Institutionen för kulturgeografi och ekonomisk geografi

Course code: SGEL36

Title of the course: Examensarbete inom Kandidatprogrammet för samhällsplanering

Semester: VT23

Flooding Vulnerability and Adaptation

Spanish policy relevance in Swedish climate adaptation under RCP 8.5 Conditions

Author: Carl Ludvig Johansson

Supervisor: Nicklas Guldåker

Abstract

This study sets out to investigate the vulnerability to coastal flooding in the Spanish city of Valencia, aiming to evaluate its adaptive capacity over time to understand how successful lessons may be learned and transferred to a Swedish planning perspective. The study utilized various indexing systems to analyze and measure the climate and multivariable vulnerability as well as the adaptive capacity. Supplemented with qualitative interviews with expert stakeholders and various analyses for interpretation and processing of data. The study found medium levels of vulnerability in the study area and an overall positive increase in adaptive capacity overtime despite severe climate intensification accompanied by other adverse events. The study concludes on identified policy and practice implications which despite simplified study methodology has found to potentially complement not only Swedish urban planning in both hard, soft and collaborative practice in the adaptation to coastal inundation. The results of the study are not solely restricted to the Swedish context and may have policy implications in other coastal cities susceptible to the effects of intensified coastal inundation.

1. Introduction 5
1.1 Challenges for Urban Planning under RCP 8.5 & Coastal Inundation 5
1.2 City and Regional Characteristics 5
1.3 Valencia: History of Flood & Policy 7
1.4 Aim of Thesis 8
1.5 Research Questions 9
1.6 Limitations 9
2. Literature Review & Theoretical Framework 10
2.1 Central Terminology 10
2.2 Adaptive Capacity Strategies 11
2.3 Environmental Perspective in Coastal Inundation 13
2.3.1 The Process of Coastal Inundation 13
2.3.2 Representative Concentration Pathway 8.5 13
2.4 Governmental Practice & Public Policy 14
2.4.1 ARCH Report 15
2.4.2 SECAP Report 15
3. Methods and Materials 16
3.1 Coastal Territorial Vulnerability Index (CTVI) 17
3.1.1 Morphological factors 17
3.1.2 Land Value 18
3.1.3 Public Area / Critical Infrastructure 19
3.1.4 Building Quality 20
3.1.5 Calculations, Aggregation & Standardization 20
3.2 Coastline Change Detection & Climate Index 21
3.2.1 Change Detection 21
3.2.2 Climate Index 22
3.2.3 Hypsometric Analysis 23
3.3 Urban Adaptive Capacity Index (UAC) 23
3.3.1 Dimensions & Indicators 23
3.3.2 Information Entropy Analysis 25
3.3.3 Grey Relational Analysis 25
3.3.4 Aggregation 26
3.4 Interviews 26
3.5 Observational Study 26
3.6 Analyses 26
4. Analysis 28
4.1 Implications & Meaning of the Coastal Vulnerability in El Cabanyal 28
4.1.1 Social and Demographic Vulnerabilities 29

4.1.2 Critical Infrastructure and Protection 31
4.1.3 Land Morphology and Associated Physical Vulnerabilities 33
4.1.4 The Role of Intensified Climate and Extreme Weather Events upon Coastal Vulnerability and Cabanyal 34
1. Anthropogenic Effects and Environmental Influence 34
2. Intensification of Extreme Weather Events 37
4.2 Adaptive Capacity Measures in Valencia 42
4.1.1 Changes in the Adaptive Capacities of Valencia Over Time & Accompanied Causes and Effects 42
1. 2005-2010 43
2. 2010-2015 44
3. 2015-2021 45
4. Future projections 46
4.2.2 What Adaptive Capacity Measures have been Implemented as of Today? 46
1. Physical & Other Hard Measures 47
2. Soft Measures 50
3. Collaborative Planning & Policies 52
4.2.3 How do the Adaptive Capacities Compare to the Overall Standard of the ICZM and Other Coastal Cities? 53
4.3 Identification & Transfer of Lessons Learned from Spanish Policymaking and Valencian Context 55
4.4 Discussion 57
4.4.1 Reflections on Policy Application in a Swedish Context 57
4.4.2 Methodology Limitations and Suggestions 58
5. Conclusions 58
6. References 59
7. Appendix 65
7.1 Interview Structure & Questions 65
7.2 Secondary Geodata Compilation 67

1. Introduction

1.1 Challenges for Urban Planning under RCP 8.5 & Coastal Inundation

Over the last 30 years the mean sea level rise of the Mediterranean region has kept a steady pace of 2,8mm per year, this period alone equates to an estimated increase of 84mm. According to the European center for weather forecasting (ECMWF, 2022), this hazard will only accelerate and together with an intensification of extreme weather events under the current and future climate, coastal inundations and yearly catastrophes will become a part of everyday life. Some scenarios predict that by the year 2100, the sea level rise is expected to reach yearly increases of 8-16mm. Which in the same interval of time would result in a sea level rise of half a meter by said factor alone. Placing millions of people at risk of displacement and endangering environments and livelihoods in coastal cities and regions throughout the world. The rising of the seas will persist, extreme weather events grow ever fierce in intensity and frequency.

Figure 1: Ruins of a house in the aftermath of coastal flooding, Spain (Kemirada, 2021)

These are but a few of the challenges awaiting the planners of tomorrow. A new reality in the face of climate change, in which none will go unaffected (ECMWF, 2022). Many cities throughout the Mediterranean region have a deep seated history of exposure to extreme weather events and severe climate. However not all possess the historical context and success story in risk reduction and strengthening of resilience as the city of Valencia. One may note early on, that the topic of climate change and coastal vulnerability to inundation is widely researched, as argued by Rocha et al (2023), however the question of learning and transfer of successful practices and policymaking is not. Thus in order to prepare Swedish policymakers and planners for the future climate challenges they will face, the study of Valencia, a city possessing characteristics and a climate similar to the south of Sweden, and what it will endure under the climate scenario RCP8.5. I argue that the findings of this study will, through a scientific and societal lens, provide valuable policy implications which may help to identify the shortcomings, and necessary adaptive measures to address future climate challenges in Swedish urban planning.

1.2 City and Regional Characteristics

The Valencian region is defined by its subtropical climate, with scorching, dry summers, followed by autumns and winters frequented by intense periods of precipitation and severe storms. As observed in figure 2, the effects of climate change have not gone unnoticed, with recent periods of severe drought and temperatures exceeding the 30 year mean and maximums (Meteoblue, 2023). Furthermore, as the study by Cabezas (2021) and figure 3 shows, every year the region experiences seasonal storms of a moderate to high intensity on the Dolan & Davis (1992) scale, making the hazards a frequent recurring part of everyday life and planning practice.

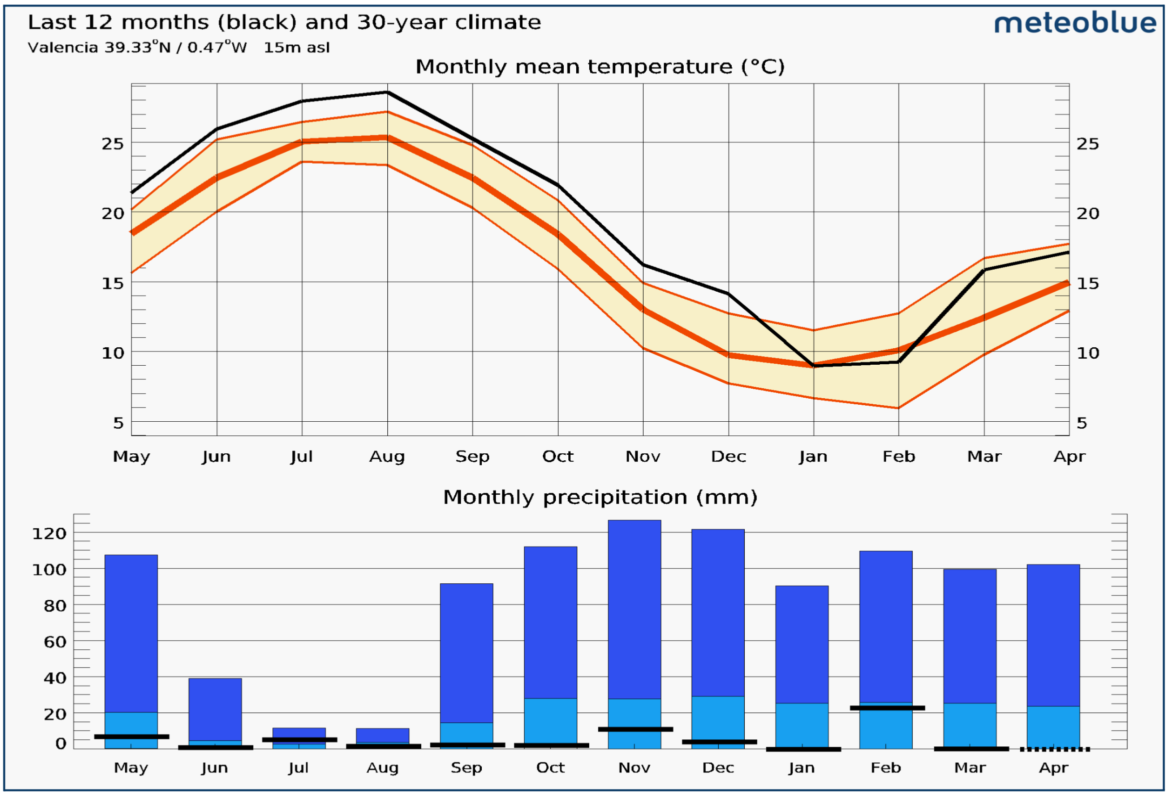

Figure 2: Yearly mean temperature and precipitation of Valencia in comparison to last 12 month observation (Meteoblue, 2023)

Valencia, as García et al (2020) explains, must be understood from its historical and contemporary cultural perspective in order to grasp the prioritizations and planning perspective. The city, in which the coastline has always been of great importance. From trading hub of silk, to an industry of shipbuilding and fisheries and the present day Valencia which is a hotspot for international tourism, the primary usage of the coast may have changed, but its importance to the city and its people has not. The culture, economy and social life of the city has always been intertwined with the coast, and such the policy and practice reflects this by actively aiming to preserve and strengthen these initiative and actors, as as seen in the policy reviews by Olcina et al (2016) and the report by García et al (2020). I therefore argue that a study in the Cabanyal neighborhood in Valencia, with historical ties to the fishing industry and despite a problematic social past, reflects a diverse socioeconomic and demographic profile of the city. Allowing for an all-encompassing which includes the exploration of social aspects, economic prioritization, tourism and an area whose terrain and topographic profile, as seen in figure 12, can be comparable to many coastal cities (García et al, 2020).

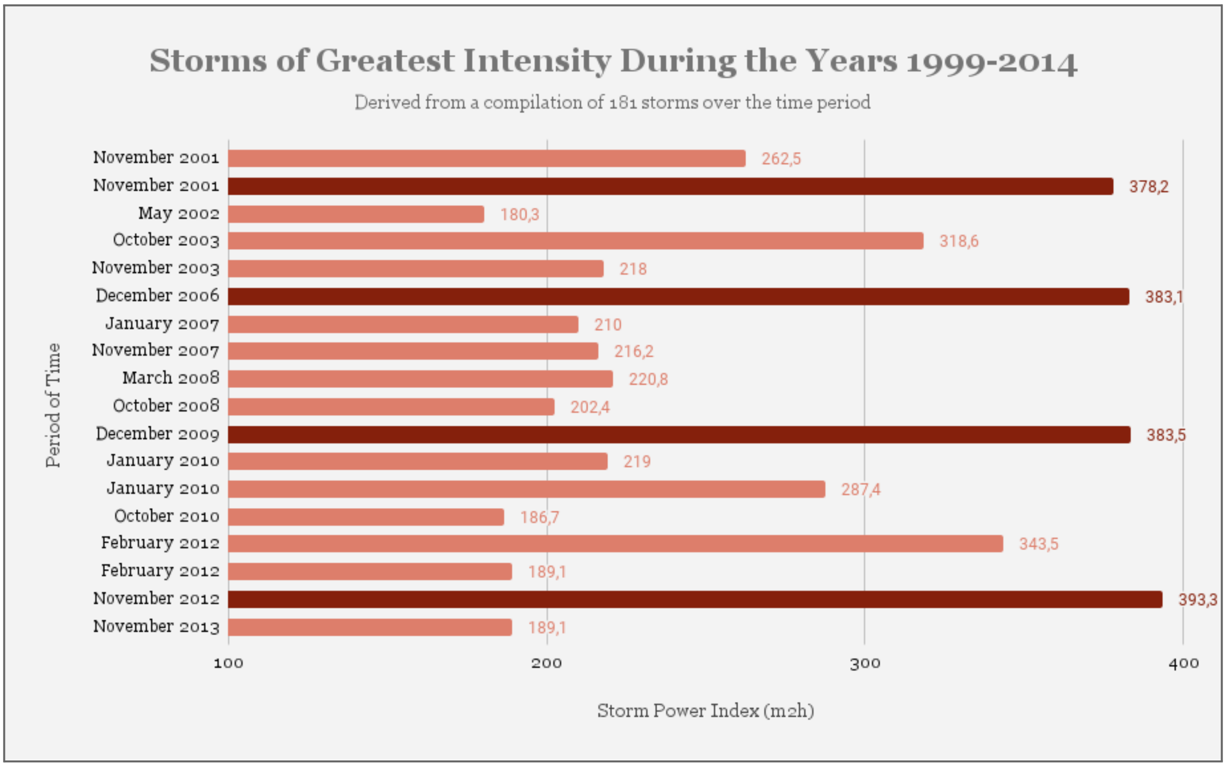

Figure 3: Graph displaying the storms of greatest intensity on the storm power index, in the Valencian region during the period 1999-2014, data from Cabezas (2021)

1.3 Valencia: History of Flood & Policy

November 20th 1975 marks the passing of Francisco Franco, and the turning point of Spain, transitioning from a dictatorship into a constitutional democracy. This period would bring about the beginning of a complete paradigm shift in flood management and how risk and vulnerability was viewed and assessed. Valencia of today has come far from its industrial roots of the 1900s. Like many former industrial cities it has transitioned into a creative city, characterized by numerous projects to further attract tourism and strengthen its sustainability trademark through avant-garde green and blue infrastructure, environmental policy and flood mitigation work (García et al (2020).

Figure 4: Riada de Valencia 1957 (Ateneo Mercantil, 2014)

However, as we may learn from Olcina et al (2016), this was not always the case. The city has during the 20th century endured numerous extreme flooding events of various character. The most notable inundation is known as "La Riada de Valencia ", the great fluvial flood of 1957. Following a three-day torrential rainstorm the banks of the great river Turia passing through the city center overflowed, submerging large parts of the city and resulting in grave human and material losses. This event prompted the first modern measures that the city would take in mitigating vulnerability and exposure, starting by rerouting Turia (Olcina et al 2016). But it would take many years before the flood mitigation planning advanced to models and understanding which reached beyond the merely basic plane of physical measures. By 1986, Spain was ready to join the European Union. After many flooding catastrophes plaguing the country during the Franco era and the years of the transitional government, in part due to over reliance on physical infrastructure, extraordinary measures were taken to modernize the Spanish institutions and policy making. Comprehensive studies were made in order to reevaluate risks, vulnerabilities and to gain a more nuanced understanding of the nature of the flooding hazards, it was no longer just a pre-crisis physical prevention, all three stages of the crisis and risks were studied. Thus measures taken accordingly, to reduce and identify risk, learning from past events and to better provide relief in the post-crisis stage (Olcina et al, 2016).

While Olcina et al´s (2016) compilation studies teaches us of the great advancements in the Spanish policy making regarding risk and adaptive measures during the late 20th century. However as seen in figure 3 and from the study by Cabezas (2021), the magnitude and recurrence of storms have only ever increased, with the exception of the 1957 outlier. Through Cabezas (2021) results of receding coastlines, increasing storm intensity and environmental damage, we can assume that the changing climate will place an increasingly large amount of people and properties in higher degrees of exposure and vulnerability. However, Olcina et al´s (2016) study indicates that through the continuously growing investments into flood planning and budget allocation since the 1980s, the vulnerability has not and potentially may not continue to grow in proportion to the increasing exposure. This leads us to the argument that despite being in the frontier of severe climate change, the Spanish policymaking and practice has thus far successfully staved off and rigorously mitigated humanitarian and material costs in the face of extreme weather events. Climate change and its effects are fickle, today's brilliant measures might bring tomorrow's failure, but despite Spanish policy requiring revision for its own challenges to future climate effects, it´s current practices, structures and shortcomings may prove highly useful lessons to other European cities, even for the planning practices in Swedish coastal cities.

1.4 Aim of Thesis

The aim of this thesis is a threefold study into the vulnerability, resilience and policy & practice learning in regards to coastal inundation and climate change in the city of Valencia, located in the eastern part of Spain. The initial aim is to first examine the territorial vulnerability on a local level in Valencia, in regards to coastal flooding, using a *Coastal Territorial Vulnerability Index* (CTVI). Secondly, an *Urban Adaptive Capacity Index (*UAC*)* will be created to quantify and analyze how and why the adaptive capacity has changed over time in Valencia. Thirdly, the Spanish policy making, praxis and planning concerning coastal inundation in Valencia will be studied, in order to understand how practices and lessons may be applied in the urban planning of coastal cities in the south of Sweden such as Malmö and Helsingborg. Measures which aim to supplement existing policy and practice in order to counter the threat of intensified climate change and extreme weather events.

1.5 Research Questions

- ➢ What is the coastal territorial vulnerability index of the neighborhood El Cabanyal in Valencia, and what does it mean in relation to other coastal cities in Europe?
- ➢ Using the UAC, policy documents and interviews with experts, how has the quality and strength of the adaptive capacities to coastal inundation and climate change changed over time, and in response to what?
- ➢ What lessons may be learned from the successes and shortcomings of the Valencian policymaking and practice in coastal inundation planning?
- ➢ How can the findings of this study regarding the Spanish policymaking and adaptive capacities be used in order to improve the adaptive capacity and resilience to coastal inundation in a Swedish context?

1.6 Limitations

Due to the complex and diverse nature of inundation, the aim of the thesis is limited to the study of coastal inundation, also known as coastal flooding, defined by Marshak (2019) as "locally high sea surface elevation reaching the shore, producing a storm surge that inundates low areas" (Marshak, 2019, p 714). Meaning studying the coastal inundation of areas in low elevation subjected to both short- and long-term effects, such as storm surge as an effect of extreme weather events and mean sea level rise, in relation to climate change as factors of increased vulnerability and exposure. This means that inundation typologies, such as pluvial and fluvial inundation, are not taken into account in the vulnerability and adaptation assessment of this paper. However, some overlap is expected. Furthermore, the study of vulnerability will be done on a local scale in order to facilitate collection of primary data and to optimize the application of the CTVI, in a neighborhood setting in El Cabanyal. Thus, establishing a study area of diverse character which contains great internal disparity in terms of socioeconomic status, levels of gentrification as well as protective measures. Regarding the study of adaptive capacities and flood management applications the research will be limited through the UAC, consulting a limited number of stakeholders within each sector, and focusing on the literature review of policy documents central to coastal inundation from both local government and by leading national policy.

2. Literature Review & Theoretical Framework

2.1 Central Terminology

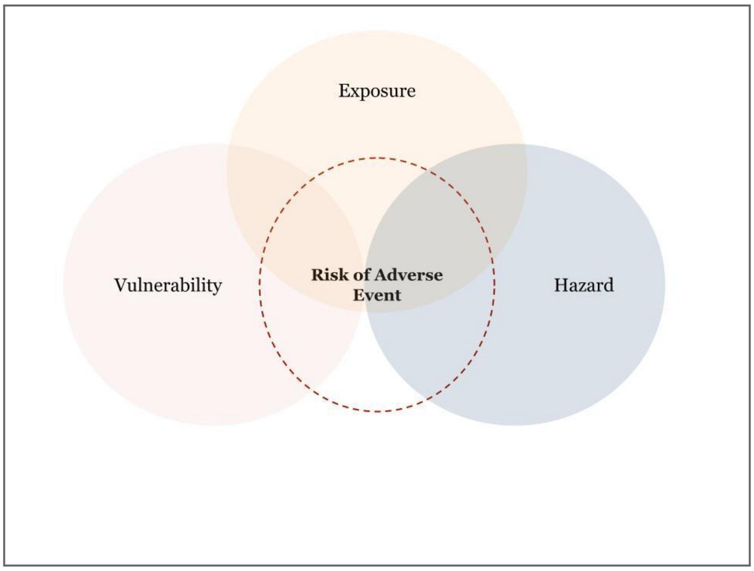

Figure 5: Composition of the risk element of the various central variables

The field of risk management is a multidisciplinary field encompassing a wide array of applications and tools of doing so. However, in the case of urban planning and coastal inundation, the main concepts related to risk management can be said to be; risk, vulnerability, exposure, adaptive capacity, resilience and hazard. These concepts embody the risk perspective.

