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# Design Practices for Flood Resilience in Istanbul: Case of Kadiköy Waterfront

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**Abstract:** Extreme weather events, sea level rise and intensified tsunamis as causes of climate change are becoming major threats for coastal cities. Istanbul, one of the most populated built-up coastal cities in the world, is prone to urban, coastal, and riverine flooding according to studies. Spatial design measurements preparing the urban waterfronts for the consequences of hazardous flooding are adopted in several cities as part of their urban resilience strategies. This paper focuses on physical measurements to adapt Istanbul to the effects of coastal flooding that is neglected so far in urban agenda. In this regard, the paper aims to develop site specific spatial design proposals as possible measurements to increase Istanbul's waterfronts capacity for an effective flood resilience approach in case of storm events and tsunami intensified through climate change.

To achieve this, status analysis and spatial configuration of possible design measures for Istanbul waterfront in a representative study area at neighborhood scale are introduced. To answer how much the waterfronts are at risk and how spatially adaptive strategies can be implemented in the current situation following flood resilience approach, site specific spatial analysis and a strategic design framework are developed. Since a comprehensive district-based guideline for spatial adaptation is currently not embedded in the urban agenda of flood management in Istanbul, this study promotes preparation of multiple guidelines adopting contemporary design measures in flood management for the entire city's waterfronts by proposing one for Kadiköy.

**Keywords:** Flood resilience, design measures, spatial adaptation, coastal flooding, Istanbul .

## 1. Introduction

Disrupted natural events threaten coastal cities with low-lying waterfronts, rivers, and other water bodies. The climate problem becomes an everyday problem affecting urban and rural settlements' social, economic, and political environment. Cities, experienced in mitigating regular tidal and storm surge events, with their existing flood management strategies face a new challenge due to the impact of climate change (Liao, 2014). Alternative approaches, therefore, are developed. Adaptive, flexible, proactive planning is recognized as a priority in today's urban agenda for effective response to uncertainty (Radhakrishnan et al., 2018; Restemeyer et al., 2017). Flood resilience as a new approach in flood risk management is part of this new response strategy. Flexibility is the core idea for decision makers to create responsive living environments where cities can tolerate the impact of changing patterns in natural events in terms of cost, time, and performance (Radhakrishnan et al., 2018).

In Turkey, with the rising climate crisis, several incidents such as erosion, flooding, inundation, and saltwater intrusion become significant problems concerning the country's coasts. Istanbul, one of the major coastal cities in the world and the largest coastal city of Turkey, is strongly affected by events of severe weather conditions. The city is amongst the most vulnerable areas in sea level rise due to dense urban development and low-lying beaches along the coastline (Kuleli, 2010). In the disaster management agenda, flooding is the second hazardous natural incident after earthquakes in Turkey (Kadıoğlu, 2019). Although Istanbul's earthquake disaster management has top priority, flooding caused by tsunamis will have a devastating impact with increasing sea levels due to climate change, recent studies show (Virginia Tech, 2018).

Istanbul Metropolitan Municipality (IBB), as part of international agreements concerning climate change, has started to develop the Istanbul Climate Change Action Plan (ICCAP) based on principles such as flexibility, holistic approach, operationalization, considering multiple benefits as the leading city in Turkey preparing its first local action plan (IBB, 2018d). Under mitigation and adaptation approaches, planned and prioritized actions are defined. However, these actions remain in macro scale (IBB, 2018c). To achieve effective management under a holistic approach, local and neighborhood scales need to be considered simultaneously (McClymont et al., 2020; Serre et al., 2018). Additionally, contemporary flood management strategies tend to shift from a reactive to a proactive approach where flexibility, adaptation and transformability become dominating concerns. Flood resilience as a new concept in disaster literature needs to be operationalized in contemporary action schemes to tackle the impacts of climate change.

Therefore, this study concentrates on flood resilience operationalization in the physical environment as part of district-based strategy implementations in Istanbul's coasts. By considering site-specific features, constraints, and risks, transmitting strategies to physical interventions will be the focus of this study. Resilience specific action plans and site-specific measures will be presented with a district-based approach, in the case of Kadıköy district.

## 2. Flood risk management and flood resilience:

There are different types of floods as is mentioned in the literature (Hegger et al., 2016) and summarized in the manual of the World Meteorological Organization (2011) where climate change is addressed as the cause of changing habits in flood regimes:

- Flash floods, caused by intense rainfall and often occur in areas with steep slopes;
- Riverine floods, caused by long-term rain events, melting snow or flow blockage leading to riverbank overflows where dikes or dams can be damaged;
- Coastal floods, caused by windstorms and other atmospheric events leading to high water levels flooding the coast; tsunamis are also considered as a cause of coastal flooding;
- Estuarine floods, caused by inland moving tidal bore;
- Drainage floods (urban floods), caused by extreme amounts of stormwater runoff blocking drainage infrastructure in urban areas.

Coastal floods are the main objective of this study. Mean sea levels are on rise according to the projections which result in extreme coastal flooding due to storm surges and tsunamis. Sea level rise is causing risk for coastal zones which need to be managed. Conventional measures for protection such as dams, storm surge barriers and flood walls are only one side of this management agenda; adaptation measurements such as using ecosystem services, land-use planning and adapting buildings and spatial planning regulations are some of the efforts to be adopted in contemporary flood risk management policies (World Meteorological Organization, 2013).

