university of groningen

Bachelor's Thesis Project 2020 - 2021,
BSc Spatial Planning and Design

Coastal flood resilience and socio-spatial justice of urban deltas by means of ecosystem services

Comparative study of initiatives in Riga and Rotterdam

Thesis theme: Spatializing climate justice
Supervisor: Dr. Ethemcan Turhan

Author: Annija Danenberga
Student Nr.: S3466523

Date: 15/01/2021

Table of contents

Summary

Many coastal delta cities worldwide face increasing flood risk due to the changing climate of extreme river discharges and sea-level rise. Previous research has shown growing awareness that the increasing vulnerability of urbanised delta and coastal cities is strongly related to urbanisation, changing socio-economic conditions and the low-lying geological position. Consequently, in response to climate change, adaptation to existing urban environments is required to cope with flood risk. In terms of risk reduction, it is often associated with increasing coastal flood resilience but not always seen as an opportunity for a systematic change of improving liveability and socio-economic conditions. Existing literature shows the need for further empirical research on this matter across different scales. The thesis investigates how spatial planning strategies address flood-resilience by means of ecosystem services and whether it also improves socio-spatial conditions. To answer the research question, this research applies a framework of Ecosystem Services Justice (ESJF) to assess adaptation pathways across spatial and temporal scales in a multi-city comparative study between European coastal urban deltas of Rotterdam and Riga. In this view, urbanised coastal areas are understood as a complex adaptive system, influenced by external pressures, such as climate and demographic change, and by the urban planning interventions. The ESJF is structured as an empirical approach, applying spatial analysis for distributional, procedural and recognition dimensions of ES justice, acknowledging the importance of institutional governance, the infrastructure within the built environment and people's perceptions. The results were strengthened by literature and policy report analysis and semi-structured interviews, targeted at experts in the spatial planning field. The comparative research study showed that spatial adaptation strategies of ecosystem services are approached in both cases with respect to coastal riverine flooding, but larger differences are noticed to what extent ES are applied across different time frames or when addressing socio-spatial justice dimensions. It is recommended to do further research on the quantitative inquiry of longitudinal analysis to replace the simplified historic timeline or either a smaller geographical scale including qualitative methods to examine in-depth perspective on local resident experiences. Furthermore, repeating this study with a larger number of interviewees, who are not selectively experts, could improve the representation of the research.

1. Introduction

Global climate change is causing more extreme weather patterns, positioning the world in unequal spatial outcomes (IPCC, 2014). The earliest cities sprung up in the fertile Tigris and Euphrates floodplain with the benefits of water supply, agriculture and regional connectivity. The tendency has continued to concentrate world populations around coastal areas; the estimate is that at least 40 percent of the world's population live within 100 km of the coast, while more than 600 million people live in coastal areas that are less than 10 meters above sea level (UN, 2017). Increasingly severe natural disasters are expected, including increased flooding, storm events, wildfires, landslides, droughts, and rising sea levels (IPCC, 2014). Accordingly, climate change has become an important community stressor, determining the importance of climate justice (UN, 2017). How to minimise the consequences of climate change spatially? How to ensure climate-just environments, where also different socio-spatial factors play a role to attain resilient cities? In order to address socio-spatial justice, not only a fair distribution of environmental concerns but also of social benefits should be strived for (Martin et al., 2016; Andersson-Skold et al., 2019). It is an issue that demands urgent and collective action, particularly given that three-quarters of the world's population resides in coastal and riverine zones. Previous studies have shown that not only the mitigation of vulnerability is of paramount importance from the justice spectrum but also the accessibility to ecosystem benefits of human well-being and to reinforce the placemaking in communities (Ernstson, 2013; Biernacka &Kronenberg, 2019; IPCC, 2019). Fortunately, urban planning can promote the ecosystem services functions responsible for providing flood protection and other socio-ecological benefits (Andersson et al., 2014. For vulnerable coastal urban deltas, as socio-ecological adaptive systems, an integrated and holistic approach is required across different scales; this concerns appropriate institutional arrangements, management over the built environment and cooperation amongst stakeholders and civil society (Sole & Ariza, 2019).

1.1. Problem Statement

Societal Relevance

Increased flooding is likely to be one of the most serious effects from climate change in Europe in the coming decades (IPCC, 2019); under the 2 degrees Celsius simulation 240 thousand people per year could be affected (Ciscar et al., 2014). As climate change and other interdependent challenges are expected to become increasingly severe and unpredictable (Ciscar et al., 2014), there is a need for adaptive measures and policies to reduce risks and uncertainties for the vulnerable coastal delta communities of European rivers, and for the country sake of future generations. The river flood analysis issued by European Commission has also studied the costs and benefits of adaptation, with the objective to maintain 1 in the 100-year level of flood protection across Europe in future time periods; the reduction in damage costs is estimated at €53 billion/year by the 2080s, at a cost of €7.9 billion/year (Ciscar et al., 2014). Nowadays adaptation of preventing flooding through large-scale infrastructure is increasingly regarded as less appropriate, due to

growing concerns over their negative ecological and socio-economic impacts (Stead, 2014). Therefore, one of the greatest challenges for flood mitigation is to maintain natural ecosystems while promoting the socio-economic conditions (Byrne et al., 2015), which in fact are often not recognised in urban planning and decision making and, consequently, the impact from their loss remains invisible.

Scientific Relevance

Although ecosystem services are addressed by major initiatives, for instance, the Millennium Ecosystem Assessment (McGranahan et al., 2005) and have received increasing attention as part of the policy debate on climate adaptation in urban areas, previous studies show to be limited by relating them to coastal flood protection compared across cases and scales. This translates to only a small proportion of coastal flood resilience studies examining multi-city comparison with regard to ecosystem services (Langemeyer et al., 2018) but rarely on side effects on socio-spatial justice. To fill this gap, this research aims to examine processes occurring in coastal delta cities, to understand how spatial planning strategies address flood-resilience by means of ecosystem services and whether it also improves socio-spatial conditions.

The research studies and compares European coastal delta cities - Riga and Rotterdam, where the potential risk of flooding is predicted to be severe for future generations (See also Figure 2). Comparison is conducted by taking into account past un current flood resilience practises, with the application of the Ecosystem Services Justice framework. By doing so, the overarching goal for this bachelor project is to act as a guideline of implementing ecosystem services initiatives in the planning field with regard to coastal riverine flood risk and socio-spatial conditions. The central research question in a comparative case study of Riga and Rotterdam is proposed as twofold:

How spatial adaptation strategies of ecosystem services may mitigate climate change-induced coastal flooding in delta city environments, while also addressing socio-spatial justice?

To answer the main research question, the thesis question is broken down into two theoretical and two empirical sub-questions. For theoretical understanding, the research asks:

1) What are the existing spatial adaptation strategies and associated benefits of ecosystem services capable of mitigating flood risk in urban environments?
2) How do spatial planning initiatives of coastal flood resilience lead to efforts to address socio-spatial justice?

Empirically study asks:

3) What steps have been taken towards the realisation of flood-proof urban environments, when comparing the cities of Riga and Rotterdam?
4) To what extent do flood-resilience transformations address socio-spatial conditions by ecosystem services approach in the city of Riga, in comparison to Rotterdam?

1.2. Case selection and description

The Netherlands is amongst the European countries with the largest shares of low-lying areas, therefore it is highly vulnerable to the sea level rise or extreme flooding (EEA, 2009; Figure 1). Fortunately, in recent years there is a growing attention for water management governance and climate change adaptation. As part of the Rotterdam Climate Proof climate change adaptation programme, the largest port city of the country is leading the way in climate-change-related initiatives; the so-called Delta Works in the southwest of the Netherlands have been implemented to protect land around the Rhine-Meuse-Scheldt delta from climate change-induced flooding (Meyer et al., 2009). Although, as engineering approaches are increasingly expensive and seem to be limited in the solutions offered, the urban planning practises are turning from "creating a habitable space" to "creating a resilient and livable place to live, work and play" (Frantzeskaki & Tilie, 2014). For instance, as part of the Delta Plan, current flood-proof strategies are shifting from 'grey' to 'green' infrastructure, making increasing use of ecosystem services (Tillie & van der Heijden, 2016). Previous research and practices for the delta city of Rotterdam have shown that flood-proof urban resilience can significantly reduce the impact of flooding for both the natural and built environment (Stead & Lu, 2013; Gemeente Rotterdam, 2013); and reduce the vulnerability of communities, as an opportunity to aid the placemaking and improve biodiversity through ecosystem's approaches (Tillie & van der Heijden, 2016).

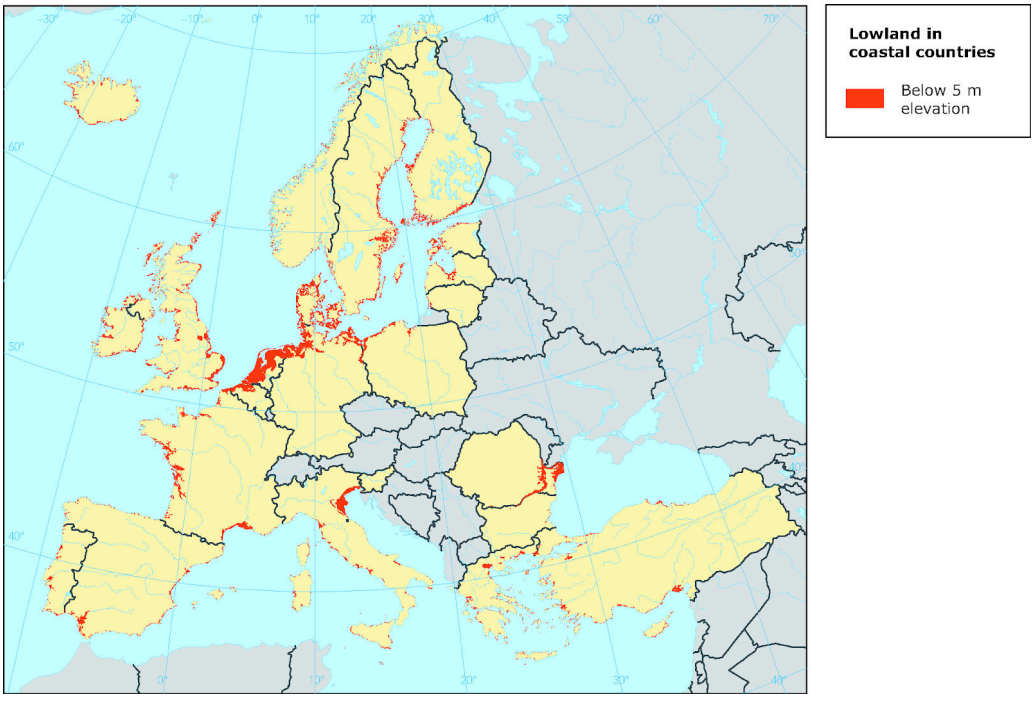


Figure 1. Lowland area indication in coastal countries, counting for below 5-metre elevation (European Environment Agency (EEA), 2009).

About three-quarters of all European cities will be affected by rising sea levels, especially in the Netherlands, Spain, Italy and the UK but not exclusively (IPCC, 2019; Figure 2). In a recent study of flood risk in European capitals, Guerreiro et al. (2018) pointed out the highest severity of flooding risk in 50 years time for the capital city of Latvia. Certain areas of Riga are subject to a regular flood, resulting in both economic and moral loss to the city's population (Kūle et al., 2013). Observations show that flood risk in the territory of Riga is constantly increasing (Klavins et al., 2007); sea-level surges pose the greatest flood threat (RdPad, 2012). In fact, Riga is a primary city which concentrates all the major functions in the country, such as governmental institutions, hospitals, universities, trade and entertainment centres. It makes up more than half of the country's GDP and one-third of the population (CSP, 2020). Based on IPCC SRES A2 scenario, Figure 2 indicates a prediction in case no adaptation takes place, the estimate is that at least 10 thousand people per year in Latvia can expect floods along with the coastal delta areas (Ciscar et al., 2014). Although rivers in Latvia are featured by vast floodplains and preserved wetlands, serving as natural flood retention areas, as a post-socialist country the current efforts towards flood risk governance are still fragmented, especially concerning the socio-spatial conditions of urban governance for the capital city of Riga (Akmentina, 2020).

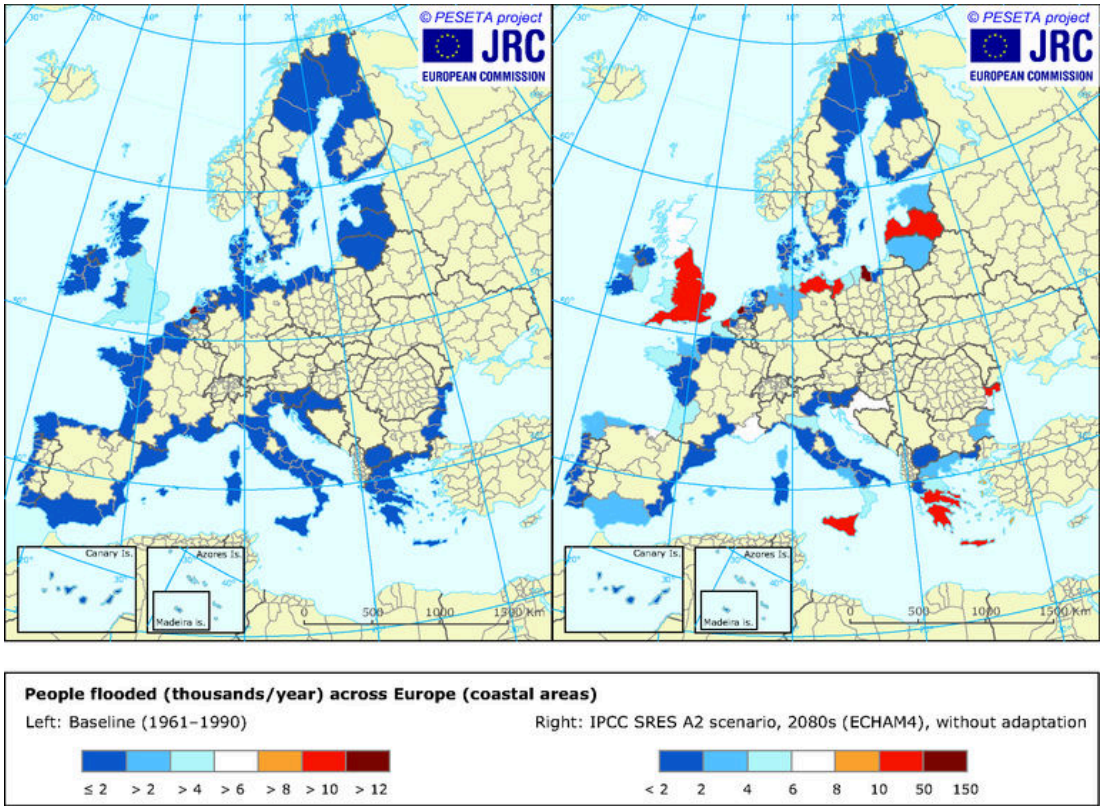


Figure 2. EU Commission PESETA project examined and compared data in the period 1961 - 1990 of people flooded across coastal European areas versus IPCC SRES A2 scenario, predicted in the year 2080, in case no adaptation takes place (Ciscar et al., 2014).

1.3. Reading Guide

The following chapter 2 underpins the theoretical foundation of this research study, including the conceptual framework regarding urban resilience and socio-spatial justice by means of ecosystem services. A conceptual framework will be presented to show the relationship between the concepts. This is further strengthened by the overall expectation of the research results. Chapter 3 introduces and describes how a literature review, expert interviews and a comparative case study have been employed within this thesis. The fourth chapter focuses on the individual case study results and compares and reflects on the findings, employing the ES Justice Framework. Further, chapter 5 concludes the research. Chapter 6 discusses the limitations of this research and proposes ideas for further research.

2. Theoretical Framework

In this chapter, the most relevant concepts and theories will be defined and discussed with the use of a literature review. In addition, the sub-question 'What are the existing spatial adaptation strategies of ecosystem services capable of mitigating flood risk in urban environments? ' and 'How do spatial planning initiatives of coastal flood resilience lead to efforts to address socio-spatial justice?' will be discussed and answered. Subsequently, the theoretical model is included to visually support the interrelationship between these concepts and theories.

2.1. Definitions and theoretical understanding

Socio-spatial Justice

The development of the relationships between geospatial distributions of resources and social justice implications have been inspired by many studies (Lefebvre, 1991; Harvey 2008, Soja 2010). The idea of the "right to the city" was first used in 1968 by philosopher and sociologist Henri Lefebvre. The concept has been uplifted by social movements and academics as a way to hinder spatial inequalities in the capitalist city. One of the most influential advocates of this idea within academia, David Harvey (2008, p 24) has outlined the ideology: *'The question of what kind of city we want cannot be divorced from that of what kind of social ties, relationship to nature, lifestyles, technologies, and aesthetic values we desire.. ."*

It is based on the idea that meaningful control over someone's built environment is not a privilege, but a right, and an essential element in the fight against radical destruction of communities (Harvey, 2008). Spatial justice is a complementary idea to that of the right of the city. According to Soja (2010), spatial justice is based on the social, temporal, and spatial experience of living life and the desire to connect space with justice. In order to understand what it means for spatial forms to be justified, the article by Dikec (2001) was analysed; it explores how the process of spatialisation and political solidarity can play an important role in (in)justice mainly in urban backgrounds. In this context, the spatialisation has been related to the phenomena interrelationship with social and material space, happening at certain times and places. While justice in the city can be conceptualised in various forms, similarly one of such phenomena was also described in the article by Dikec (2001) as a force of pushing lower-income residents into other cityscapes. In support to the previously examined paper, Steele et al. (2015) stress that the greatest injustices for urbanites might be concerning particularly peripheral areas of cities, where, unless supported by third parties, impoverished people have limited means and capacity to respond to climatic events and adapt to anthropogenic environmental change. In contrast, for climate justice, this situation tends to relate to increased exposure to environmental risks or reductions in recreational possibilities by available green space (Steele et al., 2015).

