FLOOD RESILIENCE: EUROPEAN EXPERIENCE

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Abstract

In the last couple of years, many countries suffered from flooding in Europe. The EU floods directive requires flood risk reduction for areas where risk is deemed significant. For these zones, flood risk management plans must be prepared. Each European country has opted for different solutions.

The Netherlands has opted i.e. for multi-layer flood risk management. Lately the 2nd Delta programme released their so-called delta decisions. One of these decisions states that the built environment should become less vulnerable to extreme weather conditions and potential flood-related damage. That requires a process of change: climate-proof and water- robust development should be part and parcel of spatial (re)developments in the Netherlands. This change can tie in with the ongoing (re)developments taking place in the area. All government authorities and private parties will share responsibility for this. Water and space are systematically connected in this way. In the Netherlands, prevention still remains the cornerstone of our flood protection.

In other European countries, there is a stronger focus on emergency response and recovery, i.e. France and Great-Britain. Several cities in France focus on flood issues through information campaigns, spreading knowledge about floods in the communities and raising awareness. They are also putting in place rescue and recovery plans for the population and public services. The aim is to minimize damages and enable the city to recover as quickly as possible after flood events.
In this paper, several examples will be presented to give an overview of building flood resilience in Europe.

Introduction

Floods, together with wind related storms, are considered the major natural hazard in the European Union (EU) in terms of risk to people and assets. Currently, more than EUR 40 billion per year are spent on flood mitigation and recovery (including compensation of flood damage) in EU. More than 75 % of the damage caused by floods is occurring in urban areas. About EUR 3 billion per year are spent on large scale flood defence structures alone.
A significant part of the world population lives in flood-prone areas. This includes coastal zones, river plains exposed to coastal or fluvial flooding risks and lowlands sensitive to flooding due to heavy rainfall or groundwater. More extreme weather events are expected to occur more frequently in many parts of the world, thus increasing the risk of damage to residents, economy, ecology and cultural heritage (Colette, 2007; Prasad et al., 2009). According to Kron (2005) climate change will result, in many cities, into more extreme flooding. Maplecroft (2014) showed that the UK is among the countries with the greatest risk to their economic output, from flooding, behind the US, China, India, Bangladesh, Germany and Japan.

The urban population is expected to grow over 4 billion in the next 30-35 years (UNFPA, 2007). Population dynamics have a critical influence on each of the three pillars (social, economic and environmental development), leading to a necessity to arrange for sustainable cities in a broad sense (UNFPA *et al.*, 2013).

In order to adapt urban areas (in river and coastal zones) to prevent flooding or to be better prepared for floods, decision makers need to determine how to upgrade flood defences and increasing flood resilience of protected buildings and critical infrastructure (CI) (power supplies, communications, water, transport, etc.) and assess the expected risk reduction from these measures. Global warming is expected to lead to more severe storm and rainfall events as well as to increasing river discharges and sea level rise. This means that flood risk is likely to increase significantly. Provoked by several severe flood disasters within Europe causing the death of people and large sums of damages, the EU Floods Directive (2007/60/EG) was issued in October 2007 by the European Parliament and Council. Its aim is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity.

In this paper, several examples will be presented to give an overview of building flood resilience in Europe.

EU flood policy framework

The implementation of the EU Flood Directive leads to the development of flood risk management plans. These plans are to include measures to reduce the probability of flooding and its potential consequences. They will address all phases of the flood risk management cycle but focus particularly on prevention (i.e. preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas or by adapting future developments to the risk of flooding), protection (by taking measures to reduce the likelihood of floods and/or the impact of floods in a specific location such as restoring flood plains and wetlands) and preparedness (e.g. providing instructions to the public on what to do in the event of flooding). Due to the nature of flooding, much flexibility on objectives and measures are left to the Member States in view of subsidiarity.

In line with the EU flood policy, a new Dutch policy, which was activated in 2009, is designed to create a reversal in Dutch traditional thinking. The multi-layer flood risk management still focuses on prevention as the policy cornerstone. In recent years also more focus came for the other two layers. This Dutch approach consists of three aspects:

1. Prevention
2. Sustainable floodproof spatial planning
3. Emergency management.

The consequences of climate change make the necessity to mitigate and anticipate that much greater. Examples of climate change include an accelerated rise in sea levels, higher peak discharges in the rivers, periods of drought or flooding and a shifting ecological balance. In other European countries the focus lies on recovery plans and mitigation. The aim is to minimize damages and enable the city to recover as quickly as possible after flood events.

