Water Resilience. Mapping and Active Borders as Instruments for Climate-Resilient Waterfront Design Strategies

[1] **Elena Verzella**

[1] University of Ferrara, Ferrara, IT

ABSTRACT: The recognized inefficiency of traditional defences against the water-related disasters foreseen by the scientific community on climate change (IPCC 2014) has led to the necessity of exploring innovative design approaches in coastal cities, accepting "some degree of flooding" and considering water not just as an external threat, but as a fundamental component of the design process. From this perspective, through a review of international case studies, the paper aims at defining an alternative design methodology, capable of developing possible urban and architectural strategies for climate-resilient waterfronts where the conflicting condition between flood protection and urban quality can finally be solved. The proposed methodology is based on three operative assumptions. The first one moves from the reinterpretation of the concept of "waterfront" as an "active border". Indeed, waterfront areas cannot be anymore considered as a "boundary" (Sennet 2006), a hard separation between natural and built-up, neither can they become the space of irrational or uncontrolled urbanization. On the contrary, they need to be read as a "thick" edge that can operate both as a responsive and dynamic interface between land, built-up and water and as a hybrid infrastructure connecting different scales and uses into a synergistic system. Secondly, the "temporal component" is also integrated as an essential part of the design research. As waterfront areas are intrinsically evolving contexts, the research focuses on architectural and urban expressions which can accommodate different temporal phases and be consistent with additive, adaptive, and transformative logics as a response to external perturbations. Lastly, a different interpretation of the "mapping" activity is explored, intended not just as a "tracing" operation but as an active design process (Corner 1999), capable of bringing to light the inner relations among the components acting within the waterfront system and to translate them into innovative design opportunities.

KEYWORDS: Urban waterfronts, Operative key-concepts, Active border, Mapping, Temporal component
PAPER SESSION TRACK: *Coastal Cities: Design Frameworks for Interconnectivity*

INTRODUCTION

Scientific reports have been repeatedly demonstrating the severe impacts that climate change will have upon urban settlements in the coming decades (Aerts & Botzen 2011; IPCC 2014; UNISDR 2015). In particular, urban waterfronts appear to be extremely affected by the effects of this phenomenon, being, on one side, physically the most exposed areas to short- and long-term water-related events such as sea-level rise, extreme rainfalls, storm surges, hurricanes, etc., and, on the other one, constantly under the pressure of further and more intense processes of economic and urban exploitation (Neumann et al. 2015; Nicholls & Cazenave 2010; Hallegatte, et al. 2013).
However, despite this intrinsic vulnerability, the analysis of the main morphological as well as economic, social and cultural transformations involving waterfront areas in the past decades have proved a high latent ability to adapt their built and spatial categories in tune with the always changing needs/ambitions of the related cities, becoming, on several occasions, even the trigger of city-scale regeneration processes (Marshall 2001; Hill 2007). Hence, a question arises: given the new challenges posed by the combination of climate change and socio-economic changes, how can we promote design pathways that can enhance this intrinsic transformability of urban waterfronts rather than hindering it? And, above all, how can we use this potential to make urban waterfront interventions an instrument to cope with upcoming climate threats and, at the same time, to make them still an opportunity to create an urban environment that reflects the contemporary ideas of society, culture and future development of a city?

1.0 "WATER RESILIENCE": a necessary state for a future waterfront design paradigm

To answer the previous questions, it is necessary to reformulate the main waterfront design paradigms, rooting them into a conceptual ground where the apparently irreducible realms of flood risk protection and urban planning ambitions can coexist, but also enhance each other. This conceptual ground was therefore identified in the concept of "resilience". According to the ecologist Crawford Stanley Holling, there exist two possible properties of a system during a stress event: "stability" and "resilience" (Holling 1973). "Stability" is defined as "the ability of a system to return to an equilibrium state after a temporary disturbance" (Holling 1973, 17); on the other hand, "resilience" is described as "the measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973, 17). Bringing these properties into a more "urban" framework, it could be argued that the main measures currently applied to face natural disasters in waterfront areas (dikes, floodwalls, dams, …) are conceived in order to

