Chapter 8
An Integrated Discussion Support System for New Dutch Flood Risk Management Strategies

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8.1 Introduction

Water management in the low-lying delta of the Netherlands is a precarious planning issue that continuously needs adjustment because of the ever-changing conditions of the water system and the society that inhabits this risk-prone area. The recent concern for climate change has given rise to additional challenges for the sustainability of current water management strategies. These are related to the anticipated rise in sea level, the increase in river discharge and changes in the local precipitation patterns.

To support the discussion on future water management strategies, the development of a new information system has been commissioned by the Dutch Ministry of Transport, Public Works and Water Management. This 'discussion support system' presents an overview on the anticipated future developments in the coming 50–100 years, their impacts on flood risk and the water management options that are possibly needed to anticipate those impacts. Flood risk in this project is determined by combining spatial land-use information and hydrological information. This information is available from a land-use model that operates using a 100 by 100 m grid. Flood risk is then calculated under different future trends using socioeconomic scenarios and climate information.

Flood risk assessments in the system are presented in both monetary terms and possible number of casualties following the approach that is common in Dutch water management. This approach applies fixed mathematical functions that relate the possible inundation depth with the local occupation pattern (land use and number of residents). The system, furthermore, includes a wide range of management options, related to both technical solutions and physical planning strategies, and

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also assesses their impact on flood risk. These assessments follow from a simulation of their impact on local land-use patterns and, furthermore, take the changed climate conditions into account.

The system thus provides insights into the complex interactions of changing physical conditions, socioeconomic scenarios and water management strategies. It helps water managers, politicians and stakeholders to explore different future scenarios and to discern the possible impact different management strategies have under these future conditions. This chapter will briefly describe the main components of the system and the way the different components are integrated. The graphical interface of the system will be explained and some characteristic outputs are shown. Past experiences and user feedback with the similar Planning Kit instrument (Van Schijndel 2005) are used to develop the system.

8.2 The Current Dutch Flood Risk Management Debate

Dutch hydraulic engineering still leads the world in flood safety. In governance, too, the Netherlands has a rich history in which policy makers, water managers and researchers have repeatedly acted in unison to cope with extreme weather conditions and the danger of flooding. However, new scientific knowledge calls for a critical assessment of the sustainability of the current safety policies in relation to long-term processes of climate change and land subsidence. In fact, it can be questioned whether the current investments in, for example, urban development, infrastructure and safety, are (cost) effective in the coming 50 – 100 years (Bouwer and Vellinga 2007).

Climate change will have a profound effect on flood risk in the Netherlands. The sea level along the Dutch coast is expected to rise approximately 80 cm by the year 2100. The consequences of sea-level rise in the Netherlands are exacerbated by the subsidence of land that may locally lower the ground level by 1 m in 2100. In addition, Middelkoop *et al.* (2001) estimate that peak flows of the Rhine River (one of the three major rivers in the Netherlands) may increase by about 5–8 per cent by the year 2050. This would imply that the current technical measures such as dikes are not meeting the legal safety standards, and additional adaptation measures are required.

The low-lying areas in the Netherlands are protected by a system of dikes and embankments along the main rivers and coastal areas. A so-called ‘dike ring’ is a geographical unit bounded by its flood protection system normally consisting of dikes. It is also a separate administrative unit under the Water Embankment Act 1996. According to the act, a dike ring area should be protected against floods by a system of primary embankments and each dike ring has been designed such that it meets a safety norm. These safety norms are based on the risks that were deemed acceptable in the mid 1950s, taking into account the lives and capital at risk. For example, a dike ring with a safety norm of 1:10,000 means that this dike ring has been designed such that it can withstand a flood that has a statistical probability of occurring once every 10,000 years. This expected return period of the flood water levels has been derived from extrapolation of historical records. There are 95 dike ring areas, each having