Conceptual framework

Adaptation of the water system to a changing climate is the primary focus of low-lying Deltas like the Netherlands. Even with the most far-reaching restriction on the worldwide production of greenhouse gasses, the climate will change in the course of the coming century and the sea level will continue to rise. We must adapt our water system but the question is how and when. The approach until now was to develop one or more possible climate scenarios and then use these to calculate the effectiveness of different strategies. Designs for scenarios were made for the purpose of water management strategies based on, for example, hydraulic conditions. However the scope, speed and even the direction of climate change are surrounded by huge uncertainties. The additional disadvantage of the traditional approach is that as soon as there are new insights into changing climate, the conditions change and with that the starting points for the strategy previously designed. For that reason the Adaptation Tipping Points approach (ATP) (Kwadijk et al., 2010) has been developed. Earlier research (Kwadijk et al., 2010) focussed on the issue to what extent the climate can change before the current water management and water policy are no longer adequate. This can be considered as a sensitivity analysis of the water system.

ATPs in water management are thus the specific boundary conditions where technical, economic, spatial or societal acceptable limits are exceeded. The time at which an ATP will occur (which is dependent on the climate scenario considered) defines the moment that alternative adaptation measures will be needed. ATP or adaption pathways describe a sequence of water management policies (for measures) enabling policy makers to explore options for adapting to changing environmental and societal conditions (Haasnoot et al., 2012a). Elements of the method such as the 'visualisation of moment to switch' and 'the possibility to explore options' aid in making choices that involves taking uncertainties into account.

An important building block to the development of the adaptation pathways is the information on the effectiveness over time of possible measures. A tipping point analysis defines the moment (or period) in time when climate change effects (e.g. increasing water levels or flood frequencies) reach such an extent that certain policy objectives cannot be met anymore and thus give an indication of the urgency for adaptation. A tipping point analysis can be applied to assess current policy as well as give insight into the effectiveness of proposed flood risk reducing measures in view of climate change.
Insight is given when current flood risk management strategy can no longer meet its objectives. Beyond these tipping points an alternative, adaptive, strategy is needed. By applying this approach the following basic questions of decision makers are answered: what are the first issues that we will face as a result of climate change and when can we expect this (Kwadijk et al., 2010). Depending on the ATP's governance strategies can be developed, in strong collaboration with all relevant stakeholders.

In recent years, the threats of climate change and its impact on a lowland country like the Netherlands have put flood (risk) management upfront on the political agenda (Ministery of Infrastructure & Environment, 2009) By involving citizens, NGOs and stakeholders, public decision-makers hope to enhance support for their decisions (which can heavily impact upon the daily life of citizens, and thus to accelerate decision-making processes. Moreover, participation can strengthen both the quality and democratic legitimacy of policy processes and decisions (Michels, 2011; Edelenbos et al. forthcoming). Different approaches can be identified, among the earlier described ATP's.

Setting the scene: the Netherlands

In the Netherlands the dikes and dunes are the main flood protection system. The primary water defences protects the country from flooding by the sea, main rivers and Lakes. The secondary defences are also important, but the consequences of a dike failure are not as dramatic. The Flood Defences Act indicates the safety standards for every dike ring area. The standard is higher if more economic activities take place within the ring and if the number of inhabitants is high. The standard is expressed in a probability per year that a critical water level will occur, e.g. 1:1,250 per year. The requirements for a flood defence structure in terms of height and strength are derived from that standard. Rijkswaterstaat and the regional water authorities are responsible for the primary and regional flood defences in the Netherlands. Some say that the Netherlands is one of the best protected deltas of the world (Ministry of Infrastructure & Environment, 2013).

However, three quarters of the housing in the area inside the dykes may be damaged if the primary flood defence systems are breached. There are buildings in the area outside the dykes as well, where there is often little flood protection. Vital and vulnerable functions, such as hospitals and power plants, are generally not flood-proof. As a result of climate change, built-up areas may also suffer damage caused by heat, extreme drought and pluvial flooding. This was often not taken into account when decisions on location, spatial organisation and construction method were being made. As such, it is important to make built-up areas less vulnerable to extreme weather conditions and potential flood-related damage.