[The Right to the City is] the right to change ourselves, by changing the city. —David Harvey, 2008, p 24]

Urban resilience, Vulnerability & Adaptation

With increasing populations and for the purpose of considering urban vulnerabilities, a growing number of cities are engaging in designing adaptation plans and strategies focused on resilience. Within the built environment, vulnerability is determined by a community's capacity to anticipate and/or recover from the impacts of major climate changes such as extreme weather events (Meerow et al., 2019). It has been suggested that increasing adaptability is to increase resilience and decrease vulnerability through spatial planning (Brunetta & Caldarice, 2019). The concept of resilience, although sometimes vaguely defined, offers a system-based perspective to understand complex natural and human systems, such as urbanised coastal zones when confronted with stress and change (van Veelen, 2016). Triggered by unplanned disasters, adaptation can result in reactive policy development process, based on an awareness that action is required to maintain the desired state (Byrne et al., 2015; IPCC, 2014; Depietri & McPhearson, 2017). However, this may provoke an unequal distribution of risks and costs among society or other unexpected system responses (van Veelen, 2016). Additionally, many adaptation initiatives are challenged by path dependencies resulting from the complex socio-ecological and political urban settings, and the weak political setting of priorities and cultural values, but also from financial challenges or rules (van Veelen, 2016; Depietri & McPhearson, 2017). The notions of urban resilience have gained considerable attention over recent years, not only in relation to environmental management but also in terms of urban planning and socio-spatial justice (Friend & Moench, 2013; Meerow et al. 2019). The adaptive and transformative element of resilience offers many opportunities for linking climate change adaptation initiatives with other urban needs or local agendas, for example improving urban liveability or poverty reduction (Pelling, 2011; Deppisch, 2018). According to Da Silva et al. (2012, p127), Urban Resilience Framework To Climate Change states:

''..urban resilience to climate change describes a city that is resilient on three levels:

1) *the systems of the city survive shocks and stresses;*
2) *the people and organizations are able to accommodate these stresses into their day-to-day decisions;*
3) *and that the city's institutional structures continue to support the capacity of people and organizations to fulfil their aims. ''*

Ecosystem services

In urban environments, the overall distribution of material and immaterial benefits that nature provides to people here are referred to as ecosystem services (ES). It is argued that an ecosystem approach to planning, and in particular the use of ecosystem services, can contribute to the objectives of social equity through the promotion of available resources, the encouragement of learning, participation, multi-level governance and complex adaptive system thinking (Da Silva et al., 2012; Frantzeskaki & Tilie, 2014; IPCC, 2019; Meerow et al., 2019). The TEEB report identifies 22 types of ecosystem services grouped into four categories: provisioning, regulating, supporting, and cultural services (TEEB, 2010). For example, for flood regulation, ecosystems can redirect or absorb precipitation; or mitigate the impact by providing retention space for surplus water and thereby lowering flood destructive power (Gunnell et al., 2019). According to Martin-Ortega et al. (2015), several adaptation options of water ecosystem services against flooding risk can be conceptualized, be seen in Figure 3. By regulating stormwater runoff and mitigating natural hazards, urban ecosystems control the associated weather shocks and influence the living environment. Specifically, by providing suitable space for recreation, increasing the aesthetic quality of urban spaces, offering opportunities for cultural enrichment, and preserving the local identity and sense of place, ES provides benefits that are essential for societal wellbeing in cities (Gómez-Baggethun &Barton 2013). Appendix D provides an extended general overview of ES strategies capable of mitigating floods, and Appendix F on how these are applied in case studies of Riga and Rotterdam.

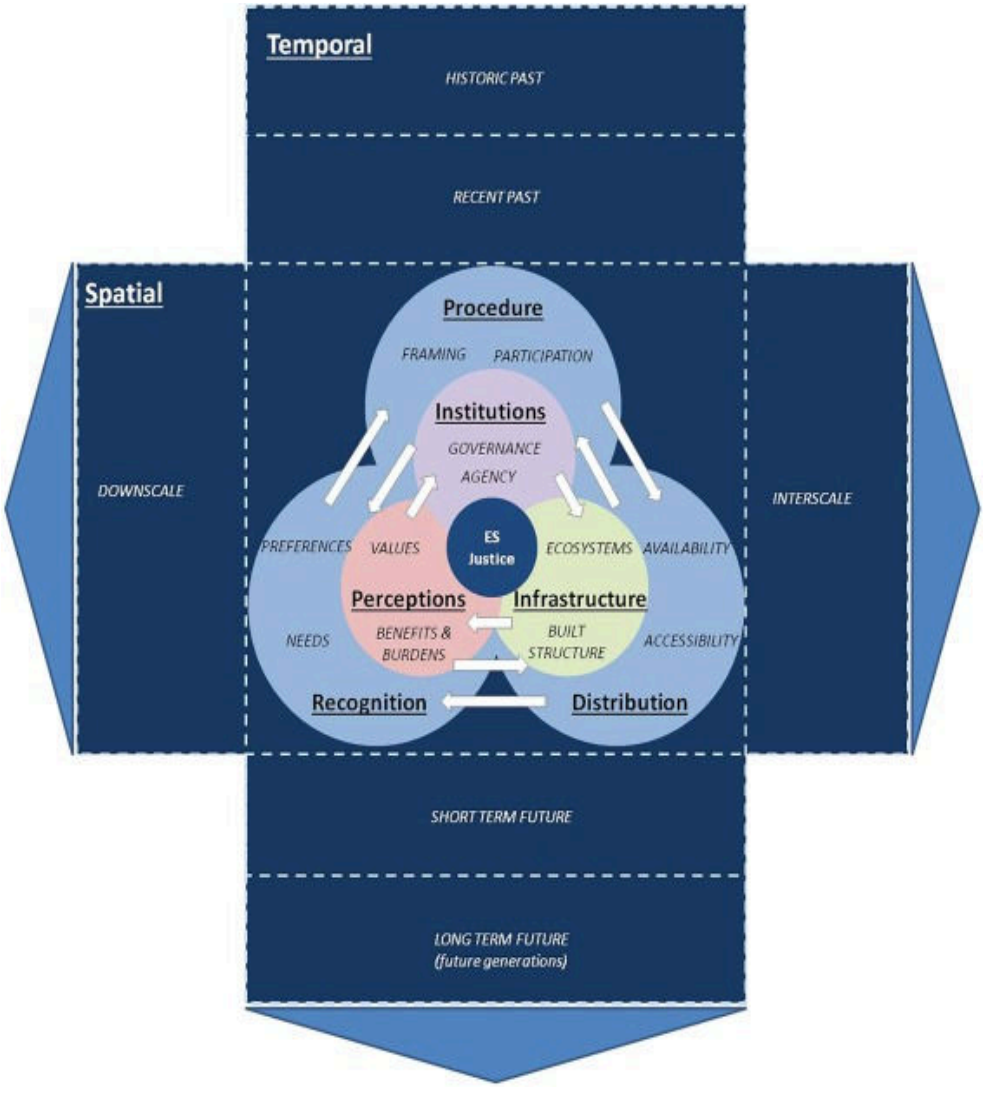
Figure 3. Examples of adaptation options of ecosystem services, against flooding risk (Martin-Ortega et al., 2015)

Adaptation aim	Examples of adaptation options
Protection of water ecosystem services	Management of existing, non-climatic stressors
	Expansion of protected area network
	Restriction of development
Restoration of water ecosystem services	Riparian vegetation restoration
	Flow regime restoration
	Dam removal
	Removal of river bank armouring
	Restore connectivity, e.g. fish ladders
Enhancement of water ecosystem services	Planting of fast-growing, high-shade riparian trees
	Storage and delivery of dilution flows to address water quality problems
	Species translocations, e.g. fish stocking
Replacement of water ecosystem services	Construction of new water storage infrastructure, e.g. dams
	Construction of artificial ecosystems, e.g. wetlands
	Construction of sea walls

Ecosystem Services Justice Framework

Recent research has been extending the ecosystem services framework to the urban context, addressing it as a policy evaluation analysis and design tool (Andersson et al., 2014; Filho et al., 2020). The empirical urban Ecosystem Services Justice Framework is picked as the main analytical framework for this research (Figure 4, Lengemeyer & Connolly, 2020) because it links closely with the objectives of this comparative study on coastal flood resilience and with previously explained perspectives on ES socio-spatial justice. Socio-spatial justice here is understood as a set of conditions — primarily concerned with the distribution of resources, political processes, and social recognition, therefore, exploring justice in this research requires attention to the distributional, recognition, and procedural dimensions of ES initiatives. Moreover, the framework is also capable of providing guidance on how to achieve urban ES justice, by evaluating the past initiative developments and day-to-day management of urban ecosystems across dimensions but also who in society benefits from them. These include the 'socio-environmental metabolic relations that come together' in a specific global-local place, as well as how environmental externalities and injustice play out at different spatial and temporal scales (Lengemeyer & Connolly, 2020).

Figure 4. Ecosystem Services (ES) Justice Framework (Lengemeyer & Connolly, 2020).



Spatial Scale

The Figure 4 accounts for the interrelated role of (**a**) **institutions**, including human agency and urban governance systems (policy and planning) that determine access to and control over ES (Berbés-Blázquez et al., 2016) and shape urban ecosystem functions, (**b**) **infrastructure** including built and green infrastructure limiting or enabling the (local) availability of ES, and (**c**) **people's perceptions** understood as the subjective understanding of ES benefits and their importance (Biernacka and Kronenberg, 2019).

Procedural ES justice

With regard to (a) institutions, in the urban environment procedural justice is largely about the presence of equitable spaces of engagement (Martin et al., 2016) that determine who is involved with shaping conditions of the city, dependent on the formal and informal rules and power structures within the urban governance systems. The path toward procedural justice is assumed in participatory democracy with collaborative and communicative engagement across a wide set of stakeholders (Fisher, 2009). Participation is theorized to lead to more just outcomes because it reinforces social rights enhancing locally-attuned benefits and increases equity in decision-making, contradicting Harvey's ideology of 'Right to the city'.

Distributional ES justice

The dimension of b) Infrastructure is further related to distributional justice and is elevated for ES because a specific planning intervention may shift benefits and drawbacks from one individual to another, but might have adverse effects for other societal groups. Limiting or providing the accessibility to ES by the built and green infrastructure responds to urban planning decisions.

Recognition ES justice

Lastly, the dimension of c) Perceptions leads to recognitional justice regarding the inclusion of different social and cultural values of what is just and the needs and preferences of different social groups (Dawson et al., 2018). If a group's interests and values are systematically excluded from decision-making about the capacities of society that allow for human success, then recognition injustice has occurred (Fraser, 1995).

Closely interlinked with the concept of procedural justice, it points toward: Whose values are included and seen as important in decision-making processes, recognizing unequal procedures in ES governance (Lengemeyer & Connolly, 2020). To summarise, distributional, recognition and procedural justice are jointly related, depending on aligned governance, social, and ecosystem processes.

Temporal scale

Temporal justice dimension proceeds from the recognition that acknowledging present manifestations of past and historic inequalities are often essential in order to ensure just outcomes for future generations (Meyer, 2017). The full model introduces a temporal dimension of justice, highlighting the need for integrated consideration of past, present and future conditions of urban social-ecological systems. Climate change, socio-demographic changes, and other drivers might also affect the future needs or demand for ES. In this context, urban ES justice research requires to be linked to vulnerability assessments that allow planners to project shifting needs for ES in the future.

The previous example demonstrates how the framework helps to move between scales of analysis —here through two local case studies Rotterdam and Riga—an understanding of the processes through which socio-spatial injustice operates, and how the sociocultural differences interlinks with the generation and distribution of benefits from ecosystem services. Following on to this, the conceptual model is illustrated and, based upon that, the research expectations are laid out.

2.2. Conceptual Model

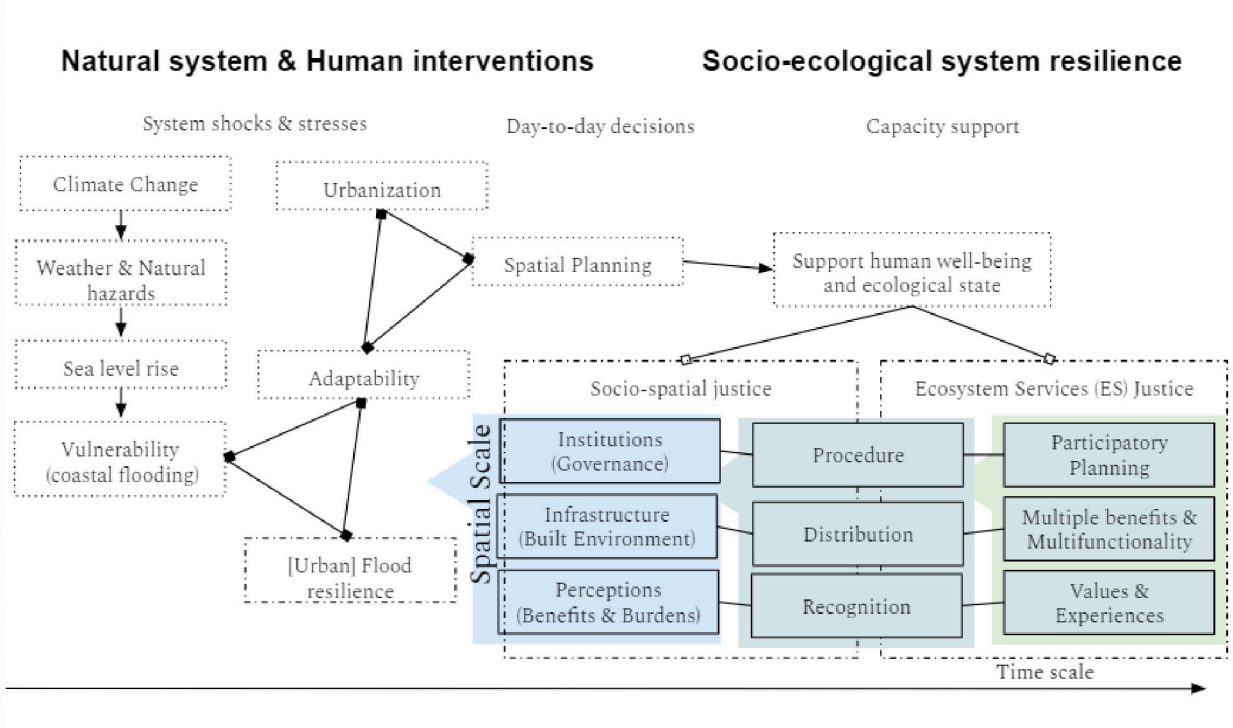


Figure 5. Conceptual framework of the research.

The conceptual model in Figure 5 illustrates how natural system shocks and stresses of human interventions within urban environments may lead to vulnerability of climate hazards. In this study, this concerns the vulnerability to coastal flooding. With increasing urbanisation, the need for spatial planning day-to-day decisions is crucial to adapt to the changing environment. With respect to flood adaptability, this relates to urban flood resilience on three levels: 1) the systems of the city survive shocks and stresses; 2) the people and organizations are able to accommodate these stresses into their day-to-day decisions; and 3) that the city's institutional structures continue to support the capacity of people and organizations to fulfil their aims (Da Silva, 2012). Social-ecological resilience is the capacity to adapt or transform in the face of change in social-ecological systems, particularly unexpected change, in ways that continue to support human well-being and ecological state. Through appropriate governance with the cooperation of civil society and the management of the built environment, socio-spatial justice can be addressed. This is further elaborated on page 12. To conclude, Ecosystem Services (ES) are capable of contributing to flooding protection, while also providing both social and ecological benefits.

2.3. Hypothesis

As this study mainly has an explorative character, no explicit hypotheses are formulated. However, some expectations can be established. Based on literature and theoretical framework, and considering the conceptual model, the following expectations can be laid out, when comparing the flood preparedness between Riga and Rotterdam:

1. Urban resilience may positively influence the vulnerability of communities, dependent on the adaptability of natural and human-response systems by spatial planning interventions.

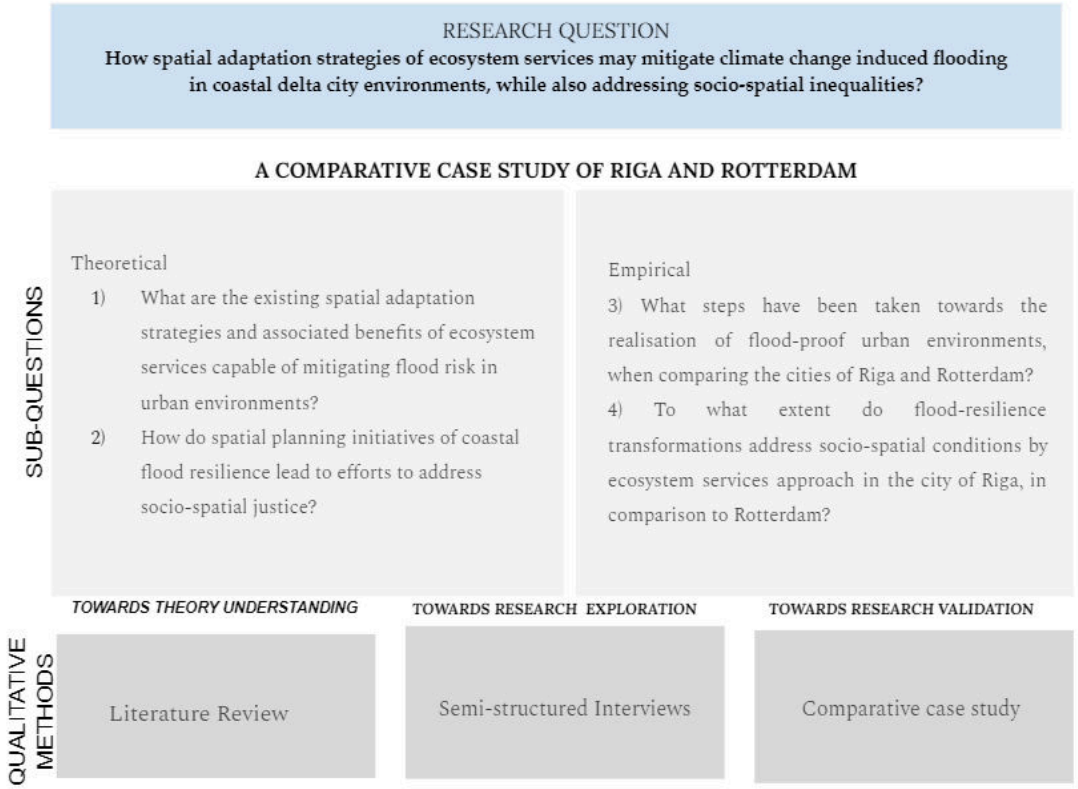
2. Climate change adaptation strategies of ecosystem services have the potential to ensure socio-spatial justice to address vulnerability to floods, while incorporating benefits to human well-being and ecological state, by addressing procedural, distributional and recognition justice dimensions.

Whether these hypotheses can be kept or disregarded will be investigated in the following chapters of this research.

3. Methodology

In the present study, a qualitative analysis is carried out by means of triangulation of primary and secondary data collection in a comparative case study of two coastal delta cities in Europe - Riga and Rotterdam (See Figure 6). The empirical research firstly tries to understand what spatial resilience strategies are there of ecosystem services against riverine flooding, and what benefits can be gained from that for the local society. A secondary method of literature review and primary method of semi-structured interviews are picked as the data methodology for understanding the core research concepts and how they are interlinked, viewed as an urban social-ecological system. Secondly, in order to provide a comparison between the cities of Riga and Rotterdam, comparative case study methodology will explore the past and present flooding risk and responses by reviewing historical web documents and books, as well as the primary method of expert interviews will strengthen the findings. I suggest three phases of sub-questions to triangulate findings: (1) Data collection, including grey literature review such as plans, policies, and visions of the Rotterdam and Riga city and interviews with experts; (2) Data analysis, including case study comparative assessment & axial coding of semi-structured expert interviews; and (3) Data validation, realized by applying the findings to the empirical framework of the Ecosystem Services Justice.