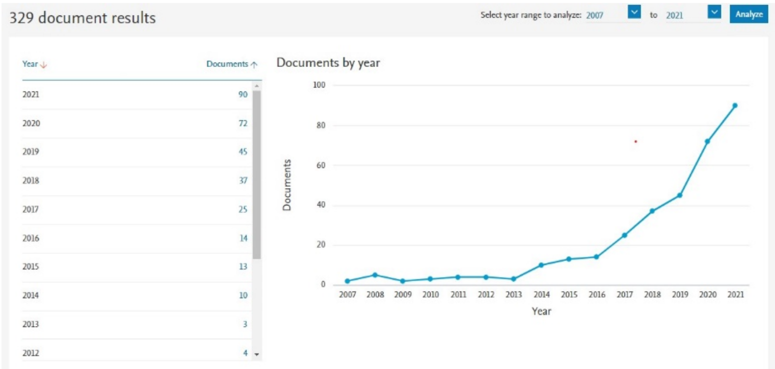


***Figure 1****: Scopus search with keyword Flood resilience*

Herein, flood resilience on urban coasts as an alternative concept within flood management has increased in popularity. The concept has only come up in academic research in the last 15 years. A Scopus search with keyword flood resilience shows 329 papers published in journals between 2007 and 2021 (Fig. 1) and a significant increase in flood resilience research in academic literature. The flood resilience concept is described as a paradigm "… shift from fighting the water to living with water" (Restemeyer et al., 2017) and from resistance to resilience, from flood control to flood adaptation (Liao, 2014). Hegger et al. (2016) define the operationalization of flood resilience under three ability factors: resist (flood defence and mitigation), absorb and recover (flood preparation through natural ways), transform, and adapt (coping with consequences/ability to tolerate change). Spatial planning, community preparedness and communication planning are designated aspects of resilience (Schelfaut et al., 2011). McClymont et. al. (2020) indicate in their review of flood resilience literature that despite the differences how to relate resilience and flood risk management, the studies agree upon the aspect of transformation, suggesting that once the flood occurs, the capacity to tolerate the impact is the key for building resilience. Getting used to the small disturbances paves the way for increased capacity to cope with larger events which is introduced in the same review as a step for "shedding a new perspective on FRM [flood risk management] for flexibility and reorganization". It is therefore necessary for coastal cities to investigate how to reinforce adaptive strategies to build resiliency.

### 3. Methods and materials:

Coastal floods in Istanbul are the central concern of this paper. According to the microzonation maps[1] conducted by IBB in 2009 focusing on flooding caused by a tsunami, several parts of the Marmara coast of Istanbul are prone to waves of 0.5 m and 3m high (IBB, 2009a). In 2018, another report[2] published by IBB calculated tsunami risk assessment out of hazard levels and vulnerability analysis according to seismic and landslide tsunami scenarios in Istanbul's Marmara coasts (IBB, 2018a). For Istanbul waterfronts prone to earthquake and earthquake-related coastal flooding, it is necessary to review the current risks, existing site potentials and constraints which paves the way for taking visible action to strengthen waterfronts' adaptability to change with rising climate crises. Design is seen as a driving force for turning an obstacle into an advantage; it contributes to redefining flood protection as a new relationship between cities and waterbodies (Hegger et al., 2016).

Given that resilience suggests both recovery and adaptation, this paper tries to constitute a framework of technical adjustments serving as

[1] Istanbul Mikrobölgeleme Projesi Anadolu Yakası *(Istanbul Microzonation Project Anatolian Side)*

[2] Istanbul İli Marmara Kıyıları Tsunami Modelleme, Hasar Görebilirlik ve Tehlike Analizi Güncelleme Projesi Sonuç Raporu *(Istanbul Marmara Coasts Tsunami Modeling, Vulnerability and Hazard Analysis Update Project conducted by IBB in collaboration with Middle East Technical University)*

a design guideline to optimize coastal waterfronts' capacity to be prepared for flood events. Its purpose is to open a discussion on the possibility of how spatial measures can contribute to the production of an adaptive built environment on a neighborhood scale. Therefore, the objectives of the study are as follows:

- Defining design measures regarding the flood resilience of urban waterfronts through literature and best-practice examples
- Detecting vulnerable zones in the case-study area through overlay maps
- Integration of the design measures into the case-study area

The study consists of two phases. In the first phase, design strategies in recent flood risk management are introduced through a brief review of literature and of international best practice examples integrating flood resilience approach into their agenda. A matrix of design measures based on this will be presented as an overview for physical representation of flood resilience. The second phase, after briefly introducing the flood risk in Istanbul and recent efforts to prepare the city's coasts, focuses on the case study area in Kadıköy. A site analysis is conducted for Kadıköy's waterfronts through overlay maps by combining the features such as flood risk areas, land cover data, landfill zones and site observations. For this purpose, open-source Google maps, Urban Atlas 2018, Kadıköy disaster information system data, base maps and data obtained through site visits are used. Through the outcome of this analysis phase, a conceptual design framework as a base guideline for flood resilience is developed at the neighborhood level which is illustrated in the form of maps. All the maps in the manuscript are produced by the author.

