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The Urban Public Space between Land and Sea: The Case of Quarteira, Portugal

Sérgio Barreiros Proença [1,*], Francesca Dal Cin [1], Cristiana Valente Monteiro [2], Maria Inês Franco [2], Maria Matos Silva [1] and Nawaf Saeed Al Mushayt [1]

[1] CIAUD—Research Centre of Architecture Urbanism and Design, Lisbon School of Architecture, Universidade de Lisboa, 1349-063 Lisboa, Portugal
[2] Lisbon School of Architecture, Universidade de Lisboa, 1349-063 Lisboa, Portugal
* Correspondence: sergioproenca@edu.ulisboa.pt

Abstract: Among the European coastal territories most vulnerable to the effects of mean sea level rise, such as flooding and erosion phenomena, are the 943 km of the Portuguese coastline where approximately 70 per cent of the population lives (Bigotte et al, 2014), a percentage that rises to around 80 per cent in the summer months, due to tourism (Andrade et al, 2002), especially in the Algarve region (southern Portugal). The case study of this research is the urban public space in the coastal city of Quarteira, which is particularly vulnerable. This space between the land and the sea has been recently framed in the inter-municipal climate change adaptation plan PIAAC-AMAL (Plano Intermunicipal de Adaptação às Alterações Climáticas do Algarve). The aim of the article is to explore the natural and anthropogenic process of formation and transformation of the urban space between the land and sea that occurred over time, up to the definition of the seashore street. Interpretative drawing is used as a methodology to understand the form of the public space. This is considered the first step for designing the public space between the land and the sea that deals both with the effects of climate change and the seasonal cycles of summer tourism. Through this analysis, it is argued that the understanding of the form (morphological characteristics) of this continuous space between land and sea is fundamental for consistent and robust adaptation design.

Keywords: Portugal; coastal public space; seashore street; urban adaptation

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1. Introduction

Flooding and erosion, fostered by extreme weather events caused by rising sea levels, are already affecting European coasts. Among the European coastal territories most vulnerable to the effects of the rise in average sea level are the 943 km of Portuguese coastline where about 70% of the population lives [1], a percentage that rises to about 80 per cent in the summer months, thanks to the phenomenon of tourism [2], especially in the Algarve region (southern Portugal). Indeed, the flooding and erosion phenomena, due to sea level rise (SLR), are particularly strong along the Portuguese coast, due to the strength of the ocean currents which Portugal faces, especially when they combine with winds from the SW [3].

The geomorphological characteristics of the coastal territory, combined with a mild climate, have turned the Portuguese coast into one of Europe's best natural resources, widely exploited for tourism purposes since the 1960s [4]. Nowadays, 35 urban settlements situated along Portugal's 943 km of coastal strip, characterised by the presence of a seashore street, an urban public space of coastal cities that, thanks to the development of mass tourism, is, nowadays, a cultural and social landmark, as well as a space in which economic activities are developed. In the decade of 1960–1970, the rise of the tourism sector caused large transformations in urban development in order to respond to the excessive demand of seasonal tourism near the seashore. The seashore street, located between the land and

the sea, interfaces with housing, tourist buildings and spaces with commercial functions, that have become vulnerable due to the rise in the mean sea level caused by climate change.

The case study of this research is the coastal town of Quarteira, located in the Algarve region, where 24,421 people live during the year, a number that triples during the summer months [5].

As the Algarve's coast is particularly vulnerable to the effects of rising mean sea level, a plan for adaptation to climate change, PIAAC-AMAL (Plano Intermunicipal de Adaptação às Alterações Climáticas do Algarve), was drawn up in 2019 [6]. PIAAC-AMAL is framed within the main objectives of the European Climate Change Adaptation Strategy (EEA) and the National Climate Change Adaptation Strategy (Estratégia Nacional de Adaptação às Alterações Climáticas 2020, ENAAC 2020) [7]. The coastal protection structures built in Quarteira over the last three decades are the clearest recent evidence of the increasing occupation of the coastal strip [8].

In this article, we argue that reading the spatial relationships between the urban and architectural elements close to the coastline, and their formation and transformation over time, allows us to understand, through phenomenological observation, the morphological characteristics of the space between the land and the sea; this is urban space that is nowadays vulnerable due to the effects of rising mean sea level, such as erosion and flooding phenomena. From a methodological point of view, the proposed research is based on the qualitative analysis of urban form data in relation to the urban flooding scenarios resulting from the mean sea level rise predicted for 2100, elaborated by Carlos Antunes [9]. The outline methodology is applied to the case study of the city of Quarteira, one of the pilot case studies of the "[ENTRA]MAR Urban form intertwined with the sea" research project, carried out in Lisbon School of Architecture of the Universidade de Lisboa. We consider the proposed analysis to be upstream from the processes of defining and designing urban legislative plans, since the purpose of the research is to provide a useful lens for interpreting, characterising and diagnosing the territory in focus. Indeed, as the future challenge will be the management of the urban landscape vulnerable to rising mean sea level, where there will be increased anthropogenic pressure, human activities and urban occupation, we consider the interpretation of the form of coastal cities to be the first step in designing effective adaptation plans and projects, as a rigorous approach to the analysis of urban form [10] from an evolutionary perspective is now more important than ever to interpret its future trajectories [11].

