AVEC
Integrated Assessment of Vulnerable Ecosystems under Global Change
EU Concerted Action

International Summer School
Peyresq, Alpes de Haute-Provence, France
14 – 27 September 2003

Vulnerability of the Netherlands to global change, a case study

"The Netherlands group are we
Who choose not to use GDP.
With relative vectors
For the value of sectors
We simulate Dutch sensitivity."

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This report was compiled by students during the AVEC Summer School 2003 as a case study

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1 Introduction

1.1 Study area

The Netherlands is a small country, situated in western Europe, bordering Germany, Belgium and the North Sea. Its total area is 41,500km^2, of which 7,600km^2 is water and 33,800km^2 is land. The country is located at the mouths of three major European rivers (Rhine, Meuse and Scheldt). The Netherlands have a temperate maritime climate with cool summers and mild winters. Most of the land is coastal and reclaimed land (polders), with some hills in the southeast. The lowest area is situated 7m below sea level, the highest point 322m above sea level. The coastline is 450km long and the length of its waterways 5,046km, of which 3,745km are canals.

Globally, the Netherlands rank among the most densely populated countries with 16 million inhabitants, and a population density of 371 persons per km^2. The country has an open economy depending heavily on foreign trade. Industrial activity is predominantly in food processing, chemicals, petroleum refining and electrical machinery. A highly mechanised agricultural sector employs no more than 4% of the labour force but provides large surpluses for the food-processing industry and for exports. The GDP composition by sector is 3.1% for agriculture, 25.7% for industry and 71.2% for services.

1.2 The Netherlands in the context of global change

It is to be assumed that global change will affect the Netherlands in a number of respects, for instance biodiversity loss, sea-level rise and extreme climate events. Due to a high proportion of low-lying areas, a long coastline and a large river delta with multiple channels, water issues are extremely important.. Basic water-related services include supplying drinking and irrigation water, shipping, fishery and tourism. Although its position close to major waterways has been important for trade throughout the country's history, the water does not only have positive aspects. For centuries the Dutch have been fighting against sea and river floods. Other water-related problems are salt intrusion, river drought and soil shrinkage in peat soils. Global change, especially climate change, will increase the water-related threats caused by sea-level rise, increased storminess and land-use changes.

The intensity and probability of the indicated threats depend on multiple factors. Sea flooding depends on the height and width of dunes, the height and strength of dykes, the effectiveness of structures like piers and breakwaters, the characteristics of natural ecosystems, actual sea-level rise and wave length and amplitude. River flooding depends on factors such as the height and strength of dykes, the characteristics of natural ecosystems (wetlands), the intensity of precipitation, the channelising and sealing of surfaces and international treaties on river flooding, which affect how land use can be altered to reduce the intensity and magnitude of floods. Salt intrusion depends on the sea level, since the salt water intrudes into the coastal soil. River drought is expected to occur more frequently due to more irregular precipitation under future climate predictions. Soil shrinkage, especially near the dykes, decreases their stability. It depends on factors such as water scarcity due to groundwater lowering, the amount of precipitation, irrigation and soil quality.

The Dutch Ministry of Public Works (RWS) is responsible for protecting land and people against flooding. Table 1 and Figure 1 show that distribution, risk and amount of water are managed in four different compartments that have different accepted risks for flooding). This has led to different levels of protection between compartments. The acceptable risk is defined on the basis of the probability of extreme events, expressed as the average return time (e.g. once in a thousand years). The acceptable return-time standard is determined by the size of the containments or compartments, the occurrence of large cities, infrastructure and other economically important sectors and the actual exposure to the threats. The probability of these extreme events is based on observed events over the past observation periods. Expected future climate change could well alter these probabilities through increased storm frequencies and sea-level rise and such potential changes question the validity of the traditional risk assessment by the RWS. Within each compartment are separate dyke-ring areas, in each of which flood events can be contained (shown in Figure 1). Areas that are not prone to major flooding are not considered in this study.

The RWS groups the low-lying clay areas in Groningen and Friesland, the islands, the Noord-oostpolder, Flevoland, the Wieringermeerpolder and the islands of South Holland and Zeeland) into Compartment 1. This area is protected against a once in four thousand years event. This coincides with a storm that generates a seawater level of NAP (Normal Amsterdam Level) +3 metres and a wave height of 5 metres. The region consists of 18 independent containments, most of which are not directly in contact with the North Sea. The northern areas (1-6) are relatively sheltered by the Waddensea, the polders (7, 8 and 12) by the Ijsselmeer, and 17 to 32 by the southern delta of the Scheldt, Meuse and Rhine rivers. Over the last decades this area was strongly enforced by the Delta works, which involved damming the major outlets to the North Sea and reinforcing the dykes. The major economic activity of this region is agriculture and tourism. It further contains some of the most important nature reserves and national parks of the Netherlands.

The low-lying areas in the provinces of North and South Holland with the cities of Amsterdam, Harlem, The Hague, Delft and Rotterdam are grouped into Compartment 2. This area is protected against a once in ten thousand years event. This coincides with a storm that generates a seawater level of NAP +5 metres and a wave height of 7.5 metres. The region consists of only 2 independent large containments (17 and 18), which are in direct contact with the North Sea. Large parts of this region are below sea level. The coastal defence is mainly dune area of varying width and height. Many people live in this region in several large cities; the region is of large cultural, economic and strategic importance.