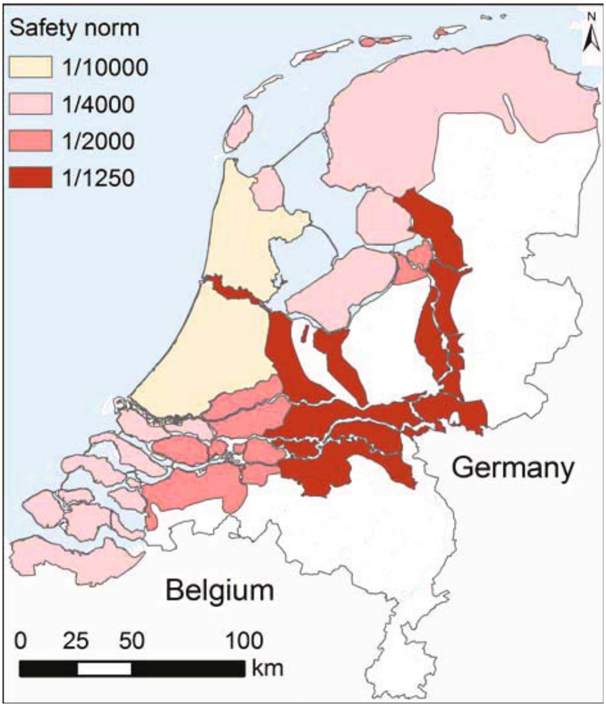

Fig. 8.1 Regional differences in safety norms in the Netherlands

different safety norms. The most important safety norm areas are shown in Fig. 8.1. In general, Dutch water management is rather technology driven and bounded by strict legislation that aims at guaranteeing a high protection level against flooding. This becomes clear from a comparison with the area of New Orleans, where the pre-Katrina safety norms of most levees were based on events occurring once in 100 years (Grossi and Muir-Wood 2006).

The Dutch government has already taken measures in response to certain aspects of long-term trends such as climate change and land-use change. Local flooding and changes to the river discharge regime are addressed by the 'Water Management for the 21st Century' policy (Commissie Waterbeheer 21e eeuw 2000). Adaptation to higher river discharges is dealt with in greater depth in the 'Space for the Rivers' programme (RvR 2006), whereas the 'Weak Links' project (V&W 2003) looks at the risks on the coast. The safety of the primary flood defences was analysed in the 'Safety of the Netherlands' project (DWW 2005).

Within this framework, we develop a method to carry out a flood risk study on long-term safety. The potential of the method is demonstrated through application in a prototype system. The questions to be answered include:

- What are the expected changes in climate and land use in the long term (50 – 100 years)?
- Which administrative, social and economic variables are important for protection against flooding?
- What flood safety strategies can be developed to deal with these changes?

The current project focuses on the following components: (i) scenario analysis; (ii) inventory of effective safety strategies; (iii) vulnerability assessment; (iv) appraisal through different evaluation methods; and (v) development of a discussion support system that is the topic of this chapter.

8.3 Building the System

The system is developed to support the *discussion* on the long-term adaptability of the Netherlands to flood risk. It aims to facilitate the learning of the user on the subject, instead of giving unambiguous answers on what management strategy is preferable. This is a significant difference with the more traditional *decision* support systems. The system, furthermore, aims to provide insight into the impact of various flood risk management strategies. For discussions on complex issues, like flood risk management, a discussion support system is a potentially powerful tool to facilitate a meaningful exchange of ideas. Advantages of such a system are amongst others are: (i) that it structures information and controls the amount of data a participant has to process; and (ii) that it develops a collective basis of knowledge for all participants.

Experience shows, however, that various decision and discussion support systems remain unused. This is often due to a lack of attention to the needs of the target group. From their survey of existing support systems in the Netherlands, Hooijer and De Bruijn (2005) distil a number of recommendations:

- The development of a system requires close contact with a real user group (wanting to solve a real problem) to prevent it from becoming an academic exercise. Furthermore, it requires a very clear statement of the problem and the solution limits;
- A system is only used when users have confidence in its results. It is thus important to calculate effects well, and make any remaining uncertainties clear;
- The system must be simple to use. This does not mean that the underlying calculations should be simple, but it implies that the user should not be bothered with their complexity;
- Effects of flood risk management strategies should be presented spatially, i.e. on maps, to make them more easily understandable for decision makers; and
- Widespread acceptance of a system can be obtained by enabling the parties involved to introduce their own knowledge to the tool. This requires a design in which it is easy to add new information.