2. Coastal Urban Settlements Vulnerable to Mean Sea Level Rise

The space between the land and the sea has been, over time, modified in order to become a habitable place. Coastal zones have always attracted humans because of their rich resources, particularly their supply of subsistence resources. They were also popular for logistical reasons, as they offer access points to marine trade and transport; for recreational or cultural activities; or simply because of their special sense of place at the interface between land and sea [12]. For this reason, the coastal area as a place for recreational activities is generally linked to the presence of the sea [13].

Since the end of World War II, the phenomenon of mass tourism, caused by economic development and the automobile as a commodity accessible to all, has meant that coastal agglomerations have been transformed to accommodate the new urban functions required by tourism. The phenomenon of tourism since the 1970s has contributed to the increase in population along coastal areas and, consequently, to the occupation of the most dangerous parts of the coastline. Moreover, population density is significantly higher in coastal areas than in non-coastal areas [14]. The increasing exposure of large numbers of people and assets along the coast significantly increases the levels of risk and vulnerability due to sea level rise [12]. Furthermore, in coastal urban areas due to high population density, the heritage and social–economic damages are more critical; thus, it is important that urban actions and urban strategies have the capacity to prevent the impact of extreme events on coastal cities [15].

As a result of anthropogenic and natural factors, private and public areas are becoming more and more vulnerable. Indeed, coastal zones at the interface between water and land, among aquatic and terrestrial ecosystems but also anthropogenic ones, are characterised by a fragile equilibrium [16]. Sea level change is an important consequence of climate change, both for societies and for the environment [17], which exacerbates the unbalanced equilibrium of the two systems. Indeed, sea level rise will impact coastal cities and villages, many of which have seen increased development in recent decades, becoming more vulnerable to coastal erosion and flooding [18]. The subsequent construction of coastal protection infrastructure for urban areas has had an impact on the natural sediment dynamics by encouraging increased erosion in other areas [19]. Coastal systems are particularly sensitive to changes in sea level. Indeed, coastal evolution forced by sea level rise and storms involve phenomena such as the increased inundation of low-lying lands, shoreface and coastline erosion, the displacement of natural habitats and sediment accretion or erosion in lagoons and estuaries, depending on the sediment availability and accommodation space [20].

Furthermore, according to sea level rise projections throughout the 21st century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding and coastal erosion [21]. However, the effects of sea-level rise on coasts are not uniform, but vary considerably from region to region and over a range of temporal scales [22,23]. It is estimated that the sea level in European coastal areas could reach more than one metre by the end of the century [24], provoking more vulnerability and losses of the various economies and activities present on the coast, if measures are not implemented.

The vulnerability of coastal agglomerations to the effects of rising mean sea level, such as erosion and flooding, depends on their location in the territory but also their urban form. Indeed, the vulnerability of the coast due to climate change is manifested in: (a) increases in flood levels; (b) beach profile changes; and (c) changes in coastal morphology, variation in littoral transport rates, and coastal erosion [25].

2.1. Effects of the Rise in Mean Sea Level on the Portuguese Coast

The Portuguese coast, which stretches for 943 km, has a high diversity of coastal types—low and sandy beaches bounded by dunes, wetlands (estuaries, lagoons) and reef islands, and infrastructural coasts—which will react differently to sea level rise. According to Ferreira et al. [26], estuaries and coastal lagoons will be the coastal areas most affected by sea level rise; these include the Sado and Tagus estuaries and the coastal lagoons of Ria de Aveiro and Ria Formosa [26]. Moreover, along sandy coastal areas, changes in shoreline position (due to erosion—a result of sea undulations and the lack of detrital material input from rivers—and accretion phenomena) are expected to occur in response to changes in sea level, sediment balance and hydrodynamic conditions [27]. Coastline evolution results showed an overall erosional tendency for the Portuguese mainland low-lying sandy coast, presenting a mean rate of -0.24 ± 0.01 m year^{-1} [27].

The effects of erosion and flooding phenomena, resulting from sea level rise, will entail significant negative externalities causing socio-economic impacts for coastal cities. Indeed, about 70 per cent of the Portuguese population lives along the coast, and about 80 per cent of the gross national product is produced there [28], with an increase in the summer months due to tourism.

Along the coastline, it is estimated that the areas affected by extreme tide flooding and SLR will be 903.1 km^2 in 2050, affecting 59,530 buildings and 145,550 residents; this will increase to 1146 km^2 (river delta areas are included in the estimate), with 82,000 buildings and 224,830 residents in 2100 (in regard to the relative average contemporary sea level on the Portuguese coast, reference is made to the Cascais tide gauge data) [29] (Figure 1).