The RWS groups the area around the large rivers, the Meuse, Rhine, Waal and Ijssel, into Compartment 3. These rivers are all contained by dykes but breaking dykes because of high river flows could flood large areas. The area is protected against a once in one thousand two hundred fifty years event, a risk based on river flooding. There are 20 relatively small containment areas, some of which (36, 37 and 39) were used as overflow areas in the past. Because of recent high river flows, it is currently being discussed whether to use these areas again and even establish new overflow areas. Although the national government wants to accomplish this, the local governments and other stakeholders are against it.

Figure 1. The four different compartments (risk regions) used in the Dutch vulnerability assessment

Compartment 4 is the inland delta of the large rivers and consists of 8 dyke-ring areas bordering the southern islands and the low-lying areas. There is no direct contact with the North Sea but high water levels could lead to significant salt-water intrusion. The region houses important industries and contains many large infrastructural works such as highways and rail connections. The region is protected against a once in two thousand years event. This coincides with a storm that generates a seawater level of NAP +2 metres and a wave height of 3 metres.

1.3 Aim and objectives of the case study

Vulnerability is a function of exposures (external driving forces), the sensitivity of the human-environmental system to change and adaptive capacity (potential to adapt to effects of sensitivity). The objective of this case study is to assess the vulnerability of the Netherlands to global change. The aims are to identify the different components of vulnerability in this system and to provide a planning framework for policy makers, which includes different scenarios, clarifies the system components and their interactions, and includes potential mitigation strategies.

2 Methodology

2.1 The SRES scenarios

The IPCC Third Assessment report (2001) describes four main emission scenarios, the A1, A2, B1 and B2 story-lines. For the assessment of the vulnerability of the Netherlands to global change, this study adopted two IPCC scenarios, the A1 and the B1 story-lines. The A1 scenario assumes a future of rapid, economic growth in a globalised world. The implications are that population will grow until 2050 and that existing technology will improve considerably while new technologies will be developed rapidly. The B1 scenario assumes a convergent world with the same population level as in the A1 scenario and a focus on clean and resource-efficient technologies. The emphasis is on the global solution to economic, social and environmental sustainability, including improved equity.

2.2 Identification of most important vulnerability issue

To perform a vulnerability assessment one has to define sensitivity and exposure at a certain scale and time. Water management in the Netherlands was considered one of the most critical services prone to global change. Therefore, the case study of the Netherlands concentrated on the assessment of water-related problems, which have the highest impact on the country. A brief description of how the group approached the problem can be found in Appendix A.

For the vulnerability assessment, three main pillars were established. Firstly, the study adopted the classification of compartments from the Dutch RWS. The four study regions were called clay areas (Compartment 1); low-lying areas (Compartment 2); large rivers (Compartment 3); and where all systems meet (Compartment 4). Figure 1 shows where the compartments are situated; Table 1 shows the characterisation of the compartments.

Table 1: Characterisation of the four compartments (risk regions) of the Netherlands

Clay areas (C1)	**1/4000**	12686	31%	2051965	13%	162	35233	17	3	13%
Low-lying areas (C2)	**1/10000**	5904	14%	4408335	29%	747	82855	19	14	31%
Large rivers (C3)	**1/1250**	9014	22%	3647620	24%	405	59016	16	7	22%
Where all meet (C4)	**1/2000**	2564	6%	1621340	11%	632	28351	17	11	11%
Total risk regions		**30169**	**74%**	**11729260**	**77%**	**389**	**205455**	**18**	**7**	**78%**
Other regions		10859	26%	3508140	23%	323	58579	17	5	22%
Whole Netherlands		41028		15237400		371	264034	17	6	

Secondly, in consultation with stakeholders, the study identified five major threats related to water issues. These were: 1. river drought; 2. river flooding (both related to river flows); 3. saline groundwater intrusion; 4. sea flooding (both related to sea-level rise); and 5. soil shrinkage due to the lowering of the groundwater table.

Thirdly, the study distinguished the five sectors in each compartment which it regarded as the cornerstones of socio-economic and environmental factors in the Netherlands. These are: 1. agriculture; 2. industry; 3. nature; 4. urban; and 5. strategic (airports, government buildings, important infrastructure). With this framework the study could assess exposure as an influence of the threat on both compartments and sectors, and sensitivity as a relation of sectors to compartments in respect of a threat (e.g. sea flooding).

As a first step towards establishing a frame, the study built up a matrix (matrix 1, see Table 2) with sectors in the columns and the compartments in the rows. Within each compartment, values were assigned to each sector for socio-economic importance and cultural importance in the form of "percentages of importance", which have to total 100. These represented relative values, based on the expert judgement of a range of stakeholders (see Appendix A), and did not relate directly to quantifiable data. This led to a ranking of sectors within compartments. The characteristics of each compartment, as derived from either stakeholder dialogue and/or data at hand (land use and cover, socio-economic factors, statistical data, cultural values (cultural heritages, historical buildings, nature conservation, etc.), were considered. For example, nature in the clay areas (compartment C1) had a cultural value of 50 because the Wadden Sea area of the East Frisian islands is of high recreational importance to the inhabitants. The economic value of 40 for industry in the Compartment “where all meet” was due to the high aggregation of industrial enterprises in this area.

Table 2: Raw data for matrix 1, socio-economic and cultural values for compartments, by sector. These values were assigned on the basis of expert judgement in consultation with stakeholders. For a description of the compartments see section 1.2.

