Thinking the unthinkable - the end of the Dutch river dike system? Exploring a new safety concept for the river management

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Abstract

Hansje Brinckers, the little boy sticking his finger in a hole of a Dutch dike is world famous for saving the Dutch lowlands from flooding. Since 1100 the Dutch relied on their continuously expanding extensive dike system for keeping dry feet and dry goods. In fact Hansje represents the inattentiveness and disregard of Dutch river dike safety management practice in the second halve of the 20th century. High waters during the last decade forced the authorities of several polders in the central river area to issue evacuation orders. 250.000 people were evacuated from the central river area. Although in the end the dikes did not collapse, an extensive dike improvement programme started immediately afterwards. For the near future the Dutch seem safe again but government agencies are now evaluating the durability and reliability of this traditional safety concept. Can the Dutch continue to raise their dikes in the future or should they give more room to the river? A first change in river management has been made recently - the river is given back the area of land between the dikes, which had been occupied so negligently by its citizens. But will this be enough? In a research project a new safety concept was explored in which the rivers got a free flow. Various impact studies and ex ante evaluations of this new safety management regime were made and the research project continues - is a new safety paradigm getting shape? Can frequent flooding be made acceptable to the Dutch citizen and the inhabitants of the Dutch polders?

Introduction

The Dutch foster their heritage of eight centuries of dike construction as primary defence against flooding (TeBrake, 1985). This history led to the dominance of this way of coping with high waters in the Netherlands, while elsewhere in the world other approaches have become dominant like acceptation, adaptation, evacuation, insurance and zoning strategies (Hekal, 2000; DWW, 2001:9). Such a dominant perspective on coping with a problem can be called ‘framing’. A frame is a perspective that is used to make sense of an amorphous complex situation and provides guideposts for knowing and acting. (Rein and Schön, 1993). Rijkswaterstaat, the national agency responsible for protection against floods, traditionally approaches

safety and risk in a probabilistic way. Their approach rests explicitly on the rational paradigm of policy making and analysis and implicitly assumes that nature has to abide for engineering skills. As a consequence of this frame river safety is seen as a technical, engineering problem in which mathematical modelling and three-dimensional dynamic models and cost/benefit analysis provide the right answers. Risk is perceived as the probability of the realisation of an adverse event. (Keeney, 1980; Zhou, 1995) This is, however, only one way of framing the complex problem of river safety and river management. Framing this safety problem in probabilities of flooding, number of casualties, costs and financial losses turns out to be problematic. The general public as well as many experts themselves find statistics hard to understand. (Hoek, 1995) Moreover, public understanding of flooding is not rational and opinions change rapidly after incidents. (Rosenthal et al. 1998; Poortvliet, 1999)

The Ministry of Transport Rijkswaterstaat's probabilistic approach often competes with a second framework: the deterministic approach, which is popular at the Ministry of Home Affairs. This deterministic approach uses 'scenarios' – descriptions of all possible events, as a basis for estimating the consequences of failure. In this approach possible coincidences or successions of events or failures lead to an accident or disaster. Risk is framed as the product of chances and consequences; the product of the probability of events and the magnitude of specific consequences. (Lowrance, 1976)

The two frames often collide as could be witnessed in the debate on the safety of the Westerschelde tunnel, a 7 km long tunnel with his deepest point 60 meters below sea-level, currently under construction. (Enserink, 1999) In the latter case this collision led to over $100 Mln for additional safety measures of which nobody really knows whether they contribute to the safety of the user. The tunnel safety debate showed that a discussion between holders of different frames soon leads to a dialogue of the deaf. (Bras-Klapwijk, 1999) Such a dialogue of the deaf has been going on for years over river dike improvement where the debate focused on safety levels, costs and the cost of smart solutions that would save natural and cultural values. (Eeten, 1999)

Neither of the two frames is easily communicated to the public; the probabilistic approach is too rational, too technical; the deterministic worst case scenarios are too good to be true (too gruesome to be believed?). A different approach or at least another way of communication with the public is required; a different discourse (Fischer and Forester, 1993) and reframing of the issue at hand is needed. Scenarios – not the description of possible disastrous events, but policy analytical scenarios depicting possible future situations, might be a good way for (re-)framing ideas and knowledge on safety and river management issues. In this article we will describe how policy scenarios and context scenarios were used to reframe the river dike safety issue.

