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ADAPTATION AS A WAY OF FLOOD MANAGEMENT

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ABSTRACT: In most well developed countries, the basic level of safety against floods is up to date. In a low lying country like the Netherlands, the protection levels are even among the highest ones found in the world, with return periods between 1.250 and 10.000 years. For the Netherlands, this brings along the fortunate consequence that floods have seldom occur in recent times. A more disadvantageous fact is that the people take protection for granted, and that the level of awareness is diminishing. However, the message of climate change is precisely that absolute safety does not exist, and that a society should be prepared for risky situations. In this paper, a new concept of adaptation is described. Instead of taking individual measures like building on moulds, for instance, we describe a society which is prepared to crises in general (and flood management in particular) by regarding a flood as just another normal situation. The society is able to cope with a crises, and can manage it's consequences. The use of networks (community based, as well as Internet based) is an important factor in this concept. The event itself cannot be avoided, but the society is structured such, that damage and loss of lives is limited to an absolute minimum. The present society might not be ready for this concept right now, and this is why for the moment, flood defense programs like Room for the River should continue. This concept is not part of actually Dutch policy, but is one of the ideas that is elaborated within the Innovation Platform of the Ministry of Transport, Public Works and Water Management.

Key Words: Flood management, Safety Standards, Adaptation,

1. INTRODUCTION

In highly developed societies in Western Europe, it is obvious that in general the land and property is protected against floods from rivers or the sea. Large rivers in lowlands are normally confined by levees and dikes, while dunes and sea-dikes protect the land from the consequences of storm surges. The protection level is often expressed in terms of return periods floods. For the Netherlands for instance, it holds that the river area (land prone to flooding from rivers) is protected against design floods with a statistical return period of 1250 year. Dunes and sea dikes protect the coastal zone against events with a return period of even 10.000 year (see Deltacommissie (1961)). For other European countries, similar figures hold, although the Dutch norms are among the highest ones in the world. In table 1, protection levels for some other European countries have been given.

Table 1: Some safety norms for different countries. Partly reproduced from Ten Brinke and Bannink (2004)

Country, area	Safety level
The Netherlands, river area	1:1.250 up to 1:2.000, free board >0.5 m.
The Netherlands, coastal area	1:2.000 up to 1:10.000
Germany, Lower Rhine	1:500, freeboard 1 m.
Great Brittain, coastal area	1:5 to 1:200, dependent on ground use
Great Brittain, Thames Barrier	1:10.000
Belgium, Flandres, coastal area	<1:10.000
Denmark, coastal area	1:50 to 1:1.000
New Orleans, before Katrina	1:30 up to 1:50
New Orleans, after reinforcement works	1:100 (overtopping frequency)
Hungary, Tisza region, after reinforcement works	1:1.000

In the past, severe floods have taken place in the Netherlands. In Ten Brinke (2007) an impressive list of floods has been listed, starting as early as 1000 A.D. up to the twentieth century. Especially in the Middle Ages, the consequences were enormous, with recorded death tolls of many tens of thousands of people. However, also in recent history floods occurred. In 1926, river dikes collapsed for the last time as a result of high discharge. The damage was substantial (10 million guilders, price level 1926) but fortunately, there was no loss of lives. In 1953, the situation was different, when a major storm surge inundated large parts of the South-West part of the Netherlands (as well as parts of England and Scotland, see Pollard (1978), Summers (1978)) and caused more than 1800 victims. After that, no floods occurred in the Netherlands due to storms or high discharges, although the situation was critical in 1993 and 1995. In 1995, more than 250.000 people had to be evacuated from the river area, but at the end, the dikes did not break. These events are now more than a decade ago. All that time, it was relatively quite and as a consequence, people have a tendency to forget that they are living in a low lying country and that they are actually still living in an area which is prone to flooding. Due to the events of 1953, 1993 and 1995, works have been carried out to in order to protect the major part of the river area with a protection level of 1:1250. Due to the high safety level fortunately floods very seldom occur, but as a result, awareness has fainted. Discussions about further protective measures are sometimes obscured by these high standards.