Whereas we may define risk as the potential for an adverse event causing property, human or other capital loss in a place in a future scenario, we may further describe it as the sum of the probability of the hazard combined with the intensity of vulnerability. In which the hazard can be explained as the phenomena or event which induces damage or loss, and the vulnerability will determine the components of a setting, for example physical, social, environmental or economical vulnerability.

Which may result in either an increased or decreased vulnerability to hazards (UNDDR, 2023). Finally we should explain the difference between vulnerability and exposure as the two are often mistakenly used interchangeably in literature, as per the definition by the United Nations Office for Disaster Risk Reduction (UNDDR) exposure refers to a recognised or known vulnerability, for example the fact that individuals, infrastructure or other housing is located in areas susceptible to flooding is an exposure.

These tools and terminology are used throughout literature of urban planning and coastal inundation, the latter a concept further explored below in 2.3. These concepts are used in order to quantify and measure the risk related characteristics, tendencies and susceptibilities of study areas on national, regional or in this case local level. Such as in the studies conducted by Barros et al (2022), Marengo et al (2017) and Rocha et al (2023), in which the concepts of vulnerability, adaptive capacity and risk are used in order to study and evaluate coastal inundation vulnerability, as well as related policy making and practice.

In the case of Marengo et al (2017) and Barros et al (2022) the concepts are approached from a multidisciplinary perspective, using versions of coastal vulnerability index model and an adaptive capacity index as explained below, to measure a large variety of physical, social and economic vulnerabilities, and adaptive capacities. However, it is worth noting that the approach to measuring these factors, is in majority a technical and quantitative approach, using flood modeling and geospatial analysis in order to study vulnerability typologies, the role of the qualitative methodology is lower in vulnerability quantification, but more prominent in the adaptive capacity. In which survey and interviews such as in the study by Marengo et al (2017), where they a are used in order to evaluate the community resilience and preparedness regarding risks and potential impacts of coastal inundation, thus encompassing a perspective which takes into account community risk education, physical and economical adaptive capacities (Marengo et al, 2017, Barros et al, 2022). Rocha et al´s (2023) literature review of the coastal inundation studies of the last decade furthers the argument that vulnerability assessment has previously been a study area which primarily focused on physical elements of vulnerability, the results of the study indicates that merely half of the studies reviewed included social variables and only a fifth included economical factors, accentuating the need for a more comprehensive approach to coastal vulnerability and resilience.

Thus, the approach in the majority of the studies over the last decade may be a mixed multidisciplinary methodology, primarily utilizing extreme event modeling and indexes to quantify and examine the study area and variables, however they are often lacking in proper evaluation of socioeconomic, demographic and more qualitative community factors. Such as risk education and community knowledge, as argued by Rocha et al (2023) and raised as potential limitations by among other Barros et al (2022). This study undertakes an attempt to approach this limitation in the study area of Valencia, to further understand how the socially based adaptive capacities and vulnerabilities may play a part in the construction of coastal vulnerability and resilience. In order to better transfer the policy and practice implications to a Swedish urban planning perspective.

2.2 Adaptive Capacity Strategies

The theoretical approach regarding adaptive capacities in academia as previously mentioned does embody a portion of the relevant literature for this project, however in practice it is vital to discuss the adaptation and mitigation strategy developed in the mediterranean context, known as *integrated coastal zone management* (ICZM) integrated into the Spanish flood planning since 2011. As a Mediterranean regional initiative led by the United Nations Environment Program (UNEP, 2019), its goal is to adapt coastal management to a more sustainable approach. Not only within ecological sustainability, but acting to preserve the cultural, social and economic aspects of the coastal environment, often interests and factors which may clash in regard to land use in the interest of climate change mitigation. This framework aims to provide tools to mitigate and provide adaptive capacity in the threat of intensified coastal erosion and inundation, through the means of good adaptive governance, empowering and integrating stakeholder participation in decision making processes, and tailored land use planning (UNEP, 2019). The framework provides guidelines and tools for regional and local planners and authorities which Burbridge (2020), has described as integral to countering the consequences of intensified climate change effects and extreme weather events. Many authors such as Burbridge (2020) and Cantasano et al (2017) do suggest caution, as the strengths of the ICZM may just as easily be hampered by poor institutional practices, knowledge and communication gaps between policymakers, experts and communities. A widespread problem of interest in both Spanish and Swedish context may also be what Burbridge (2020) argues to be distrust and conflict interest between stakeholders and public sector authorities, generating a need for balancing the autonomy of stakeholders and the competition of land use and resources in coastal areas (Burbridge, 2020).

Finally, the concept of adaptive capacity as it relates to coastal inundation, is as previously mentioned in the contexts of Marengo (2017) and Barros et al (2022) measured in a mixed approach, taking into account the risk education of the community and knowledge of the local population. However, it is worth noting that this is only one of many methods to quantify the adaptive capacity of a locality, community or organization, there is no one size fits all, as problematized by Pelling et al (2017). Through Pelling et als (2017) methodology we may argue that the method which solely takes into account the risk education and awareness regarding the impact upon a community only generates an understanding of a portion of the pre-crisis from an isolated stakeholder perspective. Thus, the mid-crisis and post-crisis stage evaluation of adaptive capacity is lost. In order to avoid a perspective solely focused on the pre-crisis stage and still preserve the integration of socially connected variables, we may utilize authors such as Hu & He (2018) and Kristensen (2004). Who argue that authors such as Pelling et al (2017) focus too much on a singular entity of adaptive capacity which they argue to be a highly complex, varied and changing topic, requiring input from a variety of disciplines and settings, not only the social and environmental.

Examples of the various applications of adaptive capacity evaluations and indexing can be seen in among others the case study of Broward county by Paterson (N.D). Where the methodology by Pelling & Zaidi (2013) is used, further revised by Pelling et al (2017). Here the adaptive capacity in regards to the flood risk assessment, is understood as an qualitative evaluation of the systems available for adaptive measures in pre, during and post stages, diverging from the traditional quantification through knowledge, technological or economic qualities and focusing on the qualities of the systems in place and their condition in the eyes of public, private and civil stakeholders. Paterson (N.D) further argues that this quantification of adaptive capacities allows insight into how the quality adaptive capacity may differ in the eyes of civil society stakeholders compared to public ones. More quantitative approaches to the evaluation of adaptive capacity can be seen in authors such as Hu & He (2018) and Kristiadi et al (2022), both studies utilizing the DPSIR framework. The adaptive capacity is not specialized specifically for a purpose of coastal inundation or extreme weather events but studies the characteristics of a city's resilience and vulnerabilities in order to determine its adaptive capacity to climate change as a whole. Whilst limited in the qualitative approach this quantitative analysis typology allows for a spatiotemporal study of the adaptive capacities, and it is possible to study the effects of policy and practice shortcomings and successfulness over time on the city's resilience and vulnerabilities. Thus encompassing the three stages of the crisis from a more shallow perspective but granting the ability to study them over time and across different disciplines (Hu & He, 2018; Kristiadi et al, 2022). Arguably this methodology would prove more advantageous for the approach of this study, as the quantification made by Hu & He (2018) grants insight into how changes in variable value and weight over the time series affected the urban adaptive capacity and thus is optimal for the understanding of policy transfer and potential strategy for mitigation of problems stemming from a decrease or increase of adverse factors. And together with the qualitative aspects with Peling et als (2017) assessment of adaptive capacity the insights into the dynamics and trends of adaptive capacity to climate change and coastal inundation can provide profound and nuanced insights and problematizations.

2.3 Environmental Perspective in Coastal Inundation

2.3.1 The Process of Coastal Inundation

To understand how climate and anthropogenic factors converge in the intensification and increased susceptibility to coastal inundation, it is important to understand the factors and conditions which the literature explain as the cause of coastal inundation.

As previously mentioned by Marshak (2019) coastal inundation is the process in which the sea level of a local area rises, as this bulge reaches the shore it submerges low lying coastal areas, covering what other times is dry land. Marshak (2019) explains that we may divide coastal inundation into two categories, short term and long term effects, which may further our understanding in the contemporary discussions in the risk and vulnerability assessment perspective. The short term coastal inundation, can refer to the phenomena previously mentioned as storm surges or high tides, which Satta et al (2017) and Marshak (2019) explain as the cause of extreme weather events such as storms, hurricanes e.t.c. It may be a sole actor or in combination with high tides, result in temporary submersion of low lying coastal areas, and acting as strong erosion agents on the coastline and nature based protection measures such as reefs and neptune grass plantations, further increasing the vulnerability of the areas. Whilst long term effects regarding coastal inundation refers to climate change and anthropogenic factors. Such as mean sea level rise on global and local levels. As well as land subsidence or land sinking in relation to sea level, as an effect of aquifer depletion or extreme water stress, causing pore collapse in the underground rock. This often occurs in karst morphology, meaning areas rich in limestone which are very porous and especially dependent on the water preventing compression, such as the Valencian region. Coastal regions are especially vulnerable to this effect as the subsidence may cause the local area to sink to a level which is below sea level (Marshak, 2019). These two perspectives allow us enhanced insight into additional risks which may exacerbate the vulnerability of the study areas and which furthermore call for adaptive measures which address topics outside the realm of inundation, such as sustainable water consumption.

2.3.2 Representative Concentration Pathway 8.5

Representative concentration pathways, more commonly referred to as RCP, are a collection of scenario models developed by the intergovernmental panel on climate change (IPCC). These scenarios used to describe the various outcomes which may occur as a result of actions taken or lack thereof, as well as the nature of climate change, factors both environmental and anthropogenic. These factors include the areas of greenhouse gas emissions, atmospheric gas concentrations, other emissions and management of land-use (IPCC, 2019). The scenario of interest in this study is the RCP8.5, a worst-case scenario for 2100, in which climate change continues to accelerate without significant mitigation measures.

This scenario would, according to the IPCC (2019) entail a severely altered climate, in which the earth would undergo extreme environmental change. Of interest to coastal inundation, the RCP8.5 would bring about an exponential rise in mean temperatures and sea surface temperatures, the prediction estimated by the IPCC (2019) is that the global mean temperature increase will range between 2.6-4.8 degrees and arguing with medium confidence that the global mean sea level rise will accelerate to 8-16mm per year during the span 0f 2081-2100 during the RCP8.5 scenario, compared to 1.7-2.3 in the period 1970-2010. We may argue that based on previous theoretical foundation by Marshak (2019) and Satta et al (2019) that an increase in these variables may intensify the vulnerability of coastal areas even further by heightening water stress and subsequently land subsidence, potential for increasing coastal erosion and inundation. Finally Sweet & Park (2015) and Vousdokas et al (2020) compilation study of the IPCCs pathway models have indicated that the RCP8.5 scenario would generate a setting, which causes recurrence rates of floods and extreme weather events such as 100 year floods to greatly increase. Thus, not only in combination with rising sea levels placing a greater amount of land area and population in increased exposure to storm surges but giving rise to a greater demand for adaptive measures for frequent extreme events, arguably making a reliance on hard measures only insufficient.

2.4 Governmental Practice & Public Policy

The Spanish policy framework regarding environmental risk and vulnerability, as well as the associated hazards, stem from a national guideline known as *el plan de impulso al medio ambiente para la adaptación al cambio climático"* or PIMA Adapta, encompassing guidelines and t0ols for regional and local public actors, to enable them to reach the goals of the national climate adaptation plan. Through the distribution of economic resources and establishing incentives for collaborative planning with affected and relevant stakeholders (MITECO, 2020).

Through the means of PIMA Adapta, the Valencian municipality has in collaboration with EU projects developed the policies and reports, known as ARCH and SECAP. Intended to address, measure and respond to the risk profile and associated vulnerabilities regarding the hazard of flooding. As well as the current quality and demands for resilience and adaptive measures in physical, social, economical and environmental sectors. The terminology of "flood" is in the public policy documents, examined as an all-encompassing term for every flood typology, grouping fluvial, pluvial, coastal and connective storm related flooding into the same category (García et al 2020). Which shows a generalization of hazards, compared to more contemporary research methodologies, such as the study by Satta et al (2017). Who focuses on a singular typology and its more unique characteristics and origins, coastal flooding in the Mediterranean setting.

These reports cover an extensive vulnerability assessment not only related to coastal inundation but covers a wide array of risks in both the current setting and under future RCP4.5 and RCP8.5 scenarios. Studying climatological aspects such as increased or decreased temperature, precipitation, intensified and more frequent storms and other extreme adverse events. As requested by the PIMA Adapta, the policies also take into account the required adaptive measures and relevant stakeholders which are identified and weighted in the reports.

2.4.1 ARCH Report

The ARCH report, known as "*Advancing Resilience of Historical Areas Against Climate Related and other Hazards"* by García et al (2020), studies the vulnerability and existing and future required resilience of the city and surrounding areas of cultural, economic and environmental importance. The areas examined are known as the Huerta, Albufera, Turia national park and the maintenance of the local Mediterranean sea. The main concept in this report is studying what García et al (2020, p5) refers to as essential "green and blue infrastructure". In order to evaluate the vulnerability and resilience of these areas Garcia et al (2020) utilizes a variety of indexes bearing similarity to the coastal vulnerability indexes by Barros et al (2022) and seemingly applying lessons learned in the compilation study by Rocha et al (2023). The report examines a select range of variables of socioeconomic and demographic aspects in the population of the city, to building quality, economic activity and land use planning in order to understand the variety and distribution in vulnerability. Subsequent work has been done in order to identify the relevant risks for each sector and demographic group such as identifying potential groups at health risk, local risks for vulnerable housing areas and areas lacking green or blue infrastructure protection. Vulnerability assessments have been made on a larger scale at the local level of the city, and García et al (2020) further explains that a large amount of vulnerability studies have been conducted in the Valencian context and thus allowed for a solid foundation, making certain assessments obsolete. Thus focus has been on a more human, usage and economic perspective rather than strictly morphological and physical (García et al, 2020).

2.4.2 SECAP Report

The SECAP report, called the "*Plan de Acción para el Clima y la Energía Sostenible de la Ciudad de Valencia"*, refers to the sustainable energy and climate action plan of Valencia, created by the Valenican municipality (2019) in order to evaluate the current energy and climate related practices, making a indepth city wide assessment, comparing the current vulnerability of the city to the future as a result of the scenarios RCP4.5 and RCP8.5. In the evaluation the effects of increased temperature, extreme weather events and decreased precipitation, as well as the anthropogenic effects of greenhouse gas emissions and energy practices have been included. The municipality (2019) further explains that the additional objectives of the report, is through the assessed vulnerability be able to identify the required measures to be taken in order for the city to be able to reach the climate goals set by PIMA Adapta, and the ministry of ecological transition and demographic challenges (MITECO, 2020). These actions involve among other measures taken to reduce dependence on fossil fuels and a transition to sustainable and efficient energy sources and applications. In a similar stance to García et al (2020), a strong emphasis has been placed upon climate justice and collaborative planning, aiming to better distribute access to resilience and adaptive measures across the city population, as well as extending the current stakeholder participation in decision making processes and through civil society involvement (Ajuntament de Valencía, 2020).

3. Methods and Materials

For the purpose of this thesis a mixed method approach has been used in order to study the versatility of the risk characteristics of coastal inundation and management. In order to assess the vulnerability and adaptive capacity of the Spanish case study, whilst taking into account policy and practice, the *Coastal Territorial Vulnerability Index* (CTVI), drawn from Barros et al (2022) methodology was applied. This CTVI and other indexes such as *Combined Coastal Vulnerability Index* by Satta et al (2017) and *Coastal Vulnerability Index* by Zhu et al (2018), share similar choice of variables and scale, all being on local level. Together they have been applied in a variety of settings in regards to coastal inundation, their methodologies have been rigorously tested by Rocha et al (2023). The authors (2023) argue that whilst showing advantage by granting multidisciplinary insight into the vulnerability of areas, the spatial segmentation of vulnerability zones may result in the loss of accurate assessment, as the index will be aggregated to the specific zone and may lose out on neighbor relations. Furthermore, the aggregation as seen below *figure 10* is criticized by Rocha et al (2023) as arbitrary regarding weight, and as such we can discuss that the choice of summatory of variables may result in the loss of importance of one variable above another in terms of vulnerability, similarly, if there are any negative relationships between variables this will not be visualized. Despite these limitations this method allows for a multifaceted approach to the overall complex nature of coastal inundation, allowing in depth study on the local level of both physical and social factors such as socioeconomic and demographic vulnerability, and land morphology and characteristics of coastal protection measures, making the index fitting for the data availability and scale of this project (Barros et al, 2022).

For the evaluation and comprehension of the adaptive capacity in the face of climate change and coastal inundation the urban adaptive capacity (UAC) index was chosen to study the time series of adaptive capacities between 2005-2021 in five year intervals. The methodology was drawn from Hu & He´s (2018) study on the threats and challenges facing urbanization in a more extreme climate. The index draws from the DPSIR framework developed by the European Environmental Agency (EEA) which assembles variables across five dimensions; "drivers, pressure, state, impact and response", in order to evaluate the urban adaptive capacity to climate change across a variety of societal, economic, social and physical capacities. The UAC allows for a quantitative study of the condition and nature of the city´s adaptive capacity at the current year and over time in a chosen interval of years. Through in-depth literature review of statistical reports and policy documents, variables were chosen from each category based on the study by Hu & He (2018) and Krisiadi et al (2022), as well as tailoring the choice of variables to better relate to the problems of inundation throughout the dimensions by the DPSIR framework by Kristiansen (2004), such as through integration of extent of stormwater infrastructure.

The study by Hu & He (2018) recommended an application of information entropy on these variables in order to mitigate the human factor of subjectivity in the weighting and analysis of these variables and results. Thus it allows for an optimal objective weighting and analysis of the data into index. Upon completion of the index the trend of the UAC across the time series, 2005-2021, was analyzed using a gray relational analysis. This allows for what Hu & He (2018) explained to be a way to work around low amounts or low quality data, which would be described as "gray data" or incomplete data. The gray relational analysis creates an optimal sequence which is used to evaluate the input variables in their relation to the optimal values. The result of the gray relational analysis is that of a grade which ranks each year or in this case sequence in relation to the optimal value, displaying trends and which years possessed the stronger adaptive capacities in a weighted sum (Hu & He, 2018. Kristensen, 2004).

3.1 Coastal Territorial Vulnerability Index (CTVI)

The CTVI is composed of four main variables of equal weight, morphology, land value, public areas / critical infrastructure and building quality, which are further divided into subsections of varying weight ranging from 1-100, depending on their importance to the variable. The weight assigned to each variable is based upon extensive literature review of studies and projects, which apply similar methodologies and areas of study and scale. However, Barros et al (2022) is used as a primary source of theory regarding choice of variable, weight and values. Finally a five to six step attractiveness factor is assigned across all variables which ranges from -1, meaning a strong reduction in vulnerability, to +1, indicating a strong increase in vulnerability.

It is worth noting that this is not a complete CTVI and the variables lack multiple variables of lower weight which may act as further enhancing the vulnerability of the zones. For example through the presence of urban furniture which may be hazards during storm surges and extreme weather events, or further examining the quality of building integrity and characteristics. However for the scope of this study a rudimentary vulnerability index can suffice in order to display spatial patterns that indicate where higher and lower levels of vulnerability are concentrated.

3.1.1 Morphological factors

As seen in *figure 6* the variables chosen for the morphological variable are in majority based on the study by Barros et al (2022) excluding the permeability of soil which was chosen from relevance determined from specialist literature study by Marshak (2019), including permeability as a factor for susceptibility to vulnerability, indicating impermeability and lower levels of permeability and porosity as factors which contribute to higher levels of flood risk and higher levels of runoff, where as more permeable soil shows tendencies for higher levels of resistance to erosion and ability for the flood waters to easier infiltrate into the soil.

