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Towards Flood Risk Management in the EU: State of affairs with examples from various European countries

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ABSTRACT
On 27 June 2006 the Council of the European Union reached political agreement on a draft directive on the assessment and management of flood risks. This directive prescribes approaches and procedures which should be met by the member states. The website of the EU on this directive links to another EU-initiative, the Integrated Project FLOODsite, which aims at providing methodologies for flood risk analysis and management. Obviously, the directive and the IP emerged in a common but much larger context of public and scientific debate on a more integrated and coordinated approach to dealing with flood risks. In this paper we briefly discuss this context and examine a few national cases in order to find out whether flood risk management is already common practice or is still in its infancy, or whether it involves merely good intentions. We base this examination primarily on our experiences within FLOODsite and on presentations held within the special session on River Flood Risk Management which was organised by The Netherlands Centre for River Studies (NCR) during the ISDF3 conference in May 2005. This paper goes into the similarities and differences between some national approaches and tries to place them in a cultural context. It appears that the seemingly most sophisticated management policies do not automatically imply the most comprehensive flood risk management approach. But the intention to evolve from flood management into flood risk management is evident and promising.

Keywords: Flood risk; EU floods directive; river floods; retention; non-structural measures.

1 Introduction

On 27 June 2006 the Council of the European Union reached political agreement on a draft directive on the assessment and management of flood risks. In Article 1 the purpose of this Directive is defined as "*to establish a framework for the assessment and management of flood risks aiming at the reduction of the adverse consequences on human health, the environment, cultural heritage and economic activity associated with floods in the Community*." The directive prescribes approaches and procedures which should be met by the member states, and products to be delivered. It applies to the whole Community territory, and therefore to flood risk management in both river and coastal floodplain areas.

Already when the directive still had the status of a proposal, the Commission's communication (COM, 2004) to the Council identified the Sixth Framework Programme Integrated Project (IP) FLOODsite as contributing to the improvement of integrated flood risk analysis and management methodologies. One of the first results of FLOODsite was a report on a common terminology and understanding of concepts, introducing flood risk and its management as the central concepts (FLOODsite, 2005) instead of the earlier and narrower paradigms of flood defence, flood control and flood management, successively. Obviously, the Directive and the IP emerged in the common but larger context of scientific and public debate on how to best deal with flood risks.

The scientific debate can be traced back to uneasiness about the development of scientific approaches and practical management in many countries in a direction of greater specialisation. This resulted in "increasing knowledge about trees, but no view on the forest". As a reaction, there was a call for more integrated approaches, as in many other scientific fields (e.g. environmental sciences; cf. de Groot, 1992) and as also reflected by the emergence of integrated water resources management (Loucks & van Beek, 2006) or – even better – integrated water management.[1]

As for flood risk research, there have been various initiatives to bridge the widening gaps between meteorology, statistics,

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[1]Water is not only a resource, but also an important condition for all living creatures. This distinction between resources and conditions is one of the key principles in ecology (Begon *et al*., 1986), whereas a resource approach could be called typical for economics allowing 'scarcity' and 'ownership' to be established.

hydrology, hydrodynamics, engineering, geography, spatial planning, etc. In Germany, for example, the Decade of Natural Hazards was very important, in which a change of paradigm for flood risk research and management was introduced (Plate, 2002). For the river basins of Rhine and Meuse, the EU-Interreg-funded IRMA-SPONGE research programme has caused lots of debate and reconsidering (Hooijer *et al.*, 2004). But these are only two examples of an overall tendency of the re-orientation of the involved sciences in the 1990's.

Scientific debate often remains isolated from public debate until some triggering events occur. In the context of flood risk management these events were a number of (near) flood disasters in Europe. In central Europe, the Oder River caused a disaster in 1997 and the Elbe basin faced its flood of the century in 2002. The Rhine and Meuse experienced major floods in 1993 and 1995; during the latter some 250,000 people were evacuated in The Netherlands raising their awareness of being vulnerable. But in this same decade also the UK, France, Italy and many other EU-countries were struck by floods which caused numerous fatalities and lots of damage (van Alphen & van Beek, 2005).

Major floods are often a catalyst for policy change, as they cause public outrage and an increase of political pressure. However, before such a change takes place a broad professional consensus must exist on the why and how of a change in approach (Samuels *et al.*, 2006).

At present, we see a move towards comprehensive flood risk management as worldwide the risk for people and property is expected to increase. Besides climate change with its potential effects on flood probability, demographic and economic developments urge us to reconsider the current flood risk management strategies as vulnerability mounts (e.g. Klijn *et al.*, 2004). This implies a shift away from the single objective of flood defence, via control of the flood *hazard* (physical defence measures) towards management of flood *risks* proper through also influencing the vulnerability of society. The need for this shift was emphasized by the IRMA-SPONGE research programme in one of its four main conclusions: "*The most effective flood risk management strategy is damage prevention by spatial planning*" (Hooijer *et al.*, 2004).

In this paper we shall examine some national cases to find out whether this comprehensive flood risk management is already common practice in EU Member States, or is still in its infancy, or whether it is just words and good intentions. We base this examination primarily on our experiences within FLOODsite and on presentations held within the special session on River Flood Risk Management which The Netherlands Centre for River Studies (NCR) organised during the Third international Symposium on Flood Defence in May 2005 in Nijmegen (ISDF3).

Before we can do so, we need to first establish what the essentials of comprehensive flood risk management are in order to distinguish it from more conventional approaches. This will be explained in the next section, which is primarily inspired by results from IRMA-SPONGE and progress within FLOODsite (Box 1). We shall end by reflecting on the common issues and differences between the approaches in the various EU member states.

2 Essentials of a flood risk management approach

In order to understand what distinguishes flood risk management from earlier approaches, we should define the component concepts, viz. flood risk and management. Without a shared understanding of what we mean by the words we use, we are in danger of being misunderstood. Moreover, it is essential to

Box 1.

FLOODsite

The Integrated Project FLOODsite is the largest ever EC research action on flood risk management, with an EC "grant to the budget" of nearly €10 Million. The project, which started in 2004, is scheduled to take 5 years to complete, and involves approximately 200 researchers from 13 countries. The project consortium consists of 37 partners including many of Europe's leading institutes and universities and involves researchers, practitioners and managers from a range of research, commercial and government organisations.

FLOODsite is interdisciplinary, integrating expertise from across the environmental and social sciences, as well as technology, spatial planning and management. FLOODsite covers flood risks from rivers, estuaries and the sea. There are 35 project tasks including pilot applications in Belgium, the Czech Republic, France, Germany, Hungary, Italy, The Netherlands, Spain and the UK.
The project will deliver:

- An integrated, European, methodology for the assessment and management of flood risk.
- Consistency of approach to the causes, consequences and management of flood risks from rivers, estuaries and the sea.
- Techniques and knowledge to support integrated flood risk management in practice.
- Dissemination of this knowledge, including the development of training media.
- Networking and integration with other EC national and international research.