### 3.1. Design strategies in flood risk management literature:

There are two different perspectives regarding the implementation of flood-related measures in the design process as one study suggests. According to the interviews with practitioners, Hobeica & Hobeica (2019) state, flood management is considered as an issue tackled only with hard-engineering techniques. In contrast, some take the issue as the main component shaping their design. In the report of the International Panel on Climate Change – IPCC- response to sea-level rise is being handled under three different strategies: retreat, accommodation, and protection (Dronkers et al., 1990). In the report, retreat is described as abounding risk areas whereas accommodation is illustrated as measures allowing flooding to a certain degree; protection on the other hand is regarded as an individual category consisting of hard and soft measures. Building defensive structures such as dikes, floodwalls, revetments, groins; elevating infrastructural elements such as bridges, roads; modification of drainage systems and adjustable flood gates are options presented as hard solutions. Building dunes, wetlands and mangroves are described as soft structures.

Floating buildings, amphibious transportation infrastructure, adapting open spaces to flood are mentioned by Liao (2014) emphasizing creative design's role in establishing urban open spaces that act as functional units for floodwater storage while serving as recreational and aesthetic utilities. Restemeyer et al. (2017) emphasize the need for flexibility of strategies for increasing capability of cities to cope with uncertainty in the long run. Combination of systems is therefore necessary for the case if one fails the other remains as backup protection.

Green infrastructure provides an additional measure option regarded as an essential investment for many benefits. The European Environment Agency (2017) report shows, a list of green infrastructure measures for flood risk reduction where green roofs, permeable surfaces, swales, infiltration trenches, rain gardens and retention ponds are introduced as high-level beneficial measures for flood management in urban areas. These components of green infrastructure are not defense measures but act as forces reducing the impact of flood on the natural and built environment.

Schelfaut et al. (2011) distinguish measures increasing flood resilience into three groups - communication & perception, policy, and management – and define residents' and authorities' roles and tasks accordingly. Some of the roles defined for authorities are the guidance of residents, involving stakeholders, political and legal guidance, providing technical tools, measures, and constructions, planning hard and soft structures and resource management.

**3.2. Boston and Hamburg – design strategies for resilient coasts:**

Boston and Hamburg, both two major coastal cities, are globally outstanding examples of how to be prepared for the effects of climate change regarding flood management. Located in different continents, Hamburg and Boston show the need and ability of coastal cities to tolerate the impact of flooding by adopting resilient strategies in design and governance. Waterfronts of both cities are consisting of densely built residential, commercial, and touristic areas like Istanbul; the paper therefore examines both cities' flood resilience approach for being pioneering examples for the case in Istanbul.

Hamburg is regularly affected by high tides; however, recent reports show that rising sea level is a significant threat for 10% of the population living in potential risk areas (van Coppenolle & Temmerman, 2019). The city develops innovative approaches in flood management tactics to increase the adaptability to the new circumstances caused by climate change. HafenCity project, in the center of Hamburg, adopting innovative physical and governance measures due to the changing climate delivers resilience prone environmental and planning aspects (Restemeyer et al., 2015). Building on elevated plots, promenades of different dimensions, terraced plazas ensuring the connection between flood safe basement level and waterfront level are some of these measures that do not withstand the flood; on the contrary that allows the water to flood areas temporarily - an aspect, encouraging to create new normal for mitigating uncertainty. HafenCity uses the advantage of being a new development to test adaptive measures reinforcing flood resilience (HafenCity Hamburg GmbH, 2020).

Boston, an experienced coastal city with high tide flooding, is also affected by severe storm surges due to rising sea levels (City of Boston, 2016). City of Boston has created a new program for flood resiliency and published several documents defining how spatially, socially, and economically the city is preparing its waterfronts for flood resilience. Cooperation with design offices, local communities and citizens is the backbone of the management strategy. Like HafenCity, similar measures in physical dimension can be discovered in the design guideline called "Coastal Flood Resilience Design Guidelines" prepared by Boston Planning & Development Agency. Concentrated on adaptive measures for existing and new buildings, such as elevating buildings on piles, piers or posts, repurposing/relocating ground floor use, wet and dry flood-proofing and using flood-resistant materials, there are also measures for open space dimension; vegetated berms, waterfront parks, temporary flood barriers, seawalls, raised roadways, using flood damage-resistant landscape materials, integrating green infrastructure elements (permeable pavements, rain gardens, bioswales, green roofs, retention basins) are some of them (Boston Planning & Development Agency, 2019).

Given the best practice examples and research on flood risk strategies, a list of spatial measures is generated (Table 1). Dams, dikes, and sea walls are hard infrastructure measures to keep water away from the cities which are grouped as hard engineering infrastructure as mentioned in literature (Vitale et al, 2020; Zandvoort et al, 2019). Accommodating measures support safety by offering building adjustments and retreat from the risk area. Green-blue infrastructure as third main category of measures is ecology-based and focuses on enhancing landscape as part of building resilience (Boston Planning & Development Agency, 2019).

