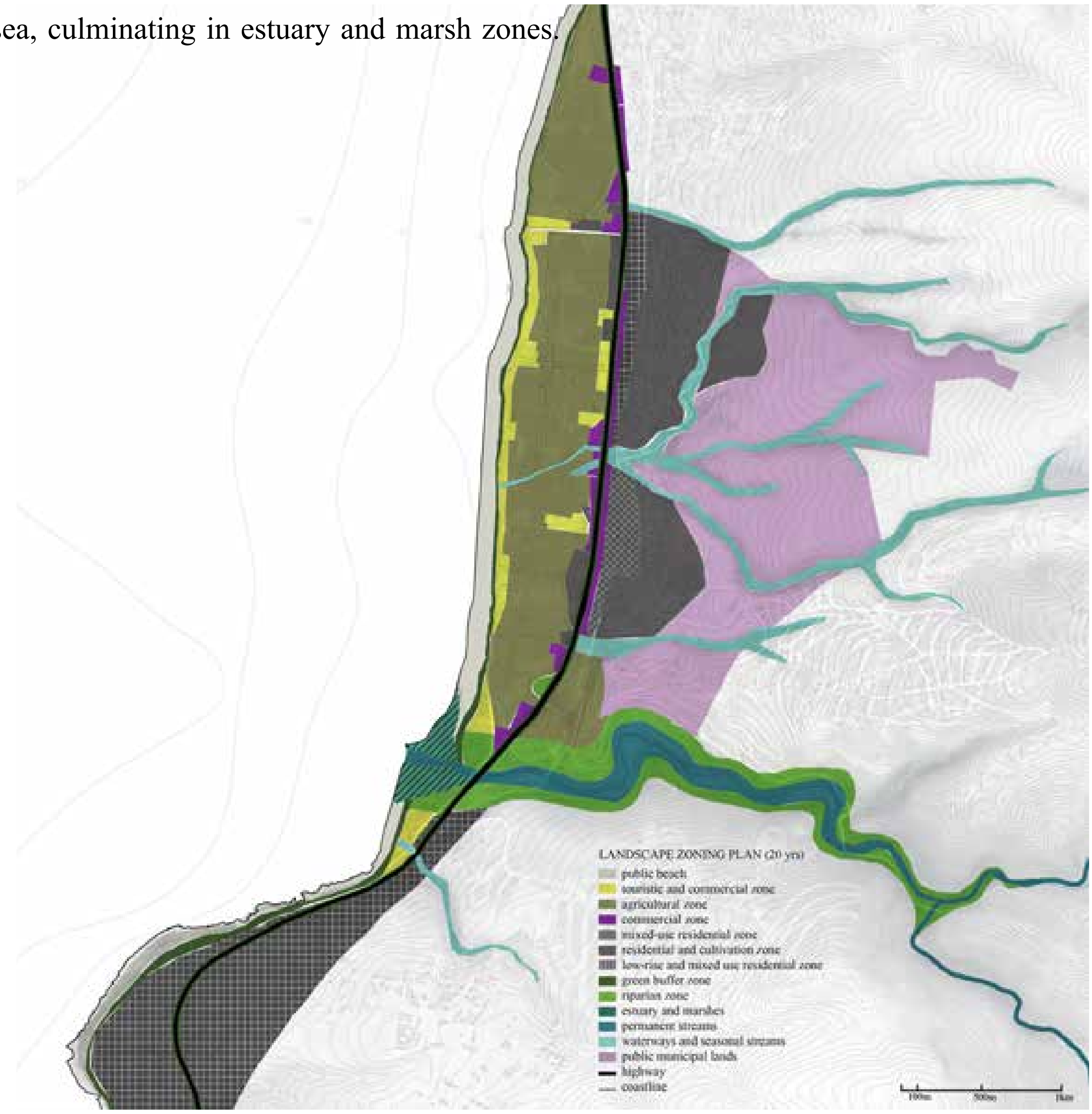


Fig. 5.28. Zoning Plan (20 years)
Source: By author

i. Resort Guidelines

Beach resorts must abide by development guidelines regarding materials used, energy efficiency, and water demand, to decrease the ecological footprint of the built environment.

1. Natural building materials must be used for resort construction, such as bamboo, rammed earth, and natural stone. Considering that resorts must abide by a maximum of three floors in height, bamboo could be used as a natural reinforcement in rammed earth walls, which are suitable building 2 - 3 stories high. This will lead to more breathable structures, with less construction impact than conventional building material.

2. Energy demand must be reduced through on-site energy production, and efficient design strategies that capitalize on potentials of natural ventilation and lighting. On-site energy production and storage can meet 100% of resorts' energy demands through use of solar panels, considering that usage of resorts is seasonal and highest during sunny and dry summer months. Design strategies to reduce the need for artificial lighting and cooling must be employed.

3. Water demand of resorts must be reduced through water collection methods such as humidity and rainfall harvesting, and condensate recuperation. An elaborate assessment of water generation capacities must be undertaken prior to resort development and works to define the scale of resorts according to assessed capacities. Water demand must also be reduced through strategies such as incorporating natural pools and reusing water resources through filtration mechanisms. Natural pools require no chemicals to make them safe for swimming, and decrease water demand by remaining filled with water year round. Following these guidelines, infrastructural works will be reduced with diminished initial and operational impacts on the littoral landscape.

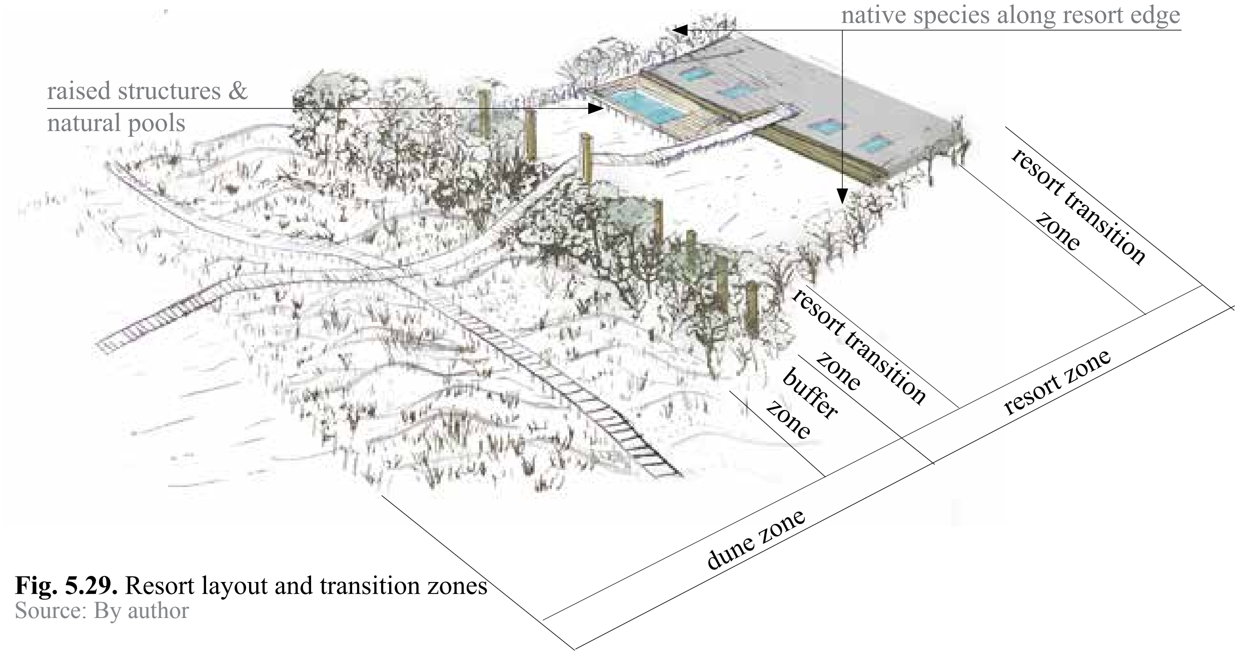


Fig. 5.29. Resort layout and transition zones
Source: By author

Resort edges are of prime importance and work to link green corridors across the plain towards the dune landscape, and attenuate flooding during intense storms. Native species must be used along the edges (fig. 5.29), while exotic species may be used within the resort space, especially for water filtration purposes. It's also recommended that pools and structures be elevated above the ground level, decreasing impacts from excavation. Resorts can form a mutually benefitial relation with agricultural development, whereby waste generated by resorts is recycled through compost heaps and reused in agriculture. Resorts will operate through a public-private partnership, undertaking the task of maintaining and managing coastal infrastructure for a contract period of 20 years.

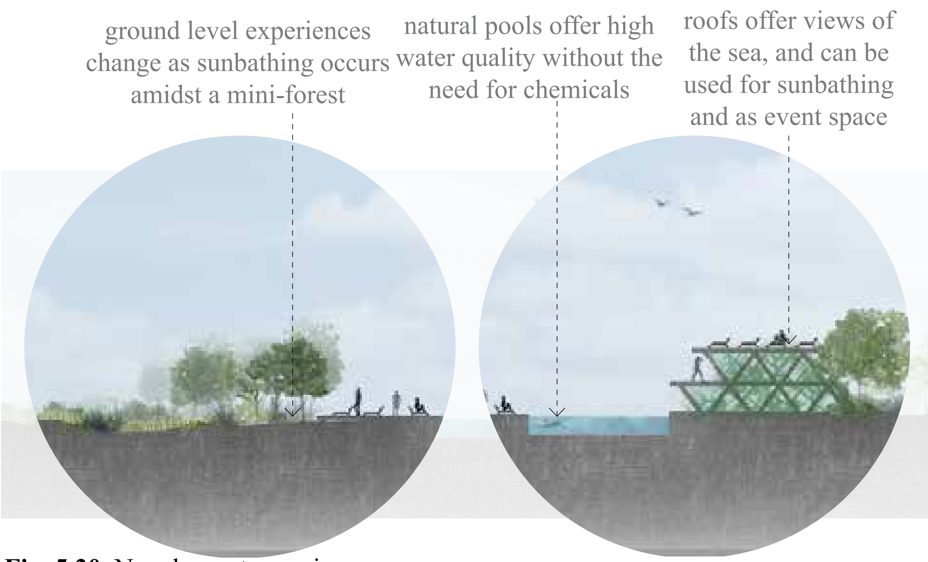


Fig. 5.30. Novel resort experiences
Source: By author

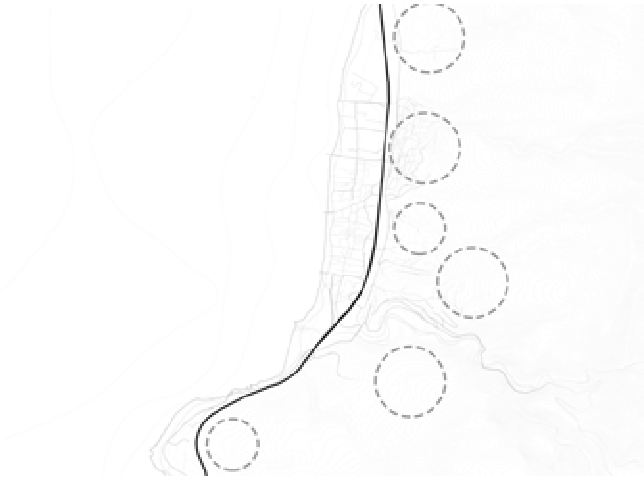
ii. Agriculture Guidelines

The aims of agricultural development guidelines are to counteract desertification and loss of soil productivity, decrease salt-water intrusion, increase yields, and use environemtnally friendly measures. Agricultural areas and farmers must diversify cultivated crops within fields through polycultures, introduce native plant corridors between fields (or border plants), increase efficient water usage through drip irrigation methods, and manage soils and pests to decrease the need for synthetic pesticides and fertilizers.

Research shows that coupling banana plantations with legume plants increases yield of both species, and enhances usage of space as these plants occupy different heights in the field. Introducing certain species of pest-repellant plants especially in field crops can greatly reduce the need for synthetic pesticides. Also, utilizing compost generated from resort and agricultural waste will decrease the need for synthetic fertilizers, and enhance soil productivity. Agricultural wastes such as nylon for strawberry fields and banana leaves should be recycled and reused, respectively. As banana is the main cultivated crop along the plain, resorts can use banana leaves as food wrapping as is often done is South-East Asian restaurants and resorts, leading to a reduced need for paper, carton, or plastic wrapping of served food.

