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2004

99101sirch.doc

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SIRCH Working Paper 5

Report number D-99/10

October 1999

IVM

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The Societal and Institutional Responses to Climate Change and Climatic Hazards: Managing Changing Flood and Drought Risk (SIRCH) project is publishing a series of working papers. The first four relate to the development of the analytical framework. Background studies and case studies are being prepared. The papers are published by partner organisations in the SIRCH project.

SIRCH Working Paper 1. Riesco, P. (1999) The challenge of climate change for water technologies: An institutional perspective. Centro de las Nuevas Technologias del Agua, Seville, Spain.

SIRCH Working Paper 2. Calatrave, J., Garrido, A. and Iglesias, E. (1999) Economics applied to drought planning and management for damage mitigation. Universidad Politechnica de Madrid, Madrid, Spain.

SIRCH Working Paper 3. Bakker, K., Downing, T., Garrido, A., Giansante, C., Iglesias, E., Moral, L. del, Pedregal, B., Riesco, P. and the SIRCH Team (1999) A framework for institutional analysis. Environmental Change Unit, University of Oxford, Oxford, United Kingdom.

SIRCH Working Paper 4. Pedregal, B. (1999) Adaptive responses to hydrological risk: A demographic perspective. Universidad de Sevilla, Seville, Spain.

SIRCH Working Paper 5. Tol, R.S.J., Grijp, N.M. van der, Olsthoorn, A.A., Werff, P.E. van der (1999) Adapting to climate change: A case study on riverine flood risks in The Netherlands. Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands.

Contents

Abstract

Climate change may lead to an increased risk of river floods in the Netherlands. However, the impacts of changes in water management are even larger, whether enhancing or reducing flood risks. Therefore, the abilities of water management authorities to learn that climate and river flows are changing, and to recognise and act upon the implications are of crucial importance. At the same time, water management authorities respond to other trends, such as the democratisation of decision making, which alter their ability to react to climate change. This complex of interactions is illustrated with changes in river flood risk management for the Rhine and the Meuse in the Netherlands over the last 50 years. A scenario study is used to seek insight into the question whether current water management institutions and their likely successors are capable of dealing with plausible future flood risks. Structural solutions to future flood risks are feasible, but require considerable political will and institutional reform.

1. Introduction

Studies of the impact of climate change often ignore adaptation[1], and studies that include adaptation often do so in a rather mechanical way (cf. Tol *et al.*, 1999, for an overview of the literature). This may well be inappropriate, because people's and systems' reactions to a changing climate depend on many factors (geography, technology, wealth), the majority of which are unrelated to climate. To understand reactions to climate change, we must study the institutions that channel people's perceptions and intentions into actual responses.

As an example of the importance of water management, let us look at the river Meuse. The Meuse is a medium-sized rain-fed river originating in the north of France, traversing Belgium and the Netherlands to mouth in the North Sea. The Limburg Meuse Valley is unique for the Netherlands because it is hilly and the soil is such that water would seep underneath the dike if there were one. Severe floods in 1993 led the government to study, through the Committee Boertien (officially, *Commissie Watersnood Maas*), what could be done to avoid flood damages in the future (cf. CAM, 1994).

Table 1 shows the estimated annual average flood damage for various management scenarios. The Committee Boertien included robustness to climate change in their study, using a temperature and precipitation scenario for the year 2050. A relatively modest change in climate (a 2ºC temperature increase and a 10% precipitation increase in winter) would more than double the average annual damage. Medium-sized European rivers typically respond in this way (Handmer *et al.*, 1998; Riebsame *et al.*, 1995). However, the studied management interventions would reduce average damage by a factor 3 to 15.

Thus, in the Limburg Meuse Valley, the effect of management dominates the effect of climate. That is, the impact of climate change is 'noise' compared to the 'signal' that management effectuates. This is true for many impacts of climate change (Tol *et al.*, 1998). So, if we want to get a better understanding of the potential impact of climate change, we would need to get more insight into the way decision makers in water management react to (the expectation of) climate change. Therefore, it is crucial to study the impact of climate change on water management institutions.

Such a study includes questions as: Do water managers realise that climate is changing? Do they recognise the implications for their tasks and objectives? If so, are they able to react timely and adequately? In the Netherlands, the impact of climate change on water resources is clearly recognised. The Committee Boertien is one example, but there are more (cf. Van der Grijp and Oltshoorn, 1999). The rest of this paper therefore focuses on the possible and likely reactions of water management authorities and stakeholders in water management, and the constraints to alternative policies.