Although the basic level of safety in the Netherlands is high, and the system of dikes and dunes is pretty much up to date, it cannot be ruled out that sometimes dangerous situations or actual floods do occur. One of the factors that plays a role in this is climate change, which alters the circumstances and hence influences the actual flooding probabilities (the safety levels itself do not change as they are formalized in legislation). Although reducing the probabilities to the norms is a possibility (by means of dike-reinforcement or preferably measures in the floodplains), we will explore a different approach to safety in this paper. The basic idea is that the society is organized in such a way that a flood is approached like ‘just another normal situation’. In this approach people know how to react in case of a flood, what to do and how to minimize danger and personal discomfort. The surrounding areas are equipped for this. This is not to say that there is no flood protection whatsoever. There is a system of flood protection, and perhaps even more innovative as it is now. There is a main system of dikes, but also large dike sections have been divided into compartments, some dikes are very wide such that they can overflow without collapsing, etc.

Before giving the details of this concept, we discuss the state of the art (from Dutch viewpoint) and discuss the current safety system in terms of uncertainties, awareness and explainability.

2. CURRENT SAFETY SYSTEM AND AWARENESS

The current system of dikes in The Netherlands protect the land from flooding with a safety level varying between 1:1250 (in the eastern part, where the Rhine River enters the Netherlands) and 1:10.000 (at the western part, at the North sea side). This safety-level is based on the probability that the water level exceeds a certain design water level, which is derived from a statistical analysis of historical high discharges. Between now and 2015, large works are carried out (a national program called 'Room for the River') to re-establish this safety-level, as calculations showed that the statistic results were not in line with the height of the dikes.

During the preparations of this program, which often had a great societal impact, it became clear that it was not always easy to explain the necessity of these plans, (see also Figure 1). Partly these were 'nimby'-effects ('not in my backyard'), but partly it was because a proper explanation of the plans involved high level discussions about river-dynamics, statistical return periods, design discharges etc which is hard to grasp for a layman. The interesting thing is that people who had lived for several generation in the floodplains, were much less concerned than people who had not yet experienced an actual high discharge. The former group could rely on practical experience (although sometimes from former generations), were adapted to the situation, and could protect and rescue themselves whenever necessary. The latter group could only interpret the theoretical information given to them in brochures or at information evenings and this sometimes led to misunderstandings. A societal debate on emergency-polders in the Netherlands (which were to be used only in case the structural system would fail, hence with an extremely low probability) lead to dispensation of the whole idea. The opposition, based on emotional rather than rational arguments was too strong. Simultaneously however, it was also shown in an additional study that the concept might not have worked altogether because the areas were too small and the unknown shape of the flood wave caused too much uncertainty in the actual application.

Figure 1. Local people protesting against government plans. The text on the signs relates to the tension between room for rivers versus room for farmers.

Rather contradictory, a complicating factor in the communication is actually the high safety level that now exists in the Netherlands. The return period for the design discharge (upon which the current dikes are designed) is so high that it is hard to communicate. In fact, for the public a safety of 1:1250 is close to meaningless and is often interpreted as: safe under all circumstances. Hence, the fact that one is living in a flood prone area with the possible consequences is vanishing. Consequence is that in case something happens, the people turn to the government for compensation, and the sense of own responsibility is little. Lundgren and McMakin (2004) point out the public view on flood risk can be viewed as 'hazard plus outrage'. In this approach the public not just reflects the danger of the action (hazard) but also how they feel about it (outrage). Problems and conflicts between public and professionals occur when a low risk is perceived as a high risk. Low awareness thus can raise problems when a threat really occurs. It is a fact that in countries with lower safety levels, the awareness is often much higher, due to the simple fact that every now and then, the water comes. With a safety level of 1:1250 year, it is very unlikely that in a time span of a decade more than one severe flood will occur. In Hungary for instance, an awareness study has been carried out along the Tisza river. In 1992, less than 2 % of the interviewed people were aware of the

fact that they lived in a flood prone area. In 2002, after some severe flood-incidents, this figure increased to 90 % (Schielen (2007)).