A good example of a flood risk management support system that is actually used in decision making in the Netherlands is the Planning Kit (Van Schijndel 2005). Many of the requirements mentioned above stem from experience with this system. In the development of the discussion support system presented here, these recommendations have been taken to heart in order to meet the requirements of the target group of flood risk managers as closely as possible. This is mainly done through organising workshops in which users, experts and others are consulted. In this way, the experiences and knowledge of all these groups have been incorporated. In addition, the lessons learned from other models and systems such as the Planning Kit were recognised and integrated.

8.3.1 Target Group and Requirements

The target groups are both policy makers and more technical water managers involved in the discussion on long-term flood risk management and for those who prepare new management strategies. The system is not meant to serve as an analysis tool for modellers. Nor is it meant for those who are involved in short-term flood event management; for example it, does not support evacuation or emergency measures. The above-mentioned recommendations and types of end users have resulted in a list of requirements of the flood risk discussion support system, of which the main requirements are that:

- the system should be user friendly and quick;
- the system should be exciting enough to keep the single user's attention;
- the user should trust the information in the system and understand its reliability; and
- it should be relatively easy to add new strategies and scenarios to the system.

To design the system such that it fulfils these requirements attention is paid to the information presentation aspects of *order*, *focus*, *spatial representation* and *comparison*. The *order* in which the system presents the aspects related to flood risk management (e.g. probability, flood damage, potential casualties and costs) is such that it is understandable and logical to the end user. The *focus* of the user is set to the main purpose of flood risk management: to meet the safety levels now and in the future. Users are, therefore, asked to explicitly define the safety levels that are to be maintained. Furthermore, most information is *spatially represented* in maps covering the full Netherlands to provide an overview. Many flood risk related aspects are aggregated here to the regional level of safety norm areas as this the level at which safety is generally analysed. To make a *comparison* between various strategies and future scenarios, users can choose among maps, graphs and tables depending on their preference for visual or textual output. Furthermore, standard reports are produced containing a summary of the results. The system thus presents a wealth of information that is required to discuss the effectiveness and efficiency of different strategies.

Concerning the technical requirements of the system, the following aspects are relevant. The system only performs simple calculations. All complex simulations and analyses have been performed in advance, where the results are gathered in a database. For each scenario or strategy selected by the user, the relevant information is obtained from this database. This guarantees a quick system, in which the user receives the results of her or his choices within seconds. The technical design of the system, furthermore, allows the easy addition of more information.

The functionality of the system can also be extended relatively easily to incorporate the new ideas that are expected to come up once it is actually used. To obtain a system that will actually be used in practice, extensive attention is paid to the user-friendliness of the system. A user group, representing the target group, is involved in the development in order to fulfil the expectations of the target group and thus gain its confidence.

8.3.2 System Design

The different components in the system are simplified and shown in Fig. 8.2. Its main components include socioeconomic and climate change scenarios, strategies and moments of investment. The choices that are made for each of these components are evaluated in terms of different indicators related to the years 2040, 2100 and the long-term future. Two different shapes (rounded rectangles and hexagons) are used in the figure to denote the two types of input that determine the model results. The rounded rectangles represent variable elements whose values can be selected by the user. The hexagons, on the other hand, are pre-set, and depend on preceding choices. These elements have fixed values as is the case with, for example, the river discharge that depends on the selected sea-level rise.