The Dutch dikes

Floods and inundation threaten large part of the world's population as most people are living in coastal plains and along rivers. The Netherlands is a densely populated river delta area and the land lies just above or just beneath sea level. The country has always been threatened by flooding both from the sea and from the rivers Rhine,

Meuse, IJssel and Scheldt that flow through the country. Since the Stormramp (storm disaster) of 1953, when the North Sea flooded large parts of Zeeland and Holland, much attention had been paid to the defence against the sea. The Deltawerken were executed. All big sea arms in Zeeland, except the Westerschelde, were closed off and storm surge barriers were constructed along the rivers. Dutch civil engineers became renowned for their capabilities all over the world. During that period relatively little attention was paid to maintenance and strengthening of the Dutch river dikes. When during the seventies and eighties the focus of attention shifted towards strengthening river dikes, the same Rijkswaterstaat and waterboard engineers that were cheered at for their robust defences against the sea met heavy resistance when they tried to build the same type of large defences along the rivers. The majority of the population did not accept their energetic approach that included the removal of complete historical villages and destruction of nature preservation areas. Fierce debates started about the preservation of the so-called LNC values (Landscape, Nature and Cultural values) of the riverland and on the costs of "smart" dikes that would preserve these values. This debate finally came to a halt in 1993 with the advice of the so-called committee Boertien and after extensive studies. (Walker et al. 1993) The delays of improvements caused by these discussions had led to a poor condition of the riverdikes in the central river zone and raised the risk of a breakthrough. Eventually, during the 1995 long-drawn high water period, the dikes became soaked and instable. Because of the threat of dike-breech several low-lying polders had to be evacuated. Nearly 250.000 people had to leave their homes. (CUR, 1995; Rosenthal et al. 1998) Historically the Dutch river dikes protected the low countries or polders from flooding. But by constructing dikes we prevented the river from changing course and forced it to deposit its sediments in the area between the dikes. Consequently this dikebound floodplain or foreland was filled with sand and clay, the riverbed-level rose and in the end came higher than the surrounding land. (See figure 1) At the same time heavy drainage and

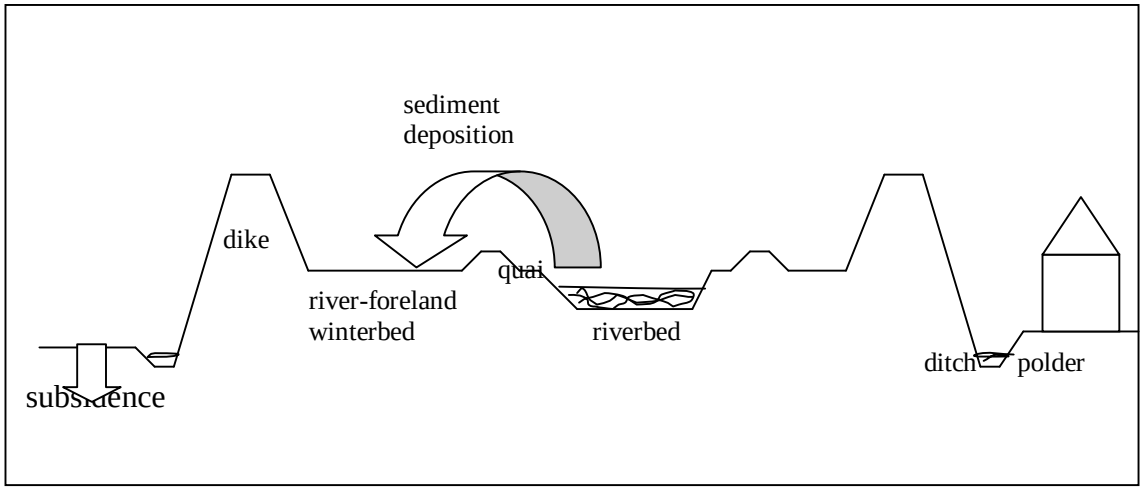

Figure 1. Typical Dutch riversystem

Intensive farming led to subsidence of the peat and clay substratum of the neighbouring polders. Nowadays the dikes can be more than 8 meters high. In case of dike breech and flooding inundation depths in the upper part of the Rhine delta will be between 4 and 6 meters (Walker et al, 1993:33); up to 8 meters in the lowest parts of some of the polders in the downstream area. As there is no natural outflow of surplus water from these low spots it might take months to drain them again. Generally speaking dike breech of riverdikes and inundation of polders in a rich and