Matrix 1 -Economic Importance	Sector					
Risk regions	Agriculture	Industry	Nature	Strategic	Urban	Grand Total
Clay areas	50.0	25.0	15.0	1.0	9.0	100.0
Large Rivers	40.0	25.0	10.0	5.0	20.0	100.0
Low-lying areas	15.0	30.0	5.0	20.0	30.0	100.0
Where all meet	10.0	40.0	5.0	30.0	15.0	100.0

Matrix 1 -Cultural Importance	Sector					
Risk regions	Agriculture	Industry	Nature	Strategic	Urban	Grand Total
Clay areas	25.0	5.0	50.0	0.0	20.0	100.0
Large Rivers	40.0	5.0	40.0	5.0	10.0	100.0
Low-lying areas	30.0	3.0	30.0	7.0	30.0	100.0
Where all meet	30.0	5.0	45.0	15.0	5.0	100.0

To allow comparison between compartments, the study performed, in a next step, a linear weighting based on the population of each compartment (e.g. population in C1 divided by total population as a weighting factor for each entity in the described matrix). The population of each compartment was derived from the Dutch national statistical data (CBS). With this step it achieved the relative importance of sectors and compartments and a precondition for matrix comparison. For the assessment of the degree of influence of each threat on each sector, the study drew up a matrix (matrix 2, see Table 3) defined by sectors in the column and threats in the rows and assigned values between 0 (low influence) to 5 (high influence) for each entity. This matrix can be seen as the sensitivity of the different sectors in respect of defined threats and, again, was produced in consultation with Dutch stakeholders.

Table 3: Raw data for matrix 2, sensitivity of sectors to different threats, produced in consultation with Dutch stakeholders.

Matrix 2 - Sensitivity	Sector				
Threats	Agriculture	Industry	Nature	Strategic	Urban
River drought	3	2	3	0	1
River floods	3	5	1	5	5
Salt intrusion	3	0	2	0	0
Sea-level rise	5	5	2	5	5
Soil shrinkage	3	1	4	2	0

Table 4: Identification of threats relevant to each compartment of the Netherlands

Matrix 3	Risk regions			
Threats	Clay areas	Large Rivers	Low-lying areas	Where all meet
River drought	0	1	0	1
River floods	0	1	0	1
Salt intrusion	1	0	1	1
Sea-level rise	1	0	1	1
Soil shrinkage	0	0	1	1

To obtain the socio-economic and cultural sensitivity of compartments and sectors for each threat, matrix 1 (either cultural or socio-economic) was multiplied by matrix 2. To reduce redundant information, matrix 3 (Table 4) matches compartments with relevant threats. The final matrix of scaled data (Table 5) represents the cultural and socio-economic sensitivity for each exposure. In analysing the matrix, one can make conclusions about sectoral and compartmental sensitivity in respect of socio-economic and cultural issues for each threat.

Table 5: Processed data showing socio-economic and cultural values, scaled by the population of each compartment, and by sensitivity to each threat.

Sum of economic sensitivity		Sector					
Threats	Risk regions	Agriculture	Industry	Nature	Strategic	Urban	Grand Total
River drought	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	21.0	8.7	5.2	0.0	3.5	38.5
	Low laying areas	0.0	0.0	0.0	0.0	0.0	0.0
	Where all meet	5.2	14.0	2.6	0.0	2.6	24.5
River drought Total		26.2	22.7	7.9	0.0	6.1	63.0
River floods	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	21.0	21.9	1.7	4.4	17.5	66.5
	Low laying areas	0.0	0.0	0.0	0.0	0.0	0.0
	Where all meet	5.2	35.0	0.9	26.2	13.1	80.5
River floods Total		26.2	56.9	2.6	30.6	30.6	147.0
Salt intrusion	Clay areas	26.2	0.0	5.2	0.0	0.0	31.5
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	7.9	0.0	1.7	0.0	0.0	9.6
	Where all meet	5.2	0.0	1.7	0.0	0.0	7.0
Salt intrusion Total		39.4	0.0	8.7	0.0	0.0	48.1
Sea level rise	Clay areas	43.7	21.9	5.2	0.9	7.9	79.6
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	13.1	26.2	1.7	17.5	26.2	84.8
	Where all meet	8.7	35.0	1.7	26.2	13.1	84.8
Sea level rise Total		65.6	83.1	8.7	44.6	47.2	249.3
Soil shrinkage	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	7.9	5.2	3.5	7.0	0.0	23.6
	Where all meet	5.2	7.0	3.5	10.5	0.0	26.2
Soil shrinkage Total		13.1	12.2	7.0	17.5	0.0	49.9
Grand Total		170.6	174.9	35.0	92.7	84.0	557.2

Sum of cultural sensitivity		Sector					
Threats	Risk regions	Agriculture	Industry	Nature	Strategic	Urban	Grand Total
River drought	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	21.0	1.7	21.0	0.0	1.7	45.5
	Low laying areas	0.0	0.0	0.0	0.0	0.0	0.0
	Where all meet	15.7	1.7	23.6	0.0	0.9	42.0
River drought Total		36.7	3.5	44.6	0.0	2.6	87.5
River floods	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	21.0	4.4	7.0	4.4	8.7	45.5
	Low laying areas	0.0	0.0	0.0	0.0	0.0	0.0
	Where all meet	15.7	4.4	7.9	13.1	4.4	45.5
River floods Total		36.7	8.7	14.9	17.5	13.1	91.0
Salt intrusion	Clay areas	13.1	0.0	17.5	0.0	0.0	30.6
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	15.7	0.0	10.5	0.0	0.0	26.2
	Where all meet	15.7	0.0	15.7	0.0	0.0	31.5
Salt intrusion Total		44.6	0.0	43.7	0.0	0.0	88.3
Sea level rise	Clay areas	21.9	4.4	17.5	0.0	17.5	61.2
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	26.2	2.6	10.5	6.1	26.2	71.7
	Where all meet	26.2	4.4	15.7	13.1	4.4	63.9
Sea level rise Total		74.4	11.4	43.7	19.2	48.1	196.8
Soil shrinkage	Clay areas	0.0	0.0	0.0	0.0	0.0	0.0
	Large Rivers	0.0	0.0	0.0	0.0	0.0	0.0
	Low laying areas	15.7	0.5	21.0	2.4	0.0	39.7
	Where all meet	15.7	0.9	31.5	5.2	0.0	53.4
Soil shrinkage Total		31.5	1.4	52.5	7.7	0.0	93.1
Grand Total		223.9	25.0	199.4	44.4	63.9	556.7