The progress of the project is monitored by three advisory boards:

- The Scientific and Technical Advisory Board considers the scientific quality of the project and publication of the results,
- The Application and Implementation Board advises on the implementation of the science in practice, and
- The Project Board overviews the whole project.

For further information on research tasks and deliverables, see www.floodsite.net agree on what we mean by flood risk before we can adequately address its management. Therefore, FLOODsite put substantial effort in defining these concepts in its 'Language of Risk' (FLOODsite, 2005).

$$\begin{aligned} \text{Risk} &= \text{probability} * \text{consequence} \\ &= \text{hazard} * (\text{exposure}) * \text{vulnerability} \end{aligned}$$

Flood risk is defined as the 'product' of the probability of floods and their consequences, or, alternatively, as the product of flood hazard and society's vulnerability to floods. These definitions are by no means new (see for example: UN DHA, 1992; Helm, 1996; Crichton, 1999; ISO/EC, 1999; ISO/EC, 2002), and so are not particularly surprising. However, they do urge one to consider the fact that:

(1) without people or property there is no risk, and
(2) that one should pay equal attention to the flood hazard and a society's vulnerability.

Especially the latter often means another mind-set for many a scientist or authority. After all, the common societal response in many developed countries is to blame the flood and to try to control it – and scientists and managers are no less human than lay-people. This definition of flood risk, however, stresses that floods are a natural phenomenon. Indeed the very concept of a hazard as a *physical event, phenomenon or human activity with the potential to result in harm* (FLOODsite, 2005) embodies human values in the concept of there being "harm" as the potential effect of a hazard. Hence both flood hazard and risk are entirely human concerns. It means that it is essential to analyse the risk as being constituted by the nature of the hazard and its probability, exposure, expected damage, expected fatalities, etc. But more importantly, a risk approach urges one to also consider whether people, property and other assets should be managed or even controlled, instead of only the flood.

This leads us to defining the first essential of flood risk management: *one should not manage the flood, but the risk (i.e. the flood hazard and the vulnerability of the flood-prone area – as constituted by people, their property and their activities – equally).*

Knowing what to manage, we may define management in contrast to the conventional flood defence, flood protection, flood control or – more recently – flood risk reduction. Obviously, the conventional terms all relate to the flood as the evildoer. Either you keep it away from your doorstep (defence, protection), or you try to keep it under control. Many – especially physical measures – are directed towards preventing floods by catchment measures (Hooijer *et al.*, 2002) or flood abatement (Parker, 2000), towards maintaining the water levels as low as possible by flood peak attenuation (Hooijer *et al.*, 2002) or towards guiding the flow through areas which are less vulnerable by dykes and other forms of flood control (Parker, 2000; de Bruijn, 2005). In contrast, flood risk reduction also applies measures and instruments aimed at damage prevention (Hooijer *et al.*, 2002), taking the flood as such for granted. Parker (2000) uses the term flood alleviation for this, although the measures are not directed towards the *flood*, but instead to lower the vulnerability, or to prevent people and property to be harmed by – primarily – non-structural measures such as land-zoning, flood-warning, insurance, and by physical measures such as flood-proofing. Obviously, we do not really support the term flood alleviation in this context.

The second essential of flood risk management can thus be formulated as *equal consideration of physical and 'non-structural'*[2] *measures, including regulatory/legal instruments, financial instruments and communicative instruments* (Hooijer *et al.*, 2002; Ölfert & Schanze, 2006).

Next, it is important to realise that risk management does not automatically imply actual reduction of the level of risk. Whether a risk should be reduced or accepted depends on the assessment whether it is acceptable or not. Furthermore, it depends on an assessment of the costs and benefits of measures and instruments required to reduce the risk. So, it is rather a question of optimizing risk reduction measures and risk acceptance, as it is generally acknowledged that complete safety against floods in floodplains cannot be guaranteed, and that living and working in such areas yields so many economic and other benefits that a certain degree of risk can be accepted. From the standpoint of economic rationality one would probably argue that cost-benefit analysis would suffice, comparing the costs of risk reduction measures with the reduced expected annual damage. But in practice, more criteria deserve attention which are not always easy to express in financial terms; such as fatalities. There may be ethical reasons not to allow huge disasters with many lives being lost. The rationalities of reducing economic risk, individual risk and collective (or 'group') risk do not always yield the same result, and may even get in conflict (van der Most *et al.*, 2006). There are also the negative or positive consequences of physical or land zoning measures on natural or cultural heritage values, on socio-economic development opportunities, etc. This requires a full assessment including all the costs and benefits of risk reduction measures in view of sustainable development, as argued by de Bruijn (2005; cf. also vis *et al.*, 2001).

This brings us to the third essential of flood risk management, which we adapt and expand from the work of Schanze (2005). Flood risk management is *a continuing cycle of assessing, implementing and maintaining flood risk management measures to achieve acceptable residual risk in view of sustainable development.*

3 Flood risk management in different member states: a common rationale for change but with many differences

We shall now briefly examine how flood risk management has evolved in different EU Member States, with their different

[2]The commonly used term 'non-structural' as opposed to structural measures would – in many European languages (other than English) – suggest that the measures are less good than structural measures; this is the reason that we abandoned the term structural measures, although the alternative (physical) has its flaws too.

socio-economic and cultural historical contexts. In the past, flood risk management has developed under the influence of societal debate and changing coalitions. Hence, current practice can be regarded as the result of a cultural history (cf. Johnson *et al.*, 2005). In different countries culture differs and history has been very different too (cf. e.g. Sultana *et al.*, 2008; Galloway, 2008). This has resulted in different management policies in different countries as we shall show below.

We do not review fully all EU Member States, but indicate some remarkable differences in approach as the outcome of physiographic and cultural differences. In so-doing, we use knowledge which was gathered by Dijkman *et al.* (2003) on how a number of European countries deal with above-design level river floods, e.g. by storing flood water in detention areas or by guiding the water through dedicated floodways. Some of the examples are illustrated by experiences with recent river floods. We look at (in alphabetical order):

- England and Wales
- France, especially how things are arranged along the Loire;
- Germany, especially the Elbe flood of 2002;
- Hungary, with a focus on the existing flood emergency polders;
- Italy, primarily the flood management along the Po;
- The Netherlands.

For the approach in the US of America, especially the flood management along the Lower Mississippi, we refer to Galloway (2008).

4 England and Wales

The documentary evidence for flood and drainage works in the UK stretches back for some 800 years. The first legislation dates back to about 1215 (Purnell, 1993), whereas in 17th century England the drainage patterns and flood levels in many thousand square kilometres of land were changed by the Dutch Engineer Vermuyden, who undertook the construction of embankments, perhaps 100 km of new channel and wind pumps.

In the UK during the 20th century, the priorities for water management have progressed through stages which have influenced the approach to flood risk management. From the 1930's to about 1970, there was a strong need to secure food production and this led to a policy of rural land drainage and flood protection. From 1970 to the early 1990's economic reasons predominated, leading to urban flood defence as a priority to protect people and property. From the mid 1990's onwards, there has been an increasing shift towards flood risk management, responding to environmental concerns and giving enhanced attention to community involvement and public awareness.

