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Planning the Urban Waterfront Transformation, from Infrastructures to Public Space Design in a Sea-Level Rise Scenario: The European Union Prize for Contemporary Architecture Case

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Abstract: Future sea-level rises on the urban waterfront of coastal and riverbanks cities will not be uniform. The impact of floods is exacerbated by population density in nearshore urban areas, and combined with land conversion and urbanization, the vulnerability of coastal towns and public spaces in particular is significantly increased. The empirical analysis of a selected number of waterfront projects, namely the winners of the Mies Van Der Rohe Prize, highlighted the different morphological characteristics of public spaces, in relation to the approximation to the water body: near the shoreline, in and on water. The critical reading of selected architectures related to water is open to multiple insights, allowing to shift the design attention from the building to the public space on the waterfronts. The survey makes it possible to delineate contemporary features and lay the framework for urban development in coastal or riverside areas.

Keywords: sea level rise; flood phenomena; waterfront adaptation; floating and amphibious housing

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1. Introduction

The sea-level rise projected for the 21st century will have negative impacts on coastal systems and low-lying areas, such as coastal flooding and erosion. Rising sea levels are causing more frequent flooding events in coastal areas and generate many issues for coastal communities, e.g., the loss of property or damages to infrastructures [1]. Flood risk associated with land-conversation, urban density and increasing population, exacerbated the vulnerability of urban agglomeration on coastal systems. This is particularly the case in Europe where approximately 74% of the population lives in coastal and riverside urban areas [2].

The need to address the effects of flooding provides an opportunity to rethink the relationship between infrastructure, ecology and society in the urban waterfront environment. Conventional responses to flooding include hard engineering works, (breachway, breakwaters, flood-plain, flood-wall, groyne, mole, pier structures) which define a rigid boundary between the mainland and the water body [3]. New urban systems, both public and private, have been designed incorporating flood risk management solutions. In fact, the architectural structures are integrating into the urban and natural landscape with varying degrees of approximation to water.

The waterfront urban space is the place where the greatest transformation of the European city has taken place, in recent decades: from port areas to new urban centres, due to a scale transformation in the shipping and transport industry the ports have moved out of urban centres [4]. The old dock areas in the inner cities were subsequently freed up for new urban developments and became in many cases extremely desiderable new city districts [5]. This public space, which first was a place of connection between the port (infrastructural activities) and the city, is today a rethought place dedicated to housing, office, and leisure activities.

Through the analysis of 68 contemporary architectural projects, mentioned in the European Union Prize for Contemporary Architecture, Mies Van Der Rohe award, on European waterfronts it was possible to outline the spatial characteristics of public space in contact with water bodies. The critical reading of the selected architectures related to water is open to multiple insights and allows to shift the design focus from the building to the public space of the waterfronts. The survey makes it possible to delineate contemporary characteristics for the urban development of coastal or riverside areas.

The waterfront is a complex space composed on one side of the water, by a dam, a pier, a breakwater, or left natural. On the land side it can be paved, built, used as a green area, or treated as a natural wetland. We consider it is necessary to decode the two systems, the natural one of the water body and the artificial one of the urban settlement, because today they are subject to equal and opposite forces that compromise their equilibrium. These areas on the edge are simultaneously under pressure of the average sea level and the urban expansion necessity. Waterfronts have a limited surface space, so we believe that future urban developments should be designed considering water as a building area, to accommodate amphibious and floating dwellings, and at the same time reconverting public space at the edge of the city to accommodate areas dedicated to water, i.e., “a room for the river”, but also to build defensive systems.

2. Urban Coastal Flooding Due to Rising Sea-Levels

Sea-level rise effects, which are a consequence of climate change, are expected to increase the risk of flooding on urban systems in low-lying areas [6]. In 2019, IPCC (Intergovernmental Panel on Climate Change) has presented updates on observed global mean sea-level (GMSL) concluded that GMSL from tide gauges and altimetry observations increased from 1.4 mm/year over the period 1901–1990, to 2.1 mm/year over the period 1970–2015, to 3.2 mm/year over the period 1993–2015, to 3.6 mm/year over the period 2005–2015 IPCC [7]. IPCC found an average climate-change driven rate of sea-level rise of 2.9 mm/year. Current acceleration of sea-level rise would lead to 65 ± 12 cm global mean sea-level rise by 2100 compared with 2005, they concluded. This roughly agrees with the projections of the IPCC made in 2013 under a high-end scenario of climate change (the so-called RCP8.5 scenario) [8]. Thus, the observed acceleration would more than double the amount of sea-level rise by 2100 compared with the current rate of sea-level rise continuing unchanged [9]. As the temperature rises, more floods are expected to affect an exponential number of people. In the last 20 years, 90% of disasters have been caused by extreme weather events, in total 6457 [10]. According to the CRED report, between 1995 and 2015 there were 3062 floods, 47% of all meteorological disasters, affecting 2.3 billion people, with a increase of 14% between 2005–2014 compared to 1995–2004, and almost double that of 1985–1995.

Coastal settlements are among the most vulnerable areas as to the impacts of climate extreme events because are predominantly located in vulnerable areas such as coastlines, mouths of major rivers or low-lying areas of estuaries and deltas. The type of risk to which an urbanized area is exposed is linked to population density, that is significantly higher in coastal than in non-coastal areas [11]. Moreover, 13 out of the 20 most populated cities in the world in 2005 being port cities [12]. A part of the urban population lives in coastal areas and on the banks of important rivers (the 40 largest cities in the world are in delta areas) where urbanization has consolidated over the centuries. Coastal growth, land conversion and urbanization are factors that significantly increase risk and vulnerability levels along the coasts and in populated deltas [13]. The exposure of large numbers of people and goods, at the global scale, to the effects of rising levels is one of the major challenges of this century [12,14].

In 2000, over 10% of total global urban land was located within the low-elevation coastal zones (LECZ), the contiguous area along the coast that is less than 10 m above sea-level, that covers only 2% of the world's land area [15]. Under high emissions, CoastalDEM (Climate Central's high-accuracy digital elevation model for coastal areas) indicates up to 630M people live on land below projected annual flood levels for 2100, and up to 340 M for mid-century, versus roughly 250 M at present. Moreover, one billion people are estimated that now occupy land less than 10 m above current high tide lines, including 250 M below 1 m [16]. From 2000 to 2030, globally, the amount of urban land within the low-elevation coastal zones is projected to increase by 230% [17].

As a direct cause of their physical location, these cities are at greater risk from climate hazards, such as coastal storms, cyclones, flooding, and coastal erosion. The impacts on urban settlements are not uniform, the intensity and different permanence of the floods vary on a geographical and temporal scale [18]. Local anthropogenic subsidence and change in wave height and period are important contributors to future changes in relative sea-level (RSL) at the coast IPCC [7].

The assessment of flood-prone areas is crucial and one of the major aspects in creating flash flood resilient cities [19]. Flood-prone areas remain attractive for socio-economic activities and it is therefore likely that the damage potential (as in the number of assets in flood-prone areas) will continue to increase in the future [20]. Yet, the effects of the flooding on the coastal territory are closely linked to the shape of the urban coastal settlements [21].

2.1. Coastal Urban Settlements: Waterfront and Riverbanks

The waterfront is a landwater interface [22], an urban space, such as beaches, harbours, pier, quay and ports, in contact with a nearshore water body, river, sea, bays, lagoons, tidal river/creek mouths. Urban areas in contact with water bodies are the most sensitive areas to more frequent and intense flooding phenomena.

The identity of cities on the waterfront derives from their relationship with the water body [5]. The proximity to the river, lake, or sea, has always been of great consideration in the choice of a community [23]. The territories on the border between the settlements and water were inhabited because of their geomorphological characteristics: their rich resources for life, freshwater and food; 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 [13].

In the pre-industrial era, cities' waterfronts were public spaces intended for the promenade, characterized by iconic architectures. After the redefinition of ports, increased by the improvement of transport and telecommunications, the close relationship between the urban and the water was interrupted by the construction of industrial port-infrastructure [24,25]. The subsequent abandonment of port areas in contact with the city, in favour of peripheral ones, has developed different types of spaces -urban voids, old unused industrial settlements, obsolete infrastructures- which have become new icons of the contemporary urban scenario [26]. Since the 1960s, the waterfront has taken on a new spatial significance, becoming an object of urban design and spatial planning [27]. In the second half of the 20th century, the urban waterfronts have undergone processes of requalification with new spaces for tourism, leisure, and new residential areas which have changed not only the form and function, but also the image of the waterfront [25].

Waterfront Public Spaces

The urban transformation that took place at the interface between city and water is the product of projects that over the years have become models for the enhancement of waterfronts [22,28].