***Table 1:*** *List of design measures increasing flood resilience prepared by the author based on literature review and best-practice examples*

| Measurements | |
|---|---|
| Hard engineering infrastructure | Dwelling mounds/Land elevation |
| | Flood wall |
| | Sea wall |
| | Revetments |
| | Dikes |
| | Storm surge barriers |
| Accommodating | Waterproof materials |
| | Flood-proofing buildings |
| | Retreat |
| Green-blue infrastructure | Beach nourishment |
| | Floodable waterfront park |
| | Vegetated berm |
| | Green streets with rain gardens |
| | Saltwater tolerant planting |
| | Green roofs |
| | Retention basins |
| | Permeable Pavements |

Some of these strategies shaping design framework will be chosen and applied in the study area to understand how spatial configuration flood resilience strategies can be operationalized on neighborhood scale and integrated into the existing urban waterfront landscape This serves as a guideline for practitioners and decision-makers focusing on physical resilience while approaching a sustainable and healthy urban environment.

**3.3. Flood risk management in İstanbul:**

As one of the major coastal cities, Istanbul has been experiencing hazardous floods in recent decades because of extreme weather events due to climate change. Kuleli (2010) studies the risk assessment of sea-level rise for coastal zones in Turkey at city-level. The research's calculated risk is determined by using parameters such as population, settlements, land use, wetlands, agricultural production, and taxes. According to the findings Istanbul has a risk value of 8.5 (where 1 indicates most risky and 28 indicates the least risky areas) and is among the high vulnerability areas since the city's coasts are low-lying and densely populated.

Another study indicates the flood risk more comprehensively, with maps showing the risk on the district level and neighborhood levels based on flood vulnerability and hazard criteria. Ekmekcioğlu et al. (2020) developed the flood risk assessment for all the 39 districts of Istanbul by linking both the hazard and vulnerability criteria distinctive for each district. Their findings show that land use, population and vulnerable structures play decisive roles in determining vulnerability. In Istanbul multiple risk factors can be considered as the cause of the flood, namely extreme rain events, extreme storms, and earthquake-based tsunami. The study is a valuable resource to visualize the flood risk situation in Istanbul, emphasizing empirical data and district scale.

On an institutional level, Istanbul Metropolitan Municipality has prepared a document on flood risk for the European side[3]; however, it considers only the risk for riverine flooding and analyzes river areas (IBB, 2009b). Other reports focusing on flooding due to tsunamis and the risk Marmara coasts face (IBB, 2009a; IBB 2018a) reveal, that Istanbul urgently needs to develop strategies for disaster adaptation and mitigation for its coasts. IBB has published a scenario and action plan for responding to climate change using an adaptive approach. In the document, Istanbul Climate Change Action Plan Climate Scenarios[4] (IBB, 2018b), Uskudar coastal zone, Port of Istanbul, Kadıköy coastal zone, parts of Golden Horn, Yenikapi, Zeytinburnu, Ataköy, Maltepe, Pendik and Tuzla are some of the low-lying zones presumed to be affected by the rise of sea level. These areas are also mentioned as high-risk zones in the report Istanbul Marmara Coasts Tsunami Modelling, Vulnerability and Hazard Analysis Update Project conducted by IBB in collaboration with Middle East Technical University (IBB, 2018a). In the Climate Change Action Plan Final report (IBB, 2018c), IBB declares adaptation measures in a general scope. For urban areas, increasing permeability, planting trees, rainwater management, improving the rainwater drainage system, increasing climate resistance of buildings, and increasing the number of recreational areas, are many strategies of integrated spatial planning for flood adaptation. However, compared with international examples as presented previously, Istanbul as a major coastal city needs detailed analysis and assessment measures covering different aspects of climate change and a district-based road map presenting data on budget, timeline, and socio-spatial options of adaptation scenarios. Thus, the paper contributes to the climate change action plan emphasizing coastal flooding through physical design guidelines based on analysis at the neighborhood level. Kadıköy is selected as the case study area since it is one of the vulnerable coastal districts in Istanbul estimated to be affected heavily by coastal flooding due to climate change.

### 3.4. Case study area Kadiköy:

Kadıköy is one of the oldest districts of Istanbul located in the Anatolian/Asian side and has an area of appr. 25km² with a population of 482.713. The district has 21 neighborhoods and a 21 km long shoreline along the Marmara Sea in the south. The coastline runs from Haydarpaşa neighborhood to Bostancı neighborhood in northwest-southeast direction. Besides recreational green spaces, the shoreline also has dense residential uses making the area quite vulnerable to flooding events. In recent events, dominant windstorms caused a hazardous impact on the built environment, where the main transportation artery connecting Kadıköy with the other districts along the shoreline and major sea transportation hubs were affected. For instance, in February 2015 a strong southwest wind caused large waves washing the shoreline and flooding the coastal road entirely. There is no concrete data about the assessment of the flood damage; information gathered from the secondary sources reveals that people needed to be rescued from trapped cars in flood water; waves reaching appr. 7m brought rocks to the inland (Deniz sahil şeridini yuttu, 2015). Measurements such as risk projections, land use regulations and disaster management still need significant research and implementation effort in flood risk management.