A move towards flood risk management needs information on the current risk level and the factors that influence it. Therefore, the government commissioned a nation-wide flood risk assessment for England and Wales, to identify the magnitude of the assets at risk from flooding and the potential effects of future climate change on the flood risk. Purnell (2002) indicates that approximately 10% of the population lives in an area of flood hazard (1% probability), with an asset base of over €300 billion.

Further important insights for the revision of the UK flood risk management policy came from the Foresight project (Office of Science and Technology, 2004). This project investigated drivers, scenarios and possible responses determining flood risk in the next 100 years. The flood risks were analysed at a scale of a 10 km grid for four socio-economic scenarios, which were linked to standard IPCC global emissions' scenarios and simulations of future climate by the UK Hadley Centre. The scenarios represent different general policy frameworks for the country and the project considered flooding from rainfall, river, estuarine and coastal flooding. Drivers of flood risks were identified and ranked under each of these scenarios and the potential flood damages estimated for the 2080's.

In late 2004 this culminated in a revision of national policy with the public consultation on "*Making Space for Water*". This new policy exemplifies the change of view since 1990, but needed the wake-up call of the wide-spread floods of Easter 1998 and the winter of 2000/01 and the scientific understanding of the Foresight project for its launch. The policy sets out a framework for the first time to cover all sources of flooding and contains an integrated portfolio of approaches which reflect both national and local priorities. It highlights the importance of spatial planning guidance and strives for sustainability.

Presently, all rivers benefit from Catchment Flood Management Plans, which fulfil many of the requirements set in the EU Directive, and flood risk management in England and Wales can be regarded to address all aspects of the risk concept as defined above.

The probability of flooding is controlled through providing and maintaining physical flood defences. Where the probability of flooding is unacceptably high for any community new flood defences may be constructed, either as permanent defences or using temporary and demountable defence systems such as those at Bewdley on the River Severn. In some areas the policy will result in the realignment of flood defences, particularly in estuaries and at the coast through "managed retreat". In such cases land is deliberately returned to a natural flooding regime.

The Environment Agency has prepared national mapping of the flood hazard; this is available to the public over the internet and at large scale with 5 m spatial resolution to local government. These maps show the estimated extent of the 100-year and the 1000-year floods. The exposure of people and property to flood hazards is strictly controlled through the national system of spatial planning, which requires each local authority to produce a strategic flood risk assessment to identify flood risks as constraints on any planned development within their boundaries. Planning policy encourages land to be set aside as designated flood storage and no new development is permitted on active flood plains. Redevelopment of existing buildings in such areas is only permitted if there are no alternatives and then the design and construction must allow for the possibility of flooding.

Once an area has been identified as being potentially suitable for development on flood risk grounds, applications for planning permission must contain a detailed flood risk assessment of the

Figure 1 Flood damage at Boscastle UK (courtesy HR Wallingford).

site to ensure that both on-site and off-site flood risks are mitigated. These flood risk assessments must consider many factors including all sources of flood water, the potential for failure of any raised flood defences, the control of increased runoff from the developments, mitigation of residual risks and make precautionary allowances for the potential increase in rainfall or sea level arising from climate change. The standards applied for acceptable probability of flooding of any development vary according to the intended use of a building, with the highest standards set for critical infrastructure (e.g. hospitals) and the lowest for water-compatible development (e.g. boatyards).

During a flood emergency the exposure of people to flooding is reduced through a flood warning service, with messages available directly to residents, through the Environment Agency, on the internet and in summary in broadcast weather forecasts. Civil contingency planning exercises are undertaken periodically including the police and fire services, the Environment Agency and local authorities.

The awareness of people is enhanced through an annual advice on what to do in the case of a flood emergency, and on how to reduce the potential for flood damage through specification and design of new building works or renovations. The financial impact of floods on individuals and businesses is reduced through the widespread availability of insurance. The insurance industry, however, has taken a more cautious approach over the past decade with adjustments to premiums and policy excess clauses in higher hazard areas. Not surprisingly, the insurance companies are a major player in negotiations with the central government about flood protection levels, especially those to be provided with any new development.

5 France: Middle Loire

The Middle-Loire is protected by embankments whose history goes back to the 11th century, suggesting a historic priority for flood defence. However, there are many spillways in the embankments, which ensure that water can flow over the dikes without causing their failure (Figure 2). These spillways prevent the breaching of the embankments which would cause such a sudden inflow of water that people might drown and unnecessary large damage occurs. The water is thus allowed to flow into the dike-protected parts of the Loire valley in a controlled manner and back into the river again further downstream. The downstream end of these 'controlled flooding areas' is fully open to prevent water depths becoming too large. This illustrates a huge awareness of the risk of high dikes among the responsible authorities. And so do the inventories of the damage potential in the flood-prone areas (Équipe Pluridisciplinaire Plan Loire Grandeur Nature, 2000). These revealed that floods with a probabilty of 1/50 per year affect some 25,000 people and may cause €500 million of damage. A 1/500 flood touches about 120,000 people and may cause €3 billion of damage. Would the dikes fail entirely, the damage would amount to €6 billion.

Figure 2 Spillway in Middle Loire embankment (courtesy HR Wallingford).

When over time the dikes gradually grew to some 3 to 4 m, breaches started turning into disasters because of the large water depths and the high flow rates. The embankments had resulted in the loss of about 100 km^2 of river valley, which is no longer available for discharge, whereas none of the diked areas remained uninhabited. Each disaster again triggered debate on whether to raise the dikes or, instead, to give room back to the river. And many spillways therefore know a history of closure, re-opening, closure, etc. The last three major Loire floods (1846, 1856 and 1866) caused 166 breaches in 600 km of river embankments along the Middle-Loire.

After 20 years of studies and debate it was established that storing the water upstream was impossible and it was decided to realise 5 emergency inundation areas from a total of 19 alternative locations which were investigated. Mind: this all happened at the end of the 19th century.

Nowadays, along the Loire, 3 different types of controlled inundation areas (*déversoirs*) exist:

1. for frequent floods (1/5–1/10 per year) usually in agricultural area (comparable to floodplain polders behind levees);
2. for medium floods with a probability of 1/50–1/100 per year near cities, especially where historic bridges hamper the discharge and cause backwater effects (Gien, Beaugency, Blois); and
3. for extreme floods (less frequent than 1/100 per year) with an earthen plug/fuse in the dike to ensure sufficient inflow capacity.

Together, these constitute what one might call the Loire's flood hazard management system. Because the three types of *déversoir* start to function at different discharges, they have different effects on the flood. All, however, aim at preventing the water level rising so high or so suddenly that it endangers the embankments proper, and cause failure and breaching at unforeseen locations and times. Thus, the course of events would become uncontrolleable.

