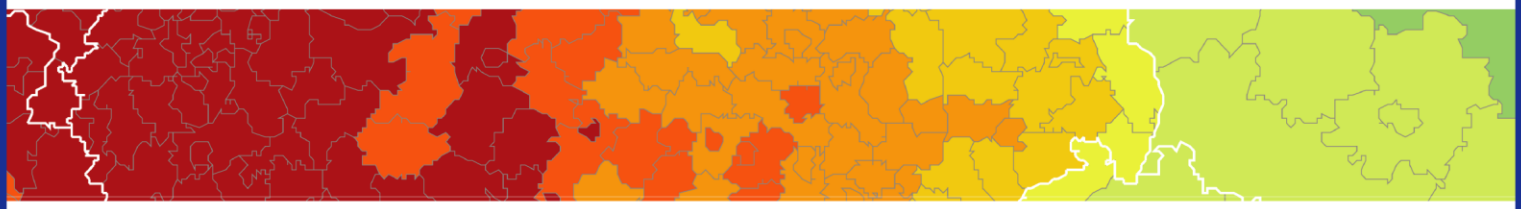
ESPON

EUROPEAN UNION

Co-financed by the European Regional Development Fund



ESPON-TITAN
Territorial Impacts of Natural Disasters

Applied Research

Final Report – Case Studies Report
City of Rotterdam (the Netherlands)

June 2021

This applied research activity is conducted within the framework of the ESPON 2020 Cooperation Programme.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States, the United KIngdom and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

This delivery does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee.

Authors
Diana Rodríguez, Joaquín Farinós Dasi, Pablo Pinazo Dallenbach, Enrique Peiró, (Universität de Valencia, Spain)
Carolina Cantergiani de Carvalho, Andoni Mateos Cabero, Efrén Feliu (TECNALIA Research & Innovation, Spain)

Advisory Group
Project Support Team: Adriana May, Lombardy Region (Italy), Marcia Van Der Vlugt, Ministry of the Interior and Kingdom Relations, Spatial Development Directorate (the Netherlands)

ESPON EGTC: Zintis Hermansons (Project Expert), Caroline Clause (Financial Expert)

Acknowledgements
Thuy Do, Vera Konings (City of Rotterdam, the Netherlands)
Stakeholders who participated on the interviews

Information on ESPON and its projects can be found on www.espon.eu.

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

Contact: info@espon.eu

ISBN: 978-2-919816-06-4

Case Study Report

ESPON-TITAN
Territorial Impacts of Natural Disasters

City of Rotterdam (the Netherlands)

Table of contents

List of Figures

List of Tables

1 Introduction

The city of Rotterdam is part of the Rotterdam–The Hague metropolitan area. Rotterdam is a coastal city situated in the province of South Holland, at the delta of the rivers Scheldt, Rhine and Meuse. The largest Europe's seaport is located in this city which population is 651.376 inhabitants, covering an area of 209 km^2 with a density of 3.120 inhabitants/km^2. The economic profile of Rotterdam is mixed, and general indicators as GDP per capita, growth rates and employment rates are lower than the average for the country.

Map 1. City of Rotterdam and Port area

Source: https://rotterdamtransport.com/maps-port-of-rotterdam/

The main hazards related to natural phenomena, to which the city is exposed are **floods** – caused by the sea level rise, rivers overflow, pluvial flooding and from groundwater –, **extreme temperatures** and **drought**. The hazards impacts are determined by the urban environment characterized by a high population density, the location of a critical infrastructure as the port and the low level of rivers that prevents the inland navigation.

The city of Rotterdam is opened to the sea and is under the sea level, so as the port and residencial areas that lack of dykes (outer dike areas) are specially at risk of flood because of the sea level rise. It is expected that extreme rainfall will be more frequent and in general, increased levels in the rivers Rhine and Meuse due to rainfalls augmentation in winter and the opposite phenomena in summer, with the consequent risk of floods in cold season along the rivers and the negative impact in the connection between the hinterland and the port because of the subsequent low navigability in summer. The water drainage is challenging as per the situation of the city below the sea level and the fact that the hard surfaces make land scarcely permeable. Ground subsidence in the peat dykes along the navigable interior water bodies and in peat grounds located in the occidental part of the country, exacerbates the problem. The

subsidence, a hazard of particular importance in the Netherlands, is caused by the water extraction as part of the water management actions and due to the increased drought.

At the European level, information on certain hazards, as pluvial flooding, is scarce, although they have been widely managed by the city of Rotterdam. For that, the presentation of Rotterdam´s experience, valuing the specificities of the management and highlighting that changes on patterns of some hazards, is an added value for the project, and the reason why including Rotterdam as a case study.

2 Main characteristics of the administrative structure and planning system

The Netherlands has an organization with a National Government, 12 provinces and 355 municipalities with political power in both regional and local levels.

The national, provincial and municipal levels participate in the cascade of Dutch spacial planning. **Spacial Visions** are policy instruments regarding expected spatial developments and their implementation, that are formulated nationally, provincially and municipally in accordance with the interests of each scale. They have replaced key state planning decisions, provincial plans and municipal structure plans.

The central administration deals with matters of national interest contained in the **Spatial Vision of Infrastructure and Territory Management** (SVIR). Provincial Spatial Visions focus on topics such as landscape management, urbanization and the preservation of green spaces.

The local level is the one in which territorial planning is mostly developed in terms of policy and implementation, considering the knowledge of the municipalities on the territory. The most important legal instrument of land management is the **Land Use Plan**; they identify developable land and related standards and rules as land-use and use intensity. Elaboration and management of these spacial plans as well as those of provincial or national scale are regulated by **The Spatial Planning Act** (Wet Ruimtelijke Ordening - WRO).