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[1] Adaptation is the knowing and unknowing response of actors and systems to climate change, either in anticipation or reaction to, so as to mitigate the negative impacts of climate change and maximise its positive impacts, whether successful or not.

Table 1.1 Annual average damage (in million guilder per year) due to river floods in the Limburg Meuse Valley[a].

Policy intervention	1995	2050[b]
Do nothing	9.9	21.8
Embankments	0.7	1.5
Nature development	0.6-3.3	1.4-7.3
Deepen summer bed	3.5	7.4

[a] Average damage is estimated using a hydrological model of the Meuse, coupled to a GIS database of the stock at risk from flooding. Modelled flood damage is calibrated to the actual flood damage of 1995 (without policy intervention). Input comes from a stochastic weather generator, calibrated to current climate and a scenario of future climate.

[b] Winter temperatures 2ºC higher than today, winter precipitation 10% up.

Source: Schuurman (1995).

2. Background trends

The Netherlands is densely populated with prosperous and well-educated people. Decisions are typically made through consensus. The country is formed by the deltas of the rivers Scheldt, Meuse and Rhine. The river Scheldt connects Antwerp Harbour in Belgium to the North Sea. The Waal branch of the Rhine connects Rotterdam Harbour to the German industrial heartland. The country is flat. Centuries of subsidence have left most of the country below mean sea and river level. Dikes and dunes are supposed to protect the country from floods. Centuries of floods have left the people rather nervous and inventive about water management. Water flows are regulated through an elaborate system of canals, sluices, pumps and so on. Dutch civil engineers are amongst the best in the world if it comes to engineering water works.

The flood risks posed by the river Rhine and its branches are much larger than the flood risks of the Scheldt and the Meuse. This has to do with the large discharge of the Rhine, and the fact that the areas adjacent to the river are polders. Most polders are below mean river level, so if water gets in, it needs to be pumped out, which takes a long time. If a dike breaks, fast flowing water would do a lot of damage.

Water is managed by a complex array of authorities. An overview of the main players and their main responsibilities can be found in Van den Berg and van Hall (1997). Van der Grijp and Olsthoorn (1999), Van Hall (1997a), Mostert (1997) and Perdok (1995). Van der Grijp and Olsthoorn (1999) identify four major trends in water management over the last 50 years. These trends may well continue to change institutions in the same direction for the coming 50 years.

The first trend is *internationalisation*, or the geographical extension of policy from the local scale to the watershed. Water management policy, traditionally a matter of local and regional authorities, was first nationalised by Louis Napoleon, viceroy for this brother Boneparte (cf. Langen and Tol, 1998, 1999, for a more extensive review of the history of flood management in The Netherlands). The responsibility of the central government for water issues was reconfirmed in the Constitution of 1848, and strengthened in the Constitution of 1983. Operational responsibility for flood safety rests with the water boards. The flood of 1953 led to a reorganisation of the water boards. There were over 2500 semi-professional water boards in 1950. There are less than 50 now, fully professional (Van den Berg and Van Hall, 1997). Geographical upscaling of institutions continues at an international level. The 1986 Sandoz incident[2] gave teeth to the International Rhine Committee, though initially only to chew on water quality and pollution issues. Since the floods of 1995, mostly in Germany, its mandate has included flood control (Van der Grijp and Olsthoorn, 1999). The Helsinki Convention provided a framework for treaties on the Meuse (De Villeneuve, 1996). The new EU Water Directive is likely to reinforce the trend of internationalisation of river water management.

The second trend is *integration*. Water has many roles, and water management serves many purposes. These include drinking water, irrigation water, navigation, recreation, nature preservation, fisheries, and cooling water. Problems may arise because of floods, droughts, and contamination. All these roles and the associated management goals come together in one system, and pretending that interactions do not exist may be seriously misleading or counterproductive. Yet, different aspects of water are often still managed by different entities with different, occasionally conflicting interests. Over the years, and particularly in the last decade, integration of water issues is pushed by the central government (Mostert, 1998). The operational reality lags behind, though (Gilhuis and Menninga, 1996). It should be noted that, currently, integration more or less stops where the water ends. Land use planning and water management remain largely separated, although there is considerable mutual consultation (Van Hall, 1997b).