The totals of the rows indicate the sensitivity between compartments in respect of economic and cultural values for a certain threat. With the totals of the columns one can assess the sensitivity of sectors for a certain threat. The total sum is useful to estimate the "weight" of each threat.

This methodological concept enables us to examine the relative sensitivity of compartments and service sectors and thus to identify the weakest links in the system, where political and social efforts should be concentrated.

3 Results on exposure and sensitivity with regard to climate change

3.1 Socio-economic versus cultural sensitivity

As a policy tool, the inclusion of cultural values can be used to examine the broader impacts of a threat in addition to the more traditional socio-economic values often used in such assessments; this makes the study's approach highly flexible. Figure 2 is a result chosen to visualise parts of the resulting socio-economic and cultural sensitivity matrix. The overall sensitivity to river drought is shown for all compartments. Economic and cultural sensitivities are remarkably different. Cultural value is highest in the agricultural and nature sectors with 36 and 45 respectively. The industrial, urban and strategic sectors are the least sensitive sectors in respect of cultural value. Taking the socio-economic value into consideration, agriculture and industry are the most sensitive sectors to the threat of river drought with figures of 26 and 23 respectively. The urban and nature sectors are less sensitive and the strategic sector shows no sensitivity at all. For conciseness, the rest of this assessment will concentrate on socio-economic sensitivity and will not address cultural sensitivity.

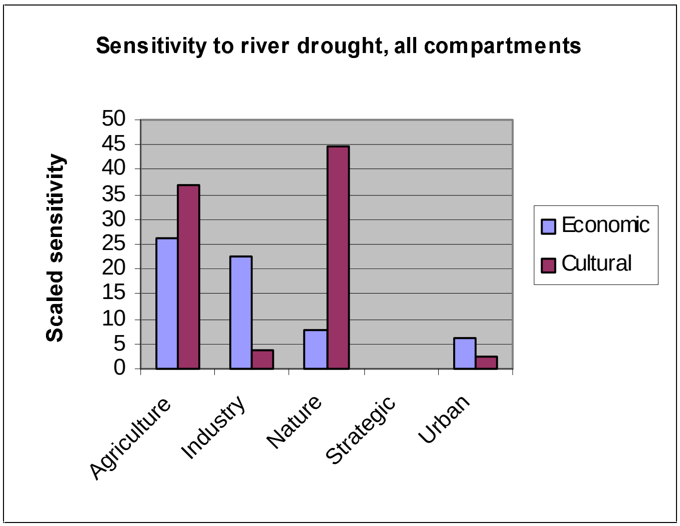

Figure 2: Results examining the threat of river drought to all compartments, comparing sensitivity values for economic and cultural matrices

3.2 Comparison across compartments

To distinguish between compartments and the influence of threats on the socio-economic sensitivity, one can analyse the map of the four compartments (Figure 3). The different compartments show different economic sensitivities for all 5 threats. Compartment 1 (the clay areas) is sensitive to salt intrusion and sea-level flood. Compartment 2 (the low-lying areas) shows highest sensitivity for sea-level flood and medium sensitivity with regard to salt intrusion and soil shrinkage. Compartment 3 (large rivers) only shows sensitivity for river floods and river drought. For Compartment 4 ("where all meet") highest sensitivities are found for the threats of river floods and sea-level flooding.

Within the compartments, the sensitivity of each sector differs depending on the relative importance of that land use (the economic scaling) and the degree of damage that would be caused by a threat (sensitivity). In Compartment 1 (the clay areas) agriculture has the highest economic sensitivity, while sensitivity of industry is the lowest of all the compartments. In Compartment 2 (the low-lying areas), industrial and urban areas have the highest sensitivity, while in Compartment 3, sensitivity is fairly equally spread between urban areas, agriculture and industry. Lastly, in Compartment 4 (where all meet), industry is high and the sensitivity of strategic land use is the highest of all the compartments. In summary, the nature and effect of the threats differ between compartments but, with the help of this information, political efforts can now be targeted at the most sensitive sectors.