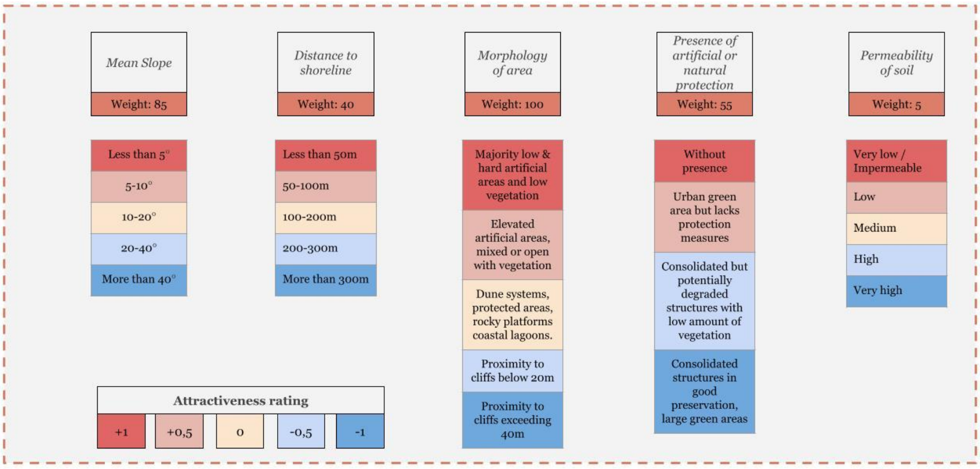

Figure 6: Morphological variables of the CTVI index, including weight, description and other values

Due to the similarity between Cabanyal and the study area of Barros et al (2022) in terms of topography and characteristics, as well as aim of study, the variables of highest weight were chosen taking in account the data availability, time and resources to collect primary data. However, the majority of the data used in order to calculate the variables of *figure 6* is based on secondary data from Generalitat Valencia, as seen in the appendix . 7.2.

3.1.2 Land Value

Figure 7 describes the variables and weight used in order to study the land value variable for the CTVI, as one of the main criticisms towards many coastal vulnerability indexes by Rocha et al (2023) have been the lack of socioeconomic and demographic factors, the choice was made to deviate from Barros et al´s (2022) modell, for a more balanced approach.

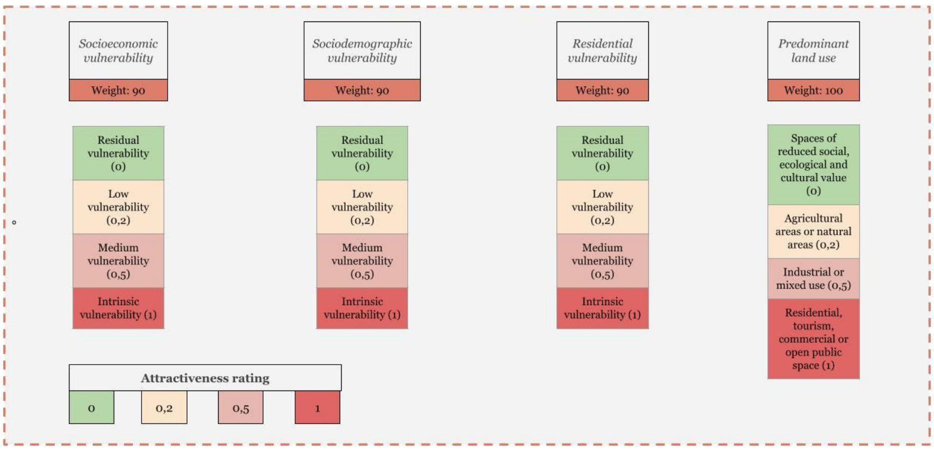

Figure 7: Land value variables of the CTVI index, including weight, description and other values

Drawing from Kunte et al (2014) coastal vulnerability study of Goa and social vulnerability data indexed by Instituto Valenciano de la Edificación (2020) using a total of nine sub categories regarding socioeconomic deprivation, lack of education, illiteracy, average income, gender based unemployment rate among others, allowing for a neighborhood level of data aggregation of the social vulnerability variables.

Kunte et al (2014) argues in their study that there is a general lack of consensus which social vulnerability takes precedence over the other and thus that a equal weight should be applied, which for these variables was 90, due to their importance in regards to the human aspect of vulnerability across multiple studies such as Kunte et al (2014) and Rocha et al (2023). Finally the predominant land use variable was drawn from Barros et al´s (2022) methodology and weighting, further supplemented by field work and discussion with locals in the study area to understand and more accurately aggregate the vulnerability typologies to each zone.

3.1.3 Public Area / Critical Infrastructure

Due to the strong prioritization regarding the protection and maintenance of function of critical infrastructure under climate change scenarios and extreme weather events in both the Swedish and Spanish context, the choice was made to focus on the critical infrastructure from Barros et al´s (2022) model in order to include the perspective of critical infrastructure as a primary area of focus. As well as the habitation and usage of space in the area, in this case referred to as occupation, and covers the use of space in terms of whether the fluctuation of people is seasonal, for example in the areas in proximity to the beach, or if the spaces studied are inhabited by a limited number of people, for example areas which are industrial, commercial or open public area. Whereas the areas of high occupational forms were identified as dense residential areas or areas which are frequented daily, for example the Mercado (market) area.

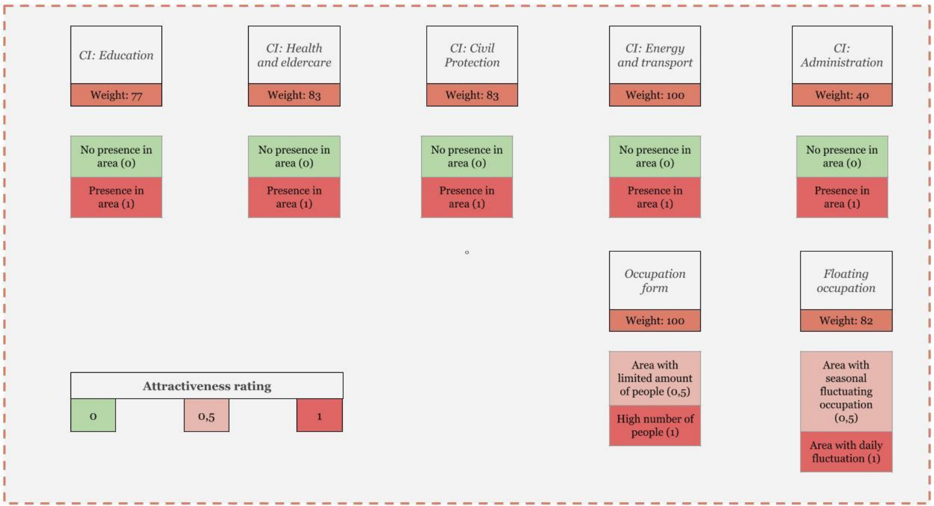

Figure 8: Public area and critical infrastructure variables of the CTVI index, including weight, description and other values

Regarding the variable weight, all values used were acquired from Barros et al´s (2022) methodology and assigned attractiveness accordingly. Deviating only from the calculation of the public area score as seen in figure 8 by allowing the PaCI summatory to contain a higher number of variables compared to the occupational summatory. As aggregation of the score is in the end a summatory of the two types, it can be argued that these variations in variables will not be a great risk of skewing the score aside from what is already prioritized.

3.1.4 Building Quality

In order to assess building quality on a large scale under the time frame which was available, the choice was made to combine secondary and primary data in order to asses the building quality of the vulnerability zones, resulting in a moderate to high level of generalization regarding in the variables such as number of floors and preservation condition, whereas the construction material of the area was more homogeneous and more easily aggregated into zones.

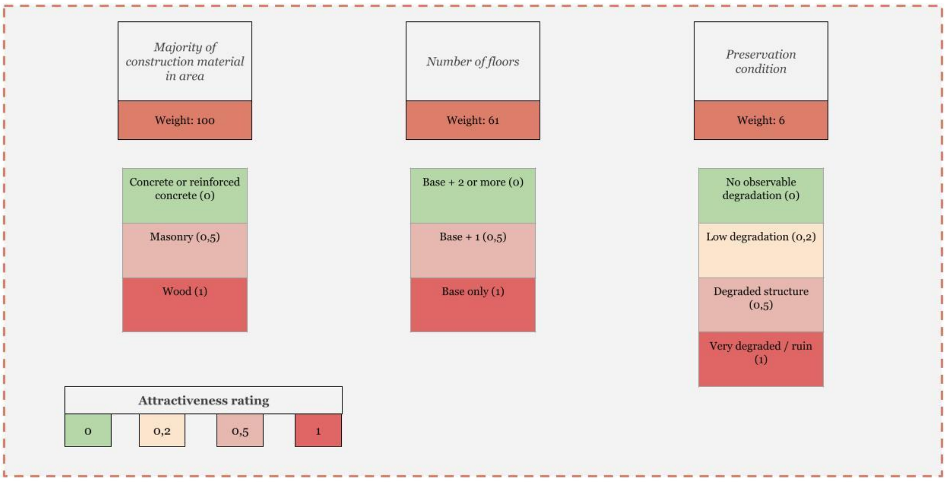

Figure 9: Building variables of the CTVI index, including weight, description and other values

The secondary data used was through the Generalitat Valenciana which offered the Catastro tool and data regarding individual houses designated as in need of urgent action, and housing areas exceeding 50 years in age. In combination with field study of the areas using the app SW Maps, it allowed the possibility of in-depth data regarding the housing quality and characteristics of each district, within a reasonable amount of generalization required. Finally it has to be noted that it was necessary to strongly limit the variables of this typology to data which was either easily accessible through secondary data or by observation.

3.1.5 Calculations, Aggregation & Standardization

The aggregation of the four main variables was done by replicating the methodology of Barros et al (2022) using the formula:

$$CTVI = (Ms + LVs + Bs + PAVs)$$

From which a score ranging from 1-4 was derived, ranging from very low vulnerability (1) to very high vulnerability (4), the standardization of this data was done by symbolizing by standard deviation in which a negative deviation (-1) indicates a low to very low vulnerability and positive (+1) deviation indicates a high or very high vulnerability. The resulting index score should be scrutinized to some extent, despite using a wider range of variables as recommended by Rocha et al (2023), by including more social variables. As well as testing the index using a square root of product sum and square root before settling on the summatory aggregation method used by Barros et al (2023). For example, we may discuss that allowing the presence of critical infrastructure and public areas to dictate the vulnerability of the area on equal basis as the morphological variable may lead to a skewed distribution of the vulnerability factor, in which certain areas will become more prominent in the final aggregation, or for example it may negate a potential substantial social vulnerability in the final aggregation. Thus it may be recommended to test the vulnerability through other indexes specializing in social and physical vulnerability in order to examine the disparities between the zones.

Morphological Score (Ms) = $\sum_{n=1}^{5} MS_n * W_n$

MS_n = equals the attractiveness or value assigned to the variable of the specific area, for example -0,5

W_n = The weight of that specific variable, for example 85 regarding mean slope

Building Score (Bs) = $\sum_{n=1}^{3} BS_n * W_n$

Original formula: $\sum_{n=1}^{x} BS_n * WS_n + \sum Bf_n * Wf_n$.

BS_n = equals the attractiveness or value assigned to the variable of the specific area, for example 0,5

W_n = The weight of that specific variable, for example 61 regarding number of floors

Land Value Score (LVs) = $\sum_{n=1}^{4} LV_n * W_n$

LV_n = equals the attractiveness or value assigned to the variable of the specific area, for example 0,2

W_n = The weight of that specific variable, for example 100 regarding predominant land use

Public Area / Critical Infrastructure Score (Pav) = $\sum_{n=1}^{5} PaCI_n * WCI_n + \sum_{n=1}^{2} PaO_n * WaO_n$

PaCI = equals the attractiveness or value assigned to presence and nature of the critical infrastructure of the specific area, for example 100 for energy and transport infrastructure

WCI = The weight of that specific variable, for example 85 regarding mean slope

PaO = equals the attractiveness or value assigned to the occupation form of the specific area, for example 0,5

WaO = The weight of that specific variable for example 82 for floating occupation

In order to convert the score of variables to range from 0-1 the following equation was used:

Rescaled = 0,5 (x / a) +1) ^log2/log(b/a)+1)
X = Value derived from formula
A = Smallest value of the sample
B = Largest value of the sample

Figure 10: Compiled calculations and descriptions for all relevant CTVI variables, including rescaling of variables

3.2 Coastline Change Detection & Climate Index

3.2.1 Change Detection

To study the change in the coastline over the period 1956-2020, a combination of orthophotos and Landsat 5 & 6 were used. The coastline of the available orthophotos was traced through digitisation in ArcGIS Pro, measuring the length and width of the beach profile for each year. Due to the poor spatial resolution of 30m, the choice was made to calculate an NDWI using the Landsat data for the years 1986 and 1996 in order to best observe where the coastline was situated. The choice of NDWI was made for simplicity and due to the unique spectral characteristics of the water in comparison with land, making such an analysis favorable under the timeframe and utilization. The NDWI was calculated with the formula using green and near infrared bands of Landsat data.

$$NDWI = (G - NIR) / (G + NIR)$$

Subsequently the total, mean, minimum and maximum change in beach profile in square meters was calculated between each period, in which a systematic sampling method was used, applying an equal distance of twenty meters difference between each measurement point, between the coastlines, allowing for an equal chance of choice, and understanding whether the beach undergoes erosion or accretion (Campbell, 2011). Thereafter the total change in beach profile from 1956 was calculated. In combination with these variables, the change in human activity / usage as well as topography was studied to allow for further insight in the analysis.

3.2.2 Climate Index

To investigate the correlation between the increasing severity of climate extremes and how it affects the change in coastline a climate index was constructed. Furthermore, this allows for insight into how adaptive measures taken on municipal and regional level may have resulted in lower erosion or even strong accretion despite high level of climate index levels.

The index was created using the variables; yearly mean temperature, precipitation and yearly mean sea surface temperature for summer months. The available data for this index was restricted and was narrowed down to the period 1986 to 2020. The choice of variables were tested using Pearson's correlation coefficient in order to understand their relevance and relationship, the results indicate a strong positive correlation of 0,948 between mean temperature and sea surface temperature, and a weak negative correlation between temperature and precipitation, finally a weak positive correlation was found between sea surface temperature and precipitation.

In order to compare the data the variables of each year were first normalized using the following equation, in which the standard deviation and mean had been derived from each variable time series.

$$Normalized\ Value = (Vn - Mean) / Std$$

V: Value of variable for specific year (n)

Mean: Mean of time series

Std: Standard deviation of time series

As the literature review did not indicate any consensus of the importance of any variable over the other, equal weight, of (0.4), was assigned to each variable and the index was finalized using the following formula:

$$Climate\ Index = (WeightTemp_n + WeightPrecip_n + WeightSST_n)$$

Furthermore to understand the correlation between change in coastline and climate index, the data was modeled with a trendline and R-squared showing a relationship between the index and change 0,489. Indicating a potential low correlation and that more variables and non-climate may be necessary to investigate.

3.2.3 Hypsometric Analysis

The hypsometric curve was calculated in order to better explain and understand the vulnerability and topological profile of the study area. The curve was calculated using a DEM model from the Valencian municipality, upon which a reclassification was made dividing the study area into 9 sections per meter where the lowest (0) is sea level. The percentage of each grid area was thereafter calculated in proportion to the total area of Cabanyal. Upon completion the percentage was summed through an ascending culmination of the values, allowing for a modeling of the elevation distribution of the total area.

3.3 Urban Adaptive Capacity Index (UAC)

3.3.1 Dimensions & Indicators

Table 1: Urban adaptive capacity (UAC) variables and effects on index aggregation

Dimension	Indicator	Effect on Index
Driver	Rate of Population Growth	Positive
	Rate of Urbanization	Positive
	Rate of GDP Growth	Positive
Pressure	Electricity consumption per unit of GDP (Kwh/1000 euros)	Negative
	Volume of wastewater discharge per unit of GDP (ton/1000 euros)	Negative
	Built areas (sq km)	Negative
	Urban Population density (person/sq.km)	Negative
State	Per capita water resource (m3/person)	Positive
	Green area coverage rate in developed urban area (%)	Positive
	Vegetation / Forest Cover (Ha)	Positive
	Consumer price index	Negative
	Area of natural reserves (10,000 hectare)	Positive
	Per capita cultivated areas (sqm/person))	Positive
Impact	Income of urban households	Positive

	(euro)	
	Rate of unemployment (%)	Negative
	"Grain Agricultural Output (tonnes)"	Positive
Response	" Number of students in higher education (person)	Positive
	Environmental protection expenditure (1 000 000 euro)	Positive
	Public budget expenditure (1 000 000 euro)	Positive
	Storm and Wastewater Infrastructure Extent (km)	Positive
	Households with internet (National Rate) %	Positive

Upon the completion of data collection the index required a normalization of the data to allow for cross comparison and further analysis, due to the variety of effects of the data two variations of normalizations were used to assign a value ranging from 0-1 to all indicators as seen in the methodology by Hu & He (2018). If the indicator possessed characteristics in which greater values indicated a stronger adaptive capacity then the following formula was applied:

$$Xij \ = (Xij \ - \ Min\{Xj\} \ / \ Max\{Xj\} \ - \ Min\ \{Xj\}$$

Or if the indicator possessed characteristics in which a lesser value would indicate a stronger adaptive capacity then the following formula was applied:

$$Xij \ = max\{Xij] \ - Xij \ / \ Max[Xj] \ - \ Min[Xj]$$

In this calculation the following applies:

I = Year
J= Item
Max = Maximum value of the indicator across all the years
Min = Minimum value of the indicator across all the years

It is worth noting that the variable of "per capita water resource" of 2005 is an outlier which resulted in a great distortion of the index with a value more than double of other years due to abnormally high precipitation rates of that year. After observing the effect of the outlier on the index an attempt was made to mitigate the effect through winsorization of the 80th percentile but the distortion persisted and the choice was made to exclude it from the calculation.

3.3.2 Information Entropy Analysis

The information entropy analysis was calculated using the results of the normalized values into the following steps calculating each indicator individually against the remaining time series before the summation of each dimension in the final step. Continuing to use the same variable annotations from the normalization, as in i = year and j = item e.t.c.

1. Weight of the indicator for the year: $Yij = Xij / \Sigma Xij$
2. Information entropy: $ej = - k \, \Sigma(Yij * ln(Yij))$
   - In which the k-value is calculated as: $k = 1 / ln(m)$
   - In which m represents the amount of years calculated
3. Information redundancy: $dj = 1 - ej$
4. Weight of index: $wi = di / \Sigma \, dj$
   - In which the summation refers to the indicators of one year as in j = 1.
5. Mark of indexes: $Sij = wi * Xij$
6. Mark of year: $Si = \Sigma Sij$

3.3.3 Grey Relational Analysis

The gray relational analysis was used in order to calculate the grade and relation of the result from the information entropy analysis. It was done first by creating an optimal adaptive capacity using the results of the previous analysis, simply choosing the most favorable indicator value for each year to create an ideal reference sequence (x0). Following this four comparative sequences were constructed using the dimension results of each year (x1-x4). Henceforth these variables will also be referred to as the (k) values.

The gray relational grade for each comparative sequence is calculated with the following calculation: $ri = \Sigma \, \xi i \, (k) * wk$

In order to calculate the weight (wk) the following calculations were made to calculate.

$\xi(x0 \, (k), \, xi \, (k))$ and $\xi 0(x0 \, (k), \, xi \, (k))$ =

$$min \, i, k \, |x0 \, (k) - xi \, (k) \, | + pmax \, i, k \, |x0 \, (k) - xi \, (k)| \, / \, |x0 \, (k) \, xi \, (k) \, | + pmax \, i, k \, |x0 \, (k) - xi \, (k)|$$

In which the *pmax* of each dimension time series is calculated using the following formula in which the range was calculated of each dimension time series and subsequently multiplied by a constant, which for this case was chosen as 0,2 as none were provided by Hu & He (2018). The choice of 0,2 was made based on the course literature “Entropy and Information Theory” by Gray (2013), explaining that a lower constant would be more sensitive to minor disturbances, vice-versa, and thus a moderate number was chosen in order to prevent oversensitivity but low enough in order to allow for a viable result.

$$pmax = 0,2 * kj$$

3.3.4 Aggregation

Due to the more restricted version of this index a lower number of variables was chosen and thus the scoring methodology applied by Hu & He (2018) was deemed inadvisable, and thus not pursued. An improvised classification was instead attempted using the z-score of the data results, due to the values proximity to one another but vastly different implications this method was considered as an acceptable alternative. It was calculated through the following formula

$$Zi = (Xi - mean) / standard\ dev$$

3.4 Interviews

The interviews were conducted using a semi-structured approach in a face-to-face or online environment, this allowed me to minimize the risk of leading questions and pathways which otherwise may limit the interviewee´s opportunity to express their experience and opinions in a diverse way. In order to prepare the interviewees for the session, basic information was provided in terms of terminology and background to equip them with a base understanding of the related theory. But in the case of non-professional interviewees, the questions were formulated in such a way to place the emphasis on experience of adverse events and quality of relation and communication with the public sector. This subsequently allowed for a transfer of the information provided into a supplement for the UAC and thus critical comparison and assessment of the results of the data stemming from policy and practice (Pelling et al , 2017).

