

CASESTUDY

ROTTERDAM RESILIENT DELTA CITY CONNECTING WATER AND ADAPTATION WITH OPPORTUNITIES

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■ Within the Rotterdam Climate Initiative, Rotterdam addresses the entire field of climate change, both reducing the causes of climate change (mitigation) and adaptation. Its adaptation programme, Rotterdam Climate Proof (RCP), was launched in 2008 and aims to ensure that Rotterdam is fully climate resilient by the year 2025¹. The RCP programme is strongly related to the Rotterdam Waterplan, a joint comprehensive plan of the City of Rotterdam and the three regional Water Boards². The cooperative development of a joint vision on urban quality, urban water and adaptation has been fundamental for a strong local water governance. The integrated approach adopted in Rotterdam's adaptation strategy is that of 'connecting water and adaptation with opportunities'. In practical terms this involves applying innovative solutions that enhance the safety and the quality of life in the city while, at the same time, offering substantial economic potential for the entire region. The programme is based on three pillars: (1) knowledge; (2) implementation; and (3) exposure and spin-off.

KNOWLEDGE - Rotterdam is able to draw on specific knowledge generated through the national Knowledge for Climate Research Programme. Crucial knowledge about regional and national flood risk management has been (and continues to be) developed through the National Delta Programme and its regional sub-programme, 'Rijnmond Drechtsteden', which is chaired by the Mayor of Rotterdam. On an international level, Rotterdam established the Connecting Delta Cities (CDC) network^{3,4,5} to share knowledge, experiences and best practices (Fig 1). Additionally the Rotterdam case increasingly acts as a source of experience and knowledge, especially regarding urban adaptation and related governance issues, which in turn generates new knowledge for the city itself.

IMPLEMENTATION - Rotterdam develops innovations and knowledge and applies these in practice to become a climate resilient city and at the same time an international showcase. In recent years several innovative pilot schemes have been implemented including: water squares, underground water storage below a car parking garage, a rowing course annex water storage and a floating pavilion.



Figure 1: Connecting Delta Cities (CDC) network

EXPOSURE AND SPIN-OFF - Rotterdam's leading position in this field is now creating new alliances and programmes, which further support the implementation of the climate adaptation strategy⁶. Additionally Rotterdam's reputation also brings new projects for knowledge institutes, consultancies and

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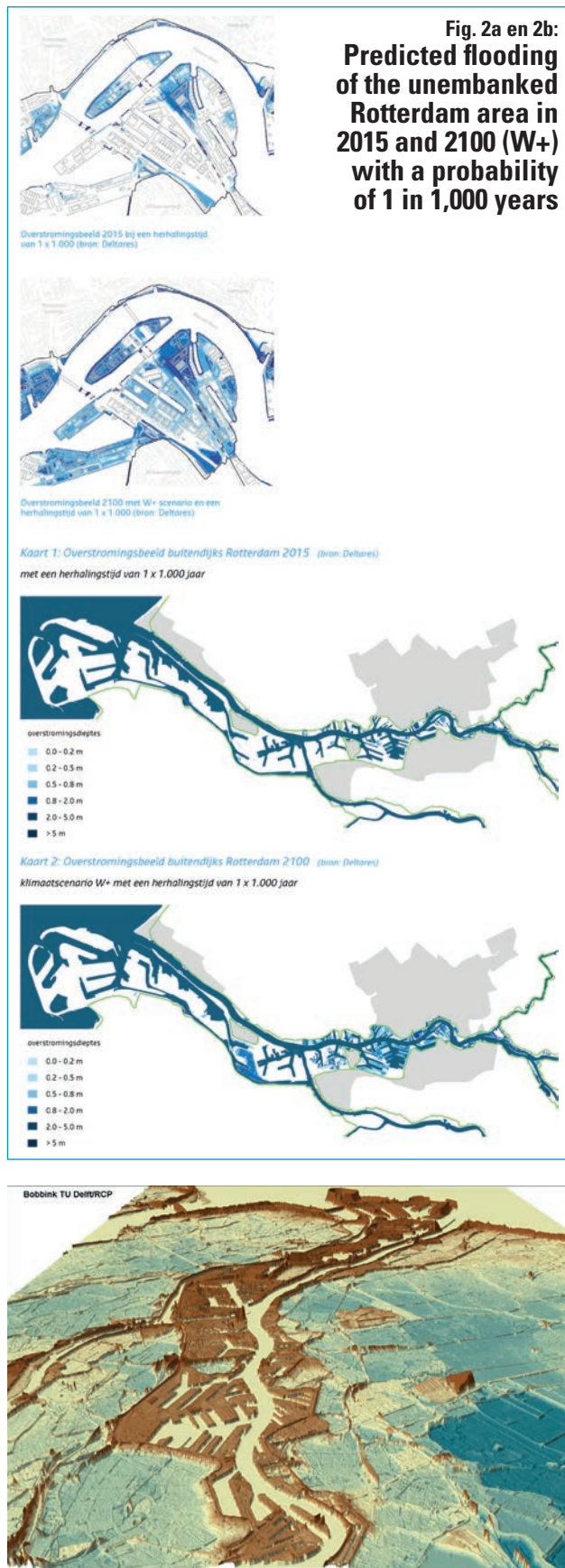