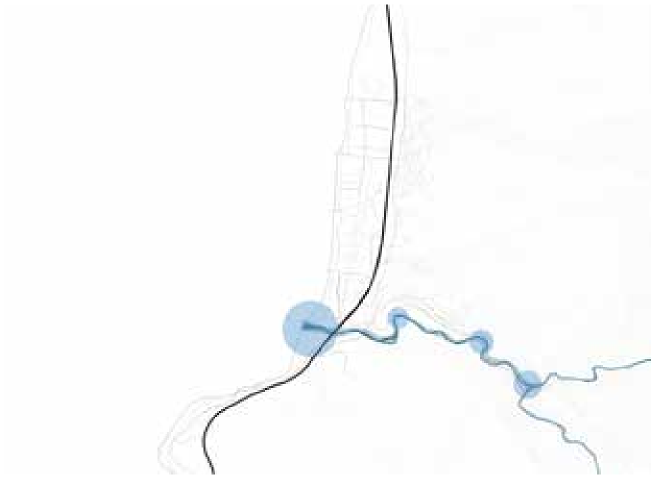
Combined, these strategies are more feasible than conventional solutions, however require increased man power on the field. By following these guidelines, products could be sold to organic markets, which may be held in Damour, creating a direct relationship between consumer and producer. Increased awareness and a shift in practices is then expected not in the area only but in bordering agricultural areas.

iii. Preservation and Protection



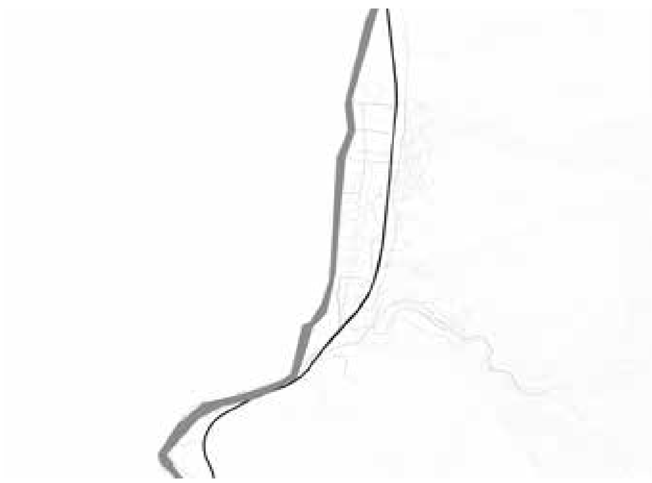
CONCENTRATE URBAN SPRAWL

Concentrated settlement ensures remnant open spaces along the coastal hills, and preserves their scenic beauty. This can be done through increasing vertical densification and decreasing horizontal sprawl of new settlement.



PROTECT RIVER
PRESERVE ESTUARY - WETLANDS - FLOODPLAINS

The river is a valuable as it sustains both agriculture, tourism, and meets the water demands of the town of Damour and a percentage of Greater Beirut. Dumping into the river must be prohibited, and towns along the river must connect their sewer outlets to waste water treatment plants. The estuary is to be preserved, as well as floodplains and wetlands.



PRESERVE SANDY AND ROCKY SHORE
PROTECT DUNE LANDSCAPE

The sandy and rocky shores are to be preserved, and the newly established dune landscape to be protected from anthropogenic impacts such as trampling, littering, etc.

Fig. 5.31. Preservation and Protection
Source: By author

b. Tourism and Public Space | Main Attractions

Fig. 5.32. Main site attractions
Source: By author

Fig. 5.33. Zoom-in plan: The Cultural Axis
Source: By author

Fig. 5.34. Photomontage of the seafront
Source: By author

4. Future Vision and Strategy Options

After the initial period of 20 years, stakeholders can decide on future management options of the landscape, based on the success of the intervention. Here, three general paths can be taken with respect to both shore and water management strategies:

1. Protect: Protection of maritime assets includes rigorous maintenance checks scheduled every 5 years, to observe site dynamics, such as erosion, accretion, dune establishment vegetation success, etc. Dune replenishment and re-vegetation may be necessary if dune falling is experienced, and regular sand fence maintenance. If severe erosion is encountered despite strategic efforts, defense structures including both hard and soft engineering are viable.

2. Advance: Advancement is an expensive option that will require another cycle of beach nourishment and dune replenishment. Beach nourishment at this stage may have negative impact on the established littoral ecology. This option is viable when an increase in shore area is sought, and to advance private properties seaward.

3. Adapt: Adaptation is a bold management option where selected strategies depend on a deep understanding of site dynamics. Adaptation includes a wide array of possibilities, and can combine multiple strategies and tools innovatively. This option requires the involvement of the community in the selection of strategies.

These options should be studied in reference to a general development vision, where increased tourism development may imply the need for further advancement, versus increased residential development which will require more protection, increase in water quality, educational facilities, and the like. Adaptation is the most flexible of those, implying a melange of different strategies, and can only be achieved with increased management and maintenance, both by the public sector and involved communities.

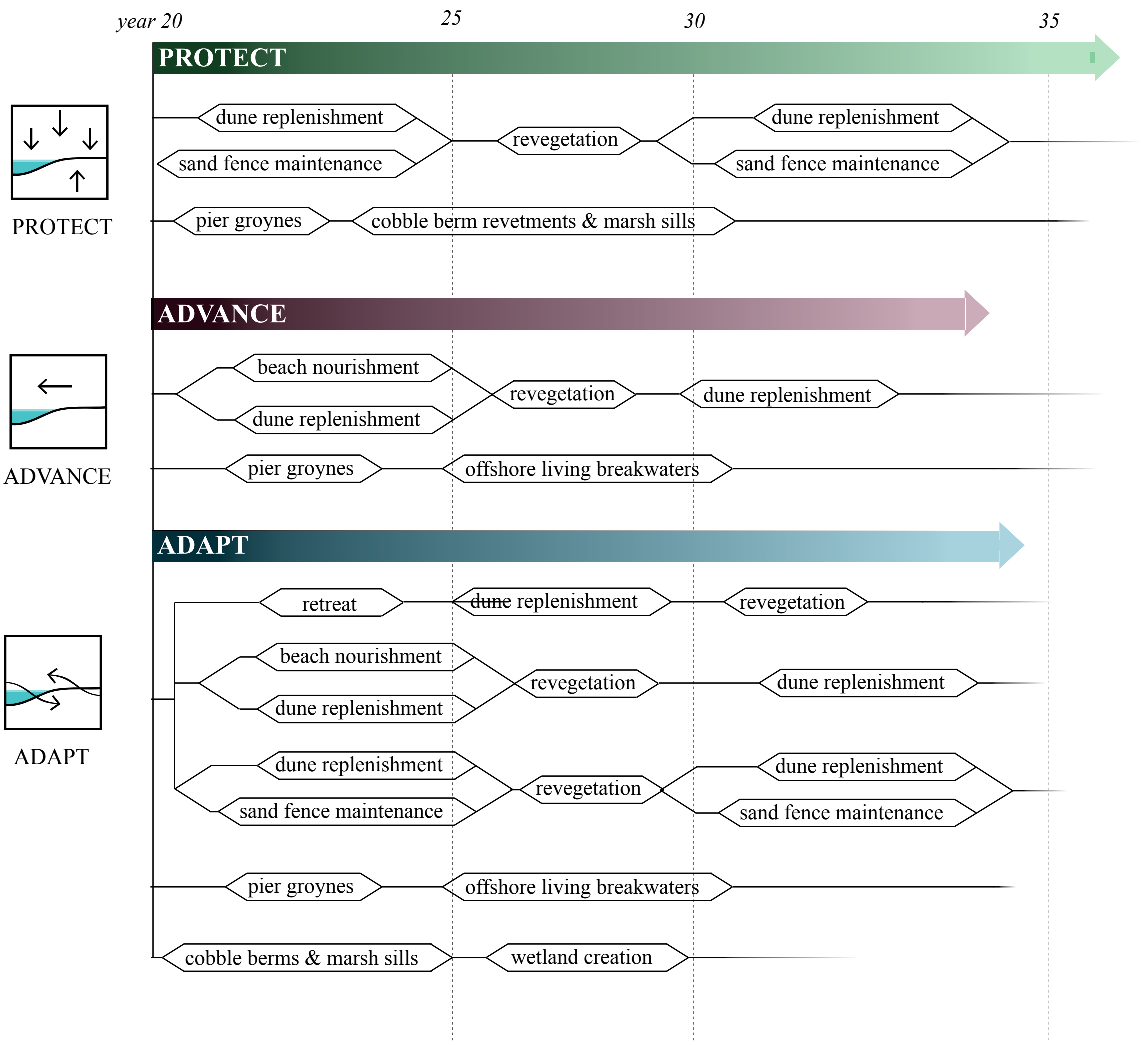


Fig. 5.35. Future vision and strategy options
Source: By author

CHAPTER VI
CONCLUSION

Planning and designing with climate change is not a simple task; however, its becoming a necessity. There is a change in attitudes towards this challenge, not only through the increased attention in advancing it as a science, but also in responding to it through governance, planning, and more recently, design. While mitigation responses received most attention as countries and the international community attuned to climatic changes and their projected impacts (around the late 80's and early 90's), today attention has shifted towards adaptation to changes, as impacts and climate-related effects are already taking place around the world. The localized and uneven distribution of climatic impacts means that more attention should be placed on assessing the vulnerabilities of different populations and localities to these changes, and addressing them through adaptation strategies.

A. Contribution of This Thesis

This thesis, in its attempt to plan and design through the lens of climate change, advocates for a more proactive rather than reactive role in urbanism and planning studies. Rather than waiting for a hazard to occur, or a disease to break out, or the sea to rise, it recognizes that the most desirable form of adaptation is adaptation that is not necessary (Howard, 2018). Through the case study of Damour, which is now attracting commercial and residential development, this thesis seeks to establish adaptation measures that not only enhance the resilience of the landscape to threats or changes, but also to guide the approach to development. Moving from controlling nature to working with it, a dynamic border is imagined between the land and sea, the sea and the river, which respects the beach as a public space, but also seeks to achieve resilience. This follows the ideology that resilience is not a system returning to an initial stable state after a disturbance, but that the system under stress can morph and adapt to achieve a new, different equilibrium that will be expressed in a new structure, a different, perhaps ephemeral landscape, without compromising basic site functions. The strategies used and documented hope to be form a framework for approaching coastal areas in general, tackling how to carry out such strategies on a practical level.

B. Limitations and Challenges

While my position regarding responses to climate change doesn't favor one over the other, the intervention mostly focuses on spatial interventions and adaptation measures to achieve resiliency at a municipal scale, which is not a fully rounded approach in light of the importance of mitigation. Considering the issue of pollution of Damour River for example, it's definitely most efficient to stop it from its source, rather than react to it downstream. Nevertheless, such a measure would require the concerted effort of the entire river watershed, which is beyond the scope of this work, but is definitely advocated.

The challenges faced in this work mainly include the lack of data in Lebanon, especially regarding climatic variables, risks and vulnerabilities. Only through my engagement in the MedScapes project was some of this data accessible to me. Moreover, although there are a few reports on climate change and its impacts in Lebanon, they have not been spatially defined making much of that data hard to use as a designer.

At the municipal level, very few studies are conducted to assess vulnerabilities and risks facing the residential community and the landscape in general. This gives the feeling of 'starting from zero' and is a limitation.

C. Further Research

One main avenue for further development of this work is the possibility of conducting national or regional studies that show different sensitivities and vulnerabilities of the Lebanese landscape, as well as geographically referenced climatic variables and impact studies. This can be based on a Landscape Character Assessment of the area, followed by a landscape sensitivity assessment, both more or less subjective studies, in parallel with a vulnerability study based on climatic impacts, landscape hazards, one that is more objective. Both these studies would work to guide future development of coastal landscapes.

This work could also be used as a model that can be applied unto other similar contexts, such as other sandy beaches in the Eastern Mediterranean, resulting in interesting comparative analysis and design interventions. Moreover, the arena of climate-responsive, and energy & water efficient coastal resort designs could be expanded upon, especially in the context of the Eastern Mediterranean.

BIBLIOGRAPHY

Agard, J.E., Schipper, L.F., Birkmann, J., Campos, M., Dubeux, C., Nojiri, Y., Olsson, L., Osman-Elasha, B., Pelling, M., Prather, M.J., Rivera- Ferre, M.G., Oliver Ruppel, C., Sallenger, A., Smith, K.R., Clair, A.L.S., (2014). Annex II Glossary, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 1757–1758.