To understand the city as a place of human relations it is necessary to analyse the characteristics of the public space that compose it. Aware that the reading of public space is a premise through which it is possible to redesign vulnerable urban areas, such as those on the waterfront that need to be adapted to flooding: i.e., seashore street. The seashore street is a linear urban element, limited by buildings on one side and open towards the water body on the other [29]. This public space along the shoreline includes urban spaces such as the street, squares, parks, but also piers and the nearby natural environments such as public greens, sandy or rocky beach, riverbanks. The seashore streets moderate the form and structure of the consolidated city's connection to the water [29,30]. In this space of mediation between the city and the water, the daily life and social activities of urban residents and tourists take place.

The concept of public space in waterfront/riverbanks cities has evolved, the physical form has been adapted to the different functions and socio-cultural paradigms that have formed. Over the years, this structuring public space of the waterfront has become an urban element that allows and promotes community life, it is a place of interaction and social representation [31], a facilitator of infrastructural support for mobility and urban activities. Among the qualities of this space, there are accessibility, proximity, liveability, and safety [32]. The waterfront spaces on the waterfront can be analyzed through the parameter of visual, physical distance and accessibility to water, which defines their overall quality of urban public spaces [33]. A public space may be a gathering spot or part of a neighborhood, downtown, special district, waterfront, or other area within the public realm that helps promote social interaction and a sense of community [34].

2.2. Waterfront Adaptation Plans

Today, there is the need to adapt the coastal urban settlements to the increased risk of flooding in floodplains areas -geologically sensitive areas- to build resilient cities [35]. Indeed, the continuing urbanization process in flood prone areas has led to a large increase in capital and population in vulnerable areas. In future climate scenarios, threshold urban areas, between the city and the water body, will become more vulnerable to flooding, due to rising average sea levels, and the reduction of permeable soil due to urbanization processes [36,37].

A risk-based perspective on sea-level rise points to the need for emphasis on how changing sea-levels alter the coastal zone and interact with coastal flood risk at local scales [38]. Through the assessment of the impact on coastal and riverfront cities, it is possible to define the threshold's criticality and improve urban management and regeneration practices to preserve the natural and man-made landscape, where human activities are concentrated.

Concerning the recurrent phenomenon of urban flooding, climate change research has been warning the fact that traditional flood management practices must be reassessed [39]. Without flood defences, almost 6% of the European population would be living in the 100-year flood area [40]. However, most of the current coastal protections (e.g., seawalls and emerged breakwaters) were built with the sole purpose of protecting urban coast, without environmental concerns for the negative consequences that such structures could cause [1].

Since 2007, the adaptation to the effects of climate change has become part of Member States' urban legislative plans. The Flood Risk Management Plan established by European Directive 60/2007 [41] provides for the implementation of structural and non-structural interventions in order to contain flood risks in areas where the potential risk is deemed significant, aiming to reduce the potential negative consequences for human health, the affected territory, assets, the environment, cultural heritage, and economic and social activities [42].

In the Netherlands since 2008, the national policy "fighting against the water" has been altered by embracing the "working with water" paradigm. The need is to reconsider the concept of adaptation in urban planning and design in favour of the concept of adaptive capacity [43] based on the vulnerability of urban settlements to flooding. Including all four capacities of the vulnerability framework, i.e., threshold capacity, coping capacity, recovery capacity, and adaptive capacity, enables better understanding of water and climate related urban areas [44].

The adaptation process concerns both the threshold capacity, to prevent damage by building a threshold of resistance to disturbances, and the adaptive capacity of the urban system. Consequently, for a complete vulnerability reducing strategy, attention should be paid to all components and domains of vulnerability [44].

2.3. *Urban Transformation of Waterfront Public Spaces*

The vulnerability of coastal cities is defined as the sensitivity of the system to exposure to shock, stress and disturbance, or the degree to which the system is susceptible to the effects of rising sea levels with the continuous and rapid urbanization of flood-prone areas.

The empirical selection of cases, Table 1, classifies examples of urban adaptation measures applied to waterfront. Traditionally, bulkheads, seawalls, and revetments have been the most commonly used type of shoreline "grey" infrastructure implemented as a primary response to coastal hazard [1]. Today, flood management infrastructures are not sufficient to respond to the scale and speed of the estimated impacts of extreme weather events, including sea-level rise [45].

Table 1. Identification of flood adaptation categories in the vulnerability framework, combined with existing examples. Authors's edition. Source Data: [43]:410. [39]: 211.

Frequency of Hazard	Damage	Component		
Low	*Anticipation*	**Adaptative capacity (De Graaf, 2009)**		
			Floating structures (Matos Silva, 2016)	
		27	Floating pathway	West India Quay, London Ravelijn Bridge, Bergen
		28	Floating platform	Yongning River Park, Taizhou Landungsbrucken Pier, Hamburg
		29	Floating islands	Spree Bathing Ship, Berlin Leine Suite, Hannover
			Wet-Proof (Matos Silva, 2016)	
		30	Submergibile parks	Rhone River Banks, Lyon Parque Fluvial del Gallego, Zuera Rio Besòs River Park, Barcelona Buffalo Bayou Park, Houston Parc de la Seille, Metz Park Van Luna, Heerhugowaard
		31	Submergible pathways	Passeio Atlântico, Porto Quai des Gondoles, Choisy-le-Roi
Medium	*Reaction*	**Recovery capacity** (De Graaf, 2009)		
Medium	*Reduction*	**Coping capacity** (De Graaf, 2009)		
High	*Prevention*	**Threshold capacity** (De Graaf, 2009)		
			Coastal defences (Matos Silva, 2016)	
		34	Multifuncional defences	Elbpromenade, Hamburg Dike of Boompjes, Rotterdam
		35	Breakwaters	Zona de Banys del Fòrum, Barcelona Molhe da Barra do Douro, Porto
		36	Embankments	Scheveningen, The Hauge Sea Organ, Zadar
			Floodwalls (Matos Silva, 2016)	
		37	Sculptured walls	Main Riverside, Miltenberg Blackpool Seafront, Blackpool
		38	Glass walls	Westhoven, Cologne
			Barriers (Matos Silva, 2016)	
		39	Demountable barriers	Waalkade Promenade, Zaltbommel Kampen Waterfront, Kampen

As the body of water and its medium level fluctuations, will have increasing effects on human environments: urban planning must incorporate water into urban design. Flood control measures decrease flood risk through lock-in strategy, yet new urbanisation theories could be developed strategies that include all four capacities to reduce urban vulnerability [44]. The overcoming of defensive logics in contrast with the concretization of the "living with water" and "room for the river" paradigms, involves the conception of protection infrastructures no longer exclusively monofunctional but integrated in the design of public space [46]. The IPCC [47] presents many options available for society to increase its adaptive capacity, varying from technical options to insurance policy and communication strategies [44]. Resistance to the effects of sea level rise on coastal cities can be improved by implementing "green/blue" adaptation measures that exploit natural processes -"building with water"- self-adaptive that produce significant co-benefits [48].

In this article, we described the public space of the waterfront, referring to its degree of approximation to water; dividing it into two types: "near" (public space along the shoreline), "in" (amphibious public space which functions in flooded situations) and "on" the water (floating public space).

2.3.1. Urban Public Space near the Shoreline

The urban public space structured on the shoreline, seashore streets and alleys, avenues and squares, walks, docks, and bridges, but also rivers and canals, banks, and beaches, whether it is near the river, on a waterfront, or near the sea, on the edge of coastal cities, is an organized system in a network to allow distribution and circulation. This public space itself comprises all ranges of build and natural environment with ease of accessibility as main prerequisite.

The social changes, that have taken place over the years, had a physical impact on the waterfront spaces, which suffered more or less deep transformations: shading elements were placed on the beach, wide sidewalks for strolling and seashore drives were opened, paved and sometimes planted with tree lines, accompanying and redesigning the coastal urban edges aiming at the fruition of the water margin [29]. In fact, a common feature of the wide variety of waterfront cases is that it is a place of representation of the identity of society, the main stages of social and political life and religious manifestations [31].

2.3.2. Urban Public Space in and on Water

At the present state of research, there are semantic typological problems in the literature of water-placed architecture [49]. The semantic issue, as pointed out by Piatek [49], of the term amphibious used in architectural and urban practice to describe both the theory of aquatecture and the floating building involves an overlapping of normative and constructive meanings. The ambiguity generates discrepancies in the conception of the floating urban agglomeration: where the building and not the public space is more investigated.

Amphibious and floating construction techniques have traditionally been developed to coexist with natural changes in the water level [36,50,51]. There are several possible construction options to deal with water level changes in settlement areas: dry-proof, wet-proof, pile dwellings and amphibians. While dry and wet-proof techniques are useful for short periods of flooding, pile-dwelling construction is useful for long periods of high water, amphibian or floating buildings offer the opportunity to "float when flooding" in seasonal or 1–3-month periods [37,52].