Fig. 3. A digital elevation map of Rotterdam
Brown color is above sea level and blue below seal level. (source TNO).

other knowledge driven businesses in the region, creating high quality jobs and attracting motivated and talented students. This mechanism becomes a new driver for the City's ambitions and enriches local water governance.

Challenges

Rotterdam, like many other delta cities, is vulnerable to the consequences of climate change in many ways. With higher sea and river levels, the risk and frequency of flooding in the outer-dike areas of Rotterdam will increase, as will depth of flood inundations. Figures 2a and 2b illustrate the predicted flooding of the unembanked Rotterdam area in 2015 and 2100 (W+) with a probability of 1 in 1,000 years. Flooding can cause considerable damage in the affected areas. Yet it is very unlikely that casualties will occur. This river zone area has a relatively high elevation (Fig. 3) which will limit the floodwater flow rates and flood depths during periods of flooding. However vital infrastructure within the outer-dike areas will be vulnerable. If no measures are taken, the risk of inner-dike Rotterdam flooding also will increase. Rising water levels will also mean that the Maeslant storm surge barrier will have to close more frequently. This barrier is designed to cope with rises in sea level of up to 50 cm. During extreme rainfall, the vulnerability of the drainage system becomes apparent. Peak downpours are already causing disruption and damage as water floods the streets, cellars become inundated and sewer overflows discharge directly into the canals and waterways. In recent years the city has made extra room for water, both within the robust system (for example, the underground water storage facility under the Museum Park) and also in additional surface water, as in Zuiderpark. The probability of flooding is increased by the fact that the low-lying peat on which many areas of Rotterdam are built is still settling and compacting. This problem will increase as a result of climate change because longer periods of drought are likely to occur and this will increase subsidence and destabilise and weaken dikes.

As a result of climate change, longer periods of drought and shortages of rainfall will also occur more frequently. One direct effect of this is that drought will lead to a groundwater deficit and lower water tables. A second consequence is that longer dry periods in the river catchment areas will lead to lower river levels. The drying up of the subsoil in certain areas will lead to further compacting and subsidence. Subsidence and lower groundwater levels in turn also pose a threat to buildings on wooden pile foundations. A further direct result of lower river levels will be the increase of salt intrusion (Fig. 4). This will have an impact on drinking water supplies and the ecology of the river. Finally, the lower river levels will obstruct shipping as the navigable depths decrease.

Climate change will also increase the number of

tropical days (hotter than 30 °C) and the likelihood of heatwaves. These changes will be magnified by the Urban Heat Island (UHI) effect. The difference in temperature between the city centre and surrounding countryside can be as high as 8 °C. The elderly and people suffering from respiratory diseases are the most vulnerable groups and there is a significant increase in mortality rates among these groups during heat waves, partly due to heat stress, but partly to poorer air quality. Malfunctioning of essential structures in the road network, such as bridges not opening or closing properly due to heat stress or melting asphalt on major roads, can disrupt the traffic in the city and damage the economy.