As is illustrated in Fig. 8.2, first a choice has to be made between two socioeconomic scenarios. In addition, a climate change scenario must be chosen by specifying an anticipated sea-level rise. Based on this sea-level rise the values for river discharge, precipitation and surge level are set. The necessary socioeconomic and climate information is taken from two recent national studies (CPB *et al.* 2006; Van den Hurk *et al.* 2006). When the socioeconomic and climate scenarios are specified, the user can vary between different safety strategies. Subsequently, an investment moment can be selected, thus introducing a time aspect in implementing management options. The output resulting from this set of choices is

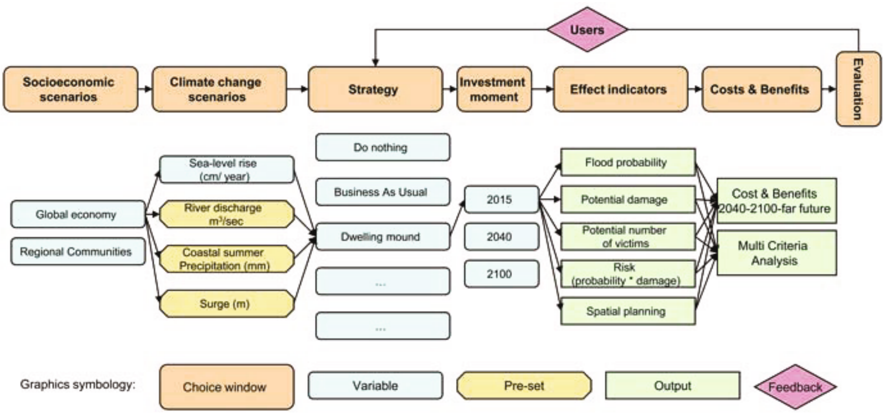

Fig. 8.2 Structural design of the flood risk management support system

presented graphically in a map showing the full Netherlands. These effect indicators represent flooding probabilities, land-use patterns, potential damage, possible number of casualties and resulting flood risks.

Finally, the user can evaluate the strategies and moments of investment by comparing them mutually and by comparing the effects of one strategy in several future scenarios. This comparison can be based on the effect indicators and estimated costs and benefits. Figure 8.3 illustrates the comparison of two maps with different content, according to the choices of the user. By incorporating user knowledge in the development of the relevant adaptation strategies, the relevance and usefulness of simulated developments are tested.

8.4 Land-use Simulations

The land-use patterns for the current situation (2015), the scenarios and the different strategies that can be chosen in the system are simulated with the *Land Use Scanner*. This is a GIS-based land-use model that simulates future land use based on the integration of sector-specific inputs from dedicated models (Dekkers and Koomen 2007;

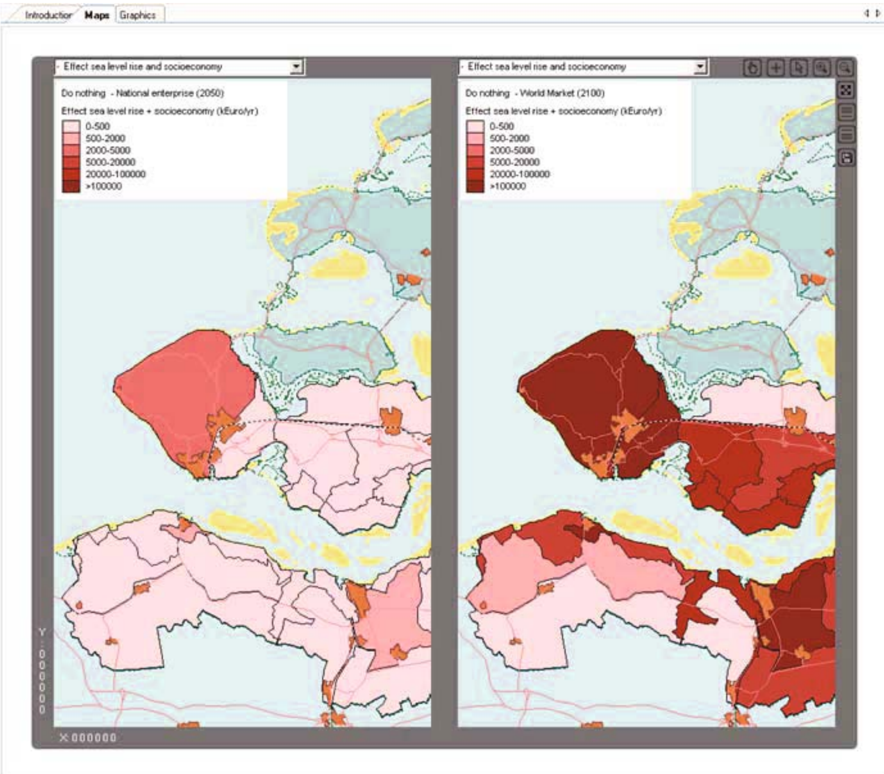

Fig. 8.3 Comparison of economic damage in two future scenarios in the system (See also Plate 19 in the Colour Plate Section)