Amelung, B., & Moreno, A. (2012). Costing the impact of climate change in tourism in. Europe: results of the PESETA project. *Climatic Change, 112(1), 83–100*

Anastasopoulos, P. G. (1989). Italys importance in the development of tourism in the Mediterranean. *Annals of Tourism Research*, *16*(4), 570–574. doi: 10.1016/0160-7383(89)90011-x

Assaf T. (2009). Lebanese Coastal Zone. Ministry of Public Work and Transportation Lebanon directorate general of land and maritime transport Marseille 2009. http://siteresources.worldbank.org/EXTMETAP/Resources/CostCoastalzoneDegradLebanon.ppt

Aston Centre for Europe (2013). *Sustainable tourism in the Mediterranean* . Retrieved from https://op.europa.eu/en/publication-detail/-/publication/30fa94a5-ce3f-4d5a-ad97-d0fdbca0ad8f/language-en

Azhari, Timour. "The Lucrative History of Lebanese Land Reclamation." *The Daily Star*, 19 July 2017, p. 3, www.dailystar.com.lb/News/Lebanon-News/2017/Jul-19/413250-the-lucrative-history-of-lebanese-land-reclamation.ashx.

Becker, K., Wulfmeyer, V., Berger, T., Gebel, J., & Münch, W. (2013). Carbon farming in hot, dry coastal areas: An option for climate change mitigation. *Earth System Dynamics, 4*(2), 237-251. doi:10.5194/esd-4-237-2013

Begum, R. A., Sarkar, M. S. K., Jaafar, A. H., & Pereira, J. J. (2014). Toward conceptual frameworks for linking disaster risk reduction and climate change adaptation. *International Journal of Disaster Risk Reduction, 10*, 362-373. doi:10.1016/j.ijdrr.2014.10.011

Berbés-Blázquez, M., Mitchell, C. L., Burch, S. L., & Wandel, J. (2017). Understanding climate change and resilience: Assessing strengths and opportunities for adaptation in the global south. *Climatic Change, 141*(2), 227-241. doi:10.1007/s10584-017-1897-0

Blondel, J. (2006). The 'Design' of Mediterranean Landscapes: A Millennial Story of Humans and Ecological Systems during the Historic Period. *Human Ecology,* 713-729.

Bonada, N., & Resh, V. H. (2013). Mediterranean-climate streams and rivers: Geographically separated but ecologically comparable freshwater systems. *Hydrobiologia, 719*(1), 1-29. doi:10.1007/s10750-013-1634-2

Boudouresque, C.F., (2004). Marine biodiversity in the Mediterranean: status of species, populations, and communities. France 20, 97–146.

Brooks, N. (2003). Vulnerability, Risk and Adaptation: A Conceptual Framework. Working Paper 38, *Tyndall Centre for Climate Change Research*, University of East Anglia, Norwich.

Burroughs, W. J. (2007). *Climate change: A multidisciplinary approach*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511803819

Bush, M. J. (2020). *Climate change and renewable energy: How to end the climate crisis* (1st 2020. ed.). Cham: Springer International Publishing. doi:10.1007/978-3-030-15424-0

Cardona, O.D., M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, R.S. Pulwarty, E.L.F. Schipper, and B.T. Sinh, (2012) Determinants of risk: exposure and vulnerability. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-108.

Castri, F. D., & Mooney, H. A. (1973). *Mediterranean type ecosystems: Origin and structure*. Berlin: Springer.

CDR-NLUMP 2004 National Physical Master Plan of the Lebanese Territory, CDR, Dar Al Handasah – Institut d'amenagement et d'urbanisme de la region d'Ile De France, 2004

Chaturvedi, S., Doyle, T. (2015). *Climate terror: A critical geopolitics of climate change*. London: Palgrave Macmillan UK. doi:10.1057/9781137318954

Childers, D., Cadenasso, M., Grove, J., Marshall, V., McGrath, B., & Pickett, S. (2015). An ecology for cities: A transformational nexus of design and ecology to advance climate change resilience and urban sustainability. *Sustainability, 7*(4), 3774-3791. doi:10.3390/su7043774

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F.B., Aguzzi, J., Ballesteros, E., Bianchi, C.N., Corbera, J., Dailianis, T., Danovaro, R., Estrada, M., Froglia, C., Galil, B.S., Gasol, J.M., Gertwagen, R., Gil, J., Guilhaumon, F., Kesner-Reyes, K., Kitsos, M., Koukouras, A., Lampadariou, N., Laxamana, E., Cuadra, C.M., Lotze, H.K., Martín, D., Mouillot, D., Oro, D., Raicevich, S., Rius-Barile, J., Saiz-Salinas, J.I., Vicente, C.S., Somot, S., Templado, J., Turon, X., Vafidis, D., Villanueva, R., & Voultsiadou, E. (2010). The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. *PloS one.*

Corner, J. (2010) Landscape Urbanism in the Field. The *Knowledge Corridor*, San Juan, Puerto Rico. · *Topos*, 71, 25-29

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J., Iglesias, A., . . . Xoplaki, E. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change, 8*(11), 972-980. doi:10.1038/s41558-

018-0299-2
Cubasch, U., D. Wuebbles, D. Chen, M.C. Facchini, D. Frame, N. Mahowald, and J.-G. Winther, (2013) Introduction. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
Cumo, C. (2012). Climate. In S. Philander (Ed.), *Encyclopedia of global warming & climate change* (Vol. 1, pp. 263-269). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781452218564.n137
Doublas, M. E. (2015). Reassessing global change research priorities in mediterranean terrestrial ecosystems: How far have we come and where do we go from here? Global Ecology and Biogeography, 25-43. doi:DOI: 10.1111/geb.12224 http://wileyonlinelibrary.com/journal/geb
Ellenblum, R. (2013). *The collapse of the eastern mediterranean: Climate change and the decline of the east, 950-1072*. Cambridge: Cambridge University Press. doi:10.1017/CBO9781139151054
Emel'ianov, E. M., & Shimkus, K. M. (1986). *Geochemistry and sedimentology of the Mediterranean Sea*. Dordrecht: D. Reidel Pub.
Eriksen, S. H., Nightingale, A. J., Eakin, H., & Sveriges lantbruksuniversitet. (2015). Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change, 35*, 523-533. doi:10.1016/j.gloenvcha.2015.09.014
Finkl, C. W., Makowski, C., & Schwartz, M. L. (2019). *Encyclopedia of coastal science*. Cham, Switzerland: Springer Nature Switzerland AG.
Flannery, T. (2008). The weather makers (2nd ed.). Melbourne: Text Publishers.
Füssel, H., & Klein, R. J. T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change, 75*(3), 301-329. doi:10.1007/s10584-006-0329-3
Füssel, H. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change, 17*(2), 155-167. doi:10.1016/j.gloenvcha.2006.05.002
Galil, B. (2007). Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. *Marine Pollution Bulletin, 55*(7-9), 314-322.doi:10.1016/j.marpolbul.2006.11.008
Garcı´a-Ruiz JM, Lo´pez-Moreno JI, Vicente-Serrano SM, LasantaMartı´nez T, Beguerı´a S (2011) Mediterranean water resources in a global change scenario. Earth Sci Rev 105:121–139
Gardoni, P., Murphy, C., Rowell, A. (2016). *Risk analysis of natural hazards: Interdisciplinary challenges and integrated solutions* (1st 2016.;1st 2016; ed.). Cham: Springer International Publishing. doi:10.1007/978-3-319-22126-7

Gehrels, R., & Masselink, G. (2014). *Coastal environments and global change* (1st ed.). Somerset: American Geophysical Union.

Grantham, T. E., Figueroa, R., & Prat, N. (2012). Water management in mediterranean river basins: A comparison of management frameworks, physical impacts, and ecological responses. *Hydrobiologia, 719*(1), 451-482. doi:10.1007/s10750-012-1289-4

Gunderson, L. H. (2000). Ecological Resilience - in theory and application. *Annual Review of Ecology and Systematics, 31*(1), 425-439. doi:10.1146/annurev.ecolsys.31.1.425

Hall, M. (2001). Trends in ocean and coastal tourism: the end of the last frontier? *Ocean & Coastal Management*, *44*(9-10), 601–618. doi: 10.1016/s0964-5691(01)00071-0

Haslett, S. K. (2009). *Coastal systems* (2nd ed.). London;New York;: Routledge. doi:10.4324/9780203893203

Hegazy, A., & Doust, J. L. (2016). *Plant ecology in the Middle East*.

Hetherington, R., & Reid, R. G. B. (2010). *The climate connection: Climate change and modern human evolution*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511750397

Jennings, S. (2004). Coastal tourism and shoreline management. *Annals of Tourism Research*, *31*(4), 899–922. doi: 10.1016/j.annals.2004.02.005

Koolhaas, R. (1995). Whatever Happened to Urbanism? *Design Quarterly,* (164), 28-31. doi:10.2307/4091351

Lenzholzer, S., Duchhart, I., & Koh, J. (2013). 'Research through designing' in landscape architecture. *Landscape and Urban Planning, 113*, 120-127. doi:10.1016/j.landurbplan.2013.02.003

IPCC (Intergovernmental Panel on Climate Change) (2001) Climate Change 2001: IPCC Third Assessment Report.Working Group II: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge.

IPCC (2012a) Glossary of terms. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.

IPCC (2012b) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K.

Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

IPCC (2013) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Lawn, P. (2016). *Resolving the climate change crisis: The ecological economics of climate change*. Dordrecht: Springer Netherlands. doi:10.1007/978-94-017-7502-1

Lavell, A. (1999) Natural and Technological Disasters: Capacity Building and Human Resource Development for Disaster Management. Concept Paper commissioned by Emergency Response Division, United Nations Development Program, Geneva Switzerland.

Lavell, A., M. Oppenheimer, C. Diop, J. Hess, R. Lempert, J. Li, R. Muir-Wood, and S. Myeong, (2012) Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 25-64.

Leal Filho, W., Nalau, J. (2018). *Limits to climate change adaptation*. Cham: Springer International Publishing. doi:10.1007/978-3-319-64599-5

Letcher, T. M. (Trevor M.). (2009). *Climate change: Observed impacts on planet earth* (First ed.). Amsterdam;Boston;: Elsevier.

Makhzoumi, J., & Pungetti, G. (1999). *Ecological landscape design and planning the Mediterranean context*. Taylor & Francis Group.

Massoud, M. A. (2012). Assessment of water quality along a recreational section of the damour river in lebanon using the water quality index. *Environmental Monitoring and Assessment, 184*(7), 4151-4160. doi:10.1007/s10661-011-2251-z

Metz, B. (2009). *Controlling climate change*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511804427

Meyer, B. C., Rannow, S., & Loibl, W. (2010). Climate change and spatial planning. *Landscape and Urban Planning, 98*(3), 139-140. doi:10.1016/j.landurbplan.2010.08.012

MoE/UNDP/ECODIT. 2011. State and trends of the Lebanese environment. 355pp.

Mossop E. (2006) Landscapes of Infrastructure. Waldheim C. (ed.) *The Landscape Urbanism Reader*. 163–179.

Murphy, C., Gardoni, P., McKim, R. (2018). *Climate change and its impacts: Risks and inequalities* (1st 2018 ed.). Cham: Springer International Publishing. doi:10.1007/978-3-319-77544-9

Nicholls, R. J., & Lowe, J. A. (2004). Benefits of mitigation of climate change for coastal areas. *Global Environmental Change, 14*(3), 229-244. doi:10.1016/j.gloenvcha.2004.04.005

Nicholls, R. J., & Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. *Science, 328*(5985), 1517-1520. doi:10.1126/science.1185782

Nicholls, R. J., Stive, M. J., & Tol, R. S. (2014). Coping with Coastal Change. *Coastal Environments and Global Change*, 410–431. doi: 10.1002/9781119117261.ch17

Opdam, P., Luque, S., Jones, K.B. (2009). Changing landscapes to accommodate for climate change impacts: a call for landscape ecology. *Landscape Ecology*. 24, 715–721.

Pelling, M., (2011). Adaptation to Climate Change: From Resilience to Transformation. Routledge, London.

Di Pippo, T., Donadio, C., Pennetta, M., Petrosino, C., Terlizzi, F., Valente, A., 2008. Coastal hazard assessment and mapping in Northern Campania, Italy. *Geomorphology* 97, 451–466.

Piégay, H., Chabot, A., & Lay, Y.-F. L. (2018). Some comments about resilience: From cyclicity to trajectory, a shift in living and nonliving system theory. *Geomorphology*, 106527. doi: 10.1016/j.geomorph.2018.09.018

Poulos, S.E., Collins, M.B., (2002). Fluviatile sediment fluxes to the Mediterranean Sea: a quantitative approach and the influence of dams. In: Jones, S.J., Frostick, L.E. (Eds.), Sediment Flux to Basins: Causes, Controls and Consequences. Special Publications Geological Society, London 191, pp. 227–245.

