Dutch dikes, and risk hikes

A thematic policy evaluation of risks of flooding in the Netherlands

Extended summary

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National Institute for Public Health and the Environment (RIVM)

Bilthoven,
May 2004

The report has been prepared for the Ministry of Transport, Public Works and Water Management.

DUTCH DIKES AND RISK HIKES

A thematic policy evaluation of flood risks in the Netherlands

Dams in the Netherlands have never been stronger so the probability of encountering floods from rivers or on the coast similar to the great flood in the south-western part of the Netherlands in 1953 has declined. However, the risks of casualties and economic damage from flooding have become much greater since this event.

The controversy intimated here (decreased probability of flooding vs. increased risks of casualties and economic damage) has been largely attributed to a creeping discrepancy between the existent set of design standards for dike strength (used for dam assessment and reinforcement programmes in the Netherlands) and continuing social and economic development. These standards, set down in national law, are, to a large extent, based on insights gained in the 1953-1960 period. The present spatial distribution of economic interests attached to the “dike-ring” areas (vulnerable lands protected by a single ring dike) is no longer in proportion to the spatial variation of security standards. Besides, the public no longer seems to consider flooding in the Netherlands as a natural hazard but rather as a sort of external risk such as industrial hazards and plane crashes. The risks of casualties due to flooding in the Netherlands are much greater than the known combined external risks. Compared to other countries in Europe, and the USA and Japan, the safety levels of dams in the Netherlands are already much higher, based as they are on the high vulnerability of the population in the Netherlands, with its low-lying areas, dense population and large investments.

A further increase in flood risks is expected due to the rise in sea level, climate change, and further economic and social development. Technical solutions no longer form the sole answer to this increase. Up till now focus has been on reducing risks of dike breaches by technical means, while efficient solutions in spatial planning have been overlooked. Solutions presented here include avoidance strategies for flood-prone areas and the construction of compartment dams for splitting up large flood-prone areas into smaller ones. Political support is essential, however past experience has shown that political interest has the tendency to rapidly decline after disasters.

Dunes at Callantsoog, North Holland

1 Origin of present flood-risk policy

The 1953 flood as basis

Present policy is based on the 1953 flood disaster. In 1960 a state commission called the Delta Commission proposed safety standards for flood defences along the Dutch coast and in the estuaries. At a later stage standards for river dikes based on the work of the Delta Commission were proposed. It was only in 1996 that standards for all primary defences were anchored into law. These standards were set up for the so-called "dike-ring" areas: areas vulnerable to floods that as a whole are protected by a single dike. Present policy aims at compliance with the standards under the assumption that adherence to such standards, in conformity with Art. 21 of the Constitution, will lead to a sustainable safe and habitable Netherlands (in terms of economic interests and people to protect).

Safety standards

Three central issues were analysed by the Delta Commission:

(i) the most adverse water level that might have occurred in the night of the 1953 disaster if the contributing factors had all been present at their maximum value at the same time; this would have resulted in a sea level at Hoek van Holland of 5 m above the NAP (the Dutch standard sea level) which is well above the actual level of 1953 (3.85 m +NAP);

(ii) flood frequency data; these data showed an annual risk of 10^{-4} for this level;

(iii) costs for strengthening the defences compared with the economic loss (including loss of life and immaterial damage); this led to a cost-benefit-optimal protection level at which the annual probability of flooding the entire dike-ring area of Central Holland had to be below 8×10^{-6} .

Given the large uncertainties in the cost-benefit analysis, the Commission advised a safety standard of 10^{-4}, assuming that dikes would have extra strength even when flooded. The Commission also took into account that when flooding occurred, maximum damage would not occur. A set of differentiated standards had been agreed to on the basis of:

1) differences in the value of the areas to be protected,
2) the lower level of damage expected by freshwater floods when compared to floods on the coast,
3) nature and historical interests and
4) river floods being much more predictable.

Figure 1 depicts the geographical distribution of standards for dike strength that resulted from the analysis.

This set of standards is very useful for designing dikes, since a dike has to be strong enough to contain the water rising to this level. A security approach based on risk control requires information on the probabilities of failure of (parts of) barriers and possible damage by flooding. This knowledge was not sufficiently available in 1960.