Hilferink and Rietveld 1999). The model offers an integrated view on all types of land use, dealing with urban, natural and agricultural functions. It is grid-based and this application uses a 100 by 100 m grid to cover the terrestrial Netherlands with about 3.3 million cells. This resolution comes close to the actual size of building blocks and allows for the use of homogenous cells that only describe the dominant land use.

The model is based on demand-supply interaction for land, with sectors competing for allocation within suitability and policy constraints. The model employs a mathematical optimisation approach to allocate land to its optimal location given a set of boundary conditions related to the regional demand for land and the local suitability definition. The solution of this discrete allocation problem is considered optimal when the sum of all suitability values corresponding to the allocated land use is maximal. This allocation is constrained by two conditions: the overall demand for the land-use functions that is given in the initial claims and the total amount of land that is available for each function. The suitability maps are generated for all different land-use types based on location characteristics of the grid cells in terms of physical properties, operative policies and expected relations to nearby land-use functions. This suitability can be interpreted to represent the net benefits (benefits minus costs) of a particular land-use type in a particular cell. The higher the benefits (suitability) for that land-use type, the higher the probability that the cell will be used for that type. The economic rationale that motivates this choice behaviour resembles the actual functioning of the land market. For a more detailed description of the most recent model version and the calibration and validation of its new allocation algorithm, the reader is referred to another publication (Loonen and Koomen 2008).

Unlike many other land-use models, the objective of the *Land Use Scanner* is not to forecast the dimension of land-use change but rather to integrate and allocate future land-use claims from different sector-specific models. The land-use simulations integrate expert knowledge from various research institutes and disciplines and thus represent the best-educated guess regarding the possible spatial patterns. It should be noted, however, that the simulations are based on many assumptions about future developments. They can by no means be seen as exact predictions and should therefore not be treated like that.

In the system, several land-use simulations have been executed under different socioeconomic scenarios. These are derived from the study 'Prosperity and quality of the living environment' (CPB *et al.* 2006) that aimed to investigate long-term developments in prosperity and their effects on the physical environment. For this analysis, we selected the two most extreme socioeconomic scenarios: *Global Economy* and *Regional Communities*. The former combines globalisation with a focus on the economy and has the following main characteristics: high population and economic growth; global free trade without political integration; and no initiatives on international environmental agreements. The latter scenario has a focus on regional development and communal values and is characterised by: moderate population growth until 2015 and a slight decline thereafter; modest economic growth; trade blocks and taxes for protection of the environment; emphasis on national environmental policy and increased public environmental awareness. A more extensive discussion of the selected scenarios is provided elsewhere (Koomen *et al.* 2008; Riedijk *et al.* 2007).

The scenarios have been made spatially explicit with the help of several sector-specific models and a number of additional assumptions. Various specialized institutes have performed the development of the socioeconomic scenarios. The Netherlands Bureau for Economic Policy Analysis (CPB) and the ABF Research company have provided the expected amount of residential development (ABF 2006; CPB *et al.* 2006). CPB has delivered the demand for industrial and commercial land and office space (CPB 2002; CPB *et al.* 2006) and the Agricultural Economics Research Institute (LEI) has provided the projections for agricultural land-use changes (Helming 2005). The Netherlands Environmental Assessment Agency (MNP) subsequently inserted the regional spatial demands in the *Land Use Scanner* model together with a spatially explicit translation of the scenario assumptions into suitability maps. The land-use simulation starts by creating a 2015 land-use map from a 2000 base map taken from Statistics Netherlands (CBS 2002). In this step current, explicit land-use plans, mainly taken from the new map of the Netherlands survey (NIROV 2005), are included in the simulation to represent autonomous developments. Based on this base situation, simulations for 2040 are made for the two scenarios according to the scenario-specific assumptions and sector-related developments discussed in the following section.