3.5 Observational Study

For the purpose of providing better understanding and support for the hypothesis of this thesis, observational studies were conducted of the neighborhood. Using Denscombe (2014) research guidelines a direct observation was conducted, capturing images of the study area, with especial attention to images relating to the index results, such as areas of high building vulnerability. Due to the limited time frame of the study secondary data had to be implemented into the observational study, to capture elements such as severe inundations of the study area or historical images.

3.6 Analyses

Data regarding the climate and weather events spanned several years and thus it was of interest to understand the change over time and thus a linear regression was used to calculate the slope and thus the gain over time. Similarly the same formula was applied to the adaptive capacity time series in order to understand the dynamics of the change. Using the independent variable of year and dependent variables of climate index, climate parameters and extreme weather variables. The following formula was used:

$$b = \frac{\Sigma(x-\overline{x})(y-\overline{y})}{\Sigma(x-\overline{x})^2}$$

In which *y* represents the dependent variables, and *x* represents the independent variables. And both are the mean values of the studied variables.

In order to calculate the rate of change regarding the index results of the adaptive capacity the following formula was used in order to calculate the percentage change between each interval, as a supplement to the regression equation, due to the risks of extrapolation when using such data for future projections.

$$RoC = (x - y) / y * 100$$

X = Value of current year
Y = Value of former year

4. Analysis

4.1 Implications & Meaning of the Coastal Vulnerability in El Cabanyal

The analysis and field surveys of primary and secondary data regarding the vulnerability of El Cabanyal, have given an indication of an area with a complex vulnerability profile. As previously pointed out in secondary data by García et al (2020) and Instituto Valenciano de la Edificación (2020), the neighborhood has a problematic past in terms of socioeconomic and social disparity, but in recent decades it has been the target of significant urban renewal and measures taken to strengthen its community and infrastructure. As shown in the map of figure 12 below the neighborhood is predominantly a dense residential area in which many buildings date back to the mid to late 1800, and early 1900s. Which furthermore has in some instances become a problem due to a disparity in terms of building maintenance and influx of expats and social groups of higher socioeconomic status, leading to a significant difference in housing quality, as seen in the picture below, where some housing complexes show mild to moderate degradation and housing vulnerabilities such as ground level entry ways into living rooms and kitchens. Whilst other areas of Cabanyal undergo renovation and improvement.

In the aftermath of the city renewal of the 90s and early 2000s, the beach front has undergone a transformation in which implementations of green infrastructure and significant investments into touristic and recreational amenities and infrastructure were made. This includes among other things, restoration of waterfront buildings, construction of barriers, and further beach nourishment (García et al 2020). These are a few of the vulnerability factors which have undergone change and compose a vital part of the analysis of the profile today.

Figure 11: Image depicting deteriorating housing quality in area of El Cabanyal (L.Johansson, 2023)

Despite significant investments and community reinforcement, the neighborhood is still vulnerable in regards to many of the examined variables. As seen in the maps below, the neighborhood as a whole possesses a high morphological vulnerability due to its low elevation and land typologies, as is further explored later. Drawing from the results of the CTVI index which indicate that the socio-economic and demographic vulnerabilities are still at moderate to high levels, with concentrations in certain areas. In the event of a coastal inundation, these vulnerabilities may prove to be a challenge for decision makers, and a large gap in risk identification and reduction if not addressed. The consequence of accepting or ignoring such vulnerability may materialize as, for example, that these groups end up lacking risk education, and even a formal connection and information input from officials (Instituto Valenciano de la Edificación, 2020). These circumstances diverge from Olcina et al´s (2016) findings in regards to an increased exposure to environmental hazard, but unchanged or decreased vulnerability, as a result of the Spanish policy making and practice paradigm shift since the 1980s. As interpreted from the interview with Garrigos, N (2023) there are instances of disparity between the public sector´s goals and assessment which diverge from the experience and exposure of private and civil society actors. The incentives for prioritization of economic development and real estate incentivization, combined with hazy day to day insight into community vulnerability risks leading to oversight of socially vulnerable areas and less prioritized vulnerability variables. This is despite significant investments into hard measures, land transformation efforts such as beach nourishment and improved post-crisis relief. Resulting in the risk of falling into the trap of lacking awareness in ICZM planning as explained previously by Burbridge (2020).

4.1.1 Social and Demographic Vulnerabilities

As previously mentioned, and as shown in the map below, the social and demographic vulnerability of the Cabanyal neighborhood indicates an intrinsic vulnerability in the majority of the zones. As drawn from Instituto Valenciano de la Edificación, (2020) the vulnerability signals the existence of substantial social vulnerability and disparity in some areas, often in combination with higher degrees of building deterioration, the vulnerability takes form as among other high degrees of individuals dependent on economic aid, lacking education or in some cases literacy. The information from this variable allows for an enhanced understanding of the spatial distribution of vulnerability in the neighborhood, which otherwise would not be possible with a sole reliability on physical variables (Kunte, 2014). The socioeconomic and demographic data shows a trend in the neighborhood in which the majority of all areas are categorized in a range of medium vulnerability, with some outliers of intrinsic vulnerability in the area known as Doctor Lluch. The outliers are given further context from interviews by Pieda.J (2023), describing the areas as characterized by social disparity and high crime rates, and are thus the target of higher degrees of the urban renewal program. Similarly, areas close to the port, having previously been targeted by urban renewal interventions and renovations, have demonstrated the lowest rates of demographic, economic and resident vulnerability in the study area. Despite insight into a wide selection of vulnerability variables of the neighborhood, we may argue that there is a potential for additional unmapped and unknown vulnerability, which may act as exacerbating elements in pre, mid or post crisis stages. For example, for optimal execution of information and education outreach campaigns, or even prioritization in evacuation and mitigation measures, from the practice established by the municipal PATRICOVA documents (2019).

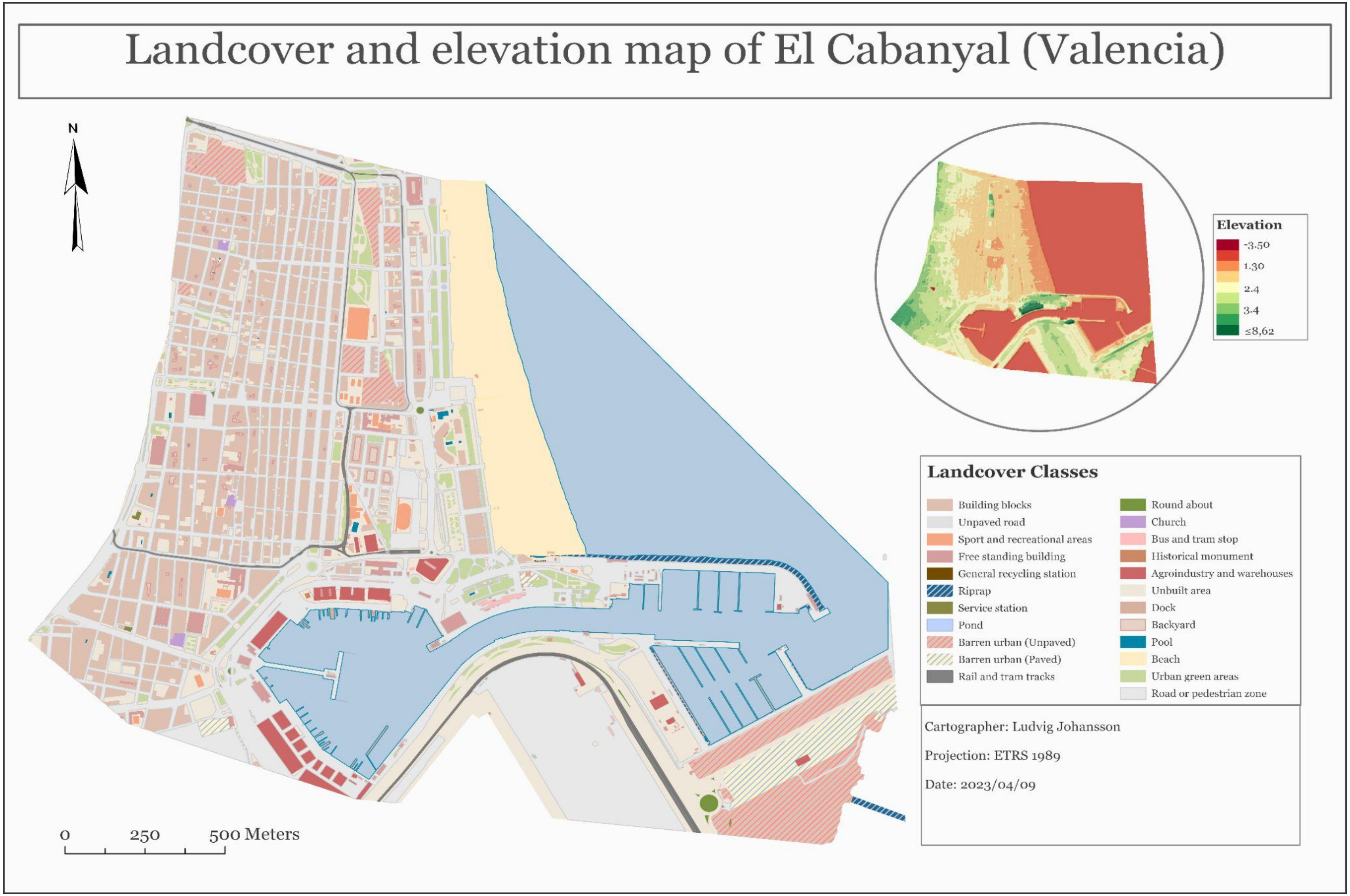

Figure 12: Terrain and Elevation Map of the Neighborhood “El Cabanyal”

These limitations have previously been brought to the attention of the municipality and planners through among other the coastal vulnerability study of Oliva by Castillo-Rodriguez et al (2016). In which the need for a revised methodology for the collection of population and urban characteristic data was required, to attain a more comprehensive and continuously updated insight into local vulnerabilities. These are themes which are displayed in the data and updated vulnerability measures displayed by Instituto Valenciano de la Edificación, (2020), however it can be argued that further ratification and application of these measures have been hampered by the COVID-19 pandemic, arguably rendering the practice regarding social vulnerability stunted compared to pre-pandemic advancements.

4.1.2 Critical Infrastructure and Protection

The definition of critical infrastructure in the Spanish context and the legislation regarding the requirement for function and protection is described in the law "8/2011 of the 28th of April", detailing the measures and demands for the protection of critical infrastructure. The BOE-A-2011-7630 article 2, defines the critical and relevant infrastructures in this study as services and functions incremental to the basic function of society, and can therefore not be substituted or in any way indisposed, whist the law encompasses all critical infrastructures they are subdivided into categories and sectors such as health, social, administrative and economic services being divided into essential services. However the criteria of what is specifically defined critical infrastructure is as follows. Areas or services whose disruption or failure would lead to an detrimental impact on a greater number of people or groups, specifically of reduced health or mobility, impacts upon public or social safety or trust toward the authority of the municipality or government. Finally, disruption or damage to areas or services which would lead to environmental degradation or economic damage (BOE-A-2011-7630, no 2-3). In the Cabanyal area only a few critical infrastructures were able to be identified due to the confidentiality and protection regulations of article 15 in BOE-A-2011-7630, especially regarding communication, information and infrastructure regarding public safety. The identified critical infrastructures include, educational facilities, hospital and eldercare, infrastructure regarding civil protection and administrative functions. All of which are within a proximity to the sea, often within a 500m distance, thus placing them in a considerably more vulnerable position. The implications of the vulnerability is as Barros et al (2022) explains the very presence of the infrastructure, and the subsequent risk of potential for disruption or shutdown of operations in a mid or post crisis stage. Which Garcia et al (2020) further explains to be of great concern in the Valencian context, as protection of the critical infrastructures are not adapted to inundation beyond pluvial or flash floods and might thus be vulnerable to a longer term inundation. These are examples of adverse events which may risk rendering some services such as transport and portions of water and energy functions inoperable. Due to the previously mentioned high socioeconomic and demographic vulnerabilities, these issues raise the need for a significant pre-crisis mitigation and preparedness, through as formerly addressed by Castillo-Rodriguez et al (2017) to further address the needs for specific needs in communities such as communication and assisting individual or groups especially at risk to prevent secondary crises as a result of critical infrastructure failure and subsequent failure to aid or maintain functions and services.

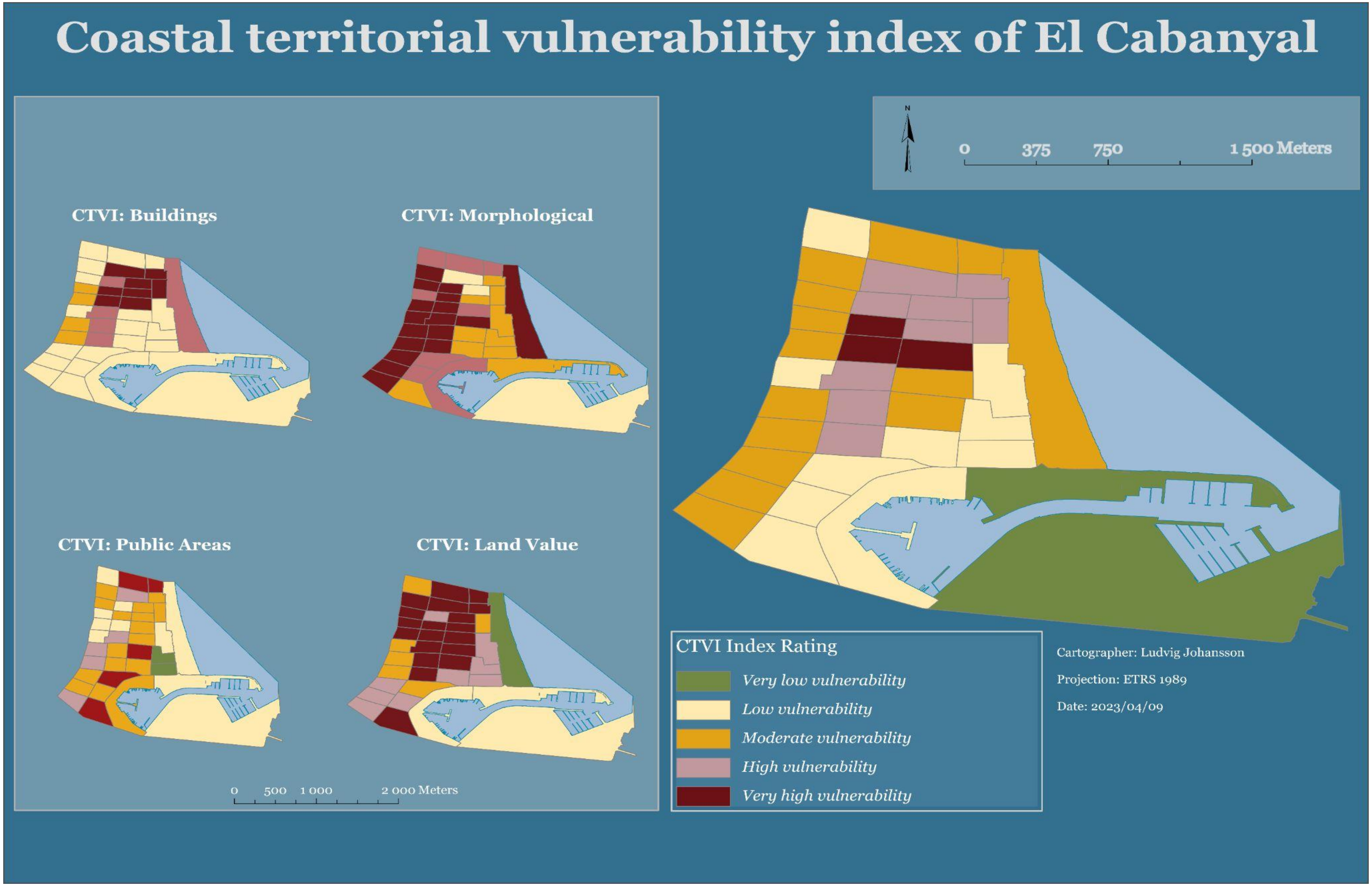

Figure 13: CTVI results on local level risk zone aggregation of all sub variables and the total index value

4.1.3 Land Morphology and Associated Physical Vulnerabilities

As observed in the graph below most of the land area of Cabanyal is at elevation levels ranging between 1-3m, in combination with a low slope angle the physical vulnerability of the area makes Cabanyal highly susceptible to coastal and other types of inundation. The correlation between increased vulnerability because of low elevation and slope is a widely accepted, and furthermore a studied topic in multiple settings according to Kunte et al (2014), showing significance across many spatial settings. The morphological vulnerability is further enhanced due to the neighborhood's proximity to the sea, in which only the centroid of a singular zone exceeded the under current circumstances safe distance (1000m) to storm surge and coastal inundation under normal conditions according to Barros et al (2022). It was first assumed that this variable will only be enhanced in the future due to the significant erosion of the last few decades. However, from Serra & Medina (1996) it was observed that after the expansion of the commercial and industrial port, the northern part of the Valencian beaches began experiencing accretion rather than erosion, as observed in the studied timeframe of 2004-2015. Drawing from Serra & Medina (1996) and the theoretical background of Marshak (2019) we may argue that anthropogenic actions disrupt the longshore drift and subsequently how the deposition of sediment is distributed along the shore. This could merely lead to locally reduced erosion and possible accretion over time in the shorelines north of the port, but to the south there is potential for a significantly increased erosion. Erosion in the southern areas would indirectly cause a rise in vulnerability in all coastal areas, as understood from Garcia et al (2020) previous analysis and data displaying and explaining the vulnerable environments of the national park Albufera, acting as vital climate buffer zone and source of food and place of great biodiversity. In other words, unhindered erosion of the southern shoreline in combination with coastal inundation could result in saline intrusion and strong negative impact upon the environment. Therefore, it may be suggested to properly capture the scale of vulnerability in this context, that there is a need for a comparison of multiple study areas or study over a larger scale.

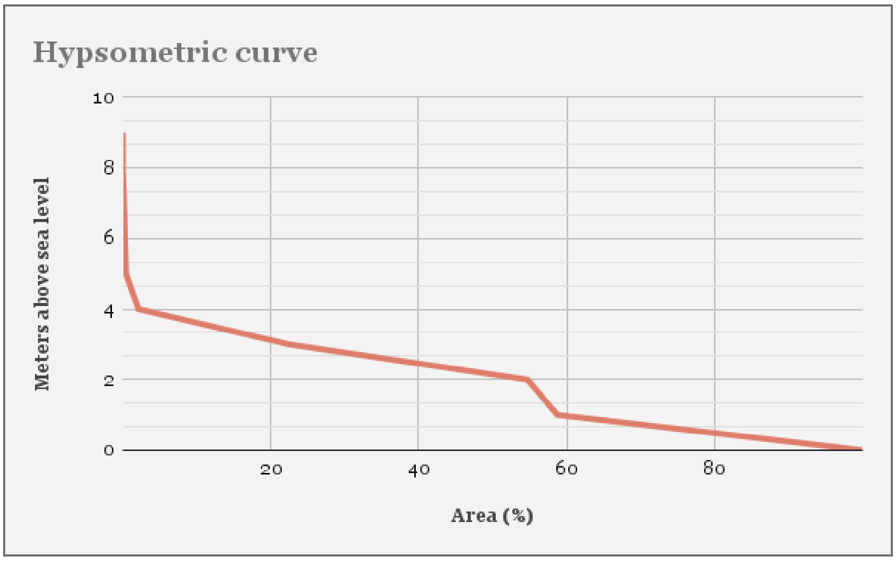

Figure 14: Hypsometric curve displaying the distribution of elevation values in the neighborhood of El Cabanyal

Furthermore, the permeability of soil was examined as a possible source of vulnerability or resilience. As previously stated by Marshak (2019) in 4.1.1, higher degrees of permeability had shown a positive correlation with increased resilience as it allowed for better infiltration and acted as a buffer for run-off and other water sheaths that may cover the soil. Compared to impermeable areas or of low permeability, in which the water will be unable to infiltrate and simply accumulate. Data from the Valencian municipality (2023) has shown that the majority of Cabanyal is classified as a range between high or very high permeability, with only the harbor areas being fully artificial and thus impermeable. However according to interviews with Gomez.A (2023) and description of challenges regarding abundance of hard surfaces by Garcia et al (2020), in which the overwhelming majority of terrain in the coastal areas in still paved or other types of hard surfaces, this could be argued to negate the positive aspects of the permeability and to put high strain on the city's drainage and storm management systems through the significant increase of discharge in the event of a coastal flood. Which in other studies such as Gold et al (2022) have shown to exacerbate flooding impact through increasing its spread by failing infrastructure and additionally causing further material and damage and facilitating for mass movements in areas of unconsolidated soil (Gold et al, 2022).