Regarding water management, the international level of planning includes standards, water management rules and measures, given that the elements that conform the main water system of the Netherlands, which are the North Sea, the Wadden Sea, the lakes IJsselmeer, Markermeer and Randmeren, the main rivers, the southwest delta region and the main canals, are part of the international river basins of the Rhine, Meuse, Ems and Scheldt rivers. The country's freshwater supply depends on the main water system.

At the national level, the central government is responsible for water quality, integrated management of the main water system and flood protection. Flood protection is based on prevention, however, it also deals more and more with controlling the impact of its occurrence through disaster management plans and territorial planning decisions. Spatial plans include water management components not only in the short, but also in the long term. Abandoned industrial zone plans and urban development plans are among those that meet these requirements.

Flood defense is also national competence, responsible for the protection of dunes, hydraulic structures, dykes and dams, that constitute the main defenses, as well as the coastal foundation. Water authorities share the water quality control and, to a lesser extent, flood protection with the central government. The regional (or secundary) flood defences are a regional competence.

The **National Delta Programme** combines territorial/spatial and water-area measures that target water quality, flood protection and spatial adaptation to climate change. The implementation of the National List of Priorities allows the Government to anticipate or respond to droughts.

Some characteristics of the Dutch spatial planning are multi level governance, the use of urban design, consultation of stakeholders, long-term objectives, integrated planning and monitoring progress.

3 Hazard profile and economic impacts of natural hazards in the City of Rotterdam

Natural hazards cause damages in infrastructure, roads, sewage systems, building, public spaces and vegetation. The economic impacts of flooding due to rise in the sea levels located in the unbanked areas, industrial and residential – highly evident in Rotterdam – has been calculated as follows:

The Royal Meteorological Institute of the Netherlands (KNMI) estimates that the sea level rise until the year 2100, will be between 35 and 80 cm, which would increase the risk of flooding in the Rotterdam area. While it would not result in human involvement for workers or residents, it is expected to result in economic losses, according to the joint study “The Botlek Flood Risk Management pilot project” developed for an specific zone of the Port outside the dykes.

A case study performed in the area outside the banks in Rotterdam estimates the financial losses due to flood risk at EUR 36 million each year. This risk lies mainly (just under 60%) in industrial lands which puts a focus on these use.

Residential unembanked areas also face a risk of flooding that would lead to material damages according to a model study which calculated the loss for the different return periods. The calculations shown a range of loss from about EUR 2 million to around EUR 14 million for a 1 in 100 year return period to aroud 1 in 10.000 year return period, respectively. Currently, floods with a return period of around 1 in 50, cause significant damage that has a peak in the return period of 1 in 3.000 years (Moel, van Vliet & Aerts, 2015).

Apart from that, subsidence is affecting the structure of many houses causing a very negative economic impact in members of the community.

Both pluvial floods and droughts have impact at the local scale and cause damages in houses due to water inlet to them and affects buildings, infrastructure, flora, fauna and water supply, respectively. The reference dates for pluvial flood are 2013, 2016 and 2017. Although in the past the phenomena of extreme rain could occur each year, the pattern of the climate change is changing, so nowadays it can reach 3 events per year.

Riverfloods occur with a yearly frequency and affect mainly the areas along the rivers. These yearly river floods do not result in relevant economic losses. But Rotterdam does expect economic losses by a 10-year river flood.

Table 1. Natural hazards clasification

Natural Hazards	How serious	Reference date	Mainly Affected area	Main impacts
River flood	Medium	Yearly	Riverbanks	Social & environmental safety, infrastructural, civil
Pluvial flood	Medium	2013, 2016, 2017.	Local scale	Water inside the house, damage
Windstorms	Medium	2019	Local scale	1 death
Drought	Medium	2018, 2019, 2020.	Local scale	Historical buildings, flora & fauna, water supply, damage to roads
Storm surge	Not defined	1953	South west Netherlands	Death Damage

Source: Interview with case study stakeholders.

Damage due to flooding in unprotected areas are to be covered by each private owners, as private insurance for river flooding is not common in Rotterdam.

4 Disaster Risk Management in Rotterdam

4.1 General remarks

Spatial planning in the Netherlands involves decision making at 3 levels:

- National level (ministries) in charge of structure vision/national plan, national interests and coordination of national policy;
- Regional level (provinces) addressing the structure vision;
- Local level (355 municipalities and 21 water authorities). Municipalities elaborates zoning plans and structure plans while water authorities lead water safety.

At the national level the most important documents addressing disaster risk management are the **Delta Act** and the **Water Act.** The details of these regulations are shown in chapter 5.

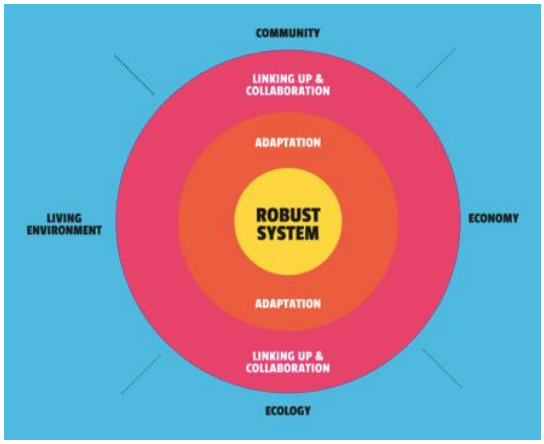
At Rotterdam region, the city climate change adaptation are led by a wide set of policy documents as the following:

- Rotterdam Weather Wise Urgency Document

It defines the measures to develop for the city adaptation strategy to face the extreme temperatures and hazards related to: Rainfall, Heat, Drought, Sea level rise, Groundwater and Land subsidence.