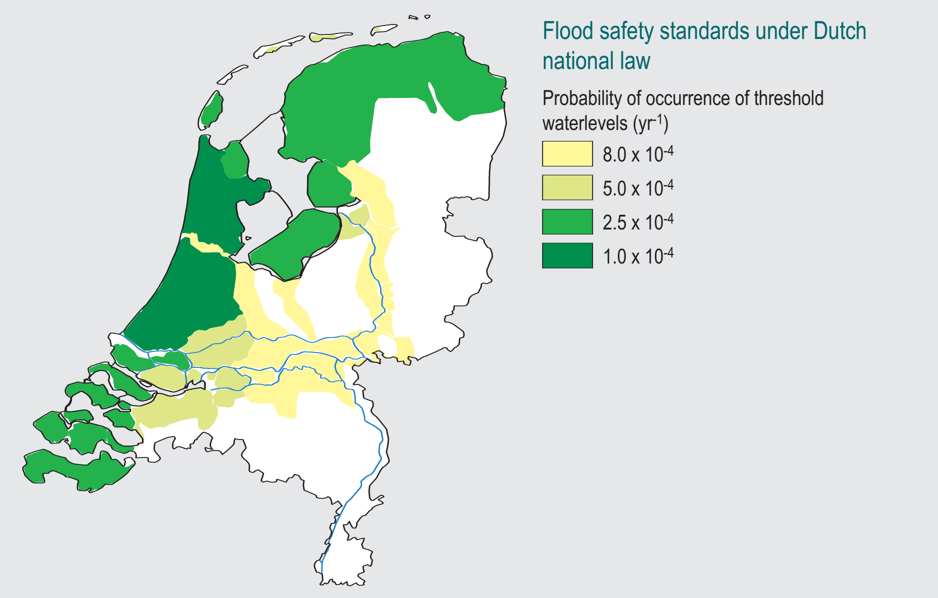

Figure 1. The Delta Commission's safety standards showing the annual risk of exceeding the normative water table.

Legal safety standards apply to primary defences around the dike-ring areas bordering outside waters (sea, rivers and large lakes). Most of the dikes protecting land from smaller regional waters have no safety standards to date.

2 Evaluation of the present policy

About 50% of primary defences in compliance with the standard

By law, primary defences have to comply with the standards, which is the case at present for about 50% of the primary defences. However, 15% certainly do not comply and 35% were found to lack the necessary information available for a proper evaluation. The deadline for compliance has been continually postponed and has now been set for after 2015.

Changing conditions make compliance difficult to realise

According to legislation incorporating these standards, which entered into force in 1996, an evaluation has to be held every five years to ascertain if the defences comply with the standards. Because of possible changes in normative conditions such as discharge of rivers, wave heights and lengths etc., evaluations have to be carried out regularly. Measures are taken on the basis of these evaluations and sometimes large projects are launched, such as the "Delta plan for large rivers" and the "Room for the river" project, to assure improvements and compliance within agreed periods. New evaluations compare the new situation against new and or revised normative conditions. That normative conditions might have become more severe in between evaluations (especially for rivers) cannot be excluded, meaning that even completion of these measures does not necessarily guarantee that the defences will comply with (new) standards.

Dynamic maintenance of the coastline successful

The coastal area policy is aimed at the realisation of agreed safety levels and dynamic maintenance of the coastline. This strategy has been chosen to guarantee security with relatively little effort. Dynamic maintenance means that not all changes in the coastline will be followed directly by sand supply or other measures but that it does allow for preserving some or all of the natural dynamics. This has proven to be a very successful and cost-effective strategy. More insight into the coastal behaviour might provide even better solutions.

Disaster response can be improved

Policy requires a system of response mechanisms in case that floods occur. An evaluation of the present situation has given cause for concern: small-scale, unrealistic training opportunities, emergency plans showing shortcomings and poor cooperation in some cases between managers of flood defences and disaster-response organisations. On a positive note, a natural and realistic near-disaster exercise in 1993 led to a much better functioning disaster-response organisation two years later.