Both scenarios indicate that the amount of land used for sectors such as residence, industry, nature and recreation increases at the expense of agriculture. Figure 8.4 depicts the local impact of these national changes and shows that the increase in residential land is more moderate in the *Regional Communities* scenarios. However, urban sprawl is expected to continue due to the continuing demand for rural residences and green, spacious urban housing. The extent of this sprawl is limited, however, because population growth is coming to a halt in all regions. The regional development in employment is strongly related to the provision of consumer services.

Based on the assumptions of the two socioeconomic scenarios and the limited literature available on scenarios for 2100, we also simulate land use for that year. Although we realise that the uncertainties related to such long-term simulations are enormous, they are included nonetheless to assess the potential effect of the projected strong increase in sea-level rise of 1.5 – 5 m.

Following the two basic scenarios, additional simulations have been made for different safety strategies. Two of these strategies are the *Business As Usual (BAU)* and the *Terpen* strategies. The *BAU* strategy contains standard water protection measures that will be prolonged until 2040. These measures include dike reinforcement, additional space for rivers, coastal supplement, replacement of flood barriers and other coastal defence works. The *Terpen* strategy contains a specific additional safety measure. The Dutch word *terpen* refers to dwelling mounds and these artificial elevations were common in the Middle Ages when dikes were absent or offered limited protection. In this strategy, all new housing development will take place at five metres above mean sea level on artificially elevated construction sites. As the surface level in parts of the western Netherlands lies up to 6 m below mean sea level, this strategy calls for enormous amounts of sand. This sand is available in the nearby, shallow North Sea and can be transported at reasonably low costs

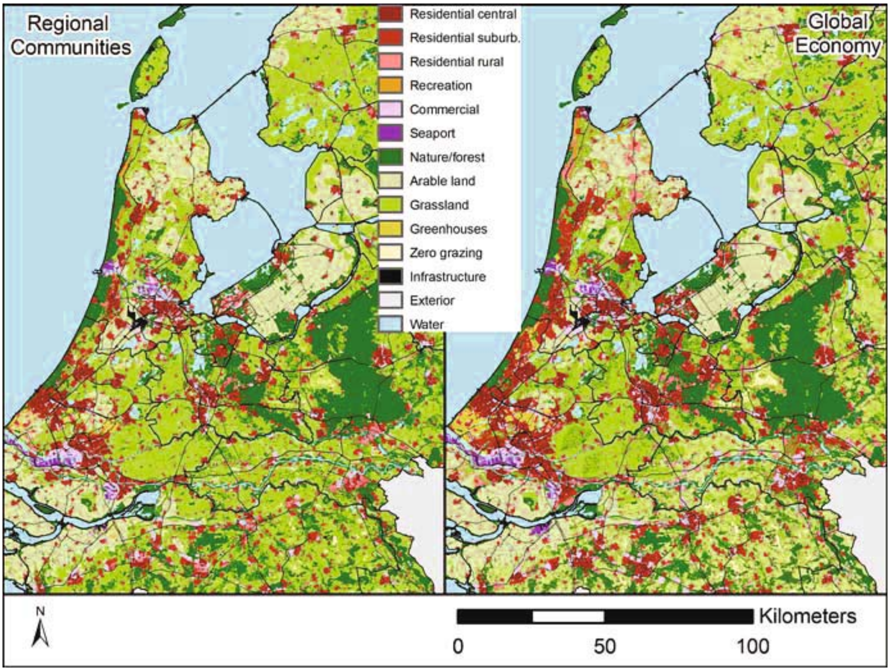

Fig. 8.4 Simulated future land use in 2040 for the *Regional Communities* and *Global Economy* scenarios (See also Plate 20 in the Colour Plate Section)

(Van der Meulen *et al.* 2007). Furthermore, flood barriers and, after 2040, dike rings will locally be reinforced to create a new integrated safety system that is interconnected with the many new *terpen*. This strategy is included in the system to test its potential as an alternative option to limit flood risk.