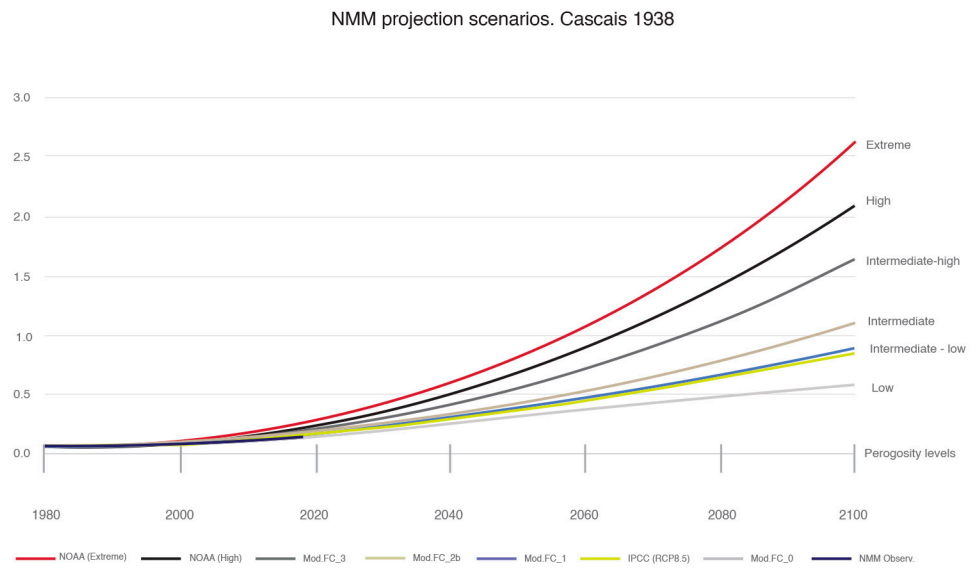

Figure 1. NMM projection scenarios for different hazards, from FCUL, IPCC and NOAA, relative to Cascais Vertical Datum 1938, Authors' edition based in [9].

Moreover, the analysis of the effects of the storm which occurred in 1941 [30] on the Portuguese coast, provides insight into the future consequences of climate change on coastal agglomerations [30]. A projection reveals that the sea level rise could reach an extreme scenario of between 58 cm and 172 cm in a time frame of 100 years, as outlined by Freitas and Dias in 2013. Compared to the coasts of Northern Europe, the Portuguese coast will be exposed to a smaller increase [24]. According to PIAAC-AMAL, due to its geographical location, Portugal is one of the most vulnerable European countries to the impact of climate change, with the greatest impact in the coastal area of the Algarve [6]. Coastal erosion in Portugal is a complex issue that relates not only to its main causes, but also to a number of other factors, namely the inherited physiographic coastal characteristics, the type of human development and its evolution over time, and the options of past coastal zone protection [31].

2.2. Coastal Urban Settlements in Portugal

Nowadays, the Portuguese coast suffers from important coastal erosion phenomena due to the shortage of sediment, which started at the beginning of the 20th century and has strongly increased since the 1940s, linked to a series of interventions such as modifications of river flows through the construction of dams, the exploitation of sand and gravel, and estuarine dredging for navigation [26]. However, the coastal zone is inherently dynamic, where changes occur at different temporal and spatial scales [27].

Due to the construction of coastal agglomerations that are increasingly closer to the water line—in response to the economic and social needs imposed by tourism—the coastline has become a rigid urban area, which delimits the natural space. The transformation of the shoreline that has occurred cyclically over time is now precluded by the construction of the urban rigid boundary of the seashore street. The rise in the mean sea level, caused by the warming of the climate, encourages the approach of the shoreline to the urban boundary, leading to an increase in its vulnerability.

Over time, Portuguese coastal cities have undergone physical and conceptual transformations to accommodate different ways of inhabiting the territory. The space between the city and the sea was, until before the consolidation of the urban boundary, a place dedicated to fishing activities. On low, sandy beaches, boats and fishermen's dwellings coexisted.

As Rocha wrote in 1984, until the 1960s, maritime activities were important for the economy and employment structures, and included fishing, salt mining, the shipbuilding and repair industry, the food processing industry and ship transport activities [32]. This is

in contrast to nowadays, where fishing represents less than 1% of gross domestic product (GDP), and 68% of GDP comes from the service sector [33]. It is important to report that in 1994, approximately 30 percent of the Portuguese coastline was occupied by housing, ports, industrial facilities and tourist infrastructure [2]. According to Andrade et al. (2002), about 85% of national GDP is produced along the coastal strip (about 60 km from the coastline) by tourism-related activities, 35% of which are located in the coastal area of the Algarve [2].

The introduction and consolidation of the boundary between the urban system and the natural system initially allowed for the formation of an urban space that could accommodate port activities that later, transformed, housed activities dedicated to tourism. Since the 19th century, the coastal landscape has undergone several urban transformations that have led to the establishment of the seashore street as a reference urban space of coastal cities.

3. Method

3.1. Data Acquisition

Although there are 35 coastal settlements along the Portuguese coast which interface with the sea through the seashore street, and are vulnerable to the effects of mean sea level rise, the article addresses the city of Quarteira (municipality of Loulé) (Figure 2).