In 2018, Kadıköy District Municipality conducted the project Integrated and Participatory Climate Action for Kadıköy Municipality[5] with funding from the European Union. According to project report (Kadıköy Belediyesi, 2018) there is a risk for the

[3] Istanbul Avrupa Yakası Sel Felaketi İnceleme Çalışması
*(Istanbul European Side Flood Disaster Investigation Study)*
[4] İstanbul İklim Değişiklği Eylem Planı İklim Senaryoları
*(Istanbul Climate Change Action Plan Scenarios)*

[5] Kadıköy Belediyesi Bütüncül ve Katılımcı İklim Eylemi

coastline buildings in the middle and long term due to the projected sea level rise. In the action plan, retreat from the coast is suggested for the new buildings, while flood proofing strategies such as using flood resistant materials or secondary drainage systems are recommended as additional measures. Moreover, stormwater harvesting and building roof gardens are additional measures for property-based flood resilience.

The study area for this paper consists of waterfronts of four neighborhoods, Fenerbahçe, Caddebostan, Suadiye and Bostancı. It focuses on a shore zone 300m wide and appr. 5.5km long along with four neighborhoods where the conducted analysis is based on map overlays combining the intersecting features such as flood risk areas from Kadıköy Disaster Information System, land-use data from Urban Atlas 2018 and Google maps, historical maps showing the waterfront line before landfill from IBB City Maps. Through the findings, plans with spatial strategies for flood resilience are created. The entire study area focusing on publicly accessible recreational shoreline runs through four neighborhoods - Fenerbahçe, Caddebostan, Suadiye and Bostanci - and is divided into three zones with approximately 2,5km long shore of each to ease the analysis and proposal approach conducted in 1/2000 scale (Figure 2).

The GIS-based Disaster Information System of Kadıköy (Kadıköy Belediyesi, n.d.) is accessible on the web portal of the district's municipality. It shows areas of importance suitable for settlement considering the risk situation regarding flooding and earthquake.

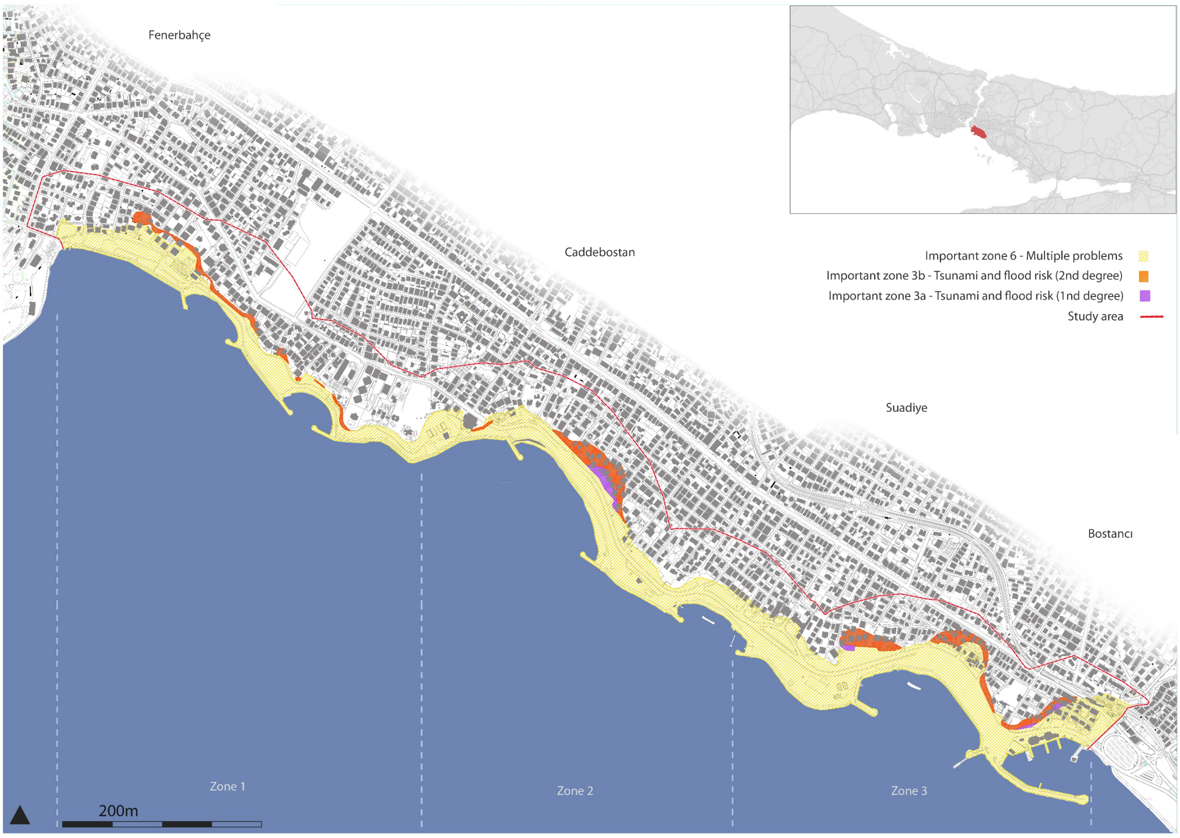


***Figure 2:*** *The study area in Kadiköy Waterfront shows three important zones of flooding caused by tsunami-affected waves. Important zone 6 with 62 ha, important zone 3b with 6.8ha and important zone 3a with 0.8ha are shown.*