Ramanathan, A. L., Bhattacharya, P., Dittmar, T., Prasad, M. B. K., Neupane, B. R., (2010). *Management and sustainable development of coastal zone environments*. Dordrecht: Springer Netherlands. doi:10.1007/978-90-481-3068-9

Rannow, S., Loibl, W., Greiving, S., Gruehn, D., & Meyer, B. C. (2010). Potential impacts of climate change in Germany—Identifying regional priorities for adaptation activities in spatial planning. *Landscape and Urban Planning, 98*(3), 160-171. doi:10.1016/j.landurbplan.2010.08.017

Roggema, R., (2009). *Adaptation to climate change: A spatial challenge*. Dordrecht: Springer. doi:10.1007/978-1-4020-9359-3

Roson, R., & Sartori, M. (2014). Climate change, tourism and water resources in the mediterranean. *International Journal of Climate Change Strategies and Management*, 6(2), 212-228. doi:10.1108/IJCCSM-01-2013-0001

Sabra, J., Imad, R., Miri, H., Yehya, Y., & Al Zein, M. S. (2017). Restoration against all odds: the case of coastal sand dunes in Ouzai. *Plant Sociology*, *54*, 61–71.

Santos, F. D., Santos, F. D., Stigter, T. Y., Stigter, T. Y., Faysse, N., Faysse, N., . . . Lourenço, T. C. (2014). Impacts and adaptation to climate change in the mediterranean coastal areas: The CIRCLE-MED initiative. *Regional Environmental Change, 14*(S1), 1-3. doi:10.1007/s10113-013-0551-2

Schipper, E.L.F., Ayers, J., Reid, H., Huq, S., Rahman, A., (2014). Community-Based Adaptation to Climate Change: Scaling It Up. Routledge.

Smit, B., Burton, I., Klein, R., Wandel, J., (2000). An anatomy of adaptation to climate change and variability. *Climatic Change,* 45, 223–251.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282-292. doi:10.1016/j.gloenvcha.2006.03.008

Smith, J. B., Klein, R. J. T., Huq, S., & Potsdam-Institut fur Klimafolgenforschung. (2003). *Climate change, adaptive capacity and development*. London: Imperial College Press.

Stewart, I.S., Morhange, C., 2009. Coastal geomorphology and sea-level change. In: Woodward, J.C. (Ed.), The Physical Geography of the Mediterranean Basin. Oxford, University Press, Oxford, pp. 385–413.

Stocker, T. (2014). *Climate change 2013: The physical science basis : Working group I contribution to the fifth assessment report of the intergovernmental panel on climate change*. New York: Cambridge University Press. doi:10.1017/CBO9781107415324

Swanwick C (2002) Landscape character assessment. Guidance for England and Scotland. Countryside Agency, Cheltenham and Scottish Natural Heritage, Edinburgh, pp 84

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., & Rockström, J. (2006). Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation. *Disasters, 30*(1), 39-48. doi:10.1111/j.1467-9523.2006.00305.x

Torquebiau, E. (2016) *Climate change and agriculture worldwide* (1st 2016.;1st 2016; ed.). Dordrecht: Springer Netherlands. doi:10.1007/978-94-017-7462-8

Turner II, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences of the United States of America 100, 8074–8079.

UNISDR (United Nations International Strategy for Disaster Risk Reduction). (2009) UNISDR terminology on disaster risk reduction; 2009. Available from http://www.unisdr.org/eng/library/lib-terminologyeng.htm.

United Nations (2004). *Living with Risk: A Global Review of Disaster Reduction Initiatives*. United Nations International Strategy for Disaster Reduction, Geneva, Switzerland.

Verdeil, E., Faour, G., Hamzé Mouin, & Gillette, C. (2019). *Atlas of Lebanon: new challenges*. Beyrouth: Presses de Iifpo/CNRS Liban.

Watson, R.T., the CoreWriting Team (Eds.), (2001). Climate Change 2001: Synthesis Report. Cambridge University Press, Cambridge, 396pp.

Zandvoort, M., Kooijmans, N., Kirshen, P., & Brink, v. d., Ai. (2019). Designing with pathways : A spatial design approach for adaptive and sustainable landscapes. *Sustainability, 11*(3), 565. doi:10.3390/su11030565

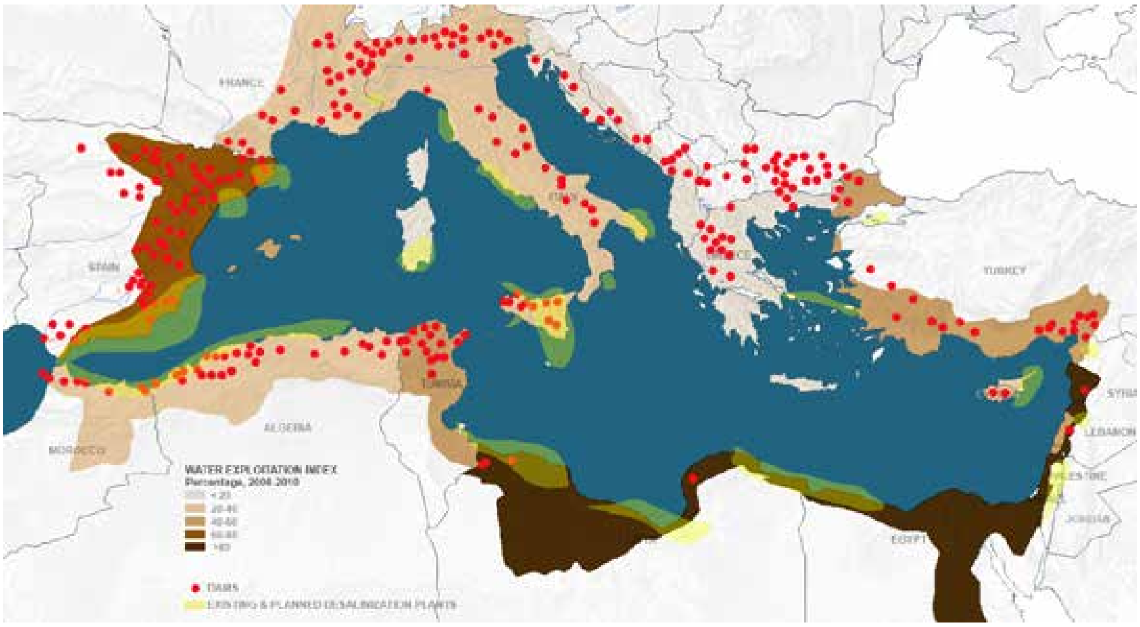
Zolnikov, T. R. (2019). *Global adaptation and resilience to climate change*. Cham: Springer International Publishing. doi:10.1007/978-3-030-01213-7

APPENDIX I

The Mediterranean Landscape: Rivers & Streams, and the Marine Environment

Blondel (2006) describes how Mediterranean landscapes are "designed landscapes," meaning that their current state of art is a result of the continuous interaction between humans and their land, resulting in a "mosaic of cultural landscapes" layered atop of each other. Blondel argues that Mediterranean landscapes are resilient, which is a main reason they host much diversity (ibid.). Two views exist on the theory of disturbance initiated by humans and resultant diversity: 'The Lost Eden theory' stresses that human actions have degraded and depleted resources of Mediterranean landscapes, leading to their desertification and loss of its lush forest-cover; and the 'co-evolution' theory which states that humans haven't necessarily degraded 'Mediterranean forests', which could have resembled savannahs more than lush forests (Naveh & Lieberman, 1994; Blondel, 2006). Arguably, a level disturbance often generates diversity rather than homogeneity until a certain threshold is crossed (Farina, 2006), which probably contributes to the high level 'structural heterogeneity' of Mediterranean landscapes, where Mediterranean terrestrial ecosystems host approximately 20% of earth's species (Crowling et al., 1996). As forests decreased in the Mediterranean landscape, erosion and runoff increased, leading to the need for sustainable water and fire management techniques, such as water channeling and diversion, and agricultural terracing to hold more water and decrease erosion, all notable features of current Mediterranean landscapes.

The Mediterranean drainage basin comprises more than 160 rivers within a catchment area greater than 200 square km (Anthony et al., 2014). Mediterranean catchment basins were found to be the most anthropogenically altered basins in any climatic zone (ibid.), resulting in high sediment budget fluctuations and water influx into the basin. Around the Mediterranean basin, a high seasonality and inter-annual patterns of precipitation and temperature fluctuations with hot and dry summers and wet, mild winters leads to wide array of species adapted to these conditions, with high fluctuations in their yearly abundance (Bonada & Resh, 2013). However, with rapid changes to river basins coupled with climatic changes, Mediterranean rivers are reportedly experiencing some of the most rapid losses of freshwater biodiversity in the world (Moyle & Leidy, 1992; Grantham & Figueroa & Prat, 2012).



A map sowing water exploitation along the Mediterranean basin, planned desaliniation plants, and dams

Source: Adapted from Blue Plan, A Sustainable Future for The Mediterranean (2005) for water exploitation index & desalinization plants; and from the Global Reservoir and Dam Database (Lehner et al., 2011).

Many freshwater species that are endemic to Mediterranean rivers have also declined, with increasing intrusion of exotic species that find it easy to colonize after extreme water events such as floods or droughts (Davis et al, 2000; Marr et al., 2013). Human activities such as water abstraction have also disrupted habitat connectivity, compromising waterways that were previously linked (Bonada & Resh, 2013).

Water exploitation levels are highly pronounced in the Southern and Eastern zones of the basin, mostly linked to intensive agricultural practices and densely populated areas. Planned and existing desalinization plants are found throughout the basin with less concentration in the Northern zone. Increasing desalinization practices can have a profound effect on the salinity levels of the basin, as resultant salt from the process is often dumped back into the sea.

The presence of dams and their effects on annual water discharge and sediment discharge are shown in the table below. Three of the largest rivers flowing into the Mediterranean have experienced a loss of approximately 90% in their sediment discharge, starving the shores and probably accelerating coastal erosion. Moreover, small rivers shouldn't be neglected in their contribution to sediment flux into the Med. Basin, because cumulatively they largely impact the influx of sediment into the basin.

Large Rivers:	Water Discharge (km^3/yr)		Sediment Discharge (Mt/yr)		Sediment loss
	pre-dam	post-dam	pre-dam	post-dam	(%)
Rhone, France	54		59	6.2	89
Ceyhan, Turkey	7		5.5	4.8	13
Nile, Egypt	80	<30	120	2	98
Ebro, Spain	50	17	18	1.5	92
Small Rivers:					
Pescara, Italy	1.7	0.9	2.1	1.2	45
Semani, Albania	5.6		30	16	47

Pre and post-dam conitions of some Med. Rivers and its influence on yearly annual water discharge and sediment discharge.

Source: Adapted from Milliman & Farnsworth (2011)

High mountains of more than 1000m in height closely border the sea, mostly in Turkey, Lebanon, Italy, Southern France and Southern Spain. In 1976, the mean rate of evaporation was 125 cm per year, leading to a high salinity of water (37-39%), and to a deficit between evaporative rates and water inputs, leading to a decrease in sea level and consequentially the inflow of water from the Atlantic Ocean and Black Sea (Emel′i͡anov & Shimkus, 1986). With the opening of the Suez canal in 1869, many alien species (>500– such as macrophytes, invertebrates, and fish) have migrated into the Med. Sea (Fig.3.3), termed Lessepsian migration (Galil, 2007). The ecological impact of these alien species on native Mediterranean species is poorly explored, however no extinction of natives has been recorded (Boudouresque, 2004). In certain cases, some alien species have predated on alien predators and aided in clearing waters of surplus algal blooms, such as the rab-bitfish. However, in other scenarios, alien species have had negative effects on species richness diversity levels (Galil, 2007). This might be attributed to the fact that the highest percentage of marine species in the Mediterrnaean basin occupy the depth range of 0-10m (Coll et al., 2016), leading to a higher sensitivity to the gradual warming of the sea and other anthropogenic impacts.

Studies on marine water quality have used indicators such as anthropogenic stress gradient, benthic macrophytes (Orfanidis et a., 2014), as well as vermetid reefs being used as indicators for sea-level and sea surface temperature (Montagna et al, 2008).