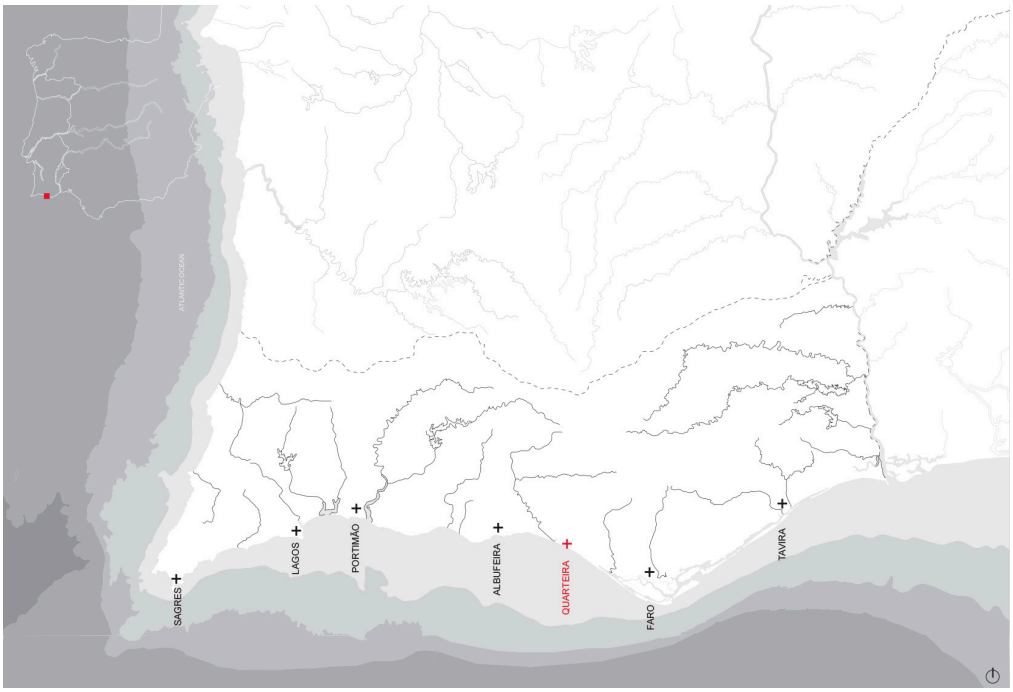

Figure 2. Quarteira location in the Algarve coast. Authors' edition, 2023.

Quarteira, located in the southern part of Portugal, in the Algarve region, is one of the pilot case studies of the research project "[ENTRA]MAR Urban form intertwined with the sea" carried out in the Lisbon School of Architecture of the Universidade de Lisboa. Moreover, the case of Quarteira was selected as a pilot case of the project, taking into account the availability of sea level rise scenarios and participatory adaptation pathways already developed by research institutes and integrated into the PIACC-AMAL (Inter-municipal Climate Change Adaptation Plan of the Algarve) [6].

The cartographic bases used to draw the representations are part of the Loulé municipal archives and were shared by the Câmara Municipal de Loulé (Loulé Municipal Council) as a partner of the research project.

3.2. Decoding the Urban form Vulnerable to Mean Sea Level Rise

The understanding and characterization of the formation and transformation process of the urban space by the sea uses interpretative drawing as an instrumental method. The

interpretation of a complex urban object, such as the urban form by the sea of the city of Quarteira, requires its simplification, as the decomposed approach of its form allows its complexity to be reduced and reveals otherwise hidden qualities and patterns [34]. Mario Gandelsonas [35] affirms that drawing is a process that allows us to see formal configurations that are not perceived in reality and therefore affects how we see the city.

In this case, two morphological layers were chosen for their relevance in the study of the urban space between the city and the sea: the urban layout, which is a bidimensional representation of the public space, and the built fabric.

These two complementary strata allow us to acknowledge the evolution of the urban agglomeration and to understand the spatial relations that have been established between elements over time. As far as time is concerned, although the observation of reality takes place in the present moment, this moment is understood as the result of successive sedimentation processes. In order to understand the contemporary urban form, the case study was decoded by drawing up different plans describing the main urban evolutions. By depicting the different temporal phases in which the seashore street was built, it is possible to observe the changing movement of space between land and sea over time.

Nevertheless, these two layers enable the understanding of the evolution of the urban form, and the formal decoding of the urban space by the sea needs a closer resolution level for its understanding. Therefore, the reconstitution, from historical photographs, of the section of the seashore street, accompanying the three evolution moments, is entailed in order to reveal the form of the public space by the sea. In fact, although the most common representation of the space is in the plan, the section view is closer to the human comprehension of the space, and reveals material qualities and the mediating role between the sea and the buildings that compose the urban seashore.

The objective of the article is, indeed, to explore the process of interpretation, through drawing, for the understanding of the urban space between land and sea. The legibility built from the morphological and morphogenetic memory of the elements that compose the city is a value of its form [36]. Indeed, the decomposition into layers offers the opportunity to recognise the characteristics and relationships that have, over time, been established in space between the land and the sea.

Furthermore, the overlapping both of the initially referred to contemporary morphological strata and the contemporary cross sections with the extreme weather events or erosion scenarios allows us to look into the future and identify both the urban fabric which is vulnerable and the public space that can be transformed to deal with the effects of climate change.

4. Results

The Case of Quarteira

The city of Quarteira, characterised by a long stretch of sand that separates the city and the sea, is located in the municipality of Loulé, in the Algarve region, between the Quarteira and Almargem streams. Until the early 1960s, the Quarteira region was an area (with a surface area of about 40 km^2) where, in addition to fishing, rain-fed agriculture predominated [37]. Approximately 24,000 inhabitants inhabit the city of Quarteira nowadays, a number that triples during the summer months, due to the phenomenon of tourism. In 2001, there were about 414 dwellings of seasonal/secondary use per km^2, a number well above that of the county seat (Loulé), which is 30 dwellings per km^2 [38].