That requires a process of change: climate-proof and water- robust development should be part and parcel of spatial (re)developments in the Netherlands. This change can tie in with the on-going (re)developments taking place in the area. All government authorities and private parties will share responsibility for this.

Setting the scene: United Kingdom

Flood and coastal erosion risk in England is expected to increase due to climate change and development in areas at risk. It is not possible to prevent all flooding or coastal erosion, but there are actions that can be taken to manage these risks and reduce the impacts on communities.

In the UK the risk management authorities should work in partnership with communities to understand the community perspective of flooding and coastal erosion, help communities understand and actively prepare for the risks, and encourage them to have direct involvement in decision-making and risk management actions. This includes giving communities a bigger say in what action is taken, greater responsibility for managing their own risks and decisions on local funding priorities, and as a result greater accountability for the level of safety and protection achieved and the way in which the risks are managed. The aim is to ensure that decision making and ownership of risk management measures are as local as possible but within a catchment, coastal cell and national framework that ensures a fair allocation of funds and avoids the transfer of risk elsewhere without prior agreement. The UK insurance industry currently provides insurance against flooding as a standard feature of buildings and contents insurance. This contrasts with the approach widely used in other countries, where flood cover is sold as a separate policy. In the Netherlands just one insurance company sells insurance against flooding. There the central government provides an overall safety level.

Examples of creating a more flood resilient environment

Two examples will be described in the remainder of this paper.

Example 1: Use of Adaptation pathways for unembanked areas

The region of Rotterdam is vulnerable for both tidal and pluvial floods. The majority of this urbanized region is protected by a network of primary flood defences. Another characteristic is that a large part lies outside the protection of the primary flood defence system. In the Rotterdam-Dordrecht floodplain about 65.000 people (distributed over 46 municipalities) live in unprotected (unembanked) areas (Veerbeek *et al.,* 2010). The Rotterdam port industrial complex, which is vitally important for the Dutch economy and that of the neighbouring countries, is located outside of the primary defence system.

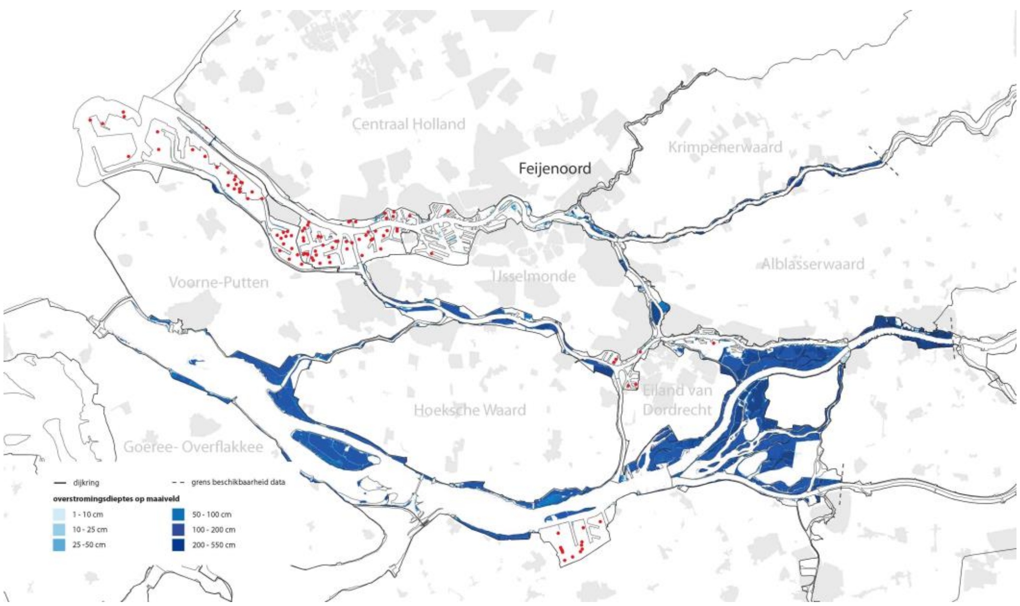

Figure 1. The unembanked areas in region Rijnmond-Drechtsteden. The blue colors indicates the flood depth at a 1/100 flood event (source: Deltaprogramma Rijnmond-Drechtsteden, courtesy picture: DeFacto Architectuur en Stedenbouw)