The third trend is *democratisation*. Engineers, bureaucrats and politicians have less to say about water management than they used to. More stakeholders get increasingly involved. This is marked by the gradual extension of voting rights in water boards from large landowners to all inhabitants (completed in 1994) (Gilhuis and Menninga, 1996; Katsburg, 1996). More importantly, elaborate impact assessments of proposed projects are now required by law, media attention to planned infrastructure can be enormous, and public hearings are extensive (Van der Grijp and Olsthoorn, 1999). Although this increases the democratic nature of decision making and thereby the quality of planning and implementation, it may also increase its costs and considerably slows down the process.

Note that, in reaction to the (near) floods of 1995, the *Deltaplan Grote Rivieren* (delta plan large rivers) was introduced. The accompanying law accelerates and streamlines decision making procedures, partially reversing the democratisation trend. This law applies also to other infrastructure than flood safety related investments (Kroon, 1997).

The fourth trend is *ecologicalisation*. Water management used to be decided on a narrow economic and engineering calculus, and used to be biased by typical civil engineering thinking. The upsurge of the environmental movement in the 1970s, reinforcing the older movement for protecting landscape and cultural heritage changed this. Notably, during that time, plans to impolder the IJssel Lake and the Waddensea were ditched, and plans to close the Eastern Scheldt Estuary were changed, all in favour of nature preservation (Hisschemoller, 1985). The thoughts behind these isolated decisions are now pervasive. Civil engi-

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[2] A factory spilled large quantities of poisonous chemicals during a fire.

neering has given way to ecological engineering. Rivers are no longer just transport channels, but important recreation areas and parts of the Ecological Main Structure. The current round of dike reinforcements is supposed to be the last one. After 2000, flood risk management should make use of natural dynamics, rather than concrete and steel (Van Hall, 1997a).

These trends both constrain and enable future management options. Together, they determine what options are feasible, and which one is likely to be adopted. Reactions to climate change should be placed against this background.

3. Implications of climate change

The implications of climate change may be quite severe for river deltas such as the Netherlands. The majority of general circulation models (GCMs) project winter precipitation to increase in the Rhine river basin.[3] This would increase the risk of river floods (Kwadijk and Middelkoop, 1994; Parmet and Raak, 1995).[4] Earlier snowmelt in the Alps could further enhance river floods. Sea level rise would slow the outflow of water. As mentioned in the introduction, water management authorities are well aware of this, and consider their options.

Unfortunately, no one has found a neat solution so far. The default solution is to continue current and past practice of solving problems as they emerge (that is, after some harm is done), and picking a solution that does not upset too much of the delicate balance of interests. This has proven to be sort of successful, although problems were often shifted rather than solved (cf. Langen and Tol, 1998, 1999). It is doubtful whether this strategy will be of great help in dealing with climate change, because of the scale of the problem and the dire state of the current water management system. Works to improve the weakest dikes were accelerated in 1995. No definite plans are decided upon for after 2000. Proposals, focusing on increasing the retention and recreational value of the flood plains, tweak the water discharge system, but do not substantially alter it.

The alternative would be a radical re-design of the delta of the water management system. The research institute Delft Hydraulics (1998) produced a blueprint. This plan is not painless, but it could take away a number of current problems and prevent a number of future ones. The core element of the blueprint is to redistribute the water flow over the three branches of the Rhine, viz. the Waal, the Lek and the IJssel; see Figure 1. The Waal discharges most of the water. It is the major shipping route from Rotterdam to Germany and back. The Lek and the IJssel are less important.

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[3] That is, GCMs that look at the effect of greenhouse gas emissions generally project the northern half of Europe to get wetter. GCMs that also include sulphate aerosols occasionally project a drying of northern Europe (Brignall *et al.*, 1998). However, acidification policies in Europe rapidly decrease sulphur emissions (Gruebler, 1998).

[4] Note that sizeable rivers such as the Rhine react to above-average rainfall for an extended period (at least a month) over the whole watershed (Penning-Rowsell and Fordham, 1994). GCMs are more reliable for this type of floods than for flash floods and floods of small rivers.

Climate change is likely to increase the peak flow. In the study of Delft Hydraulics, the design peak discharge is assumed to increase from 15,000 m^3/s to 20,000 m^3/s.

The design peak discharge is the maximum river flow – as measured at Lobith where the Rhine enters the Netherlands – that occurs without causing severe floods downstream. The design peak discharge constitutes the first element of the guidelines for flood protection. The second element of flood protection is the acceptable risk of dike overtopping. This risk is set by Parliament, upon advice of a committee of wise men. The current risk is 1/1250 year, that is, river dikes and other water works should be build such that they fail less than once every 1250 years. The tolerated risk is so low because the would-be damage is so high. Should a dike break or be overtopped, a large polder would fill with fast streaming water. It would take months to get the water out. The acceptable risk does not comprise a valuation of personal risks.