This document develops the Delta Programme according to which the design of Netherlands has to respond to climate-resilience and water-robustness by the year 2050. The city follows this approach but as per its vulnerability due to its location in the Dutch Delta, needs to be more ambicious. The measures look for a more intense adaptation to be able to build an approach based on climate resilience and to face other goals as circular economy and energy transition. The objective is to have the minimum increase in the damage caused by floods, excess of water, heat and drought as well as consider this when constructing residencial areas, commercial buildings, renovating urban and green areas and infrastructure maintenance (e.g., roads and sewerage system).

Figure 1. Rotterdam Adaptation Strategy (Ras)



Source: Rotterdam Weather Wise Urgency Document (2020)

- Rotterdam Climate Change Adaptation Strategy (2013)

The Rotterdam Climate Change Adaptation Strategy has multiple layers. The basics of the strategy are:

- Robust system. Refered to the management of the defense infrastructures as water barriers, lakes, canals, dykes, outlets, sewer system and pumping stations.
- Adaptation. Include solutions to make the robust system more flexible and take some wheight away from it. Also, to adapting the functioning of the city to the changing natural behaviour of the delta and its water levels. Besides this, wide application throughout the city of small scale responses are previewed.

- **Municipal sewerage plan (2016-2021)** (GRP - Gemeentelijk rioleringsplan)

It develops the municipal sewerage policy and shows the changes that should be implemented by the city for the future.

- Waterplan 2 (2007)

- **National Strategy on Spatial Planning and the Environment (projected) (NOVI)**

Mayor transitions in the living environment as transition to renewable energy, adaptation to climate change, conversion to smart and green transport and a circular economy, liveable and accessible cities, and societal demands for more efficient procedures ask for a new and more integrated laws and planning, in response, the National government is working on integrating the Spatial Planning Act into the Environmental and Planning Act. From this new Act and transitions, a new Strategy is needed. The National Strategy on Spatial Planning and the Environment (NOVI) that is being evaluated by the Parliament, has four priorities: (i) a sustainable and competitive economy, (ii) a carbon neutral and climate resilient society, (iii) a sustainable and accessible working and living environment, and (iv) a sustainable and valuable rural environment.

4.2 Risk assessment

The **Rotterdam Climate Change Adaptation Strategy** describes that the traditional formula for the management of spatial planning, flood protection and water supply involved the participation of the vertical levels of government and the water boards; nevertheless the challenging of adaptating to climate change requires a wider participation of actors including non government organizations, businesses, eduation institutions, corporations and its providers and society in general. Education on climate change adaptation strength is necessary at the regional level; the city of Rotterdam in the frame of the Strategy has developed as a good example of communication tool for participation, an online application called 'Climate Game' in which: "an active and accessible digital environment, the effects of climate change can be brought to life and it is possible to play an active role in the adaptation of Rotterdam and to learn more about the various interests involved".

The adaptation to extreme weather needs the participation, deep involvement and agreements as a consecuence of deliberation by the different actors as "public authorities, the private sector, community organisations, knowledge institutions and the citizens of Rotterdam" (Rotterdam Weather Wise Urgency Document).

The existing cartography for the natural hazars are shown in the chart below:

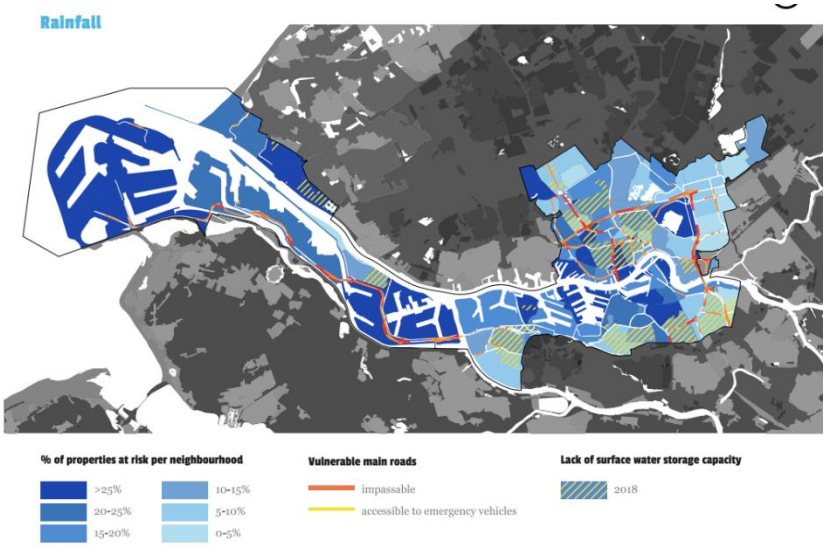
Table 2. Existing cartography for natural hazards

Natural Hazards	**Existing cartography**
River flood	https://rotterdam.maps.arcgis.com/apps/webappviewer/index.html?id=3ce1ddfc071e4551821400df2b5f10ff
Pluvial flood, Drought	http://zuid-holland.klimaatatlas-net/
Storm surge	https://www.zeeuwsarchief.nl/zeeuwse-verhalen/de-ramp-van-1953-en-de-deltawerken-2/de-ramp-feiten-cijfers-en-links/

The Rotterdam´s Weather Wise – Urgent Document, shows the maps for the hazards and includes a description of the problem, a description of the methodology to construct the map, the location of the vulnerable objects, the challenges and the response lead actors. To identify the vulnerability, a stress test is performed, locating the areas in the city where the effects of the hazards are higher. The maps are elaborated using exiting cartography and other data that has been collected and measured and it is up-to-date.

Rainfall map: "*Heavy rainfall can cause problems in the city because the sewers cannot remove all the rainwater immediately and the water cannot be stored adequately. This can lead to blocked roads and damage to buildings in certain places. A (model) calculation has been used to identify the districts with greatest risks. This has been based on 70mm of rainfall in one hour as a representative threshold of extreme rainfall in 2050. The map also shows the areas where there is still an inundation of the canals and where potential vulnerable objects are located. Heavy rainfall can lead to problems in the surface water system in certain areas. These areas have a water challenge that the waterboards are addressing in partnership with the City of Rotterdam"* (City of Rotterdam, 2020).