Although these unembanked areas benefit protection by the Maeslant Barrier, there is still a considerable risk of flooding (Veerbeek et al., 2012, Van Veelen et al., 2010). Large parts of the areas has already been raised to 3 to 3,5 meters above average sea level. Few areas, like Heijplaat and Noordereiland have a higher potential risk (e.g. between a yearly to a one every 100 years event) of flood damage (Veerbeek *et al.,* 2012). In the following decades the city of Rotterdam encounters two major developments: (1) the land use of the unembanked areas will be intensified and (2) climate change will increase risk of flooding. This aggravates both the risk of future disasters, while at the same time the increased economic value and activities could cause the possible consequences of flooding to become more severe.

Flood risk management for the case Feijenoord, Rotterdam

At this moment, there is no integrated flood risk policy for flood protection in the unembanked areas. The prevailing long-term flood risk policy i.e. of the City of Rotterdam is based upon a formal regulation to raise the ground level of new building lots to the 1/10.000 storm surge flood level. The current storm surge flood level height is set to a level that fluctuates between 3,90 to 4,10 m above sea level, depending on certain local conditions, such as wind direction and wave upset. This policy implies that new buildings and assets have to be raised to approx. 1 m above average street level. For existing urban areas there is no additional policy or regulation in effect to minimize the effects of a potential flood (Veelen *et al.*, 2010). Homeowners are held responsible for possible damages caused by a flood and to take precautionary measures, although at this moment they are poorly informed about local flood risks. Community disaster management is currently limited to closing-off quay sections and public areas. In addition flood risk is not included in Dutch home insurance.

Previous Knowledge for Climate (KfC)-research projects, (Veerbeek *et al*., 2012; Nabaliek *et a*l., 2013) on potential physical-spatial measures to reduce the negative impacts of climate changes, indicated that an integrated local(ized) strategy could be cost effective. Current strategy is a mandatory elevation of ground levels in case of new developments. This strategy will not suffice for the long term. Real estate investors and housing corporations already search for alternatives as this strategy implies a large percentage of their investments. In the current economic times it is difficult to start feasible projects.

Although the Noordereiland and Kop van Feijenoord are both low-lying flood prone areas, they differ when it comes to flood characteristics such as flood frequency, water depth and flood duration (Veerbeek *et al.,* 2012). The Noordereiland is a low-lying mound shaped island that has to deal with high flood frequencies. The quays of the island are flooded at a yearly or 10 year flood event. At a 50-year flood event (3,04m+NAP) water can enter the basements and ground floors of buildings that are situated at the southern and northern end of the island. By the mound shape of the island the duration of a flood event is expected to be short. The higher part of the island also forms a relatively safe ´backbone´ that can serve as an evacuation route when the low-lying areas along the quays are flooded.

Figure 2. Flood characteristics at different return periods and climate change scenarios for Noordereiland (Nabielek *et al*., 2013)

The Kop van Feijenoord is a deep basin with a high risk of flooding (Nabielek *et al*., 2013). In contrast to Noordereiland, the area can be compared to a ´bath tub´ that retains floodwater after a flood event. Already, at a 50-year flood event (3,04m+NAP), half of the case study area would be flooded to a water depth of 50-75 cm (see figure 3). Water enters the ground floors of more than half of the buildings in this area. During extreme flood events, the exposed area hardly changes but the water depths rise considerably to 80 – 100 cm and serious damage to the façade and the interior of buildings can be expected (Veerbeek *et al.,* 2013). Due to the bath tub-like shape of the area, the floodwater cannot run-off or drain to the river. It is expected that recovery in this area will last for a couple of days.