well-developed country like the Netherlands will not lead to many casualties as high waters can be predicted and people and cattle will be evacuated in time. The economical damage, loss of production capacity and production goods is what counts here and amounts to billions of dollars. (Walker et al, 1993:42; Rosenthal, 1998:144; Kuijper, 2000) Next people will suffer from the disruption of their well-organised social life and some will suffer from emotional shock, as many Dutch believe they have mastered nature.

Traditional risk safety management

Rijkswaterstaat works along probabilistic lines, as the latter is believed to prevent over-dimensioning and needless expenses. An example of this probabilistic approach is the fault tree of the Dutch flood defence system as depicted by Hekal (2000) given in figure 2.

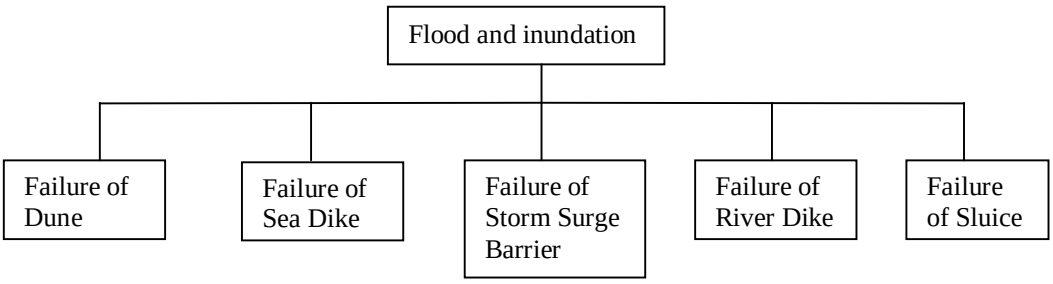

Figure 2. Fault tree due to floods

Within this rational framework different safety levels are assigned to various regions in the Netherlands, which are determined in the 'Wet op de waterkering', the Law on flood prevention of 1996. The dike rings in the central river area have a safety level op 1/1250, while in the western part of the country these levels rise through 1/2000 to 1/10.000 for the dike ring 'Central Holland' where the large cities are located. This high safety level coincides with the economical interests and high population density, as well as with the fact that inundation by salt seawater will result in higher damage levels.

In the Dutch central river area 665 km of dikes protect the low lands and polder areas from flooding. In determining the height of these riverdikes probabilities are the dominant frame and the so-called design discharge ('maatgevende afvoer') is the determining statistical factor. This design discharge is the discharge, which according to statistics occurs once every 1250 years, which is considered the acceptable flooding risk for the Dutch central river area. It is the basis for the design water levels ('maatgevende hoogwaterstanden') on which the height of the dikes is based. (Walker et al. 1993 The current discharge of 15.000 m^3/s was derived from linear regression of a relatively short time series of measurements between 1901 and 1990 in Lobith where the Rhine enters the country. (Silva et al. 2000) The two recent highs of 1993 and 1995, although statistically occurring with a possibility of once every 80 years, led to this change. It is generally expected that in 2001 the design water levels will be upgraded as the design discharge will rise from 15.000 m^3/s to 16.000 m^3/s. Expectations about sea-level rise and climate change are expected to lead in the long-term to design discharges of 18.000 m^3/s in 2050 and 20.000 m^3/s in 2100.