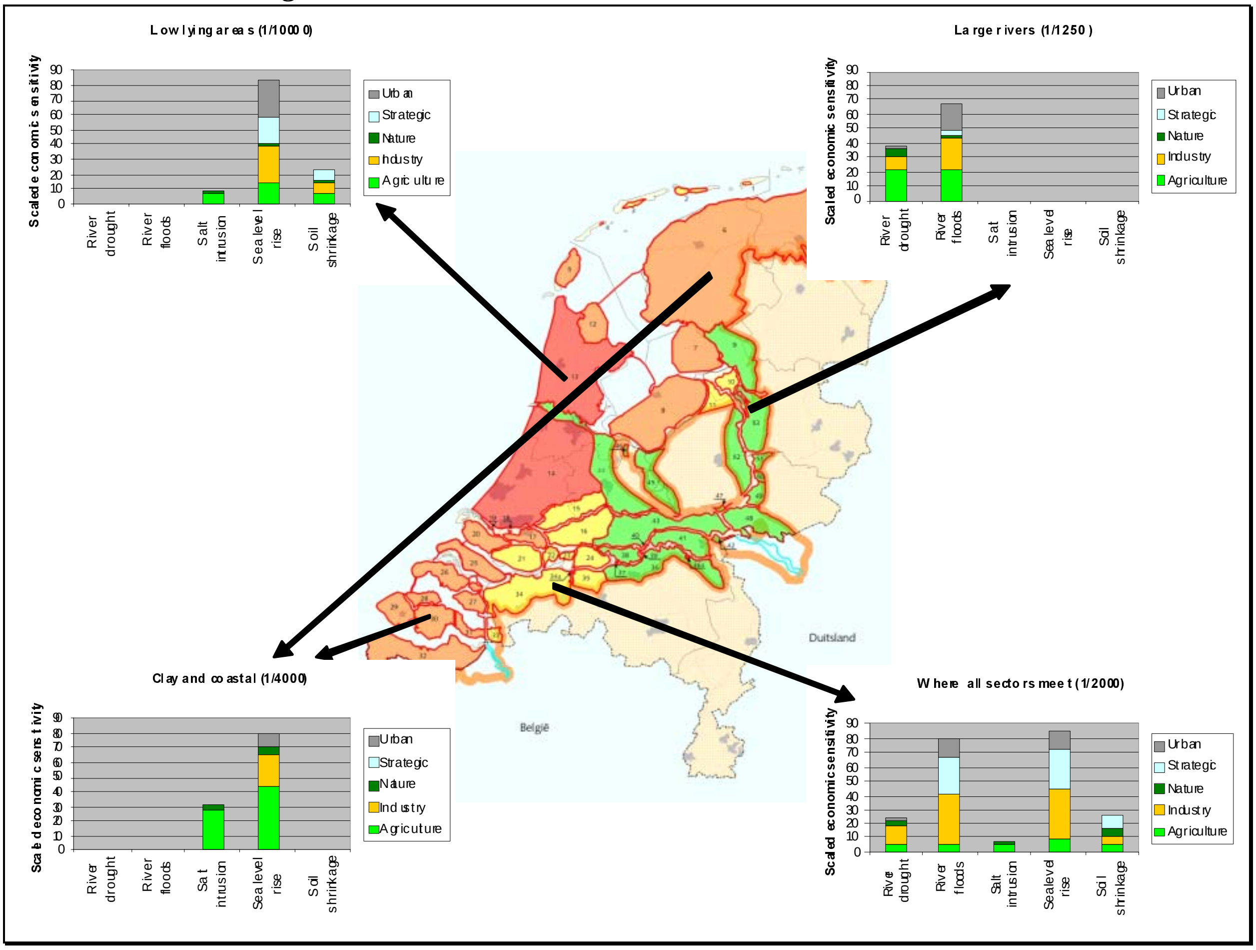

Figure 3: Sensitivity of the four different compartments in the Netherlands to climate change related threats, divided by service sector.

3.3 Focus on threats

In Figure 4 the study compares the total economic sensitivity for all compartments regarding the 5 threats. It is clear that the Netherlands shows highest sensitivity to river flood (150) and sea-level flood (250). Taking the two threats with the highest sensitivity, and using these as examples, the sensitivity of each sector to the relevant compartments is calculated (Figures 5 and 6). For river flooding, the sensitivity of industry is higher overall, but the balance between the compartments varies depending on the sector.

For sea-level flooding the sensitivity is again highest for industry, but other sectors are more evenly represented, and again the value in the different sectors varies according to the dominant land use. Sensitivity of agriculture is highest in Compartment 1 (clay areas) and sensitivity of urban land use is highest in Compartment 2 (low-lying areas). Thus, one can focus on the most damaging threats and identify how they affect each of the service sectors.