Figure 6. The methodology of qualitative methods



3.1. Primary data methodology

The use of primary data is conducted by means of qualitative semi-structured interviews, aimed at experts in the field, involved in the process of mitigating floods within the selected case studies. From the course literature by N. Clifford et al. (2016, p134), it is stated that the most appropriate methods for your research depend on the questions asked and the information that the researcher is willing to generate. By conducting expert interviews, the aim is to receive deeper insights into the research topic and to enhance the relevance of water-sensitive ecosystem practises against future flooding. Another criterion was an equal number of respondents from the different cities in the national & municipal and private sector, as this study aims for comparing Rotterdam and Riga situation. For an interview guide, see Appendix C. To recruit participants, an invitation email was sent out timely, asking to be interviewed for the purpose of research, as part of the Bachelor's thesis. The interviews took place via Google Meet application. Table 1 provides an overview of respondents and Table 2 gives an impression of how the coding was applied. The information from the semi-structured interviews is strengthened by secondary data collection.

Table 1. An overview of the semi-structured interview characteristics.

Interviewees	Scale	Organisation/position	Expertise/ focus projects	Date	Total time
Expert 1	National	Representative of Ministry of Environmental Protection and Regional Development of Latvia (VARAM)	National Policy document 'Climate change adaptation plan 2030;'Flood risk governance for Daugava river basin'. Regional coordination	29/10/2020	[no recording]
Expert 2	Municipal	Municipality of Riga - Spatial planning department Researcher into water systems	15 years of expertise in spatial planning department Project: 'Riga AgainstFloods 2012'; Research article 'Adaptation to Floods in Riga: Historical Experience and change of approaches.	12/11/2020	55 min
Expert 3	EU - National	Coordinator of the EU Water Platform for Green Infrastructure (WssTP); Current member of EarthWatch Europe for Sustainable Cities; Former Deltares representative.	Eco-engineering, Climate-proof cities; Nature-based solutions; Alternative benefits of ecosystems. Project: 'River as a tidal park' focusing on the application of Building with Nature in Rotterdam	17/11/2020	59 min
Expert 4	Municipal	Member of Resilient Rotterdam foundation; The municipality of Rotterdam	Project: Rotterdam Water City 2035; Go BoTu initiative - community involvement of resilient neighbourhoods	07/12/2020	43 min
Expert 5	Private sector on local scale	Member of the Riga's leading architecture firm 'Group69'; Directly involved in 'CitiesforPeople' foundation	Sustainable urban planning, mobility, green infrastructure, scientific research Projects: (D)rain for Life; ''Skanste ''	11/12/2020	67 min

Table 2. An example of quotes and according coding applied from the interview transcripts.

Semi-structured interviews		
Quote (original/translated)		Coding applied
Expert 3	''By showing that the river is a dynamic system, you can also create an awareness and an understanding among citizens that you live in a very complex hydrological system.'' Let's see, if you take an average over the year, that is something we can cope with. But because it is put in one short time frame, with such an excess of water we cannot cope with it anymore.''	Main code: Challenges - Sub-code: Awareness - Sub-code: Climate change
	''You can have green roofs and all those kinds of solutions that can hold water and to flow towards the sewage system or towards the street level, that helps.''	Main code: Spatial Design - Sub-code: (Flood regulating) ES*

3.2. Secondary data methodology

Firstly, the data as collected from secondary sources, gathered based on the qualitative data collection methods. Secondary research includes:

3.2.1. Literature review

It was acknowledged that reading and reviewing academic literature is a requirement to relate the researcher's own ideas to a wider understanding of the discipline (Clifford et al., 2016). In order to begin with the literature search, data methodology should identify and construct a list of key search terms (Clifford et al., 2016). The search engine of Google Scholar was used on 'Coastal flood resilience', 'Ecosystem services'; 'Socio-spatial justice'; 'ES justice'. Moreover, the bibliographic database Science Direct on scientific publications was used to filter relevant data on selected case studies of Riga and Rotterdam. For this research study, the literature review laid the foundation for theoretical understanding in order to conduct interview questions and to propose a theory-driven coding tree. Also, it gave answers to the theoretical sub-questions. Moreover, it also created the opportunity to compare the secondary research findings with existing literature (Clifford et al., 2016). Reviewing policy documents and plans of Riga and Rotterdam may indicate expectations of the research results.

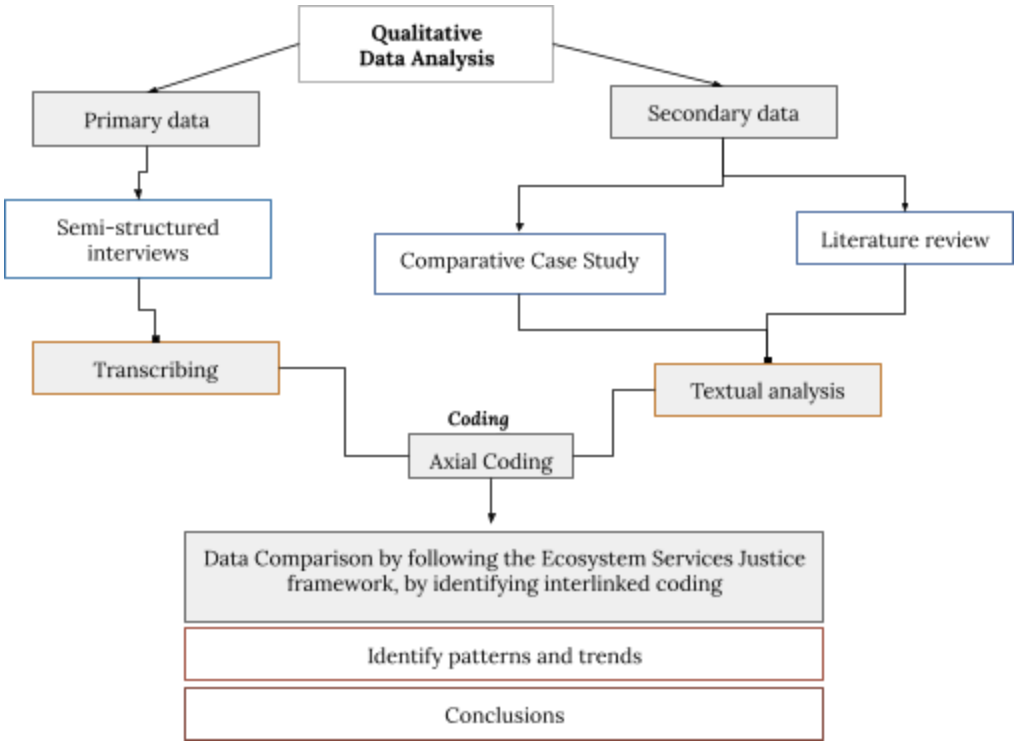
3.2.2. Comparative case study

Case study by Yin (2014) is defined as "an empirical inquiry that investigates a contemporary phenomenon (the 'case') in-depth and within its real-world context" (p16). In evaluation, case studies can be used to capture the complexity of a case, including temporal changes, as well as explore the contextual conditions of a case. In a comparative setting for research like this, temporal changes and flood defence evaluations can be used to explain the causal links between the effectiveness of ecosystem services as a resilience strategy. Previous findings indicate that comparative study promotes a model of multi-sited fieldwork that studies through and across sites and scales (Yin, 2014; Barlett & Vavrus, 2017). It encourages simultaneous and overlapping attention to three axes of comparison: horizontal, which compares how similar policies or phenomena unfold in locations that are connected and socially produced; vertical, which traces phenomena across scales; and transversal, which traces phenomena and cases across time (Barlett & Vavrus, 2017). Therefore, this method is applied to help to understand the paths of different regions or nations and to detect patterns of similarities and differences across these (Nadin & Stead, 2013). Likewise, comparative research is necessary to inform policymakers of alternative policy approaches when facing similar societal problems (Barlett & Vavrus, 2017). This also mirrors the framework of Ecosystem Services justice framework, it enables a more effective way of identifying how changes in ecosystems can influence human well-being, where the security from flood disasters is just one aspect and provides information in a form that decision-makers can obtain other information on social, ethical, cultural, technical and ecological aspects. An in-depth characterization of the research area can be found in Section 1.3 'Case Selection and Description' and further elaborated in Chapter 4 as a comparative case study by using the historical timeline and providing analysis across spatial scales.

3.3. Data Analysis

In this research, qualitative data is referred to as non-numeric information such as interview transcripts from primary data collection and text documents from secondary sources. The categorization of data will be necessary by means of coding, or in other words, identifying short phrases that represent a relevant topic for the research question. Specifically, axial coding interlinked the categories of codes by using qualitative data analysis software Atlas.ti. To identify common themes throughout the different semi-structured interviews, coding was applied according to the categorisation of a coding tree (See Appendix A). An analysis scheme is shown in Figure 6 of undertaking a qualitative research project.

Figure 6. Analysis scheme of qualitative data - primary and secondary.



3.4. Ethical considerations

According to The Netherlands Code of Conduct for Research Integrity issued principles, the data collection process should be transparent, making it clear to others on what type of data the research was based on, how it was obtained, how the findings were achieved, and also indicated what role played external stakeholders. Ethical consideration within the research design mainly concerned COVID-19 safe environments when conducting an in-depth interview. The interviews were held via an online platform Google Meet on a voluntary basis. Therefore before the interview took place, the informed consent was sent out electronically. See Appendix B for an example. By signing the document, interviewees confirmed that they agreed with the explicit agreements.

4. Research results

This chapter presents the research results of the comparative research study, following the structure of the theoretical framework, specifically based on the Ecosystem Services Justice framework (see page 11-13).

4.1. Comparative case study

This thesis explores ways to manage coastal flooding impact from a holistic perspective in a comparative case study of urban coastal delta cities of Riga and Rotterdam. Accordingly, the empirical urban ecosystem services justice model, introduced by Langemeyer & Connolly (2020), is applied to recognise temporal and spatial asymmetries in the distribution of benefits for climate-just urban environments in the perspective of ecosystem services (ES). In turn, larger spatial and temporal justice goals can only be built upon functional distributional, recognition, and procedural justice measures.

Temporal scale To illustrate how the urban and peri-urban areas have been flooded in the past, the historical timeline is used, with respect to institutional and spatial design initiatives respectively (See Figures 9 and 14 of Riga and Rotterdam case studies). Current practises of flood mitigation respond to the literature review and the information from semi-structured expert interviews, as part of primary data collection. Future coastal flooding climate scenarios are retrieved from the Climate-Adapt EEA Europe assessment publications of climate change impacts in Europe, reaching a 100 year period. Further, the case studies of Rotterdam and Riga describe the vulnerability of flood risk.

Spatial scale Ecosystems are highly dependent on the larger enabling environmental processes. Often, ecosystems cannot be sustained by managing individual sites in isolation. Therefore the management is required across spatial scales with respect to flood risk management arrangements, concerning: 1) The institutional level of governance with respect to procedural ES justice; 2) The infrastructure of built and green environment practises regarding distributional ES justice; and 3) Perceptions with respect to values and the recognition of associated ES benefits (see page 11-13).

4.1.1. Case study: Rotterdam (The Netherlands)

As one the most densely populated city in the country, the Rotterdam urban area is not only vulnerable to inland floods (Esteban et al., 2020) but also, due to its geographical and geological position, the coastal and tidal-riverside location makes it threatened by storm surges and sea-level rise (Tillie & van der Heijden, 2016; De Urbanisten, 2014, Figure 7). Although Rotterdam's water management system is considered as robust and well-maintained, the city is experiencing extreme water levels (Gemeente Rotterdam, 2013). In latter-days intense weather patterns have become more common, and such events demonstrate how vulnerable the urban settlement is to changing climate (Gemeente Rotterdam, 2013). Accordingly, Expert 3 pointed:

''..Sea level is also rising and these amounts are becoming so big in spring and in autumn that the dikes are not giving enough space anymore to retain this water. So I think it is a build-up of how we have treated, or how we have done our water management in the past, and which was perfectly suited, but climate change is now showing a different pattern and our water management is not well fit for that."

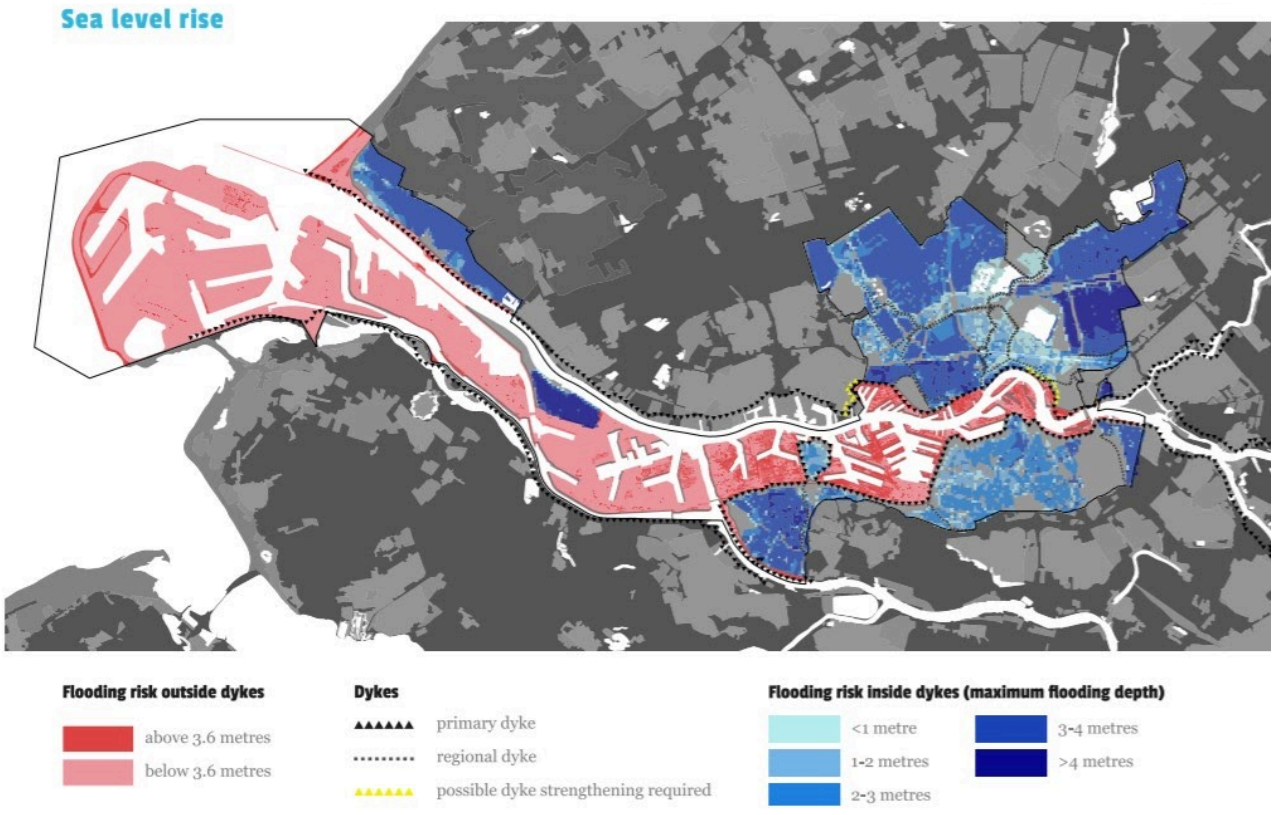
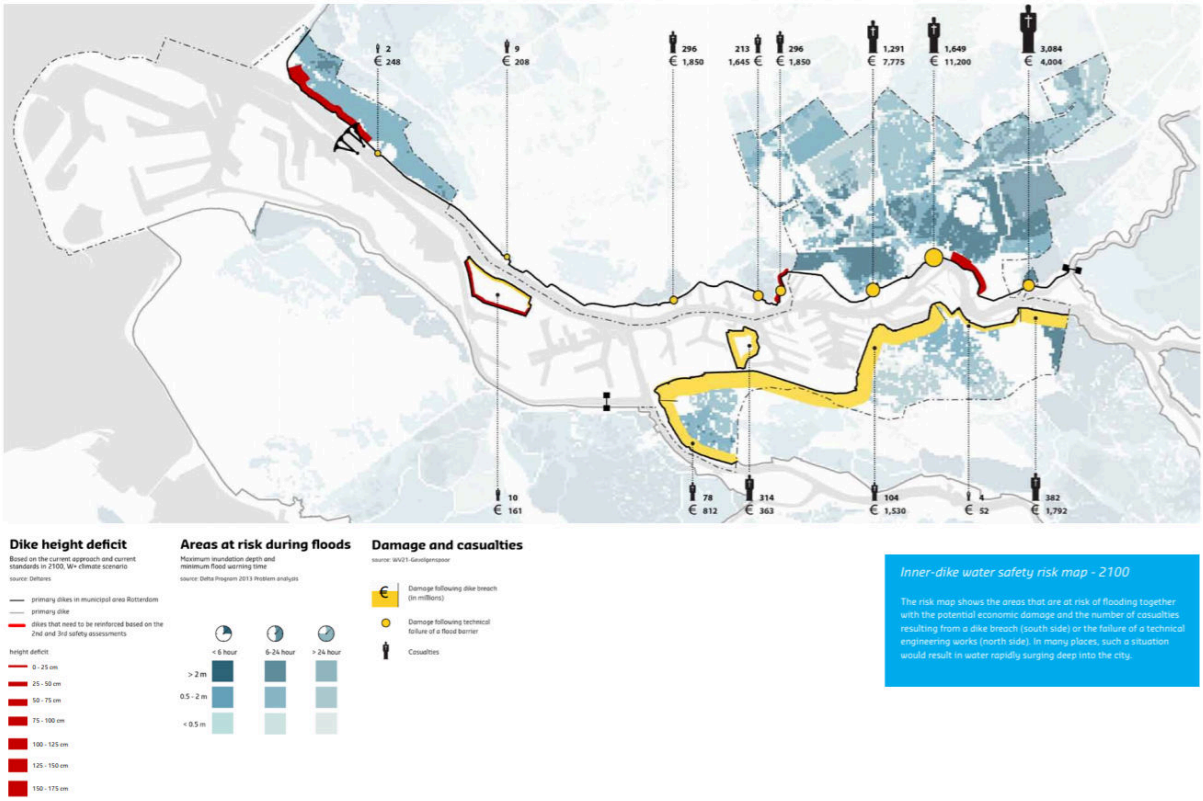


Figure 7. Projected sea-level rise effect on inner and outer dyke areas in Rotterdam. Source: Waterwise Rotterdam Urgency Document, De Urbanisten (2014).