Rotterdam's Climate Adaptation Strategy

The challenges that Rotterdam faces as a result of climate change are not acutely critical. The city does have enough time to adjust to and evolve with the 'delta dynamics'. It should be able to adapt to the effects of a changing climate on a changing urban environment. These are the basic pillars of Rotterdam's Climate Adaptation Strategy (Fig. 5):

Rotterdam can continue to rely on the current robust system, which consists of storm surge barriers and dikes, of canals and lakes, outlets, sewers and pumping stations. This, however, is not enough. Rotterdam has to adapt by introducing additional measures across the entire city. This will generally involve a widescale application of small-scale measures. With new measures in the public and private area and on top of buildings an additional 'layer' of measures will be added to the more traditional solutions related to the sewer system. These measures need to be done together with new partners and stakeholders and to be linked with projects and maintenance programmes. All measures should generate added value to the living environment, communities, economy and ecology. Wherever possible these measures should involve ecologically sound solutions. New stakeholders means new governance. Additional to the partnership between City government and the water boards, now new coalitions will be necessary with housing companies, utility companies the Port Authority, etc. In densely built-up urban areas there is a lot of pressure on public areas and very little available space. Here, the focus is on combining urban functions, such as including space for underground water storage underneath or on top of a car parking garage as has been done at Museum Park and Kruisplein (Fig 6), and water squares such as the Bellamyplein. The Bethemplein water square (Fig 7) has a capacity to store 1,800 m³ of rainwater. It was completed in December 2013. Benthemplein is the world's first large water square, designed by Rotterdam-based architects (De Urbanisten). It is an example of both a multifunctional solution and a true participatory approach. The design involved collaboration with representatives of the

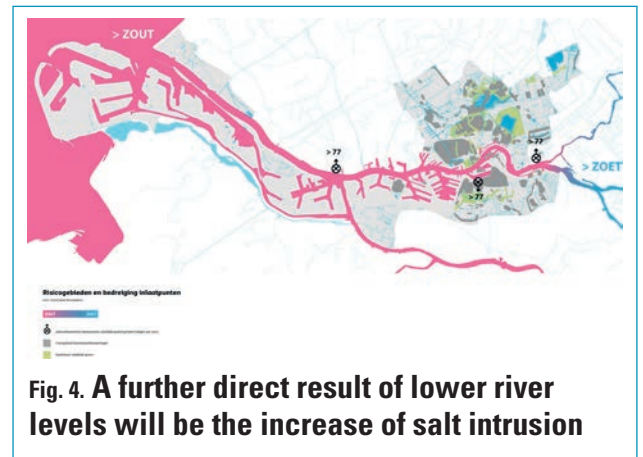


Fig. 5. The basic pillars of Rotterdam's Climate Adaptation Strategy



Fig 6. Water storage with Water Shells on top of the Kruisplein Car Parc



Fig 7. The Bethemplein water square

neighborhood such as students, teachers, members of the adjacent church, youth theatre and residents. In addition, green and blue roofs, the removal of paving, the planting of trees and bushes in the streets, the provision of more open areas and ‘waterproof design’ all contribute to increased resilience. In the post-war urban districts there is more potential for creating additional stretches of open water, such as canals and lakes. In the outer-dike areas the strategy focuses on a combination of prevention and adaptation. New building codes will be developed. Over the coming years, the City Harbours will provide a location for floating communities. Adjustments of the dikes will be linked to specific local area development. A sound and effective measure to combat the effects of drought is to create extra surface water in the city. It is possible to achieve this at city level by expanding and constructing green-blue networks. Ideas in this respect include the creation of rain gardens on privately owned land while, in the public domain, the effectiveness of linear green areas where water can infiltrate is being investigated.

Smart Delta City Rotterdam

Rotterdam’s strategy does not just involve developing and implementing adaptation measures, but also the development of innovative smart tools that will enhance the climate proofing of the city. A number of smart climate adaptation tools has already been developed and are in use, including the Rotterdam Climate Atlas, the Adaptation Design Toolkit, the Rotterdam Climate Societal Cost Benefit Analysis and the Rotterdam Climate Game. Another method used is to integrate IT technology into the most modern and innovative adaptive flood control science and development. Smart flood control and climate adaptation is not just about technology and innovation; it is also about human capital. Rotterdam needs a future generation of engineers, civil servants and scientists to deal with the ongoing challenges of climate change and to develop the next generation of innovative solutions. Young talents need to be attracted to start a career in the water sector and, recognising this, the city cooperates with research institutions, businesses, the Rotterdam University of Applied Sciences and its students, in what the Dutch call a ‘golden triangle’.