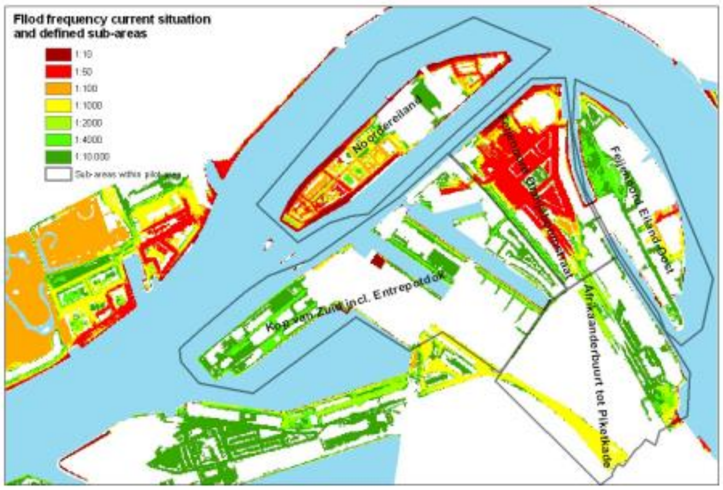

Figure 3 Defined sub-areas according to the flood characteristics (Veerbeek et al. 2012)

The mandatory elevation strategy has worked well in recent past, when abandoned port areas were redeveloped within large-scale redevelopment projects, based on public land-development models and supported by public investments. Investments in elevating building plots and public space were developed within an integral land development plan and funded from the surplus value of the area after development. This policy is a clear example of traditional hierarchical government steering (Kokx, 2012). Due to the financial crisis and structural decline in demand for housing, business premises and office space, the coming period will be characterized by limited need for developing new urban areas. It is expected that large-scale urban area developments will increasingly give way to small-scale transformations of the existing city, with other stakeholders and limited public funding involved and plan periods that are prolonged or kept open (Krabben, 2012). Evidently these changes affect urban flood risk policies.

Adaptation Pathways For Noordereiland And Kop Van Feijenoord

In order to be able to identify possible FRM strategies the ATP has been used for the locations of Noordereiland and Kop van Feijenoord (Stone, 2012). When using the ATP the current urban layout was taken as the reference situation and compared to a situation with implementation of measures. The effectiveness over time of the measures was tested against a set of maximum acceptable limits on flood risk. The method results in an insight into the urgency to adapt to climate change, insight into the effective-ness over time of the possible measures and visualizes the link between long term policy approaches and the possible measures.

A tipping point analysis assesses for an area the moment in time at which the maximum acceptable limits are reached due to climate change. This point in time is called the

tipping point. A tipping point analysis was performed in a small group of experts for the unembanked areas of the Feijenoord neighbourhood and the Noordereiland.
The next step was to assess the list of possible (packages of) measures (Nabielek *et al.*, 2012). Implementation of measures will result in a reduction of flood impacts and risk and therefore stretch the moment in time at which the tipping point is reached. Some measures will be more effective in moving the tipping point than others. For the ATP, the objectives and threshold values have been defined in line with the policy of the Province South Holland. At the time of the research, they were developing an alternative policy for new urban developments based on a maximum tolerated flood risk to people and social disruption. These objectives have been extended with those for damage to buildings and infrastructure.

The results from the tipping point analysis, an overview of the effectiveness of the possible measure, act as building blocks for the development of adaptation pathways. The adaptation pathways visualise the possible flood risk management measures through time and indicate if and when a switch should be made to another measure when due to climate change the effectiveness of a measure reduces.
During a workshop with stakeholders (mainly public agencies) and specialists, the adaptation pathways were developed with different policy approaches as a starting point. A simplified version of the workshop process, as described in Roosjen (2012), was followed. By following this method the participants were stimulated to an ‘adaptive way of thinking’ through elements such as the diversity of future perspectives and the possibility to switch to other measures or adaptation pathways (Roosjen, 2012). It was found that issue of climate change adaptation (figure 4) is interconnected with other issues and was differently interpreted by the stakeholders.