Vulnerability of flooding from sea level rise in Rotterdam is the highest in outer dyke areas, where the elevation is the lowest (Gemeente Rotterdam, 2013). The inner-dyke area is secured by a network of dykes and barriers (Port of Rotterdam Authority, 2020). Specifically, the Maeslant storm surge barrier can handle a sea-level rise of up to 50 cm, and remain effective until 2070-2080 (Gemeente Rotterdam, 2013). This does not apply for the outer-dyke areas, where to limit the consequences, inhabitants are themselves responsible to take action (Port of Rotterdam Authority, 2020). The Rotterdam Port, although is open to the North sea and lays in the outer-dyke zone, is currently well protected against flooding (Port of Rotterdam Authority, 2020). With the flooding depth of exceeding 4m, the most vulnerable neighbourhoods can be indicated: Rosenberg located in-between the two waterways bordering with the outer-dyke areas. Also, the peri-urban areas, by the primary and regional dyke, of Bospolder & Tussendijken are highly vulnerable in case of unexpected defence breaches. Therefore, strengthening of protection is suggested (Gemeente Rotterdam, 2013); indicated in Figure 8. The highest flooding risk of sea-level rise in outside dyke areas has been indicated in Noordereiland, forming an artificial island by the river Meuse in the middle of the city. In case extreme flooding takes place, as shown in Figure 8, the impact in terms of the number of casualties and risk costs would be substantial (Gemeente Rotterdam, 2013).

Figure 8. Inner-dyke water safety risk map (Gemeente Rotterdam, 2013, p47).



Spatial analysis across historical timeline

The first water management defences in perspective of Rotterdam dates back to the 13th century when the dam Rotte gave the city its name; it was built to separate freshwater from saltwater and to give protection for first residents, which still forms the heart of the city today (Gemeente Rotterdam, 2013). Figure 9 visualises the main institutional responses of Flood Risk Management Strategies, taken place across the historic timeline. The continuation of increased flooding introduced Rose's canal plan [*The Singel Plan 1954*] to improve the water quality, and simultaneously, new canals gave the city additional social benefits of urban liveability (Gemeente Roterdam, 2013; Esteban et al., 2020). The historic cornerstone for water management has been marked by the disastrous floods of 1953, with the birth of the Delta Works to avoid such a catastrophe happening in the future again (Esteban et al., 2020). Specifically, in the 90's it originated the Maeslant storm surge barrier (Gemeente Roterdam, 2013). Since then, the governmental institutions have had a strong understanding of flood vulnerability on Rotterdam's flood risk. The Rotterdam Water Plan was introduced first right after *the National Flood Defence Act in 1997*. Specifically, for flood risk management by soft measures the year 2000 was a turning point, followed as a response to flooding events in 1995 and 1998 acknowledging the need for an ecosystem approach. A new policy '*Different Approach to Water in the 21st Century (Ministry of TPW, 2000)'* was introduced with the aim to deal with the excess and surrounding water, not by the traditional practises of applying hard infrastructure measures, but by focusing on giving more space for water to flood (Esteban et al., 2020). Moreover, the Second Water Plan of Rotterdam was adopted in 2007 in order to address climate change through adaptive measures (Tillie & van der Heijden, 2016; Esteban et al., 2020). In fact, it was integrated into the Rotterdam City Vision 2030 to make the city more liveable by a greening policy, which originated from studies and strategy developments in the Architectural Biennial back in 2005 with a central theme '*The Flood*'. For example, Room for the River was a government initiative, active from 2006-2015, which addressed flood protection and environmental conditions in the areas surrounding the Netherlands' rivers, by increasing the discharge capacity and improving the spatial quality of aesthetics (van Alphen, 2020). Respectively, Expert 3 mentioned:

''..Room for the river. There are several programmes that give more flooding space, provide more greening design. This particular project gives flooding space. But there are a lot of other examples; they call it: Nature-inclusive structures, with respect to ecosystems, to give more surplus value to nature with ecosystem services''.

At the same time in 2006, an adaptation program the Rotterdam Climate Initiative (RCI) also envisioned to be the leading role in water management and resilience to climate change, creating a movement of collaboration between the government, institutions, companies and citizens (Gemeente Rotterdam, 2013). For the largest European port city, carbon dioxide reduction and energy savings were crucial to achieving a status of Climate-proof Rotterdam by 2025, and therefore nature-based solutions could not be avoided

anymore. This was strengthened by joining the Rockefeller Foundation in 2014 of the 100 Resilient Cities network (Esteban et al., 2020), and therefore introducing the world with more and more examples of collaborative urban ecosystem resilience. A recent example is an initiative of GoBotu 10-year action plan of the first resilient neighbourhood in Rotterdam (GoBoTu, 2019). Endorsed by the mayor, the plan intends to climate-proof the district in a way that will bring the area's social and economic standard in line with the city's average.

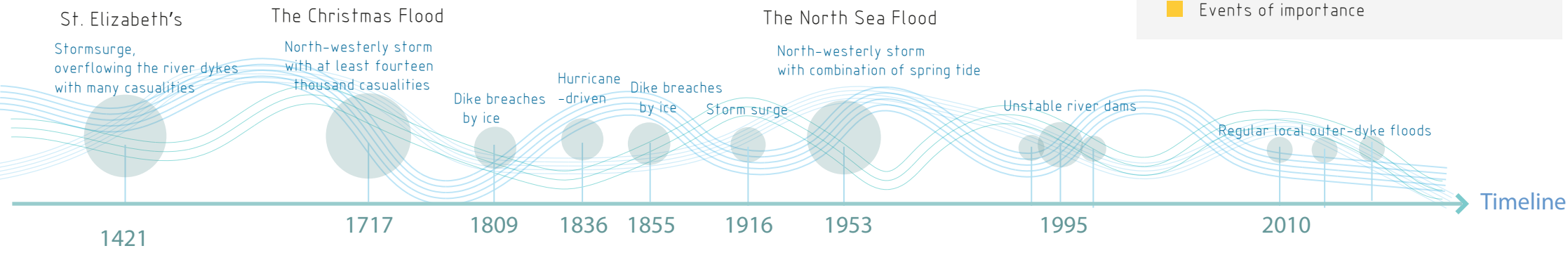
Figure 9. An overview of spatial analysis across the historic timeline with regard to Rotterdam's flood resilience initiatives of institutional and infrastructure responses (Author, 2021; based on the Rotterdam Climate Initiative, Gemeente Rotterdam (2013); Tillie & van der Heijden (2016); GoBoTu (2019) and Esteban et al. (2020))

ROTTERDAM, CASE STUDY OF COASTAL DELTA CITY FLOODING

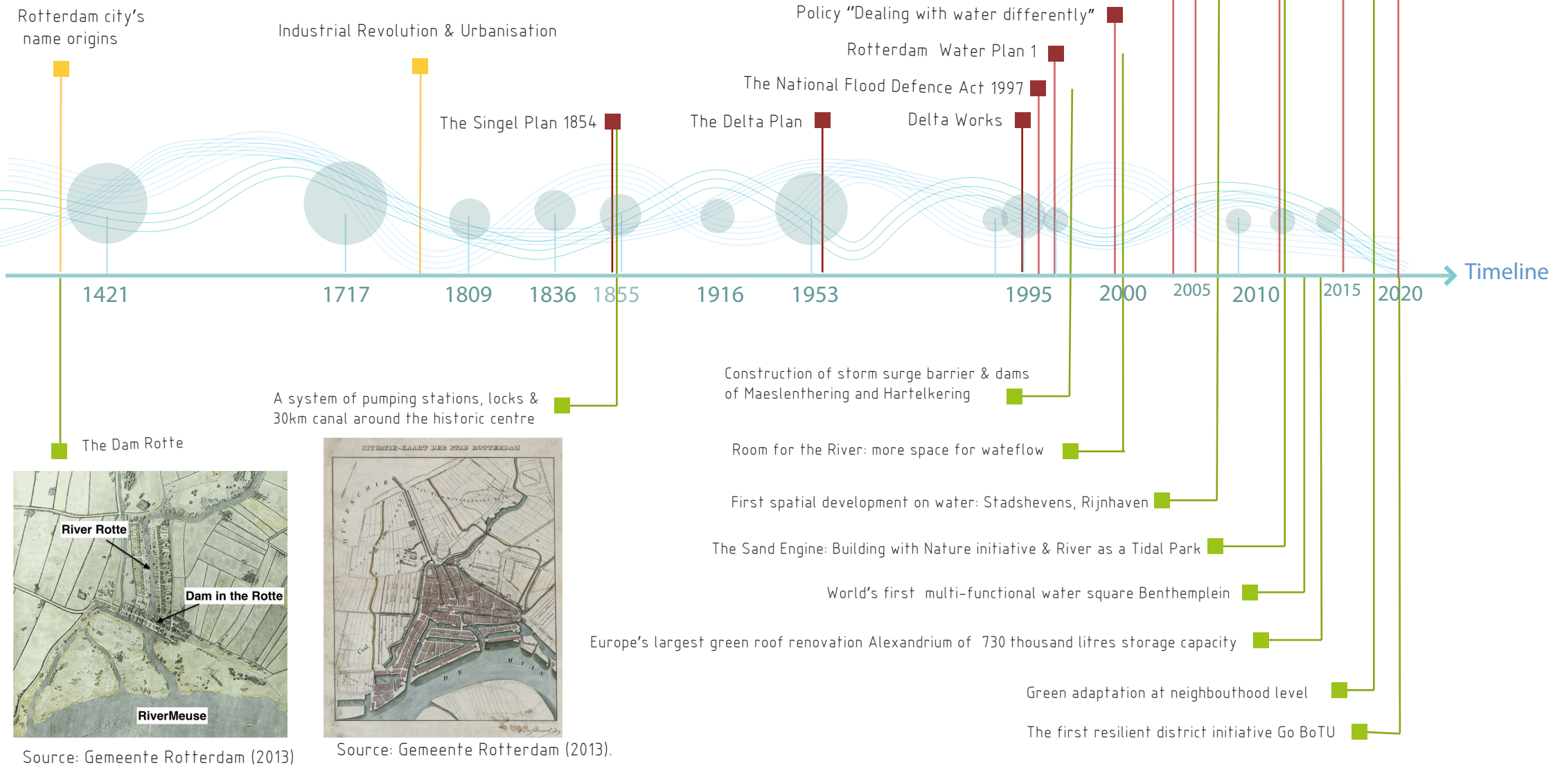
LEGEND

- Impact
- Major insitutional responses of flood control
- Spatial Design initiatives of flood control
- Events of importance

MAJOR HISTORIC FLOOD TIMELINE



SPATIAL ANALYSIS ACROSS TEMPORAL SCALE

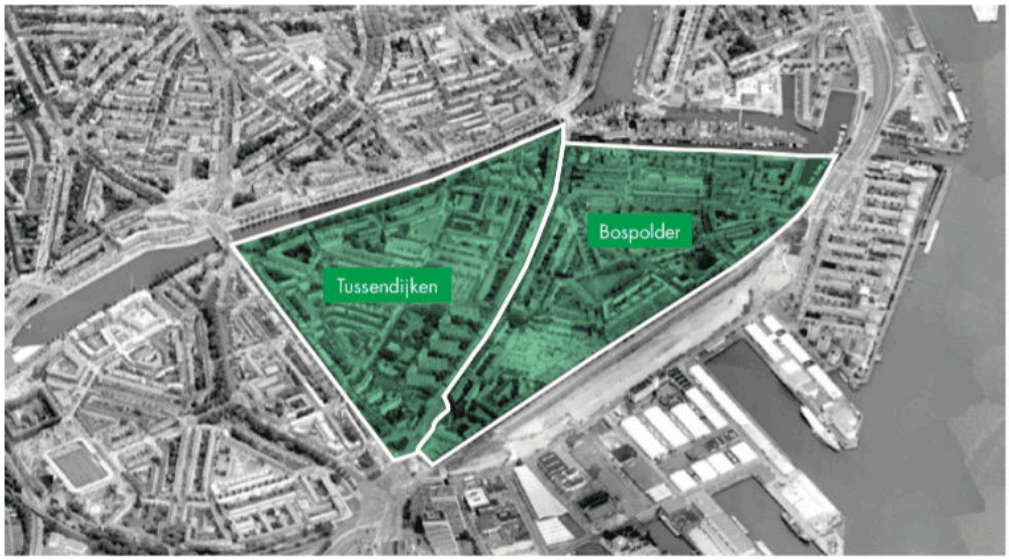


Source: Gemeente Rotterdam (2013)

Source: Gemeente Rotterdam (2013).

a) Procedural justice dimension of institutions

Climate adaptation programmes, including Rotterdam climate-proof initiatives, anticipates mutual effort from inhabitants, businesses and different interest groups (Gemeente Rotterdam, 2013). One of the most recent examples can be mentioned - the GoBoTu initiative. Expert 4 explained, when the resilience strategy process began, the Rotterdam's Mayor approached Chief Resilience Officer about the idea of making the model district for bringing social and climate resilience of the city's energy transition and water solutions together as tools to achieve a higher level of neighbourhood resilience. By doing so, it provides opportunities to strengthen the economic conditions, to improve the living environment of neighbourhoods and actively engage within decision-making (Gemeente Rotterdam, 2014). Launched in 2019, Resilient BoTu empowers the two adjoining neighbourhoods, Bospolder and Tussendijken, which are within of the five poorest neighbourhoods in The Netherlands and has the lowest social resilience scores (GoBoTu, 2019). Resilient BoTu builds on the work that the city began in the district over the past decade; although Expert 4 noted that it has received attention and investment in the past, a breakthrough was never achieved. In the urban environment, procedural justice is largely about the presence of equitable spaces of engagement (Martin et al., 2016) that determine who is involved with shaping the social, built, and ecological conditions of the city and based on participatory democracy across a wide set of stakeholders. Interlinked with the recognition justice dimension, to improve resilience is the acknowledgement of recognizing unequal power relations and influences in ES governance (Martin et al., 2016). Another lesson Rotterdam learned as part of the Resilient Cities Network, the BoTu Foundation invited stakeholders and inhabitants to propose initiatives to help the district address some of the district's specific resilience challenges, including climate adaptation, family support, debt management, job preparedness and public spaces (GoBoTu, 2019).

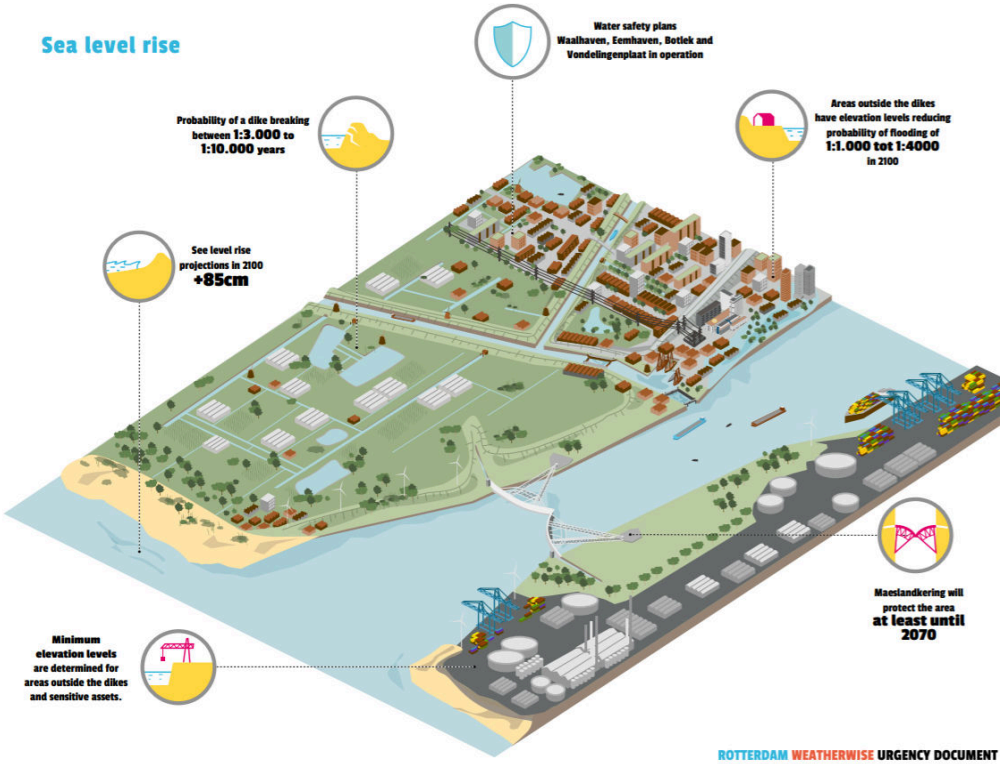


Further, a description will be given on the relevant application of ecosystem services overlooking the realised initiatives within the built environment, responding to distributional justice. An example is described concerning the Building with Nature initiatives and River as a Tidal Park project. The information is based on the review of web pages and policy documents, as well as the analysis of expert interviews.

b) Distributional justice dimension of the built environment

In the case of Rotterdam, natural sand dunes, constructed dikes and floodgates ensure protection against coastal wind-surges (Gemeente Rotterdam, 2014). Due to increased river flow, caused by large volumes of melt and rainwater from the upstream regions, a new approach was needed (Municipality of Rotterdam, 2019). Distributional justice is elevated for ES because a specific planning intervention may shift benefits and drawbacks to other social groups. As part of the Rotterdam Climate Adaptation Strategy 2050, instead of continuing to increase the height and size of the dikes, it required an area-specific approach to adapt the infrastructure to changing circumstances (Municipality of Rotterdam, 2019). Therefore shifting the delivery of multiple ES for a few, to recreational benefits for the many. For instance, in outer-dike Rotterdam, the principle is multi-layered flood protection based on adaptive approach by 'Building with Nature' and water-resistant public spaces (Municipality of Rotterdam, 2019). Behind the inner-dikes, methods like water squares and bioswales capture and store rainwater. For a detailed overview of spatial measures against seal-level rise, see Figure 10 .

Figure 10. Infrastructure measures against the sea-level rise in Rotterdam (Municipality of Rotterdam, 2019).



Reinforcing the dikes, for low-lying areas, is also part of the city's spatial design task(Municipality of Rotterdam, 2019). Within the densely built-up parts of Rotterdam, the dikes are multipurpose designs that have been applied in several locations across the city with respect to ecosystem services. The attractiveness of the dikes in Rotterdam plays a part in making the inhabitants more aware of the risks of flooding (Municipality of Rotterdam, 2019, Figure 11).