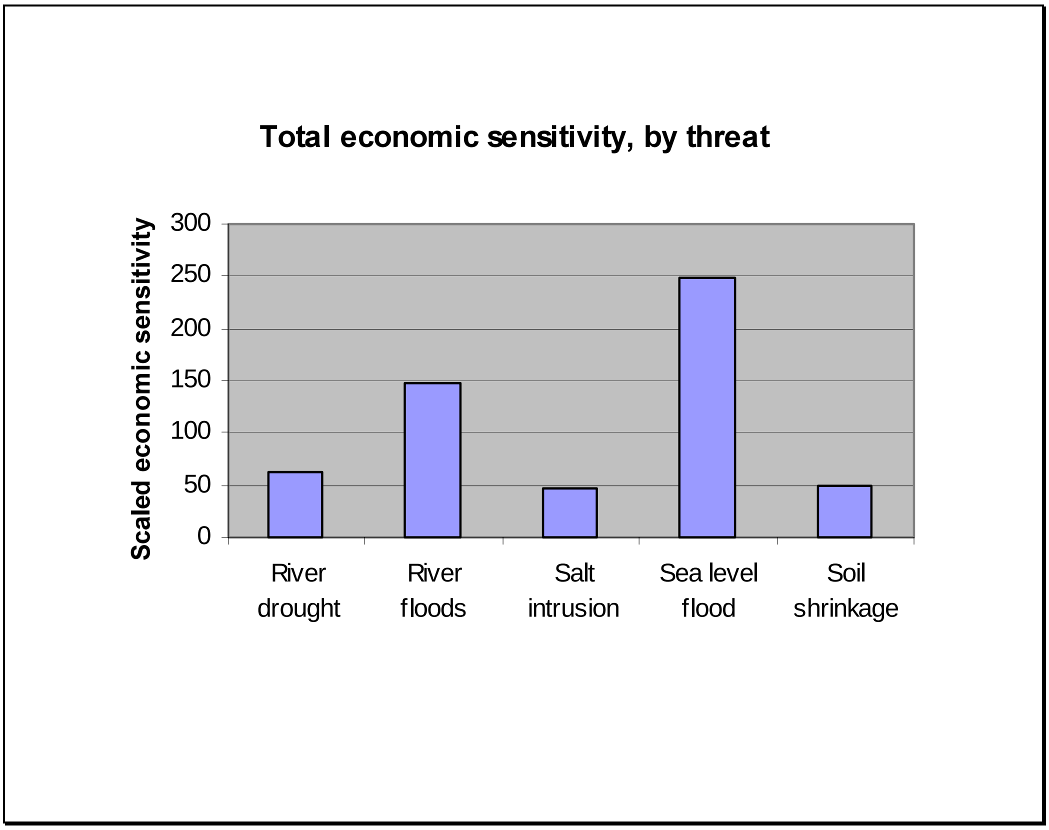

Figure 4: Overall economic sensitivity in the Netherlands towards climate-related threats. Data pooled across all compartments.

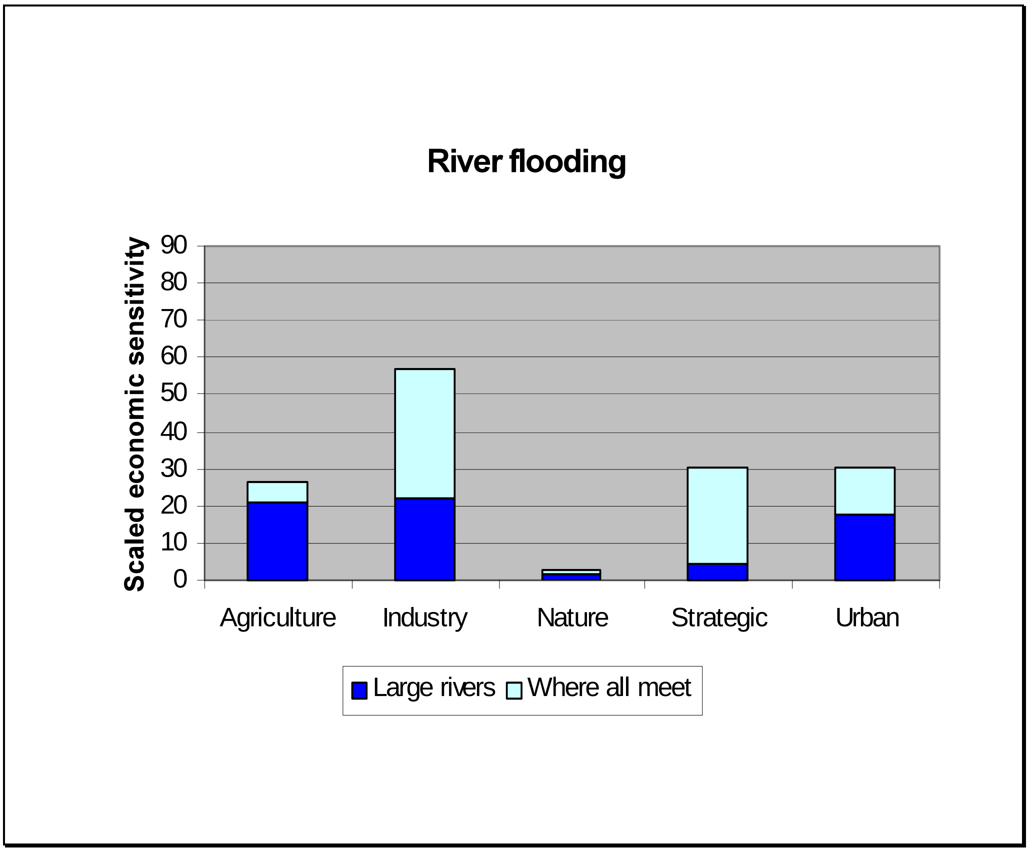

Figure 5: Sensitivity of each service sector towards the threat of river flooding. Data pooled across all compartments.