Figure 2. Rainfall risk in Rotterdam



Source: Rotterdam Weather Wise Urgency Document (2020)

Heat Map: *"The red on the map shows the heat in the city due to physical spatial characteristics such as a high level of paved public space and little shade (urban heat island effect), based on the Rotterdam study (2015). This is calculated with the heat index temperature. In a number of districts people have insufficient cooling in their home and immediate surroundings (based on survey). The elderly are particularly vulnerable to heat"* (City of Rotterdam, 2020).

Figure 3. Heat risk in Rotterdam

Source: Rotterdam Weather Wise Urgency Document (2020)

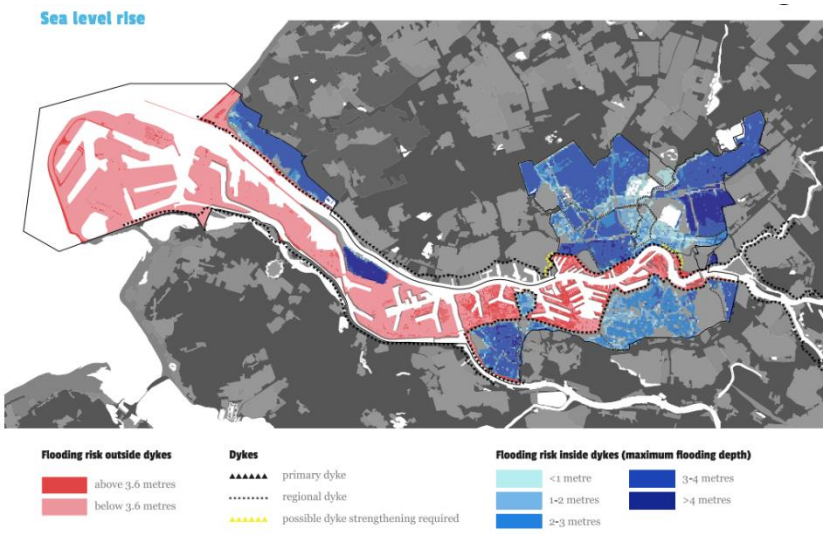
Drought Map: "*Long periods of drought can lead to damage to trees and other greenery, but also to peat dykes and foundations made of wooden piles. The map shows the percentage of vulnerable trees per area (there are 600 thousand trees in Rotterdam, of which a third part is managed by the City). Together with the parks and large green spaces that are vulnerable to drought because of their need for water. Peat dykes can dry out and thereby crack and shift. They must be kept wet during long periods of drought. The swimming locations in open water that are vulnerable to poor water quality have also been marked*" (City of Rotterdam, 2020).

Figure 4. Drought risk in Rotterdam

Source: Rotterdam Weather Wise Urgency Document (2020)

Flooding Map: *"Flood risk management involves protection against rising sea levels and high river water levels. Areas outside the dykes are not protected by a dyke, unlike the area inside the dykes. For the area outside the dykes the map shows which areas are higher and which are lower than 3,6 m above sea level (NAP). This is the current base construction level for new construction plans behind the Maeslantkering. Many older areas are at a lower elevation, and have a greater chance of flooding. The flooding depth has been shown for the area inside the dykes (the polder areas behind the primary flood defences). This shows what the water level could be in the event of a dyke breach in the primary defences. Parts of the primary defences that may need to be strengthened are marked in yellow"* (City of Rotterdam, 2020).

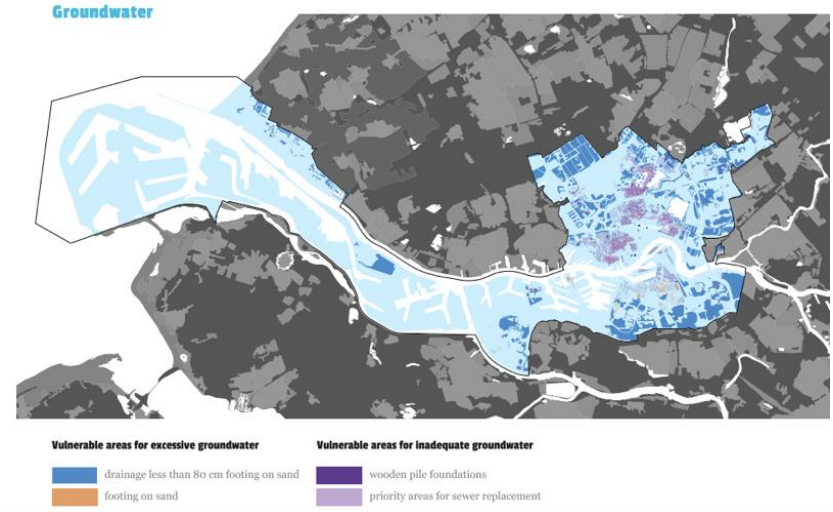
Figure 5. Sea level rise risk in Rotterdam



Source: Rotterdam Weather Wise Urgency Document (2020)

Groundwater Map: *"The map shows where groundwater problems can arise due to excessive or inadequate groundwater levels. If the difference between ground level and open water level (drainage) is less than 80 cm, there is an increased risk of excessive groundwater, particularly for buildings without poles (footing on subsoil). When groundwater levels are too low, problems can arise with wooden poles, which leads to land subsidence. Replacing sewers can lead to a change in the groundwater levels. That is why the areas with wooden poles where sewer replacement is being given priority have also been marked"* (City of Rotterdam, 2020).