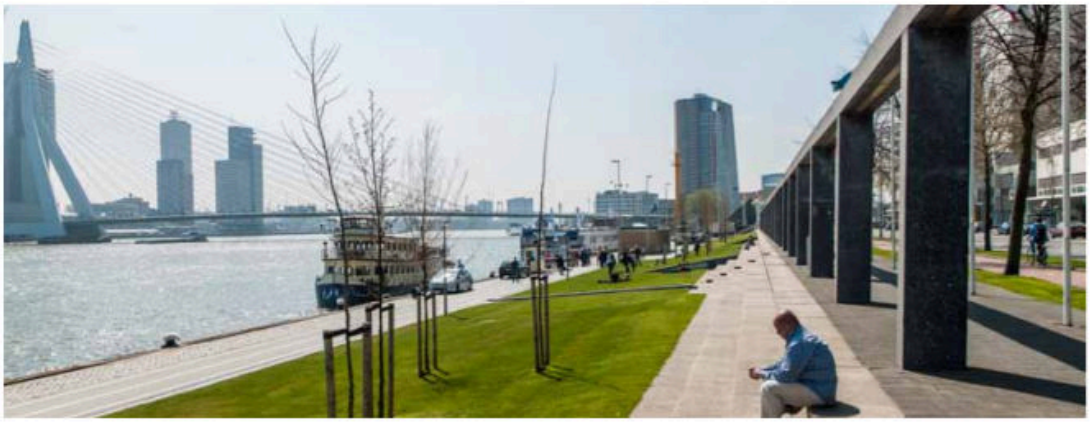


Figure 11. Multifunctional dikes form an attractive recreational landscape by the river Meuse.

In the context of multi-functionality, Building with Nature (BwN) is a design philosophy that uses natural processes (ecosystem services) to contribute to solving the challenges in ports and delta cities in such a way that ecological, economic and societal benefits are combined (De Vriend et al., 2014). For instance, it contributes to reducing the ecological footprint of port infrastructures and can be applied to reduce flood risk and improve sediment management or increase flooding space. Additional benefits include the creation of attractive, green living environments within the densely populated neighbourhoods. For example, The 'River as Tidal Park' programme was introduced with BwN measures to soften the river banks (See Appendix G). In Mallegat Park, a dam was built to create a natural tidal area covering 1.5 hectares. Experts of Rotterdam indicated that the benefits included the enhancement of natural values and the relationship with the tidal system, and the general public became aware once again of the tidal system. For instance, Quote (Expert 3): *''..And with that, by showing that the river is a dynamic system, you can also create an awareness and an understanding among citizens that you live in a very complex hydrological situation. ''*
Moreover, the local projects enhanced ecological value by attracting wildlife and by creating mudflats and salt marshes. However, there were also other important reasons for the implementation of these projects: improved flood risk management and water quality and recreational possibilities with knowledge development in the field of BwN. Lastly, experts explained that it allowed for positive interaction with the system, by ultimately delivering projects with benefits for various stakeholders (Expert 3; Expert 4, 2020).

The following chapter will introduce a recognition justice perspective in the case of Rotterdam via consideration of the different social values and preferences in the decision-making process. This is presented by the Green Roof programme and multi-functionality benefits by means of ES, as part of the Rotterdam Climate Initiative.

c) Recognition justice dimension of perceptions

Steele et al. (2015) stressed that the greatest injustices for urbanites might be concerning particularly peripheral areas of cities, where, unless supported by third parties, impoverished people have limited means and capacity to respond to climatic events and adapt to anthropogenic environmental change. Awareness-raising amongst coastal residents and other stakeholders that their system is changing, sea level is rising, and that each storm is different in terms of track, size, and intensity is crucial. For instance, residents of Noordereiland experience low level flooding every 2–5 years usually during the storm season. Since the residents regularly experience flooding and seawater daily they understand that living in the area comes with risks of flooding (Gementee Roterdam, 2014). Experts pointed out that the public awareness of flooding risk from climate change has always been there in the Netherlands, and that also by recognizing this internationally, other countries are also becoming aware of the climate risk. This also concerns inland flood risk management, where consideration of the different social values and preferences are included in the decision-making process. Recognizing that all residents can play a significant role not only to manage pluvial flooding but also to improve the spatial quality of life by means may ensure equitable power relations and influences in ES governance (Martin et al., 2016). Besides the previously mentioned GoBoTu initiative, one of the examples can be mentioned on the Green Roof programme. The municipality of Rotterdam has been a front runner on green roofs for years; over 360,000 square meters of green roofs have been installed (Gementee Roterdam, 2014). Gradually a change is taking place from green roofs towards multifunctional rooftop use. Adding to this, Expert 3 explained: *".. you can have green roofs and all types of solutions that can hold water and to flow towards the sewage system or towards the street level, that helps. People think it's really a minor effect, but it can have a large effect if you have enough green roofs. And also, I mean, those are nature-based solutions for water management. People tend to always look at one benefit for solutions. It's a combination of all types of benefits."* Expert interviews showcased for the recognitional justice that preferences are not only influenced by ES governance amongst public organisations but also in the world of investors; one factor is adapting to circumstances 'but if the risk is too large, the outcome is not profitable'.

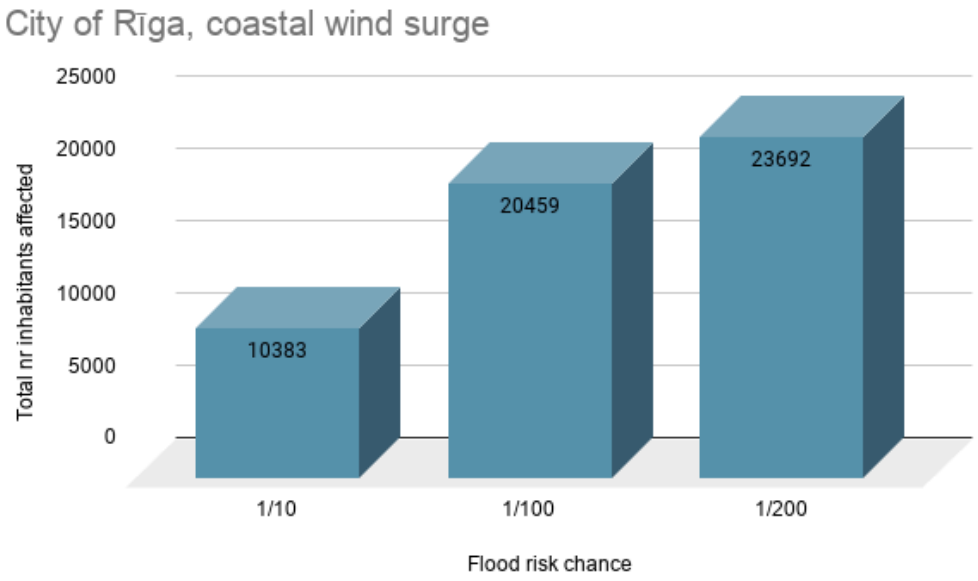
To conclude, a more profitable business case can be developed for entrepreneurs by combining various functions on rooftops, and citizens can benefit from multifunctional roofs of their added value in liveability. The main functions also include improving biodiversity, delaying excess water and providing social functions, to tackle lack of space and enhance social cohesion.

4.1.2. Case study: Riga (Latvia)

This section will introduce another comparative site in a study of coastal flood resilience. The following section indicates the most vulnerable neighbourhoods of future coastal flooding, based on the national datasets.

Due to increasing sea level rise, the Latvian coastline and urban territory of Riga are highly vulnerable to future climate change effects (Klavins et al., 2007). Based on IPCC A1B scenarios, it suggests that future climate changes will significantly increase the urban flood areas, the estimate by Rīga city planners is that the current 1% probability of Riga's flooded area of 31.1 km2 will increase in 2100 by 28 per cent (IPCC, 2012; RigaCityCouncil, 2013). The total number with the flood risk areas reaches at least 20 thousand people affected (See Figure 12; METEO, 2020). Other risks concerning climate change adaptation are related to sea storm surges, increasing river discharge trends and flash floods due to intensive precipitation and outdated technical infrastructure of the urban water system (Briede et al., 2012). The existing flood protection system in Riga (polders, sewage pumping stations, dykes, water level regulators etc.) protects the urban territory from wind surges, which in the Daugava mouth do not exceed two meters (Malakova et al., 2017). However, it is expected that at the same flood probability the water level will already reach a 2.60 mark (Malakova et al., 2017). The earliest observations of river discharge in Latvia can be dated back to the 19th century, essential for effective water resource management and therefore has immense socio-economic significance (Klavins & Rodinovs, 2007). According to the most recent data of the European Environment Agency, the economic losses caused by the extreme weather conditions in Latvia in the period from 1980 to 2017 amounted to 412 million euros.

Figure 12. Coastal wind surge characteristics of the total number of inhabitants affected according to flood risk change (METEO, 2020).



At the risk of potential sea-level rise is Rīga city's 15 km of the coastline and about 60% of land adjacent to the river (RigaCityCouncil, 2013). Obtained from the Latvian Environment, Geology and Meteorology Agency, METEO (2020) indicates the most vulnerable areas with the highest number of inhabitants for future flooding risk in Bolderaja (Daugavgrīvas sala), resulting in at least 6000 people affected from coastal flooding with a 1 in 100-year risk chance. See Figure 13 of the top left imagery, with the orange indication showcasing the total number of inhabitants affected. Significantly vulnerable is also the neighbourhood of Sarkandaugava, resulting in around 4000 inhabitants being at risk (METEO, 2020). These are both lower elevated neighbourhoods located close to the coastline and river Daugava banks and estuaries. See Figure 13 for 1 in 100-year flood risk visualisation of the urban territory of Riga, including the vulnerability of buildings of Sarkandaugava neighbourhood.

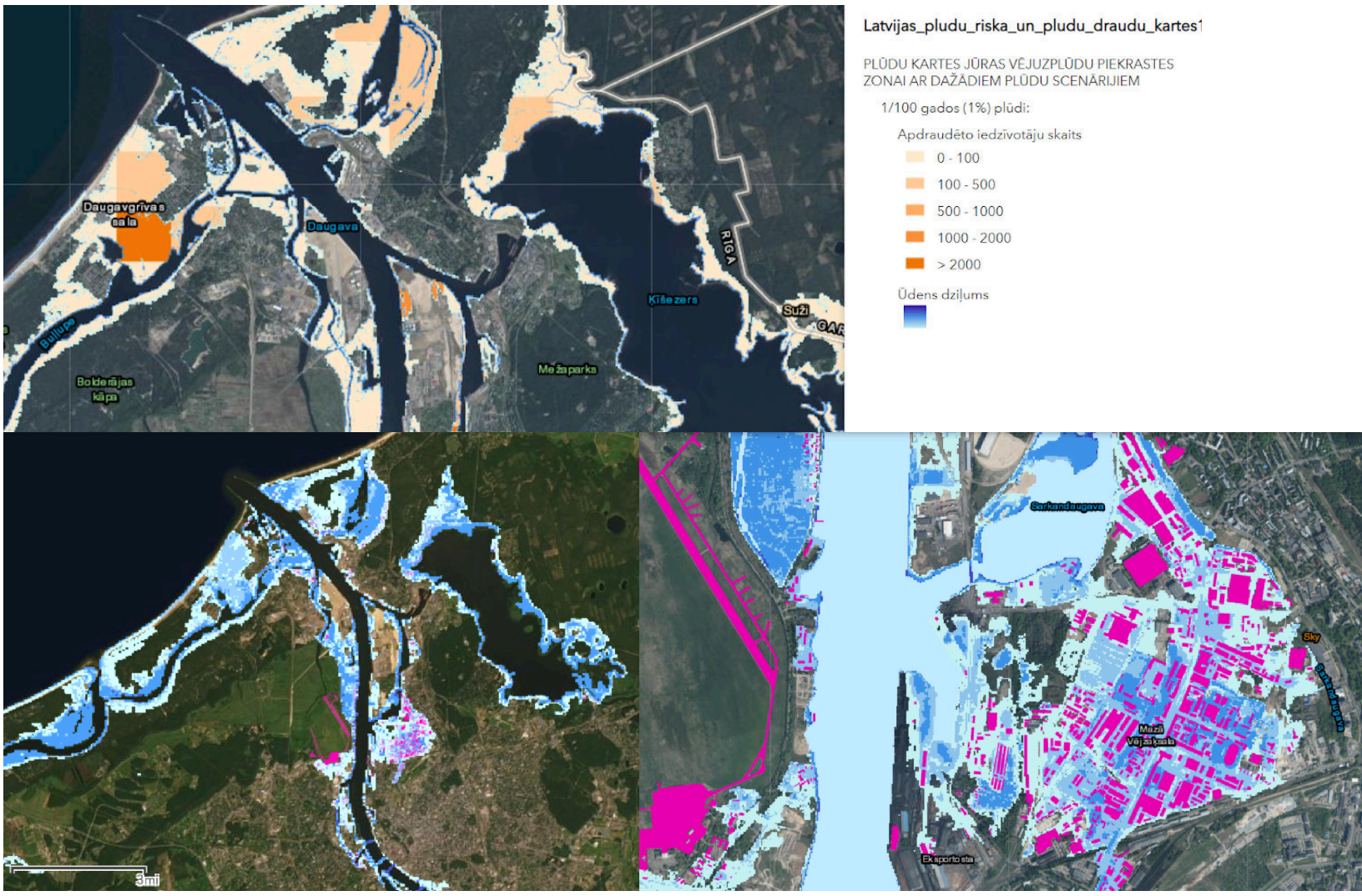


Figure 13. *Coastal flood risk modelling along the river Daugava, obtained from the Latvian Environment, Geology and Meteorology Agency (METEO, 2020).*

Spatial analysis across historical timeline

In the history of many medieval cities fortified walls and city gates, clogged in the spring, was the only escape from the blockade of ice and flooding. Figure 14 visualises the main Riga's institutional responses of flood risk management strategies taking place across the historic timeline. Safer flood protection was achieved when the city expanded beyond the medieval walls and was completely surrounded by ramparts 11–12 m high and more than 30 m wide (Briede et al., 2011). The construction of these ramparts began in 1537 and lasted until the end of the 16th century, and in 1567 a special port gate was built for it, which was closed in spring to prevent water from entering the city. After the construction of the ramparts, an artificial water barrier or city moat was erected in front of the ramparts. The first scientific study on weather conditions in the Baltics and on river runoff and flooding, based on historical evidence is E. Moskovkina's book '(Floodings on the Daugava River). Over a period from the year 1000 until the second half of the 19th century, especially catastrophic spring floods on the Daugava River occurred most often from 1600 to 1860. The rise of catastrophically high water levels from 1600 to 1700 can be explained for the most part by the fact of rapid deforestation, land cultivation and reclamation relating to the increase in population, development of agriculture, construction of buildings in cities and countryside, the building of ships, and also exports of timber (Klavins et al., 2007). After 1857, when Riga lost the status of a fortress, the gradual demolition of the ramparts and the partial transformation of the moat into a city canal began. Although with the construction of Riga's HES (Hydro-electric Power Plant) in 1974, the risk of snowmelt floods, that used to be one of the major causes of flooding in the past, had been minimized. In order to build Riga HES, a dam was constructed across the Daugava River through the middle of Doles Sala, half of which has since been flooded to make room for Riga Reservoir. Due to the dam, the risk of increased summer rainfall and winter storm surge floods have risen (RDPAD, 2012).

Only recently, the traditional way of 'coping with floods' had a turning point for the Riga's flood risk management with the policy document ''Riga Against Floods'' in 2012. The impulse of this was given by The Floods Directive 2007, requiring the Member States to carry out an initial flood risk assessment based on which flood risk areas are to be identified in each river basin district and to prepare flood hazard and management plans. Until 2007, the only policy planning document that determined the action and cooperation of the responsible institutions in taking preventive, preparedness and response measures in the event of floods was the National Civil Protection Plan (Latvijas Vestnesis, 2007). That plan contained only general information on the areas at risk of flooding but did not propose specific solutions for preventing the risk of floods in those areas. Moreover, for the recent decade there have been major flooding events in 2005 and 2010, and in fact, have continued yearly during the spring and autumn months. These incidents concerned the existing sewerage system, incapable of dealing with the excess stormwater and rainwater. Following these events, the Municipality of Riga launched the project of "Integrated Strategy for Riga City to Adapt to the Hydrological Processes'. This is the first project to

estimate the possible flood risk to Riga City, with recommendations of flood prevention measures (RDPAD, 2012). Recently, 'Latvian National Plan for Adaptation to Climate Change until 2030' (CCA Plan) was developed for inter-ministerial coordination and public consultations. The CCA Plan aims to reduce the vulnerability of people, economy, infrastructure, construction and nature to the impacts of climate change (CC) and to promote the use of potential opportunities.

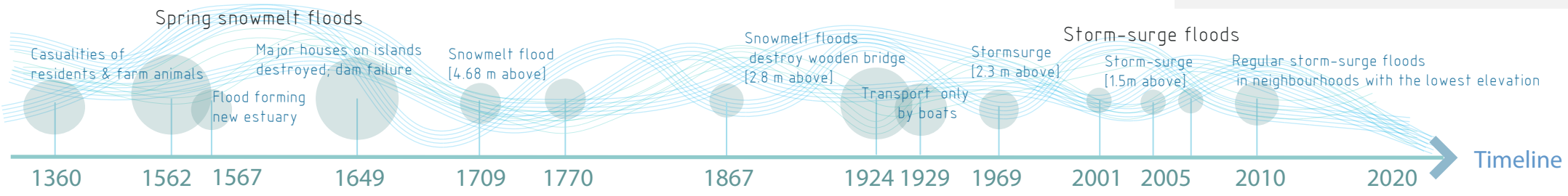
Figure 14. An overview of spatial analysis across the historic timeline with regard to Riga's flood resilience initiatives of institutional and infrastructure responses (Author, 2021; based on Latvijas Vestnesis, 2007; Briede et al., 2011; RDPAD, 2012 - *Riga Against Floods* programm).