To go beyond the semantic problem, the article used the definition of urban space in relation to its degree of approximation to the water body: "in" and "on" water [53].

Public space "in" water is a space built between dry and wetlands area, which cyclically undergoes non-constant and non-permanent flooding phenomena. This space is characterized by the same construction features as amphibious buildings. Namely, a waterside building and public space is located in direct proximity, partly or entirely in a water basin, and erected on a waterproof foundation a ground-based openwork structure rising it over water for a designed height [49]. Pile dwellings held a special fascination for the founding fathers of modern architecture who adopted them as architecture à pilotis [23]. Urban space "on the water" has not yet been decoded and designed, in fact, floating buildings have been given priority for analysis in architectural literature. A floating building is a building located in a water basin, partly submerged, floating on the water surface thanks to special structural elements like the buoyant foundation or the watertight basement that displaces surrounding water, that is held in place by variety of systems like mooring piles (dolphins), stopping piles, anchors, mooring lines and combination of those [49]. Important is the distinction between a house-boat typology and a floating home, that is a building that rests on a buoyant base of foundation [54], designed to rise and fall with the level of the water. Floating architecture can adapt to changes in water levels and different climatic conditions, signaling a possible way to solve the effects of sea level rise.

3. Building a Methodology to Analyse Urban Waterfronts, the European Union Prize for Contemporary Architecture Case

3.1. Data Acquisition

Waterfronts are the urban areas where the transformation of the contemporary European city is most evident. In order to understand how to adapt the waterfront public space to the effects of the sea-level rise, it was decided to analyse the 68 projects, collected in the EU Mies Award Archive, European Union Prize for Contemporary Architecture, the Mies van der Rohe Award [55]. In the morphological urban transformation of the urban-water interface of the different European cases (Amsterdam, Barcelona, Copenhagen, Lisbon, Marseille, Oslo, Paris, Reykjavik, and Rotterdam), through the replacement of fragments of urban fabric, a different port and coastal landscape was built.

3.2. Matrix Parameters for The correlation

In the Table 2, 68 projects are described through the parameters and technical data of the architectural project (geographical location, atelier that drew up the project, year of construction, type of building).

Following this, the matrix in Table 3 provides a reference framework that allows one to understand and evaluate the design of the urban space of the waterfront by comparing it between similar spaces through the cross reading of data.

The range of projects on the waterfront, collected in the Mies Van Der Rohe award, are analyzed through references and theories regarding the characteristics of public space, to decode the relationships that are established between the architectural object, the building, and the public space of the waterfront. Understanding whether urban redevelopment has been made to the public space in the construction of the building is, we believe, a necessary step to demonstrate that the process of transformation of the waterfront has not been concluded (9).

In the analysis of waterfront as a system, five parameters of the 10 Principles for Sustainable Development of Urban Waterfront Areas [56] were analysed (Table 4) because they allow to evaluate the urban transformation of the public spaces.

The points listed above [56] allow us to understand what the urban vulnerability [42,44] of the waterfront is, i.e., which are the urban and architectural elements that need protection due to flooding phenomena: among them the architectural and historical heritage of the port areas (2, 3). Furthermore, they define the qualities of public space (4, 5) that must be maintained even in transformation processes, such as: accessibility, bringing people together, livability, safety and comfort [32].

The typology of the public space is investigated following the classification proposed by Brandão and taken up by Matos Silva [39]. Through the reading of the data (Table 4), the evident empirical result is that the public space in the waterfront is attributable to the "layout typology" (L) -plazas, streets, avenues- only in some cases partially to the "landscape" (Ls) -gardens, parks, belvederes, viewpoints. This result shows how the urban space, near the water, is structured by the seashore street: a fixed boundary of the city. In order to decode urban space in relation to the rise in average sea level, the spatial relationship of architectural elements to water was investigated, namely the degree of approximation to the water body: "near", "in" and "on" [53]. Regarding sea-level rise in the matrix are shows the absolute trends data (mm/year) provided by NOAA [57] and EEA [58]. The sea-level trends measured by tide gauges (measurements are made with respect to a local fixed reference on land. NOAA's Laboratory for Satellite Altimetry) that are presented here are local relative sea-level (RSL) trends as opposed to the global sea-level trend. Yet, the trend of rising average sea-level, without the altimetry and topography of coastal and river basins areas is not sufficient to understand which areas, and in what extension, will be subject to flooding. For this reason, it was considered empirically useful to include the scenarios to 2050 and 2100 projected by Kulp & Strauss [16]. In the matrix 4, there are European and National legislative adaptation plans, which are active in the areas of the urban projects analysed. When in the table, reference is made to flood mapping in European countries, it is important to keep in mind that there are different methodologies, with different indicators, for the definition of risk maps. This leads to a difficult possible comparison. In fact, in this part of the analysis, we want to underline that all projects are within national plans and programmes complying with the EU Floods Directive (2007/60/EC) [41]. This is not applicable in the case of Iceland. The adaptation plans do not refer to flood defences and works to prevent flooding, as these are critical elements in the delineation of risk factors.

The description and analysis of urban waterfronts, of areas vulnerable to flooding, by comparing the forms and processes of urban transformation has provided datasets useful for morphological systematization and spatial planning. As the current morphological conformation, the limits and characteristics of this public space, occurred in consecutive moments, are the result of different urban processes [59]. Cross-referencing urban waterfront characteristics (Table 4) with data on mean sea level rise and subsequent adaptation policies provides an understanding of vulnerability values (Table 5). Which differs according to the strength of the floods due to the different water bodies: river, sea, ocean. This provides a basis for considering water body characteristics in urban adaptation planning.

Table 2. Matrix parameters for the correlation. Authors's Edition. Source Data: [55].

								ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S.; 2019)					
	N-S	**Location**		**River**	**Sea**	**Ocean**		**Project**	**Atelier**	**Constraction Data**		**Building Typologies**	**Labels**
1	1	Copenhagen	Denmark		X		Øresund Strait	**The Silo**	COBE	2016–2017	Nominee 2019	Ch	FT
2	2	Copenhagen	Denmark		X		Øresund Strait	**FIH A/S Headquarters**	3XN/GXN	?–2002	Nominee 2003	O	-
3	3	Copenhagen	Denmark		X		Øresund Strait	**Bech-Bruun Dragsted Law Office**	Frederiksen & Knudsen	?–2001	Nominee 2003	O	-
4	4	Copenhagen	Denmark		X		Øresund Strait	**Kvæsthus Pier**	Lundgaard & Tranberg Architects	2012–2016	Shortlisted 2017	Up	PSW
5	5	Copenhagen	Denmark		X		Øresund Strait	**The Royal Playhouse**	Lundgaard & Tranberg Architects	?–2008	Nominee 2009	C	-
6	6	Copenhagen	Denmark		X		Øresund Strait	**Unibank Headquarters**	Henning Larsen Architects	?–2000	Finalist 2001	O	-
7	7	Copenhagen	Denmark		X		Øresund Strait	**Extension of the Royal Danish Library**	Schmidt, Hammer & Lassen architects	?–2000	Nominee 2001	E	-
8	8	Copenhagen	Denmark		X		Øresund Strait	**The Circle Bridge**	Studio Olafur Eliasson	2012–2015	Nominee 2017	I	B
9	9	Copenhagen	Denmark		X		Øresund Strait	**Maritime Youth Centre**	PLOT Bjarke Ingels, Julien De Smedt	?–2004	Shortlisted 2005	Sl	-
10	10	Copenhagen	Denmark		X		Øresund Strait	**Gemini Residence**	MVRDV	?–2005	Nominee 2007	Ch	-
11	11	Copenhagen	Denmark		X		Øresund Strait	**South Harbour School**	JJW Arkitekter	2008–2015	Nominee 2017	E	C&YS
12	12	Copenhagen	Denmark		X		Øresund Strait	**Teglvaerkshavnen Housing**	Tegnestuen Vandkunsten	2006–2008	Nominee 2009	Ch	-
13	1	Kastrup	Denmark		X		Øresund Strait	**Kastrup Sea Bath**	White Arkitekter Fredrik Pettersson	?–2005	Shortlisted 2007	Sl	-
14	1	Helsingør	Denmark		X		Øresund Strait	**Danish Maritime Museum**	BIG - Bjarke Ingels Group	2007–2013	Finalist 2015	C	-
15	1	Marseilles	France		X		Mediterranean Sea	**Marseilles Docks**	5+1AA Alfonso Fernia Gianluca Peluffo srl	2013–2015	Nominee 2017	Oc	-
16	2	Marseilles	France		X		Mediterranean Sea	**Museum of European and Mediterranean Civilization MUCEM**	Rudy Ricciotti	2010–2013	Nominee 2015	C	-
17	3	Marseilles	France		X		Mediterranean Sea	**Marseille Vieux Port**	Foster + Partners	2012–2013	Shortlisted 2015	Up	-
18	1	Nord-Pas de Calais, Dunkerque	France			X	Atlantic Ocean	**FRAC - Regional Contemporary Artwork Collection**	Lacaton & Vassal Architectes	2011–2013	Shortlisted 2015	C	-
19	1	Paris	France	X			Seine River	**Quai Branly Museum**	Ateliers Jean Nouvel	1900–2006	Nominee 2007	C	-
20	2	Paris	France	X			Seine River	**Orsay Museum**	Gae Aulenti Architetti associati	?–1986	Shortlisted 1988	C	-
21	3	Paris	France	X			Seine River	**Arab Cultural Centre**	Ateliers Jean Nouvel	?–1987	Shortlisted 1988	C	-
22	4	Paris	France	X			Seine River	**Docks de Paris (Cité of Design and Fashion)**	Jakob + Macfarlane	2007–2008	Nominee 2009	Mu	-
23	5	Paris	France	X			Seine River	**New Ministry of Economics and Finances**	Chemetov + Huidobro	1984–1989	Shortlisted 1990	Gc	-
24	6	Paris	France	X			Seine River	**Pedestrian Bridge Simone de Beavoir**	Dietmar Feichtinger Architectes	?–2006	Shortlisted 2007	I	-
25	7	Paris	France	X			Seine River	**French National Library**	Dominique Perrault Architecture	1995	Prize Winner 1996	E	-
26	1	Thessalonki	Greece		X		Mediterranean Sea	**Redevelopment of the New Waterfront in Thessalonki**	Nikiforidis-Cuomo Architects	2006–2014	Shortlisted 2015	Up	-
27	1	Reykjavik	Iceland			X	Atlantic Ocean	**The Marshall House**	Kurtogpi Architects	2016–2017	Nominee 2019	C	AG
28	2	Reykjavik	Iceland			X	Atlantic Ocean	**Reykjavik Art Museum**	Studio Granda	1998–2000	Nominee 2001	C	-
29	3	Reykjavik	Iceland			X	Atlantic Ocean	**The Supreme Court of Iceland**	Studio Granda	?–1995	Nominee 1996	Gc	-