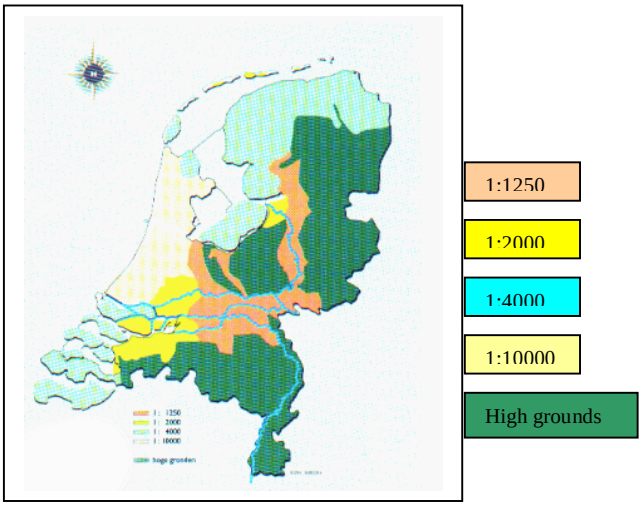

Figure 3. Safety levels in the Netherlands

Thinking about new safety concepts

After the high waters of 1993 and 1995 the national government decided to the so-called 'Deltaplan Grote Rivieren'. This plan concerned the immediate execution of dike improvement programs in order to reach a safety level of 1/1250 in the year 2001. Execution of this program is on schedule. (CIW, 2000: 31,32) But immediately after this, in 1996, discussions started on the durability of the concept and the formal policy objective became 'Ruimte voor de Rivier'. This 'Room for the River' program had the explicit objective to maintain and if possible to expand the capacity of the riverbed as well as the prevention of damage in case of high water levels. (Silva et al. 2000). Moreover in 1998 the 12th Conference of Rhine Ministers adopted the "Action Plan on Flood Defense" earmarking up to 12 billion ECUs to durable flood prevention measures to be implemented in the next 20 years. (Worm and Villeneuve, 1999). The discussions on durable river management were held against the background of the expectation that due to climate change the future might bring more frequent and (much) higher peaks in river discharges. Room for the River aimed at creating more storage capacity through technical and managerial measures in the area between the dikes, like deepening the riverbed, digging by-passes, lowering the forelands, bringing back dikes and creating retention capacity. (Silva et al. 2000) Room for the River is now being executed and has a firm social base. The implementation of this policy program is planned to be ready by 2015.
The discussion on durable safety measures led to a discussion within the research unit of Rijkswaterstaat DWW on the durability of the traditional (dike) safety concept in the very long term. They argued that if we are confronted with an expected sea-level rise of 1 meter, changing rain patterns leading to discharge peaks and subsidence of polder-grounds by 50 centimetres, in less than 100 years from now, dikes might no longer guarantee safety. Continued river dike improvement might then not be a durable concept. A program was started in search of a new safety concept that would not depend on dikes alone. A paradigm shift might be needed. Starting point should be that water is the steering factor. In their Project Plan (DWW, 2000) they write: "New possibilities should be explored how water can find its way, also outside existing dikes, and consequently how people would organise their society at those

places where this is possible: at high places, in the zone between wet and dry areas and even on the water. This safety concept is robust because it really guarantees safety. Living and working are no longer threatened by water at higher places." [translation BE] In their Riviere*n*land Courant – a leaflet on the results of the project, issued March 2001, it is explained that "the concept leads to so many space for the water that even the highest discharges will lead only to a small increase of the general water level in the river basin area. Part of the land will be permanently drowned, but at other places dry spots can be found depending on the height."

Scenarios

By anticipating on possible changes one can deal with the dynamics in the problem setting to get robust or flexible solutions. (Riet, 2002) When exploring long-term changes historical analyses as well as scenarios can be good instruments. Historical analysis of the Dutch river system showed that in unrestricted conditions the meandering rivers changed their flow every 325 years in average, filling up the lower areas with their sediments until the course of the river changed again. This knowledge was used as a basis for assessing the geomorphologic and hydrologic situation after disbanding the dikes, which in turn served as a basis for the design of an 'image' of the central river area after implementation of this radical new safety regime. This 'image' can be considered to be a policy scenario as it describes a normatively wanted future situation.
Scenarios can be defined as a rich and detailed portrait of a plausible future world or as a future state of a system. (Beroggi, 1997:16) A scenario is not a prediction or a specific forecast per se; rather, it is a plausible description of what *might* occur. Plausibility is what distinguishes scenarios from mere fantasy. (Enserink, 2000) Distinguishing between the system and its environment as depicted in figure 4 is helpful to differentiate between various kinds of scenarios: policy scenarios relating to the future state of the system and context or environmental scenarios relating to the impact of the changing environment on the system.