RÍGA, CASE STUDY OF COASTAL DELTA CITY FLOODING

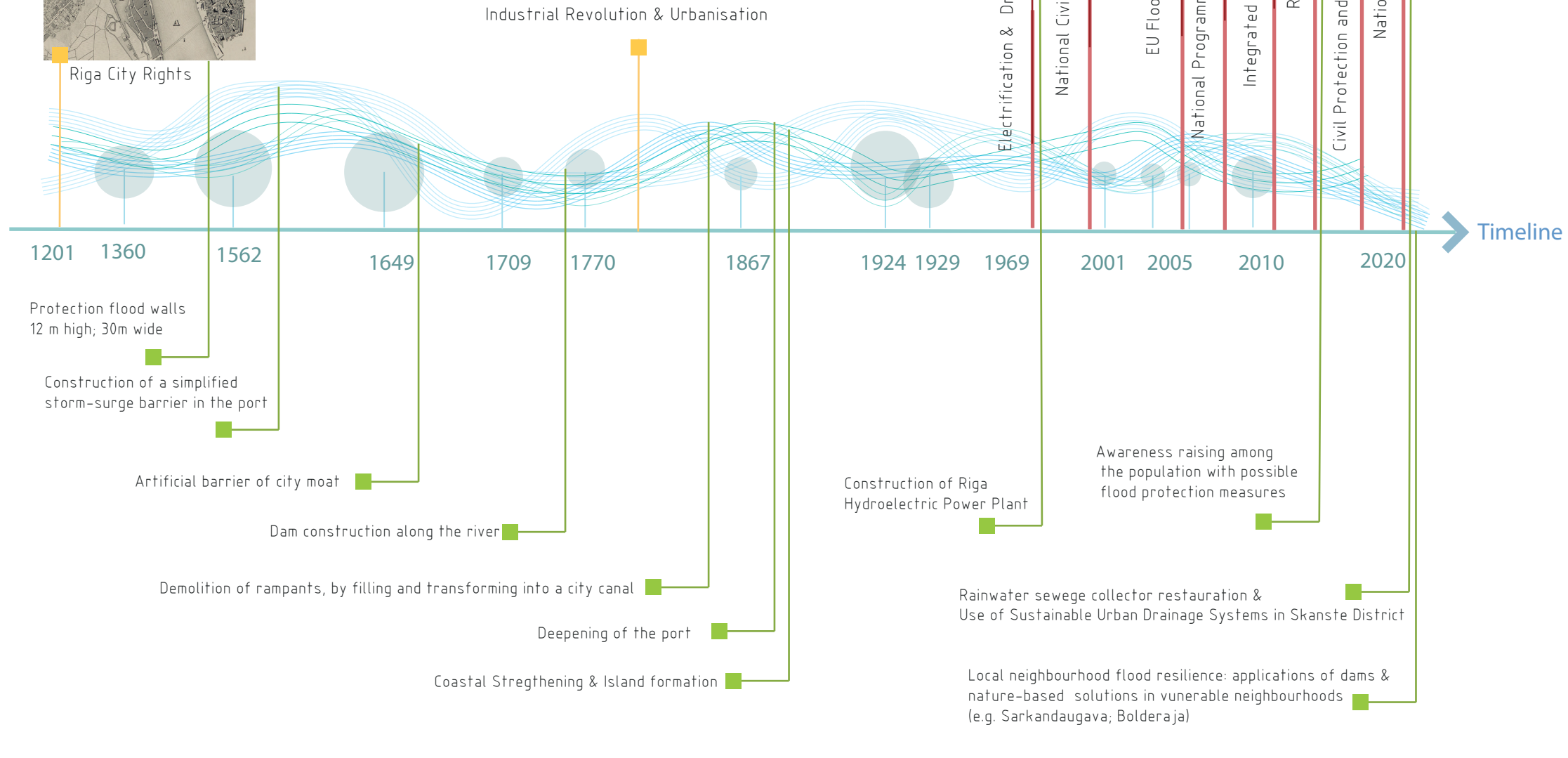
LEGEND

- Impact
- Major insitutional responses of flood control
- Spatial Design initiatives of flood control
- Events of importance

MAJOR HISTORIC FLOOD TIMELINE



SPATIAL ANALYSIS ACROSS TEMPORAL SCALE



Further, a description will be given on the relevant application of ES overlooking the dimension of procedural justice by participatory democracy and communicative engagement. An example is described concerning the Skanste district project. The following section gives an overview of the Riga Against Floods 2012 policy implications for distributional justice.

a) Procedural justice dimension of institutions

Currently, Skanste occupies the largest underdeveloped territory near the historical centre - the former floodplain meadows around the Sarkandaugava tributaries; the nearby neighbourhood of Sarkandaugava is amongst the most vulnerable of coastal flooding risk in Riga (METEO, 2020). Despite the convenient location, the former city pastures have been left empty due to high groundwater, flooding and a soil base unsuitable for convenient construction, as the historically most important watercourse - Sarkandaugava - has been filled up (Pabērza, 2020). The neighbourhood has a large proportion of undeveloped and degraded territories, which forms a significant reserve of public outdoor space (Pabērza, 2020). Specialists of the Riga City Council together with experts informed about the development solutions of the Skanstes territory, including the vision of the future park, rainwater collection system, as well as the construction of newly built streets and related infrastructure (Figure 16-17). In addition, the Skanste site of the Sarkandaugava tributary has an industrial character of the place, along with the development of the railway, extensive pastures and meadows, as well as the culture of small gardens, which has been inhabited since the 20th century (Pabērza, 2020).

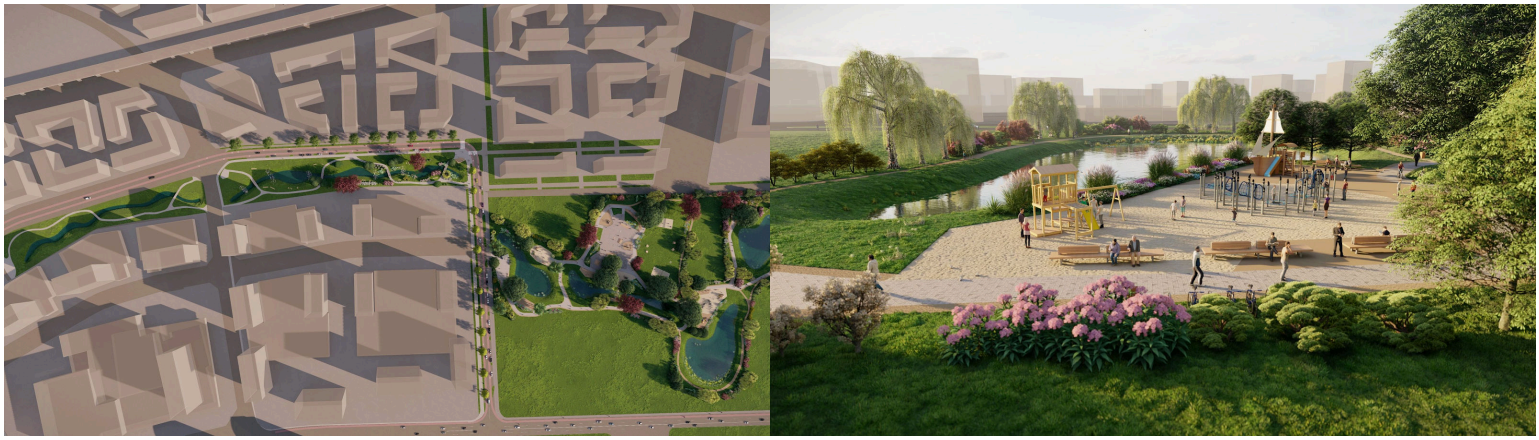


Figure 16-17. Skanste District project visualisations by use of Sustainable Urban Drainage Systems (Pabērza, 2020).

With the Skanste project development, procedural justice determines the societal access to ES, and largely depends on who is allowed to take part in decision-making processes (Fisher, 2009). Expert 5 explained that some have used the opportunity offered by the municipality to rent land for the needs of a vegetable garden elsewhere in Riga. In terms of the affected party participation, namely for the residents and owners of the

former gardens, communicative engagement was excluded in the planning process, according to the expert interview. The municipality of Riga has noted that all Rigans living in the territory of the former small gardens of the Skanstes territory have found new homes, as well as provided other types of social assistance. Temporary land lease agreements for vegetable gardens were formed with a total of 83 persons (Municipality of Riga, 2020). To conclude, Skanste, as a modern centre of Riga, is becoming a multifunctional green oasis, giving the general public multiple benefits with the opportunity to participate in natural processes both directly and indirectly, while a minor group of residents have experienced adverse effects, not able to access ES, in form of private gardens with proximity to the city centre.

b) Distributional justice dimension of the built environment

After three decades of socio-economic and political changes, participation in urban planning is still an emerging practice in post-socialist countries such as Latvia (Akmentina, 2020). The turning point for Latvia's urban flood-risk governance came with the publication of 'RigaAgainstFloods' policy in 2012 with the increasing spread of information and consultations outside the Rīga City's municipal institutions (Expert 2). In close cooperation between the specialists of Rīga municipality and the Latvia University, possible adaptation options for urban development were prepared (Figure 18; RigaAgainstFloods, 2012).

The outcome proved that in spite of public finances cuts at the national level, the local level and the expert community was capable of attracting EU funding (BaltCICA and Life+ project) and continued to work towards safer places and thus climate change adaptation measures for vulnerable communities (RigaCityCouncil, 2012; Expert 2). According to Expert 1, the policy plan also revealed that Riga has a rather high number of flood-prone areas that tend to be unconnected with water management. Therefore for developing flood prevention and climate change adaptation measures there is a need to define comprehensive criteria for planning purposes (Expert 2), including prioritization of measures via the continuation of participatory planning (Akmentina, 2020).

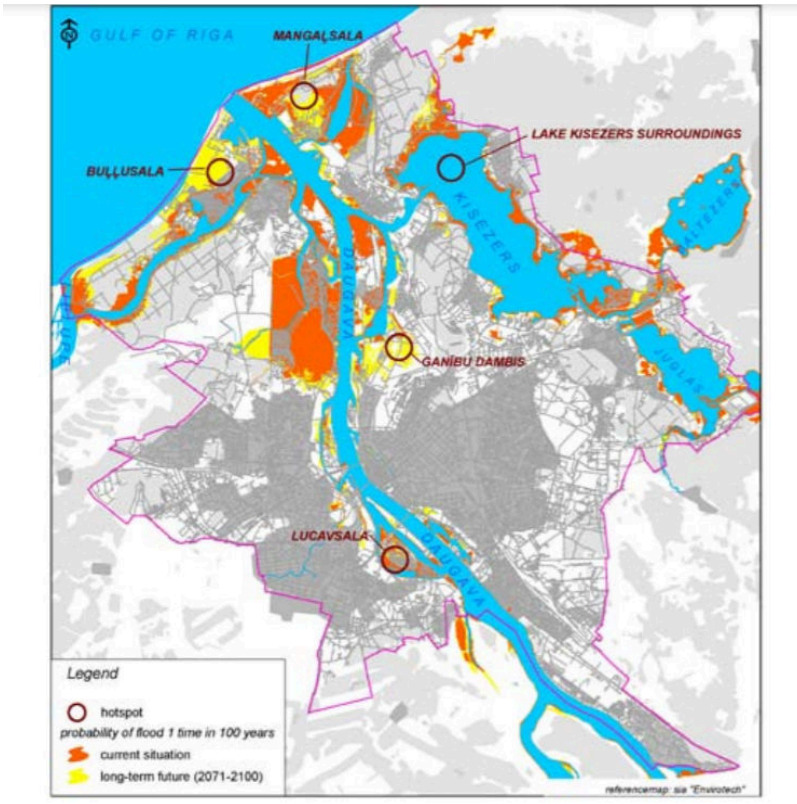


Figure 18. Indication of hot spots under discussion that were identified as places for technical structures for climate change adaptation measures (Riga City Council, 2012)

c) Recognition justice dimension of perceptions

Although many Eastern and Central European countries have looked to the Western democracies for practices in urban planning, adjusting their planning system in a relatively short time was rarely possible due to varied features of the post-socialist context (Nedovic-Budic, 2001; Akmentina, 2020). Lack of individual initiative and personal responsibility, low level of participation in the public domain (Prilenska & Liias, 2015), the misbelief of climate-change and pessimism (Auzins, 2018) have had a continuous impact on participatory planning resulting in fragile and sensitive societal democracy (Guesti, 2016); but with emerging positive tendencies in the recent years (Treija & Bratuskins, 2017; Akmentina, 2020). One of the most recent events with regard to the resiliency of Daugava river has been the pilot project by Augmented Urbans (Medium, 2020); the Water Club exchanges competences for cross-industry collaboration by bringing added value to both academic research and real-life practical development. 'Augmented Urbans' initiatives provide the city of Riga a unique perspective and tools for a resilient future by expanding the knowledge from the banks of river Daugava to Riga metropolitan region. In collaboration with Riga Technical University, the workspace acts as a playground of participatory planning processes for all interested parties, showcasing small-scale city interventions for public engagement and changing attitudes (Medium, 2020).

To conclude, participatory planning in Riga can be characterized as government-led participatory planning dominated by consulting strategies, but shifting towards increasing citizen involvement and local initiatives (Akmentina, 2020). To create positive efforts towards recognition of people's perceptions and values, a step forward would be to strengthen the focus on people's experiences of ES, in the form of dialogue, with specific emphasis on vulnerable, historically disadvantaged and silenced groups within society (Langemeyer & Connolly, 2020).

4.2. Result comparison: Rotterdam versus Riga

Spatial Analysis across Temporal Scale

While the flood risk governance in the Netherlands has a long history of preventing floods not only by spatial measures but also by governing the water management along the rivers; As an example can be mentioned the Water Boards, as the oldest demographic institution still existing, cooperating with the municipality of Rotterdam, which resulted in Waterplan Rotterdam 2 (Municipality of Rotterdam, 2007). The situation in Latvia becomes complicated due to its different regimes of governance and power relations as a post-socialist country (Guasti, 2016; Akmentina, 2007). Despite recent advances, for Riga's urban flood resilience many interventions still miss the warning signals of sudden surprises and struggle to cope with history, politics and long-term cumulative pressures. See Figure 8 and 14 (page 24 and 34) for an extensive analysis concerning the historic coastal riverine flooding and additional institutional responses and spatial planning interventions. The findings indicated similarities for both urban areas of Rotterdam and Riga, respectively institutional responses have followed the so-called shock events - in this study referred to major flooding. In water management, shock events tend to accelerate interaction patterns, stimulate response mechanisms, and can eventually lead to changes in rules and resources (Wiering, 2006). For Rotterdam, the most significant paradigm shifts to incorporate ecosystem services (known as, Dealing with water Differently' policy and 'Building with Nature' approach) came after the coastal storm surge flooding events in 1954 and 2000. Significant progress is made towards the stimulation of flood preparedness and consulting strategies for an increasing flood risk awareness. With respect to the Rotterdam case study, public participation in flood risk governance is not only government-led but in close cooperation with local stakeholder groups. This was proved by the Rotterdam Climate Initiative (RCI) established by local and regional organisations or the participation within Green Roof initiatives, offering a platform for multi-stakeholder governance. In the case of Riga, recent initiatives approaching ES for flood-risk has been noted with the increasing awareness by the participatory planning process (Akmentina, 2020). The selected cities of Riga and Rotterdam are intensively focusing on flood resilience, and outcomes are increasingly recognized among communities. An analysis has been given in Figure 19, comparing the flood risk governance arrangements.

Figure 19. Comparison across scales of flood risk governance arrangements

Dimensions of a Flood Risk Governance Arrangement (FRGA)	**Rotterdam**	**Riga**
Discourse What is the flood risk management strategy (key concepts, metaphors, policy principles?)	Hard engineering - storm surge barrier and extensively used dyke systems across the city ; Room for the River policy principle and River as a Tidal park Dynamic & multifunctionality approach: Building with Nature	Hard engineering - dyke systems along the river Mostly preventative ''Against Floods'' approach Individual projects that aim less for multi-functionality
Actors Which actors (public, private), and their coalitions, are involved? *See Appendix E.	National government; Regional Waterboards; Resilient Cities Network. Municipality of Rotterdam; Ecoshape etc. Public and private divide: Shared responsibilities, cooperation among all types of actors	EU cooperation with Ministry of Environmental Protection and Regional Development of Latvia; and Municipality of Riga. Private organizations specialised in water treatment, hard engineering construction companies, landscape architects.
Critical reflection: barriers, what are the opportunities for the future in terms of ES?	More extensive green space conservation is needed, with a long-term perspective Finance from investors is challenging, especially convincing stakeholders to invest in uncertain risk projects, where group risk plays a more crucial choice than in an individual case. Opportunity: a holistic approach, focus on the hydrological & physical systems as a whole, by integrating the decision-making process	Barriers to financial resources; Barriers of cooperation: Project expertise integrated management, including involvement of various parties, with the expertise of coastal delta flooding; Barriers of active citizenship & Public participation of not only affected interest groups Barriers of changing perceptions of compensation mechanisms, multi-functionality Opportunity: increasing awareness by participatory planning in ES governance

Vulnerability to floods

The most vulnerable urban areas to flooding tend to be located closest to the coast, but also near river banks with lower elevation (under predicted sea level). In the case of Rotterdam, it responds to mostly the outer-dyke neighbourhoods, especially downstream the river Meuse, which in fact are also the most vulnerable in social terms (e.g. Bospolder & Tussendijken). Whereas, for the urban area of Riga, exposure to floods is caused by wind surges from the Gulf of Riga. Western winds cause water inflows from the Baltic Sea, and as a result of changes in wind direction, it has blown up along the Daugava River and its tributaries, flooding the low-lying areas near the river, including the neighbourhoods of Sarkandaugava; Daugavgrīva and Bolderāja. Together they account for at least 20 000 inhabitants. As for Rotterdam, also these neighbourhoods in Riga are amongst impoverished, therefore strengthening the need to address socio-spatial justice.

Linking ES Justice Framework with coastal resilience initiatives

Urban ecosystem services (ES) are increasingly recognized for their role in contributing to health and wellbeing, therefore encouraged as a legitimate nature-based solution to many urban challenges, (Gómez-Baggethun, 2013) including the safeguarding of flooding events (Karrasch, 2014). In the case of Riga and Rotterdam, progressively both cities are incorporating resilience into their plans and policies, by focusing on enhancing the ability of institutions, the infrastructure, and communities to cope with them and adapt (Meerow et al. 2019). Through urban planning local administrations can manage the distribution of urban ecosystems and their services in a city, determining who will benefit the most (Kremer et al. 2013). Institutional responses with respect to coastal resilience, such as the Rotterdam Water Plan 2 and its Climate Initiative and the 'RigaAgainstFloods' programme, followed by the Riga's Integrated Adaptation Plan, has given awareness and increased cooperation amongst different stakeholder groups. Yet, urban ecosystems are heterogeneously distributed over space, and so are the ES they provide, which may cause inequality in the distribution of benefits to citizens (Ernstson, 2013). The qualitative comparative analysis in Figure 20 provides an overview of ES flood initiatives discussed in this research, and analyses socio-spatial justice from the following perspectives: Interdisciplinarity; Cooperation; Use of Ecosystem Services; Multi-functionality and Public Awareness. The results indicate that in most cases the high level of community participation leads to successful project outcome evaluation.

Figure 20. Qualitative comparative analysis project specific: socio-spatial justice of ES flood initiatives

Institutional responses with ES of flooding risk: policies, programmes; initiatives	**Institutional collaboration & *Interdisciplinarity***	**The level of community participation & *Cooperation***	**Use of Ecosystem Services (ES)**	**Social benefits of ES & *Multifunctionality***	**Outcome evaluation of public perceptions & *Awareness***
Rotterdam Water Plan 2	High	Relatively high	High	High	Success
Rotterdam Climate Change Initiative	High	High	High	High	Success
River as a Tidal Park (2012)	High	Relatively high	High	High	Success
GoBoTu 2028 (ongoing)	High	High	Relatively high	High	Success (however, the project is still ongoing)
Riga Against Floods policy plan (2012)	High	Relatively high	No indication	No indication	Success
Integrated Adaptation Plan (2016)	Relatively high	Relatively low	Relatively high	Inclusion of other international examples	Moderately successful
Skanste District project (ongoing)	Relatively high	Low	High	High	Failure amongst public (however, the project is still ongoing)

In the past decade, much awareness of multi-level governance and public involvement has risen in Rotterdam, and as in Riga, however public discussions often tend to dismiss the varying socio-spatial vulnerabilities and capacities of citizens. The examples of coastal flood resilience by means of ecosystem services, that have the potential to provide multiple benefits (e.g. River as a Tidal park; Go Botu initiative or Skanste multi-functional development), have given a turning point to socio-spatial justice considerations in coastal urban environments.