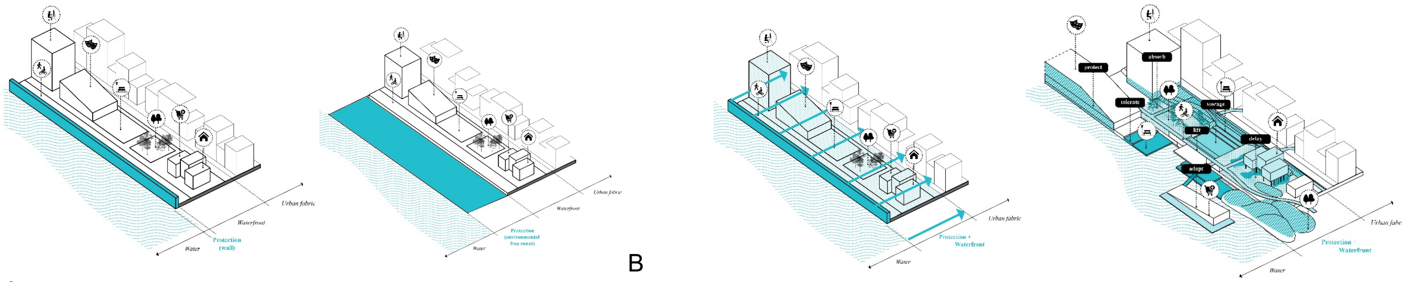
guarantee the "stability" condition, where water is prevented, with all possible means, from coming in contact with the built and human environment. However, the increase of magnitude and frequency of water-related hazards has revealed the current (economic, urban and environmental) un-sustainability of these models and all their intrinsic limits. For this reason, it seems to be necessary to elaborate alternative design pathways, which are established on the more complex concept of "resilience". However, how could this concept be actualized in the urban waterfront realm?
The first action is to reconceptualize the traditional idea of waterfront, starting exactly from the origins of this concept. A secular tradition of cartographers, hydrologists, engineers, and even urban planners has been representing water bodies as a continuous "line", establishing, once and for all, what is supposed to be permanently "dry" and what permanently "wet" (da Cunha 2019). From this moment, two extremely different (and sometimes deeply disconnected) realms have been developing on the two sides of this line: the urban system on one hand, totally absorbed by the city's expansion logics and safely protected by levees, dikes, and seawalls; and the water systems on the other, continuously channelled, dredged and reshaped to facilitate navigation and other water activities.
However, it is from this same act of abstraction that suddenly also the idea of "flood" has originated, conceived as a deviation from this established and unanimously accepted artificial action. And, over time, the stronger the flood risk, the harder this separation line has become, with always higher and reinforced barriers (Mathur & da Cunha 2014).
Therefore, given the definition of resilience mentioned above, a possible pathway to create a resilient condition in urban waterfronts would be to "dissolve" this line into a more engaging transition between water and land. The traditional attitude of living *separated* from water needs, indeed, to be replaced with the idea of living and working *with* water, whereby urban dynamics and human activities are not imposed over but modulated on the water and its natural cycle. From this viewpoint, natural water level fluctuations as well as even more rare events such as storm surges or extreme river discharges would not be just exceptional situations against which only protection is required but become different equilibrium states of the same waterfront ecosystem: «The question is whether we should build faster and harder to keep it out, or find a way to gently merge ourselves with the water once again, transforming the hard boundary into a continuum, a smooth transition, a commingling rather than a battle zone» (Nordenson et al. 2010, p.13).
From a design perspective, this means that the design needs to involve water and the possibility of water not only as a context feature or a risk factor, but as an active and fundamental design component which informs, shapes, and steers the design choices, in a joint effort between different disciplines (architecture, urban planning and landscape) and scales. In other words, the design of the urban waterfront needs to be conceived as a combination of natural and artificial structures which can withstand but also tolerate or accommodate water in an always varying degree of approximation to it. The underlying design challenge is, therefore, to explore the different possibilities entailed by the "living with water" paradigm (such as living *near* the water, *in* the water or *on* the water) and ultimately to originate a system where a certain degree of "flooding" is not only accepted, but actually turns out to be a peculiar feature characterizing the identity of the waterfront space. In this way, the property of "absorbing disturbances and still persisting" required by the resilient system definition is not only satisfied, but potentially becomes a trigger to a wider process of urban regeneration and improvement of both public and private space.

2.0 ACTIVE BORDER, TEMPORAL COMPONENT AND MAPPING AS OPERATIVE KEY CONCEPTS FOR RESILIENT WATERFRONTS

The aforementioned necessity of incorporating the property of "resilience" into the traditional urban waterfronts raises the need of an alternative design methodology which can help to include these assumptions into a single and consistent design process. Therefore, the paper has identified three "operative key-concepts": *active border, temporal component and mapping*. The importance of the latter lies in the fact that on one side they represent the c*onceptual* framework through which to read and understand the waterfront system from a resilient perspective, while, on the other one, they are also conceived to be translated into operative design tools, becoming instruments to explore design propositions and enable the definition, application and combination of possible resilient strategies in more specific contexts.

2.1. Active border

The first operative key concept concerns the idea of urban waterfront as an "active border". The starting point for the understanding and utilization of this key-concept is to retrieve the theoretical duality between "boundary/border" and reconceptualize the conventional urban waterfront interpretation from a "boundary", a hard separation «where things end», to a "border", a territory «where different actors interact» (Sennet 2006). If the boundaries are typically mono-dimensional entities, reading urban waterfronts as "boundaries" will lead to the same "lines-based" interpretation mentioned in the previous paragraph; on the contrary, assuming urban waterfronts as a "border" enables to exponentially expand this dimension into a "thick edge" and create that liminal space that is not a barrier between antagonist characters, but rather a threshold between two components that are actually part of the same organism (Bergdoll 2011). In this way, not only does the urban waterfront become the terrain of coexistence of (traditionally) opposite realms, but even the place to promote the *interaction* between water/land, build/unbuilt, natural/artificial. In this sense, the "border" becomes "active", since it does not give protection by passively preventing from any type of contact between water and urban settlements in case of a climate event (such as several conventional defences), but, on the contrary, it is capable of both absorbing or mitigating through its (natural, urban or architectural) structures the magnitude of extreme climate events and adapting its components and their uses according to the different external conditions. As a result, from this design perspective flood protection in urban environments is not addressed anymore by a single "wall" (such as in several highly dense urban contexts, which dramatically hinders the traditional link between waterfronts and water) nor by cities' environmental "free zones" which, despite being designed to accommodate natural and temporary expansions of water bodies, are still regulated to prevent from any type of urbanization or utilization, representing, at the end, another barrier (even if natural) between water and urban realms. On the contrary, through the "active border" paradigm flood protection is extended to the whole space of the waterfront, in an urban system that combines rather than impedes the development of new activities which can positively engage with the presence of water and, consequently, enhance the attractiveness and value of the area.