Distribution of endemic fish species in the Mediterranean Sea

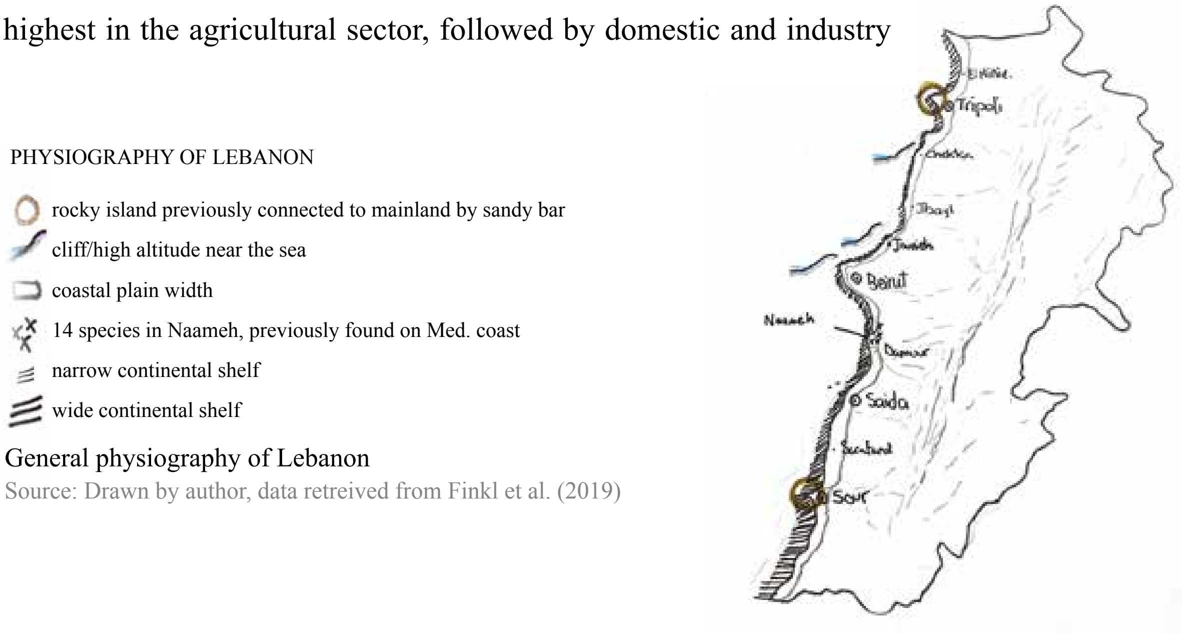
Distribution of alien fish species in the Mediterranean Sea

Source: Adapted from Coll, et al. (2016)

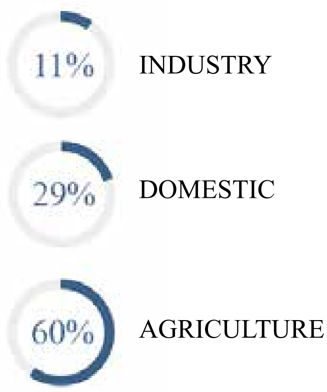
APPENDIX II

Geophysical and Hydrological Description of Lebanon

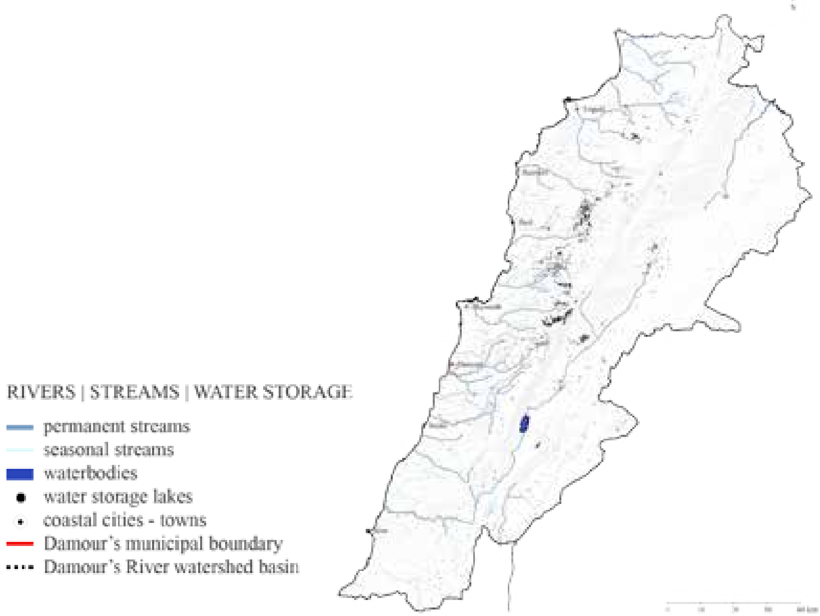
Around 15 rivers flow East to West unto the Mediterranean Sea, including Nahr El Kebir, which defines the Lebanese-Syrian border. The rivers have been the main attractors of settlements throughout history, and today harbor the four major coastal cities: Beirut, Saida, Tyre, and Tripoli. Moreover, agricultural fields, mainly as fruit orchards, have been established on the soft sloping coastal plains adjacent to streams. Water demand is highest in the agricultural sector, followed by domestic and industry



General physiography of Lebanon
Source: Drawn by author, data retreived from Finkl et al. (2019)



Annual water demand by sector
Source: Adapted from MOE/ UNDP/ECODIT (2011)

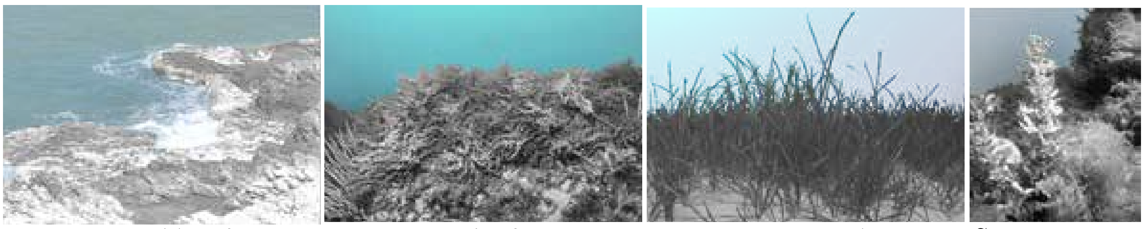


Rivers, streams, and water storage lakes in Lebanon
Source: produced by author from data collected from CDR (2005)

APPENDIX III

Marine Ecosystems in Lebanon

In Lebanon, there are four main marine ecosystems as outlined by Badreddine (2018), which are Vermetid reefs, Cystoseira forests, Seagrass meadows, and seagrass beds. Vermetid reefs are mostly found on rocky shores, and have a high ecological value for their role in productivity, biodiversity, spaces for refuge, and nursery areas for many marine species (ibid.). As previously mentioned, they also act as bioindicators of global changes, namely rising sea levels and surface seawater temperature (Galil, 2007; Badreddine, 2018). Vermetid reefs include Dendropoma spp., often in association with Vermetus triquetrus, and Coralline algae (Badreddine, 2018). Dendropoma anguiliferum, cystoseira spp., and sargassum spp. are actually endemic species to the Levant basin, and are threatened ecosystems (Galil, 2013; Milazzo et al., 2017). Shallow large brown algae, also known as Cystoseira forests, have a habitat-forming role, where Cystoseira rayssiae is endemic to Lebanon (Badreddine, 2018).



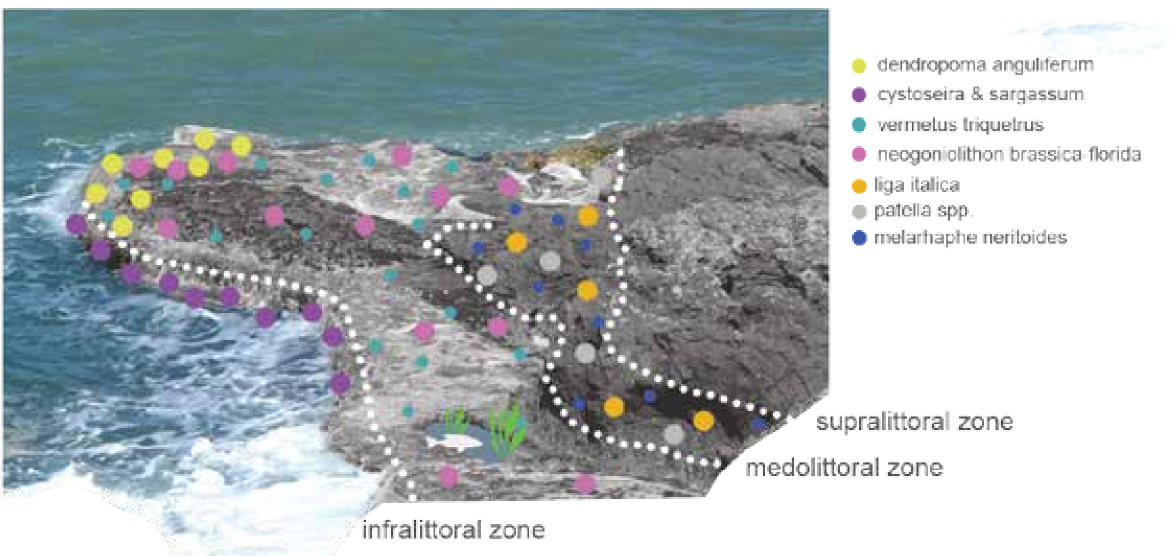
Vermetid reefs | Cystoseira forests (brown algae) | Seagrass meadows | *Sargassum spp.*

Four main marine ecosystems found in along the Lebanese coast
Source: Images edited by author based on Badreddine et al. (2018)

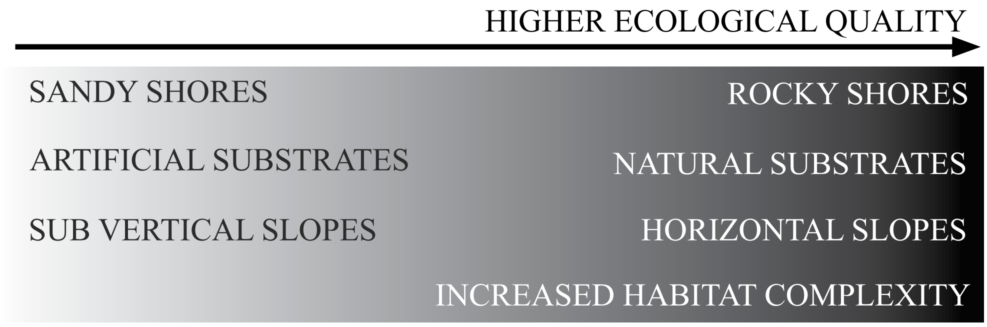
On the Lebanese shore, both habitat complexity, i.e. substrate complexity, and depth were main factors of species richness and abundance of littoral fish species (Harmelin-Vivien et al., 2005). This study on Lebanese rocky shores conducted in 2005 concluded that increased diversity and density was observed on rocky substrates, followed by macroalgal and seagrass beds, and was least on sandy shores. Finally, abundance of lessepsian fishes was highest among herbivores, where they dominated shallow waters (<12m depth), however not excluding other native species at those depths (ibid.).

Of these herbivorous fish, one species has successfully adapted to the Eastern Mediterranean, Siganus rivulatus (rabbitfish), a fish with a high market value that is promising in aquacultures (Saoud, Ghanawi, & Lebbos, 2007), possibly enhancing this economy in the Eastern Mediterranean.

In a study conducted on macroalgal species along the Lebanese coast, Badreddine et al. (2018) concluded that coastal slopes, and the artificial vs. natural status of substrates mostly affect these species, where natural substrates and horizontal slopes yielded highest ecological quality values. In Saadiyat, the coastal area between Damour and Jiye that is mostly rocky, Ecological Status (ES) of macroalgal assemblages was analyzed as moderate, considering Nakkoura as the comparative baseline zone (an area lacking much anthropogenic impacts) (ibid.).