8.5 Impact Assessment of Flood Risk

The concept of risk encompasses both the probability and the consequences of a failure (Howard 2002). Generally, it is defined as the product of probability and consequences. In our case, these consequences consist of economic damage and number of casualties. The following aspects have to be considered when deciding upon a method to assess flood risk:

- the focus is on the long-term impacts, for which the inherent uncertainty in the circumstances is large;
- the incorporated strategies have a relatively global, explorative character and are not described in exact technical details; and
- consequently the uncertainty in flooding probability and the related long-term impact is large.

Therefore, the flood risk assessment used in this system is largely based on simple heuristics and expert knowledge. In the following sections, we will describe the method used to compute both the probabilities and the impacts of a flood in the Dutch safety or dike ring areas.

8.5.1 Flooding Probability

As discussed in Section 8.2, the protection level of Dutch water defences is expressed in safety norms that are related to the statistical return periods of specific flood water level. It is assumed that the system is designed to safely (i.e. without failure) withstand water levels below this design water level. Higher water levels will lead to severe overtopping and consequent failure of the flood defence system. As no other failure mechanisms are considered, the probability of failure of the flood defence system equals the probability of exceedence of its design water level.

Under the influence of the changing climate, the flooding probabilities are expected to increase as the sea level is thought to rise further, storms may become more severe and river discharges are likely to increase. From complex probabilistic analyses, it is known how flooding probability increases with increasing water levels, assuming that no measures are implemented. Of course, it is unlikely that no additional flood management strategies are implemented. The system shows the impact of this option, nonetheless, as it aims to provide policy makers with an opportunity to analyse the effectiveness of different strategies in terms of flooding probability and associated risk against a common reference point.

8.5.2 Flood Impact

The impact of flooding, both in terms of economic damage and in casualties, depends largely on the location of failure in the water defence and the hydraulic conditions of the flood. For example, sea floods have different impacts than river floods and the impact of a flood in an extensive deep polder differs from a comparable flood in an area where height differences may offer a rettfuge from flooding. Also the economic value and the number of inhabitants present in the flooded area determine the impact of the flood.

To estimate the effects of a flood, the so-called ‘Damage scanner’ has been developed within the *Land Use Scanner*. This instrument computes the economic damage and number of casualties per scenario and strategy. Per scenario, per strategy and per year (2015, 2040, 2100), the flood effects are computed by applying damage functions to maps describing water levels after flooding and land-use configurations. These functions relate economic damage and number of casualties to specific land-use types, considering the expected water levels. These results are aggregated per dike ring area to facilitate an easy comparison of the different strategies. As a reference for the flood risk computed for the different future situations, we use the expected situation in 2015. For this year, we assume the actual flooding probabilities to match the safety standards. Until that time, some major projects are being undertaken in the Netherlands to meet the standards (RvR 2006).

8.5.3 Uncertainties

Flood risk analysis involves many uncertainties. The input data are uncertain, the models involve uncertainties, the analyses are usually not complete and the simulations of future situations are inherently uncertain. However, these uncertainties should not prevent us from drawing conclusions. Although the exact figures may be wrong, the order of magnitude is probably right and the differences between alternatives become clear through a consistent comparison. In the analysis it is important to explain clearly which assumptions were made, where uncertainties are large and what effect they may have.

8.5.4 Current Experiences and Further Development

A first demonstration version of the discussion support system was presented to end users in a seminar late 2007 to derive feedback for further development. During the session most users claimed that the system clearly added value to the discussion on long-term climate change effects and flood risk. Many stakeholders expressed that the issue of climate change is complex as its effect and hence the solutions, are inherently uncertain. Apart from climate change, other issues were also deemed important such as land-use change and socioeconomic trends. Together, these issues pose huge dilemmas to many policy makers and experts in water management as to what policy would be most robust in the future. For this discussion, the system is considered to be important as it provides insight into the possible consequences of the combined changes in climate and society. It, furthermore, shows what impact possible management strategies may have. So, the facilitating role of the system has been clearly acknowledged. An issue mentioned for further development is the use of more detailed quantitative information. The current version uses straightforward hybrid methods and consequently the resolution of the results is coarse. Some experts expect that technology-oriented users may see this as a disadvantage of the system. Furthermore, they suggest making the methods and assumptions underlying the outcomes more explicit.