B

A

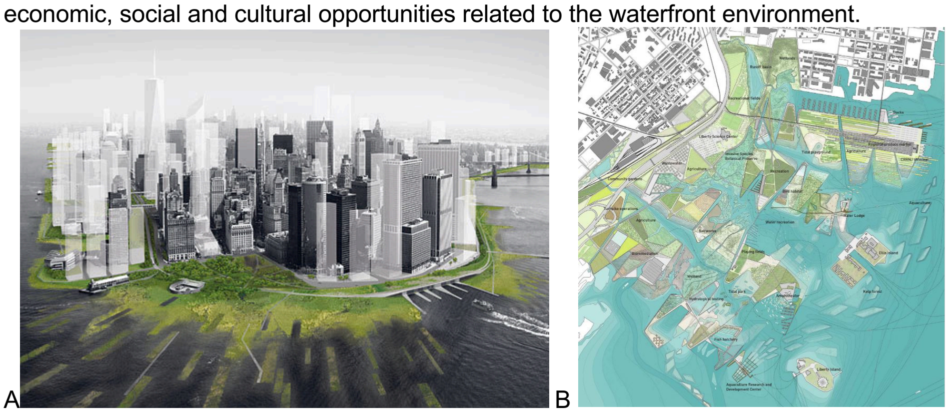
Figure 1: Comparison between traditional flood protection systems (A) e new design paradigms (B). Source: Author 2021.

From this primary assumption, the following implications of the "active border" can be deduced:

- the "active border" has an *undefined character* (Clémant 2004). As mentioned before, the notion of "active border" conceptually allows the possibility of different states (wet and dry) within the same system, determining a transitional landscape where it is not possible any more to precisely identify the traditional definitions of the urban and the water paradigms. On the contrary, a progressive "blurring" of any notion of edge is generated: water enters in what is conventionally deemed the "urban realm" as well as urban structures expand towards water. This originates an "aqueous" urban landscape which, despite this intrinsic undefined character, can generate a very strong identity, allowing to read the waterfront as a specific, new, urban category.
- the "active border" is based on *diversity*. The waterfront as an active border is *physically* diverse since it can be articulated in different forms such as natural systems (like absorptive wetlands, tidal parks, berms, artificial islands, …) and built ones (buildings, landform buildings, piers, quays, floating platforms, …). This diversity not only improves the urban quality and attractiveness of the space, but it can actually enhance the adaptive behaviour of the urban waterfront in case of a climate event. The combination of different structures, indeed, enables to achieve some fundamental properties of a resilient system such as "redundancy" and "resourcefulness"(Nazif, Mohammadpour & Eslamian 2021): instead of relying on a singular type of protection response in case of a climate event (as in many types of traditional flood protection systems), the diversity of the components of the "active border" can deploy a wider range of counteraction typologies (essential if we consider the uncertainty of future consequences of climate change) as well as guarantee protection even if one actor/element of the system temporary fails. Additionally, the diversity of the "active border" is also represented by a strong *programme diversity*. The necessity of a multifunctional character especially in waterfront redevelopments has been analysed several times and recognized as a way to foster connections, aggregation, leisure, nature and culture as well as to guarantee a profitable cooperation between public and private (Bruttomesso 2001). However, this diversity in functions can also become an opportunity in terms of resilience against flood threats since it in turn increases the possibility of exploration of innovative flood protection measures that can be combined with the development of new activities related to the water (such as recreational and cultural spaces, natural areas, research activities, food production, energy production, …) which, ultimately, also exponentially enhance the urban value of the area instead of undermining it.
- the "active border" can work as *hybrid infrastructure*. The benefits that a transitional environment might entail also concern the development of the natural ecosystem of the urban waterfront. The positive contribution of organisms such as mangroves, algae, molluscs, etc. in the reduction of effects of water-related threats (absorption of water, coastal erosion, reduction of waves energy, …) can foster processes of restoration/implementation of natural systems such as wetlands, natural reefs, mudflats, and marshes. This can lead to the creation of an ecological infrastructure, which will work both as a biodiversity refuge, recreation facility, protection buffer against climate change and, ultimately, also as a trigger for the implementation of alternative slow mobility networks (such as cyclo-pedestrian paths). In particular, innovative water-based transportation systems can be developed, with ferries and boats and intermodal hubs. This aspect not only improves the connection between the different components along the waterfronts (Nordenson 2009), but also (and more importantly) strengthens the perception of water not as a limit of the urban space, but just as a different "shape" of it (Shannon & Smets 2010).