Figure 6. Groundwater risk in Rotterdam



Source: Rotterdam Weather Wise Urgency Document (2020)

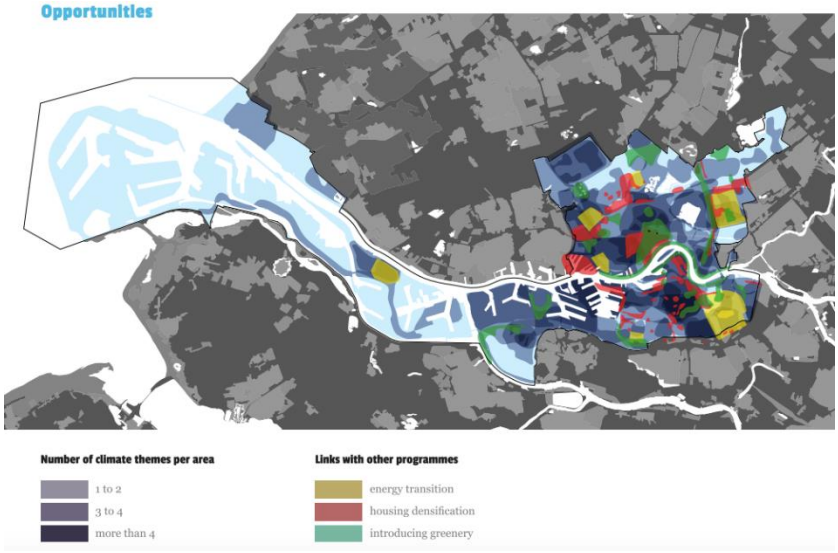
Land subsidence: *"Peat soil is particularly sensitive to settlement and uneven land subsidence during long periods of drought. This can result in damage to homes, roads, cables and pipes, amongst other things. The groundwater level also plays an important role in this. This map shows the annual average land subsidence per sub-neighbourhood calculated over the period 2008-2014. Local land subsidence can vary considerably. Areas with properties without poles which are vulnerable to uneven settlement of the soil have also been marked. The prioritisation shown indicates the urgency for measures to keep these districts liveable in the long term"* (City of Rotterdam, 2020).

Figure 7. Land subsidence risk in Rotterdam

Source: Rotterdam Weather Wise Urgency Document (2020)

Opportunities Map: *"The other transitions in Rotterdam are not standing still either. Pilots for energy have been identified, the compact city is giving rise to new locations which will be densified, and there is a desire to introduce greenery for reasons of liveability and health. Placing these on top of the Rotterdam Weatherwise challenge maps provides insight into where other major programmes within Rotterdam overlap, influence one another and can reinforce one another. These are high opportunity locations where we can make the biggest steps towards being climate-resilient together"* (City of Rotterdam, 2020).

Figure 8. Opportunities



Source: Rotterdam Weather Wise Urgency Document (2020)

4.3 Risk management

The municipality of Rotterdam has settled main and indirect related goals in the Rotterdam Weather Wise Urgency Document:

Main goals:

- Increase the percentage of properties that do not have an increased risk of flooding in the event of heavy rainfall from 88% to 90%;
- Add 20 hectares of green space by 2022 compared to 2018.

Related goals:

- A carbon emisions reduction of 49% in 2030 compared to 1990 emissions;
- There will be a air quality improvement in 2022 in comparison to 2017. In 2020 all the streets will fullfill the European health standard for NO_2;
- The Rotterdam inhabitants perception of participation regarding thinking and making decisions on action taken in their neighbourhoods will increase.

5 Climate Change Adaptation in the City of Rotterdam

5.1 General remarks

At the national level, the legal basis document containing the determinations for adaptation to climate change in the Netherlands is the **Delta Act**. The Delta Act mandates the existence of the **Delta Programme**, led by a Commissioner who oversees the mandatory annual update of the program and its implementation. The primary objectives of the Delta Program are:

- Adaptation to impacts caused by extreme changes in climate;
- Provision of fresh water;
- Flood protection.

The Program contains Plans, a schedule, and a funding plan that includes an overview of costs. There is also the Delta Fund for programme funding and its Plans. These updates are presented annually to the Parliament. The Delta Program Plans ensure that the country adapts to climate change, counts on sufficient freshwater provision and flood protection.

The second high-importance regulation at the national level is the **Water Act**, which is applied by the water authorities, as well as the provinces, municipalities and Rijkswaterstaat, it contains the most important regulations on water management and use, under the principle of prudence in decision-making. The Act includes provisions related to protection dykes, to maintain safety at water level-up events.

The Rotterdam region has several documents that develop the policy of adapting to climate change for the city, adressed in chapter 4 of this report.