This also raises the question whether the current system can be explained to the general public in the first place. Perhaps, the concept of *exceeding* (of a critical water level) probabilities is too complex for a layman, although for practical use this cannot be the only argument to change the system. On the other hand, a system based on *flooding* probabilities, rather than exceeding probabilities seems to be more appropriate, because it also takes into account actual failure mechanisms of dikes. In terms of explainability, some mechanisms are easy (failure of slope through overtopping of waves, for instance) while other mechanisms are again more technical (piping, heaving). The latter are not only hard to model, but perhaps also hard to communicate. Intermediate results of a study towards *current* flooding probabilities show sometimes higher probabilities than the legal norms (i.e. the system is actually stronger than might be expected on the base of exceeding probabilities, or, putting is differently, whenever the water level exceeds the design level, the dikes will still hold), but sometimes also lower probabilities. In the latter case, the government has to communicate an inconvenient message. At this moment, a debate is going on in the Netherlands whether the system should be changed (a discussion about a transition from exceeding, to flooding probabilities, as well as the probabilities itself, see Roos (2008)). A possible outcome might be a differentiated safety-level which will reveal almost certainly again a societal debate.

3. CLIMATE CHANGE AND CHANGING ATTITUDE

The current safety system in the Netherlands (and also in many other countries) is still based on flood defense. Measures to increase the discharge capacity are planned and carried out, and dikes are being reinforced. We maintain high safety-standards, and protect the flood prone areas as good as we can. This attitude, however, is changing. More and more we become aware that our structural system is under attack, and that climate change is the main attacker. Due to global climate change, it is the general impression that a country like the Netherlands will get more trouble caused by the water, in four different ways (see for instance, Van Dorland (2008) or the website of the Royal Dutch Meteorological Institute, www.knmi.nl): from above (more, and more intense rainfall), from below (increasing groundwater levels, and increased salinity levels), from the east (more discharge from the main rivers) and from the west (sea level rise). Although the ‘old’ approach is perfectly capable of dealing with these problems at least for another century or so (by reinforcing the defense system), it becomes ever more clear that a strategy must be present for those times when the structural system fails. This strategy was always present in the form of evacuation plans, but gets nowadays more and more attention. Large scale exercises are being carries out to see whether the plans are still up to date and how and where improvements are necessary.

New trends in flood protection are ideas about adaptation. As climate change is happening, and the consequences will be felt for low lying countries like the Netherlands, it’s better to be prepared and to adapt to this new reality. A lot of initiatives are under investigation at this moment. They vary from building new individual houses on mounds in flood plains (although this can hardly be called a new development!) to floating houses (already put in practice along the Meuse river in the Netherlands). One also considers to raise future large scale building locations to at least 5 meters above mean sea level, such that the inundation probabilities are extremely low. The idea is to use sand from the North Sea, from which experts say that there will be more than enough (although this is subject of research). Also the construction of a defense system of very wide dikes, which can practically not collapse, is part of current investigations. These kinds of dikes are already constructed in Japan (there they are called ‘super levees’) and the idea is that although they cannot collapse, the can overflow. This causes inconveniences for the protected land, but no immediate life threatening situations.

These concepts of adaptation will be taken up to a higher level in the next section. Instead of adaptation by individuals (living on mounds), or limited groups of individuals (high water proof district) we explore the concept of the adaptation of the entire society. The concept will be explored from the viewpoint of flood risks, but can be applied to general crises.

4. NEW DEVELOPMENTS

Up to now, the current system (or possible changes as proposed in the previous section) are still based on flood protection. By means of dikes, one tries to prevent flooding. An interesting viewpoint however, is to actually *ignore* the threat of a possible flooding. The idea is that a flooded or no flooded situation is essentially not a different, or a special situation, but just another normal situation. In such a situation, we no longer consider a flood as a crises, but rather as a manageable situation. People react in such a situation accordingly (see Ajzen and Fishbein (1980)). A disaster as a self extinguishable situation. The flood itself can perhaps not be avoided, but the society can be adjusted such, that damage and victims are limited to an absolute minimum. Hence, the society can get back on track as soon as possible. In the next section, we will expand this concept.

An important aspect in this concept is the safety-chain, which is often used in situations in which a crisis may happen. There are 5 elements:

-Pro action: excluding risks
-Prevention: minimising risks
-Preparation: suppress a crisis
-Repression: actual suppressing of consequences of the crisis
-Recovery: returning to a normal situation

Sometimes, a sixth element is added: Learning of the event.

In flood management, little can be done on the first link: excluding risks. A program like Room for the River is a typical example of the Prevention-link of the safety chain. A lot of attention is paid to the second and third elements, while the other ones are sometimes a little bit underestimated. The sixth, learning, is also often ‘forgotten’. The concept that we are going to present below aims particular upon the last links of the chain.