From the operational perspective, the notion of "active border" is translated into the design of a sequence of architectural, urban and landscape episodes that incorporate the qualities described above and develop a different degree of interaction with water. An overview of the possible interpretations of this concept could be provided by the analysis of some of the design proposals presented at the exhibition *Rising Currents: Projects for New York's Waterfront*, an initiative organized by the Museum of Modern Art and P.S.1 Contemporary Art Centre in New York and curated by Barry Bergdoll (24th March – 11th October 2010). The purpose of the exposition was to analyse the effects of climate change on the New York and New Jersey 's Upper Bay waterfronts and develop solutions able to transform phenomena like sea level rise and storm surges from threats to opportunities for reorienting the perception and the

experience of the city around water. In almost all the proposals, the notion of the "active border" plays a fundamental role. In *New Aqueous City*, the proposal elaborated by nARCHITECTS for the south part of the bay, the traditional division between land and sea is almost totally denied in favour of a smoother and gradual transition between these two realms: the urban grid is indeed extended towards the water through wave-attenuating piers, which not only constitute a memory of the past harbour character, but also represent a support structure for ferry stations, public leisure areas, protected wetlands and even innovative residential building settlements hung from shared bridge structures; finally, land is stretched till open water through an archipelago of man-made island connected by inflatable storm barrier which will ensure protection in the event of a storm surge but will also provide space for the development of new natural (or even human) habitats. On the other side, water is brought inside the urban fabric, through infiltration basins, bioswales and culverts which usually work as green-blue public spaces, improving the quality of the area, but can absorb and store water runoff during storm events.
Thea same approach but in a more ecological perspective is adopted in the proposal *New Urban Ground* by ARO for the Lower Manhattan site. Here, the waterfront is designed as a continuous green infrastructure made of saltwater and freshwater wetlands that actively and dynamically interact with daily water level variations as well as during high water occasional extreme weather situations. This infrastructure relates to the existing urban edge in different ways, both accreting it (through land reclamation, creating natural protection ridges parallel to the shore) or carving it (obtaining shallow waters and transition areas), until it lastly dissolves into a more scattered system of sediment-filled constructed islands which act as natural breakwaters against waves in the highly exposed Lower Manhattan area.
Lastly, the complexity of the "active border" can also be found in the proposal *Water proving Ground* made by LTL Architects for Liberty State Park and Ellis Island. In this project, the waterfront does not exist anymore as a solid entity, but it frays into a completely different landscape of hard and soft edges, higher grounds, gradual slopes, and water channels which actively embrace tidal fluctuation as a main identity feature. Moreover, the design investigates urban and architectural expressions that are not only prepared to bear variable water levels (waterproof buildings, suspended paths, tidal parks, "water amphitheatre" with floating stage, …) but also promote the flourishing of a wide range of new urban activities deeply connected with the cyclical presence/absence of water (agriculture, water recreation, culture, protected natural areas, aquaculture research centre, hydrological testing facilities, …) exponentially expanding the economic, social and cultural opportunities related to the waterfront environment.



A B

Figure 2: *New Urban Ground* (A) and *Water Proving Ground* (B) proposals. Source: Bergdoll, 2011.

2.2. Temporal component

As previously described, one of the main features of the "active border" concept is its "undefined" nature. However, this "undefinition" does not exhaust only in a vagueness of spatial structures or blurred boundaries between the water and urban spaces but multiplies its potential if conceived also in a temporal perspective. Additionally, the "active border" had been defined as fertile terrain for the dynamic interactions between these two realms; still, the idea of "interaction" intrinsically assumes the existence of a temporal dimension that determines the modalities, the actors and the duration through which this exchange act between different realities unfolds.
Therefore, the second operative key concept is focused on exploring the "temporal" extension of the waterfront design process both as a prerogative and instrument to create resilience. One of the main objectives of traditional design processes is the immutable persistence (both in terms of morphologies and functionalities) of the design products over time, almost as if the quality of the latter was assessed according to their capability of preserving their propositions regardless of the external influences. However, in the framework of urban waterfronts, an approach of this sort may result in an over-constraining of the potential adaptive character of these areas. Especially when considering urban waterfronts as ecosystems (Corner 2006), the traditional anthropocentric attitude which tries to restrict an evolving reality into a pre-ordinated fixed scheme appears more and more inapplicable. On the contrary, the idea is to read (and live) the urban waterfront space through the lens of time, as a living environment that assumes different shapes and opens to multiple scenarios following the inputs of the external world. For this reason, the design should actually promote the characteristic temporal dynamicity of the components of waterfront areas and their interactions, including temporality already into the design process. This means that the output of the design should not be a particular urban or architectural form but rather a more complex set of possible states which can temporally evolve one into the other.
In this sense, the idea of time assumes a twofold extension, both intended as physical transformation of the waterfront structures over time and as a variation of their perception by people who happen to enter in contact with them: the

alternance between absence/presence of water or the continuous variation of water levels, indeed, can become a tool to dynamically shape the space in an always changing urban landscape, which can resiliently respond to climate stresses as well as actively involve people to harmoniously experience the dynamics of the water environment.
In order to incorporate "time" into the design process of urban waterfronts, the following pathways have been identified:

1) *the acceptance (and design) of different appearances and uses of urban and architectural structures over the time*. In this sense, "time" is intended not in its linear interpretation, but rather as a summary of different "moments of water", which include daily or seasonal water fluctuations as well as high levels during "punctual" extreme weather events or long-term permanent transformations due to the climate change impacts. As mentioned in the previous paragraphs, a possible way to achieve resilience within the waterfront system is to allow a certain degree of water. This approach implies the distinction of spaces that need to stay dry (primary infrastructures, health facilities, power utilities, etc.) and spaces that, on the contrary, will be let partially flooded under specific conditions. The latter, therefore, need to be designed from a very broad spectrum of different degrees of interaction with water. From this perspective, public spaces offer great opportunities to be developed according to a temporal dimension (Matos Silva & Costa 2017). Through stepped squares, labyrinthic playgrounds, undulated profiles, they are shaped to accommodate water in order to "shape" water afterwards as an opportunity before than a threat. In this way, not only will these spaces be able to tolerate and accommodate excessive water, but also contribute to the flourishing of new activities connected to the (temporary) presence of water and, ultimately, increase the quality and the identity of the urban environment.
An interesting example of this logic can be represented by the study carried out by the Dutch firm De Urbanisten on the concept of the "water squares" (Boer, Jorritsma, van Peijpe 2010). Despite not being directly addressed to the waterfront context, this research highlights an extremely insightful vision of possible relationships between urban space, time and water. Developed during the IABR exhibition *The Flood* (2005) as a part of a wider climate adaptation vision for the city of Rotterdam (NL), the target of this concept was to address the issue of water storage in highly dense urban contexts as a response to extreme weather events driven by climate change. As the name may suggest, they try to envision design solutions, mainly belonging to the public space realm, able not only to collect, but also to change according to the external stresses. Through the manipulation and reinterpretation of the traditional public space components (street furniture and pavements, squares, playgrounds, gardens etc…), the idea is the creation of a space which is dry for most of the year, allowing the carrying out of recreational and collective activities, but, in case of heavy rainfalls, it could be easily turned into a water storage facility, temporarily reducing the water pressure of the city's drainage system. Following this logic, several urban expressions were then developed: sloped or stepped squares that can be used as a tribune for events or performances or sports arenas in dry days and catchment facility during wet ones; street furniture that works as a temporary dam or corrugated street pavement to slow down the runoff of rainwater; floating square floors or grassy fields, which move up and down according to the amount of water stored underneath; sponge or inflatable furniture, which grows and shrink based on how much water it contains during a specific moment of the day. The special character of these urban and architectural solutions lies exactly in the fact that each of them is already conceived and shaped from different time perspectives during the design phase, resulting in a temporally dynamic urban landscape that changes according to the presence (or absence) of water, and, above all, that embrace water as a tool to develop new and further uses and perceptions of the public spaces in relation to the different weather conditions. As many realised examples demonstrate (such as Benthemplein 2011-2013, Bellamyplien, 2012), this concept has strongly succeeded in integrating water management in the case of extreme climate events with the improvement of the quality of the urban public space and the identity of local neighbourhoods.

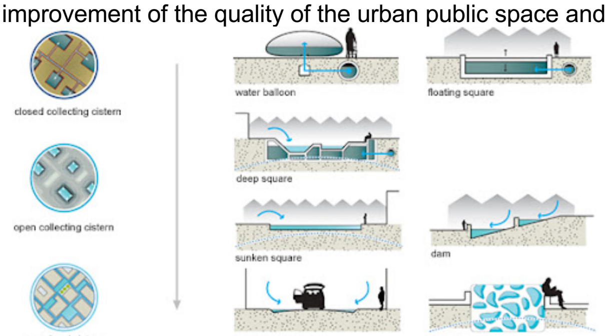


Figure 3: Different examples of "water squares". Source: Boer & at. 2010.

2) the exploration of architectural and urban expressions compatible with additive and incremental logics. Besides the idea of temporarily allowing water in the "urban realm" as a result of both natural processes or extreme climate events, recognizing the "temporal dimension" of the waterfront design means to prepare urban and architectural manifestations to "flow" along with the flow of time also in a long-term perspective. As already mentioned, the effects of climate change in the coming decades are still uncertain. For this reason, it is necessary to conceive the urban waterfront as a system that can be upgraded and developed in different phases over time, to respond to the always changing safety and urban demands. From this perspective, the elements of the waterfront are designed to be consistent with transformative and incremental patterns of long-term development which, far from converting the waterfront into the terrain of further and indiscriminate urbanization, will align the upcoming flood protection needs with the future urban ambitions, in order to achieve safe spaces without compromising neither the intrinsic multifunctionality and (physical, visual and social) accessibility of the waterfront nor its urban quality: in the long run, parks and green areas are designed in a way that they might be either reshaped as protective berms or further carved to allocate more water; public space can expand

and develop into protective pavilions or community buildings; as well as more traditional defence infrastructures (such as traditional dikes), which are enlarged and become the space for extra residential, recreational or retail activities.