4.1.4 The Role of Intensified Climate and Extreme Weather Events upon Coastal Vulnerability and Cabanyal

1. Anthropogenic Effects and Environmental Influence

As observed in the map below the local coastline has since 1956 experienced an overall total accretion of 233 547 sqm until the year 2020, however during this period there has been decades in which the erosion negates the erosion, such as the period 1994-2004, a period in which the city according to Garcia et al (2020) experienced significant economic hardship and simultaneous major public projects. This recession is most likely part of the reduced ability to provide hard and soft measures to enhance resilience and counteract the erosion of this period through for example beach nourishment. Furthermore Cabezas (2021) data suggests that this period was also characterized by a high amount of storms, the years 2003-2004 experienced 32 storms alone with an average duration of 32 hours and on average medium intensity on the Dolan & Davis (1992) storm index, these highly erosive events can further be argued to have contributed to the extraordinary erosion during this period of time. From the period 2004 and onwards the coastline started transitioning towards primarily undergoing accretion rather than erosion, but as previously mentioned this is in part due to the expansion of the port, leading to an increase in sediment deposition according to the interview with Garrigos.N (2023).

Figure 15: Remote sensing analysis results displaying change detection in coastal line changes from the beginning of data collection of 1956 to intervals between 1996 to 2020.

In order to understand the intensifying effects of the climate change on the coastline and subsequently vulnerability and potential for increased exposure, a rudimentary index was established as mentioned in 3.3.2. This was done using variables tested for correlation using a Pearson's correlation coefficient in order to understand how they influence one another, and thus understanding their significance in terms of climate influence.

Through previous studies such as Oktaviani et al (2021), using a climate index as a way of quantifying a connection between vulnerability to adverse weather events and changing of climate, it was common to see a moderate correlation between the intensification of climate, erosional effects and potential for increase of vulnerability. As table 2 indicates the temperature and sea surface temperature have shown an increase over the last 40 years which furthermore can be seen through time as a linear regression slope of 6.92 and 5.46 respectively. Indicating a steady rise of the temperatures over the years, whilst the precipitation shows a negative slope of -2.21 indicating a decrease of yearly precipitation over time.

Table 2: Change detection results of coastline compared with normalized climate parameters and compiled index of the same interval.

Period of Coastline	Total change in area of beach profile (sqm)	Normalized mean temperature (Period)	Normalized mean precipitation (Period)	Normalized mean SST (Period)	Climate Index (Period)
Before 1986	117445	- 1,230	0,586	- 1,994	- 2,638
1986-1996	96485	- 0,835	0,386	- 0,667	- 1,115

Period of Coastline	Total change in area of beach profile (sqm)	Normalized mean temperature (Period)	Normalized mean precipitation (Period)	Normalized mean SST (Period)	Climate Index (Period)
Before 1986	117445	- 1,230	0,586	- 1,994	- 2,638
1996-2000	- 27778	0,080	- 0,457	- 0,380	- 0,757
2000-2004	- 24233	- 0,428	- 0,062	0,198	- 0,292
2004-2010	18836	0,155	0,091	0,234	0,480
2010-2015	75266	0,611	- 0,397	0,240	0,454
2015-2020	- 22474	1,141	0,196	0,856	2,194

Table 3: Pearson correlation testing between variables and comparison with similar study to validate choice of parameters for indexation

Variable tested	*Pearson's correlation coefficient test for variables between the coastline periods*	*Correlation description*	*Comparative study (Oktaviani et al, 2021)*
Temperature to sea surface temperature	0,865	Close relationship	0,450
Precipitation to sea surface temperature	- 0,513	Moderate negative relationship	- 0,05
Temperature to precipitation	- 0,542	Moderate negative relationship	

In combination, the increased severity of the climate parameters leads to a vulnerability increase across many areas, among others through the potential for increased beach erosion, as the graphs below indicate. However, it is worth noting that a longer time series is required to more accurately model the correlation between change in coastline to climate index. The available data indicates a result which shows that the climate parameters do independently and as an index together with the mean sea level rise, result in an intensification over time.

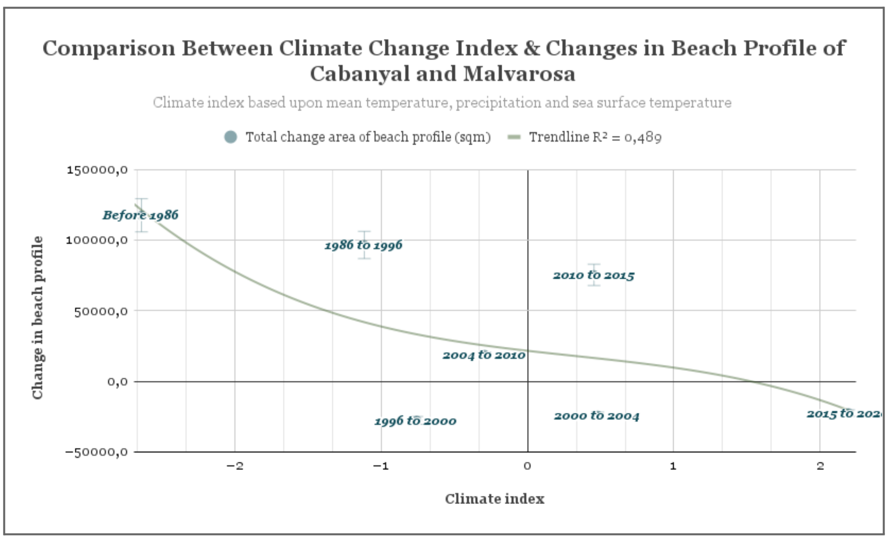

Figure 16: Correlation trend between climate change index and beach profile changes throughout the period 1986-2020

Which we may through the scope of the local vulnerability analyses by Garcia et al (2020) and Castillo-Rodriguez et al (2016) correlate to a multitude of vulnerability and future exposures. The SECAP report (2019) predicts increases of vulnerability as a result of mean temperature rise across all examined sectors, being, water, biodiversity, coastal areas, health and infrastructure, rising from current low levels of vulnerability to high within a range of 40 years. Whereas the vulnerability to changes in precipitation patterns are mainly thought to affect health, biodiversity and water variables, but to a high degree already in 2040. Due to the city's already precarious vulnerability profile in other areas and high dependency on coast related income such as tourism and port industry, an increase of climate parameters which may alter coastline width, groundwater access and quality, or other detrimental effects to limit recreational and economic usage of the coast could be very harmful for not only the natural buffers and nature-based protection measures. But also raising issues regarding the potential social and economic impact, which in a study by Luque et al (2021) has demonstrated the risk and potential future consequence of such vulnerability increase. In an area in which the income from tourism equates to approximately 35% of the total income, the Balearic Islands in Luque et als (2021) study provide examples such as substantial loss in beach profile leading to incremental effect on the local and touristic industry under RCP8.5, expected to lead to loss in GDP of 4.2-7.2%. Drawing from Luque et als (2021) findings it can be argued that projected increased vulnerability and erosion for the city in the SECAP report (2019), could imply similar or greater losses in terms of recreational, local, tourism industry and economy. Potentially leading to exacerbation of the socio-economic vulnerabilities through loss of property and or income. However, these parameters should also be considered for their potential impact upon environmental buffers and groundwater depletion and stress. Together with anthropogenic factors such as population and urban growth as well as unsustainable water consumption and usage, the increasing temperatures and prolonged drought periods have caused concern for impacts on water resources and quality as described by Garcia et al (2020). This water stress and depletion, combined with severe drought could as previously mentioned in 3.3.2 by Marshak (2019) and Satta et al (2017) contribute to increasing the morphological vulnerability through land subsidence, consequently resulting in an already low elevated area sinking even further.

2. Intensification of Extreme Weather Events

Finally, providing the greater challenge for adaptive measures and the increases of vulnerability and exposure is the IPCC (2007) prediction of an intensification of frequency and intensity regarding extreme weather events. The increase of cyclone intensity in synergy with greater wave height and magnified storm surges will according to the IPCCs report be common throughout the world, in various amplitudes. As mentioned in the previous section the effects of these hazards are expected to bring about increases of widespread vulnerability across all typologies, and more than often resulting in additional indirect increases of exposure and vulnerability. In the study by Cabezas (2021) the frequency and intensity of storms was studied from the turn of the millennium to the mid-2010s in order to evaluate their impact on coastal vulnerability and beach profiles of Valencia. The most impactful events over the period are seen below in table 4. Whilst the intensity between each year is not showing a consistent increase through the variables, it can be argued that for this brief period of time there is no possibility to determine a correlation between climate change effects and intensification. It is even argued in some literature such as by Satta et al (2017) that future climate change will not produce an exacerbating effect on storm surges or storm frequency in parts of the Mediterranean region. However, studies through for example the Xaida project (2021) have strongly suggested that increases in mean temperature and sea surface temperature will allow for the formation of hurricanes due to the increased potential and ability to be sustained over time, which will be enabled with sea temperatures exceeding a 27 degree threshold. These hurricanes are considered to be exceedingly more destructive than the current instances of "gota fria" or cold drops. (Xaida project, 2021).

Table 4: Most severe extreme weather events 1999-2014 using the Dolan & Davis (1992) storm scale being the product of duration by maximum wave height (Cabezas 2021)

Date	Duration of event (hours)	Average wave height (m)	Minimum wave height	Maximum wave height	Storm power index (m2h)
November 2001	70	2.49	1.45	3.8	262.5
November 2001	62	2.75	1.45	6.1	378.2
May 2002	54	2.34	1.45	3.1	180.3
October 2003	108	2.17	1.41	3.0	318.6
November 2003	69	2.49	1.42	3.2	218
December 2006	122	2.26	1.45	3.1	383.1
January 2007	56	2.32	1.5	3.8	210
November 2007	89	1.93	1.42	2.4	216.2
March 2008	69	2.35	1.46	3.2	220.8
October 2008	59	2.14	1.47	3.4	202.4
December 2009	66	2.86	1.42	5.8	383.5
January 2010	60	2.32	1.43	3.7	219
January 2010	64	2.46	1.41	4.5	287.4
October 2010	49	2.22	1.43	3.8	186.7
February 2012	99	2.39	1.58	3.5	343.5
February 2012	61	2.22	1.41	3.1	189.1
November 2012	95	2.68	1.44	4.1	393.3
November 2013	46	2.61	1.43	4.1	189.1

Furthermore an intensification of extreme weather events can also be traced through the study of Valencias beaches over time, as done by Cabezas (2021), despite being difficult to separate the exact difference of effect between anthropogenic and environmental parameters, we may still deduce that the change in coastline across the multiple beaches has shown an increasingly negative trend as response to extreme weather events. But to understand its gain over time a greater sample size would be needed, which is further seen as problematic by authors among the Xaida project (2021) due to the necessity of satellite imagery to capture the necessary information, thus restricting the availability of accurate data to a limited time frame. However as previously mentioned data is available for the current time period and thus modeling of current and future coastal inundations are possible, as seen in the map below. The current 100- and 500-year floods levels show storm surges which primarily inundates the areas within 500 meters of the beach, which overlap with the areas previously displaying high morphological and land value vulnerability in the CTVI index in figure 13. With the exception of the port area in which the elevated surfaces and protection measures prevent flooding under current conditions. However, the data from the directorate of climate change (2021) predicts that under RCP8.5 the storm surge levels will result in a catastrophic spread in both 100 and 500 floods, implicating a inundation of the entirety of Cabanyal during latter, flood types which the IPCC (2007) predicts expected to become more common.

The result of such inundation would not only impact recreational, touristic and economic factors as found in the Luque et al (2021) study, but wide spread and felt across all sectors. As Cabezas (2021) data showed, the occurrence of intense storms and in particular in fast succession, such as in 2001 and 2012 in table 4, led to loss in beach profile which the city has not yet recovered from. Thus, we can only speculate regarding future human and material loss.

Figure 17: Inundated beachfront in Benidorm (Valencian region) during late spring of 2023, image by news agency Levante Valenciano (M.Minguez, J.Gimeno, P.Gil 2023).

Based on the modeling below and existing vulnerabilities from municipal data and surveys, however, it is certain that a lack of multifaceted mitigation measures and failing to understand the social context from a nuanced perspective will result in unprecedented damages, from which the environment of the city, its people and economy will not recover.

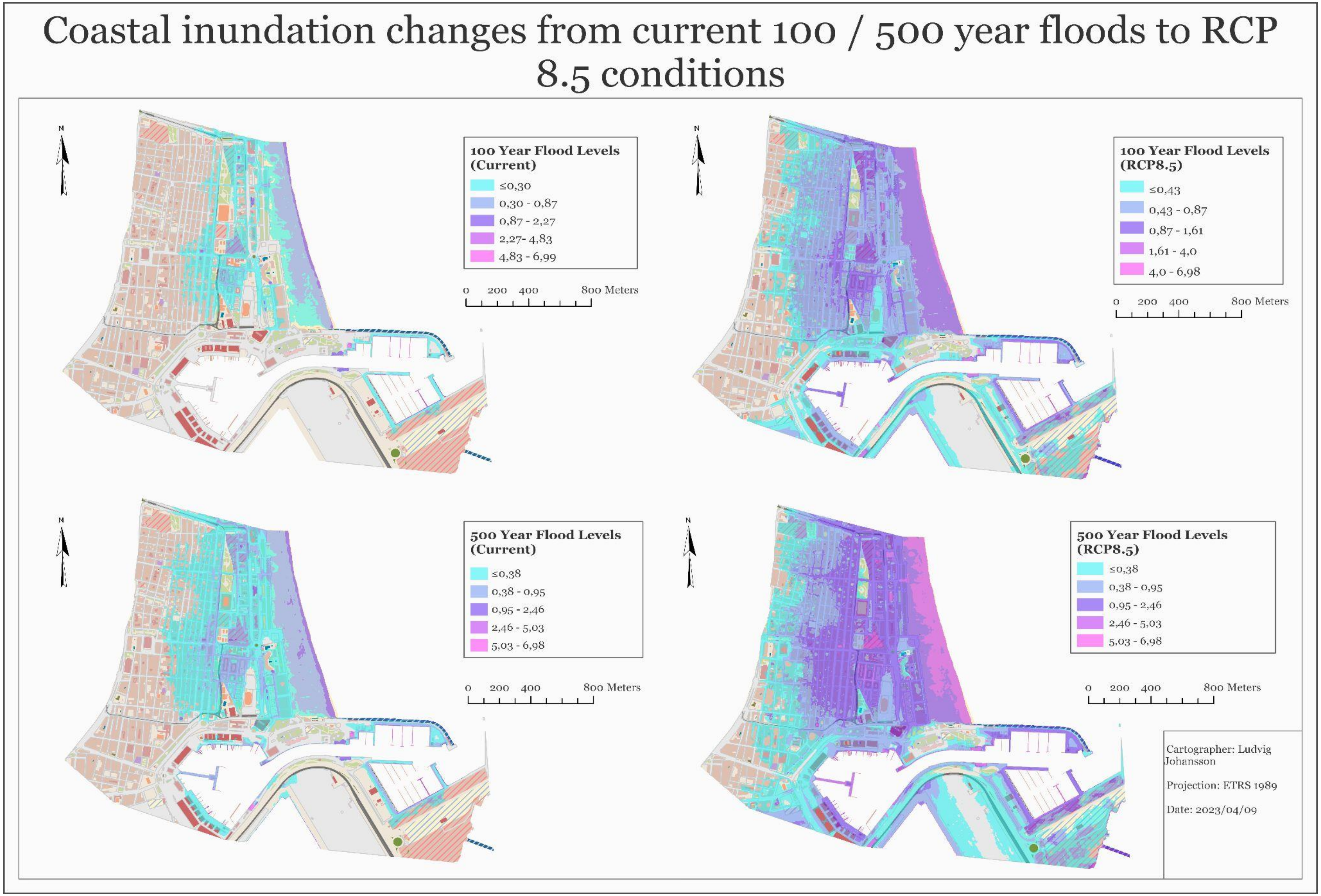

Figure 18: Inundation modeling of 500 year flood levels in Cabanyal, comparison between current and RCP8.5 scenario impacts

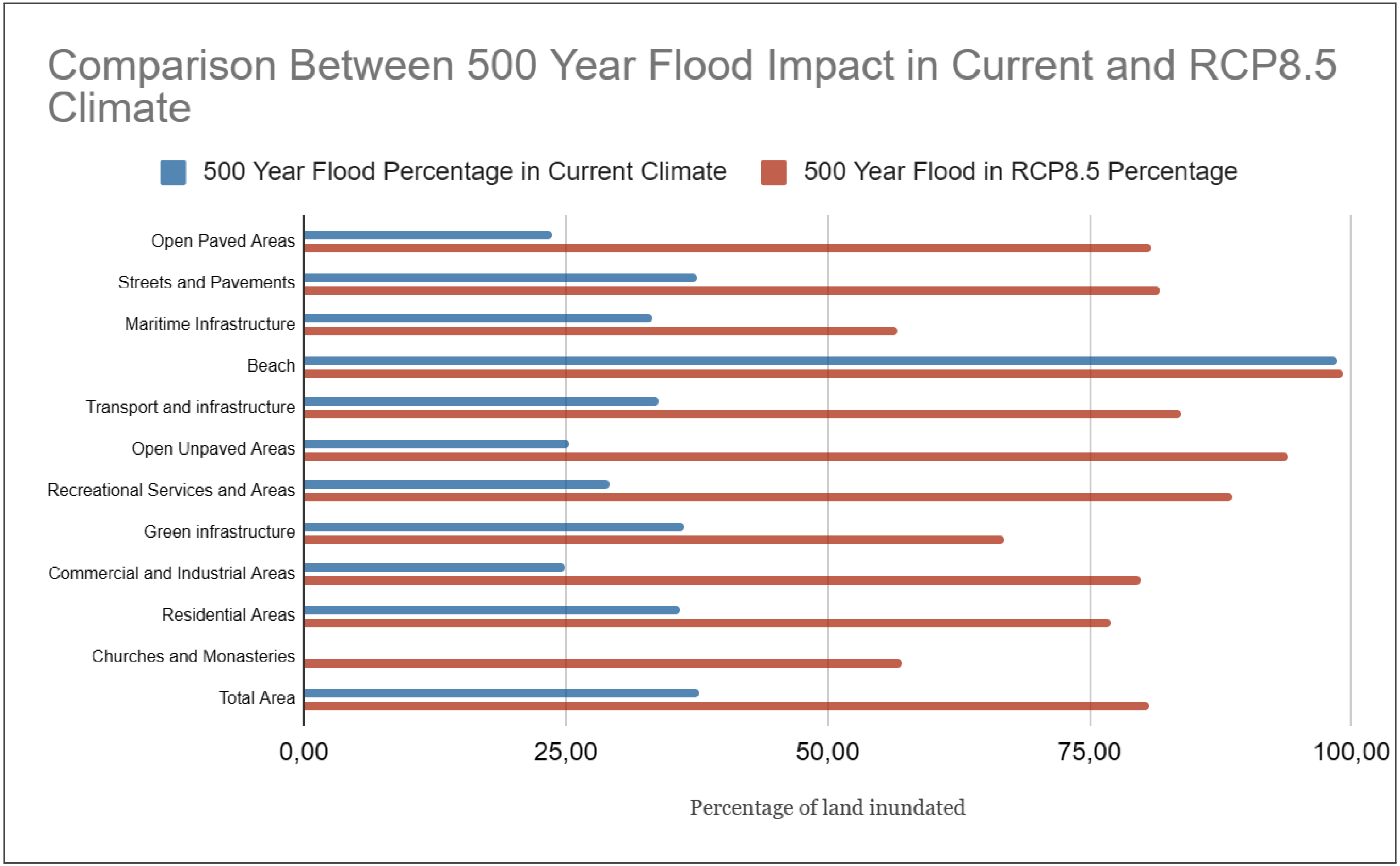

Figure 19: Comparison in percentage of inundation across various land classes during 500 year flood scenarios in the neighborhood of El Cabanyal