Model research showed that the diversions of type 1 allow the Loire River to discharge over a much wider bed resulting in lowered water levels. It does not involve the temporary storage of water, but only enhances the discharge capacity with some 1,000–1,500 m^3/s flowing behind the levees. The spillways into the floodways or bypasses along the urban bottlenecks (type 2) can accommodate about 500–1,000 m^3/s, resulting in water depths in the dike-protected areas of 2 m and more. The water flows fast there and hardly any peak attenuation occurs. Finally, the emergency detention areas are supplied with earthen plugs or fuses in order to delay the inflow of water as long as possible and, thus, to ensure that sufficient storage capacity is still available when required.

Still thousands of people live along the Loire in four fully closed dike-rings, where chance of failure and breaching cannot be excluded. The authorities regard this to be an unacceptable risk situation and consider the realisation of three additional emergency inundation areas. Also, it is being studied whether the functioning of the existing spillways can be improved, for example in those cases where the 19th Century spillways are too long and allow the water to enter too fast. In some cases the inundation areas are so long that there is still a risk of dikes breaching, because the water level differences between the river and the protected land become very large. Also for such cases improvements are being sought; it must be remarked that the 19th century engineers already foresaw this and proposed compartmentalisation.

Whatever measure is considered, the authorities aim to limit the water depths to a maximum of 2 to 3 m, because more is being regarded unbearable for the inhabitants. Also, new defences which are likely to function only infrequently are avoided, because those protected will forget about the *raison d'être* of the structures.

Thus we have come to the question whether and which non-structural instruments are applied. The responsible authorities attempt to prevent developments in the protected floodplain and even to relocate some housing. But this has to be enforced by legal instruments as existing financial incentives work counteractively: everyone struck in France by a flood which is officially classified as '*catastrophe naturelle*' may apply for financial compensation – of the material damage only. This is assessed by experts, paid by insurance companies and reinsured by the state. Presently, no difference is being made between those who live in the floodplain proper, those who live in emergency inundation polders and those who live elsewhere.

Figure 3 The 2002 flood in Dresden.

6 Germany: Elbe

The Elbe River basin is some 150,000 km^2 in extent. One third is located in the Czech Republic, two thirds in Germany. The Elbe is a typical rain-fed river, with peaks in early spring and low flows in summer and autumn. At the mouth, the mean discharge is 880 m^3/s. In the upstream part of tributaries in the Czech Republic and Germany we find 24 reservoirs with a total volume of 4 billion m^3. These reservoirs are primarily used for energy production; and only a part of the capacity is available for flood abatement (460 million m^3). This storage capacity is of utmost importance for floods with a recurrence interval up to 50 years. But for more extreme events – with a smaller probability – the effect of the reservoirs on downstream water levels is limited as the reservoirs are full before the flood peak arrives.

In Germany the major part of the river is embanked. The present embankments primarily date from the second half of the 19th century, but the oldest dikes date back as far as the 12th century. The embankments have reduced the original floodplain area of some 6,000 km^2 to only 800 km^2 of active floodplain. As long as the embankments do not fail, they cause the flood levels to rise.

In 2002, heavy, prolonged and extensive rainfall caused large-scale flooding in August: first in the Czech Republic and then in Germany. At the German border the peak discharge reached over 5,000 m^3/s. At 12 locations along the 90 km of river between the border and Dresden the embankments failed and breaches developed. Because large volumes of water entered the polders through these breaches, the discharge in the river itself decreased substantially. Thus the upstream dike failures reduced the discharge downstream. If the embankments upstream had been higher or stronger, the flooding further downstream would have been far more severe. Despite the dike failures, the old city of Dresden was not spared. In Dresden the water level was some 0.6 m higher than the highest on record so far, dating from 1845. The total damage of the 2002 Elbe flood in Germany is estimated at about €25 billion.

Further downstream along the Elbe River the river management authorities succeeded in reducing the inflow from the Havel tributary into the Elbe River to zero during the flood wave for 60 hours by manipulating the weirs in the Havel. This caused the water level in the Havel's sections to rise, but prevented an additional rise of 10 cm of the Elbe at the point of confluence and further downstream. In addition, on the 20th of August a designated low-lying area near the inflow of the Havel (the so-called Niederung) was filled with some 75 million m^3 of water from the Elbe. This reduced the downstream discharge by 650 m^3/s (Figure 4). All in all this 'detention basin' and – more importantly – the dike failures provided a temporary storage of 500 million m^3 in total.

In an evaluation of the Elbe flood the Bundesanstalt für Gewässerkunde (BfG, 2002) states: *"Wie die Überlegungen zu Grösse und Wirkungen der durch Deichbrüche erzeugten Überflutungen sehr deutlich gemacht haben, wären Schäden zum Beispiel in Bitterfeld oder Magdeburg sehr erheblich geworden, hätte es die ungewollten Rückhaltungen nicht gegeben. Darüber hinaus wären die eingetretenen Überflutungsschäden reduzierbar gewesen wenn neben der Flutung der Havelniederung noch andere – gering schadenträchtige – Gebiete gezielt hätten geflutet weren können. Da die verbreitet geforderte ungesteuerte Flutung bisheriger Polder hinsichtlich der Hochwasserminderung nur sehr begrenzte Wirkung haben kann, ist im Sinne der Anlieger zu fordern, dass geeignete Polder ganz oder teilweise für gesteuerte Flutung vorgesehen werden."*

In other words:

- upstream flooding has substantially reduced the downstream damage;
- the total damage could have been reduced further had there been the possibility of purposeful inundation of relatively less vulnerable areas; and
- the BfG recommends to provide the possibility of the controlled flooding of suitable polders.

The foregoing suggests an approach to flood hazard management in Germany which primarily uses structural measures. However, as reported by Dr. Schanze of the Dresden Flood Research Centre during ISDF3, a paradigm change can be observed in Germany since the floods of the Oder in 1997 and the Elbe in 2002. This paradigm change is based on the understanding that absolute protection against floods is