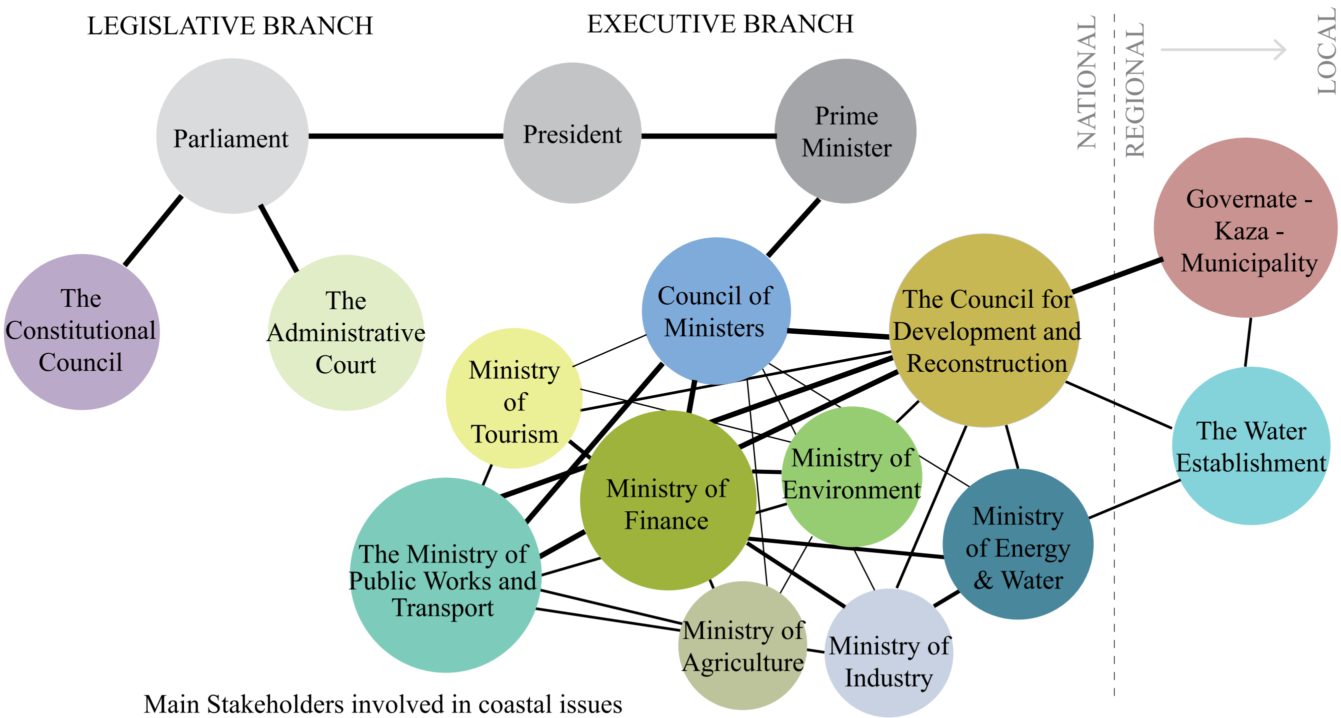
Species distribution along vermetid reefs in Lebanon
Source: Drawn by author based on Badreddine et al. (2018)



General conclusion of findings on shore morphology and ecological quality
Source: Drawn by author based on Badreddine et al. (2018)

APPENDIX IV

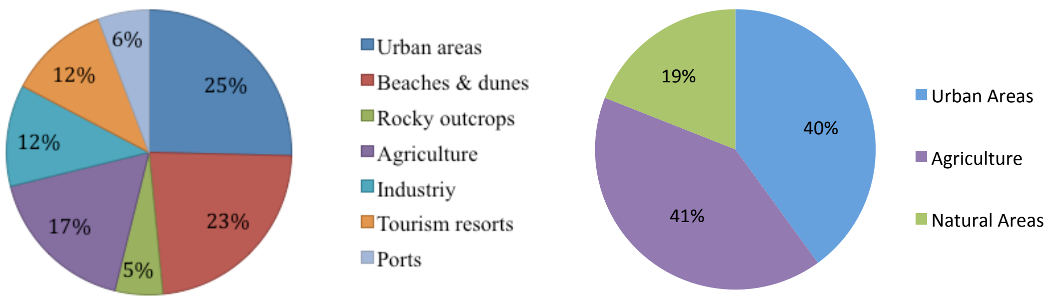
Overview of Planning & Policy: Current Unsustainable Practices in Lebanon



Main Stakeholders involved in coastal issues

Source: By author

Till today, the coastal region isn't delineated, and is ill-defined by public authorities and in the National Physcial Master Plan of the Lebanese Territory (NPMPLT). The NPMPLT considers the coastal region as "including the West side of Mount Lebanon between 0-800m in altitude, as well as the vast zones of North and South Lebanon" (DAR-IAURIF, 2005, pg. 18). The NPMPLT simplifies the ambiguity of the delineation of the coastal area by considering the 50m stretch from the coastline as the basis for their study. In effect, confusion arises as different studies delineate the coastal region arbitrarily, for example, Assaf (2009) considers the coastal region as a 500m offset of the coastline, while others such as MoE/UNDP/ECODIT (2011) consider it as a 800m offset. This yields different statistics of the same subject retarding efforts to strategically plan the coast.



Coastal landuse data comparison between different sources of data due to lack of a defined coastal region

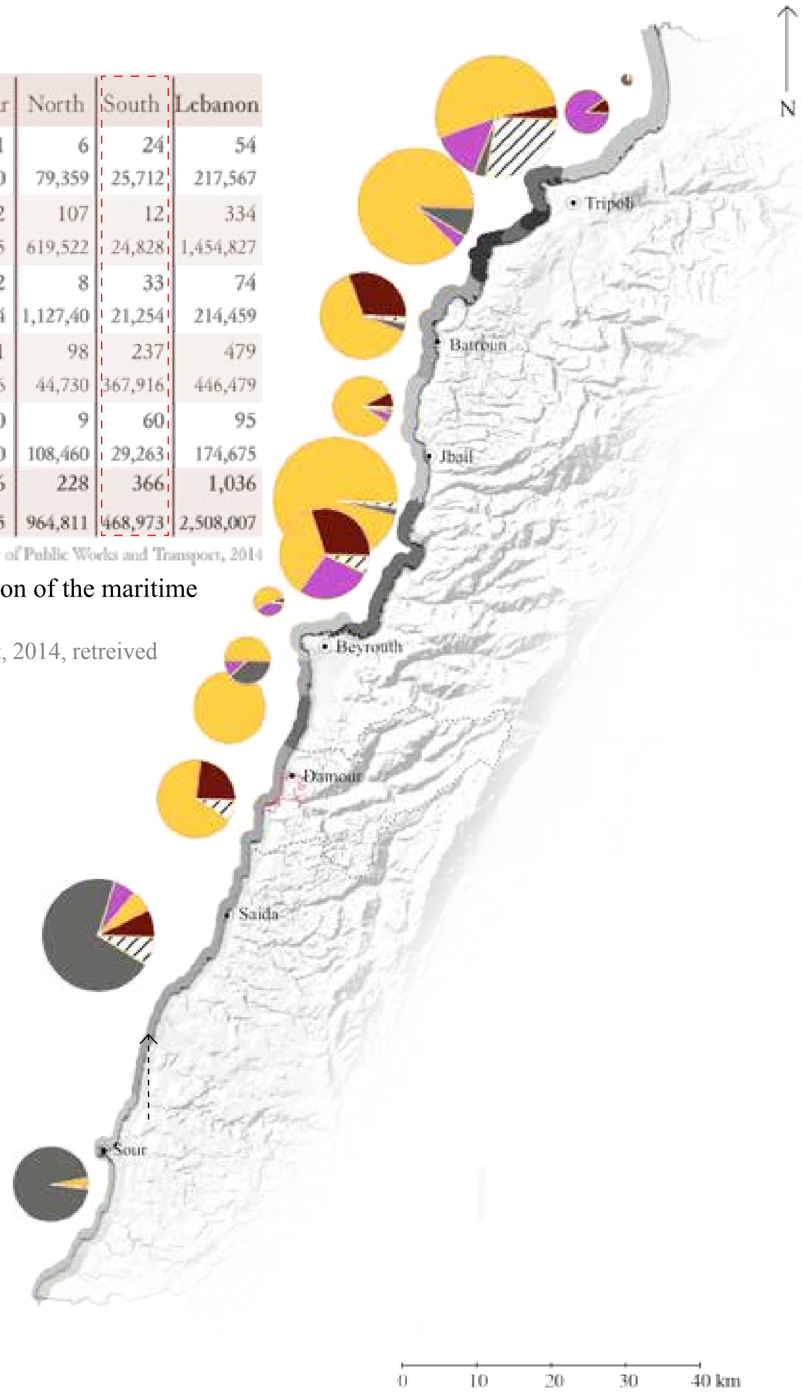
Source: left: adapted from (Assaf, 2009); right: NPMPLT, DAR-IAURIF (2005)

Type of violation		Beirut	Mount Lebanon	Akkar	North	South	Lebanon
Industrial activities	Number	3	20	1	6	24	54
	in sq. m	1,127	111,289	80	79,359	25,712	217,567
Tourism activities	Number	10	203	2	107	12	334
	in sq. m	13,056	796,576	845	619,522	24,828	1,454,827
Commercial activities	Number	8	23	2	8	33	74
	in sq. m	9,137	711,94	134	1,127,40	21,254	214,459
Residential areas	Number	8	115	21	98	237	479
	in sq. m	469	30,048	3,316	44,730	367,916	446,479
Unspecified	Number	1	25	0	9	60	95
	in sq. m	180	36,772	0	108,460	29,263	174,675
Total	Number	30	386	26	228	366	1,036
	in sq. m	23,969	1,045,879	4,375	964,811	468,973	2,508,007

Source: Ministry of Public Works and Transport, 2014

Fig. 3.39. Type and area of illegal occupation of the maritime public domain.

Source: Ministry of Public Works and Transport, 2014, retreived from Verdeil et al. (2019)



TYPE OF ILLEGAL

OCCUPATION OF THE COAST

- tourism
- industry
- commercial
- residential
- other

illegally occupied area in m² by km of coastline

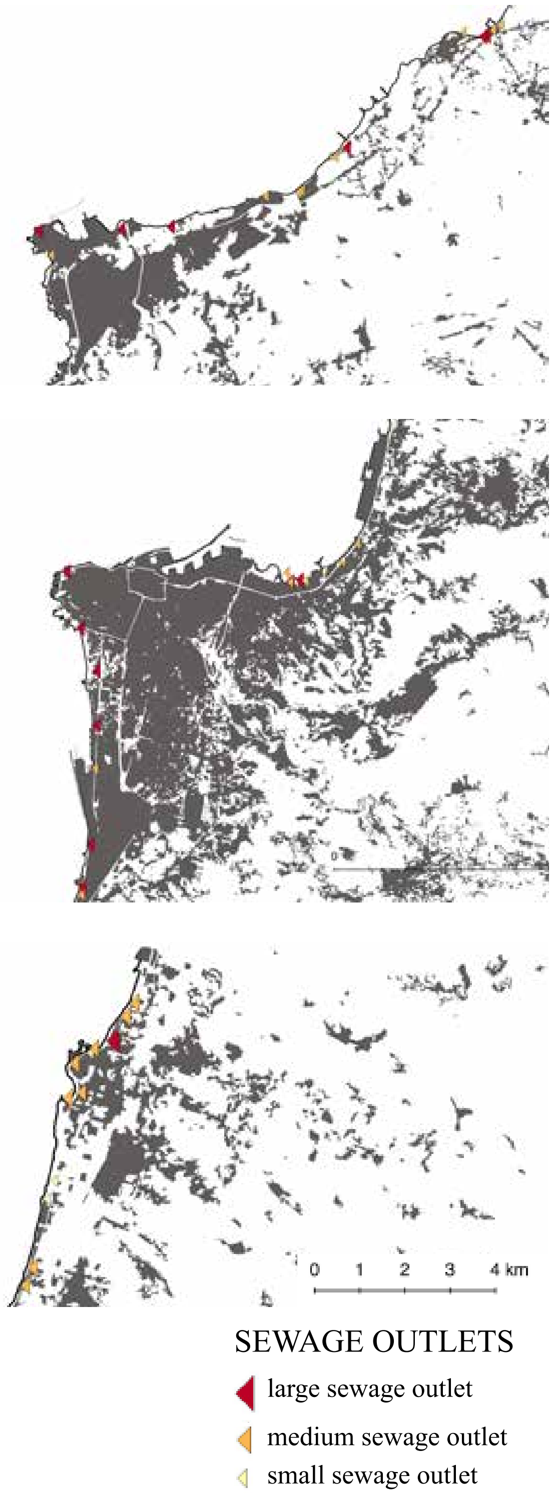
250 5,000 10,000 15,000 20,000

Type and area of illegal occupation of the coast

Source: Edited by author, based on data from Ministry of Public Works and Transport, 2014, retreived from Verdeil et al. (2019)