The contemporary urban form of the town was defined from the second half of the 20th century to respond to the new cultural, economic and social needs related to tourism. In the same years, the seashore street began to be built, an urban public space parallel to the sea, which promoted the urban agglomeration's development and transformation. Along the recently completed urban space, summer cottages began to be built, for wealthy families coming from the nearby hinterland, as well as small structures supporting seaside use.

Since the 1970s, the area has undergone a major urban transformation, in the sequence of the construction of tourist urbanisation, with the massive construction and urbanisation,

for tourism purposes, of the Quarteira coastline (Figure 3) and the neighbouring town of Vilamoura, located 3 km to the east of the town under analysis. As a result of the massive urban transformation, the seashore street was built and, at the same time, rigid infrastructural elements such as pontoons were erected to defend the new buildings constructed for tourist purposes. However, the construction of breakwaters and port infrastructures along the coastal strip from Quarteira to Vilamoura has encouraged coastal erosion phenomena in front of the urban agglomeration, as the introduction of the rigid system into the dynamic environment of the sea caused a mutation of the sea currents and, therefore, the consequent lack of detrital material needed to replenish the coastline [37,38]. On the leeward (in this case eastern) side of the breakwaters, erosion has intensified and the retreat of the coastline has caused successive cliff collapses. In the early 1980s, this caused the collapse of Fort Novo, built about 2 km S-E of Quarteira (Lagos, Algarve) around 1500, which had been declared a monument of public interest by a decree of 1974 (Figure 3).

Figure 3. I. Quarteira Stream; II. Vilamoura; III. Quarteira; IV. Almargem Stream; V. Fortress ruins; VI. Streets. Cartographic bases provided by Câmara Municipal de Loulé. Authors' edition, 2023.

Observing the plans depicting the public space and buildings—dated 1940, 1960, 1970-80 and 2022—it is possible to recognise a progressive process of expansion of the original core from the land towards the sea (Figure 4). Until the 1930s, the urban agglomeration of Quarteira was not in contact with the sea, indeed the few buildings built on the sand were located in today's Largo das Cortes Reais, originally called *Largo da Praia (Praia Square)*. It was from the 1970s, with the development of mass tourism, that the urban front began to regularise. In the 1930s, we can clearly identify two settlements: the Povo, an inland village structured by the main street and the main church at the intersection of the road to Loulé

and the road to the beach; and the Praia, literally the beach, where the fishing activities and fishermen huts occupied the sand. On the beach area, activities related to fishing and work at sea took place, boats were moored and fishing nets were spread out.