2.3. Mapping

As presented in the previous points, the "active border" and the temporal component become essential aspects to achieve a resilient behaviour in urban waterfronts. These assumptions, however, pose serious issues within the design process. How is it possible to picture in one single, traditional frame all the variables affecting the urban waterfront environment as well as the huge uncertainty produced by climate change? How is it possible to design or even simply represent the temporality intrinsically embedded in the urban waterfront system without falling into the constriction of predetermined categories? How is it possible to "grasp" and translate into the design language the dynamicity of concepts such as transformability and adaptability that a resilient urban waterfront must embed? Mapping, and specifically "operative mapping" (Paez 2019), becomes the framework to answer these questions.
The notion of "map" and the related act of "mapping" have assumed different interpretations over time. Nevertheless, the main reasons behind the latter have rarely referred to just a neutral reproduction of reality, but they have been rather (consciously or unconsciously) connected to deeper aims, such as political aspirations, power creation or consolidation, social claims and recognition, or even cultural expressions. Especially from the second half of the past century, the operation of mapping started to move from a strongly descriptive and objective character (heritage of a long positivist tradition), to a more critical one (Harley & Paul 2001; Wood 2010) and, consequently, revealing soon its potentials also in fields different from traditional cartography. In particular, a strong relationship could be established between mapping and the design environment, where mapping is not a representation of the state of art *before* and *after* the deployment of a design act, but itself is intended as a design process (Corner, 1999). In these terms, in the context of this paper, three aspects of the "operative" character of mapping appear to be extremely resourceful:

1) *Mapping can become a mechanism for revealing and visualising hidden relations between the different components acting in urban waterfronts*. Unlike tracing products, which tend to reproduce a particular aspect of the reality and from a specific perspective, maps usually present several interpretation layers and, consequently, different interpretation "entryways", which allow to establish connections among different agents of the same field or even different fields. In this way, mapping unfolds its inestimable potential of "uncovering realities previously unseen or unimagined, even across seemingly exhausted grounds" (Corner 1999, 213). In the context of the urban waterfront redevelopment, this potential of mapping plays a central role, since it represents the necessary operative framework that can help to bring together all the "hidden forces" influencing the development of waterfront areas, such as scientific and technical data (extreme weather and sea level rise predictions, flood risk areas, natural tidal fluctuations and water altimetry variation, …), morphological characteristics (waterfront typology, geological conditions, bathymetry, …), economic and social aspects (asset values and distribution, population growth and distribution, average income, …), natural and cultural factors (traditional local activities, existing monumental artifacts, preserved natural ecosystems, …) and urban features (urban fabric density and porosity, land use and urban development patterns, infrastructural systems, abandoned or poor quality areas, public spaces and green systems, …) . Far from being just an analytical exercise, this moment already represents a first step of the design process, since it is exactly from a particular (subjective) combination and overlapping of certain indicators rather than others that possible design pathways unfold, leading to alternative and site-specific strategies of interventions able to explore spaces resilient against the unpredictability of climate change as well as to promote urban regeneration processes.
2) *Mapping is a tool for addressing dynamism and time.* The description of the previous key operative concepts has proved how the potential dynamism (both in its physical and temporal extensions) through which the urban waterfront system moves between the water and urban realms constitutes an essential requirement of a resilient behaviour. For this reason, it becomes fundamental to adopt tools that can visualize design possibilities rather than final statements, capturing the intrinsically changing nature of the waterfront system. From this perspective, mapping offers a possible answer to this necessity: despite the conventional two-dimensional and static format of the map, the already mentioned possibility to overlap different interpretation layers (describing, each of them, a particular feature or, in this case, "moment" of the system) in a single document enables the incorporation of wide variety of time-related information with great richness and precision as well as their understanding into a synthetic vision. In the context of urban waterfronts redevelopment, this characteristic has a twofold implication: on the one hand, it allows to critically *understand* of the (physically and functionally) evolving character of a context (the urban waterfront) which is in constant flux and to question the traditional vision of a static territory; on the other hand, it enables to *design* transformation and adaptation to climate change events, becoming the instrument to conceive, represent and then consequently produce different states of the water-urban transition within the same design process.
3) *Mapping allows to manipulate and, ultimately, generate new realities*. A fundamental assumption of mapping, intended in its operative character, is to ultimately broaden our concept of reality and promote its transformation. Hence, rather than merely representative supports, maps can be interpreted as highly performative operations. Indeed, the potential of maps of creating links among different fields, besides the already mentioned capability to highlight the latent relational structures inside a system, can also turn the map itself into a working and experimentation space where to manipulate, distort or transpose reality according to the established design assumptions and, eventually, originate further unexpected connections. From this perspective, mapping becomes a tool to question conventional paradigms in favour of an active design exploration of different horizons, which, ultimately, has the potential to foster the sprout of new realities. In the context of urban waterfront, the extension of expression of "new realities" lies in the production of alternative realities that involve an innovative and more engaging interaction between water and urban settlements.

Through the mapping platform, flood protection systems and urban and architectural structures can be combined in a potentially infinite sequence of explorative propositions, releasing the friction between the two fields but at the same time unfolding innovative scenarios and promoting the design creation.