4.2 Adaptive Capacity Measures in Valencia

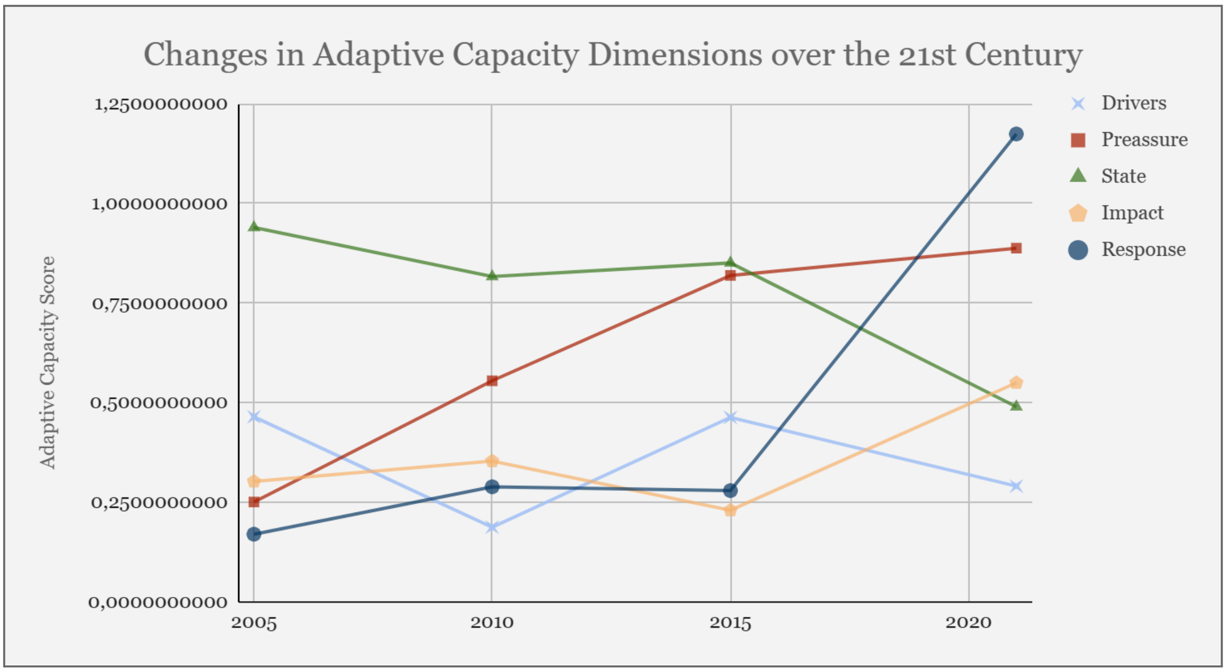

Figure 20: Graph over trend changes in DPSIR dimensions over the period 2005-2021

4.2.1 Changes in the Adaptive Capacities of Valencia Over Time & Accompanied Causes and Effects

As suggested by the statistical compilations by the Ajuntament de València (2022) of the years 2005-2021, the city has during the 21st century undergone major economic hardship as a result of major global and national economic events. Which led to the regional recession in 2015 and near bankruptcy in the beginning of the millenia. Trends which are further reflected in the data in figures 20 and table 5, showing the transition of urban adaptive capacity and the associated sub-dimensions. As seen in figure 20 above the beginning of the time series began with relatively low levels of response, impact and growth after the economic hardships however maintained moderately high levels in the state variable until 2015, which we may trace to the significant investments into green and blue infrastructure and policy ensuring preservation of agricultural and green areas as previously explained by García et al (2020). The data traces the decline in 2021 to be heavily influenced by the changes in consumption price index during this period of time.

The values of the variables at the start of the time series can be traced to consequences of the rapid urbanization from the 1980s onwards, that brought about underlying vulnerabilities in the urban setting. Resulting in increasingly heavy demands on the urban drainage and water infrastructure as well as overall exacerbation of flooding due to how hard surfaces increasingly became a majority in the urban environment as explained by Almódovar et al (2023). The authors (2023) further explain that the legacy of the latter part of the 20th century brought about a challenge for the planners and policymakers. In part due to previously strong incentives for rapid construction and investments into real estate and tourist related infrastructure, leading to loss of agricultural and natural land, but also due to previously unsustainable and lack of regulation regarding the usage of flood and runoff water (Almódovar et al, 2023). This can be seen as a manifestation of the increasing pressure variable throughout the time series in figure 20, reaching a peak in 2015 before beginning its stabilization and decline. Authors such as Almódovar et al (2023) and Olcina et al (2016) have traced such effects to incentives and initiatives in the areas of nature based solutions, specifically investments into green infrastructure and innovative water preservation and absorption practices in the urban setting. They are often characterized by what Almódovar et al (2023, p.3) refers to as "connectivity, multifunctionality and spatial planning", examples of such may be the sponge city model, entailing the planning parks and green areas as intentionally floodable areas, able to retain and divert water during floods, as explained as one of the central strategies in the Valencian setting by García et al (2020). These are but a few examples of the planning paradigm shift from the late 20th century to the prioritizations, challenges and perspectives which arose during the 21st century.

The data indicates a change over the time series showing a rapid increase in the response variable, responsible for the major generic adaptive capacity variables whilst maintaining and by the end of the sequence decreasing despite higher pressures in population and climate change impacts. Through the climate change index indicated in table 2, the severity of precipitation and temperatures increased from levels of 0,480 to 2,194 during the period intervals 2005-2020. Increases which Marshak (2019) explanation of climate challenges and water resources would describe as having a strong correlation with the increases in water stress and demand on urban infrastructures from both environmental and anthropogenic factors. Correlations and changes in trends which are explored further below.

Table 5: Aggregated results of the Urban Adaptive Capacity Index and subsequent classification and study of trend changes.

Year	Grey Relational Grade of UAC	Z-Score Classification	Rate of Change
2021	0,5747	1,3232	20,1745
2015	0,4782	−0,2839	−3,9173
2010	0,4977	0,0408	15,6355
2005	0,4304	−1,0801	
Slope	0,1317		

1. 2005-2010

The period of 2005-2010 was as previously mentioned characterized by the recovery from an economic recession and hardships, both political, environmental and economic from the turn of the millenia. It was also a time which Olcina et al (2016) describes as undergoing high levels of urbanization and population growth. Particularly an urbanization which placed housing and services in flood prone and areas considered hazardous (Olcina 2023). In combination with a legacy of the urban planning practices, previous growth and policies enacted during the transitional government of the 1980s leading to detrimental challenges in terms of climate change adaptation. Practices and trends which followed into the early 00s seen through the steady rise of the driver variable in figure 20.

Trend changes may also be observed across various societal levels, through among other maintained levels of high discharge of wastewater, potentially related to an increase in urban population and GDP changes rather than infrastructure and practice change. The trends also indicate loss of agricultural land and increasing consumer price index, resulting in an elevation of the pressure variables of this interval. However this period of time saw increases in investments of green infrastructure and beach nourishment, leading to moderate increases in overall green surfaces and major shoreline accretion as seen in the budget compilation of 2010 (Ajuntament de Valencía, 2011). Despite underlying vulnerabilities and detrimental legacy factors, the overall adaptive capacities increased by 15,6% during this period of time. From policy studies by Olcina et al (2021) and interview with Olcina (2023), factors which attribute to this can in part be identified as paradigm shifts regarding the prioritizations in among others urban planning practices and regarding flood mapping.

As discussed in detail in the Soft Measures, this period also saw an implementation of European directives and legislation regarding flood mapping, such as the flood directive of 2007, creating frameworks which facilitate and demand more profound risk identification and analysis on local and regional levels. This sets up for potential for incremental adaptive growth (Directive/2007/60/EC). Furthermore J.Olcina-Cantos (2023) and the statistical compilations of the years 2005 and 2010 reveal that the research related to inundations and environmental impacts increased significantly during this period of time, which may lead to further insight into how variables were measured, understood and practiced around during the coming interval years (J.Olcina-Cantos, 2023; Ajuntament de València 2006,, 2011).

2. 2010-2015

The period between 2010 and 2015 led to an overall decrease in adaptive capacity and comprehensive increase of vulnerability factors as seen in figure 20, where variables of pressure, a fully negative impact can be seen increasing as well as the impact variable containing both positive and negative variables, however data from the analysis and statistical compilation (2016) indicate increases in unemployment rate as well as a decrease in household income. This loss in adaptive capacity by the year 2015 can be traced to the economic challenges of the financial crisis during the period 2008-2013, following the economic boom and overall strong growth of the early 2000s. A period which also led to benefits stemming from intrinsic macro and microeconomic reforms taken during the 1980-90s. further strengthened through a considerable and extensive EU integration, accelerating modernization as well economic and societal resilience according to a study by Royo (2020), simply until it did not. Royo (2020) explains that the economic collapse had large-scale societal effects leading to among other rapid increase in unemployment, large increases in governmental and public debt, and overall decline in GDP constant and balance (Royo, 2020). Further seen in the great reduction in government spending during this interval into both public and environmental budget, thus leading to lessened investments into green and blue infrastructure projects and other adaptive measures such as decreases in stormwater infrastructure construction (Ajuntament de València, 2016).

However, drawing from Cabezas (2021), García et al (2020) and the climate index in table 2, we may understand that despite recession and economic hardship practices regarding environmental protection were still maintained, in spite of an overall intensive climate period of high temperatures and meager precipitation. Showing successful practices such as continued beach nourishment leading to large scale accretion of the beach profiles in this period as previously noted in table 2. However authors do seem to agree that progressing measures were scaled back, a trend further supported through interviews with A.Gomez (2023).

3. 2015-2021

The final interval between 2015 to 2021 saw some of the most significant recovery and growth of most adaptive variables that the city had undergone since the start of the time series. As seen above in figure 11 and table 2. Furthermore despite a strong impact from the Covid19 pandemic the city recovered from and managed to begin a stabilization and return to lower levels of the impact variable. The causes behind the 20,17% increase since the 2015 interval are numerous and in the scope of this thesis are not possible to be explored fully and with clear correlation.

As seen in figure 11, the dimensions of response, state, drivers and impact begin a steady and in some cases a radical increase, as in the case of the response dimension. These increases can in part be attributed to the economic recovery from the financial crisis as explained by Royo (2020), learning from previous lessons regarding overly relying on singular sectors for economic growth, leading to major economic reforms and booms across various service and production sectors. These changes are however not entirely positive as argued by N.Garrigos (2023) as regions along the Costa Blanca allowed rather lax regulations of real estate development, leading to habitation being constructed in hazardous areas, she explains however that this problem was and is not as frequent in the Valencian region.

Regarding overall increase in adaptive capacity across this time period, it may also be attributed to possibilities enabled by this economic recovery and what N.Garrigos (2023) and A.Gomez (2023) described in their interviews as a political paradigm shift from the previously ruling right-wing party PP to a left-wing progressive ruling party coalition of the parties Compromís and PSOE. This period was characterized by strong measures and investments into green and blue infrastructure, policy and framework reworking as well as a significantly expanded collaborative planning initiative, producing projects such as the public procurement of innovation (PPI). Almodóvar et al (2023) and J.Olcina-Cantos (2023) have explained this period as transitioning towards adapting the measures and analysis of risk to a local scale of adaptation and implementations. Examples of which may be the PATRICOVA (2019) beginning to integrate social parameters into the flood risk assessment as of 2015, and is of 2019 one of categories in which the vulnerability to flooding is analyzed, aside from the economic and environmental categories. Furthermore infrastructure implementations made in order to augment and optimize the usage of electricity and stemming the water scarcity and unsustainable water usage. Which as previously mentioned has a direct impact on the potential for land subsidence and thus exacerbated flood vulnerability (Marshak, 2019). Such measures can be compared as similar to those of the attack, retreat and defend strategies seen applied in cities and regions, among other Gothenburg in a study by the authors Valencia et al (2021). These strategies include some of the measures mentioned in table 7, such as designating certain areas exposed to high hazard as non-urbanizable and utilized for other purposes or flood mitigation infrastructure, such as dry-bowls, submersible parks or other multifunctional measures (Almodovar et al 2023).

Finally, as seen in the study by Valencia et al (2021) the intensifying climate over the last few decades is a matter which has in many regions such as the study´s Malmö, Sheffield, Gothenburg, Cape Town and Buenos Aires led to challenges regarding the requirements of adaptive capacity and bringing it up to levels capable of resilience as well as having it recover from adverse events, such as floods. Something which Valencia et al (2021) found to be a problem in some case studies such as the case of Malmö, in which the authors found that the experienced adaptive capacity plummeted in the post-crisis stage during storms and heavy cloudbursts during the 2010s. Results which emphasize the problems of systems lacking in collaborative frameworks and what Valencia et al (2021) argues to be lack of risk identification and locally assessed mitigation implementations.

Drawing the parallel to the Valencian time series of adaptive capacity change ratio to climate change intensification. As seen in table 2 and figure 16, the climate has radically increased in severity over the last 40 years, leading to higher temperatures and lower rates of precipitation, as previously mentioned leading to underlying vulnerability increases. However as interviews with N.Garrigos (2023), A.Gomez (2023) and J.Olcina-Cantos (2023) shows the experienced adaptive capacity has in some sense undergone changes through the early 00s however as of 2015 and onwards there seems to be little doubt in the capability of the existing frameworks and practices. Comparatively to other cities in the study by Valencia et al (2021), the Valencian region has showcased over the last 8 years a steady increase in adaptive capacity as well as a public trust in the system for its function and success. Something which N.Garrigos (2023) and García et al (2020) has argued to be linked to increases in collaborative measures and projects, and overall increase in mitigation of impact as a result of infrastructure and flood mitigation implementations, leading to lower human, economic and environmental costs.

4. Future projections

The future projections regarding the adaptive capacity of Valencia can in short be summarized by an understanding gained from interviews with J.Olcina-Cantos (2023), despite overall positive projections from his earlier works (Olcina et al 2016) and an increase of implementation of measures and practices showcasing a strengthen resilience and adaptive capacity. It is still argued by Olcina-Cantos (2023) and Almodovar et al (2023) that future increases in climate severity will result in increasing potential for high risk and increased exposure, if proper mitigation measures are not taken within the coming years. Measures which the authors relate to mitigating the effects of anthropogenic induced increase in vulnerability and exposure. Which according to J.Olcina-Cantos (2023) cannot be allowed to further add to the already existing severe climate impact and must be stemmed with multifaceted actions ranging from hydraulic measures and more soft practices such as adaptation through enhanced territorial planning.

4.2.2 What Adaptive Capacity Measures have been Implemented as of Today?

Grindlay (2012) investigation into the paradigm shifts of adaptive capacities over the 20th and 21st century in Spain, found that over the last two decades the Spanish urban and regional planning has transitioned towards a harmony between the artificial and the natural environment. This transition has been defined by its focus on nature based solutions and transition away from the traditional reliance on structural solutions such as flood management control works. Which as found by Olcina et al (2016) has resulted in exacerbation of crises and was found to obstruct the post-crisis work in floods during the latter part of the 20th century due to the increased severity. As such a combination of hard and soft measures have been implemented and developed in order to address the current and future enhanced challenges. Furthermore the pressing question regarding good and adaptive governance in combination with an integrated collaborative approach has been increasingly seen as of importance to improve decision making processes, as well as to adapt planning and risk assessment frameworks to local needs and unique characteristics (PPI, N.D). Thus a multitude of plans and initiatives have been developed to integrate public and private stakeholders into decision making processes such as Compra Publica de Innovacion Valencia (PPI) and specific local collaborative planning documents which follows below.

1. Physical & Other Hard Measures

Table 6: Compilation of adaptive capacities of physical or hard characteristics in Valencia

Adaptive Measure	Description	Imagery
Beach Nourishment	According to Cabezas (2021) the beach nourishment program has been an ongoing adaptive measure which has attempted to mitigate the continuous erosion of Valencia's beaches since the 1980s. It has constituted a preferable option to armoring the beaches, despite higher economic cost but is a much more sustainable option in comparison. Data by Cabezas (2021) and García et al (2020) explains that the nourishment has acted as buffers post extreme weather events and have thus enabled a moderate accretion of the beach profile and restoration of the dune systems. ➢ Sustainable option for beach accretion allowing for moderate recovery from strong erosional effects of storms. ➢ Risk of acting as band aid rather than all inclusive mitigation method (Martin & Adams (2020) ➢ Continuous anthropogenic related erosion leading to uneven ratio of accretion/erosion (N.Garrigos, 2023).	 *National Park Service U.S (2019)*

Beach monitoring	García et al (2020) describes beach monitoring as a vital adaptive measure in enabling tools for risk identification and better visualization and insight into emerging and existing vulnerabilities. The measure has been explained and evaluated in the Valencian setting by Serra & Medina (1996), who describes it as an essential tool for vulnerability and for observing hazard impacts. ➢ Cost efficient and technically simple tool for risk identification (Olcina et al 2016) ➢ Simplistic yet allows for profound results of beach profile changes and potential vulnerabilities and risks.	
Coastal Barriers	The hard protective measures used by the city are mainly restricted to riprap, groins and breakwaters throughout the coastline; they are not discussed extensively in the public documents or associated literature but merely mentioned as existing sheltering measures by García et al (2020). ➢ Object function provides a barrier towards erosional agents and excessive longshore drift of sediment (Marshak, 2019) ➢ Potential local imbalance of deposition of sediment and uneven impact may prove to be undesirable for stakeholders engaged in beach function and services (Cabezas, 2021).	
Neptune grass Plantations	Neptune grass, also known as *Posidonia oceania,* is an endemic species to the Mediterranean, its a sea grass growing on the seabed acting similar to that of a forest according to the Atlas of Seagrass Meadows in Spain (2015), acting as a diverse ecosystem. Furthermore, it produces high levels of oxygen, granting ability to filter water and consolidate soil, making it a strong measure in preventing erosion of the shoreline and coastal slope, thus enabling a strengthening local resilience. ➢ Overall popular and relatively cheap mitigation measure ➢ Conflict with touristic service stakeholders leading to removal of neptune grass, risk of greater susceptibility to erosion and	 *Damocean (2019)*

	degradation of ecosystem (Cabezas, 2021; Atlas of Seagrass Meadows in Spain, 2015).	
Green & Blue infrastructure	The integration between green and blue infrastructure has become a centerpiece in developing the "sponge city concept", a measure designed to increase the city resilience and provide a multifaceted adaptive capacity. The sustainable drainage plan, known as SuDS (2021), aims to plan for nature based and artificial solutions capable of filtrating, retaining, treating and enabling enhanced infiltration in urban areas which otherwise may be mostly impermeable. ➢ Function contributes to reduction and retention of precipitation runoff and storm surges. ➢ Measures include among other dry bowls, depressions throughout the city allowing for intentionally floodable parks and green areas (SuDS, 2019). ➢ Challenge has been exacerbated and demanded greater innovative action, due to the intensive urbanization trends of the period 80-00s, resulting in overwhelming hard surfaces and impermeable surfaces (A.Gomez, 2023).	
Urban and Storm Drainage Infrastructure	The storm and water infrastructure has from 2005 expanded from a network spanning 970 km to 1 168 km in 2021. As an infrastructure enabling the mitigation of wastewater and overall discharge this function is essential to the physical adaptive capacities according to Hu & He (2018). Spiller (2017) further argues that an extensive and integrated storm drainage infrastructure not only leads to lessened crisis impact through greater capacity of discharge. Furthermore the integration of this infrastructure may lead to secondary beneficial enhancement of adaptive capacities, such as reduced water scarcity and resilience towards potential economic and social costs (Spiller, 2017).	

2. Soft Measures

Table 7: Compilation of adaptive capacities of soft and policy related characteristics in Valencia

Adaptive Measure	Description	Imagery
Risk Identification Systems (Early warning)	Interviews with J.Olcina (2023) have demonstrated the strengths of the Valencian adaptive capacity systems and strategies, which lay in the frameworks enabling strong risk identification and reduction. In other words, early warning systems, modeling, as well as frameworks and strategies for predicting arising vulnerabilities and impacts. These measures have come as results of among other; implementation of the law of the European flood directive of 2007 upon which the Spanish regional policy, practice born of previous praxis shortcomings and failures (Olcina-Cantos & Díez-Herrero, 2021). ➢ Predating the European flood directive the PATRICOVA plan was enacted in 2002, entailing a comprehensive cartography and documentation of; Impacts, vulnerabilities and risks of projected, previous and occurring adverse events. This practice was further enhanced following the European flooding directive of 2007. ➢ Aspects of strong risk identification has also been made manifest through extensive collaboration between local and regional actors, such as through compiling, sharing of data and resources. Thus facilitating for smaller local communities to attain the goals set by the flood directives and acquire a good understanding of the risk profile (J.Olcina-Cantos, 2023)	
Planning for Critical Infrastructures & Emergencies	The success of the soft policies have not only been in the frameworks and everyday practices, facilitating and enabling identification of risk. But also in the contingency planning of protection of critical infrastructure and emergencies. Incorporated into the local, regional and national frameworks, the policies and practice ensure a thorough analysis of the risk profile from multifaceted and required analysis which takes into account the potential for cascading events and their unpredictable impact, as described in the Spanish environmental law (BOE-A-2015-186, 2014).	