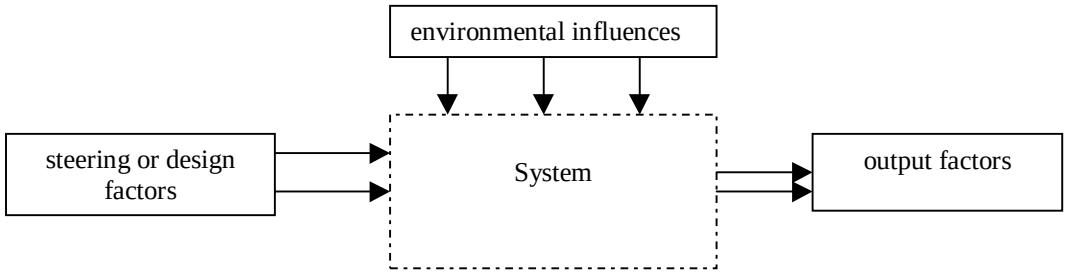

Figure 4. Framework for delineation of system and environment

The goal of generating scenarios is to understand the mix of strategic decisions that are of maximum benefit in the face of various uncertainties and challenges posed by the external environment. Awareness raising can be another goal of scenario making and was indeed formulated as one of the objectives of the Riviere*n*Land research project. Several scenario and 'imaging' studies were made. The aforementioned distinction between strategic and context scenarios is relevant for discussing the

different kinds of scenarios or 'images' of the future that were designed and their role in developing the new safety concept.

Images of the Riviер*en*Land safety concept

The essential characteristic of Riviер*en*Land is the free flow of river water and the adaptation of society to this situation. Several partial studies were made to create an impression of the situation in the central river area after 200 or 300 years with respect to landscape, hydrology and human occupation. These studies resulted in an 'image' or scenario in which in the higher middle and eastern parts meandering rivers flow through natural areas, which to the west develop into a delta area with lakes at the west-side, which once were polders. Once a year almost the entire area will be flooded, but the fluctuation of the water level will be restricted and inundation depths in most parts rather limited. The inhabitants will have adapted to living on the water; they live in floating or elevated houses or houses built on stilts. The image is split up in four different (geomorphologically based) types of land use and urbanization:

1. The 'Waarden' or low areas which are periodically flooded, containing main transport axes, natural areas, wetland crops and extensively populated, mounts,
2. The Old Riverbed, high and dry, with high natural, cultural and historical values and occupation,
3. The Randstad Lake area, with mainly recreational activities and waterfront living,
4. The New Biesbosch, a nature reserve with tidal influence.

These four areas together form the normative 'image' or policy scenario of *Riviер*en*Land.* It depicts as concrete as possible how a radically different but robust and durable safety concept would affect the hydrological and natural circumstances and consequently the organization of society in the area. The 'image' was created to be an intriguing and tempting metaphor of what the future could look like.

Context scenario

Another scenario study was made which concentrated at the assessment of robust implementation strategies; strategies that are compatible with multiple futures. (Meijer and Ruigh-Van der Ploeg, 2001). For this exercise a more systematic design process was used. Although numerous methods have been developed to create scenarios, many methods recognize the need to understand the system under study and to identify the trends, issues and events that are critical to the system. In this study the Schwartz (1991: 226-34) approach for a systematic design process was followed. An important element in this approach, apart from the identification of the focal issue or decision, is the identification of the key forces and trends in the environment. This is followed by a ranking exercise in which the 'driving forces' are ordered by importance and uncertainty. As these context scenarios are used to assess the robustness of policies they should be based on those factors that are uncertain and hard to influence by the policy makers themselves.
A one-day workshop was organized in which a core group of the project staff participate. The participants designed a rudimentary policy plan for a possible transition trajectory as well as a scenario-logic. The axes of this scenario-logic are depicted in Figure 5.

After reaching consensus on the scenario-logic four possible futures were detailed in which the transition from dikes as dominant safety concept to 'no-dikes' would have to come about:

- 'Country of isles'; man abides, space saving and individualistic society
- 'City land'; nature abides, space saving, individualistic society
- 'Villapark'; nature abides, space consuming, individualistic society
- 'Parkland'; nature abides, space consuming, collectivist society.