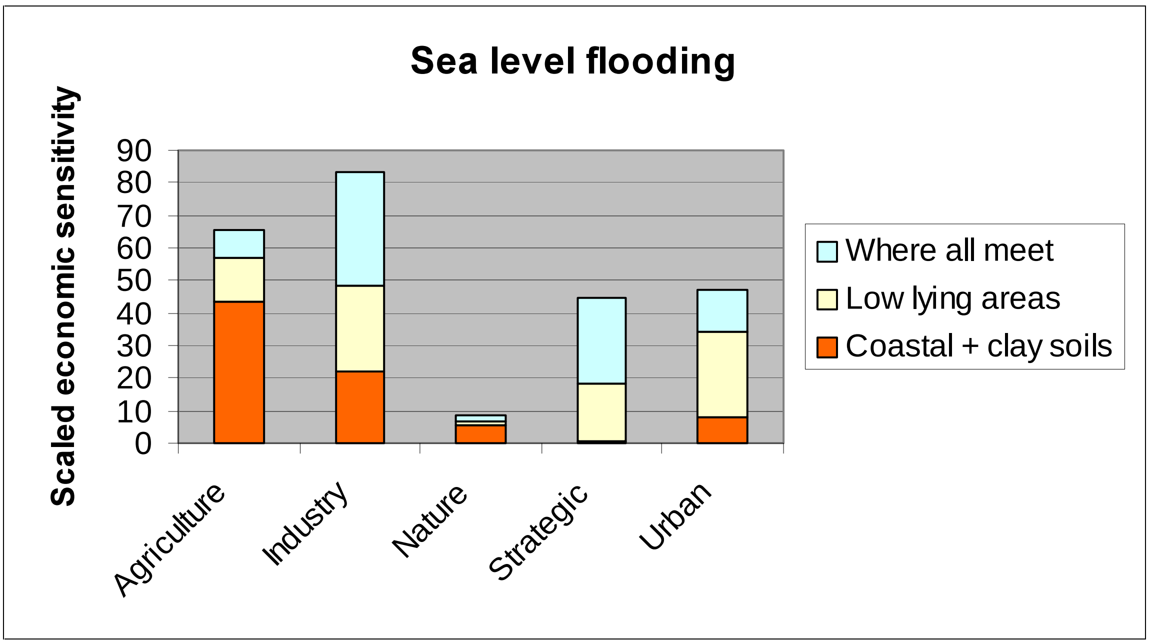

Figure 6: Sensitivity of each service sector towards the threat of sea level flooding. Data pooled across all compartments.

3.4 Incorporating risk

Lastly, by the incorporation of the likelihood of an event to happen, the study shows the scaling of sensitivity by the probability of a catastrophic flood event based on the height of the dykes, which are built to withstand events of differing return times. These are shown in Table 1. Incorporating the risk factor for sea-level flooding strongly increases the sensitivity of compartment 4 (where all meet) as this area has the lowest dykes of the areas that may be affected by this threat (Figure 7).

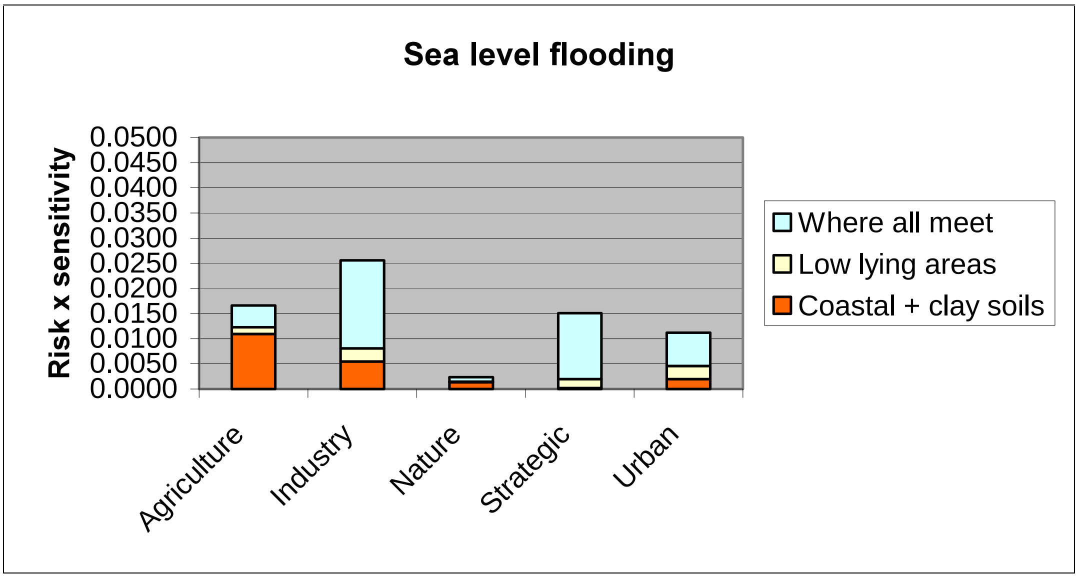

*Figure 7: Risk x sensitivity for sea-level flooding among different sectors under **current** probabilities of flooding*

3.5 Incorporating the SRES scenarios

The probability of flooding will be different under different SRES scenarios due to the varying degree of climate forcing. Under the A1 scenario, both temperature rise and sea-level rise will be greater than under the B1 scenario. Over a long time scale, this will increase both the frequency and magnitude of river and sea flooding. It should also be noted that the scenarios will alter the relative economic and cultural importance of the different sectors. However, this assessment concentrated on examining current values under future climate. For example, if an increased risk of flooding is hypothesised and one assumes the dyke heights are not increased, then the sensitivity of all compartments will increase (Figure 8, in comparison with Figure 7). This is particularly so in Compartment 4, where the dykes are not built to withstand as severe a storm event as in the other compartments.