Table 2. *Cont.*

ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S.; 2019)													
	N-S	**Location**		**River**	**Sea**	**Ocean**		**Project**	**Atelier**	**Constraction Data**		**Building Typologies**	**Labels**
30	4	Reykjavik	Iceland			X	Atlantic Ocean	**Harpa Concert Hall and Conference Centre**	Henning Larser Architects; Studio Olafur Eliasson; Batteríid architects	2005–2011	Prize Winner 2013	C	-
31	1	Oslo	Norway		X		Oslo Fjord	**Norwegian National Opera & Ballet**	Snohetta	2003–2008	Prize Winner 2009	C	-
32	2	Oslo	Norway		X		Oslo Fjord	**Sorenga Seawater Pool**	LPO arkitekter AS; Atkitekt Kristine Jensens Tegnestue	2013–2015	Nominee 2017	Up	PSW
33	1	Cascais	Portugal			X	Atlantic Ocean	**D. Diogo de Menezes Square**	Miguel Arruda Arquitectos Associados	2007–2009	Shortlisted 2011	Up	-
34	2	Cascais	Portugal			X	Atlantic Ocean	**Santa Marta Lighthouse Museum**	Aires Mateus	2006–2007	Shortlisted 2009	C	-
35	1	Lisbon	Portugal	X			Tagus River	**Portugal Pavillion Expo 98**	Alvaro Siza Vieira Arquitecto	?–1997	Nominee 1998	C	-
36	2	Lisbon	Portugal	X			Tagus River	**Pavillion of Knowledge of the Seas**	JLCG arquitectos	?–1997	Nominee 1998	C	-
37	3	Lisbon	Portugal	X			Tagus River	**Lisbon Cruise Terminal**	Carrilho da Graça	2015–2017	Shortlisted 2019	I	P
38	4	Lisbon	Portugal	X			Tagus River	**Museum of Art, Architecture and Technology**	AL_A	2014–2016	Shortlisted 2017	C	M
39	5	Lisbon	Portugal	X			Tagus River	**Maritime Control Tower**	Gonçalo Byrne Arquitectos	?–2001	Nominee 2003	I	-
40	1	Barcelona	Spain		X		Mediterranean Sea	**Barcelona International Convention Centre**	MAP Architects	2002–2004	Shortlisted 2005	C	-
41	2	Barcelona	Spain		X		Mediterranean Sea	**Diagonal Mar Park**	Miralles Tagliabue _EMBT	?–2002	Nominee 2003	L	-
42	3	Barcelona	Spain		X		Mediterranean Sea	**Environmental Complex Coastal Park**	Abalo & Herreros	1900–2004	Nominee 2005	L	-
43	4	Barcelona	Spain		X		Mediterranean Sea	**Forum 2004 Esplanade and Fotovoltaic Plant**	Martínez Lapeña - Torres Arquitectos	?–2004	Finalist 2005	I	-
44	5	Barcelona	Spain		X		Mediterranean Sea	**Illa de Llum Housing at Diagonal Mar**	Clotet, Paricio i Assoc. S.L.	?–2005	Shortlisted 2007	Ch	-
45	6	Barcelona	Spain		X		Mediterranean Sea	**Pedestrian Bridge and Capitania Building**	Mamen Domingo i Ernest Ferré Arquitectes	?–2004	Shorlisted 2005	I	-
46	7	Barcelona	Spain		X		Mediterranean Sea	**South-east Coastal Park**	Foreign Office Architects FOA	?–2004	Shortlisted 2005	Up	-
47	8	Barcelona	Spain		X		Mediterranean Sea	**Gas Natural Office Building**	Miralles Tagliabue - EMBT	?–2005	Nominee 2007	O	-
48	49	Donostia	Spain		X		Bay of Biscay	**Kursaal Centre**	Rafael Moneo	?–2000	Prize Winner 2001	C	-
50	1	L'Estartit Girona	Spain		X		Mediterranean Sea	**Yacht Club of L'Estartit**	OAB - Office of Architecture in Barcelona Carlos Ferrater, Gerardo Rodriguez	?–1991	Shortlisted 1992	Sl	-
51	1	Madrid	Spain	X			Manzanarre	**Madrid Río**	Burgos & Garrido Arquitectos, Porras & La Casta; Rubio & Álvarez-Sala estudio de arquitectura; West 8	2007–2011	Shortlisted 2003	L	-

Table 2. *Cont.*

ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S.; 2019)													
	N-S	**Location**		**River**	**Sea**	**Ocean**		**Project**	**Atelier**	**Constraction Data**		**Building Typolo-gies**	**Labels**
52	1	Valencia	Spain		X		Mediterranean Sea	**America's Cup Building**	David Chipperfield Architects, b720 Arquitectos	?–2006	Finalist 2007	Sl	-
53	1	Amsterdam	The Netherlands	X			IJ River	**Kraanspoor**	OTH	2006–2007	Nominee 2009	O	-
54	2	Amsterdam	The Netherlands	X			IJ River	**REM Island Amsterdam**	Concrete	2007–2011	Nominee 2013	M. U.	-
55	3	Amsterdam	The Netherlands	X			IJ River	**Silodam**	MVRDV	?–2002	Nominee 2003	Ch	-
56	4	Amsterdam	The Netherlands	X			IJ River	**Magistrate's Court**	Felix Claus Dick van Wageningen Architecten	2011–2013	Nominee 2015	Gc	-
57	5	Amsterdam	The Netherlands	X			IJ River	**EYE Film Institute Netherlands**	Delugan Meissi Asssociated Architects DMAA	2009–2012	Shortlisted 2013	C	-
58	6	Amsterdam	The Netherlands	X			IJ River	**Social Housing - KNSM Island**	Bruno Albert architect	?–1993	Shortlisted 1994	Ch	-
59	7	Amsterdam	The Netherlands	X			IJ River	**Residential Housing KNSM-Eiland**	Prof. Kollhoff Generalplanungs – GmbH	?–1993	Shortlisted 1994	Ch	-
60	8	Amsterdam	The Netherlands	X			IJ River	**Borneo Sporenburg**	West 8 urban design & landscape architecture b.v.	?–2000	Shortlisted 2001	Up	-
61	1	Huizen, Amsterdam	The Netherlands	X			Gooimer Lake	**Sphinxes**	Neutelings Riedik Architects Williem Jan Neutelings, Michiel Riedijk	?–2003	Shortlisted 2005	Ch	-
62	1	Rotterdam	The Netherlands	X			Nieuwe Maas River	**Housing Ensemble de Landtong Rotterdam**	de Architekten Cie	-	Nominee 1998	Ch	-
63	2	Rotterdam	The Netherlands	X			Nieuwe Maas River	**The Bridge**	JHK Architecten	?–2005	Shortlisted 2007	O	-
64	3	Rotterdam	The Netherlands	X			Nieuwe Maas River	**New Luxor Theatre**	BOLLES+WILSON	?–2000	Shortlisted 2001	C	-
65	4	Rotterdam	The Netherlands	X			Nieuwe Maas River	**De Rotterdam**	O.M.A.	1998–2013	Shortlisted 2015	Mu	-
66	5	Rotterdam	The Netherlands	X			Nieuwe Maas River	**Office Imd**	Ector Hoogstad Architecten	2011–2011	Nominee 2013	O	-
67	6	Rotterdam	The Netherlands	X			Nieuwe Maas River	**Shipping and Transport College**	Neutelings Riedijk Architectus	?–2005	Shortlisted 2007	E	-

Table 3. Matrix parameters for the correlation. Authors's Edition. Source Data: [16,39,53,55–58,60–68].

	ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S., 2019)					**Urban Floods and Climate Change Adaptation (Matos Silva M., Costa J.P., 2018)**			**10 Principles for Sustainable Development of Urban Waterfront Areas (Centre for Cities on Water, Venice; 2000)**					**Water Approximation (BACA, 2009)**			**SEA LEVEL TRENDS mm/year**		**SEA LEVEL RISE SCENARIO**		**ADAPTATIONS PLANS**	
	N-S	**River**	**Sea**	**Ocean**	**Project**	**Public Space**	**Re-Qualified Public Space**	**Public Space Typologies**	**2**	**3**	**4**	**5**	**9**	**Near Water**	**In Water**	**On Water**	**NOAA, 2019**	**EEA, 2019**	**2050 (Kulp & Strauss, 2019)**	**2100 (Kulp & Strauss, 2019)**	**European Level**	**National Level**
1	1		X		The Silo	X	X	L	X	X	-	X	X		X				**X**	**X**		
2	2		X		FIH A/S Headquarters	X	X	L	X	X	-	X	X		X				-	-		
3	3		X		Bech-Bruun Dragsted Law Office	X	X	L	X	X	-	X	X		X				-	-		
4	4		X		Kvæsthus Pier	X	X	L	X	X	X	X	X		X				-	-		
5	5		X		The Royal Playhouse	X	X	L	X	X	X	X	X		X				-	-		
6	6		X		Unibank Headquarters	**X**	**X**	**L**	**X**	**X**	**X**	**X**	**-**	**X**			0.59 mm/year 0 to 3 (1889–2017)	3 to 4 (1993–2019)	**X**	**X**		Coastal Protection Act. Nature Protection Act. Planning Act.
7	7		X		Extension of the Royal Danish Library	**X**	**X**	**L**	**X**	**X**	**X**	**X**	**-**	**X**					**-**	**-**		
8	8		X		The Circle Bridge	**X**	**X**	**L**	**X**	**X**	**X**	**X**	**X**		**X**				**-**	**-**		
9	9		X		Maritime Youth Centre	X	X	L	-	-	-	X	-	X					-	-		
10	10		X		Gemini Residence	X	X	L	X	X	X	X	-	X					-	-		
11	11		X		South Harbour School	X	X	Ls	-	-	-	X	X		X				-	-		
12	12		X		Teglvaerkshavnen Housing	X	X	L	-	-	-	X	X		X				-	-		
13	1		X		Kastrup Sea Bath	**X**		**L**	**-**	**-**	**-**	**-**	**X**		**X**				**X**	**X**		
14	1		X		Danish Maritime Museum	X	X	Ls	X	X	X	X	-	X			0.4 mm/year 0 to 3 (1891–2017)		-	-		
15	1		X		Marseilles Docks	X	X	L	X	X	X	X	-	X					-	-		
16	2		X		Museum of European and Mediterranean Civilization MUCEM	X	X	L	X	X	X	X	X		X		1.3 mm/year 0 to 3 (1885–2018)	2 to 3 (1993–2019)	-	-	MAP	PNACC-2
17	3		X		Marseille Vieux Port	X	X	L	X	X	X	X	-	X					-	-		
18	1			X	FRAC - Regional Contemporary Artwork Collection	**X**	**X**	**L**	**-**	**-**	**-**	**X**	**-**	**X**			1.68 mm/year 0 to 3 (1942–2018)	1 to 2 (1993–2019)	**X**	**X**		CPER 2007–2013 of Nord-Pas-de-Calais
19	1	X			Quai Branly Museum	X	X	Ls	X	X	X	X	-	X					-	-		
20	2	X			Orsay Museum	X	X	L	X	X	X	X	-	X					-	-		
21	3	X			Arab Cultural Centre	X	X	L	X	X	X	X	-	X					-	-		
22	4	X			Docks de Paris (Cité of Design and Fashion)	X	-	L	X	X	X	X	-	X			-	-	-	-		-
23	5	X			New Ministry of Economics and Finances	X	X	L/Ls	X	X	X	X	X	X	X				-	-		

Table 3. *Cont.*

	ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S., 2019)					Urban Floods and Climate Change Adaptation (Matos Silva M., Costa J.P., 2018)			10 Principles for Sustainable Development of Urban Waterfront Areas (Centre for Cities on Water, Venice; 2000)					Water Approximation (BACA, 2009)			SEA LEVEL TRENDS mm/year		SEA LEVEL RISE SCENARIO		ADAPTATIONS PLANS	
	N-S	**River**	**Sea**	**Ocean**	**Project**	**Public Space**	**Re-Qualified Public Space**	**Public Space Typologies**	**2**	**3**	**4**	**5**	**9**	**Near Water**	**In Water**	**On Water**	**NOAA, 2019**	**EEA, 2019**	**2050 (Kulp & Strauss, 2019)**	**2100 (Kulp & Strauss, 2019)**	**European Level**	**National Level**
24	6	X			Pedestrian Bridge Simone de Beavoir	X	X	L	X	-	-		X		X				-	-		
25	7	X			French National Library	X	X	L	X	X	X	X	-	X					-	-		
26	1		X		Redevelopment of the New Waterfront in Thessalonki	X	X	L	X	X	X	X	X		X		3.83 mm/year 3 to 6 (1969–2017)	2 to 3 (1993–2019)	-		MAP	ICZT
27	1			X	The Marshall House	X	-	L	-	-	X	X	-	X					-	-		
28	2			X	Reykjavik Art Museum	X	-	L	X	-	X	X	-	X			2.35 mm/year 0 to 3 (1956–2018)	1 to 2 (1993–2019)	-	-		-
29	3			X	The Supreme Court of Iceland	X	-	L	X	-	X	X	-	X					-	-		
30	4			X	Harpa Concert Hall and Conference Centre	X	-	L	X	-	X	X	X		X				-	-		
31	1		X		Norwegian National Opera & Ballet	X	X	L	X	-	X	X	X		X		−3.12 mm/year −6 to −3 (1885–2018)	3 to 4 (1993–2019)	-	-		-
32	2		X		Sorenga Seawater Pool	X	X	L	X	-	-	X	X			X			-	-		
33	1			X	D. Diogo de Menezes Square	X	X	L	X	X	-	X	-	X			1.32 mm/year 0 to 3 (1882–1993)	2 to 3 (1993–2019)	-	-		POC
34	2			X	Santa Marta Lighthouse Museum	X	X	L	X	X	-	X	-	X					X	X		
35	1	X			Portugal Pavillion Expo 98	X	X	L	-	-	X	X	-	X					X	X		
36	2	X			Pavillion of Knowledge of the Seas	X	X	L	-	-	X	X	-	X			1.32 mm/year 0 to 3 (1882–1993)	2 to 3 (1993–2019)	-	-		ENAAC
37	3	X			Lisbon Cruise Terminal	**X**	**X**	**L**	**X**	**X**	**-**	**X**	**X**		**X**				**X**	**X**		
38	4	X			Museum of Art, Architecture and Technology	X	X	L	X	X	-	X	X		X				-	X		
39	5	X			Maritime Control Tower	-	-	-	-	-	-	X	X		X				X	X		
40	1		X		Barcelona International Convention Centre	X	X	L	-	-	-	X	-	X					-	-		
41	2		X		Diagonal Mar Park	X	X	Ls	-	-	-	X	-	X					-	-		
42	3		X		Environmental Complex Coastal Park	X	X	Ls	-	-	-	X	-	X			*3.45 mm/year 3 to 6 (1984–2018)*	2 to 3 (1993–2019)	-	-	MAP	
43	4		X		Forum 2004 Esplanade and Fotovoltaic Plant	X	X	L	-	-	-	X	X		X				-	-		PNACC
44	5		X		Illa de Llum Housing at Diagonal Mar	X	X	Ls	-	-	-	X	-	X					-	-		