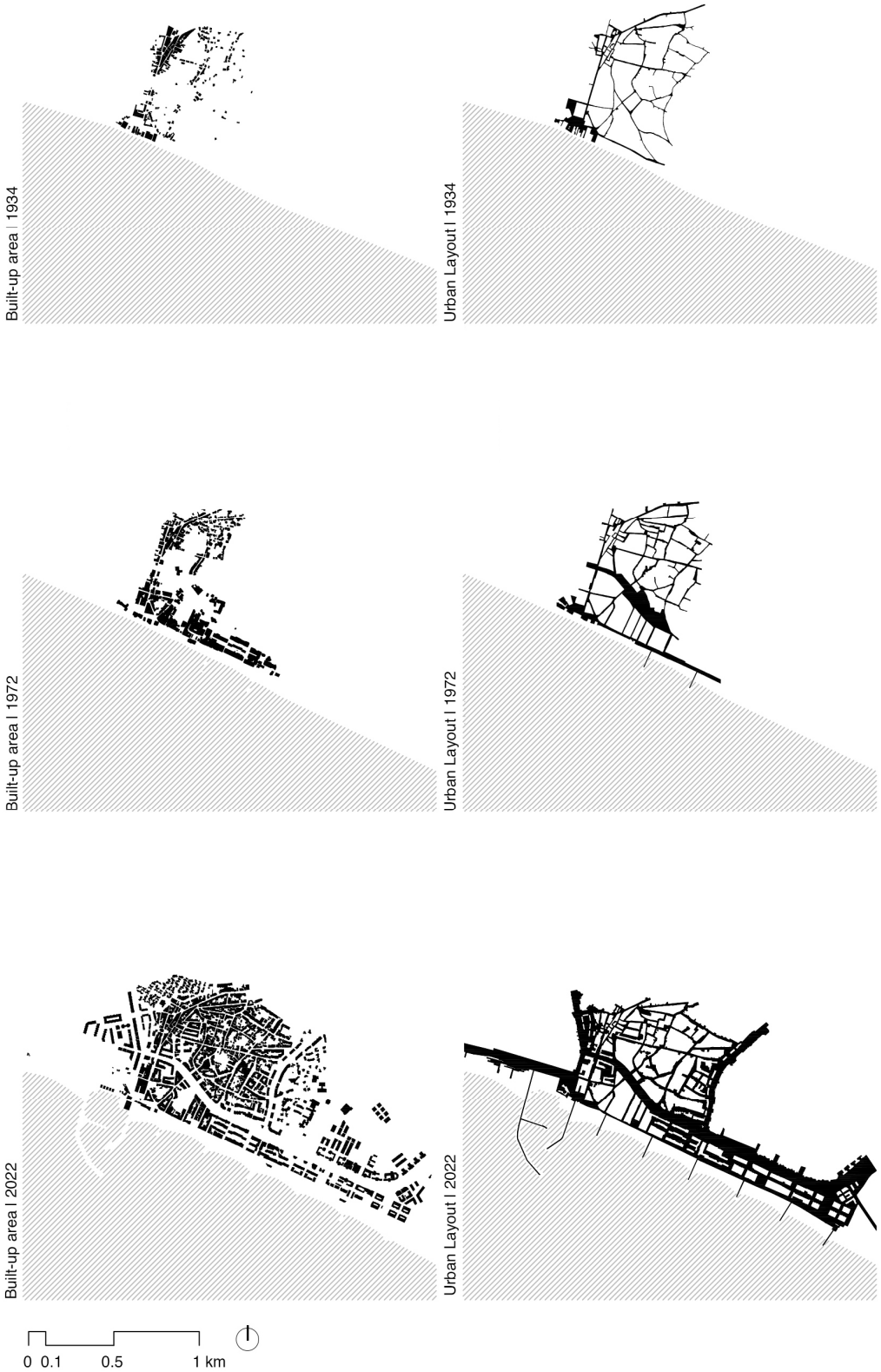

Figure 4. Quarteira. Morphological evolution: Urban Layout + Built fabric. Cartographic bases provided by Câmara Municipal de Loulé. Authors' edition, 2022.

From the 1940s onwards, the initial construction of the seashore street allowed for the construction of a number of summer cottages, facing the sea. It was, however, from the 1970s onwards that the major transformation of the space adjacent to the sea began. In fact, in those years, the marina was built at the mouth of the Ribeira de Quarteira as well as the consolidation of the seashore street, which extends for about 3 kilometres with an average width of about 60 metres, transforming the urban fishing agglomeration into a new tourist city devoted to the cult of "sun and sea tourism" [39]. In fact, with the consolidation of the space between the land and the sea, buildings began to be constructed, mostly to accommodate functions related to tourism.

In parallel, along the built front that expanded towards the east, in order to keep the sand and prevent coastal erosion, breakwaters were built perpendicular to the shore.

In the urban transformation that has taken place since the second half of the 20th century, the interface between land and water, the seashore street, has become a new urban centrality (Figure 5). A place where multiple balances of socio-economic and historical interests meet. Moreover, during the 1970s, as can be seen in the Largo da Praia, *(Praia Square)*, elements built with functions dedicated to fishing activities coexisted while new buildings were being constructed to accommodate the new functions related to tourism. With the consolidation of public space—as it is known today—the seashore street became a rigid boundary between the urban system and the natural one. It is on the seashore street that the main social and economic activities of the coastal city nowadays happen. This linear urban public space makes it possible to accommodate the different fluctuating flows of the inhabitants and visitors, accommodating the seasonal increase in public life during the summer.

Figure 5. Quarteira. Morphological evolution: sections (**I**) 1930, (**II**) 1960, (**III**) 1970-80. Cartographic bases provided by Câmara Municipal de Loulé. Authors' edition, 2022.

The city's main economic and social activities take place in this space—commerce (27.6%), restaurants (17.2%) and accommodation (6.9%) [36] (p. 50)—however, due to the

height of the land on which it is built, it is vulnerable to the effects of rising mean sea level (Figures 6 and 7).

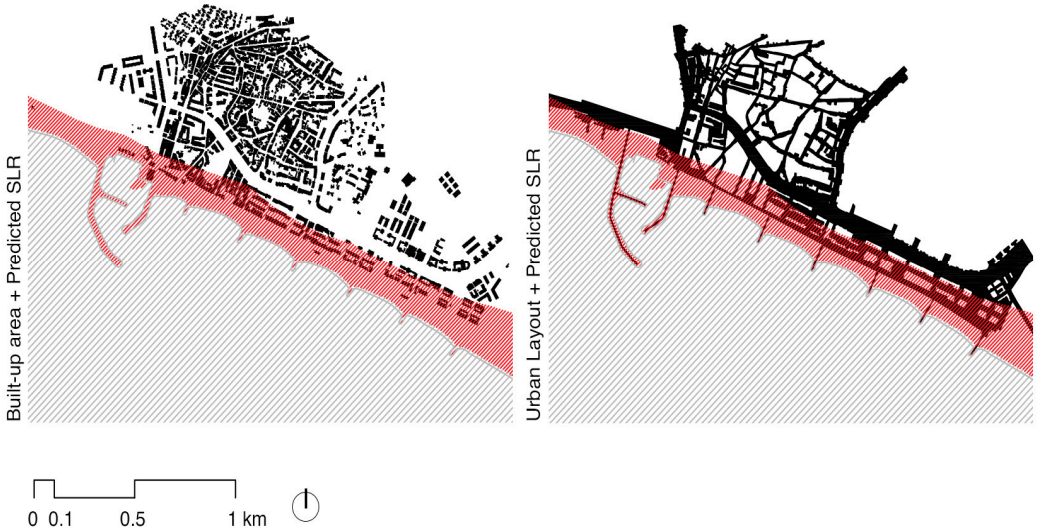

Figure 6. Quarteira. Urban layout overlaid with the projected sea level rise scenario for 2100 based on [6]. In red, urban areas vulnerable to rising mean sea level are identified. Cartographic bases provided by Câmara Municipal de Loulé. Authors' edition, 2022.