Confronted with a higher peak flow, one could do several things. Firstly, water management authorities could hope that the Germans would solve the problem, and store excess water somewhere in a reservoir. The current discussion in Germany suggests that this is an unlikely scenario. Firstly, water management is the terrain of the *Bundeslaender* rather than the federal government, which hampers any structural solution to the flood problems along the Rhine (Kraemer, personal communication, 1999). Secondly, building (temporary) reservoirs is not the preferred option from a German perspective (Delft Hydraulics, 1998).

Secondly, one could accept more frequent floods. This is not an issue in the Netherlands. The 1995 evacuation of 1 in 60 of the population is still fresh in people’s minds, and not to be repeated. Recent attempts to introduce flood risk insurance failed for lack of interest by insurers and reinsurers (Tol, 1998a,b; Van Schoubroeck, 1997, 1999).

Thirdly, one could build higher dikes. This runs against the trend of ecologicalisation, and is counter to the recently adopted government policy. Dikes are considered ugly and spoil the landscape. Dikes are also expensive, particularly if done properly. A lot of river dikes were built and rebuilt over the centuries. It is seldom known what they were made of, and thus hard to re-engineer (Delft Hydraulics, 1998). Furthermore, there is always a residual risk of dike failure, particularly in the light of the uncertainty about climate change projections. Floods in the densely populated areas of Brabant and South-Holland or the petrochemical industry near Rotterdam would be extremely expensive.

Fourthly, one could increase the discharge capacity of all three branches, by deepening and widening the river bed. However, getting the water as quickly as possible to the North Sea would cause other problems. Increasing discharge capacity would reduce water flows in summer, which, particularly if combined with higher temperatures, would enhance the probability of droughts, hurting nature, recreation, agriculture, drinking water and navigation. The current, already elaborate system of sluices would need to be substantially and expensively extended to prevent this. Reliable and speedy navigation is important for Rotterdam Harbour, competing with Antwerp and Hamburg. Standards for navigability of the Rhine are laid down in a treaty between the Netherlands and Germany (Van der Grijp and Olsthoorn, 1999).

Fifthly, one could dig a fourth branch. This would be expensive and risky, since such a branch would need to run against natural geography and would require land already used for other purposes (Delft Hydraulics, 1998). This branch would inevitably flow through *'t Gooi*, which is hilly and populated by well-to-do and well-connected people.

Sixthly, one could introduce a bypass. A bypass is a river branch that only occasionally discharges water. Delft Hydraulics (1998) opts for this idea. Figure 1 shows the consequences. If the discharge of the Rhine at Lobith is less than 15,000 m^3/s, everything remains as it is now. All water in excess of 15,000 m^3/s is discharged northwards, through the countryside of the province of Gelderland and Overijssel, and later joined with the IJssel to mouth in the IJssel Lake, from where the water would need to be discharged or pumped into the Waddensea.

The plan contains two more features. The Waal is turned into a canal, so that navigation is improved. The Lek is turned into a nature reserve.