Role of non-primary defences underestimated; supreme control lacking

Present policy clearly distinguishes between primary and non-primary defences, with emphasis on the first. National government's role as supreme controlling body – applying to non-primary defences as well – has not been transformed into targets for evaluation, even though this responsibility was stipulated in the law of 1900 (Waterstaatswet) and reconfirmed in 2001-2002. The recent necessary evacuation in Stein (province of Limburg), initiated when a non-primary dike partly slid off, showed the vulnerability of dikes as safety threats. A breach in the secondary dike at Tuindorp-Oostzaan as long ago as 1960 inspired discussions, but most of the secondary defences still lack safety standards.

Present policy targets location-specific risks, with less emphasis on economic and societal risks

Only in origin are the present Dutch standards related to economic arguments. Immaterial values (including loss of life) have originally been taken into account, at least implicitly. However, no adjustments in defences have been made to conform standards to economic developments. At the moment policy hardly focuses at all on economic risk reduction.

National policy in the field of external safety now distinguishes between location-specific (individual) risks and societal (group) risks. In 1960 this distinction in policy had not yet been made. Present water safety policy aims at maintaining equal risks of flooding in large areas (e.g. dike-ring areas). This resembles the location-specific risk concept. External safety policy also reckons with societal (group) risks: the probability that large groups of people will perish from a single event. Present water safety policy does not take societal risks directly into account.

Low location-specific risks and high societal risks in the Netherlands compared to other countries

More than half the Netherlands will be flooded if all defences along the coast, large lakes and rivers fail. There are 9 million people living in these areas, and 65% of the gross national income is earned there. In the surrounding countries flooding will only occur in a small percentage of the surface area, while in the Netherlands this can occur in 70% of the country. This explains the reason for high safety standards in the Netherlands and why these are legally binding. The consequences of flooding in the Netherlands, however, are so severe that even higher standards will be needed to achieve equal societal risks in comparison with other countries.

3 Circumstances change: standards need to be updated

Flood risks develop over time because of changing physical conditions that can overtax defences, and as a result of economic and social developments. The probabilities of topping the dikes change with changing physical conditions and, implicitly, so change location-specific and societal risks. Present policy includes adapting the standards in response to changes in physical circumstances. The probability of flooding thus remains more or less the same. Present policy does not include adaptation to changing economic values or population. Economic and societal risk can thus increase substantially over time.

A The development of physical factors

Flooding from the sea

New insights: wave load higher than previously thought without hitherto proven effects of a changing climate

The flood defences in the Netherlands have been designed to safely withstand high water tables and waves under extreme conditions. It is generally accepted that these conditions will become more extreme because of climate change, and that dikes will have to withstand ever higher water tables and wave loads.

Along the coastline waves at several locations have already been measured that are equal to or higher than the waves in the extreme scenarios used for the design of the flood defences. These recent measurements of loads heavier than previously thought possible, cannot be traced to changes over time. The 20th century has not shown changes in storm climate and effects on the water table. These should be seen then as new insights and not, yet, effects of climate change.

Normative conditions lowered despite rising sea level
Water tables along the coast have risen by 10-20 cm the past century, but normative storm tide levels (used in the design of flood defences) have lowered. Despite the relative rise in sea level, it was thought safe to lower the normative conditions in comparison with the ones set by the Delta Commission in 1960. According to present knowledge, the safety level used by the Commission appears to be higher than the agreed standards, leaving some room for adjustment; at least when average values of calculated storm-tide water tables are used. The new insights into normative storm-tide conditions, however, are accompanied by new insights into the uncertainty of these water levels – an uncertainty much higher than the Delta Commission had assumed. The increased uncertainty makes lowering the normative water tables difficult to understand, with an increase in risk of flooding to levels above the standard as a possible result.

Flooding from rivers

Risks substantially lowered by the project, "Delta plan for large rivers"
In 1993 and 1995 river dikes were shown to be substantially not as strong as previously thought. The change of overtopping was much higher than the safety standard for these dikes. Location-specific and societal risks have probably increased in the river areas, along with economic risks that have most certainly increased. The "Delta plan for large rivers" has brought about a substantial increase in the strength of the dikes, reducing the probability of floods and risks. Proposed measures in the project "Room for the river" will lead to a further decrease in probability of floods and risks.