	➢ Barrionuevo et al (2020) explains in their contribution to the 34th International Geographical Union (GRU) that the practices regarding the protection of critical infrastructures is a matter not only included in the scenario and projections for future impacts such as the Valencian impact modeling of RCP 4.5 and 8.5 scenarios (Ajuntament de València 2023). ➢ The practices also extend to a mandatory practice to analyze the potential for hazards and specifically the susceptibility of the critical infrastructures to these hazards. Examples of which may be water network overflow due to coastal inundation, electricity failure due to similar hazard e.t.c (Barrionuevo, et al 2020). Specific focus has argued to be on classifying risk zones and identifying areas in which hazards converge to generate exacerbated risk for critical infrastructures.	
PATRICOVA Framework & Risk Reduction	As explained in the interview with J.Olcina-Cantos (2023), the Spanish practice and policy making has led to a strong ability in risk reduction in regards to coastal inundation. This has been achieved through among other land use planning, classification and subsequent risk and vulnerability analysis. An integral part of this practice is found in the aforementioned PATRICOVA framework; ➢ Specific land use planning as part of the PATRICOVA (2019) framework, overarching classification of soil prohibited from any type exploitation and subsequent urban and buildable soil. ➢ Further non-structural and policy approaches to risk reduction in the PATRICOVA framework (2019) has been the designation of "sacrificed areas" and "protected areas" and planning of flexibility in the localisation and relocation of services and infrastructure in response to results regarding increased levels of exposure in the urban och buildable zones. ➢ Finally the PATRICOVA (2019) and territory plan (2022) argue for a land use planning which is meant to mitigate the exposure to hazards through the continuous evaluation of urban, buildable and prohibited land classifications.	
Post-Crisis Relief Efforts and Support	Olcina et al (2016) study of the policy changes since the 1980s has remarked on an element which has been integral in the post-crisis stage, ensuring both economic and physical recovery as well as preventing any excess loss	

	in trust and safety of the authorities. This relief has taken various forms throughout the years; ➢ In highly severe crises, catastrophe zones could be established in which the state will take on and compensate for all costs, whether public or private. However the need for this practice has faded over the last few decades, in response to adaptive measures according to J.Olcina-Cantos (2023). ➢ Other examples of relief and insurance provided by the state have previously included tax-cuts, economic incentives to the private sector and public. Olcina et als (2016) study has found that approximately 65% of all claims for compensation during the period 1971-2013 were paid, going in line with their argument of providing a relief system available to all.	

3. Collaborative Planning & Policies

Regarding collaborative planning practices and policies, the interview with J.Olcina-Cantos (2023) found that the usage of civilian collaboration is highly varied depending on the political climate of the region. The Spanish political landscape is highly polarized and it is primarily left-wing governments favoring such collaborative practices, becoming highly prominent in the Valencian region during from the mid 10s and onwards. J.Olcina-Cantos (2023) argued however that collaboration with private stakeholders and research institutions were far more common in regards to adaptive capacity and related projects. These collaborations and projects have yielded results such as collaborative funding for water and hydraulic and flood infrastructures, in which private actors and local governments plan and partially fund these projects in collaboration with the national leadership (Olcina et al 2016).

Other collaborative initiatives attempting to stem sociodemographic inequalities in regards to vulnerability have included information campaigns and tailored communication outreaches to both businesses and individual households who are in risk zones. By extension investments have also been made for easily available risk education and promoting resilience, through access to guides and tools to thoroughly educate households and businesses regarding how they may better protect themselves against floods, as well as education on the associated risks and expected response from authorities (Consorcio de Compensación de Seguros 2017).

Furthermore, as part of the “Missions Valéncia 2030” project (2021), in order to produce a more adaptive and good governance with potential for frameworks and systems to be flexible and versatile programs specialized in integration of innovation and stakeholder engagement in the development of practices and policies. This project is known as the “public procurement of innovation” (PPI), a collaborative project intended on integrating local knowledge and experiences into innovative solutions for resilience and mapping and projecting future demands and trends within the city and locality in terms of changing vulnerabilities, exposures and susceptibilities (Ajuntament de València, 2021)

4.2.3 How do the Adaptive Capacities Compare to the Overall Standard of the ICZM and Other Coastal Cities?

The ICZM and Spanish national frameworks overall coincide in their established goals and standards to achieve regarding planning for climate adaptation, however it is worth mentioning the structure and how these goals align with the current progress and potential shortcomings of the Valencian adaptation progress. The ICZM framework goals are stated as by the UNEP (2019) to achieve good governance, collaboration between stakeholders across all sectors and foremost a sustainable planning and usage of the coastline for all interests and purposes, further explained in 2.2 Adaptive Capacity Strategies. Desirable outcomes and results are noted as, for example: requirements regarding protection of coastal ecology and areas of cultural importance, and strengthening resilience of such areas with sustainable development. Furthermore desirable results include collaboration with relevant stakeholders reaching balanced planning to further environmental, economic and social values, and among other the promotion of green and blue infrastructure (UNEP, 2019).

Albeit difficult to quantify the exact fulfillment with said guidelines and goals, some understanding in their realization and shortcomings can be understood from interviews with the expert stakeholders, self-critical review in policy reports, and through comparison with other coastal cities within the ICZM framework. Such as the Italian coastal cities by Cantasano et al (2017) and Valencia et al (2021).

As previously mentioned by Burbridge (2020) some of the common pitfalls in the ICZM practice are incompatibilities and conflicts in stakeholder engagement, seen in study area such as Malmö in the study by Valencia et al (2021) and lacking either insight of ability to identify problems between the environment and economic, social and ecological factors.

The interviews with the stakeholders (2023) have illustrated a ICZM system which possesses strong frameworks for risk identification and mitigation, capably addressing ICZM goals such as issues regarding the monitoring of coastal erosion and nature based solutions in managing coastal areas, as well as integrating the ICZM and associated practices and goals into all policy and planning documents and practices across all levels of authority. Examples such as the SECAP (2019), PATRICOVA (2019) and EU integrated documents such as the ones by García et al (2020). Examples of such compliance and success can be seen in the coastal mitigation measures studied by Cabezas (2021) through intrinsic beach nourishing and offshore plantation of seagrass. As well as previous examples in Physical & Other Hard Measures and Soft Measures demonstrating examples from the PATRICOVA (2019) and García et als (2020) report regarding land use planning practices which addresses the ICZM guidelines and goals striving towards an integration of environmental protection whilst preserving economic, social and cultural values in each area. Overall the Valencian policy as of today reaches a satisfactory level in the majority of the ICZM framework as drawn from the interviews with N.Garrigos (2023), A.Gomez (2023) and J.Olcina-Cantos (2023). However due to the previous shortcomings and receding adaptive capacity over the early 2010s as previously explored, some aspects of the ICZM are still lacking, such as the collaborative efforts between stakeholders. An issue brought up by J.Olcina-Cantos (2023) as a legacy issue due to previous political prioritizations regarding stakeholder engagement, an issue now thoroughly addressed with projects and initiatives mentioned further in Collaborative Planning & Policies. Despite cohesion being on good levels between established stakeholders, such as research institutions and private sectors as mentioned by García et al (2020), having led to promising results in terms of mitigation measures, there is still a need for further collaborative engagement with stakeholders to fulfill the ICZM goals. This issue can be seen in localities such as Oliva in the study by Castillo-Rodriguez et al (2016) in which the call for further collaboration in order to optimize local understanding of the risk profile, an issue which then has seen attention through the demand mapping through the PPI initiatives, further explored in Collaborative Planning & Policies.

Regarding the comparison with other cities within the ICZM framework and coastal cities studied from an adaptive perspective by Valencia et al (2021) the argument from authors such as Cantasano et al (2017) that regions in Italy face similar challenges as described by Burbridge (2020), and their capacity to counter them has a strong correlation with their overall GDP and economic strength, with only two regions within Italy being described as having good compliance with the ICZM goals and guidelines, one of which is Emilia-Romagna, described as a leading example for the ICZM implementation. The policies and planning which are used within this region are highly similar to contents of the SECAP (2019) and PATRICOVA frameworks (2019). Focusing on measures addressing the risk identification and mitigation measures aiming to strengthen the resilience through among other better usage of water systems, regulation of anthropogenic impact through sustainable tourism e.t.c (Cantasano et al 2017). Similar prime examples raised by Valencia et al (2021) possess alike characteristics, desirable and cities with good adaptation are described as being avant garde with the practices of risk identification and mitigation, through tools expanding beyond the physical and into multifunctional land use planning and multifaceted solutions, such as the Gothenburg "attack, retreat & defend" initiative (Valencia et al, 2021). To conclude the interviews with J.Olcina-Cantos (2023) and N.Garrigos (2023) illustrate the existing ICZM compliance as a overall fulfilling one, with current shortcomings being a legacy factor from previous political paradigm and economic recession, issues which slowly are mended through previously mentioned initiatives. Thus the interviews argue for that Valencia does not possess similar problems regarding the ICZM as other coastal cities and regions do in the Valencia et al (2021) and Cantasano et al (2016) studies, primarily focusing on stakeholder cohesion issues and linkages between research institutions and public sector for the furthering of climate adaptation.

4.3 Identification & Transfer of Lessons Learned from Spanish Policymaking and Valencian Context

Table 8: Policy and practice lessons learned from shortcomings and successful uses in the Spanish context

Extensive Flood Risk Mapping *Establishing requirements and frameworks for flood risk mapping and demands on local level*	**Revised Land Use Regulation** *Land use policy aiming to identify and classify land from a risk assessment perspective for future scenarios*	**Post-Crisis Relief Practices** *The role in which the state can and may be required to intervene and assist in post-crisis stages*	**Threat of Anthropogenic activities and Tourism** *The need for a revised understanding of risk, vulnerability and exacerbated exposure from human activity*	**Collaborative Incentives and Procurement of Innovation** *Collaborative planning aiming to better understand local vulnerability and needs*
General requirement to on a local level assess and map occuring flood impacts and damages, furthermore a continuous mapping of the shoreline in order to attain short and long term understanding changes in vulnerability. *Can range from simple remote sensing analysis using open source satellite imagery such as Sentinel 1-3 for European projects or more complex yet cost-efficient such as the coastal supervision model described by Olcina et al (2021) in 4.2*	Land use planning which aims to utilize knowledge from risk identification in order to classify land according to its current and future hazard exposure and risk profile. Identifying land which is usable for urban construction, which may be suitable for flexible construction and infrastructure with high resilience or low importance and finally areas regulated against or advised against any construction.	The post-crisis relief practice can in the face of exacerbated risk for extreme weather events on a greater scale, benefit from practices such as a more intrinsic post-crisis relief. This policy encompasses a measure meant to boost recovery on local level whilst providing a buffer for potential loss in trust and damage in stakeholder relations. Whilst assumed to lessen in need over time in ratio to increasing resilience the policy can prove a valuable bandaid in the face of intensified extreme events.	The lessons learnt from the revised Spanish perspective and research implications from leading experts such as J.Olcina-Cantos (2023), the need for an expanded vulnerability evaluation is required in order to capture the full risk profile. Such examples may relate to studying the full impacts of seasonal tourism on the integrity of the coastline and how it affects the capacity of green infrastructure and other vital infrastructures.	The collaborative planning initiative aims to counter a frequent barrier in risk management, being good data on local level and being able to better predict future needs and vulnerabilities before they come to pass. This policy implementation helps to bridge the gap between policymaker and the public by utilizing local knowledge and experience. Furthermore it may also help in bettering the relation between stakeholders and allowing a more transparent and inclusive planning process.
As of today the local risk identification is a process using both physical and collaborative tools to understand the risk profile. Remote sensing analysis is utilized to study the coastline in steady intervals, expansive data is collected and studied regarding impacts of floods in terms of extent and impact across all dimensions. Such data and analysis is done and collected primarily by public officials, however the process is enhanced using collaboration with local	In the Valencian and Spanish this policy and practice is utilized as a categorization of land which is used in order to plan for better mitigation in both current and future contexts. This has been done through classification of "urban, developable and non-urbanizable" zones, as well as polizing zones within any construction can only be done in dialogue and consultation with the local environmental public offices,	Examples of such relief can be drawn from policies extending back to the 80s in the Spanish setting and have had a variety of characteristics. For example; tax exemptions, economic incentives to boost recovery among local business and service providers. More extreme measures have included catastrophic zoning in which any affected business or individual may receive	In the Spanish context this practice is thoroughly applied both in the public sector and as a frequent topic of research. See examples: Cabezas (2021). These practices range from both inexpensive means such as data analysis over time series and rudimentary fieldworks to more complex and comprehensive studies. Practices which have been applied can be identified as qualitative methods such as	The Valencian municipality has, as mentioned in Collaborative Planning & Policies, used collaborative practices and procurement of innovation frequently in order to attain the Mission 2030 goals, as an extension of the climate adaptation work and enhancing good governance. Its practices has included stakeholders from all sectors moderated by public

Extensive Flood Risk Mapping *Establishing requirements and frameworks for flood risk mapping and demands on local level*	Revised Land Use Regulation *Land use policy aiming to identify and classify land from a risk assessment perspective for future scenarios*	Post-Crisis Relief Practices *The role in which the state can and may be required to intervene and assist in post-crisis stages*	Threat of Anthropogenic activities and Tourism *The need for a revised understanding of risk, vulnerability and exacerbated exposure from human activity*	Collaborative Incentives and Procurement of Innovation *Collaborative planning aiming to better understand local vulnerability and needs*
stakeholders and private stakeholders.	which have the power to advise against any such construction.	compensation for losses.	interviewing stakeholders and tourists in order to understand their experience and knowledge regarding climate and various nature based measures to risk and shoreline mapping as previously mentioned.	officials, and ranges from as previously mentioned procurement of local knowledge and experience to better identify and mitigate risk, to integrating risk education and training into communities.
Criticism towards these implementations could be argued to be primarily regarded to the economy and capacity of the locality, as not all regions or cities possess resources and capabilities to utilize all these tools.	This policy implementation has a risk of controversy as it demands a careful balance and dialogue regarding stakeholder interests and demands in ratio to the environmental goals.	Similar to other measures this policy requires various levels of financial commitment from the public sector which may render some regions and cities unable to provide a standardized post-crisis relief, thus contributing to a disparity in terms of climate adaptation ability.	An overhaul of the current paradigm no matter the context may result in challenges regarding cohesion and common methodology in planning and practice throughout the public sector.	Challenges which stakeholder interviews have indicated regarding this policy is fostering a culture of participation, in other words, there may be challenges in getting people involved and committed to the projects long-term.

4.4 Discussion

4.4.1 Reflections on Policy Application in a Swedish Context

As previously noted by Valencia et al (2021), the Swedish framework has strengths in its innovation regarding infrastructure and nature based solutions. However, we may question to what degree these mitigation strategies may hold up in the face of a changing climate. Despite showing good promise in the face of today's challenges, there is no guarantee that their quality will withstand the impact of intensified climate and extreme weather events. The argument therefore stands that they may thus be in need of supplementation and revising in terms of how they approach climate adaptation. Whilst the Valencian and Swedish context share similar values regarding nature based solutions and green- and blue-infrastructure implementation, as a means of mitigation, the soft policy approach still differs. To a point in which it can be argued that the Swedish planning perspective may benefit from lessons learned in the Valencian context.

The shortcomings in the Swedish planning system benefiting from the policy implementations, can be understood from Valencia et al (2021), and as described as shortcomings and issues requiring further attention in the MSB report of Malmö´s risk management plan (2021). These issues consist of concerns regarding cohesion and collaboration, but also areas such as mapping and relevant analysis for understanding a wider scope of impacts regarding coastal inundation. Examples of which could include the profound economic impact mapping provided in the PATRICOVA plans (2019). An idea supported by the annotations by Länsstyrelsen (2021). It can be argued that more extensive mapping would not only be beneficial for the identification of risk and strengthening of the adaptive capacity, but a greater vulnerability assessment through cost-maps and demand maps, can be beneficial for both stakeholders and the public sector. Thus granting better insight into localization and the need for flexible placement of services, infrastructure and future construction projects. This would not only mitigate the weakness of information deficit, a problem raised by MSB (2021) and as a common occurrence by Valencia et al (2021) but provide a collaborative opportunity with local stakeholders of all groups, furthermore this collaboration could be argued to not be stemmed by an individuals or groups education levels as this collaboration would focus on local experiences and known demands in creating demand maps, rather than expertise knowledge. Arguably transfer of such collaborative policies would assist in integrating local knowledge and assist in a fulfilling of desirable sustainable goals and mitigate division in stakeholder relations through relatively inexpensive measures. Finally, as explained by the MSB report (2021) the shortcomings of the Malmö and surrounding coastal municipalities is that they do not include potential retreat strategies, as part of the "attack, retreat and defend" method. It may be asserted that such failures could be mitigated by an inspiration from the three category land use planning as seen in 4.3. I argue that such measures are inexpensive and potentially easily integrated into existing planning frameworks. These measures would promote enhanced flexibility and altered land use, in the planning of infrastructure and other public and private projects, and thus help in mitigating unnecessary future increases in human caused exposure (PATRICOVA, 2019). Furthermore, such land use planning policy may be beneficial to allocating land to multifunctional mitigation measures, thus providing an opportunity for mitigating economic costs while providing green cultural and social spaces throughout the city which otherwise may not have benefited from such.

4.4.2 Methodology Limitations and Suggestions

Simplified versions of index methods were chosen due to the timespan of the project, as in the case of Barros et al (2022) and Hu & He (2018). The limitation refers to variable sample size in terms of quantity and time. It can therefore be argued that the results of this methodology should not be interpreted as a fully reliable indicator for the study area ́s vulnerability and adaptive capacity but provides a valid and comparable indication of trends and characteristics. Limitations impacting Barros et al (2022) methodology in terms of reliability can be traced to its choice of index aggregation. The aggregation method of the study utilizes a summatory of the dimensions, a choice which may simplify relationships and negate insight into potential negative relationships within the index parameters (Rameri et al 2011). Regarding the choice of normalization in the Hu & He (2018) methodology the chosen normalization methodology as seen in section 3.1, it was proven to work well within the Chinese study context, however in the case of the Valencian variables this choice of normalization led to distortion among certain variables. As such, a different normalization methodology may be desired. Finally as previously mentioned the collection of data was limited due to the timespan of the project, and data for the adaptive capacity index methodology should be taken with some consideration. The choice of data intervals in the quartile division between the years 2005-2021 may have led to a lower insight into the actual trend changes of this period and only grants a partial insight into the alterations of the trend.

5. Conclusions

This project set out to study the adaptive capacity and gain an understanding of the vulnerability of the Valencian region and the neighborhood of El Cabanyal. With a further objective to identify potential lessons learned from successful adaptive measures in resilience against coastal inundation and how they may work in a Swedish urban planning context. The results of the CTVI have indicated a total vulnerability on average levels, which has aligned with the assumptions provided by PATRCOVA (2019). However it has shown despite intensifying climate parameters and anthropogenic accelerated hazard exposure , there has not been a proven exacerbated vulnerability increase, but rather an adaptive capacity and resilience that has seen a steady increase over time, with some exceptions. The implications of these findings have resulted in successful policy and practice transfer which may help in the revising and alteration of current Swedish practice and policy shortcomings (MSB, 2019). In order to help them better utilize collaborative resources and tools, examples include, land use planning and geo-analysis for climate and inundation adaptation. As previously mentioned in the discussion the timespan of this project was limited and as such the findings should be taken with some consideration and calls for further analysis completed with more extensive data collection. Examples of such are smaller time gaps between adaptive index intervals and larger variable selection. The recommendations from this project concludes that the lessons learned from the Valencian and Spanish successes and shortcomings have, despite an overall similar framework to the Swedish context, strong benefits that may help optimize the adaptive capacity of southern Swedish coastal cities and their population to future climate and intensified inundations.

6. References

Ajuntament de Valéncia (2005). *Recull Estadistic de la ciudad de Valéncia*. [online] Ajuntament de Valéncia. Available at: https://www.valencia.es/estadistica/Recull/Recull2005_Castellano.pdf [Accessed 4 Jul. 2023].

Ajuntament de Valéncia (2010). *Recull Estadistic de la ciudad de Valéncia*. [online] Ajuntament de Valéncia. Available at: https://www.valencia.es/estadistica/Recull/Recull2010_Castellano.pdf [Accessed 4 Jul. 2023].