An example of how mapping can be used in urban waterfronts to deal with both climate change consequences and urban planning aspirations can be found in the research *On the Water* | *Palisade Bay* (2007-2009). The two-year investigation, carried out by a multidisciplinary team led by the engineer Guy Nordenson and funded by the AIA's 2007 Latrobe Prize, focuses on the redesign of the upper harbour of New York and New Jersey in response to the rise of sea levels and storm surges. The fundamental assumption of the research is to replace traditional "hard" engineering defence systems with "soft" strategies (such as wetlands and artificial islands), aiming at a more resilient relationship between land and water capable of becoming an enrichment for both people and natural habitats of the area. To achieve this purpose, mapping was assumed as both analytical and design instrument. Indeed, several indicators were identified in order to reveal information such as flood hazard characteristics (water depth, return periods, …), elevation data (both above and under the water level), land cover (from "high intensity" development areas to more natural ones), buildings and infrastructures inventories (about building typologies and values, asset distribution, existing transportation pathways, primary facilities locations) and demographic data (population distribution, income, growth projections, …); through the mapping act, these parameters were then combined to reveal how their interaction would affect the vulnerability of the research area to climate events in terms of inundation areas, direct and indirect economic impact and casualties. Furthermore, mapping played a fundamental role in the design development of the research proposal. The investigation of the historical profiles of the harbour, the current edge condition (paved, seawall, pier, building, revetment mud, natural, park, wetlands) and the predicted inundation areas (100 and 500-years floods) were combined in a series of maps (the "Edge Atlas") which opened up the way for the definition of the site-specific strategies based on the idea of the waterfront as broad, porous, "fingered" resilient threshold between water, land and the city.

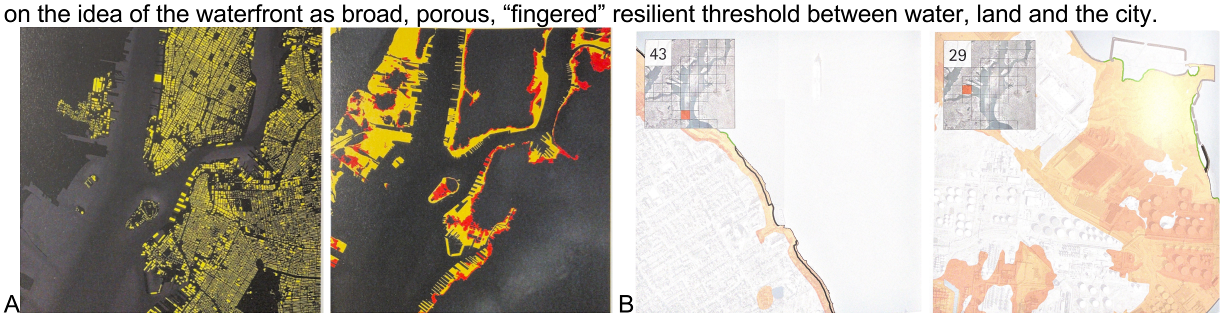


Figure 4: Mapping as an analytical tool (A) and a design tool (B) in the research *On the Water* | *Palisade Bay*. Source: Nordenson & al. 2010.

Another and maybe more extreme interpretation of mapping as an operative tool can be represented in the study the *Biesbosch Stad* presented by the landscape architect Michel Desvigne for the Architecture Biennale Rotterdam *The Flood* in 2005. The proposal tries to solve the challenge of reducing the flood exposure in the low-lying Dutch delta territory of the Biesbosch area, at the confluence of the Rhine and the Meuse rivers, by making room for water and, at the same time, creating scenarios for the massive construction of residential neighbourhoods (Tiberghien, Corner 2009). The solution to this apparently irreconcilable dichotomy is found exactly through the use of mapping as a design tool. This operation is seen as an opportunity to reveal time-based processes in the historical exploration of the existing landscape and, at the same time, to incorporate them as a main component of the design development. The map, indeed, is used not only to investigate the mechanisms which generated the current form of the polder landscape, but it becomes the operative field where to perform design actions to exasperate these processes, till the creation of an almost paradoxically "inverted landscape": at the moment the peat-rich area has gradually sunk due to the extensive drainage for agricultural activities perpetuated over the past decades, while the incompressible sandy riverbeds of the former streams (now dried out) have remained at the same level, creating a sort of pattern of "higher ridges" over the flat farmland; through his proposal, not only does Desvigne accept this phenomenon, but he exacerbates it, breaking the dikes to allow the water to flow unconstrained in case of flooding and, at the same time, rising the sandy beds and creating a safe space where to build on new dense neighbourhoods, circulation paths and parks.

Figure 5: The *Biesbosch Stad* study. Source: Tiberghien & Corner, 2009.

CONCLUSION

As discussed at the beginning of this paper, the consequences of climate change will deeply affect the future developments of urban settlements and especially urban waterfronts, where the combination of this phenomenon with the recent socio-economic transformations has exacerbated the vulnerabilities of these areas, arising new challenges that traditional measures seem to be unable to effectively address. In particular, what seems to be missing in the development of urban waterfronts is a systemic approach which combines flood protection necessities with urban planning ambitions. As demonstrated in this paper, a possible starting point to solve this opposition is to reformulate the idea of urban "waterfront" through the concept of "resilience" and, in particular, to rethink the traditional relationship between built up and water, developing a design approach which involves water already in the early design stages as a main component of the space rather than background feature or a potential threat.