5.2 Climate change impact assessment

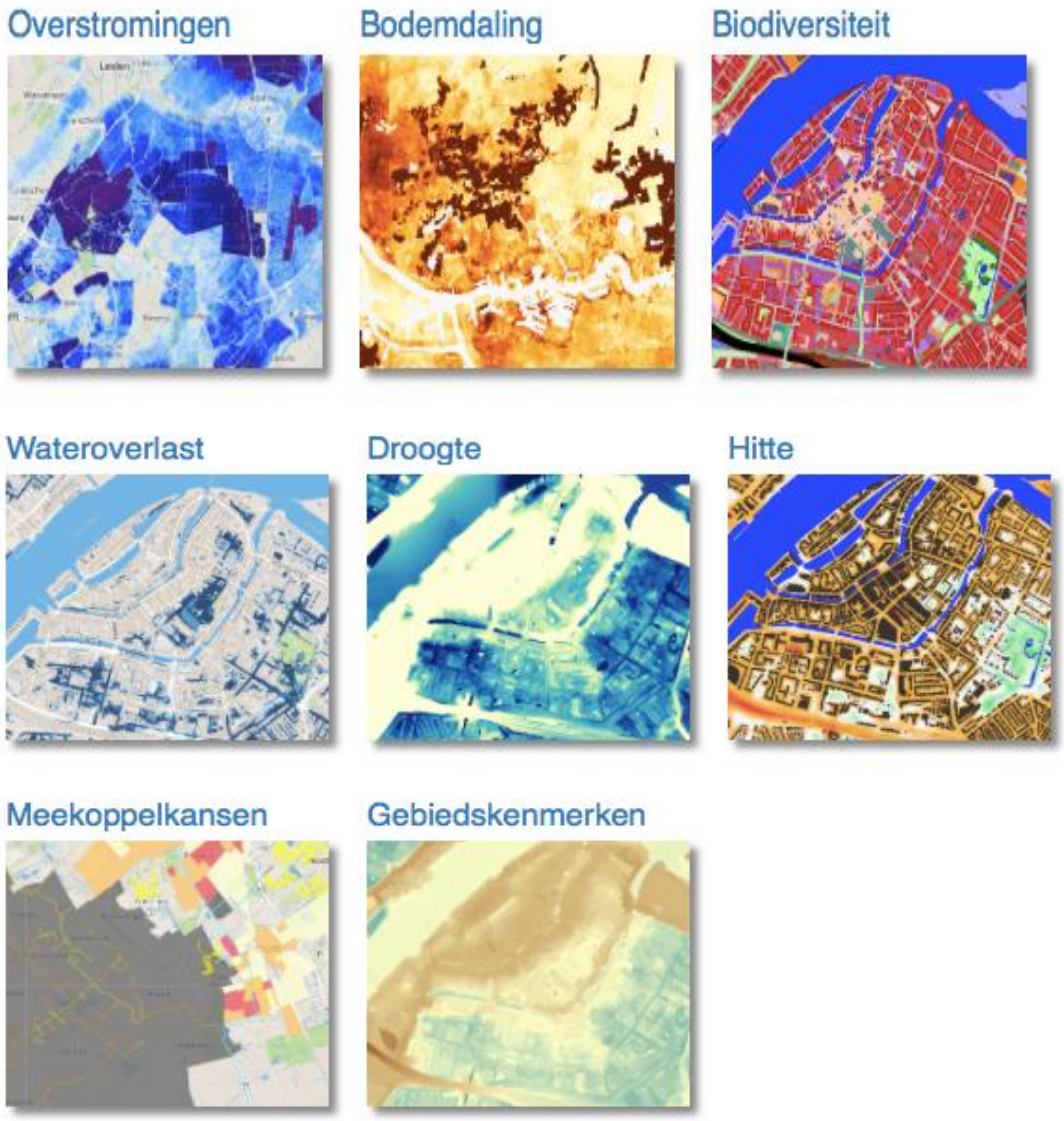
One of the sources of basic information for conducting climate change impact assessments in the Netherlands, also called resistance tests (in dutch, Stresstesten), are the climate change scenarios developed by the national Delta Program from inputs such as the speed of climate change (KNMI, the meteorologic institute in NL, and IPCC) and economic growth.

Governments of different levels do climate change impact assessments, because they have a responsibility for adaptation measures according to their competencies: The national government produces and communicates knowledge, generates policy at this level, and exercises leadership over other governments. The provinces and cities, in this case Rotterdam, are responsible for spatial planning. The regional planning includes infrastructure, housing and facilities; the local level are the one in which the spatial planning is mostly developed.

There are climate change impact maps for various threats/risks at the national level. The information used is based on national policies and guidelines. Climate change impact maps are also produced at the provincial and local levels.

- Provincial level: The South Holland province has a website (zuid.holland.klimaatatlas.net), that shows climate change impact maps for various threats at the provincial level. The information on this website focuses more on the challenges of the province and makes use of more local datasets.

Figure 9. Climate change impact maps for the South Holland province



Source: Climate Atlas Province of South Holland (https://zuid-holland.klimaatatlas.net)

- City level: **Rotterdam** also develops its own climate change impact assessments. The dataset is more local and in more detail than provincial. Assessments are done at the city level, but they are discussed with various parties such as water boards, social housing organizations, inhabitants, security regions.

Several layers of these resiliency tests also show the vulnerability of assets (such as housing, infrastructure, and public buildings).

Maps to asses the impact of climate change are mainly available on-line; they are increasingly accesible for the general society through an internet connection. The ideal, and also a challenge, is to find a balance between technical information for experts and more understandable data for the general community.

Impact assessment maps occur by following a number of steps that include:

1) Setting the goal: Defining the objetive of the map, the intended user and the format for publication (online, pdf).

2) Obtaining information and defining starting points: Collecting data from national and local levels as well as using the national starting points.

3) Developing the map.

4) Publishing the map and communicate the intended users.

5.3 Climate change adaptation

The Delta program, which is the main roadmap for adaptation of climate change at the national level defines three steps for adaptation, in which spatial planning is involved through climate agendas, which guide the implementation of actions related to the production of knowledge, social and communication, as well as physics in the territory.

The first step refers to information related to the effects of changes in the climate through impact assessments or stress tests that are developed and concreted in maps and research. This step is called "knowing".

The second concerns stakeholder participation in map content and deliberation to identify what is considered important and what is not, based on the costs associated with certain decisions. This step is known as "wanting" or "risk dialogue" and a climate agenda can emerge from it.

The third and final step, called "working", refers to actions arising from the integration of the climate agenda into the planning system, to perform research or generate knowledge, social actions such as communicating, stimulating or physical related for example to green areas and vegetation.

Primary flood defenses for their reinforcement and level of protection are handled through a process other than that mentioned above, that is in charge of the national level.