Increase in peak discharges of the Rhine and Meuse probable because of climate change; probability of flooding and risks in the future greater than anticipated
The rivers Rhine and Meuse will quite probably have to discharge increasingly higher peak flows, mainly as a result of climate change. This development may have already started and, if so, will lead to an increase in the height of the dikes and / or the morphology of the riverbed in the course of time. The discharge capacity in the Netherlands' part of the rivers also depends on flood protection measures taken in upstream countries. The system of adapting normative circumstances to trends in physical developments in the river system will take a number of years to get the level of protection back up to standard again. The protection against floods in the intermediate period most of the time will be less than targeted. After the completion of projects to strengthen the dikes or increase the discharge capacity of the river, a new series of measures will probably be necessary to deal with new situations and predictions.

B The trends in economic circumstances: economic risks

Safety policy overtaken by economic expansion

Present policy still aims exclusively at limiting the probability of floods by applying the safety standards that were largely established more than 40 years ago (with data of more than 50 years ago). The possible economic damage has to date not played any role. A safety policy update would seem necessary. This has been pointed out several times in the past. Even the Delta Commission (1960) had been fully aware that the level of protection had to be in balance with the values to be protected.

The economic values requiring protection in the Netherlands have increased by a factor of 6 (locally even much more) the past 40 years. In the meantime the costs of strengthening the dikes has increased much less. If the level of safety in Central Holland in 1960 has indeed been considered the economic optimum, then the present level of protection of that area, and hence the rest of the low lying area of the Netherlands, is insufficient. This conclusion also holds for the rivers. The standards for river dikes have been adjusted or confirmed by several commissions, but only relatively: the starting point remained the same: the cost-benefit analysis for Central Holland (1960).

Present policy includes adaptation of dikes and discharge capacity of the rivers when climate change or other physical changes make this necessary. The estimated increase in the probability that a flood will occur in the River Rhine (about 1%) is periodically compensated. Present policy does not include adaptation of dikes based on an increa-

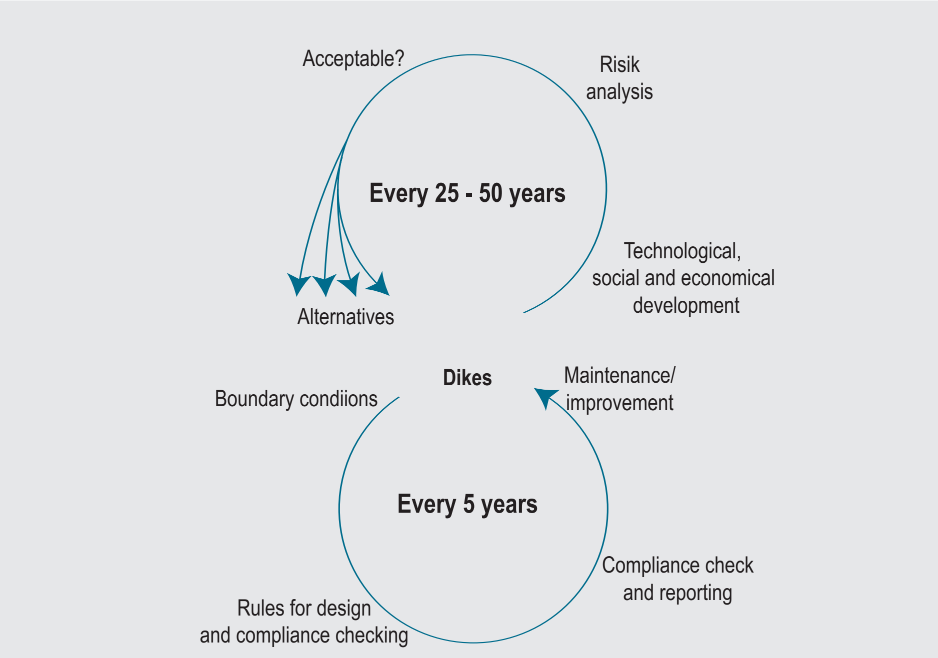

Figure 2 The five-year evaluation cycle (lower circle) completed with a periodical evaluation of the potential damage (upper circle; periodicity indicative).

se in expected damage. This increase can be assumed to be proportional to the real growth of the economy: about 2% per year. In this example, the effect of economic growth is determined as being twice as high as the increase in the risks compared to the effect of climate change. This illustrates that future policy should include a periodical evaluation of the potential damage (Figure 2).