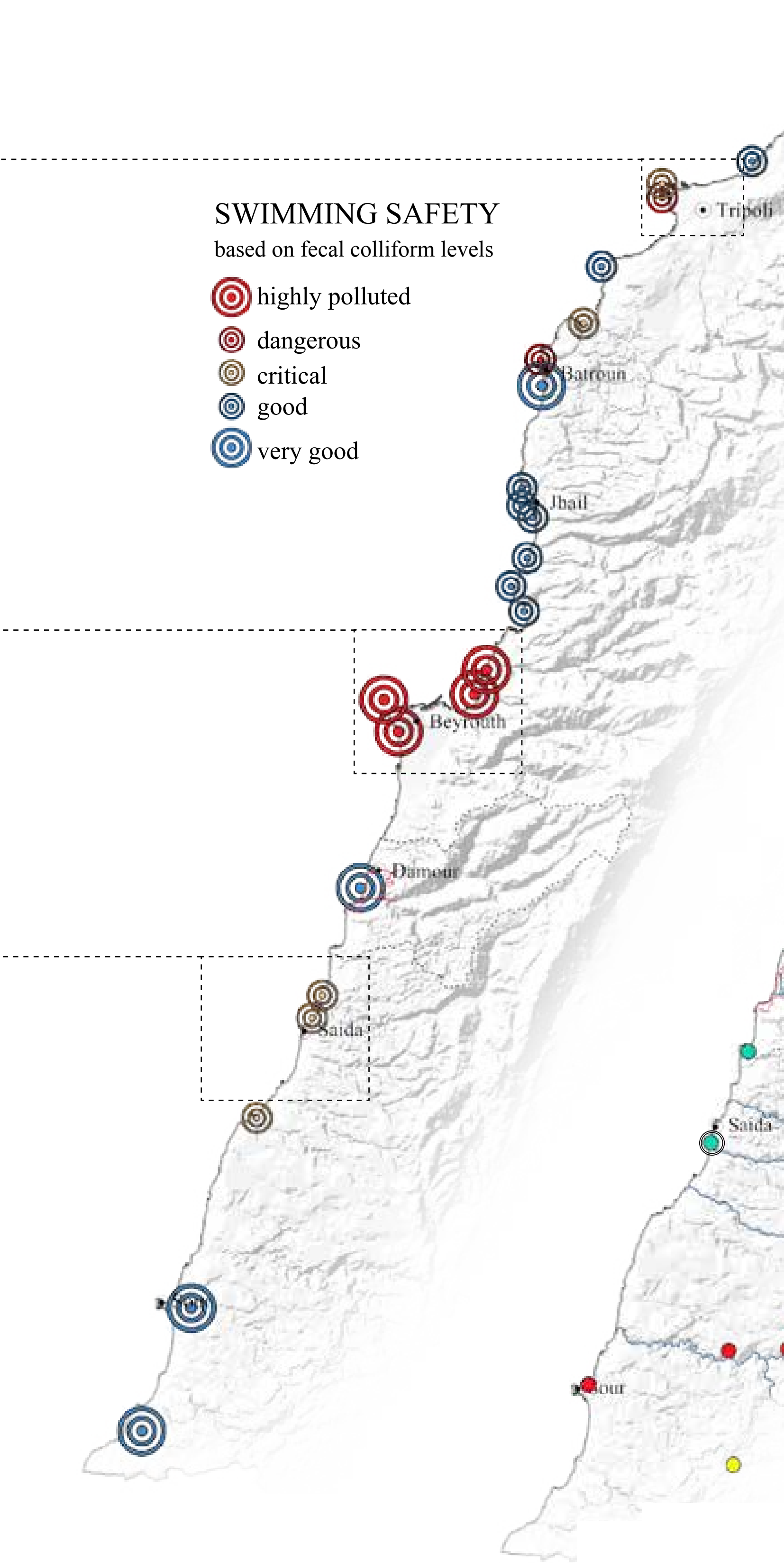
Sewage and waste water flow freely unto Mediterranean coastal waters, and sometimes inland along water bodies and river valleys. It's estimated that around 248 million m^3 of municipal waste water enters the sea or inland waters without prior treatment, equivalent to approximately 120,000 tons of BOD (Bio-oxygen demand (Sarhan & Arif, 2011). 52 waste water treatement plants are planned in Lebanon, however to date only 11 are operational, 3 of which are on the coast. Studies show that much of this wastewater can be treated and re-used, alleviating pressures from water shortage which are projected to escalate with climatic changes in the region (MoEW/ UNDP, 2014).

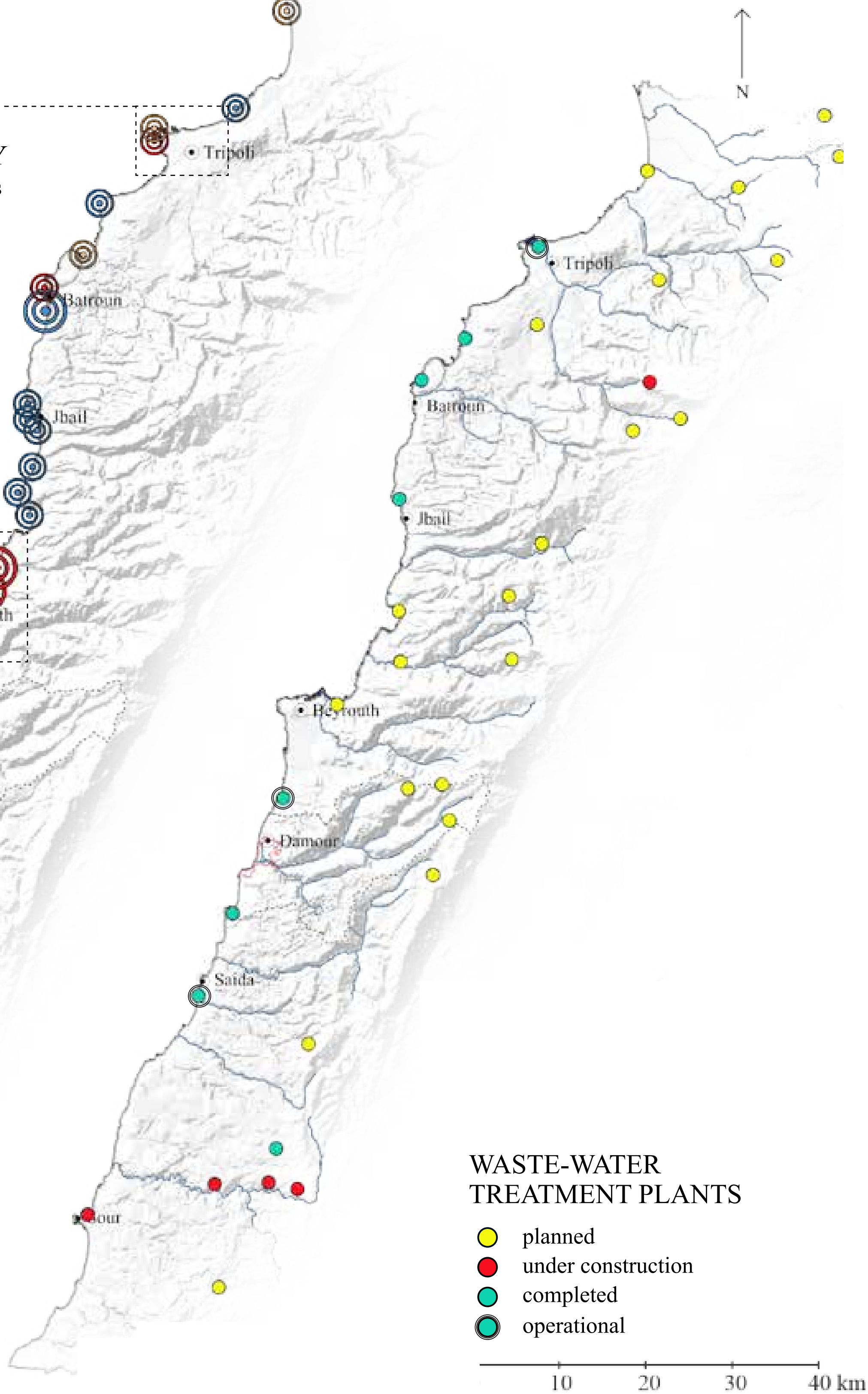
Swimming and tourism has been severely affected by alarming rates of pollution along the coast, also impacting marine life and fishing. The National Centre for Marine Sciences (2019) released a map showing safe and unsafe areas to swim in for the summer of 2019. Most unsafe areas are found near sewer outlets in major coastal cities resulting in high levels of fecal colliform.



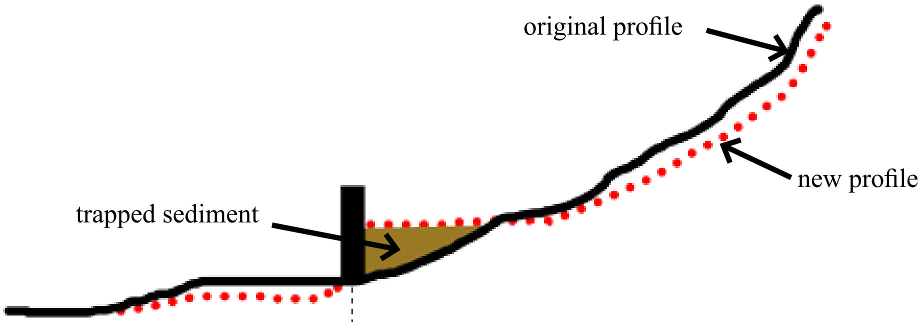
Sewage outlets along the coast.

Source: Drawn by author, data from CDR (2005)





Source: Drawn by author, data retreived from CNRRS National Center for Marine Sciences (2019)



downstream effects:
deepening and narrowing of river channel
"hungry waters" i.e. more eroding capactiy
less sediment delivery to deltas & coastal areas
limited groundwater recharge

↓

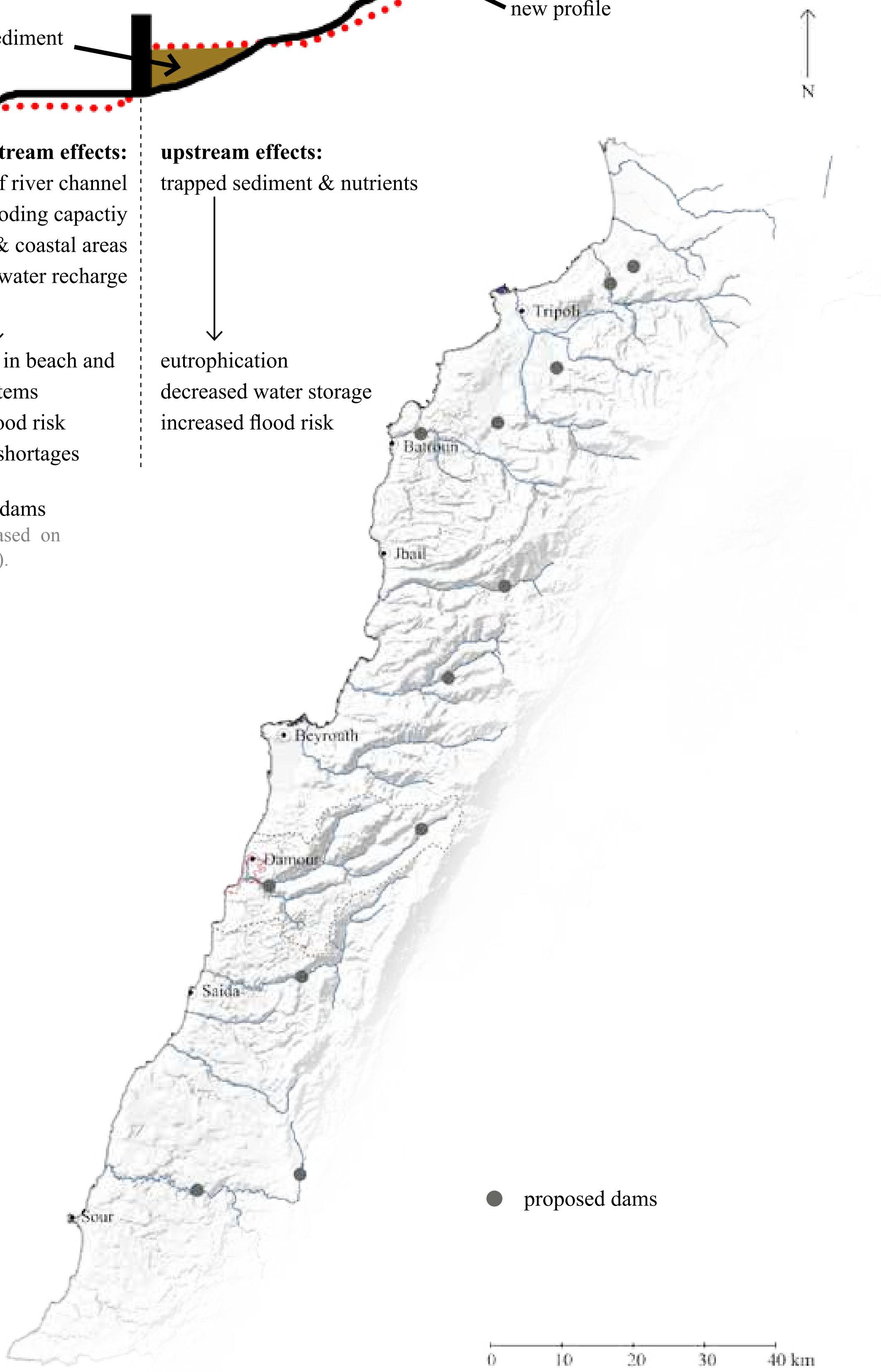
increased erosion in beach and dune systems
increased flood risk
risk of water shortages

upstream effects:
trapped sediment & nutrients

↓

eutrophication
decreased water storage
increased flood risk

Fig. 3.34. Effects of dams
Source: By author, based on (Schleiss et. al, 2016).