Table 3. *Cont.*

	ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S., 2019)					Urban Floods and Climate Change Adaptation (Matos Silva M., Costa J.P., 2018)			10 Principles for Sustainable Development of Urban Waterfront Areas (Centre for Cities on Water, Venice; 2000)					Water Approximation (BACA, 2009)			SEA LEVEL TRENDS mm/year		SEA LEVEL RISE SCENARIO		ADAPTATIONS PLANS	
	N-S	**River**	**Sea**	**Ocean**	**Project**	**Public Space**	**Re-Qualified Public Space**	**Public Space Typologies**	**2**	**3**	**4**	**5**	**9**	**Near Water**	**In Water**	**On Water**	**NOAA, 2019**	**EEA, 2019**	**2050 (Kulp & Strauss, 2019)**	**2100 (Kulp & Strauss, 2019)**	**European Level**	**National Level**
45	6		X		Pedestrian Bridge and Capitania Building	X	X	L	-	-	-	X	X		X				-	-		
46	7		X		South-east Coastal Park	X	X	Ls	-	-	-	X	X		X				-	-		
47	8		X		Gas Natural Office Building	X	X	L	-	-	-	X	-	X					-	-		
48	49		X		Kursaal Centre	**X**	**X**	**L/Ls**	**X**	**X**	**X**	**X**	**-**	**X**			*1.52 mm/year 0 to 3 (1942–2017)*	1 to 2 (1993–2019)	**X**	**X**	-	
50	1		X		Yacht Club of L'Estartit	X	X	L	X	X	X	X	X		X		*1.52 mm/year 0 to 3 (1942–2017)*	2 to 3 (1993–2019)	X	X	MAP	
51	1	X			Madrid Río	X	X	Ls	-	-	-	X	X	X			-	-	-	-	-	
52	1		X		America's Cup Building	**X**	**-**	**L**	**-**	**-**	**-**	**X**	**-**	**X**			−0.21 mm/year −3 to 0 (1960–1997)	2 to 3 (1993–2019)	**X**	**X**	MAP	
53	1	X			Kraanspoor	X	-	L	-	-	X	X	X		X				X	X		
54	2	X			REM Island Amsterdam	-	-	-	-	-	-	-	X		X				X	X		
55	3	X			Silodam	X	-	L	X	X	X	X	-		X				X	X		
56	4	X			Magistrate's Court	X	-	L	-	-	X	-	X			X	2.1 mm/year 0 to 3 (1887–2018)	2 to 3 (1993–2019)	X	X		
57	5	X			EYE Film Institute Netherlands	X	-	L/Ls	-	-	X	X	-	X					X	X		
58	6	X			Social Housing - KNSM Island	**X**	**-**	**L**	**-**	**-**	**X**	**X**	**-**	**X**					**X**	**X**		
59	7	X			Residential Housing KNSM-Eiland	**X**	**-**	**L**	**-**	**-**	**X**	**X**	**-**	**X**					**X**	**X**		Delta Programme
60	8	X			Borneo Sporenburg	**X**	**-**	**L**	**X**	**X**	**X**	**X**	**-**		**X**				**X**	**X**		
61	1	X			Sphinxes	-	-	-	-	-	-	-	X		X		2.1 mm/year 0 to 3 (1887–2018)	2 to 3 (1993–2019)	X	X		
62	1	X			Housing Ensemble de Landtong Rotterdam	**X**	**X**	**L**	**X**	**X**	**X**	**X**	**-**	**X**					**X**	**X**		
63	2	X			The Bridge	**X**	**X**	**L**	**-**	**-**	**-**	**X**	**X**		**X**				**X**	**X**		
64	3	X			New Luxor Theatre	**X**	**X**	**L**	**X**	**X**	**X**	**X**	**-**	**X**			1.67 mm/year 0 to 3 (1848–2018)	2 to 3 (1993–2019)	**X**	**X**		
65	4	X			De Rotterdam	**X**	**-**	**L**	**X**	**X**	**X**	**X**	**-**	**X**					**X**	**X**		
66	5	X			Office Imd	**X**	**-**	**L**	**X**	**X**	**-**	**X**	**-**		**X**				**X**	**X**		
67	6	X			Shipping and Transport College	X	X	L	X	X	X	X	-		X				X	X		

Table 4. 10 Principles for Sustainable Development of Urban Waterfront Areas. Authors's Edition. Source Data: [56].

10 Principles for Sustainable Development of Urban Waterfront Areas (Centre for Cities on Water, Venice, 2000)		
1	**Secure the quality of water and the environment**	The quality of water in the system of streams, rivers, canals, lakes, bays and the sea is a prerequisite for all waterfront developments. The municipalities are responsible for the sustainable recovery of derelict banks and contaminated water.
2	**Waterfronts are part of the existing urban fabric**	New waterfronts should be conceived as an integral part of the existing city and contribute to its vitality. Water is a part of the urban landscape and should be utilized for specific functions such as waterborne transport, entertainment and culture.
3	**The historic identity gives character**	Collective heritage of water and city, of events, landmarks and nature should be utilized to give the waterfront redevelopment character and meaning. The preservation of the industrial past is an integral element of sustainable redevelopment.
4	**Mixed use is a priority**	Waterfronts should celebrate water by offering a diversity of cultural, commercial and housing uses. Those that require access to water should have priority. Housing neighborhoods should be mixed both functionally and socially.
5	**Public access is a prerequisite**	Waterfronts should be both physically and visually accessible for locals and tourists of all ages and income. Public spaces should be constructed in high quality to allow intensive use.
6	Planning in public private partnerships speeds the process	New waterfront developments should be planned in public private partnerships. Public authorities must guarantee the quality of the design, supply infrastructure and generate social equilibrium. Private developers should be involved from the start to insure knowledge of the markets and to speed the development.
7	Public participation is an element of sustainability	Cities should benefit from sustainable waterfront development not only in ecological and economical terms but also socially. The community should be informed and involved in discussions continuously from the start.
8	Waterfronts are long term projects	Waterfronts need to be redeveloped step by step so the entire city can benefit from their potentials. They are a challenge for more than one generation and need a variety of characters both in architecture, public space and art. Public administration must give impulses on a political level to ensure that the objectives are realized independently of economic cycles or short-term interests.
9	**Revitalization is an ongoing process.**	All master planning must be based on the detailed analysis of the principle functions and meanings the waterfront is concerned. Plans should be flexible, adapt to change and incorporate all relevant disciplines. To encourage a system of sustaiable growth, the management and operation of waterfronts during the day and at night must equal priority to building them.
10	Waterfronts profit from international networking	The re-development of waterfronts is a highly complex task that involves professionals of many disciplines. The exchange of knowledge in an international network between contacts involved in waterfronts on different levels offers both individual support and information about the most important projects completed or underway

Table 5. Waterfront public space decode. Authors's Edition. Source Data: [55,69–73].

Flood Phenomena per Country 10,000 km^2 (EEA, 2016)	Coastal Flood Damage Million € (PPP) (EEA, 2018)	ARCHITECTURES ON THE WATERFRONT (Blasi, I.; Giralt A. S., 2019)				Climate Risk Typology of NUTS3 Regions in Europe, 2020 (EEA, 2020)			Vulnerability (EEA, 2016)				
				Project		KH	EX	AC	P	S	C	EN	EC
		1	1	**The Silo**	C				Low negative	Low negative	Medium negative	No marginal	Low positive
			6	**Unibank Headquarters**	C								
3–10	<1000	2	7	**Extension of the Royal Danish Library**		c. Flooding	High (c. Hazards)	Average	Low negative	Low negative	Medium negative	No marginal	Low positive
			8	**The Circle Bridge**									
		3	13	**Kastrup Sea Bath**	C				Low negative	Low negative	Low negative	No marginal	Low positive
3–10	2000–3000	4	18	**FRAC - Regional ContemporaryArtwork Collection**	C	c. Flooding	High (c. Hazards)	Average	Low negative	Low negative	No marginal	Low negative	No marginal
1–3	1000–2000	5	37	**Lisbon Cruise Terminal**	M	c. Hazards	High (landslides)	RelativeLow	No marginal	No marginal	No marginal	Medium negative	Highest negative
10–20	<1000	6	48	**Kursaal Centre**	M	c. Hazards	High (landslides)	RelativeLow	No marginal	Low negative	No marginal	Medium negative	Low negative
10–20	1000–2000	7	52	**America's Cup Building**	M				Low negative	Low negative	No marginal	Highest negative	Highest negative
			58	**Social Housing - KNSM Island**	C								
		8	59	**Residential Housing KNSM-Eiland**		c. Flooding	High (c. Hazards)	Average	Medium negative	Medium negative	Medium negative	Medium negative	No marginal
			60	**Borneo Sporenburg**									
1–3	>3000		62	**Housing Ensemble de Landtong Rotterdam**	C								
		9	63	**The Bridge**		c. Flooding	High (c. Hazards)	Average	Medium negative	Medium negative	Medium negative	Medium negative	No marginal
			64	**New Luxor Theatre**									
			65	**De Rotterdam**									

In the Figure 1 different architectural projects built on waterfronts are decoded through empirical analysis. It allows to build a reference framework aimed at identifying and characterising the public space of the waterfront. Aim of the analysis is to investigate the types of public space existing on the edge of the water body, in order to open the interdisciplinary debate on what are the future measures of urban transformation able to respond to multiple purposes [39].