The data for Kadiköy in this system is based on the microzonation studies for the Asian side conducted by IBB and adopts the areas shown in the Flooding Hazard Distribution Map prepared in 2009 as part of the microzonation studies. Areas belonging to the categories “Important zones in terms of flooding due to heavy rain and tsunami” and also “Important zones of multiple problems” are detected within the study area. These are integrated into the analysis maps of all three zones respectively (Figure 2).

In Zone 1, the location of the old waterfront line from the 1970s and coastal buildings show that landfill area is exposed to multiple problems (Figure 3). There is a 1.5ha area of flood risk (important zone 3b) where buildings of residential social and educational use are located. The study area is part of a large landfill which was constructed between the years 1984-87 with a coastal road longer than 5 km (T.C. Kadıköy Kaymakamlığı, n.d.) which makes the area extra vulnerable to disaster risks. Another crucial issue is the presence of two historically important buildings close to the risk zone. Both Tevhide Hanım Mansion and Ragıp Paşa Mansion can be affected by flood water due to their location on low lying land. Along the waterfront park hard engineering structures composed of a rock armour and seawall are conventional infrastructural bodies imposing engineering resilience. There are two sand beaches in the area which are popular recreation areas especially in warm seasons.


***Figure 3:*** *Overlay maps showing risk areas, topography with contours every 1m (top), and land cover (bottom) in Zone 1*

Zone 2 located in Caddebostan neighbourhood and contains areas of important zones category of 3a (appr. 0.5ha) and 3b (appr. 0.27ha), showing tsunami and flood risk with primary and secondary degree (Fig. 4). Several residential units are built within this area. Unlike Zone 1, areas located within multiple problems zone 6 does not contain any buildings reducing the vulnerability degree of the area. However, a large supermarket with car parking is close to the shoreline to the west without any floodproof measures detected (Figure 4). Other uses, such as Istanbul Wind Surf Center located in one of the beaches where surf courses and summer schools take place, and two major children’s playgrounds are to be found in the waterfront park. Contradictory to flood mitigation strategies two central car parking spaces with impermeable surfaces of appr. 0.7ha. are detected along the coastal road.

In Zone 3, the coastal roadway runs through the important zone of multiple problems putting the main transportation artery in a risky position (Figure 5). There is a 3.4ha area (important zones 3a and 3b) detected as flood risk zones containing several residential buildings. A commercial zone to the west



*Figure 4: Overlay maps showing risk areas, topography with contours every 1m (top), and land cover (bottom) in Zone 2*

where a hotel and several restaurant facilities are located, is partially within the zone of multiple problems (Important zone 6). On the east, Suadiye marina harboring small sized boats and Bostancı ferry terminal are to be found as important uses in this area (Figure 5). A large sports field with football and tennis facilities is located between the marina and ferry station. A large car parking space of 1ha size in the waterfront park close to the ferry station serves the ferry users. Additionally, another car parking space of 0.9ha is to be found in the waterfront which increases the vulnerability to flooding due to extended