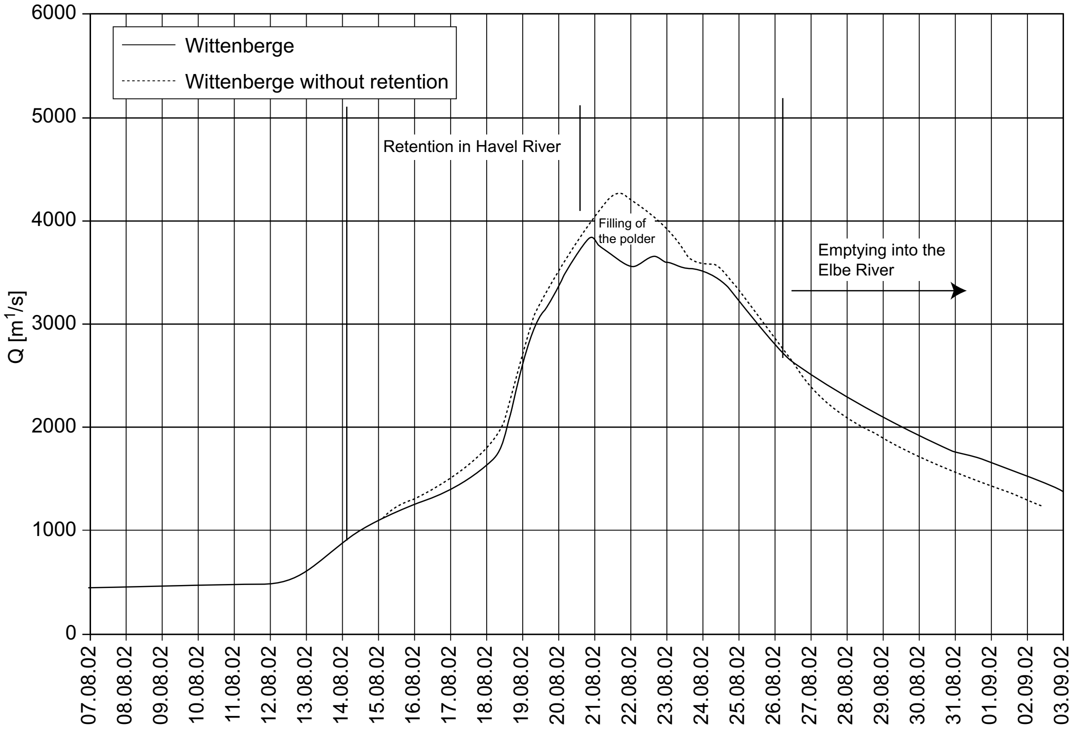

Figure 4 Discharge over time in the Elbe at Wittenberge during the 2002 flood with and without temporary retention in the Havel tributary (moments of beginning and ending indicated by vertical lines). The retention causes the flood peak to be lowered significantly.

unachievable. Therefore, the approach to managing flood risks is shifting away from flood protection only to flood risk management by putting more emphasis on spatial planning instruments.

In practice, this changing view is reflected by the number of plans which are being drafted or already implemented in Germany. Because of the federal structure of the country, plans are being made at various levels. There is a Flood Protection Act at the federal level, there are Water Management Plans in most Länder (e.g. the Saxony Water Management Plan) which address the issue of flood risk, and most large communities have an important role in decisions on land use. Land use zoning according to flood hazard zones should be enforced at local level by the communities. This means that on paper flood risk management is well organised, but there is no single managing entity responsible for the whole. Moreover, things may be arranged differently in different Länder, which is the logical consequence of the German federal structure.

7 Hungary

Over half of Hungary lies within the natural floodplains of the Donau River and its tributaries. Flood defence works were already constructed along the River Danube in the 13th century to protect communities like Szigetköz and Csallóköz (Zorkóczy, 1993). Nowadays, an area of some 20,000 km^2 is protected against river floods by more than 4,200 km of embankments. These constitute 151 polders in total, in which 2.5 million people live. The polders are subdivided in compartments by levees and transport embankments.

The protection level against floods in Hungary varies between 1/100 per year for sparsely populated areas and 1/1000 per year for densely populated areas. These protection levels have recently been evaluated and found adequate in view of the expected damage and casualties, although it was also found that many of the embankments had to be reinforced in order to effectively provide this level of protection (Vituki, 1998).

A distinction is made between flood control for normal – i.e. below-design level – floods and hazard management for extreme floods. For the normal floods the flood defence consists of the embankments, complemented with flood control by reservoirs which lie upstream in a number of river basins. These are operated in such a way as to attenuate the flood wave. These reservoirs are part of the structural flood control system and are, hence, brought into action before design conditions along the embankments are reached.

For extreme floods, likely to cause the overflow or breaching of embankments, emergency storage is provided by 11 inundation polders. These provide storage for some 300–360 million m^3 of water. During the period 1966 to 1997 emergency inundation polders have been used for 14 times, with the desired effect: the downstream water levels were lowered significantly (Szlavik, 1999; 2000). Emergency inundation polders are, by definition, meant for above-design conditions. They are, consequently, used less frequently than the reservoirs. The emergency inundation polders reduce the flood peak when design water levels are in danger of being exceeded. This may be the case when (1) the discharge is above design discharge, (2) because of ice jams; but they are also used when (3) the dike stability is feared for or (4) to decrease the damage during a dike breach at a downstream location. In all cases, the objective is to prevent large damage elsewhere. The polders are filled by cutting or blasting the dike or through weirs and sluices.

As for managing the vulnerability in the flood-prone areas, this is well-considered for the emergency inundation polders. The land in the polders is not purchased, but instead the land use is regulated in the customary zoning plans. The use of the area for water storage is legally fixed, with limitations for land use development such as a prohibition of new housing developments. Any damage incurred through intentional inundation is refunded by the government.

As it was established that the protection levels are adequate in view of the expected damage and number of casualties, plans to improve the flood risk management in Hungary focus on further emergency inundation areas instead of on raising dikes or making more room for the rivers. This was found to be the most cost-effective approach (Halcrow *et al.*, 1999). Some 30 new locations with a total storage volume of 1,500 million m^3 are being investigated and publicly debated.

8 Italy, with special emphasis on the Po River

The longest rivers in Italy are the Po (652 km, ca 75,000 km^2 basin), followed by the Adige (410 km, ca 12,000 km^2 basin), the Tiber (405 km, ca 17,000 km^2 basin), and the Arno (241 km, ca 8,000 km^2 basin). Most rivers originate either in the Alps or in the Apennine mountains.

For a large portion of their length both the Po River and the Adige River flow in regulated river beds between dikes. The large sediment load in both rivers has silted up the river beds so much that they now flow higher than the surrounding land. Along their course, these rivers are confined by embankments erected over several centuries and which have been improved over time. These regulation works have mainly been carried out in the context of drainage and land amelioration activities. For exceptional runoff events, flood control measures comprise various expansion and storage zones, commonly enclosed between embankments, which provide room to the river. These areas constitute wetlands and natural habitats along the river course. Some floodplains in the lower part of the Po River are designated as natural parks and/or nature reserves. Other floodplains are used for agricultural activities, such as arable land or poplar plantations.

Active floodplains constitute a large part of the cross section of the Italian rivers. When the active floodplains have insufficient capacity in case of extreme runoff, storage basins are used for flood control (b), or levee cutting is applied (c):

(a) Active floodplains allow a river to expand during high runoff events. The active floodplain is usually confined by two main levees only, which protect the adjacent land. Along the Po River a 'double' cross section is encountered with a main levee somewhat inland and a secondary levee close to the main channel, which protects the floodplain area between the main and the secondary levee from floods with a probability of about 1/10 per year (Figure 5). These floodplains are used for agricultural purposes, and in some cases for tree plantations.

(b) Storage basins (in Italian "*casse d'espansione*") are another frequently used flood control measure. Especially uninhabited areas or former gravel or sand mining pits have been designated as such. During exceptional runoff events water can be diverted towards these basins reducing the flood peak further downstream. These basins are either delimited by natural relief or confined by a levee, and always separated from the main river by a levee with a spillway. It is clear that such a basin can only store a limited volume of water and may prove insufficient in case of exceptional and rare events.