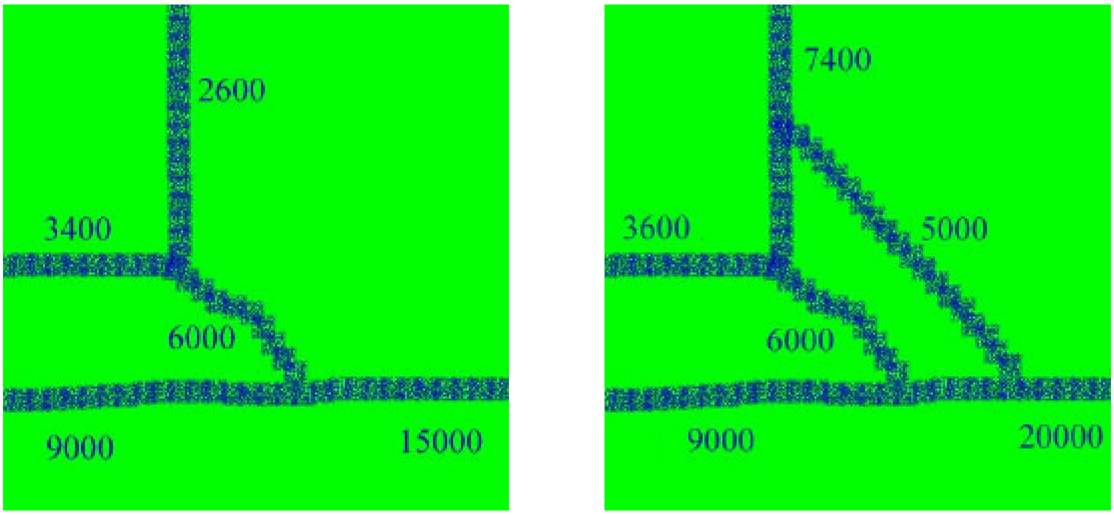

Figure 3.1 Current (left panel) and proposed future (right panel) distribution of the Rhine's peak flow over its branches. The 5,000 m^3/s branch is additional and only used in times of high water. It involves digging a new canal but largely relies on an earlier branch of the river. After: Delft Hydrualics (1998).

4. Institutional response

The implications for the provinces of Gelderland and Overijssel are quite drastic. Figure 4.1 compares the current and the proposed situation. Large stretches of land would need to be set aside for the newly created bypass. Isolated houses and hamlets would need to go, some villages and towns would need to be protected by circular dikes. The occasional flooding would be detrimental for agriculture, so that nature development would be the alternative. The bypass is designed so as to minimise such impacts, but they are still large.

Figure 4.1 The proposed bypass and restructured IJssel river. The light green areas are currently flood-safe, but will occasionally flood in the proposed situation. Source: Delft Hydraulics (1998).

Placed in the context of *democratisation*, it is unclear whether this or a similar plan will ever make it. Locals would be asked to leave house and hearth for a questionable cause. In the series of interviews we are currently conducting in the area, one of interviewees remarked “Climate change? Ha! One professor says it gets wetter, the other says it gets drier”. Fact is, the current decision making process lends substantial ear to ‘not in my polder’ feelings. Initial results of the series of interviews suggest that farmers may be willing to move, provided they are adequately compensated. Recent migrants to the region particularly appreciate the open landscape, and are thus opposed to the required new dikes. This group of people is well-organised, and effectively influenced the planning of the *Betuwelijn* (a major new railroad) and dike reinforcements in the same area (Van der Grijp and Olsthoorn, 1999).

Another issue is that the people of Gelderland and Overijssel would be asked to bear most of the costs (that is, increased flood risks), whereas the benefits (reduced floods risks) would largely befall the people of Brabant and Holland. Similar regional sentiments, particularly tensions between centre (i.e., Holland and Utrecht) and periphery (the rest of the country), have played a role in the management of the Limburg Meuse.

The Delft Hydraulics plan is not inconsistent with the trend of *ecologicalisation*, particularly because the Waal does not need higher dikes and the Lek is turned into a nature reserve. The actual bypass requires hard engineering, though, and new dikes are needed to protect the towns and villages of Gelderland and Overijssel. As mentioned above, the plan disregards upstream solutions in Germany, ignoring the trend of *internationalisation*.

The plan requires *integration* to be taken two steps further. Most importantly, water management and land use planning need to be interwoven. At the moment, the relevant authorities merely talk to one another, and only occasionally listen. A recent example is the *Betuwelijn*, the planned location of which gets in the way of flood safety reinforcements.

The difficulties in getting different authorities and other stakeholders to agree on policies and actions that address problems overarching specific interests are recognised. New ideas for water management (e.g., Rooy *et al.*, 1995) focus on the process of finding feasible approaches to deal with an uncertain future rather than on attempting to find support for a pre-engineered solution to a pre-defined problem. The initiative of Delft Hydraulics may be seen as an attempt to start such a process.

5.Conclusion

Climate change could seriously increase flood risks in the Netherlands. This is recognised by the water management authorities. A structural solution, an example of which is sketched above, would require strategic thinking, political courage, individual sacrifice for the greater good, and integration of land use planning and water management. The current institutional setting is such that a structural solution is likely to give way to incidental solutions.

Acknowledgements

This paper was presented at the EuroConference on Global Change and Catastrophe Risk Management: Flood Risks in Europe, June 6-9, IIASA, Laxenburg, Austria and the Stanford EMF Workshop on Climate Change Impacts and Integrated Assessment, July 26-August 3, Snowmass, CO, USA. Welcome comments by participants at those workshops helped improve the exposition. The research was done in the context of the SIRCH (social and institutional responses to climate change) project. Financial support by the Environment and Climate Programme of CEC-DG12 is gratefully acknowledged.

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