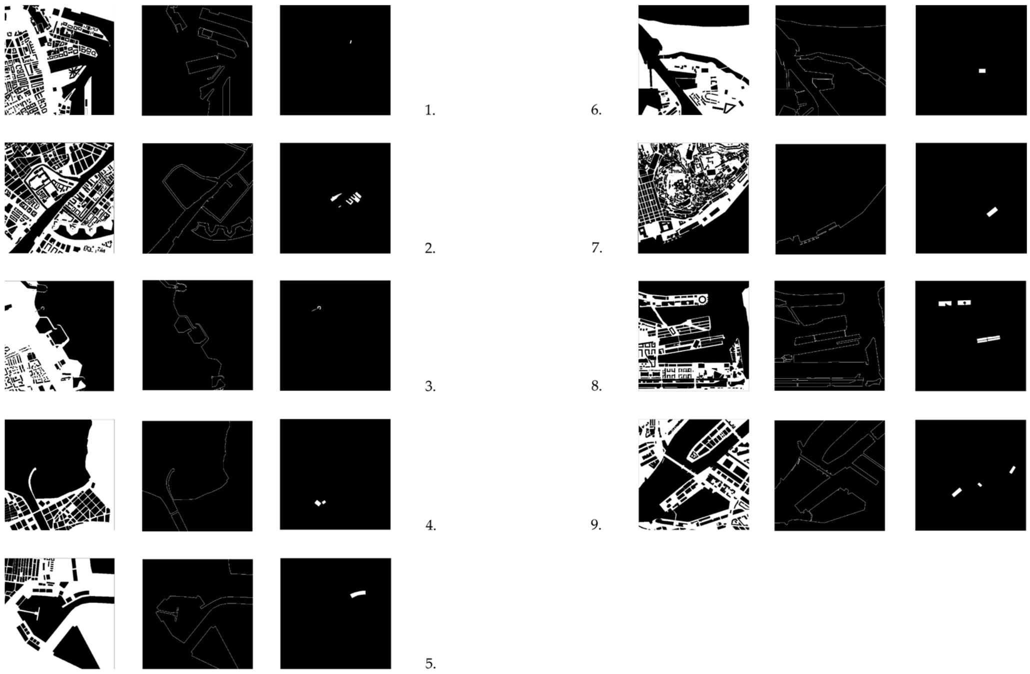

Figure 1. Waterfront public space decode. Authors's Edition. Data: Google maps.

4. Waterfront Public Space Decode

As can be seen from Table 5, the range has been reduced from 68 initial cases to 16 projects through the results obtained by cross-referencing the data collected in Table 4.

The collection of nominated projects of the Mies Van Der Rohe award are treated in the collection as individual objects located in urban waterfronts. Since the aim of the article is to analyze the public space in which the building is located and to understand its spatial relationships, it was decided to group the projects that were no more than 500 m apart. The projects within the r500m (where the fulcrum is the building that suffers the rise in average sea-level) although on two different sides of the riverbanks, they are part of the same continuous urban space, i.e., the waterfront as a system. Moreover, it allows to shift the focus of the analysis from buildings on the waterfront [55] to public space and its transformation and adaptation.

The grouping into uniform and homogeneous areas is also consistent with the need to read sea level rise data, trends and scenarios. The 9 urban areas have been chosen because they represent a range of cases where the effects of sea-level rise will have a greater impact, as highlighted by the mm/year data provided by NOAA [57], EEA [58] and cross-referenced with SLR scenarios, at 2050 and 2100 provided by Kulp & Strauss, 2019 [16].

As can be seen from the comparison between Tables 4 and 5, the cases "in" and "on" water are absent, due to the implicit characteristic of amphibious/floating projects: the absence of flood impact. Indeed, most western buildings and public spaces are built "near-water." In the urban waterfront redeveloped there is still a traditionally approach to water, showing that there are still few amphibious and fluctuating architectural experiments.

Table 5 decodes the exposure and vulnerability to the effects of rising sea level, of the existing public space at the water body boundary, both at national and local level. Through the analysis of the comparison matrix (Table 4), it is possible to observe how National and European coastal policies contribute to the definition of efficiency and effectiveness parameters for the mapping of risk and vulnerability (Table 5) of urban areas. In the table, the reading allows to cross-reference the relevant data on the physical vulnerability of the waterfront territory [72,73] with respect to the associated climate risk typology [71]: coastal flooding and coastal hazard. The difference in climatic hazard (KH) divides the nine urban areas into two categories: "north-western coasts" (C) -Denmark, France, the Netherlands- subject to coastal flooding and "southern lands" (M) -Portugal, Spain- subject to coastal hazard [71]. High density in coastal cities in Denmark, France and the Netherlands leads to a high risk of population exposure (EX) to flooding. In contrast, Mediterranean countries are more at risk from erosion. This difference in potential risk factor for coastal urban areas must be taken into account when defining urban edge adaptation. In "north-western coast" cases, it is necessary to prevent flooding, while in Mediterranean cases it is necessary to create barriers that break the force of the waves and thus, once the force is dissimulated, do not cause coastal erosion. The definition of the adaptive capacity of urban areas (AC) is the result of the climate hazard and the exposure of the population. Yet, this data takes on greater definition when intergrated with the analysis of the physical (P), cultural (C), social (S), environmental (EN) and economic (EC) vulnerability of coastal areas to climate change. The potential impact of sea level rise on equipment, dwellings, historic buildings and infrastructure is reflected in the economic impact of coastal flood damage [69,70]. Basic knowledge about the physical vulnerability and urban criticality of cultural heritage (C), economic activities (EC), and social (S) [42] coastal settlements is needed to implement adaptation measures.

Analysing the vulnerability of the existing public space at the national macro scale (Table 5) allows to define the flood risk at the local scale [38] of the waterfront.

After the analysis of the physical characteristics of the public space of the 9 urban areas (Table 4) and the comparison with the data on physical vulnerability (Table 5) it was considered to decode the urban structure of the waterfront through the urban morphology (Table 6). The graphical and analytical conceptualisation allows to understand and interpret the complex dynamics of the city at the water's edge, in order to understand where to operate choices of adaptation to flooding phenomena. The space between the city and the water body is a paradigmatic space for its contemporary urban form, in which different isotropic forms of use and appropriation have developed over time. The similar but not identical characteristics of the public space in contact with the water has generated a non-homogeneous and richly diverse model of territory. This model is susceptible to the effects of climate change and must be adapted, recognising the ethorogeneities and synergies.

The first image shows the spatial contextualisation of the analysed waterfront area (Table 5). Yet, the aerial view shows in equal measure all its components and physical characteristics of the area. It allows us to understand what the spatial relationships are, all being different, in the waterfront cities. Instead, through the reading of the built fabric (second square) it is possible to recognise the two components necessary for the decoding of the city form: the building and the open public space. Therefore, through the graphic representation, the figure ground, and the decomposition by layers of the waterfront territory, the relationships established between the built-up area (the solids) and the public space both urban and water (the voids) are highlighted. The visual relationship between the voids and the parts helps to emphasise that the water body must be considered part of the design of the city and the waterfront. This allows, also, to observe the physical contextualisation of the object, the building selected by the Mies Van Der Rohe award, in the urban waterfront space (fourth square).

Through the graphic representation it is possible to see the relationship between the voids and the parts, between the city and the building, where the limit or water edge (third square) is a line that in the process of adaptation will take on new physical characteristics. In fact, this line or edge, the urban space of the waterfront, has been transformed over the years to accommodate uses and functions, and today it will have to be redesigned to accommodate infrastructural and urban elements capable of adapting to the effects of the rise in the sea.

We argue that the outcome of the tables demonstrates the importance of public space, although in a new form, definition and concept, in meeting future climate change adaptation needs. The dynamic inherent to the urban object underlines the fact that the present state is just a transitory moment in the evolution of these elements [29].