Ajuntament de Valéncia (2015). *Recull Estadistic de la ciudad de Valéncia*. [online] Ajuntament de Valéncia. Available at: https://www.valencia.es/estadistica/Recull/Recull2015_Castellano.pdf [Accessed 4 Jul. 2023].

Ajuntament de Valéncia (2021a). *Plan de Accion para el Clima ya la Energia Sostenible de la ciudad Valéncia*. [online] Valencia: Ajuntament de Valéncia. Available at: https://www.valencia.es/estadistica/Recull/Recull2021_Castellano.pdf [Accessed 4 Jul. 2023].

Ajuntament de Valéncia (2021b). *Recull Estadistic De La Ciudad De Valéncia*. [online] Ajuntament de Valéncia. Available at: https://www.valencia.es/estadistica/Recull/Recull2021_Castellano.pdf.

Ajuntament de Valéncia, Las Naves and Missions Valéncia 2030 (2021a). *PPI València*. [online] CPI València. Available at: https://www.missionsvalencia.eu/cpivalencia/en/ppi-valencia/ [Accessed 4 Jul. 2023].

Ajuntament de Valéncia, Las Naves and Missions Valéncia 2030 (2021b). *STAGE 3: CHALLENGE IDENTIFICATION – EARLY DEMAND MAP*. [online] CPI València. Available at: https://www.missionsvalencia.eu/cpivalencia/en/stage-3-challenge-identification-early-demand-map/ [Accessed 4 Jul. 2023].

Barros, J.L., Santos, P.P., Tavares, A.O., Freire, P., Fortunato, A.B., Rilo, A. and Oliveira, F.S.B.F. (2023). The complexity of the coastal zone: Definition of typologies in Portugal as a contribution to coastal disaster risk reduction and management. *International Journal of Disaster Risk Reduction*, 86(86), p.103556. doi:https://doi.org/10.1016/j.ijdrr.2023.103556.

Barros, J.L., Tavares, A.O., Santos, P.P. and Freire, P. (2022). Enhancing a Coastal Territorial Vulnerability Index: Anticipating the Impacts of Coastal Flooding with a Local Scale Approach. *Coastal Management*, 50(5), pp.442–468. doi:https://doi.org/10.1080/08920753.2022.2107858.

Burbridge, P. (2020). Commentary 7 to the Manifesto for the marine social sciences: integrated coastal zone management. *Maritime Studies*, 19. doi:https://doi.org/10.1007/s40152-020-00190-2.

Cabezas Rabadan, C. (2021). *Beach Morphology and its dynamism from remote sensing for coastal management support* . PhD.

Camarasa-Belmonte, A.M. and Soriano-García, J. (2012). Flood risk assessment and mapping in peri-urban Mediterranean environments using hydrogeomorphology. Application to ephemeral streams in the Valencia region (eastern Spain). *Landscape and Urban Planning*, 104(2), pp.189–200. doi:https://doi.org/10.1016/j.landurbplan.2011.10.009.

Cantasano, N., Pellicone, G. and Ietto, F. (2017). Integrated coastal zone management in Italy: a gap between science and policy. *Journal of Coastal Conservation*, 21(3), pp.317–325. doi:https://doi.org/10.1007/s11852-016-0479-z.

Castillo-Rodríguez, J.T., Porta-Sancho, J.R., Perales-Momparler, S. and Escuder-Bueno, I. (2016). Risk-informed local action planning against flooding: lessons learnt and way forward for a case study in Spain. *E3S Web of Conferences*, 7, p.11011. doi:https://doi.org/10.1051/e3sconf/20160711011.

Cortekar, J., Bender, S., Brune, M. and Groth, M. (2016). Why climate change adaptation in cities needs customised and flexible climate services. *Climate Services*, [online] 4, pp.42–51. doi:https://doi.org/10.1016/j.cliser.2016.11.002.

Cristina, M., Saponieri, A., Matteo Gianluca Molfetta and Damiani, L. (2020). The DPSIR Approach for Coastal Risk Assessment under Climate Change at Regional Scale: The Case of Apulian Coast (Italy). *Coastal Engineering*, 8(7), pp.531–531. doi:https://doi.org/10.3390/jmse8070531.

de Arajulo Moreira, F., Paterson, S., Nunes, L. and Pelling, M. (2017). *Adaptive Capacity Index: Part II. Santos, Brazil*. London: Kings College Department of Geography.

Decreto 1/2011 de 13 de enero, del Consell, por el se apueba la Estrategica Territorial de la Comunitat Valenciana . Available at: https://dogv.gva.es/es/eli/es-vc/d/2011/01/13/1/ [Accessed 4 Jul. 2023].

Directive 2007/60/EC on assessment of flood risks.

ECMWF (2021). *Forecasts*. [online] ECMWF. Available at: https://www.ecmwf.int/en/forecasts [Accessed 4 Jul. 2023].

European Environmental Agency (2011). *Methods for asessing coastal vulnerability to climate change*. Bologna Italy: EEA .

Freire, P., Fortunato, A.B. and De Brito Ferreira de Oliviera , F.S. (2023). Project Mosaic P.T Multisource Flood Risk Analysis for Safe Coastal Communities and Sustainable Development Final Report. *National Labratory for Civil Engineering*. doi:http://dx.doi.org/10.13140/RG.2.2.30359.44963.

Garcia, L., Roig, G., Servera, E. and Zorita, S. (2020). *ARCH D3.3 City Baseline Report - Valencia*. [online] *savingculturalheritage.eu*. Available at: https://savingculturalheritage.eu/fileadmin/user_upload/Deliverables/ARCH_D3_3_City_baseline_report_Valencia.pdf [Accessed 4 Jul. 2023].

Generalitat Valenciana (2019). *Guía de Aplicacion Del Plan Accion Territorial Sobre Prevencion del Riescos de Inundacion en la Comunidad Valenciana* . [online] *politicaterritorial.gva.es*. Generalitat Valenciana. Available at: https://politicaterritorial.gva.es/documents/20551069/167206402/Gu%C3%ADa+PATRICOVA+%28castellano%29/e1a0b83a-8846-45fa-aff7-0d98b5b4fcc0 [Accessed 4 Jul. 2023].

Gobierno de Espana and Ministerio para la Transicion Ecologica ye el Reto Demografico (2020). PIMA Adapta: Plan Nacional De Adaptacion Al Cambio Climatico.

Gray, R.M. (2023). *Entropy and Information Theory*. 1st ed. Springer Science & Business Media.

Grindlay, A. (2012). Integration of Hydraulogical and Regional and Urban Planning in Spain. In: *Advances in Spatial Planning*.

Hu, Q. and He, X. (2018). An Integrated Approach to Evaluate Urban Adaptive Capacity to Climate Change. *Sustainability*, 10(4), p.1272. doi:https://doi.org/10.3390/su10041272.

Kristensen, P. (2004). *The DPSIR Framework*. Copenhagen: National Environmental Research Institute.

Kunte, P.D., Jauhari, N., Mehrotra, U., Kotha, M., Hursthouse, A.S. and Gagnon, A.S. (2014). Multi-hazards coastal vulnerability assessment of Goa, India, using geospatial techniques. *Ocean & Coastal Management*, 95, pp.264–281. doi:https://doi.org/10.1016/j.ocecoaman.2014.04.024.

Ley 8/2011 de 28 abril por la que se establecen medidas para la proteccion de las infrastructuras criticas . Available at: https://www.boe.es/eli/es/l/2011/04/28/8/con [Accessed 4 Jul. 2023].

Luque, P., Gómez-Pujol, L., Marcos, M. and Orfila, A. (2021). Coastal Flooding in the Balearic Islands During the Twenty-First Century Caused by Sea-Level Rise and Extreme Events. *Frontiers in Marine Science*, 8. doi:https://doi.org/10.3389/fmars.2021.676452.

Marengo, J.A., Muller-Karger, F.E., Pelling, M., C. Patrick Reynolds, Merrill, S.B., Lucí Hidalgo Nunes, Paterson, S., Gray, A.J., Lockman, J.T., J. Kartez, Moreira, F.A., Greco, R., Harari, J., Regina, C., Alves, L., Hosokawa, E.K. and Tabuchi, E.K. (2017). An Integrated Framework to Analyze Local Decision Making and Adaptation to Sea Level Rise in Coastal Regions in Selsey (UK), Broward County (USA), and Santos (Brazil). 06(02), pp.403–424. doi:https://doi.org/10.4236/ajcc.2017.62021.

Marshak, S. (2019). *Earth : portrait of a planet*. New York ; London: W.W. Norton & Company.

Martin, K.L.M. and Adams, L.C. (2020). Effects of Repeated Sand Replenishment Projects on Runs of a Beach-Spawning Fish, the California Grunion. *Journal of Marine Science and Engineering*, 8(3), p.178. doi:https://doi.org/10.3390/jmse8030178.

MSB (2021). *Riskhanteringsplan för Malmöområdet 2022-2027*. [online] *www.msb.se*. Malmö: Länsstyrelsen Skåne . Available at: https://www.msb.se/siteassets/dokument/amnesomraden/skydd-mot-olyckor-och-farliga-amnen/naturolyckor-och-klimat/oversvamning/riskhanteringsplaner-2022-2027/riskhanteringsplan-malmo-inkl-bilagor.pdf [Accessed 4 Jul. 2023].

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodroffe, C.D. (2007). *Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press UK : M.L Parry, O.F Canziani, J.P Paulitikof, P.J Van Der Linden and C.E Hanson , pp.315–356.

Oktaviani, F., Miftahuddin and Setiawan, I. (2021). Cross-correlation Analysis Between Sea Surface Temperature Anomalies and Several Climate Elements in The Indian Ocean. *Journal of Statistics*, 1. doi:https://doi.org/10.22487/27765660.2021.v1.i1.15354.

Olcina, J., Sauri, D., Hernández, M. and Ribas, A. (2016). Flood policy in Spain: a review for the period 1983-2013. *Disaster Prevention and Management*, [online] 25(1), pp.41–58. doi:https://doi.org/10.1108/dpm-05-2015-0108.

Olcina.J and Herrero.A (2021). Technical Evolution of Flood Maps Through Spanish Experience in the European Framework. *The Cartographic Journal*, 59(1), pp.55–68. doi:https://doi.org/10.1080/00087041.2021.1930678.

Porta-Sancho, J.R., Castillo-Rodríguez, J.T., Escuder-Bueno, I. and Perales-Momparler, S. (2016). The need for municipal action planning against flood risk: the risk-informed journey of the municipality of Oliva (Spain). *VITRUVIO - International Journal of Architectural Technology and Sustainability*, 1(2), p.67. doi:https://doi.org/10.4995/vitruvio-ijats.2016.6849.

Ricart, S., Villar-Navascués, R.A., Hernández-Hernández, M., Rico-Amorós, A.M., Olcina-Cantos, J. and Moltó-Mantero, E. (2021). Extending Natural Limits to Address Water Scarcity? The Role of Non-Conventional Water Fluxes in Climate Change Adaptation Capacity: A Review. *Sustainability*, [online] 13(5), p.2473. doi:https://doi.org/10.3390/su13052473.

Rivas, V., Garmendia, C. and Fernando, D. (2022). Analysis of Ocean Parameters as Sources of Coastal Storm Damage: Regional Empirical Thresholds in Northern Spain. *Climate*, 10(6), pp.88–88. doi:https://doi.org/10.3390/cli10060088.

Rocha, C., Antunes, C. and Catita, C. (2020). Coastal Vulnerability Assessment Due to Sea Level Rise: The Case Study of the Atlantic Coast of Mainland Portugal. *Water*, 12(2), p.360. doi:https://doi.org/10.3390/w12020360.

Rocha, C., Antunes, C. and Catita, C. (2023). Coastal indices to assess sea-level rise impacts - A brief review of the last decade. *Ocean & Coastal Management*, 237, p.106536. doi:https://doi.org/10.1016/j.ocecoaman.2023.106536.

Royo, S. (2020). From Boom to Bust: The Economic Crisis in Spain 2008–2013. *Why Banks Fail*, [online] pp.119–140. doi:https://doi.org/10.1057/978-1-137-53228-2_4.

Salas, J. and Yepes, V. (2020). Enhancing Sustainability and Resilience through Multi-Level Infrastructure Planning. *International Journal of Environmental Research and Public Health*, 17(3), p.962. doi:https://doi.org/10.3390/ijerph17030962.

Sánchez-Almodóvar, E., Olcina-Cantos, J., Martí-Talavera, J., Prieto-Cerdán, A. and Padilla-Blanco, A. (2023). Floods and Adaptation to Climate Change in Tourist Areas: Management Experiences on the Coast of the Province of Alicante (Spain). *Water*, 15(4), p.807. doi:https://doi.org/10.3390/w15040807.

Satta, A., Puddu, M., Venturini, S. and Giupponi, C. (2017). Assessment of coastal risks to climate change related impacts at the regional scale: The case of the Mediterranean region. *International Journal of Disaster Risk Reduction*, 24(24), pp.284–296. doi:https://doi.org/10.1016/j.ijdrr.2017.06.018.

Satta, A., Snoussi, M., Puddu, M., Flayou, L. and Hout, R. (2016). An index-based method to assess risks of climate-related hazards in coastal zones: The case of Tetouan. *Estuarine, Coastal and Shelf Science*, 175, pp.93–105. doi:https://doi.org/10.1016/j.ecss.2016.03.021.

Spiller, M. (2017). Measuring adaptive capacity of urban wastewater infrastructure – Change impact and change propagation. *Science of The Total Environment*, 601-602, pp.571–579. doi:https://doi.org/10.1016/j.scitotenv.2017.05.161.

Tsavdaroglou, M., Al-Jibouri, S.H.S., Bles, T. and Halman, J.I.M. (2018). Proposed methodology for risk analysis of interdependent critical infrastructures to extreme weather events. *International Journal of Critical Infrastructure Protection*, 21, pp.57–71. doi:https://doi.org/10.1016/j.ijcip.2018.04.002.

United Nations Environmental Program (UNEP)/MAP/PAP (2019). *Common Regional Framework for Integrated Coastal Zone Management*. Split: PAP/RAC.

Valencia, S.C., Simon, D., Croese, S., Nordqvist, J., Oloko, M., Sharma, T., Taylor Buck, N. and Versace, I. (2019). Adapting the Sustainable Development Goals and the New Urban Agenda to the city level: Initial reflections from a comparative research project. *International Journal of Urban Sustainable Development*, 11(1), pp.4–23. doi:https://doi.org/10.1080/19463138.2019.1573172.

Vousdoukas, M., Mentaschi, L., Mongelli, I., Carlos Ciscar, J., Hinkel, J., Ward, P., Gosling, S. and Feyen, L. (2020). Adapting to rising coastal flood risk in the EU under climate change JRC PESETA IV project -Task 6. [online] doi:https://doi.org/10.2760/456870.

7. Appendix

7.1 Interview Structure & Questions

Q1: Please describe yourself, your work and relation to risk management and climate change / vulnerability to coastal inundation.

Q2: To the best of your knowledge, describe two inundation events occurring within the last 10-15 years in which relevant actors were involved in mitigation and assessment work.

Addendum: This question relates to all crisis stages (before, during and after) and further questions will use these events as a basis.

Q3: Regarding risk identification, how have public officials and departments performed their work to identify risks and hazards in a pre-crisis stage?

Addendum: With the previous events in mind, are the moments or gaps in policy and practice which were made obvious and called for need in change?

Q4: In the relevant frameworks what tools and policies are available in order to evaluate and identify risk factors and hazards relating to inundation? Focusing mainly on proactive measures.

Addendum: On a five step likert scale, let us evaluate the overall Valencian capacity for risk identification.

Q5: Discussing risk mitigation strategies, what would you describe as constituting successful risk mitigation strategies and measures taken by the municipality?

Addendum (1): What do you think made them successful?

Addendum (2): To your knowledge, how did they come to be created? Both in terms of identifying shortcoming and how the need was prioritized.

Q6: Further regarding the creation of policies, to what extent and if at all, how were stakeholders involved in this process?

Addendum: On a five step likert scale, let us evaluate the overall Valencian capacity for risk mitigation.

Q7: Regarding flexibility and adaptive planning, how has the municipality acted to strengthen potential for experimentation and innovation in the policy and practice regarding risk and climate change adaptation? Can you think of any initiatives or projects?

Addendum: Regarding these initiatives, have they been characterized by any collaboration or involvement with relevant stakeholders?

Q8: To what extent and quality has the public and stakeholders been involved in identifying and mitigating risks? Relating to previous mentioned events.

Q9: How is diverse stakeholder engagement boosted, are steps taken to include vulnerable groups in the decision making process of adaptation and risk planning?
Addendum: Regarding these measures, do they ensure adequate equity and social justice in an impactful way?

Q10: Regarding the existing practices and frameworks, how would you rate their ability to adapt and change rapidly under stressful or demanding scenarios?

Addendum: Are there frameworks or systems in place to facilitate this process?

Q11: On a five step likert scale, let us evaluate the overall Valencian capacity for organizational learning.

Q12: To what degree and quality do you view or experience that public officials and relevant departments incorporate feedback and lessons learned from previous extreme events and/or crises into decision-making processes?

Q12: Regarding the frameworks and practices in place, how well do they and the overall culture of the planning practice allow for incorporation of feedback and implications from lessons learned from previous adverse events into decision and policymaking processes?

Q13: Regarding the actors involved in the risk management process, how would you rate and assess their ability to coordinate and collaborate with one another?

Q14: How flexible and adaptable are the existing frameworks and practices in dealing with coastal inundation, especially in the face of climate change?

Q14: In the threat of intensifying climate change, how would you assess the existing frameworks and practices in terms of ability to change and adapt? Does the current state of practice have the ability to change into what is demanded?

7.2 Secondary Geodata Compilation

Contents	Contents (Es)	Spatial Distribution	Format	Source	Coordinate System	Resolution
CORINE_Landcover_2018	CORINE_Landcover_2018	Municipal (Valencia)	Shapefile	European Environment Agency (2019)	ETRS 1989 UTM 30	Polygon
DEM of the Valencian municipality (2017)	MDT de resolució de la Comunitat de Valenciana (2017)	Municipal (Valencia)	TIF	Infraestructura Valenciana de Dades Espacials (2017)	ETRS 1989 UTM 30	Cell size: 5m
Ortophotograph 1956-2020 of the Valencian municipality (RGB)	Ortofoto de la Comunitat de Valenciana, 1956-2020 (RGB)	Municipal (Valencia)	RGB-TIFF	Institut Cartográfic Valencia	ETRS 1989 UTM 30	Cell size: 0,25-0,5m
Landsat 5 data		World	TIF	United States Geological Survey	WRS	Cell size: 30-120m
Landsat 6 data	-	World	TIF	United States Geological Survey	WRS	Cell size: 30-120m
Affected critical infrastructures in the Valencian municipality (2021)	Infraestructuras críticas afectadas en la Comunidad de Valenciana (2021)	Municipal (Valencia)	GPKG (Shapefile)	Dirección General de Cambio climático , Conselliera de agricultura Desarrollo Rural, Emergencia Climática y Transición Ecológica y Ministerio para la Transición Ecológica y el Reto Demográfico (2017)	ETRS 1989 UTM 30	Polygon, point, lines
Scenarios of inundation impact: Current climate , RCP4.5 and RCP8.5 (2021)	PIMA Adapta: Impactos - Escenarios de Inundación (2021)	Municipal (Valencia)	GPKG (TIF)	Dirección General de Cambio climático, Conselliera de agricultura Desarrollo Rural,	ETRS 1989 UTM 30	Variation across files

				Emergencia Climática y Transición Ecológica y Ministerio para la Transición Ecológica y el Reto Demográfico (2017)		
Mean year temperature 1986-2020		Municipal (Valencia)	CSV	Meteoblue (2023)		
Mean year precipitation 1986-2020		Municipal (Valencia)	CSV	Meteoblue (2023)		
Mean year sea surface temperature 1986-2020		Valencian Coastal measurement station	CSV	Copernicus (2023)		
Socioeconomic vulnerability	Vulnerabilidad socioeconómica	Municipal (Valencia)	GPKG	Instituto de Valenciano de la edificación (2020)	ETRS 1989 UTM 30	Polygon
Sociodemographic vulnerability	Vulnerabilidad sociodemográfica	Municipal (Valencia)	GPKG	Instituto de Valenciano de la edificación (2020)	ETRS 1989 UTM 30	Polygon
Residential vulnerability	Vulnerabilidad residencial	Municipal (Valencia)	GPKG	Instituto de Valenciano de la edificación (2020)	ETRS 1989 UTM 30	Polygon