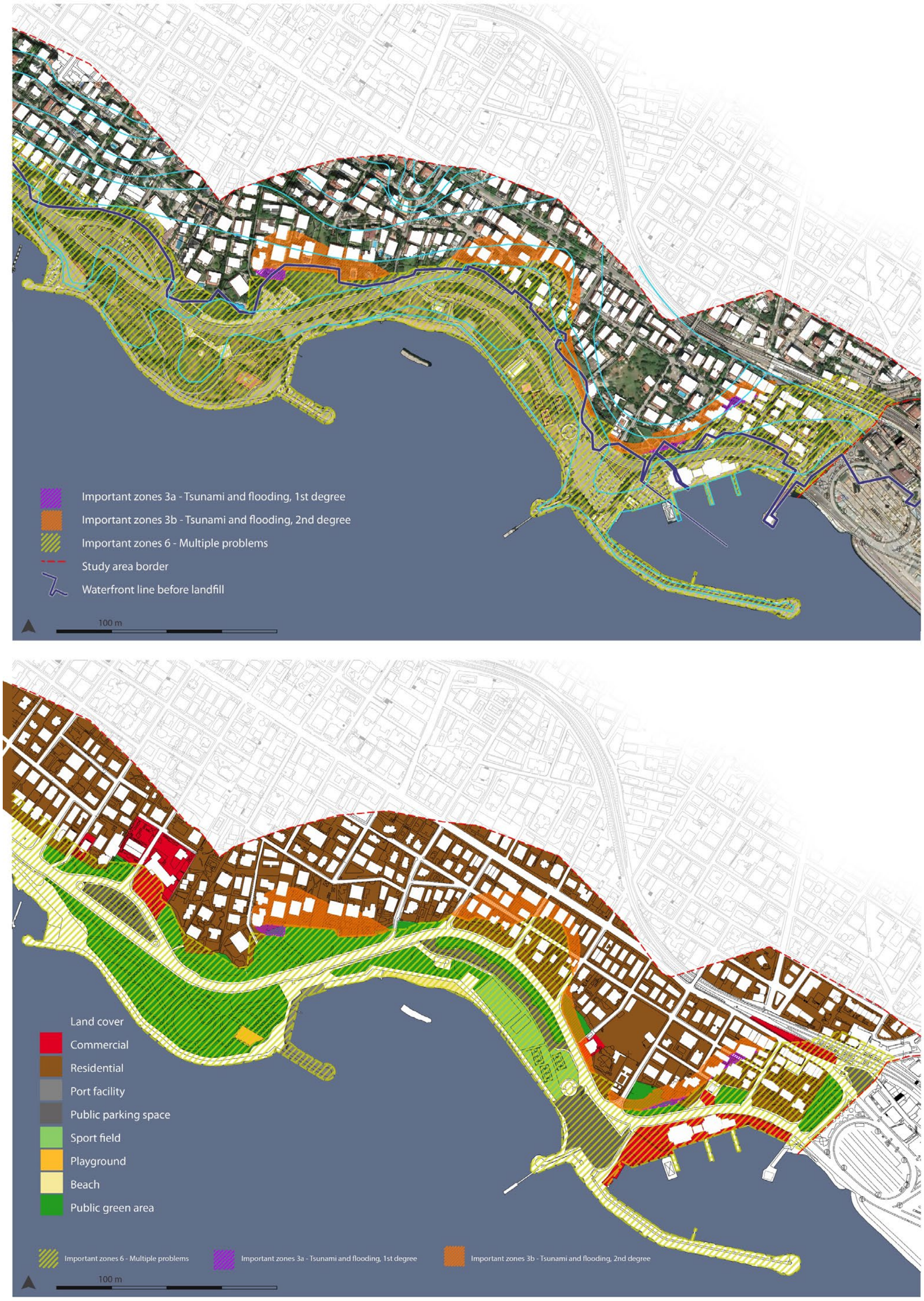


***Figure 5:*** *Overlay maps showing risk areas, topography with contours every 1m (top), and land cover (bottom) in Zone 3*

impermeable surfaces. In Bostancı neighborhood Camasirci stream, the natural border between Kadıköy and Maltepe districts, has its mouth reaching the Marmara Sea in a covered caisson whereby part of it can be seen as open caisson (Dinç & Bölen, 2014). With a new roadway project by IBB connecting Bostancı with northern neighborhoods, Camasirci Stream is planned to be part of a large-scale rehabilitation project announced as one of the 15 Valley of Life projects.

**4. Results: The design guideline**

In the design scheme, part of the strategies listed in Table 1 are integrated into the zones according to the circumstances revealed through the analysis phase. Areas that seem to be vulnerable in terms of flooding, are in focus.

ZONE 1

For Zone 1, the design scheme suggests mobile flood walls as protection strategies for the placement in the edge of the parcels facing the shoreline (Fig. 6). The concern of limiting the view to the water is here not relevant since the properties themselves have walls for privacy issues. Considering the lack of permeable areas within the boundaries of important zones, a new material with greater permeability is proposed for the pavement of the tennis courts within the social facility Cercle d'Orient (Büyük Kulüp) and the car park nearby. A vegetated berm is proposed as a landscape element to protect the high-risk area in the inland section that can be hit heavily by waves caused through a tsunami or extreme storm surges (Figure 6). The area therefore becomes a landscape attraction in dry seasons for recreational activities. More towards the east,


***Figure 6**: Proposal for design guideline in Zone 1*


***Figure 7:*** *Proposal for design guideline in Zone 2*

for the historical buildings Tevhide Hanım Mansion and the Ragıp Paşa Mansion flood wall construction is suggested which can be integrated into the buildings' landscape from southern and eastern parcel edges.

ZONE 2

In Zone 2, multiple measures are integrated for flood resilience (Figure 7). Some of these strategies are increasing green surfaces for more space to absorb flood water, increasing permeability of hard surfaces and elevated topography for flood protection. Zone 2 is located both within the borders of Caddebostan and Suadiye neighborhoods. As one of the major design strategies for the long term, it is proposed that the supermarket site will be relocated, and the area is redeveloped as part of the urban green along the shoreline which increases the amount of the floodable area as a natural defense. As a short-term measure for this area flood proofing the supermarket building with additional defense structures for instance flood gates, clearance of ground floor use, flood resistance material usage can be proposed in the guideline. Beyond this location, a 2m wide section of the coastal road is designed as a green street that absorbs flood water as part of a green infrastructure to prevent flooding of the coastal road and protect Caddebostan's dense urban residential area within the risky zones according to the analysis. Another important measure as an adaptation strategy is to develop an elevated green surface built along the green area in the waterfront allowing recreational use. When reaching the berm, the shoreline promenade becomes an elevated walk that functions on the one hand as a barrier against the waves and on the other hand as a new landscape experience. Additionally, greening parking lots with grass paver and extending green surfaces along the waterfront park are other measures developed for Zone 2.