The qualitative evaluation of the physical and morphological characteristics of public spaces is essential to provide key concepts that can be used to planning the waterfront transformation.

A theoretical framework, based on the literature review, Table 6, has been developed through which to read what the characteristics of urban public space on the waterfront should be. Among the principles listed by Jan Gehl in 1987 [33], it is considered most relevant that the principle of protection can be associated with the meaning of adaptation to sea level rise, with consequent delineation of flood risk and vulnerability. The qualitative analysis drawn up in Tables 5 and 6, provides the possibility to put in dialogue the data of the sea level rise with the parameters of the public space. It highlights how the risk of flooding should be considered as a variable in design processes.

Table 6. Waterfront public space definition. Authors's Edition. Source Data: [32,33].

		Protection (Gehl, 1987)	**Comfort (Oportunities to) (Gehl, 1987)**	**Enjoyment (Gehl, 1987)**		
II Requirements (Jacobs, 1993)	**I Requirements (Jacobs, 1993)**	***To Flood***	**To Walk, To Stand, To Stay, To Sit, To See, To Talk, To Listen, To Play and Exercise**	**Human Scale**	**Positive Aspects of Climate**	**Aesthetic Qualities**
Accessibility; Length; Slope	Places for people to walk with some leisure		Multiple use and users			
Trees	Physical comfort (climate related)	Includes build and natural environments			Includes build and natural environments	
Beginning and endings; Places	Definition (boundaries)			Safe, accessible and accommodating		
Contrast	Qualities that engage the eyes		Attractive			
Time	Transparency		Attractive			
Many buildings rather than few; Density helps	Complementarity		Attractive			
Diversity; Parking	Maintenance			Robust		
Special design features: deitails	Quality of construction and design			Vital and viable		Attractive

The link between the urban physical parameters of the design of a good public space and socio-economic criteria is not always easy to achieve. For this reason, at the intersection between the two types of parameters, indicators are found that, also, respond to the characteristics outlined by APA [34]. The resultant parameters allow to synthesise the characteristics that describe the concept of public space, applicable to urban areas bordering water bodies. The cross-referencing of parameters we obtain a rationalization of what can be the values to design the transformation and adaptation of public space on the waterfront. The pier and the quay, for example, have always been waterborne, infrastructural spaces that vary in size and structural complexity, from a simple lightweight wooden structure to large structures that extend over a mile into the sea. Used for mooring ships, they became obsolete in the 1960s due to container transport. These elements of articulation between land and water can once again become part of the public space of the waterfront: as a part of the urban fabric, a space of protection, comfort and enjoyment [33]. In the transformation of the city, the pier and the quay can be transformed from a port infrastructure to a street through the evolutionary process that takes place by addition—element, extension, and juxtaposition—overlap, and sedimentation—deformation and regularization [74].

In fact, the proximity to the water body, although it involves sea-level rise adaptation processes, is a resource for redesigning the urban areas of waterfronts. The theoretical framework opens up to the debate on what qualities and standards must be taken into account in urban transformation and adaptation of public space on the waterfront: from a infrastructural space next to the water body to an amphibious or a floating space connecting the city with new water-constructions. The comparative matrices allow us both to qualitatively analyse architectural projects by comparing the physical values of public space and its vulnerability, and to outline the parameters needed to transform it (taking into account scientific data on the rise in average sea level). Moreover, adaptation plans also approach resilience from a positive view on "living with water", i.e., interpreting proximity to water not as a threat but as an opportunity [75]. The very conception of what makes a public space successful requires a continuous adjustment given the unrolling of obstacles presented before contemporary cities [76], such as climate change effects.

5. Discussion

Flood risk management implies the need to adapt the consolidated city to the effects of sea-level rise. It is necessary to highlight the emerging change from the conventional approach of reducing the likelihood of flooding to the objective of reducing existing vulnerability. This dynamic has promoted the emergence of new flood management approaches that have begun to integrate risk into its practice, in particular by fully recognising and embracing natural water cycle processes [39]. Analysing urban vulnerability, allows planning the adaptation of the waterfront through legislative actions, the construction of infrastructure to cope with flooding and the design of public spaces to accommodate water.

In this article, a sample of European urban waterfront architecture has been analysed by correlating different interdisciplinary parameters through the matrix, Table 4. The examples presented involve: 8 countries and 19 cities, moreover, the article is contextualised in the requirements for maritime spatial planning, required by the European Directive 2014/89/EU [77,78]. The range of cases collected inevitably provides a non-global perspective, as projects with greater dissemination and better access to information have been favoured. Together, they are not intended to offer a comprehensive collection, but rather a significant sample on which to base further urban and architectural research and decision-making processes. Through empirical analysis of the cases, it was possible to investigate the plurality of the characteristics of public space, aware that in the exercise of recognizing common, isotropic and non-homologous characteristics, it allows to rethink new measures of adaptation and transformation of the waterfront. We affirm that the analysis of cases, in their constitutive characteristics and in the overall relationship between them in the cluster, is based on the elementary strategy that allows, through abstraction, to move from the observation of complex reality to the formulation of analytical theories. Because, the architectural/urban waterfront project should have a diachronic relationship with the water body (be it river or sea) in order to reduce urban vulnerability through public space design [46].

Urban waterfronts areas are under two different pressures that compromise the fragile balance of the border spaces between the water body and the urban agglomeration. The waterfront needs space to accommodate flooding, but also free areas for the expansion of the city.

The public space on the border between the city and the water body allows the construction of flood protection measures, but also areas to accommodate flooding, i.e., "room for the river" and/or "make space for water planning"- and then implement amphibious projects of spaces that are dry and wet-proof. However, there is currently a lack of research into combined hard and soft engineering techniques [1].

Moreover, the public space on the edge of the water body becomes a node for the expansion of the city. Expansion that has already begun with the implementation of floating dwellings projects, yet the connection between the new dwellings and the city on the bank of the water body has not yet been solved: there is no integrated infrastructure for their systemic urbanisation. The design of amphibious and floating public spaces allows for spaces with a high degree of adaptability compared to traditional ones. It implies, therefore, the need to implement policies of "living with water" and "making space for water".

We believe that, through the empirical analysis carried out, the article provides the necessary basis for discussion to outline how to transform the waterfront infrastructural space, into a complex system of urban public space, a street where the water body becomes part of public space [3] and contributes to the development of the urban fabric. In addition, it provides an opportunity to discuss the spatial potential of public spaces—areas that can be transformed more into cities—on the urban waterfront.

In conclusion, waterfront areas can be transformed by integrating infrastructure adaptation strategies (Table 1) into the design of public space. Planning and design projects should take into account the existing physical characteristics of waterfront areas (Tables 4 and 6), its vulnerability to flooding phenomena (Table 5) and the qualities of public space (Table 6). Aware that in adapting urban margins, systematic design of public space can reduce urban vulnerability through qualitative analysis of physical urban characteristics cross-referenced with data on average sea level rise.

6. Conclusions

The need to adapt the threshold space between the urban agglomeration and the water body to climate change scenarios reveals the importance of public spaces. The methodology developed in the article highlights the need to rethink the public space on the waterfront: in order to develop design techniques on the urban environment to accommodate the effects of the sea level rise, but also to connect new amphibious and floating dwellings to the consolidated city near the water. The research carried out demonstrates that the public space on the waterfront cannot be considered simply as a limit, but should be more correctly conceived as a network of places, functions, additions and hinges between the natural environment and urban settlements. In fact, it is the urban space that still allows the transformation of the city to provide it with an adaptive capacity able to counteract the growing pressure of the natural and anthropic system. We assume, that in the redesign of the threshold space the water body must be integrated into the design, so that new types of public space can be delineated, whether it is amphibious—wet-proof or dry-proof—capable of accommodating flooding phenomena, or whether it is floating, therefore "on" water.

Therefore, we argue that the contribution of our study to scientific research is to highlight the role of public space on the waterfront, both to implement adaptation to flooding phenomena and to implement the urban transformation necessary to accommodate floating settlements. In the future perspectives, the coastline will no longer be a border but a connector, a layout space, between the consolidated city and the floating buildings, thus becoming an urban floating and/or land-based centre. The centre between the waterfront and the new floatings dwellings will be mobile because the process of appropriation of water as building land will be a continuous process. In conclusion, the aim of this research is to highlight the importance of the existing public space at the water body boundary for adapting coastal cities. We believe that the research conducted will open the debate on new spatial and urban planning plans, such as the development of integrated coastal zone management (ICZM) [79]. However, it will also be the basis for future research to outline new types and construction techniques of amphibious and floating public space which will respond to the needs highlighted in this article.

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