The safety chain is sometimes also visualised in the bow-tie model (see Figure 2). In the left side of the model, the risk factors are listed which may lead to the unwanted event, the crises. On different levels, there are barriers which prevent the crises from happening. On the right side, the consequences of the crises are listed. These consequences are determined by recovery actions. The first three links of the safety chain are located in the left part, the other links are located in the right part of the figure. A recovery action can also be something that reduces possible damage. In case of flood management, one can think of flood-prove housing (floating, building on moulds, for instance) or dividing big dike sections into smaller ones.

4.1 The defensible society

A defensible society (a strong, up to date society, which can take care of itself) plays a crucial role in this concept. The interesting thing is that a possible flood can be seen as a ‘productive’ event which can also lead to new ideas, experiences and adaptations.

In this concept, the society is organised in adaptive and efficient cells. These cells are ‘real’ (community level) as well as ‘virtual (‘network, internet based’). The idea is that inside the cells, the people have the ability to cope with them selves, and to save them selves in case of an inundation. Either by leaving the area independently, or by going to a save shelter within the area. In this way, a defensible society can be viewed as the sum of awareness, and the ability to save one self.

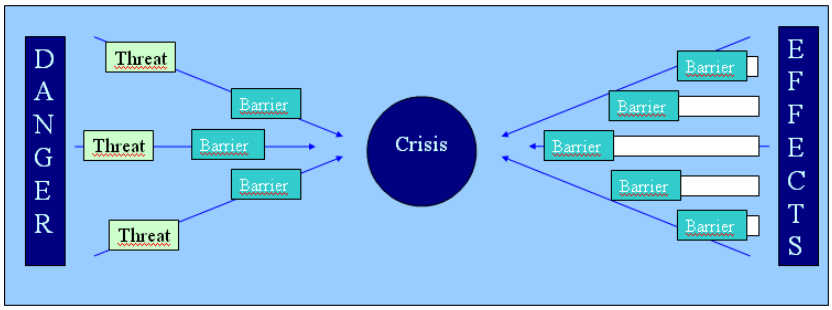

Figure 2: The bow-tie model. At the left side ('control of the danger') the causes of a possible crisis are given. At the right side ('limitation of the consequences') the consequences are visualized. 'Barriers' are measures to prevent a cause or a consequence.

The society as such is in this cell-concept the key element. There is no physical limitation to the cells. The cells are just present in the society and are formed by church or mosque, by sport-clubs, and the virtual communities on the Internet. Starting from these cells, new ones will develop. In practice, there are no individual cells, but there will be a network of overlapping cells (see figure 3).

Before, during and after a flood, there will be all sorts of connections between the cells. Before, there are connections coming from all day activities, from live itself. Immediately before and during a flood, there is off course evacuation, transportation of goods as well as providing all kinds of assistance between inundated and not yet inundated cells. The flood itself also passes from one cell to another. After a flood, by exchanging experiences, cells learn from the situation and are better prepared to the future. This is enhanced by the diffusive overlapping character of the cells. During all stages, the cells communicate by advanced IC-techniques.

There is also a more general aspect of development and coherence (as contrast to the 'local communities' within the cells). This is ensured by financial stimuli and social coherence. There is coordination and communication structure at an 'upper-cell-level', guaranteed by the government. Communication should be possible at all times. Evacuation routes are clear.

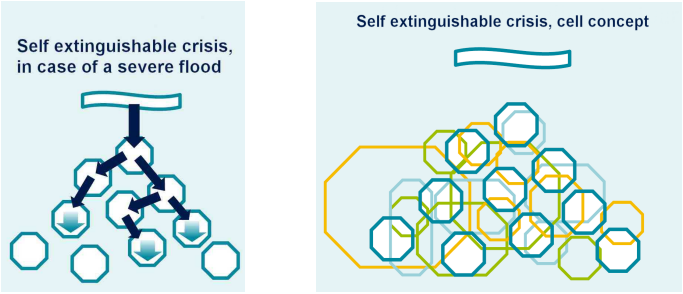

Figure 3: Schematic representation of the cell concept. On the left, an event (a flood) reaches several cells, but each cell knows how to handle. In the end, some cells are left untouched. On the right, an impression of the diffuse cell system is visualized.