6 Vertical and horizontal cooperation and coordination in DRM and CCA in the City of Rotterdam

The cross-cutting Sustainability and Climate Adaptation Offices are in charge of coordinating action related to sustainability, climate and resilience. They work in collaboration with other levels of government as the central government and the regional water boards, that manage the quality of water, barriers agains water and waterways.

In Rotterdam, actions against climate change with a comprehensive and inclusive approach and experimentation are emerging, they are cross-sectoral, even though developed in sectors such as energy, transport, health and justice, which strengths one another.

The city develops strategic agendas as Gemeente Rotterdam, 2015, 2016, and other on sustainability, climate and resilience which deliver general guidelines on climate most revelvant concerns to be included in sectoral policies, as well as possible solutions to climate isuues that can benefit the various actors involved.

The Rotterdam Climate´s Office works in coordination with other departments of the city government. In order to ensure that its agenda is taken into account in the developments of the different local departments, the members of the Climate´s Office are distributed to work in those institutions.

In terms of information, communication campaigns are carried out in the Netherlands to raise awareness and inform about risk. The city of Rotterdam has developed an online communication tools to encourage climate change adaptation by its inhabitants. Good information and citizens' engagement help to see plans for resilience to climate change as a way both to adapt to climate change, and to improve quality of life and living standards.

7 Lessons learned

7.1 Strengths and weaknesses in dealing with natural hazards and climate change impacts

The fact that the standards for the defence against flooding caused by raise of sea and rivers level are defined by law, maintaining the safety is a **strength**. So it is, the continuous improvement and adaptation of the Adaptation Plan at national and regional scales (as part of the Delta Program), which also leads the production of knowledge and stimulate the implementation of adaptation measures at the local level by these governments.

The Delta Program, which is, besides the Water Act, the most important national policy instrument in the context of this report, addresses both risk management and climate change, and defines that spatial planning responds to the climate adaptation goals and approach through climatic agendas, which are the result of deliberation and the identification of priorities associated with the cost evalution of certain decisions.

A new national strategy that seeks to integrate the Spatial Planning Act into the Environmental and Planning Act is under elaboration (National Strategy on Spatial Planning and the Environment, NOVI). It is intended to guide the transition from renewable energy, adaptation to climate change, the conversion to smart and green transport and a circular economy, liveable and accessible cities, and to respond to societal demands for more efficient procedures.

At the case study, both documents, the Adaptation Strategy and the Rotterdam Weather Wise Urgency Document opt for the participation of public authorities, the private sector, the education sector, community organizations and citizenship in decisions on adaptation to climate change.

At the city scale, the Climate Change Adaptation Strategy (2013) opts for adapting the city functionng to the changing natural behavior of the delta and its water levels. It also combines different scales such as large water infrastructure, city land-use and small scale interventions.

The level of vulnerability of the city of Rotterdam is an input to define both, goals and approaches for adapting to climate change, as well as the urban land-use, the developable areas and those to densify (Rotterdam Weather Wise Urgency Document, 2020).

There are climate change impacts maps at provincial level. At the case study level the impact of climate change is also considered – the natural hazards are mapped, and this mapping includes the identification of vulnerable areas, as well as an opportunities map regarding energy transition, densification and introduction of vegetation.

The Rotterdam city climate governance approach is certainly innovative, as well as its strategies and actions; however, they have not covered the whole city in terms of spatial planning and decision-making process, being, in fact, most of the initiatives yet independent and mostly communicated in international arenas than in the local scenario to take the opportunity to create a net of knowledge for local companies.

Dealing with climate change for mitigation and adaptation is still considered extra-work in most of the practices of governance because the initiatives and solutions involve, so far, only a group of key actors. There are no formal conditions for collaborative financing, necessary to reach the long-term and systemic goals, then, the goals are threatened by the instability of the priorities.

According to Hölscher et al. (2019):

- the issues related to climate are not sufficiently addressed in spatial planning;
- long-term decisions that imply risk, costs and benefits are not yet present enough in the process of decision-making because the existing regulations favour initiatives of short-term economic return;
- the regulations still incentive investments that produce the opposite result to the desired and difficult the effectiveness of the innovative responses;
- adaptation responses are still presented generally, in the first two layers of the strategy, and a necessary behavioural change has been addressed through training and campaigns, tools that research in social science has highlighted as not enough to reach the objective.

The Rotterdam case study addresses hazards from which there is little evidence and information in the European context. Although it is probably not applicable to the entire territory of the continent, the exchange in the C40 Connecting Delta network Cities (which objective is supporting *"the efforts of coastal delta cities to address climate change related spatial development, water management and adaptation"*) has shown that it is useful for cities like Mexico City and Los Angeles, and in general for metropolitan areas around the world, especially those that are located along large rivers.

7.2 Useful elements for best practices and methodologies

Examples of successful actions implemented, are useful for plans on a city scale like RAS, GRP, Weerwoord. Integrating physical planning and climate change adaptation goals are examples of good practice, for example, the semi-detached dams in Rotterdam, designed to providing collective public space and defending against floods, or recreational waterways serving a similar purpose (Rotterdam Climate Initiative, 2014). In the same way, are the spaces that store water, floating adaptable buildings (Rijnhaven) (Rotterdam Climate Initiative, 2014) (Braw, 2013), green roofs (Alexandrium), water squares for collective use (Bellamyplein), (Braw, 2013) and the blue roofs (Kruisplein and in Museum Park). An urban renewal project for the Rotterdam waterfront area plans to combine these good practices in a project that includes the Stadshavens district – of around 1.600 ha – using an adaptability approach (Piert Dircke, 2015).

Other physical projects that show succesfull measures for climate change adaptation are rowing lane, as water retention area near Zevenhuizenplas, the floating forest and floating pavillion near Wilhelminapier, the floating Park in Rijnhaven (not yet built), the water storage in

Museumpark parking garage, the Vierhavenstraat multifunctional flood defence with park and shopping mall, and water squares like Benthem water square.