ZONE 3

Zone 3 consists of two neighborhoods, Suadiye and Bostancı's waterfronts. Unlike two other zones, here a central transportation hub, the Bostancı ferry station is in the eastern part close to the neighborhood border; therefore, large car parking areas are to be found close to the shore. The design scheme proposes multiple measures focusing on the waterfront


***Figure 8:** Proposal for design guideline in Zone 3*

park and inland area (Fig. 8). Two separate car parking areas are merged into one single space next to the coastal road following the waterfront line to design flood resilient landscapes. A large concrete surface west of the ferry station becomes part of the green infrastructure. And again, permeable paving of the car parking area allows runoff water to be drained locally without overwhelming the sewage system to help reduce the site’s vulnerability

Between the parking space and waterfront, a dike-like topography is created to protect vulnerable areas from the risk of a flood (Figure 8). The new surface is terraced to sit and relax reinforcing an adaptive landscape with rising sea level. Current sport fields need to be relocated to a new place westward to build the new waterfront. A similar structure in the form of an elevated green area located on the inland side of the coastal road will protect several properties from a risky flood incident. Since there is a limited area near the ferry station to implement soft strategies for flood resilience, a flood wall is a crucial infrastructure to help the properties be protected; it is located on the edge of the property parcels close to the ferry station. To achieve a fully rehabilitated Camasirci stream bed, a concrete analysis in terms of areas at risk needs to be conducted and transformed into open spaces to avoid hazardous impacts on human health and revive the diverse riverine ecosystem.

In the project report of Integrated and Participatory Climate Action for Kadıköy Municipality (Kadıköy Belediyesi, 2018), increasing green areas is introduced as one of the measures for tackling climate change impacts on urban areas. In three locations within the waterfront park, structures such as elevated islands as playful landscapes are proposed to ensure protection for inland flooding by providing an attractive waterfront experience at the same time. Here, the design proposal intends to constitute a new landscape layer by integrating green infrastructure measures into the existing fabric for realizing an adaptive and resilient urban setting.

In the document of the district municipality IBB Kadıköy Tsunami Risk Analysis and

Action Plan Report (IBB, 2020), it is recommended that the waterfront should be free of flood walls because of the undesired outcome as blocking the view. In this study, mobile flood walls as a design strategy are part of the program; however, considering the report's concern, they are proposed not in the waterfront park but for properties in the inland area that have already walls for security issues. As an overall design measure, the vegetation character is also redefined since it is critical in terms of salination. Using salinity tolerant plants is essential to generate resilient landscapes (Yener, 2020). It is recommended to use species such as Ailanthus altissima, Eleagnus angustifolia, Fraxinus excelsior, Gleditsia triacanthos, Platanus orientalis, Populus alba, Robinia pseudoacacia 'Umbraculifera', Salix alba and Salix babylonica species to ensure sustainable vegetation management.

Kadıköy, having the status commercial, cultural, touristic, and residential district of Istanbul, is prone to several risk factors and needs therefore strategies tackling the complex problems waterfronts are exposed to. Climate change as a triggering factor for sea level rise intensifying storm surge and tsunamis (Li et al., 2018) should be considered from a resilient spectrum to adapt cities to coastal flooding. Flood resilience in this regard opens a wide range of possibilities for operationalization of physical measurements on a local scale more effectively and quicker than in larger scale implementations (McClymont et al., 2020). This study is a tool for the place-based understanding of flood resilience strategies, for opening the path to the spatial implication of climate action plan and for thinking on district and neighborhood scale in disaster management.

Further research concentrated on sea level rise impact on Kadıköy coasts is necessary. Data on wave depth, simulations regarding 50- and 100-years projections on sea level and tsunami inundation maps under sea level rise need to be presented via deeper examination since simulations, spatial modeling and generating risk maps are essential in preparation, response, and recovery for urban infrastructure flooding as it is increasing with sea level rise (Allen et al., 2019). Technical measures need to be broadened and conducted locally through collaborative workshops with experts, residents, and private stakeholders since good communication and cooperation between the public and private stakeholders are essential for trustful relationships and effective flood resilience (Restemeyer et al., 2015).

**5. Conclusion:**

Considering Istanbul, the need for research on the economic, social, and spatial risk of sea level rise is alarming. As one of the important coastal cities of the world, Istanbul lacks a holistic approach to flood management, the study demonstrates. Prone to flooding and tsunami, climate change is a priority issue on the city's urban agenda. Regarding the risk analysis, tsunamis are comprehensively handled whereas action plan strategies need more concrete steps to fulfill the mission for a flood resilient urban environment. In this regard, this paper explores the opportunities for spatial integration of flood resilience measures. In further research it is necessary to generate flood maps and simulations to understand the risk better. With rising concerns on sea level rise, studies regarding the risk of tsunamis need to be revised and recalculated according to the changing pattern of natural events.

This study strongly recommends a district-based approach about short-term and long-term options with relevant low and high-cost alternatives of design strategies. Hereof, adaptive planning and governance approach with a transdisciplinary collaboration of private and public sectors is necessary. It is crucial to include schemes created through spatial adaptation of planned strategies by considering site-specific features into flood resilience policy.

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