Attractive City and Added Economic Value

With Rotterdam Climate Proof the city is becoming more attractive by adding urban value in the public area. Equally, and perhaps even more importantly, adaptation also offers economic opportunities. In recent years, Rotterdam has already started to harvest the benefits from this approach. New partnerships and coalitions have been set up helping to start and finance pilots in the city. New innovation and valorisation programmes have been started. Usually Rotterdam welcomes 20-to-25 delegations, who visit the city

every year to experience at first hand our approach to climate adaptation. This is creating new business, jobs and research programmes. Also the 'Peer City' status Rotterdam had within the European Adaptive City Project, contributed to building its reputation. Part of the spin-off was that Mayor Aboutaleb received an invitation from Mayor Bloomberg of New York and former President Clinton to participate in round-table talks about Climate Resilient Cities in May 2013. Currently Rotterdam's status of leading city resulted in becoming member of the first group of cities selected through the Rockefeller Foundation's 100 Resilient Cities Centennial Challenge, which generates additional financing to become a resilient delta city.

Dutch Delta City Approach

One can conclude that in Rotterdam adaptation has been and still is a flywheel for innovation and valorization regarding water and delta technology. Nowadays the regional cluster of consultancies, knowledge institutes and local governments in the Delft-Rotterdam-Dordrecht region act as a centre of expertise for resilient delta cities. Regional initiatives like the Clean Tech Delta strengthen this position. All activities and spin-off mentioned above are examples of results generated by this innovation and valorization chain (Fig. 8). This includes knowledge development and pilots with respect to both technical solutions and governance aspects ('hardware and software'). The Rotterdam Climate Adaptation Strategy already proved to be an export product as Dutch consultancies developed a strategy for Ho Chi Minh City after this Asian delta city visited Rotterdam. Integrated strategies and measures are ingredients of the Dutch Delta Approach. More specific the case Rotterdam is used as the Dutch Delta City Approach and increasingly acts as a portfolio of the Dutch Water Sector. In this context the Connecting Delta City network proves to be a strong network that not only supports knowledge exchange, but also opens doors to a growing international market. It is clear that here the so called water diplomacy by innovative urban water governance and adaptation is brought into practice.

Lessons Learned

The past decade Rotterdam has been through a water governance transition: from a sectoral city water plan (2001), to an integrated water plan (2006), followed by the holistic adaptation strategy (2013). This learning by doing process, including the associated governance development, can be a source of inspiration for other cities in the world. A strong governance structure, political leadership, committed employees and local participation of residents are keys to success. The development of a first water square had to be stopped due to late involvement of the community. The Benthemplein water square however is an inspiring example regarding the participation process. These



Fig. 8. The Rotterdam Innovation and valorization chain

and other experiences will be used in the most recent phase of Rotterdam's adaptation process and that's the development of the first climate resilient district Zomerhofkwartier, also known as ZoHo.

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SAMENVATTING

De Rotterdamse Adaptatie Strategie (RAS) is weer een nieuw ijkpunt in de water governance transitie die Rotterdam het laatste decennium heeft doorlopen. Van een sectoraal waterplan, naar een integraal waterplan en vervolgens de holistische adaptatie strategie. Met de RAS is de koers aangegeven hoe de stad kan anticiperen op extremere weersituaties en stijgende zeespiegel. Hierbij werkt de gemeente met steeds meer en nieuwe stakeholders. Het partnership met de waterschappen vormt de basis. Nieuwe stakeholders zijn in beeld, want er wordt een nieuwe generatie aan maatregelen geïmplementeerd met nieuwe financiële arrangementen. Tegelijkertijd is de samenwerking met kennisinstellingen en bedrijfsleven essentieel. Inmiddels is er in de regio Rotterdam een vliegwielt op gang gekomen: kennisontwikkeling leidt tot nieuwe innovaties, de innovaties worden toegepast in de stad, daarmee creëert de triple helix haar eigen showcase en etalage, wat weer leidt tot export naar andere deltasteden. Kortom, slimme adaptatie loont. ■