Source: By author, based on data retreived from CDR(2005)

APPENDIX V

Maritime Public Domain Law S-144, 1925

قرار رقم 144 /S تحديد الاملاك العمومية صادر في 10/6/1925

ان الجنرال سراي المفوض السامي للجمهورية الفرنساوية لدى دول سوريا ولبنان الكبير وبلاد العلويين وجبل الدروز،
بناء على مرسومي 23 ت2 سنة 1920 و 29 ت2 سنة 1924،
وبناء على تقرير اللجنة المؤلفة بموجب الامر عدد 2573 الصادر في 16 ايلول سنة 1924،
وبناء على اقتراح امين السر العام،
يقرر ما يأتي:

الفصل الاول - تحديد الاملاك العمومية

المادة 1 - تشمل الاملاك العمومية في دولة لبنان الكبير ودولة العلويين جميع الاشياء المعدة بسبب طبيعتها لاستعمال مصلحة عمومية.
وهي لا تباع ولا تكتسب ملكيتها بمرور الزمن.

المادة 2 - تشتمل الاملاك العمومية على الاخص على الاملاك المذكورة ادناه بدون ان يمنع ذلك تطبيق المادة الثالثة من هذا القرار:

1 - شاطئ البحر حتى ابعد مسافة يصل اليها الموج في الشتاء وشطوط الرمل والحصى.
- الغدران والبحريات المالحة المتصلة رأسا بالبحر.
- مجاري المياه من اي نوع كانت ضمن حدودها المعينة بخط ارتفاع مياهها الجارية في حالة امتلائها قبل فيضانها.
- المياه الجارية تحت الارض والينابيع من اي نوع كانت.
- كامل ضفاف مجاري المياه اي القطعة من الارض الكائنة على طول مجاريها والتي تمكن من السهر عليها وتنظيفها والمحافظة عليها.
- البحريات والغدران والبحرات ضمن حدودها المعينة بموجب مستوى اعلى ما تصل اليه المياه قبل فيضانها ويضاف اليها على كل ضفة للمرور قدرها عشرة امتار عرضا ابتداء من هذه الحدود.
- الشلالات الصالحة لتوليد قوة محركة.

2 - اقنية الملاحة وطرقاتها التي تسحب منها المراكب في مجراها واقنية الري والتجفيف والتقطير وكامل ضفافها وقناطر الماء عندما تكون تلك القناطر منشأة للمصلحة العمومية وكذلك توابع هذه الانشاءات داخلة ايضا في الاملاك العمومية.
- السدود البحرية او النهرية والاسلاك التلغرافية على الشواطئ (السيمافور) وانشاءات التنوير او العلامات البحرية وتوابعها.
- الخطوط التلغرافية والتلفونية وتوابعها التي تستثمرها مصلحة عمومية.
- انشاءات التحصين والمراكز الحربية او المراكز العسكرية.

3 - الطرقات والشوارع والممرات والخطوط ووسائل المواصلات من اي نوع كانت وتوابعها ما عدا الانشاءات التي يقوم بها الافراد لحاجاتهم الخصوصية.
- السكك الحديدية والترامولايات وتوابعها.
- المرافئ والفرض البحرية والخلجان.
- الانشاءات المشيدة للمنفعة العمومية ولاستخدام القوى المائية ونقل القوة الكهربائية.

المادة 3 - ان الاشخاص الذين لهم على ملحقات الاملاك العمومية كما هي محددة في هذا القرار حقوق ملكية او تصرف او استمتاع بموجب العادات المتبعة او سندات قانونية ونهائية قبل وضع هذا القرار موضع التنفيذ لا يمكن انتزاعها منهم اذا احوجت الى ذلك المنفعة العمومية الا بعد تعويض عادل ومسبق.

APPENDIX VI

Maritime Public Landuse Law, 1966

نظام إشغال الأملاك العامة البحرية مرسوم رقم 4810 - صادر في 1966/6/24

ان رئيس الجمهورية اللبنانية،
بناء على الدستور اللبناني،
بناء على القانون التنظيم المدني الصادر في 24 ايلول 1962 المعدل بموجب مشروع القانون الموضوع موضع التنفيذ بموجب المرسوم رقم 13472 تاريخ 1963/7/26،
بناء على قرار المجلس الاعلى للتنظيم المدني المتخذ بجلسته المنعقدة بتاريخ 1966/5/12 (محضر رقم 20) وتاريخ 1966/5/26 (محضر رقم 22)،
بناء على اقتراح وزير الاشغال العامة والنقل بعد استشارة مجلس شورى الدولة،
وبعد موافقة مجلس الوزراء بجلسته المنعقدة بتاريخ 8 حزيران 1966.
يرسم ما يأتي:

المادة 1 - معدلة وفقا للمرسوم رقم 1300 تاريخ 1978/5/15 والمرسوم 3543 تاريخ 1980/10/16
تبقى الاملاك العامة البحرية باستعمال العموم ولا يكتسب عليها لمنفعة احد اي حق يخول اقفالها لمصلحة خاصة.
اما السماح بتخصيص جزء من الشاطئ لاستعمال افراد او مجموعات وحصر هذا الانتفاع بهم دون سواهم يكون عملا استثنائيا يمكن تطبيقه في حالات خاصة تخضع للاسس العامة التالية:
أ- الاسس العامة المفروضة في حال السماح باستثمار الشاطئ البحري:
1- يجب ان يكون المشروع المنوي القيام به ذا صفة عامة وله مبررات سياحية او صناعية حسب افادات تصدر عن الدوائر المختصة (المجلس الاعلى للتنظيم المدني).
2- ان لا يشكل الاستثمار المطلوب عائقا لوحدة الشاطئ في حال وجود مساحات يتوجب ابقاؤها مفتوحة للعموم.
3- ان لا يسمح بانشاءات دائمة على الاملاك العامة البحرية سوى ما يعود منها للتجهيزات الرياضية والتنظيمية وملحقات الانشاءات التي يتوجب ايجادها قريبة من الشاطئ على ان لا يتعدى معدل الاستثمار السطحي لهذه التجهيزات 5% وان لا يعلو البناء فوق مستوى الاملاك العامة البحرية اكثر من ستة امتار مع عامل استثمار اقصى 0.075،
4- ان ينشأ هذا المشروع وفقا لوجهة استعماله في المناطق المصنفه للسياحة والفنادق او للصناعة وذلك بسبب تنظيم الشواطيء اللبنانية (وتعتبر الخرائط المرفقة بالمرسوم رقم 4809 تاريخ 1966/6/24 جزءا لا يتجزأ من هذا المرسوم).
لا يمكن استثمار الاملاك العامة البحرية للمشاريع الصناعية ضمن المناطق المخصصة لها لهذه الغاية وان تستوجب بطبيعتها استثمار الاملاك العامة البحرية. ويحصر فقط الاستثمار للمساحة من الاملاك العامة البحرية اللازمة للانشاءات الواجب ايصالها الى مياه البحر ضمن النسب المحددة اعلاه.
5- ان يلحظ المشروع المقدم تفاصيل فنية ومبررات تبين المساحات المنوي تخصيصها لكل نوع من الرياضة ونسبة مساحة غرف السباحين والمساحات الحرة في الاملاك الخاصة وكذلك المساحات الحرة لكل شخص كما وعلى المشروع ان يلحظ حركة السير ومواقف السيارات المعدة لزبائن المؤسسة وغيرها من التجهيزات والنسب وكل ذلك ضمن النسب التي تحددها الادارة.
6- على طالب الترخيص ان يكون مالكا لعقار متاخم للقسم المراد اشغاله من الاملاك العامة البحرية.
لا تعتبر الطرق العامة والسكك الحديدة ضمن نطاق هذا النظام فاصلا بين الاملاك الخاصة والاملاك العامة البحرية في حال سماح المختصة عبور هذه الطرق او السكك بواسطة نفق او جسر.
ان مساحة الاملاك العامة البحرية المنوي اشغالها يجب الا تزيد عن ضعفي مساحة العقار الخاص المتاخم وان لا تزيد واجهة هذه الاملاك عن واجهة العقار الخاص المتاخم.
وفي حال وجود طريق عام يؤدي الى البحر لا يمكن اشغال الاملاك العامة البحرية الممتدة على طول خمسين /50/ مترا من محور الطريق وتترك هذه الفسحة للعموم.
الا انه يمكن الترخيص باشغال الاملاك العمومية البحرية والمياه الاقليمية، دون ان يكون طالب الترخيص مالكا لعقار متاخم للقسم المراد اشغاله، اذا كان طلب الترخيص يعود لاقامة مشروع سياحي متكامل على متن سفينة سياحية كبيرة محتوية على تجهيزات سياحية ضخمة قابلة لاستعمالها كفندق وملاهي ومطاعم واماكن للتسلية، شرط ان تكون المساحة المطلوب اشغالها متاخمة لطريق عامة وان يتم تحديدها بموجب خرائط على ضوء حاجة المشروع موضوع الترخيص.
ب- الشروط المتوجب توفرها في العقارات الخاصة ضمن نطاق المنطقة السياحية والمتاخمة للاملاك العامة البحرية ليسمح لها باشغال الاملاك العامة:

ملاحظة: ان التراجع عن العقارات المجاورة المنصوص عليه اعلاه لا يشمل الحد الفاصل بين الاملاك العامة البحرية والعقار الخاص المتاخم لها موضوع مشروع الاستثمار.
يسمح بتخفيض الطول او العمق الادنيين عن ما هو محدد اعلاه بنسبة لا تتعدى العشرة بالمائة 10% شرط ان يقابلها زيادة في مساحة اعقار بنفس النسبة ، ولا يستفيد افراز العقارات من هذا التسامح.

ج- شروط منح الرخصة: تمنح رخصة بناء المؤسسات المبينة اعلاه على مرحلتين:
المرحلة الاولى:
بعد تقديم المشروع الاجمالي والوثائق اللازمة والموافقة عليها من قبل المديرية العامة للتنظيم المدني يرخص لصاحبها بالقسم الواقع منها على الاملاك الخاصة.
يجب ان يحتوي المشروع على بيان تفصيلي بمواد البناء المنوي استعمالها وكشف تقديري بقيمة الاشغال.

المرحلة الثانية:
بعد اتمام هيكل الانشاءات المرخص بها في المرحلة الاولى والتاكد من مطابقتها لمستندات المشروع، يرخص باشغال الاملاك العامة البحرية وبناء الانشاءات التي تكون قد سبق للادارة ان وافقت عليها في المشروع الاجمالي.

د- احكام مختلفة:
1- في حال تعذر تطبيق هذه الشروط من الناحية الفنية على مشروع ما، يمكن الشذوذ عنها باستثناء عامل الاستثمار الاقصى بمرسوم يتخذ بناء على اقتراح وزير الاشغال العامة والنقل بعد طلب صاحب المشروع وموافقة المجلس الاعلى للتنظيم المدني، وفي هذه الحال يمكن للادارة فرض شروط فنية اضافية.
2- يحظر اشغال الاملاك العامة البحرية:
أ- في المناطق الخارجة عن المناطق السياحية والصناعية المحددة على الخرائط المرفقة بالمرسوم رقم 4809 تاريخ 1966/6/24 العائد لتنظيم منطقة الشواطئ.
ب- في المنطقة العاشرة في مدينة بيروت.
3- يسمح باشغال الاملاك العمومية البحرية وفقا للشروط الواردة في هذا المرسوم في المناطق المنظمة سابقا، غير المذكورة اعلاه، وفي المناطق التي تنظم بعد صدور هذا المرسوم، وذلك باستثناء عوامل الاستثمار والتراجعات التي يطبق بشانها ما هو محدد في نظام المنطقة الخاص المصدق تبقى سارية المفعول جميع انظمة الشواطئ المصدقة سابقا عندما لا تتعلق باستثمار الاملاك العامة البحرية.
4- تخفض الى الثلث المساحات الدنيا للقطع والطول الادنى للواجهة والعمق الادنى للقطعة المفروضة بموجب البند (ب) من المادة الاولى من هذا المرسوم، وذلك ضمن حدود مدينة بيروت باستثناء المنطقة العاشرة منها.

المادة 2 - ينشر هذا ويبلغ هذا المرسوم حيث تدعو الحاجة.

سن الفيل في 24 حزيران سنة 1966
الإمضاء: شارل حلو
صدر عن رئيس الجمهورية
رئيس مجلس الوزراء

الامضاء: عبد الله يافي

وزير الاشغال العامة والنقل
الامضاء: كمال جنبلاط