If the society is ordered such that this concept works, one can speak of a learning society. Shared experiences are the basis of new, or adapted strategies. There is actually no such thing any more as a crises situation. A crisis is just another situation which can be dealt with. People are to a certain degree used to the situation and know exactly what to do.

In literature, a crisis is often denoted as a situation which occurs if:

- there is an clear and present danger
- the idea that there are only few escape-routes
- possible escape router are closing down, hence the danger is even more imminent
- there is little communication

It is clear that a threatening flood falls under this description of a crisis. It should also be clear that a learning society, based on shearing experiences, and organised in a cell-structure, should cope better with this kind of situations, than a society in which people are living more individually. The idea is that virtual training, sharing information actual exercises improve this behaviour. A boundary condition is an adequate and reliable information facility and supply.

4.2 The elements of a defensible society

We distinguish six key elements in this concept. We will discuss them briefly.

1. The cell concept. This has already been introduced in the previous section. The impact of the crises becomes less and less in every next cell. Not only because the actual effect of the crises becomes less (for instance because large areas have been divided into smaller ones) but also (and more important) because each cells has learned, and has a better knowledge of what to do.
2. A stimulating and directing government. The government promotes the defensible society, rather then imposing it with rules and regulations. It raises awareness, stimulates experimental, flood proof, housing projects, and constructs local, fully equipped, shelters. The actions of the government are based on the question: what do the people need to survive? In this way they take care of finances, stimulate the early learning at schools, and ensure good communication. In this way they enable the society actually to be defensible.
3. The society is taking care of itself. He is aware of the danger and the consequences, and knows what his options are in times of crises. For this, some features are essential: the ability to read out information at all times, a shelter in their vicinity, training in handling crises and, not unimportant, being member of a cell.
4. An adaptive infrastructure. Through compartments-dikes and other measures, the floods are guided as much as possible. There is, also during the floods, infrastructure that either can be used to evacuate, or that lead to shelters. Energy- and water supplies are guaranteed because they are constructed such that the flood has no influence. This also holds for communication infrastructure. Central idea is that every facility is build as it should be. Floating is possible (housing, roads), but securely protected if needed (hospitals, energy supplies).
5. Information is always and everywhere. People have a Personal Digital Assistant with essential information. On key-spots in towns, there are big screens with information about ‘the state of the country’. The government has all the essential information about water levels, wind conditions but also conditions of the shelters, and predictions of traffic.
6. Money. The basis of the concept of this concept is enough money to realise the desired society. Here is actually where the safety-chain comes in again. Money is needed at the prevention side, as well as at the preparation and repression. In the Netherlands, this is already done. At the prevention level, we are carrying out Room for the River. At the preparation level, we are studying adaptive housing (floating, on moulds, or just high enough) as well as dividing the big dike sections into smaller ones. Repression is taken care of by reconsidering our evacuation plans and conducting large scale exercises.

5. DISCUSSION

In the above presented concept, there are a few important elements. One of them is that a flood is no longer a crisis, but is considered as a controllable situation. The society is not concerned with safety *against* floods, but with safety *at* floods. This concept is no instant solution and we are well aware that it cannot be applied to the current society as it is. The concept offers merely new, and perhaps unexpected

combinations that sheds new light on our safety strategies. Climate change only shows that new concepts might be of increasing importance.

We think that this concept might work for the larger part of the Dutch river area or similar areas elsewhere. The prediction times are quit long and the areas do not belong to the most densely populated areas. For the coastal areas, for instance the dike sections in which the Dutch cities like Amsterdam, Rotterdam and The Hague or similar delta areas, the situation might be a little bit different. It are usual the areas with are densely populated, have the highest inundation depths and the prediction times (for storms at sea) are considerably shorter. Nevertheless, just for these areas, in which evacuation is difficult the ability to cope for oneself might be the best way to reduce possible damage and casualties.

Of course, money is needed to realise the new infrastructure and adaptive buildings. Whether this becomes available is at this moment not clear and should be studied more closely. Also, it is not clear whether the society is ready or will be ready in the near future. The society nowadays is not makeable. The government cannot impose this. The government can direct, but has otherwise a position on the background. To get to a defensible society in the future means that we have to start now, by educating the youth. On the other hand, the virtual communities as exist on Internet might add to the development. An added result can be that the society becomes more resilience to large crises.

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