Present safety standards no longer relate to the spatial differentiation of economic values for protection

The original distinction into four levels of safety has no longer any relation to the spatial differentiation of the values in the Dutch dike ring areas. Figure 3 (left-hand side) shows the maximum financial-economic value per kilometre of dike as being not necessarily high in the relevant dike-ring areas with a relative high standard. The right-hand side of this figure shows the total set of dike-ring areas distinguished according to the maximum damage per kilometre. The groups are fully mixed and the distinction between the four groups has disappeared. Applying spatial differentiation of safety levels according to potential economic damage can increase policy efficiency.

Safety is relatively cheap

The costs of strengthening dikes can be considered as an insurance premium for protecting the relevant interests here. Safety is shown to be relatively cheap compared to 40 years ago. Achieving safety according to the level set in 1960 in Central Holland cost the Netherlands at that time 0.5% of the total expected damage by flooding. The even higher investments for the famous Delta Plan, with annual costs of 0.5% of net national income had, at that time, been considered “by no means inadmissible”. Calculations for the area of Central Holland with the high level of investments today reveal that the strengthening of the dikes in the past, aimed at attaining the legal safety level, would now cost only 0.13% of the total possible damage. Prevention of loss of life and the protection of landscape, nature and cultural values are not included in this calculation.

Failing interaction between water policy and spatial planning increases risks

Policy for spatial planning hardly takes into account the risk of flooding. Investments have taken place without proper consideration of the risks associated with the location, with the result that many houses have been built and investments made in deep polders behind high dikes. The possible consequences have not been taken into account, leading to much higher risks. Both water policy and spatial planning have failed to acknowledge this.

Even the new Policy document on Spatial Development does not connect urban development investment schemes with increases in flood risk. This creates a contradiction with another governmental policy line in the document stating that these developments are only allowed where no costs are passed on to the national infrastructure. Increased risks can only be compensated with additional infrastructural measures such as strengthening the dikes and creating compartments within dike-ring areas.
Compartments within larger dike-ring areas can reduce the risks substantially