However, rather than offering a *ready-to-use toolbox* of possible design solutions that might be used regardless of the peculiar characteristics of a particular context, this paper aimed at defining a *design methodology* for the development of urban waterfronts, conceived as a conceptual and operative ground to develop a systemic design paradigm capable of interpreting the specificities of different environments and then responding to future challenges according to these characteristics.

For this purpose, three operative key concepts were established, namely *"active border", time component and mapping*. As demonstrated, these concepts are conceived as instruments to read an urban waterfront in its specific features, either existing or, as seen is some of the case studies, belonging to past development stages (*mapping*); to understand and reconceptualize it according to unconventional and innovative design perspectives which question the traditional temporal and physical design constraints (*"active border"+ temporal component*); and, finally, to select, combine or generate design actions that can actually shape the space and make it able to react in different ways according to the always changing external influences (*"active border"+ temporal component + mapping*). In other words, as highlighted by analysis of the selected case studies, through these operative key concepts it is possible to incorporate into the design that degree of adaptability and dynamicity that will make urban waterfront capable of withstanding the always higher unpredictability coming both from climate uncertainties and urban future development patterns and, at the same time, to be still deeply rooted in their peculiar context. Only in this way, the design process will be able to overpass the traditional dichotomy between safety necessities and urban ambitions and, at the same time, will not generate a general and abstract "urban quality", but will effectively help to promote the enhancement of social, cultural and urban values peculiar of a specific context.

REFERENCES

- Aerts, J. and Botzen, W. 2011. *Climate adaptation and flood risk in coastal cities*. London: Earthscan.
- Bergdoll, B., & Museum of Modern Art (New York, N.Y.). 2011. *Rising currents: Projects for New York's waterfront*. New York: Museum of Modern Art.
- Boer F., Jorritsma J., van Peijpe D. 2010. *De Urbanisten and the Wondrous Water Square.* Rotterdam: NAI publishers.
- Bruttomesso, R. (2001). "Complexity on the urban waterfront". In *Waterfronts in post industrial cities*, edited by R. Marshall, 39-49. London: Spon Press.
- Clément, G. 2004. *Manifesto del Terzo paesaggio*. Macerata: Quodlibet.
- Corner, J. 1999. "The Agency of Mapping: Speculation, Critique and Invention". In *Mappings*, edited by D. Cosgrove, 213–252. London: Reaktion Books,
- Corner, J. 2006: "Terra fluxus". In *The landscape reader*, edited by C. Waldheim, 21-33. New York: Princeton Architectural Press.
- da Cunha, D. 2019. *The invention of Rivers: Alexander's Eye and Ganga's Descent*. University of Pennsylvania Press.
- IPCC 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A.
- Hallegatte, S., Green, C., Nicholls, R. *et al.* 2013. "Future flood losses in major coastal cities". *Nature Clim Change* 3.
- Hill, K. 2011. "Climate-Resilient Urban Waterfronts". In *Climate adaptation and flood risk in coastal cities*, edited by J. Aerts and W. Botzen, 123-143. London, UK: Earthscan.
- Holling, C. S. 1973. "Resilience and Stability of Ecological Systems", in *Annual Review of Ecology and Systematics* Vol.4 pp.1-23.
- Marshall, R. 2001. *Waterfronts in post industrial cities*. London: Spon Press.
- Mathur, A., and da Cunha, D. 2014. *Design in the terrain of water,* Print.
- Matos Silva, M. and Costa, J.P. 2017. "Flood adaptation measures applicable in the design of urban public spaces: Proposal for a conceptual framework". *Water*, 9, 243.
- Nazif S., Mohammadpour Khoie M.M., and Eslamian S. 2021. "Urban Disaster Management and Resilience". In *Handbook of Disaster Risk Reduction for Resilience*, edited by Eslamian S., Eslamian F. Springer, Cham.
- Neumann B., Vafeidis A.T., Zimmermann J., and Nicholls R.J. 2015. "Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment". *PLoS ONE* 10(3): e0118571.
- Nicholls, R. and Cazenave, A. 2010. "Sea-Level Rise and Its Impact on Coastal Zones". *Science* (New York). 328.
- Nordenson, G., Seavitt, C., Yarinsky, A., Veit, R., The Museum of Modern Art, & Exhibition Rising Currents: Projects for New York's Waterfront. 2010. *On the water: Palisade Bay.*
- Paez, R. 2019. *Operative Mapping: Maps as Design Tools*. Barcelona: Actar Publishers, Elisava.
- Sennet, R. (2006). "The Open City". In Urban Age. Towards an Urban Edge. Available at: https://urbanage.lsecities.net/essays/the-open-city (accessed October 2021).
- Shannon, K., and Smets, M. 2016. *The landscape of contemporary infrastructure*. Rotterdam: Nai Publisher.
- Tiberghien, G. A., Corner, J. 2009. *Michel Desvigne - Intermediate Nature*. Birkhäuser: Basel.
- UNISDR 2015. *Sendai framework for disaster risk reduction 2015 to 2030.* https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030, (accessed August 15, 2021).
- Wood, Denis, John Fels, and John Krygier. 2010. *Rethinking the power of maps*. New York: Guilford Press.