5. Conclusions

Cities face environmental, social, and technical challenges, from rising infrastructure repair costs associated with extreme weather events to risks of climate fragmentation in low-lying neighbourhoods as coastal residents are at risk from rising seas and wind-surges. In the face of these threats, cities have increasingly incorporated the concept of resilience into their policies and plans. Therefore, an urban resilience approach is applied to cope with a variety of shocks and stresses, such as those posed by climate change. Specifically, research results show that ecosystem-based adaptation solutions can reduce vulnerability and build resilience of urban areas to climate change. For both selected coastal delta cities - Rotterdam and Riga, flood management is based on extensive and long-term flood risk research, modelling, monitoring, forecasting and planning. However, the application of measures and the approaches to cope with flooding risk differs.

To answer the central research question of:" *How spatial adaptation strategies of ecosystem services may be applied to mitigate climate change induced flooding in coastal delta city environments, while also addressing socio-spatial justice?'* Urban planning in Rotterdam addresses urban ES through a great variety of actions, capable of dealing with local problems. The research findings indicate that recreational spaces that use ecosystem-based adaptation measures improve people's well-being and create tourism services, that in turn, can create jobs and stimulate local economies. This has been visualised with the examples of Go Botu initiative and River as a Tidal Park in Rotterdam. While accounting for distributional justice of ES are still lacking in the majority of spatial planning actions in Riga. An exemption can be regarded the multi-functional Skanste district project. To conclude, planning, implementation, and maintenance of ecosystem-based adaptation measures require the cooperation of city departments, each with the need to adapt their policies, procedures, regulations, and practices but also with the civil society. The question with respect to this study is if the policies have followed the desirable pathway, by adapting to the changing conditions in such a way as to enhance the future equity to the ecosystem services. All in all, the case of Rotterdam shows significantly more advanced flood risk preparedness across the historic timeline, compared to the case of Riga's urban flood resilience initiatives. Similarly, recent progress is made towards multi-scale governance and cooperation amongst agents, including the participatory planning process.

6. Recommendations

Several suggestions can be laid out with regards to spatial adaptation strategies of ES in comparison to the other European city. For instance, improvements could be seen with the public participation in decision-making, as well as to develop projects and plans of including multifunctionality, where not only one aim is of importance but to provide several benefits for the society. The case of Riga shows the relationship between local government and the civic sector is fragile and requires further learning and trust-building on both sides. Moreover, it is necessary to address the issues of transparency and legitimacy of the participatory planning processes on all planning levels to reduce conflicts and protests and to facilitate change in the societal attitude towards participation in urban planning (Akmentina, 2020). Further experimentation with dialogue-based and interactive public engagement approaches, like The Water Club initiative by Augmented Urbans, could strengthen the emerging collaborative practices.

For future improvements, a better understanding of the multi-scale and spatial dimensions that drive the resilience of linked social-ecosystems will help address the imbalance between the ongoing ecological change and effective long-term governance across institutional, the built environmental and societal scales. Moreover, for the future adaptation to incorporate flood defences of ecosystem services, consideration of the scale of the problem and how it will change over time is essential. Therefore it is recommended to do further research on quantitative inquiry longitudinal analysis, as ecosystems evolve over decades, which means that the benefits they provide also change over time. One of these benefits is that an ecosystem services approach to flooding can adapt to changing environmental and risk conditions, thereby potentially exceeding the design lifetime of engineered structures, and therefore also potentially contributing to socio-spatial justice in the long-term. Further research is suggested on a smaller geographical scale including qualitative methods to examine in depth perspective on people's perceptions and experiences. Furthermore, repeating this research with a larger number of interviewees, that are not selectively experts, could improve the representation of the research.

References

Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., Gren, Å. 2014. Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *Ambio, 43*, pp. 445-453.

Andersson, J. Langemeyer, S. Borgström, T. McPhearson, D. Haase, D. Barton, M. Davis, J. Kronenberg, S. Naumann, L. Röschel, E. Stange, F. Baró. 2019. Enabling green and blue infrastructure to improve contributions to human well-being and equity in urban systems. *BioScience, 58.*

Andersson-Sköld Y., Klingberg J., Gunnarsson B., Cullinane K., Gustafsson I., Hedblom M., Knez I., Lindberg F., Ode Sang Å., Pleijel H., Thorsson P., Thorsson S. 2018. A framework for assessing urban greenery's effects and valuing its ecosystem services.

Akmentiņa, L. 2020. Participatory Planning in Post-socialist Cities: A Case Study of Riga. *Architecture and Urban Planning*, *16*(1), pp. 17-25.

Avotniece, Z., Klavins, M., & Rodinovs, V. 2012. Changes of Extreme Climate Events in Latvia. *Environmental and Climate Technologies, 9*, pp. 4-11. DOI: https://doi.org/10.2478/v10145-012-0010-1

van Alphen, S. 2020. Room for the River: Innovation, or Tradition? The Case of the Noordwaard. In: Hein C. (eds) *Adaptive Strategies for Water Heritage. Springer, Cham.* DOI: https://doi.org/10.1007/978-3-030-00268-8_16

Bartlett, L. & Vavrus, K. 2017. Comparative Case Studies: An Innovative Approach Article. *Nordic Journal of Comparative and International Education (NJCIE).* DOI: 10.7577/njcie.1929

Berbés-Blázquez, M., González, J.A. and Pascual, U. 2016. Towards an ecosystem services approach that addresses social power relations. *Current Opinion in Environmental Sustainability*, 19, pp. 134-143.

Biernacka, M., Kronenberg, J. 2019. Urban green space availability, accessibility and attractiveness, and the delivery of ecosystem services. *Cities and the Environment (CATE)*, 12 (1)

Brunetta, G. and Caldarice, O., 2020. Spatial Resilience in Planning: Meanings, Challenges, and Perspectives for Urban Transition. *Sustainable Cities and Communities*, pp. 628-640.

Byrne, J.A., Lo, A.Y. and Matthews, T., 2015. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landscape and Urban Planning*, 138, pp. 155-163.

Birkmann, J., Garschagen, M., Kraas, F., Quang, N. 2010. Adaptive urban governance: new challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science, 5*, pp. 185-206. DOI: 10.1007/s11625-010-0111-3.

Centrālā Statistikas Pārvalde (CSP), 2020. RESIDENT POPULATION BY STATISTICAL REGION, CITY AND COUNTIES. *CSP.* Retrieved via: http://www.csb.gov.lv/statistikas-temas/metodologija/iedzivotaju-skaits-un-galvenie-demografiskieraditaji-36803.html

Ciscar JC, Feyen L, Soria A, Lavalle C, Raes F, Perry M, Nemry F, Demirel H, Rozsai M, Dosio A, Donatelli M, Srivastava A, Fumagalli D, Niemeyer S, Shrestha S, Ciaian P, Himics M, Van Doorslaer B, Barrios S, Ibáñez N, Forzieri G, Rojas R, Bianchi A, Dowling P, Camia A, Libertà G, San Miguel J, de Rigo D, Caudullo G, Barredo JI, Paci D, Pycroft J, Saveyn B, Van Regemorter D, Revesz T, Vandyck T, Vrontisi Z, Baranzelli C, Vandecasteele I, Batista e Silva F, Ibarreta D. 2014. Climate Impacts in Europe. The JRC PESETA II Project. *JRC Scientific and Policy Reports,* EUR 26586EN.

Clifford, N., Cope, M., Gillespie, T. and French, S. 2016. *Key methods in geography.* Sage.

Dawson, N., Coolsaet, B. and Martin, A., 2018. Justice and equity: emerging research and policy approaches to address ecosystem service trade-offs. *Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance*, pp. 22-38.

Depietri, Y., McPhearson, T., 2017. Integrating the grey, green, and blue in cities: nature-based solutions for climate change adaptation and risk reduction. *Nature-based Solutions to Climate Change Adaptation in Urban Areas*, Springer, Cham, pp. 91-109

Deppisch, S., 2018. Smart, Resilient and Transition Cities. Emerging Approaches and Tools for a Climate-Sensitive Urban Development, ELSEVIER. 12, pp. 95-100.

de Vriend, H. J., Van Koningsveld, M. and Aarninkhof, S. G. J. 2014. Building with Nature: the new Dutch approach to coastal and river works. *Proceedings of the ICE, Civil Engineering*, 167 (CE1).

de Vriend, H. J., Van Koningsveld, M., Aarninkhof, S. G. J., De Vries, M. B. and Baptist, M. J. 2015. Sustainable hydraulic engineering through Building with Nature. *Journal of Hydro-environment Research,* 9, pp. 159-171.

Dikec, M., 2001. Justice and the spatial imagination. *Environment and Planning,* HAL Id: hal-01258169. Retrieved via: https://hal-enpc.archives-ouvertes.fr/hal-01258169.

Ernstson, H., 2013. The social production of ecosystem services: A framework for studying environmental justice and ecological complexity in urbanized landscapes. *Landscape and Urban Planning,* 109(1), 7–17.

Esteban. T, Edelenbos. J, and van Stapele. N., 2020. Keeping Feet Dry: Rotterdam's Experience in Flood Risk and Resilience Building. *Flood Impact Mitigation and Resilience Enhancement,* DOI: 10.5772/intechopen.91147. Retrieved via: https://www.intechopen.com/books/flood-impact-mitigation-and-resilience-enhancement/keeping-feet-dry-rotterdam-s-experience-in-flood-risk-and-resilience-building

Frantzeskaki, N. and Tilie, N., 2014. The dynamics of urban ecosystem governance in Rotterdam, The Netherlands. *Ambio,* 43(4), pp. 542-555.

Filho, W., Barbir, J., Nagy, G.J., Sima, M., Kalbus, A., Paletta, A., Villamizar, A., Martinez, R., Azeiteiro, U.M., Pereira, M.J. and Mussetta, P.C., 2020. Reviewing the role of ecosystem services in the sustainability of the urban environment: A multi-country analysis. *Journal of Cleaner Production,* p.121-338.

Fischer, F., 2009. Discursive planning: social justice as discourse. *Searching for the Just City*, Routledge (2009), pp. 72-91

Fraser, N., 1995. From redistribution to recognition? Dilemmas of justice in a'post-socialist'age. *New left review*, pp. 68-68.

Friend, R. and Moench, M., 2013. What is the purpose of urban climate resilience? Implications for addressing poverty and vulnerability. *Urban Climate,* 6, pp. 98-113.

Gemeente Rotterdam, 2013. Rotterdam Climate Initiative (RCI). Edition City of Rotterdam, October 2013. Retrieved via: http://www.urbanisten.nl/wp/wp-content/uploads/UB_RAS_EN_lr.pdf

Gemeente Rotterdam, 2014. Rotterdam Climate Initiative (RCI). The programme: Rotterdam Climate Proof. Retrieved via: http://www.urbanisten.nl/wp/wp-content/uploads/publication_UB_RCI_Delta_Magazine.pdf

GoBoTu, 2019. Resilient BoTu 2028'. TOWARDS THE URBAN SOCIAL AVERAGE IN 10 YEARS. Retrieved via: https://www.gobotu.nl/wp-content/uploads/2019/04/Resilient-BoTu-2028.pdf

Gómez-Baggethun, E., Gren, Å., Barton, D.N., Langemeyer, J., McPhearson, T., O'farrell, P., Andersson, E., Hamstead, Z. and Kremer, P., 2013. Urban ecosystem services. *In Urbanization, biodiversity and ecosystem services: Challenges and opportunities*, pp. 175-251. Springer, Dordrecht.

Guasti, P., 2016. Development of citizen participation in Central and Eastern Europe after the EU enlargement and economic crises. *Communist and Post-Communist Studies*, Vol. 49, Issue 3, 2016, pp. 219–231. https://doi.org/10.1016/j.postcomstud.2016.06.006

Guerreiro, S.B., Dawson, R.J., Kilsby, C., Lewis, E. and Ford, A., 2018. Future heat-waves, droughts and floods in 571 European cities. *Environmental Research Letters*, 13(3), 034009.

Gunnell, K., Mulligan, M., Francis, R.A. and Hole, D.G., 2019. Evaluating natural infrastructure for flood management within the watersheds of selected global cities. *Science of the total environment,* 670, pp. 411-424.

Intergovernmental Panel on Climate Change (IPCC), 2014. AR5 synthesis report: Climate change 2014: Impacts, adaptation, and vulnerability. Accessed via: https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

Intergovernmental Panel on Climate Change (IPCC), 2019. Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. CifuentesJara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari, 2019: Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.* In press.

Harvey, D., 2008. The right to the city. *The City Reader*, 6(1), pp. 23-40.

Karrasch, L., Klenke, T., Woltjer, J., 2014. Linking the ecosystem services approach to social preferences and needs in integrated coastal land use management – A planning approach. *Land Use Policy*, 38, pp. 522–532. https://doi.org/10.1016/j.landusepol.2013.12.010

Kūle, L., Briede, A., Klavins, M., Eberhards, G., Loĉmanis, A., 2013. Adaptation to Floods in Riga, Latvia: Historical Experience and Change of Approaches. *Climate Change Adaptation in Practice: From strategy development to implementation.* 65-81. 10.1002/9781118548165.ch6.

Latvijas Vēstnesis, 2007. Ministru kabineta 2007. gada 20. decembra rīkojums Nr. 830 "Par Plūdu riska novērtēšanas un pārvaldības nacionālo programmu 2008.-2015.gadam". Publicēts oficiālajā laikrakstā "Latvijas Vēstnesis", 22.12.2007., Nr. 206 Retrieved from: https://www.vestnesis.lv/ta/id/168474

Langemeyer, J. and Connolly, J.J., 2020. Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science & Policy*, 109, pp.1-14.

Lefebvre, H., 1991. Critique of everyday life: Foundations for a sociology of the everyday. Verso, 2.

Martin, B. Coolsaet, E. Corbera, N.M. Dawson, J.A. Fraser, I. Lehmann, I. Rodriguez. 2016. Justice and conservation: the need to incorporate recognition. *Biol. Conserv.*, 197, pp. 254-261.

Malahova, J., Vasiļevska, D. and Ketners, K., 2017. Potential flood impact on natural and socioeconomic environment in Riga. *Rural development 2017*: bioeconomy challenges: proceedings of the 8th international scientific conference, 23-24 November, 2017, Aleksandras Stulginskis University, 2017, p. 663-668.

Meerow, S., Pajouhesh, P., Miller. T., 2019. Social equity in urban resilience planning. *Local Environment.* DOI: 10.1080/13549839.2019.1645103

Medium (2020). Augmented Urbans. The Water Club. Medium: Riga, Latvia. Retrieved from: https://medium.com/augmented-urbans/riga-the-water-club-for-exchanging-competencies-and-making-new-friends-6bae154faffe

METEO (2020). Pludu riska informacijas sistema. Latvijas plūdu riska and plūdu draudu kartes. “LATVIJAS VIDES, ĢEOLOĢIJAS UN METEOROLOĢIJAS CENTRS”. Retrieved from: https://www.meteo.lv/lapas/vide/pludu-riska-informacijas-sistema/pludu-riska-informacijas-sistema?id=2103&nid=889

Meyer, H., 2009. Reinventing the Dutch Delta: complexity and conflicts. *Built Environment*, 35(4), pp.432-451.

Municipality of Rotterdam. 2007. Waterplan 2 Rotterdam. Working on water for an attractive city. Waterplan 2 Rotterdam: Rotterdam, The Netherlands. Retrieved from: https://issuu.com/citypolska/docs/waterplan_engels

Municipality of Rotterdam, 2019. Preparing our city for a more extreme climate together. Rotterdam Weatherwise Urgency Document: Rotterdam, the Netherlands. Retrieved from: https://www.rotterdam.nl/wonen-leven/rotterdams-weerwoord/Urgentiedocument-2020_EN.pdf

Nedović-Budić, Z., 2001. Adjustment of Planning Practice to the New Eastern and Central European Context. *Journal of the American Planning Association*, Vol. 67, Issue 1, 2001, pp. 38–52. DOI: https://doi.org/10.1080/01944360108976354

Ortega, M., Julia, Ferrier, Robert C., Gordon, Iain J., Khan, Shahbaz. 2015. Water Ecosystem Services: A Global Perspective. *International Hydrology Series.*

Pabērza, I. 2020. Skanstes apkaimē top daudzfunkcionāls jauns parks un Baltijā mūsdienīgākā lietus ūdens savākšanas sistēma. Retrieved from (Accessed: 14 December 2020): https://www.riga.lv/lv/jaunums/skanstes-apkaime-veidos-jaunas-ielas-un-publiski-pieejamu-parku

Prilenska, V., Liias, R. Challenges of Recent Participatory Urban Design Practices in Riga. Procedia Economics and Finance, Vol. 21, 2015, pp. 88–96. DOI: https://doi.org/10.1016/S2212-5671(15)00154-9

Pelling, M., O'Brien, K. and Matyas, D., 2015. Adaptation and transformation. Climatic Change, 133(1), pp.113-127.

RDPAD, 2012. Flood Risk Management Plan. HydroClimateStrategy, Riga pret Pludiem: Riga, Latvia. Nr.LIFE08 ENV/LV/000451. Retrieved from (Accessed: 18 October 2020): https://www.rdpad.lv/wp-content/uploads/Rigapretpludiem/dokumenti/04about_eng.pdf

RigaAgainstFloods, 2012. Layman's Report. Integrated Strategy for Riga City to Adapt to the Hydrological Processes Intensified by Climate Change Phenomena. LIFE08 ENV/LV/000451. Published by the Department of City Development Riga City Council. Retrieved from (Accessed: 18 October 2020): https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE08_ENV_LV_000451_LAYMAN.pdf

da Silva, J., Kernaghan, S. and Luque, A., 2012. A systems approach to meeting the challenges of urban climate change. *International Journal of Urban Sustainable Development,* 4(2), pp.125-145.

Solé, L., and E. Ariza. 2019. A wider view of assessments of ecosystem services in coastal areas: the perspective of social-ecological complexity. *Ecology and Society* 24(2):24. DOI: https://doi.org/10.5751/ES-10883-240224

Soja, E.W., 2013. Seeking spatial justice (Vol. 16). U of Minnesota Press.

Stead, D., 2014. Urban planning, water management and climate change strategies: adaptation, mitigation and resilience narratives in the Netherlands. *International Journal of Sustainable Development & World Ecology,* 21(1), pp.15-27.

Spaans, Marjolein, and Bas Waterhout. 2016. "Building up Resilience in Cities Worldwide – Rotterdam as Participant in the100 Resilient Cities Programme." *Cities,* 61: 109–116. doi:10.1016/j.cities.2016.05.011.

Steele, W., Mata, L. and Fünfgeld, H., 2015. Urban climate justice: creating sustainable pathways for humans and other species. *Current opinion in environmental sustainability,* 14, pp.121-126.