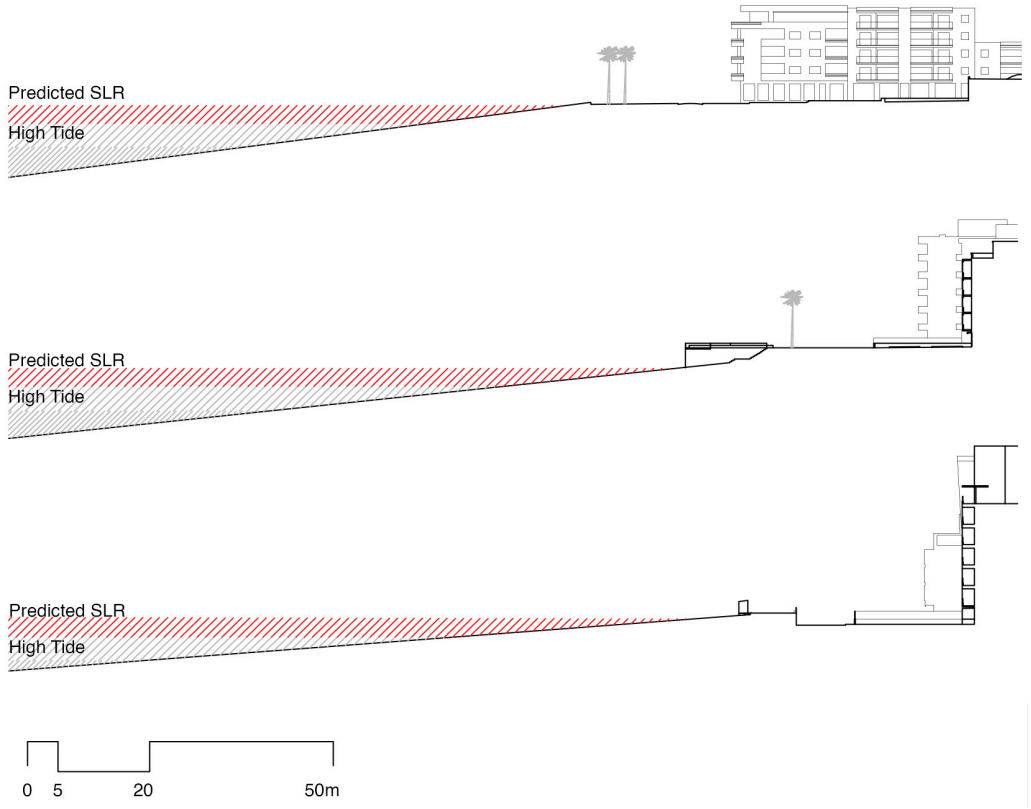

Figure 7. Quarteira, the public space of the seashore street represented through the transverse section. In red is identified the rise in mean sea level, based on [6], which will result in an approximation of the hydrographic zero at the urban boundary. Cartographic bases provided by Câmara Municipal de Loulé. Authors' edition, 2022.

In particular, the sandy coastline of the Algarve, from Olhos de Água to the mouth of the Guadiana River, is expected to be highly vulnerable to rising mean sea level, due to the

impact of waves on a natural and urban landscape of extreme socio-economic importance for the region [20] (Figures 6 and 7). On the Quarteira coastline, stretching from Olhos de Água (Albufeira) to Cabo de Santa Maria (Faro), the direction of the transport of sandy material, sand produced by the erosion of sandy cliffs and sediments transported by water lines, is from west to east [8]. According to the results obtained by Sampath et al. [20], the shoreline retreat or accretion will show high spatial and temporal variability during the 21st century; if from Olhos de Água to Praia da Rocha Baixinha, the shoreline retreat due to SLR will be insignificant, from Quarteira to Faro, the shoreline retreat will be about 100 m due to the RCP 8.5 SLR scenario by the end of the 21st century. Moreover, through photographic comparisons and photogrammetric restitution, several authors, cited by Braz Teixeira, S. (2009) [8,38–40], affirm that before the construction of the coastal infrastructure of the Vilamoura/Quarteira tourist harbour pier, the cliff retreat rates reached values in the order of 0.20–0.80 m/year, undergoing an increase from the 1970s onwards [8].

The temporal evolution of the retreat rates of the entire coastal stretch between Quarteira and Garrão in recent decades clearly shows the effect of increased erosion associated with the construction of maritime works [8]. In the report titled Coastal Erosion and Protection [31], it is stated that some stretches of the Portuguese coast can be considered 'artificial', as the contact between the land and the sea is entirely achieved through hard infrastructure; among them piers and docks. Indeed, since the beginning of the 20th century, rigid protective infrastructures have been considered the main solution to the frequent coastal hazard problems. Among the works undertaken for maritime protection are beach nourishment, carried out cyclically; among them is the nourishment of an extension of 4.5 km between Quarteira and Vale do Lobo (8 km west of Ancão) with sandy material [41,42].

Different urban adaptation scenarios are foreseen in the PIAAC-AMAL to solve the urban vulnerability of the Quarteira urban front. In the plan, the proposed adaptation measures include: (i) artificial beach feeding; (ii) construction and maintenance of a boundary wall and artificial beach feeding; (iii) construction and artificial dune feeding and construction and/or maintenance of walkways and boardwalks, with the elevation of buildings (beach supports); (iv) spur remodelling; (v) removal and relocation of occupation (first line of houses); and (vi) removal and relocation of occupation (second line of houses) [6].