Figure 10. (left) Floating pavilions and trees in the outer-dike area (2018)

Figure 11. (right) The Benthemplein water square (credits: Ossip van Duivenbode)

Figure 12. (left) Water storage combined with a rowing course (2013)

Figure 13. (right) Water storage, nature and recreation in the Zuiderpark (2013)

Source: Adaptation Strategies to Climate Crisis (2019)

In this chapter several strenghts in the management of natural hazards and climate change adaptation for this case study has been shown. The above are also good examples of the integration of physical planning and climate change adaptation goals, that are also nature-based solutions. Anyway, considering the high economic costs that the hazards have caused, and those that are expected, a deeper practical integration between climate change adaptation policies and strategies and the decision making for spatial planning issues are key factors to implement corrective actions all along the case study area and control the negative economic impacts.

References

Batist, D. (2019) Rotterdam Tackles Climate Change and Poverty: The city in the Netherlands is betting that climate change adaptation can uplift residents in one of its poorest neighborhoods. Available at: https://www.usnews.com/news/cities/articles/2019-09-17/rotterdam-looks-to-tackle-climate-change-and-poverty-at-once

City of Rotterdam (2020) Rotterdam Weather Wise Urgency Document Available at: https://www.rotterdam.nl/wonen-leven/rotterdams-weerwoord/Urgentiedocument-2020_EN.pdf

City of Rotterdam (2013) Rotterdam Climate Change Adaptation Strategy. Available at: http://www.urbanisten.nl/wp/wp-content/uploads/UB_RAS_EN_lr.pdf

Gemeente Rotterdam Municipal sewerage plan. Available at: https://www.rotterdam.nl/wonen-leven/grp/

Generalitat Valenciana, Universitat de Valencia (2019) Adaptation Strategies to climate crisis. Valencia 2019. The Rotterdam Climate Change Adaptation Strategy. Available at: https://prospectcv2030.com/wp-content/uploads/2019/12/Bass-Amelung-2.pdf

Government of the Netherlands. Delta Act, Delta Commissioner and Delta Fund. Available at: https://www.government.nl/topics/delta-programme/organisation-of-the-delta-programme

Government of the Netherlands. Summary National Policy Strategy for Infrastructure and Spatial Planning. Available at: https://www.government.nl/topics/spatial-planning-and-infrastructure/spatial-planning-in-the-netherlands

Hölscher, K., Frantzeskakia, N., McPhearson, T., Loorbach, D. (2019). Tales of transforming cities: Transformative climate governance capacities in New York City, U.S. and Rotterdam, Netherlands. Revista de Gestión Ambiental (231): 843-857. Available at: https://www.sciencedirect.com/science/article/pii/S0301479718311770?viewFullText=true

Moel H, M van Vliet, JCJH Aerts (2014). Evaluating the effect of flood damage-reducing measures: a case study of the unembanked area of Rotterdam, the Netherlands. Regional environmental change, 2014. Available at: https://link.springer.com/content/pdf/10.1007/s10113-013-0420-z.pdf

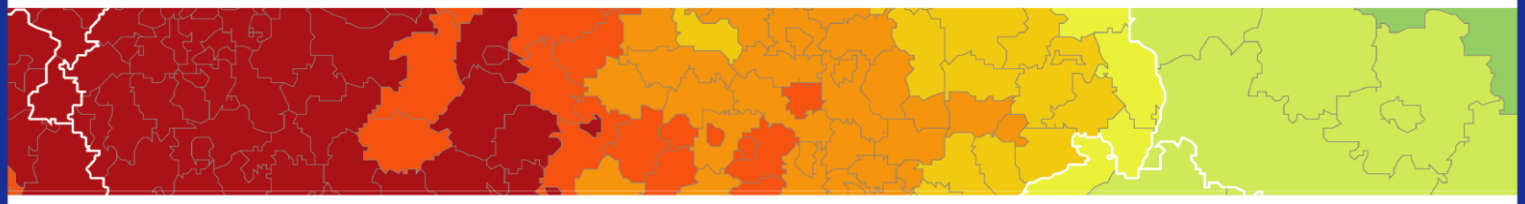
Moel H, M van Vliet, JCJH Aerts (2015) Adapting to Climate change in urban water management: Flood management in the Rotterdam-Rijnmond Area, in Understanding and managing urban water in transition. Available at: https://books.google.es/books?id=UMAlCQAAQBAJ&pg=PA565&lpg=PA565&dq=rotterdam+building+codes+climate+adaptation&source=bl&ots=xVfkLeIJjd&sig=ACfU3U0OfA8y45O3DOWW5Qiq2VBcYrlkQg&hl=es&sa=X&ved=2ahUKEwjfnN3u5pfqAhWNX8AKHQivD5sQ6AEwBHoECAkQAQ#v=onepage&q=rotterdam%20building%20codes%20climate%20adaptation&f=false

Port of Rotterdam (2017) The port of Rotterdam anticipates climate change. Available at: https://www.portofrotterdam.com/en/news-and-press-releases/port-of-rotterdam-is-anticipating-climate-change

Rotterdam Transport. Map Rotterdam Port Area. Available at: https://rotterdamtransport.com/maps-port-of-rotterdam/

Rising sea level. Available at: http://15146-group1-climatechange-sealevel.weebly.com

South Holland Province. Climate Atlas Province of South Holland. Available at: https://zuid-holland.klimaatatlas.net



ISBN: 978-2-919816-06-4

ESPON 2020 – More information

ESPON EGTC
4 rue Erasme, L-1468 Luxembourg - Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: **info@espon.eu**
www.espon.eu, **Twitter**, **LinkedIn**, **YouTube**

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States, the United Kingdom and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.