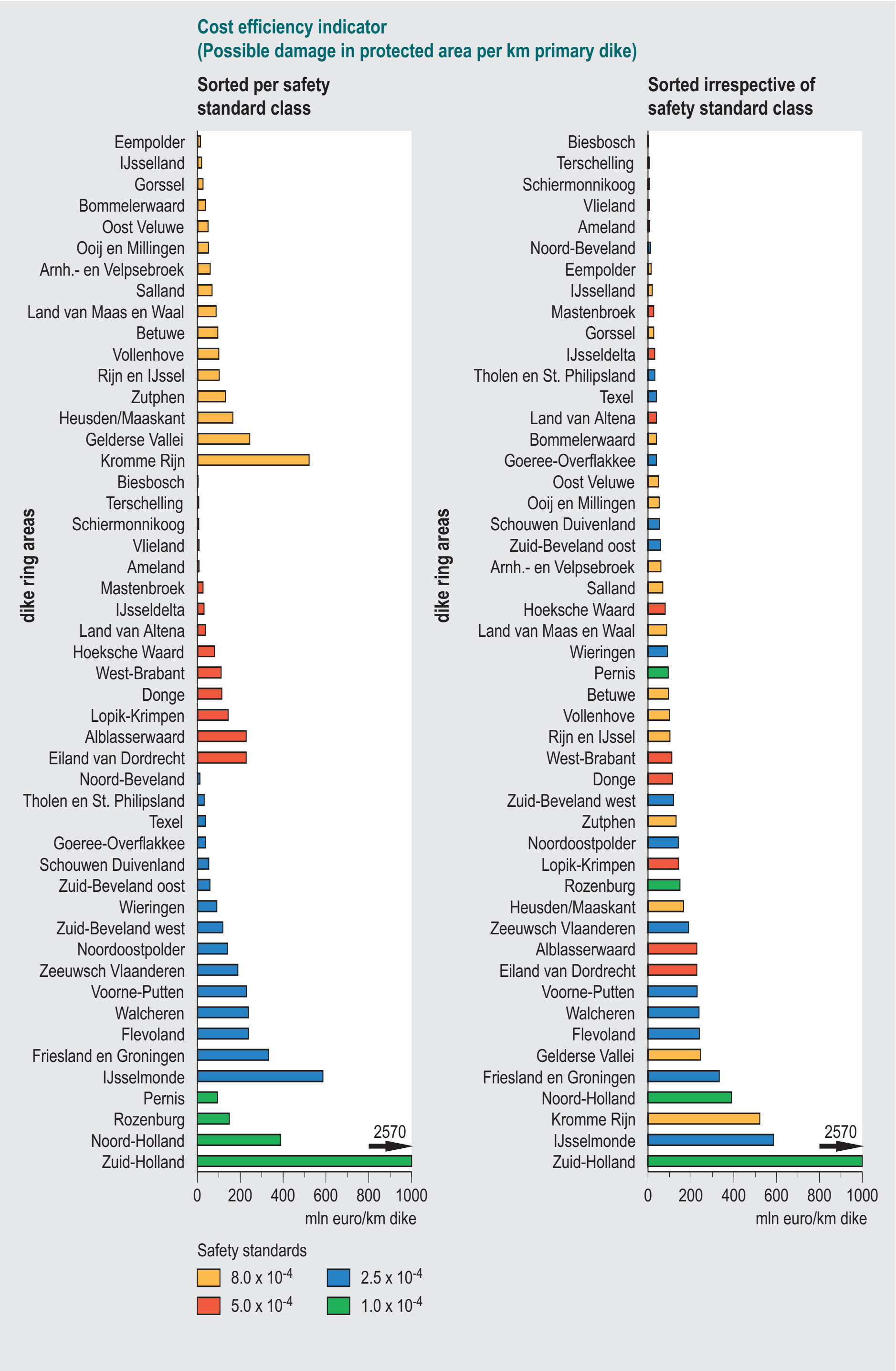

Figure 3 The maximum damage per kilometre of dike for all dike-ring areas for standard (left) and potential damage (right).

because a smaller area will be affected if the dike breaks through. In the Delta Commission reports (1960) the creation of compartments was proposed but never followed up. Receiving little attention in the past, this compartment measure is found on the interface between spatial planning and water policy.

C The development of society: societal (group) risks

Flooding not considered a natural disaster in the Netherlands

Society does not accept high risks of flooding. The way in which Water Boards and the Dutch Directorate for Public Works and Water Management ("Rijkswaterstaat") act, as well as the man-made character of the country give us the notion that prevention of floods in the Netherlands is well taken care of.

To the average citizen flooding is not a natural disaster that still can happen but with a very small chance.

In societal perception the danger of flooding has indeed moved from being considered as a natural phenomenon to an external risk (in the Dutch policy context , "external risks" are human-induced and include disasters in industrial plants, air crashes, fireworks etc.). Therefore this perception has changed in the direction of considering disasters from something that can happen to something that must not happen again. Translated into standards, societal perception assumes that risks are decreasing with increasing potential impact, but policy-making has not followed suit. If this trend continues, the consequences will be substantive. External safety domains have very low acceptable risk levels or standards, especially when it comes to societal risk (higher numbers of casualties).