The current system is not exhaustive in its scope and applied methods, leaving room for further innovations in the long term. Three aspects of climate change are now integrated in the system: sea level, river discharge and precipitation. From these, the user is currently only allowed to vary sea-level rise. In the future, it could be interesting to also vary river discharge and precipitation and maybe even integrate other climate change aspects such as temperature, drought or storms. Information from other projects about climate change could supply the necessary information. Besides climate change, land subsidence is another important safety issue in the Netherlands. Isostatic changes and tilting are causing the Netherlands to sink by about 10 cm per century. Local subsidence within peaty polders caused by the oxidation of organic matter may even lower surface levels by about 1 m by 2100. Relative to the raised sea level, ground level can locally drop 1.5 m or more. Inclusion of this phenomenon would be a valuable addition to the system.

We currently follow a scenario approach where the 'uncertain future' is captured in a set of climate and socioeconomic scenarios that will or could influence flood safety and vulnerability to water damage in the Netherlands. An innovation in this respect could be the inclusion of discontinuities since most existing scenario studies take a linear outlook and thus produce a limited variety of scenarios for the future. Future research will pay more attention to identifying extremes, unanticipated events, trend breaks and feedback mechanisms. The challenge is to convert these discontinuities into spatially explicit changes in land use and related flood risk.

8.6 Conclusions and Future Directions

The last report of the Intergovernmental Panel on Climate Change (IPCC) shows that human activities lead to global warming and that extremes in the hydrological cycle, such as flooding and extreme rainfall, will be more frequent (IPCC 2007). Also other future developments will have an effect on flood risk and their management. For example, European and global political developments will have an increasing influence on Dutch flood safety policies. These include liberalisation and privatisation, decentralisation of responsibilities to regional government and an increased importance of private parties and public participation (Van den Brink *et al.* 2007). The Netherlands has, furthermore, become richer, and should therefore be more capable of defending itself against flooding. The drawback, though, is that the cumulative value of physical assets and the increased population mean that the risk—defined as the probability of flooding times the damage—has risen rapidly. It has recently also become clear that floods are much more likely to cause high numbers of casualties than most other disasters at, for example, industrial plants, airports and railway marshalling yards combined.

This chapter has demonstrated the development of a system that facilitates the discussion of different future trends, their impact on flood risk, and the effects of new flood safety strategies. The system follows a scenario approach where the 'uncertain future' is captured in a set of climate and socioeconomic scenarios that may influence flood safety and vulnerability to water damage in the Netherlands. The system is targeted at water managers that need to take action now to be safe in the future. This involves a lot of uncertainty, which is inherent in long-term flood risk assessments. There are simply too many options about how the socio-economic situation in the coming decades will develop or how the climate will change. Hence, the system will not predict exactly what will happen or tell us precisely what measurements we should take, but it is a learning instrument that gives more insights into what future scenarios are possible and which options exist in answering the possible changes. Not only will this lead to a better understanding but also to a more creative and integrative approach to climate change impact analysis.

Several possible methodological extensions to the system related to, for example, the inclusion of more variable climate indicators or land subsidence were discussed in the previous section. The addition of new safety strategies would also help to make it a more complete system dealing with future water safety. A different direction for future improvements of this and other systems for discussion support, however, is to offer such systems to different groups of users. The current system is, like many comparable instruments, intended for relatively well-informed experts. A challenge for future versions is to open the wealth of available information to non-expert users, such as interested citizens and local or regional stakeholders. This calls for serious improvements of, amongst others, the current user interface and the level of detail. To interest a younger user group it is worth exploring the option of introducing a game element to playfully familiarise them with the topic of flood risk management. In all these cases, however, the fundamental issue remains how to attractively translate complicated technical knowledge to a broad audience while doing justice to the uncertainties, choices and assumptions underlying the results.

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