(c) Extreme runoff events may require that at critical locations levees are cut, in order to reduce the peak discharge. This cutting is performed at particular points that have been identified as most suitable through experience. The locations are known to the civil protection agencies and to the local communities that are potentially affected.

Most floodplains in Italy contain houses or other premises. The reason is that, in the past, the land in the floodplains has been sold by the public administration at low cost and some people accepted this economic advantage in exchange of higher exposure to flooding. In some cases houses have been in flood-prone areas for centuries and have obviously survived past flooding events. The people living here are usually aware of the risk and do not expect to be protected by the government beyond common evacuation measures. In contrast, the people living on the land side of the main levees, in the protected plains, expect that the main levees offer full protection from flooding (Figure 5).

The responsibility for the flood management lies with the Interregional Agency of the Po River (AIPO), which also decides

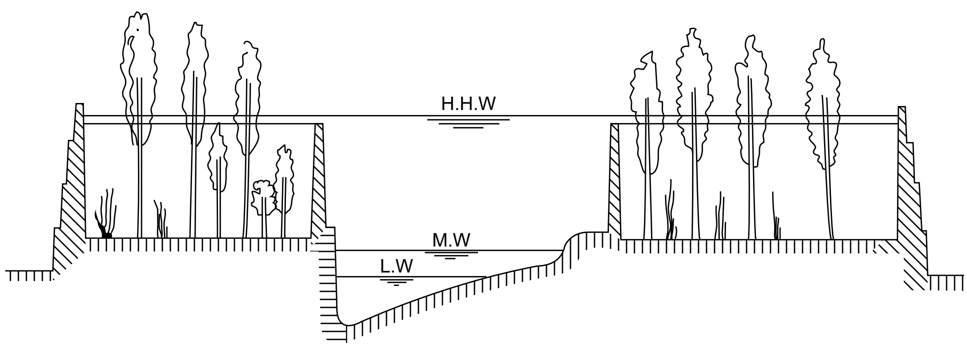

Figure 5 Typical cross section of the Po River with main levees and secondary embankments along the channel.

Figure 6 Main embankment along the Po River, in the vicinity of the town of Agoiolo.

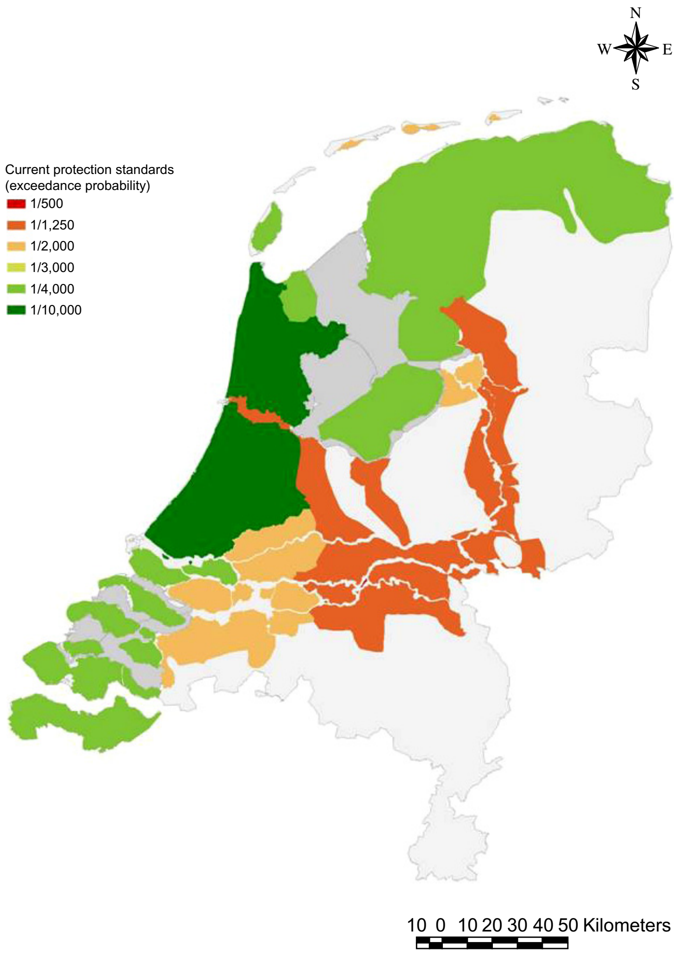

Figure 7 The present safety standards for flood protection: the ultimate result of the advice of the Delta committee after the 1953 disaster, supplemented and updated for the rivers.

on whether, when and where levees should be cut. AIPO is a technical committee of supra-regional character with representatives of all regions crossed by the river. AIPO is responsible for all decisions of technical and hydraulic nature.

Decisions which require evacuation or which could imply danger for citizens are communicated to the civil protection agency which is responsible for the protection and rescue of the citizens; this must act in case of evacuation and rescue. The civil protection agency, which has a central office in Rome, also has regional, provincial and local branches spread over the country. The local branches know threats to the citizens in their area – and are supposed to know how to intervene in case of flood. They are responsible for evacuation, rescue from danger and providing food and shelter.

Once damage has occurred, the area affected is identified and declared a calamity zone by the mayor or competent local authority to the central government. Subsequently, financial aid is provided by the central government. This aid constitutes a base funding mainly directed at repairing the most urgent damage, such as the road and communication network and public infrastructure. It also guarantees some compensation for farmers and individuals in the case of total loss. This aid can be supplemented with financial aid supplied by the regional or provincial governments. This aid obviously depends on the economic strength of a particular region. Finally, financial aid from fund raising actions can help to compensate damage from a natural catastrophe. Usually, the financial aid is supplied in a distributed manner, and compensation payments are carried out in instalments that can stretch out over several years. Thus, the most urgent interventions are carried out immediately, while less important actions are taken later.

9 The Netherlands

The Netherlands has a long tradition of flood risk management, dating back some 1000 yrs. By the 14th century, the dikes along the rivers had been connected to form closed dike-rings around polders where land and settlements were protected from flooding (Klaassen, 1998). This system was gradually further developed and added to, resulting in a very intricate flood defence system with thousands of polders and local responsible authorities (water boards) in the 1950's.

The 1953 storm surge, which caused the death of some 1800 people, was an important policy catalyst for better protection. It led to the installation of the so-called Delta Committee, which performed many studies and came up with much advice to the Government, finalising their work in 1961 (The Delta Committee, 1962). This advice focussed on the coast, but in its wake the polders on the former floodplain areas along the large rivers (esp. Rhine and Meuse) were treated in a similar way.

The Delta Committee advised to base safety standards on flood risk, indeed as a combination of flood probability and flood consequence, in balance with the construction costs for realizing a certain flood probability. Because of insufficient knowledge and to keep things simple, in practice an approach has been adopted based on safety standards for 53 individual so-called dike-rings, each with a safety level of either 1/1,250, 1/2,000, 1/4,000 or 1/10,000 per year. Those safety levels relate to exceedance probabilities of design conditions.