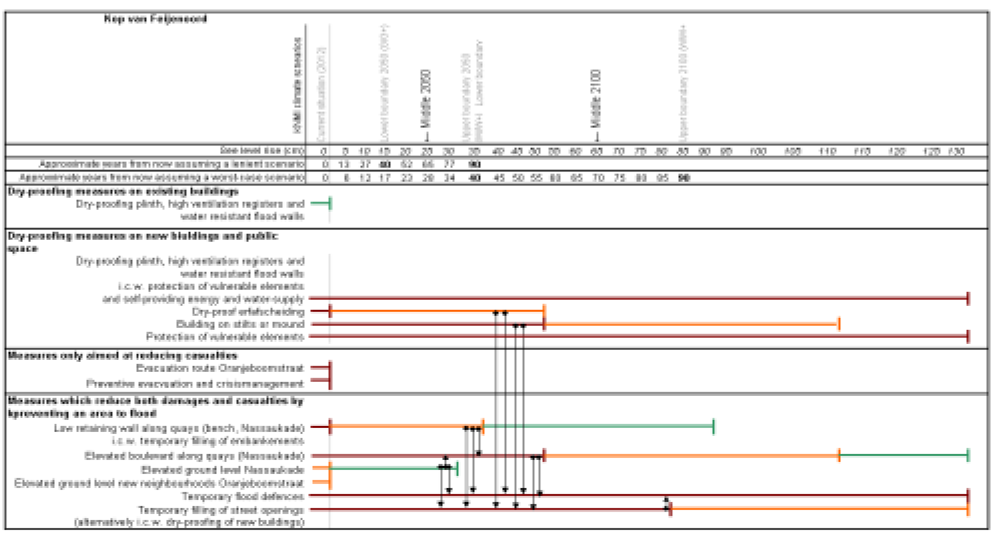

Figure 4 Effectiveness of flood risk reducing measures for the case study area ‘Kop van Feijenoord’ on reducing damage to existing buildings and public space (green lines), reducing damage to all buildings (orange lines) and reducing risk of social disruptions as well as damage to all buildings (red line). Note that measures aimed at reducing damages to new developments will not have an effect on reducing damages to existing buildings. The arrows indicate the possibilities to switch to other measures (Stone, 2012).

In figure 5 the results of the adaption pathways for Kop van Feijenoord are shown. The adaptation pathways, which assume a flood defence policy, provide a long term solution that addresses both the casualty risk and the prevention of flood damages. The research focused mainly on the areas where the flood risks were highest. For the area where large flood depths are expected, the emphasis is on solutions aimed at flood prevention such as flood walls and temporary barriers. Solutions where water can flow controlled within the urban area are less effective in these areas, but these measures could be interesting in areas which flood with smaller water depths. The urban scale of the study resulted in very specific and concrete measures. The choice of a policy cannot be made without considering the larger scale level.
During the first workshop the project team outlined the different adaptive FRM strategies, with possible measures to be taken. We have encountered difficulties to take the stakeholders on board with choices made in earlier research. It is interesting to see however that during the interviews and workshops the respondents came with a whole new adaptation path. They suggest that first investments should be made in bringing back social security and thus creating a more liveable and attractive neighbourhood. In this way a return potential could arise to invest in flood safety. Social equity is an important aspect of a possible FRM strategy.

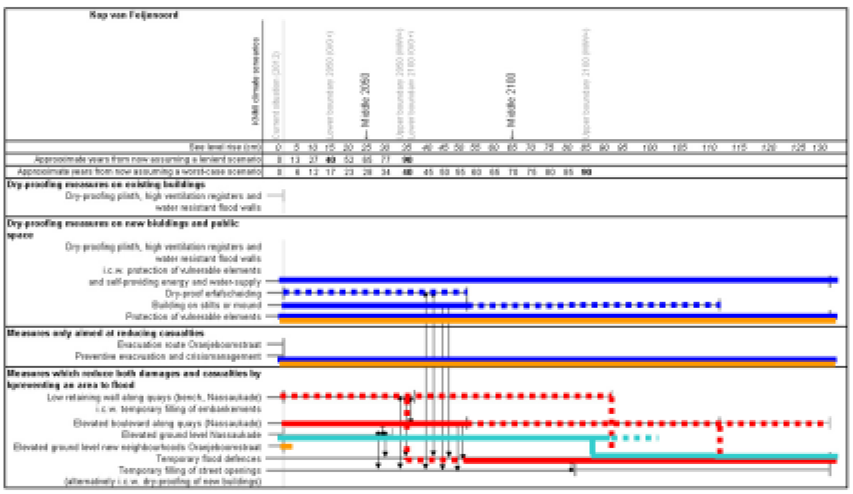

Figure 5 Overview of adaptation pathways Kop van Feijenoord (Stone, 2012)

The method proved to be an added value to the design research process as it adds an extra dimension through the insight into the effectiveness of solutions on the longer term. By connecting the technical solutions, different policy approaches and information on the physical boundary conditions such as the flood risk and climate change, a bridge towards developing long term policy was created. In addition it links the urban planning and flood risk management.