Tillie, Nico & van der Heijden, Roland. 2016. Advancing urban ecosystem governance in Rotterdam: From experimenting and evidence gathering to new ways for integrated planning. *Environmental Science & Policy*, 62. DOI: 10.1016/j.envsci.2016.04.016.

Treija, S., Bratuškins, U., 2017. Participatory Planning: The Role of NGOs in Neighbourhood Regeneration in Riga. Spaces of Dialog for Places of Dignity: Fostering the European Dimension of Planning. *Lisbon AESOP Annual Congress 2017: Book of Proceedings*, 2017, pp. 609–616.

United Nations, 2017. Ocean fact sheet package. Retrieved via: https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf

van der Brugge, R. 2009. Transition dynamics in social-ecological systems. The case of Dutch water management. Erasmus University Rotterdam: Rotterdam, The Netherlands.

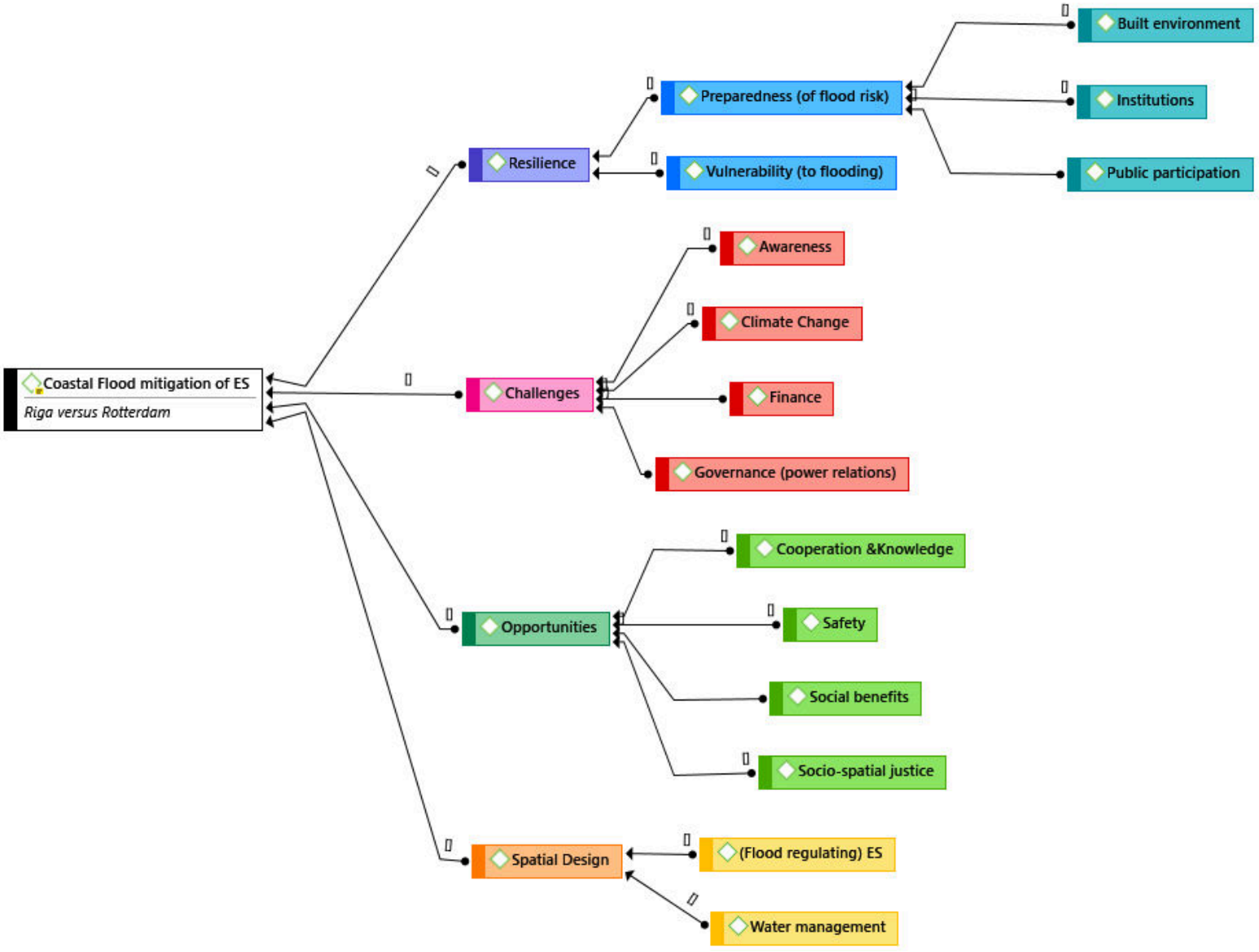
van Veelen, P.C., 2016. Adaptive planning for resilient coastal waterfronts. *A+ BE| Architecture and the Built Environment*, (19), pp. 1-248.

Ward, P.J., Pauw, W.P., Van Buuren, M.W. and Marfai, M.A., 2013. Governance of flood risk management in a time of climate change: the cases of Jakarta and Rotterdam. *Environmental Politics*, *22*(3), pp. 518-536.

Appendices

APPENDIX A. Applied coding and the coding tree via Atlas.ti.

Document Group – Main codes	Groups	Sub-Codes	Comment
Spatial Design	2	(Flood regulating) ES Water management	What spatial mitigation strategies are there (of ecosystem services) to reduce the vulnerability to future coastal delta flooding?
Resilience	5	Preparedness (of flood risk) -Institutions - Public participation - Built environment Vulnerability (to flooding)	How prepared is the urban area of Riga and Rotterdam against future coastal flooding, in terms of applied techniques of resilience?
Challenges	4	Awareness Climate Change Finance Governance (power relations)	What are the challenges to mitigate future coastal floods for the cities of Riga and Rotterdam?
Opportunities	4	Cooperation & Knowledge Safety Social benefits Socio-spatial justice	What are the opportunities towards coastal flood adaptive cities of Riga and Rotterdam?



Appendix B. The consent form of expert interviews.

university of groningen

DECLARATION OF INFORMED CONSENT

Research project name:
Urban flood resilience and socio-spatial justice for urban deltas by means of ecosystem services. A comparative case study of Riga and Rotterdam.

Student's name: *Annija Danenberga*

This bachelor thesis research investigates coastal flooding in urban delta environments, where specific interest is given to ecosystem services (nature-based) solutions and social justice spectrum. The research is a comparative study between European cities Riga and Rotterdam. The interview would provide valuable data on the past flood event practises; how the urban environments are prepared for future flooding from the institutional and built environment perspective, and help to acknowledge what strategies are there to ensure climate-just cities that also have the potential to bring social benefits. To continue, acknowledging multifunctional approaches of flood regulating ecosystem services that also respond to cultural services are the aim for this research study of future urban resilience. Examples include nature-based solutions that mitigate floods and provide alternative societal value, to be specific: Recreational bio-swales / Tidal parks / Tiny urban forests etc.

You have been invited to participate in this research as an interviewee.

Please provide your consent that

1. You have been informed about the purpose of the research;
2. You have spontaneously and in complete freedom accepted to be interviewed;
3. You consent the use of anonymized interview data for the research aims of the project, including its publication.

I declare that I am aware that:

- The research includes the collection of individual responses, opinions, evaluations
- each participant is free to ask for clarifications on the data collection procedure and about every other aspect of the project;
- each participant is free to leave the session in every moment;
- the eventual refusal to participate or the renunciation during the session will not involve any negative consequence for the participant;
- personal data collected for research purpose will not be transmitted to third parties;
- the collected personal data will be elaborated anonymously
- the research is conducted in the light of the RUG ethical policy (https://www.rug.nl/about-ug/policy-and-strategy/research-ethics/?lang=en)

Name _____

Signature_____

Date_____

In case you believe you have been mistreated during this interview or for any more information you may wish to have regarding the research, please contact the thesis supervisor, Dr. Ethemcan Turhan (e.turhan@rug.nl)

Appendix C. Interview guide of the expert semi-structured interviews.

Interview Guide: Expert semi-structured interviews

Where?

- Via Google Meet platform

Who?

- Experts in the field, familiar with the flood-proof urban strategies, project implementation, policy indication, Ecosystem Services practises in Rotterdam / Riga

---

Introduction

0. Thanking for their time / ask about recording / explaining structure of the interview / introducing myself and my research

1. Could you tell some background about yourself and the organisation/ institution you are representing?
   a. What is your function/ expertise?
   b. How is your institution structured?

2. Could you provide a description on the projects you are working on at the moment?

3. Have the city of Riga / Rotterdam historically been exposed to flooding risk?

4. When was the last extreme flooding in the urban area of x city? Could you describe it, what was the response, what was done to avoid it from happening again?

5. How likely, according to you, coastal flooding could affect x city in the future? What are the main drivers for it?

6. Which areas would you identify as the most vulnerable to future coastal flooding, due to future sea level rise (e.g. 2m above sea level, in 100 years time)?

7. What flood-defense systems /mitigation measures have been implemented for the flood events in x city?

8. How past flood management practises / mitigation strategies, that the institution you are representing has implemented, have contributed to the vulnerability of flooding?

9. What nature-based solutions are there for coastal flooding?

10. Are you familiar with the ecosystem services potential for flood protection and other societal benefits? [*Giving description, extra explanation with examples].* If YES, what is the potential of ecosystem services-based solutions to mitigate flooding risk and the quality of life?

11. What are, according to you, important factors that flood-proof policy in Rotterdam/ Riga should focus on in the upcoming years?

Specifically, asking about the 'Project of Interest')

- What was the main aim of the project?
- What flood-proof measures have been implemented?
- How successful was the outcome of the project? What major challenges were there, what improvements could be expected in the future?
- How supported was the project amongst the general public? How the society responded to the flood mitigation strategies?
- Are there any other existing projects where public participation is included for the city's flood preparedness and overall awareness? E.g. Implementation of wetlands with social benefits

Context dependent questions

For experts of Riga institutions

- Are you familiar with specific examples with regard to flood protection that are being implemented in Riga, from elsewhere? *It is known to me that experts from Rotterdam have given expertise for the RigaAgainstFloods policy for example, back in 2012.*
- If we compare the situation back in 2012 when the policy 'RigaAgainstFloods' was implemented, how the situation has changed with regards to flood preparedness? This concerns:

1) *The built environment*
2) *Institutional level*
3) *Public perception, participation*

For experts of Rotterdam institutions

- If we compare the situation for example looking back 10 years ago, how the situation has changed with regards to flood preparedness? This concerns:
    1) *The built environment*
    2) *Institutional level*
    3) *Public perception, participation*

Closing interview

Thanking for the interview. Explaining how data will be used again. Asking if there is anything you would like to add or if there are any other questions. Asking for who should I contact next, regarding the research topic.

Appendix D. An overview of ES adaptation strategies for flood protection per categories.

1 Enhancing ES, Natural elements (soft measures):	**2 Replacement of ES, Green & Blue Infrastructures (artificial) :**	**3 Protection of ES, Maintenance including Flood and Coastal Erosion**	**4 Restoration of ES**
Floodplains slow down and store floodwaters, reducing erosion and flood risk. **Flood bypasses** can redirect flood waters around a community without reducing the natural connectivity of a river. **Beaches and Dunes** reduce wave energy, help prevent inland storm surges, improve community appeal and provide wildlife habitat and recreational opportunities. Protective, floadable **waterfront park** acts as a natural sea wall. (''A 100-meter-wide mangrove belt can reduce wave height by 13 to 66 percent.''	**Urban wetlands:** Coastal Marshes can reduce storm wave heights by over 50 percent, provide habitat for spawning fish and wading birds, and improve local water quality. Construct new **water storage:** ability to store excess water **Horizontal levees** rely on coastal habitats like marshes to reduce wave energy and height, they're smaller and can cost 50% less than traditional levees.	**Managing existing stressors** e.g. Open Space Preservation creates opportunities for recreation while also reducing the potential for development in vulnerable areas, therefore restricting further development in vulnerable areas **Expansion of protected areas:**coastline, forests, nature parks etc. **Oyster reefs and mussel beds** are capable of reducing the energy of high power waves by as much as 76 to 93 percent,they act as hard, natural barriers that protect shorelines from erosion, rising tides and increasingly severe storm surge.	**Dam removal** **Riparian vegetation restoration:** moderates flooding by slowing flood water and allowing it to recharge shallow aquifers. To stabilize slopes and banks is to leave native riparian vegetation. The water-loving plants that grow in riparian areas have deep roots to ensure this. **River bank armouring:** Reinforcement of streambank with protective covering, such as rocks, vegetation or engineering materials. It Reduces bank cutting and erosion due to peak flows

Source: The ES adaptation overview by UNESCO's classification, in combination with an interactive web-tool accessed via NRCsolutions.org, is used to identify opportunities for nature-based flooding solutions. Sasaki's multidisciplinary team have addressed specific case studies for communities along rivers or coasts, to incorporate ecosystem-based solutions in local planning, zoning, regulations, and built projects to help reduce their exposure to flood and erosion impacts. Moreover, the results are also given based on Millennium Ecosystem Assessment: Ecosystems and Human Well-Being Synthesis.

Appendix E. Indication of coalision actors of flood risk governance across different levels

Coalition actors of flood risk governance

➔ **European Union**

At the international level, the acknowledgement of the need to secure a sustainable and fair provision of ES was explicitly at the basis of the adoption of the Aichi Targets by the Convention on Biological Diversity (2010) and of the creation of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2012). The European Union is at the forefront in pursuing these obligations and is leading the way toward mainstreaming the ES approach by progressively embedding the ES concept in its policies (Bouwma et al. 2017). Through the EU Biodiversity strategy to 2020, EU Member States committed to map and assess ES in their territory, thus setting the base for continuous monitoring and the inclusion of ES in the system of national accounting and reporting across the EU (Maes et al. 2012, 2016). With regard to flooding, the 2007 EU Flood Risk Management Directive committed member states to carry out evaluations posed by flooding risk, with implementing flood mitigation protection plans. Additionally, predictions of climate change and recent flood emergencies have directed attention to the necessity of adapting urban river spaces.

➔ **The Netherlands** (**National**)

Historically, flood risk management (FRM) in the Netherlands is characterised by a defence approach to reduce the probability of flooding (Van de Ven, 2004). The traditional Dutch spatial planning arrangement can be characterised as a `facet sector planning hierarchy', established on the three governmental layers of municipalities, provinces, and the national government. However, living with such uncertainty requires resilience-building approaches to management and governance of social-ecological systems (Folke et al. 2003). The Delta works and the increase of the shipping to the Rotterdam Harbor were the reason to set up regional Hydro-Meteo centers of meteorologists and "tidal hydrologists" from different organizations in one building. The national warning service SVSD is still separated from the Hydro-Meteo centers and is responsible for publication and communication of the storm surge alert. Warnings for high precipitation events are sent to water boards (regional water authorities) by the meteorological service KNMI. Following the banking crisis of 2008, the Cabinet announced in Spring 2009 that it wanted to reduce the budget for water management by € 100 mln. The Association of water boards used this announcement to come up with a proposal that many saw as a "flight forward"approach (Meijerink 2010). It proposed to take over part of the costs for strengthening the main flood defences. Moreover, it proposed to take over responsibility for the sewers from the municipalities. This would result in better coordination with sewage treatment and in large efficiency gains that could be used for financing the main flood defences (letter of 4 November 2009 to the Deputy-Minister of Infrastructure and the Environment: the "Storm brief"). Moreover, storm surge Flood and River Flood Warning Services, The Water Management Centre of Rijkswaterstaat in Lelystad is responsible for sending out the storm surge and flood warnings and matching the different input from the regional centers.

➔ **Latvia (National)**

The Ministry of Environmental Protection and Regional Development of Latvia (MEPRD) is the responsible authority for the climate change policy in Latvia. MEPRD has established an expert group on adaptation and an inter-institutional working group on adaptation. Experts from agencies, scientific institutions, ministries, municipalities, business and NGOs have participated in many workshops and conferences regarding CC scenarios, risk and vulnerability assessment, discussions on indicators and adaptation monitoring systems, flood risk warning system, spatial and coastal zone planning. The new State Civil Protection Plan and Risk Mappings, based on risk assessments and scenarios are increasingly taken into account in national planning, which links CC risk assessment, prevention and adaptation and civil protection much more tightly. According to Civil Protection and Catastrophe Management Law (2016) and its subordinate Cabinet of Ministers regulations the civil protection commissions of 36 municipal cooperation territories have to develop their own civil protection plans that includes indicated risks, scenarios, matrices, mapping, prevention, preparedness, response and recovery measures for each risk. In fact, flood risk management plans have been elaborated for all territories under significant flood risk. Moreover, Latvian Environment, Geology and Meteorology Centre (LEGMC) has performed a detailed analysis of long term historical climate data and developed CC future scenarios (until 2100). For wider public the visualization of the CC scenarios is available online in the CC Analysis Tool. CC Analysis Tool allows to explore current and projected future climate scenarios in Latvia in the form of maps and graphs. LEGMC is responsible for continuous CC data collection, as well as monitoring extreme events, data storage and analyses of long-term observation results. LEGMC prepares reports and provides information to the public, to the State and local governments, and to international organizations.

National body --> Municipal --> Private

Ministry of Environmental Protection and Regional Development Republic of Latvia

LVĢMC

RĪGAS DOME

G93

Appendix F. Assessment - Ecosystem Services (ES) of flood control (Linking Appendix D)

ES Application of flood control	1 Enhancing ES	2 Replacement of ES	3 Protection of ES	4 Restauration of ES
Rotterdam	Floodplains; Sand dunes (known as Sand Engine); Floadable waterfront park	Urban wetlands Multi-functional water storage Horizontal levees Green & blue public squares and playgrounds Green roofs and facades	Expansion of protected land [Limited] Open space preservation	Riparian vegetation restoration Partial dam removal (River as a Tidal Park - See also Appendix G)
Riga	Floodplains, marshlands Sand dunes Coastal trees	Water storage Ditches Urban parks and gardens	Open space preservation Expansion of protected land: coastline, forests	Riparian vegetation restoration in the past River bank armouring
Potential of Cultural ES	Health & Psychological Ecotourism Historical heritage Aesthetics	Aesthetic value Recreational Educational Social relations	Historical heritage Educational Ecotourism	Health & Psychological Social relations Aesthetics

Explanation:Green - highly applied; Orange - moderately; Red - barely applied

Different ES applications of flood control per categories have been identified within the urban areas of Riga and Rotterdam in Appendix F, also indicating the potential of social benefits associated. The results show that Enhancing ES are highly applied in both cases, improvements could be seen in overall protection of the existing ecosystem services and restoration. Highly applied the approach of replacement of ES is noticed in Rotterdam, with application of multifunctional water storage and public squares, as well as popularity is given to green roof practises. This might be explained by the compact city environment, where nature-based solutions are crucial for a liveable environment. In case of Riga, water storages, urban parks and coastal forests and marshlands ensure local flood protection by ES, as well as many residents have an extensive garden space.

Appendix G. River as a Tidal Park visualisation (Gemeente Rotterdam, 2013).