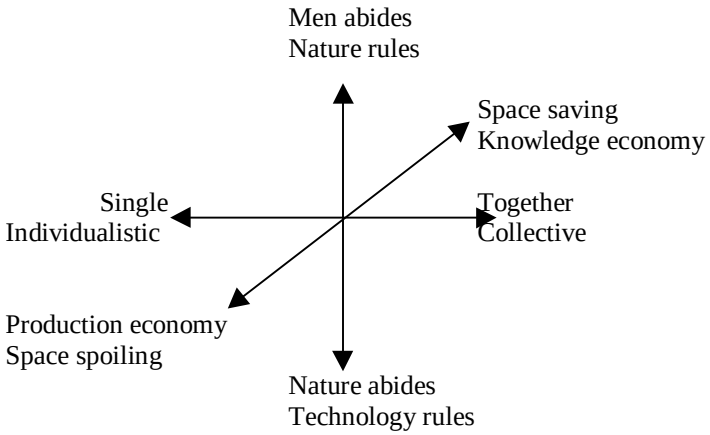

Figure 5. Scenariologic context scenarios Riviere*n*Land

After detailing these four context scenarios the transition plan was assessed upon its robustness in these four very different, but all possible and plausible future environments. The evaluation made clear that in all scenarios the initiative for starting up a transition trajectory towards a new safety and river management regime should come from the national government. This is the only forum that can initiate research projects and stimulate debate on the outcomes of these projects. In time the initiative in the transition process should shift to other, private and semi-governmental parties. Surprisingly the *ex ante* evaluation of a possible transition showed that chances for success were better in more liberal and individualistic societies in which government regulation is restricted. When central collective and shared responsibility for river dike maintenance and safety issues are lacking, regions with insufficient social and financial base will have weak defenses against high waters. (Enserink et al. 2000) Another revelation was that currently popular images of 'living near water' and 'living on water' and the gain of natural areas and preservations prove to be ineffective for gaining support. In most scenarios the citizens seem to focus on the attractive densely populated urban spheres.

Round Up

In the paragraph on frame reflection it was argued that neither Rijkswaterstaat's traditional probabilistic approach, nor the Home Affairs' deterministic approach of safety issues was suited for awareness raising on safety issues, nor for engaging in debates on river dike safety or river basin management. A different discourse was needed. The Riviere*n*Land case presented such a new way of framing a safety concept. Rivierenland's 'images' and context scenarios seem well suited for the communication and debate on handling the risks of flooding by presenting a radically

different perspective. People had to abide their traditional way of thinking about safety and risk and were confronted with an 'image' of a possible future in which sustainable security was reached through adaptation of society to a new situation.
The 'image' or policy scenario depicted by the project group showed the prospect of a new society adapted to a new river management regime leading to an inherent safe situation. This 'image' now has been presented to a broader public for the fist time. The conceptual idea was well received although skeptical comments could be heard too. The policy scenario will be presented to the general public in the months and years to come and research will continue.
The context scenarios helped the project group to assess the strengths and weaknesses of their implementation plan. Can this controversial plan be made public; will there be much upheaval and resistance or will people go along with the concept and debate on the details? The context scenarios allowed discussion on these issues and gave insight in the hurdles and strategic insights in the way to start discussion on the reliability and long-term durability of the riverdike safety concept. Clearly scenarios proved to work well for reframing the river dike safety debate.

References

Beroggi, Giampierro E.G., 1997. *Decision Modeling in Policy Management, An Introduction to the Analytic Concepts.* SEPA, Delft

Bras-Klapwijk, R.M. 1999. *Adjusting Life Cycle Assessment Methodology for Use in Public Policy Discourse.* PhD thesis Delft University of Technology

CIW, 2000. *Water in Beeld, Voortgangsrapportage over het waterbeheer in Nederland.* Commissie Integraal Waterbeheer (Committee on Integral Watermanagement)

CUR/TAW, 1995. *Syllabus Hoogwater 1995. Voordrachten Symposium Hoogwater.* Civieltechnisch Centrum Uitvoering Research en Regelgeveing, Technische Adviescommissie voor de Waterkeringen.