Among the actions planned is the retreat of the urban front, that is, the demolition and relocation of the first line built from 2040. At the same time, the plan proposes to continue the artificial feeding of the beach for the next decade, subsequently proposing the construction of a dune over a dike (dike-in-dune). As of 2013, Portuguese coastal protection policy is no longer based on rigid protection structures; most interventions are now dedicated to the maintenance or redesign of existing structures [31]. Soft protection, indeed, intends to return the coastal zone to a more natural state using beach nourishment, dune nourishment, sand fencing, access restriction, elevated footpaths, social awareness and education, and housing removal [31].

In conclusion, we can affirm that the construction of the linear public space, the seashore street, coincides with a linear infrastructure that allowed the development and consolidation of the urban front. Indeed, nowadays, the seashore street, together with defensive infrastructures, such as piers, acts as a defence for buildings close to the sea, the first constructed line that prevents erosion phenomena. Nowadays, the public space as a protective element of the city from the sea takes on new connotations, including that of being the infrastructural element that can be adapted in its characteristics to respond to future needs.

In the scenarios outlined for the qualitative definition of urban spaces vulnerable to flooding and erosive phenomena due to sea level rise, it is noted that the most vulnerable areas are those where there are urban areas dedicated to the development of seaside tourism.

5. Discussion

A sea-level rise risk perspective highlights the need to emphasise how the effects of extreme weather events affect urban transformation at the local scale [4]. Littoral areas are

dynamic in nature and the behaviour of the materials that define the coastline is the result of natural and anthropogenic processes that occur and interact on a variety of temporal and spatial scales [43]. Indeed, climate change impacts in coastal cities are expected to represent a major challenge this century, with millions of exposed people and thousands of billions of USD of exposed assets at the global scale [22,44].

Unlike other regions, which spread in a bi-dimensional space, coastal areas are essentially linear: they certainly have a width, but this second dimension is irrelevant when compared with the alongshore dimension [13]. In fact, the spatial organisation of a coastal area hinges upon a line and rapidly loses significance within a short distance from it [13]. Indeed, if we consider that the urban form of coastal agglomerations can contribute to aggravating the negative externalities of extreme events related to climate change, the hypothesis arises that decoding the characteristics of the urban form of coastal cities allows for intervention, transformation and adaptation to the seashore street.

Nonetheless, it is important to report that there are significant gaps in the scientific literature regarding the definition of the urban space vulnerable to mean sea level rise, having as its lens the morphological characterisation of the urban elements that compose it. Although until a few years ago the topic was mostly approached from a climate science perspective, in recent years the need to outline effective adaptation measures has prompted the theoretical study of the subject [45–48].

Therefore, we consider that the proposed study can be considered a basis which can be used in the process of urban adaptation, be it through legislative plans or urban projects, to draw up an efficient design of the interface between land and sea. We hence consider that this article can be a basis from which to enhance the characterisation and diagnosis phase of legislative plans to adapt coastal urban areas vulnerable to the effects of mean sea level rise.

Characterisation of the evolutive moments of Quarteira enables us to understand how from the 20th century onwards, the response to seasonal tourism was given through the construction of equipment and through the definition of public space, the seashore street where tourist activities could take shape, while in the same years, the response to coastal erosion phenomena was given through the construction of defence infrastructures, such as piers, and through the artificialisation of the natural dynamics of the space between the land and the sea. We consider that in the face of the necessary urban transformation and adaptation of public space vulnerable to the effects of extreme events caused by the rise in mean sea level, the possible response for effective adaptation is to consider the seashore street as both a public space and a defence infrastructure. This is because, contrary to the PIAAC-AMAL, in tourist areas, it might be too costly to imagine demolishing and rebuilding the first built-up area further inland, as this is the urban public space in which the life of the city takes place, and the permanence of the seashore street allows the perpetuation of the tourist industry [6].

6. Conclusions

The contemporary city, complex and stratified, has undergone transformation processes over time, in its forms of response to the emergence of socio-economic and cultural phenomena. Coastal landscapes have always stimulated the collective imagination, generating various urban forms of appropriation. They have undergone rapid development that has been accentuated by anthropogenic pressure, both in terms of population, economic growth and urbanisation [49].

While the coastal city is an expression of change—a change that in practical terms translates into urban planning methods and tools, architecture, innovation and modern technologies—it will also be a place where memory is preserved and historical heritage is protected [50].

The observation of the urban transformation of the seashore street, through urban morphology, allows us to understand permanence and change but also contemporary urban dynamics, and to ground and outline future scenarios of adaptation, as a process

of territorial modification. Faced with the effects of rising mean sea level, the design of the adaptation and transformation of the space between the touristic city and the sea must consider an articulated response to both the effects of climate change and the seasonal tourist occupation cycles.

The decoding of the direct and indirect impacts that mutually exist between the anthropogenic system and the natural system makes it possible to understand the close relationships that are established between the two, ultimately allowing for the definition of coastal protection and adaptation plans and programmes.

In conclusion, in decoding the space between the land and the sea, the formation and transformation of the urban boundary, it is therefore possible to recognise the role of public space in accommodating physical and social, natural and anthropogenic transformations; as well as imagine a transformation in continuity that considers the design of the public space as a mediating space and defensive infrastructure.

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