Both the safety levels (with a differentiation into 4 levels only) and the location of the dike-rings are specified in the Law on Flood Defence, which is revised periodically. The state of the defences is monitored constantly and evaluated in relation to the latest scientific insights and measurements of river discharge, sea level and waves every 5 years.

Whether the standards for exceedance probability are still up-to-date and in tune with economic development (Figure 8) is just becoming a point of consideration, after a publication on flood risks in relation to the risks of other environmental hazards (Ten Brinke & Bannink, 2004). It was established that flood risk in The Netherlands has never been so low before, but exceeds the risks of all man-induced external safety risks by far. This caused some discomfort among the authorities, followed by a current public debate.

As the title of the law already indicates, the current approach in The Netherlands is not a full risk approach, but rather a flood defence approach. Little is done to prevent an increase of the vulnerability of society in the dike-protected polders[3]. There have been many attempts to change this in the recent past, e.g. by the Technical Committee on Flood defences, WL | Delft Hydraulics, The National Institute of Public Health and the Environment (Ten Brinke & Bannink, 2004) and the Central Planning Bureau (Eijgenraam, 2005). The idea of changing towards a full risk approach is gaining ground, as can be deduced from speeches by the minister of Public Works and Water Management, but implementation seems to be delayed again and again because of the complexity of the analyses (especially flood probabilities are much more difficult to establish than exceedance probabilities of water levels; cf. Klijn *et al.*, 2004a; Figure 9) as well as because of political opposition to any further 'differentiation of standards for safety' as such.

10 Reflection and discussion

Firstly, the change in approach and policy from flood defence, via controlling the flood hazard to, most recently, understanding and managing the flood risk proper can be discerned in many countries. But the progress along this way differs a lot. *A real risk-based approach for both analysis and management is seldom explicitly applied.*

England & Wales, France and Hungary seem the furthest in a comprehensive analysis of the risk situation, but in France the implementation of management measures along the Loire is hampered by the fact that no significant flood has occurred for more than a century: the sense of urgency is lagging behind. In The Netherlands, the comprehensive analysis of flood risk is voiced for more than a decade but putting it into practice has been delayed again and again. Only recently some preliminary analyses have been made public (Ministry of Public Works and Water Management, 2005). We tend to conclude that in many countries the risk-based approach is increasingly being applied, but still in its infancy.

In this context we would also like to ask attention for the potential weakness of the linear source-pathway-receptor-consequence (SPRC) model. Application of this model may easily lead to classifying the flood as the enemy: the flood is the source, after all. Because – from a flood risk management perspective – this is undesirable, we tend to prefer the less biased web of cause-consequence-chains for our flood risk analyses, as with this the threads can be followed in various directions; leading to either a physical cause (floods), a socio-economic cause (floodplain development) or even a normative conviction (zero-risk tolerance) as being the major cause of an undesired risk situation (cf. de Groot, 1992).

Also, the actual management policies differ strongly between member states, as each applies a different portfolio of physical measures and 'non-structural' policy instruments. The differences in management approach seem partly related to differences in river type and flood regime characteristics, but there are also clear cultural differences, which are reflected in – or caused by – different institutional arrangements. These translate into biases towards either physical flood control or, in contrast, non-structural measures predominantly. This leads us to the second conclusion, viz. that *the required balance between hazard management and vulnerability management is still seldom found in practice*.

It seems that in many countries there is a tendency to first and foremost blame the flood and try to control it as much as possible, instead of questioning the land use and housing developments. This is especially the case along the large rivers in France, Italy and The Netherlands. It may be the logical and natural reaction to a threatening situation or disaster, but it does not rely on a rational risk assessment based on societal costs and benefits. On the other

[3]Developments in active floodplains and in the coastal dunes are strongly regulated.

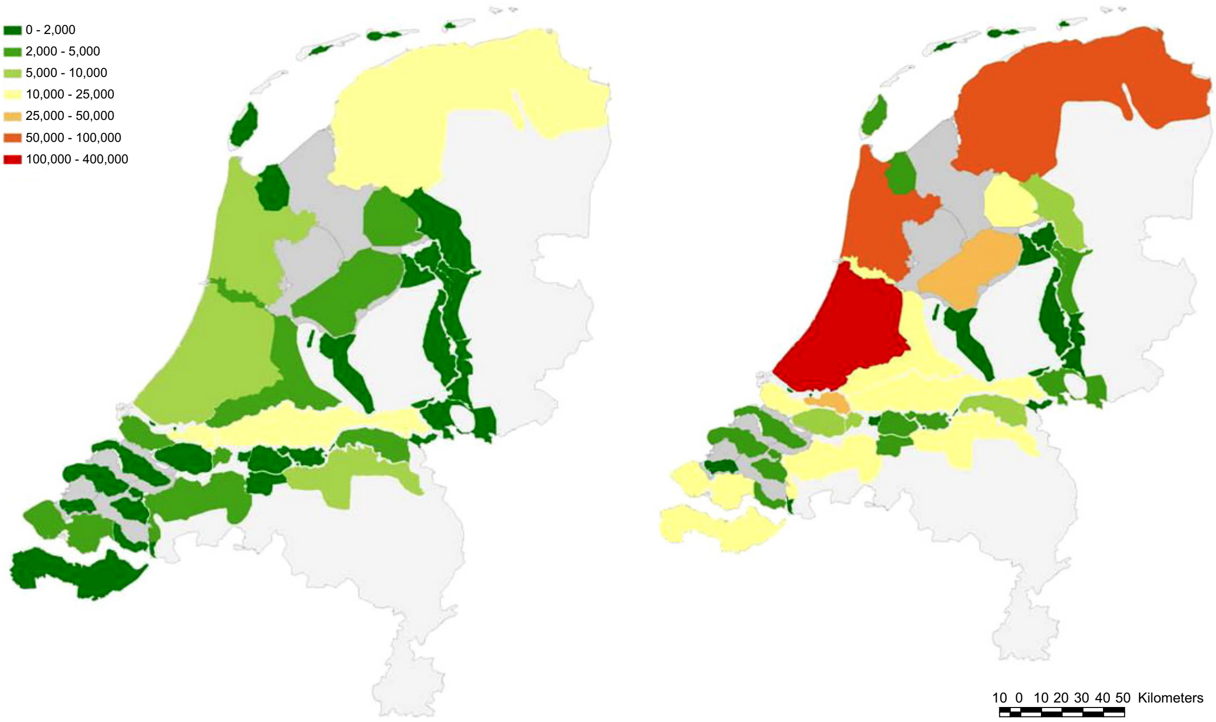

Figure 8 Expected economic damage per dike-ring (millions of Euros) in case of flooding: lower and upper estimate (data from Klijn *et al*., 2004a; published in Ten Brinke & Bannink, 2004).