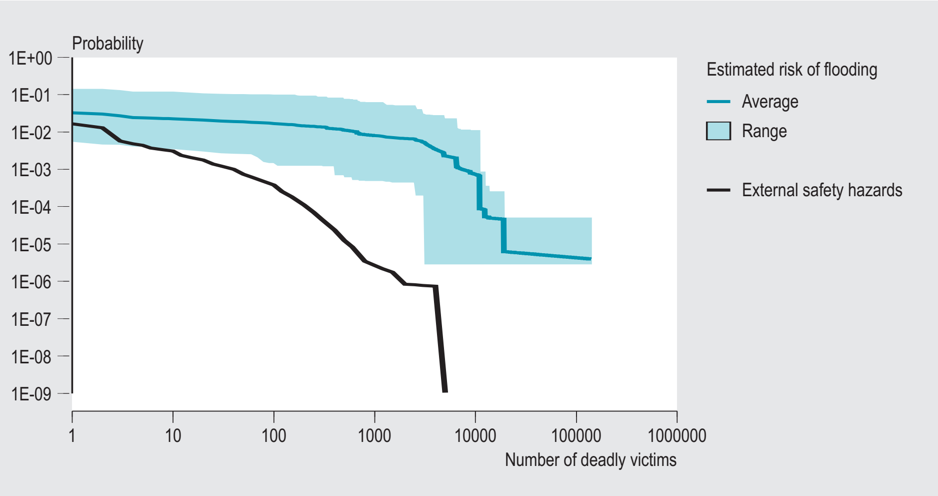

Figure 4 Societal risks of flooding in the Netherlands compared to the sum of external safety risks (on a logarithmic scale). Number of victims shown on the x-axis and the risks on the y-axis.

The expected number of casualties in the event of a flood much higher than all external safety risks put together

Figure 4 shows the societal risks for the sum of a number of external safety domains in Dutch society compared to the risks of flooding. Even when taking the high uncertainty into account, indicated as a band in the graph, flood risks are well above external safety risks. The probability of large numbers of casualties is much larger with floods than with all the external safety risks put together. Even with favourable estimates of numbers of casualties and risks (the lower boundary of the uncertainty band), the expected number of casualties by flooding is 10 times greater than all expected deaths from external safety risks (as far as accounted for in RIVM studies on this subject).

4 Concluding considerations: coping rationally with risks

Evaluation framework for flood risks comparable to external safety?

Quantifying risks is an important first step in making risks comparable. However, not all risks are the same. Some risks are taken voluntarily (mountain sports), some are inflicted upon us (the nuclear power plant just across the border) or are difficult to avoid (participating in traffic). Besides voluntariness, other aspects determining the acceptability of risks are, for example, the (un)controllability of developments when thing go wrong, the cost-benefit division of the activity (who profits and who takes the risk), the (un)familiarity with the danger and the catastrophic potency.

Methods have been developed to quantify the external safety risks and make them comparable. This is the basis for a just and efficient approach to these risks. The question now arises on whether these methods are applicable to risks associated with flooding. Answering this question is important for the comparison of flood risks with external safety risks.

Highlighted here is that people do not see flooding in the Netherlands as a natural phenomenon. Dikes change floods from frequent happenings with limited consequences into rare events with potential huge consequences. People assume that they will be protected, as affirmed in government housing projects situated right behind dikes.

In 1953 a storm tide caused more than 1800 casualties and wreaked enough havoc to send a shock right across Europe. A disaster like that, or worse, must never happen again. This and other arguments (including voluntariness, controllability and collective gain) place risks of flooding in the Netherlands close to external safety. This means that evaluation methods are plausible and handling these risks using an approach similar to that of external safety can be considered.

For accidents connected with human activities use is made of a maximum site-specific annual probability of death (individual risk) of 10^{-6}. For large-scale catastrophic events more stringent standards are used by applying the concept of societal risk. This standard is more than proportionally stricter. For accidents with higher numbers of expected casualties, every increase by a factor 10 makes the standard a factor of 100 stricter.

Equal chances or equal risks: specific standards and a common basis

For flooding a minimum site-specific probability of flood (individual risk) might be considered; this would give an equal, minimum protection to every citizen against the danger of flooding, representing a generic basis according to the principle of equality. This probability is directly connected to the probability of failure of flood defences. A policy incorporating this probability with some minor adaptations would resemble the present flood protection policy and set of standards.

When large concentrations of people have to be given extra protection, standards along the lines of societal risks can be considered. Public aversion of large catastrophes will then need to be taken into account. Custom-made safety levels related to the economic values in dike-ring areas might lead to an efficient protection against flooding. A policy dealing with societal and economic risks might lead to a spatially differentiated set of safety levels different from the present system of only four groups (as in Figure 3a). Spatial planning based on control of flood risks, creation of compartments within dike-ring areas, building “watertight” infrastructures and buildings are also instruments that fit very well into a future policy.

The project “Safety of the Netherlands Mapped” has got Dutch policy-makers onto the same track. In 2003 the State Secretary of Transport, Public Works and Water Management made a plea in her Cleveringa lecture for both a risk approach and an indicator method for comparing different societal risks. Hopefully, this policy evaluation has succeeded in showing the relevance of such a comparison .