DWW, 2000. *Rivieren**land. Verkennende studie gericht op de verre toekomst. Plan van Aanpak.* Rijkswaterstaat Dienst Weg- en Waterbouwkunde

DWW, 2001. *Dijken voor de Eeuwigheid? Een troef achter de hand.. Rapportage Project Rivieren**Land,* Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstat, Dienst Weg- en Waterbouwkunde, W-DWW-2001-017.

Eeten, M. van, 1999. *Dialogues of the Deaf, Defining New Agendas for Environmental Deadlocks.* PhD thesis Eburon, Delft

Enserink, Bert., 1999. "Integral assessment: the role of safety management". P*roceedings of the Sixth Annual Conference of The International Emergency Management Society*, June 7-11, 1999, Delft, The Netherlands, pp. 402-410

Enserink, Bert, 2000. "Buiding Scenarios for the University" *International Transactions in Operational Research,* Vol. 7, No. 6. pages 569-584.

Enserink, B., I van Bemmelen, O. Kuiper, 2000. *Rivieren**Land, Ex-ante evaluatie van het Transitieproces – een scenariostudie. Report to DWW, DG RWS, Min VenW.* TBM, TU Delft

Fischer, F. and J. Forester (eds.) 1993. *The Argumentative Turn in Policy Analysis and Planning,* Durham, NC and London: Duke University Press

Hekal, Nasr, 2000. *An Inventory of Measures and Solutions Coping with Floods around the World.* M.Sc thesis IHE, Delft

Hoek, A.W. van der, 1995. “Elfstedentocht en Deltaplan Grote Rivieren” in: CUR/TAW , *Syllabus Hoogwater 1995.*
Keeney, R.L. 1980. “Equity and Public Risk”, *Operations Research,* 28(3), 527-534.
Kuijper, Olaf. 2000. *Rivierenland, Risico's van het huidige waterbeleid. Report to DWW, DG RWS, Min VenW.* TBM, TU Delft
Lowrance, W.W. 1976. *Of Acceptable Risk, science and the determination of safety,* William Kaufman, Inc. Los Altos, California
Meijer, M.H., and M. Ruijgh-van der Ploeg (2001) ‘Critical factors in strategic planning for infrastructure design’ *Proceedings DIOC Infrastructures,* TU Delft (*forthcoming*)
Poortvliet, Abraham van. 1999. *Risks, disasters, and management; a comparative study of three passenger transport systems*; TU Delft
Riet, O.A.W.T. van der, 2002. *What's the Problem in Infrastructure Planning,* TU Delft (*forthcoming*)
Rein, M. and D. Schön, 1993. 'Reframing Policy Discourse' in Fischer, F and J.Forester (eds.), 1993. *The Argumentative Turn in Policy Analysis and Planning.*
Rosenthal, Uriel, Menno van Duin, Michel Bezuyen, Marie-Louise de Vreeze-Verhoef and Paul ‘t Hart, 1998. Flood Management in the Netherlands, in: Uriel Rosenthal, paul ‘t Hart (Eds.), *Flood Response and Crisis Management in Western Europe. A Comparative Analysis.* Springer
Schwartz, Peter. 1991. *The Art of the Long View: Planning for the Future in an Uncertain World.* New York: Doubleday.
Silva, Wim, Frans Klijn, Jos Dijkman, 2000. *Ruimte voor Rijntakken. Wat het onderzoek ons heeft geleerd.* RIZA-nota 2000.026; WL-rapport R3294
TeBrake, W.H. 1985. ‘Medieval Frontier. Culture and Ecology’ in: Melosi, M.V.(ed.), *Number Seven: Environmental History Series.* Texas A&M University Press, College Station
Walker, Warren, Allan Abrahamse, Joseph Bolten, Marjan den Braber, Steven Garber, James Kahan, Matthijs Kok, Odette van der Riet, 1993. *Investigating Basic Principles of River Dike Improvement, Safety Analysis, Cost Estimation, and Impact Assessment.* RAND European-American Center for Policy Analysis
Worm, J. and C.H.V. de Villeneuve, 1999. Flood/discharge management; Rhine Action Plan on flood defence, in: Mostert (ed.), *River Basin Management, Proceedings of the International Workshop,* The Hague, 27-29 October 1999.
Zhou, Hao-Ming, 1995. *Towards an Operational Risk Assessment in Flood Alleviation – theory, operationalization and application.* PhD thesis, Delft University Press

Biography

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