Example 2:Raising self-awareness home owners/ communities NL-UK- France

In line with flood risk management in the UK, flooding can have a devastating impact on homes and families. This was clearly shown by the terrible floods, which hit so many parts of England and Wales in 2007, Cumbria in both 2009 and 2012, and many areas over the winter of 2013/14. As there is no overall flood protection level, protecting homes from being flooded still continues to be a very sensible option as insurance arrangements cannot prevent the appalling disruption and emotional trauma that comes with the flooding and its aftermath.

Many documents are available for homeowners in the UK to gain more information on how to protect their homes. Whether and to what extent flood protection measures are necessary will depend on the degree of flood risk, and the vulnerability of the house and occupants. Different flood maps and sources are available to choose a strategy.

Many different measures have been listed and documented. For instance resilience measures are aimed at allowing a building to flood, but constructing the interior from materials that are not damaged by water. Following flooding, a clean-up will be needed but not major drying and refurbishment. Correctly applied resilience should ensure that no permanent damage is caused, the structure of the building is protected and drying and cleaning are quickened. Similar to the UK, cities in France focus on flood issues through information campaigns, spreading knowledge about floods in the communities and raising awareness. They are also putting in place rescue and recovery plans for the population and public services. The aim is to minimize damages and enable the city to recover as quickly as possible after flood events.

In the Netherlands, recently a new media campaign was launched to raise awareness on the possibility of flooding. The Dutch Minister of Infrastructure and Environment believes it is important that people are aware of the consequences of flooding. "*I have seen the destructive power of water seen in Vietnam and Indonesia. Roads, railways and electricity candisrupt the economy and life of the people. In the Netherlands we are unaware of this prospect.. We export our knowledge about prevention and water works,* from other cultures, *ie. the Americans and British can we learn how people should be aware of the risks and what people can do."* For this reason central government has launced the app: "*Do I live in a risk area for flooding*?" (in Dutch: Overstroom ik?)

Figure 6 Water height in your own neighborhood. In the presented example the maximum water height is 2.5 metres. (Source: Overstroom ik? App)

In the Netherlands this app works to raise awareness, but people are not taking any action to protect their homes from flooding. This is also due to the high overall protection level.

Conclusions

Each country in Europe develops their own flood risk management strategies. These strategies are partially based on their own history and culture. In a low lying country, such as the Netherlands, they have been fighting against the water for centuries. Their main effort lies in prevention. Countries like France and UK opted for mitigation measures. Raising awareness and resilience of their residents. In recent years, several parts of Europe suffered from flooding. The necessity to create a more flood resilient Europe became more evident. Several tools were developed, i.e. the ATP approach for urban areas.

From the case in Rotterdam, it was found that The ATP approach is an useful instrument for a systematic assessment on the adaptive measures. Biggest disadvantage is that it is a time-consuming technique, which relies on a detailed analysis of vulnerabilities and effectiveness of measures and a consensus among policy-makers and stakeholders on objectives and thresholds. Moreover, until now the ATP approach encounters difficulties to define spatial tipping point for so-called 'soft' adaptation measures (i.e. evacuation plans or early warning systems). For these kinds of measures thresholds are not clearly defined. It is of great importance to choose a set of objectives for the ATP which is sufficiently supported by the stakeholders.

Creating more flood resilient communities means involving all stakeholders. Co-creation suggests a process of social learning, where all stakeholders develop mutual understanding on the problem statement and possible strategies. Creating a sense of urgency requires thoughtful communication (Moser & Dilling, 2006) and cannot without processes of social learning and frame reflection (Dewulf, 2013). For solving unstructured problems, the key is learning. Sometimes institutional choices from the past hinder the implementation of effective adaptation strategies and thus redesigning existing regimes can be necessary (Tompkins & Adger, 2004). When the various responsibilities are combined, an adaptive flood risk strategy can be implemented (Van Buuren *et al*., 2013). The case study in Rotterdam underlines the importance of creating awareness when developing adaptation strategies (Hulme, 2009) during the different stages. Local people stick to the traditional distribution of roles and responsibilities and don't feel the urgency to invest in uncertain consequences of climate change, as they were no part in the process. Raising awareness is of the utmost importance in countries where there is a high level of protection, as there is always a possibility that the flood protection system fails, leading to flooding of a certain area.

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