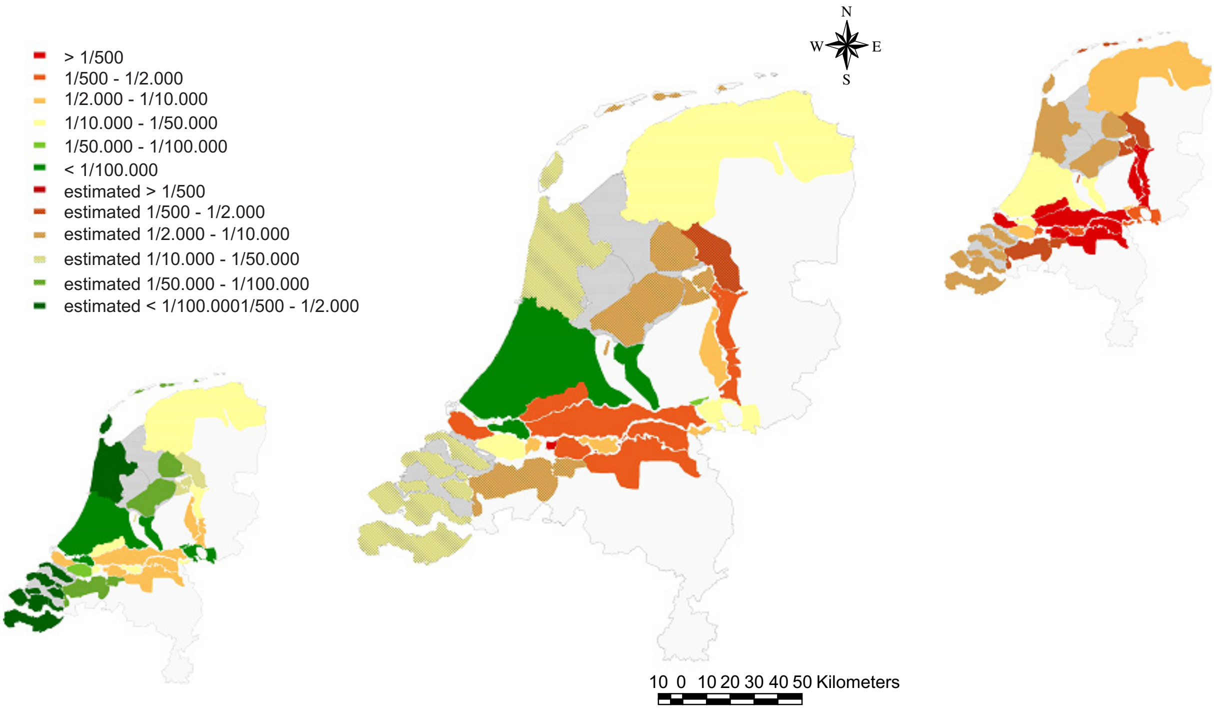

Figure 9 Actual flooding probabilities, 'best-guestimate' for some dike rings and extrapolation for the remainder, with lower (left) and upper (right) limits (data from Klijn *et al*., 2004a; published in Ten Brinke & Bannink, 2004).

hand, we cannot exclude a bias towards flood control related to who the responsible organisations are; flood risk management is – in most countries – the daily activity of engineers, who tend to look for solutions in a direction familiar to them. Changing this may need some more time.

A bias towards hazard control is thus common in various countries, certainly in The Netherlands and Italy. Interestingly, the new approach of Room for Rivers (The Netherlands; cf. van Stokkom & Witter, 2008) to our opinion still primarily classifies as flood control, although it is supplemented with policy measures aimed at preventing any new floodplain development.

A bias towards the opposite may, in spite of our earlier description, be the case in Germany, where land use planning, zoning and raising awareness among civilians are quite common. This can be understood from the fact that flood risk management in many Länder lies with the ministry for spatial planning (or alike), and not with a national (Netherlands: Rijkswaterstaat) or supra-regional (Italy: AIPO) authority dominated by hydraulic engineers. In England and Wales the financial instrument of private insurance is commonly applied, which is not the case in The Netherlands or Italy.

Cultural and historical differences may thus be an explanation for the large national differences. If we take the significance of the insurance industry in flood risk management as example: This is very strong in the individualistic and market-oriented UK; It is present, but backed-up by the national authorities in the centralistic France; and it is virtually absent in The Netherlands. In The Netherlands we can partly relate this to the history of water management being carried out by water boards, which are the oldest democratic institutions responsible for providing protection against flooding, in some cases since about 1100 AD. Where such collective responsibilities exist and burden sharing is historically arranged, there is little room for market parties such as the insurance industry. Moreover, a flood disaster in The Netherlands may be a very rare event, but it could have consequences exceeding the insurance companies' capacities.

Against the above conclusions it is no surprise that we have our doubts about the third essential of flood risk management being fully met: *a continuing cycle of assessing and implementing flood risk management measures to achieve acceptable residual risk in view of sustainable development.* Obviously, one might argue that each member state has always acted accordingly given the physical, social, cultural, organisational and financial context of the country, region or local area. But the criteria have changed over time, with changing societal objectives and standards and ever more convergence at global and/or EU level.

The adoption of sustainable development as an over-arching policy objective is quite recent and it is not yet internalised at all levels of decision making. Neither does it solve problems of costs and benefits being unequally distributed over areas, sectors, people, or generations. Thus, having made sustainability the prime guiding principle has not solved all problems, but instead poses new challenges for having to balance benefits and costs over three areas: the people (society), the planet (ecology) and the profits (economy). This must be done over intergenerational time scales, which poses additional problems of how to account for future costs (Wallis, 1996) and how to deal with uncertainty in decision making: uncertainty about the present, but even more so about future developments. These are challenges which we are merely beginning to tackle in flood risk management research (cf. Vis *et al.*, 2003; de Bruijn, 2005).

11 To conclude

Flood risk management in Europe is changing towards becoming a process of achieving acceptable levels of flood risk through a combination of: 1) appropriate governance and institutional arrangements, 2) implementation of physical and non-structural measures, and 3) maintaining and optimising the performance of these measures. The move from flood protection and defence to comprehensive flood risk management is reflected in many national policy frameworks and most evidently in the recent draft EU Directive on the assessment and management of floods. This Directive is likely to enhance the convergence of national approaches to flood risk assessment and management, whilst the European principles of subsidiarity and proportionality will allow for physiographic, demographic, economic, cultural, institutional and historical differences.

As remarked in the introduction, this change in approach has been brought about by the parallel development of the science of flood risk management and that of the flood risk management policies of the member states that were urged to respond to many flood disasters since the 1990's.

This change in approach, required by the EU Directive, is also at the heart of the FLOODsite project since its conception. It is therefore expected that the advances made within FLOODsite will support the implementation of the flood risk assessments and management plans envisaged under the Directive. FLOODsite, like the Directive, may therefore contribute to a further convergence of approaches in the EU member states. In this context it is important to notice that FLOODsite collaborates intensively with national, regional and local authorities in several countries in order to ensure that the methods developed for analysis and assessment are practicable and applicable in real problem situations, while at the same time being rooted in a common scientific background of harmonised concepts, terminology, approach and methods.

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