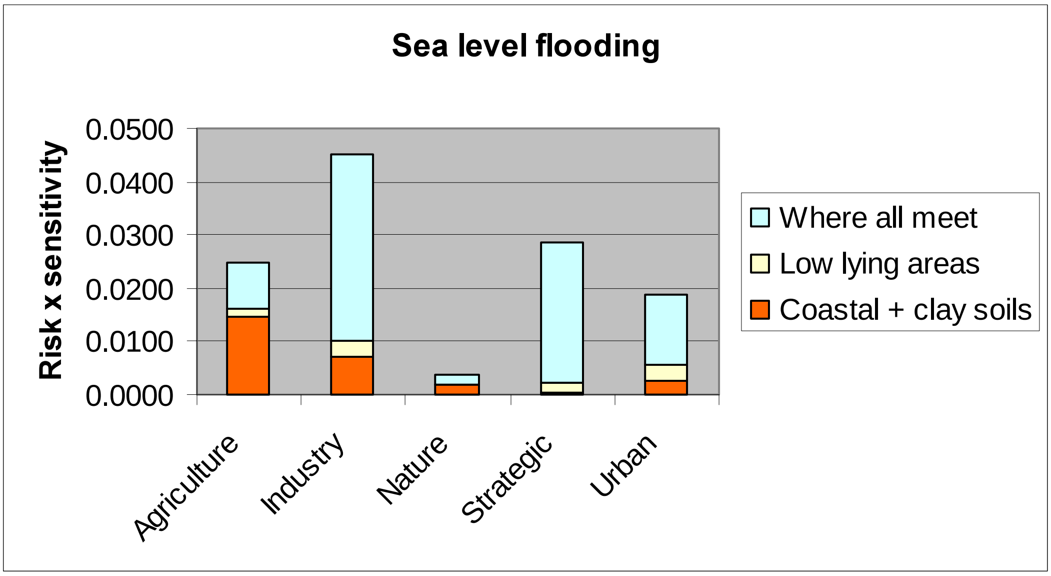

Figure 8: Risk and sensitivity of sea-level flooding among different sectors under hypothesised ***increased risk*** *in flooding*

4. Methodology and results on adaptive capacity towards climate change

In the last part of this assessment, the study examines the adaptive capacity of the Netherlands to deal with threats related to water management, using the threats of sea flooding and river flooding as examples.

4.1 Methodology on adaptive capacity towards climate change

Vulnerability is a function of integrated elements: exposure, sensitivity and adaptive capacity. The latter is a property of the human-environmental system and includes the knowledge, will and power of people to innovate. In this case study it is mostly expressed in a qualitative way. For the assessment of the vulnerability of The Netherlands, this case study follows the methodology for the assessment of adaptive capacity used by Tol et al. (2001)[1]. We adopt the seven determinants proposed in their study. The determinants are: (i) the availability of resources and their distribution across the population; (ii) the structure of critical institutions and the allocation of decision-making authority; (iii) the stock of human capital; (iv) the stock of social capital; (v) the access to risk spreading processes; (vi) the ability of decision makers to manage information; and (vii) the public's perceived attribution of the source of stress. The list of determinants is supplemented by three indicators of vulnerability. These indicators are: (a) the feasibility factor (FF), meaning how technically feasible an option is; (b) the efficiency factor (EF), assessing the efficiency of options, both concerning the different determinants; and (c) the potential contribution of any other adaptation to the coping capacity

[1] Tol, R.S.J., van der Grijp, N.M., Olsthoorn, A.A., and van der Werff, P.E., 2001, "Adapting to Climate Change: A Case Study on Riverine Flood Risks in the Netherlands", in Tol, R.S.J and Olsthoorn, A.A. (eds.), Floods, Flood Management and Climate Change in the Netherlands, Institute for Environmental Studies, Vrije Universiteit, Amsterdam, Netherlands.

of a system (PCC). The PCC can be defined as the product of its overall feasibility factor and efficiency factor according to: PCC = {EF}{FF}. The values of the indicators were derived in consultation with stakeholders (see Appendix A). The value of EF ranges from 0-1; the values of FF and PCC from 0-5.

For the case of sea flooding, we considered four options: (i) raising of dykes; (ii) acceptance of flooding; (iii) building of piers and breakwaters; (iv) coastline retreat by giving land back for water storage and the forming of wetlands. The weighting of the options for each determinant is given by numbers from 1 to 5 (1 means low; 5 means high).

The A1 and B1 SRES scenarios have very different implications for sea and river exposed areas in the Netherlands and subsequent land use. Figures 9 and 10 show the A1 and B1 SRES scenarios developed by the RIVM (2002) for different land and water use under the two story-lines. In the A1 story-line no land is assigned to water storage, while, on the other hand, in the B1 storyline almost half of the land area is required for water storage. We therefore chose these two scenarios for the assessment of the adaptive capacity of the Netherlands.

4.2 Assessing current adaptive capacity and trends for the A1 and B1 scenario

Table 6 shows current adaptive capacity with regard to sea flooding and trends for the two selected scenarios. It shows that at the current stage raising the dykes is the favoured option, while coastline retreat by giving land back for water storage and the forming of wetlands is less preferred. The other options observe intermediate values. Arrows show shifts of preference under future scenarios A1 (red) and B1 (green).

Table 6: Adaptive capacity for sea flooding in the Netherlands. Evaluation of available options by grouped determinants under two scenarios A1 (dark) and B1 (light). The arrows show the shift of preferences. See text for a detailed explanation of the terms used.

	Higher dykes	Accept flooding	Piers and breakwaters	Coastline retreat
Resources	5 ▶(red)	4 ▲(red) ▲(green)	3 ▲(red)	2 ▲(green)
Institutions	4 ▶(red) ▲(green)	5	3	1 ▲(green)
Human capital	5	2 ▼(red) ▲(green)	4	1 ▲(green)
Social capital	4 ▶(red)	3 ▲(green)	3 ▲(green)	2 ▲(green)
Risk spreading	5	1 ▲(red)	4 ▲(red)	2 ▲(red)
Info Management	4 ▶(red) ▶(green)	3 ▶(red)	4	2
Awareness	5 ▼(green)	3 ▲(green)	5	3 ▲(green)
FF	4	1	3	1 ▲(green)
EF	1.0	1.0	0.7	0.8
PCC	4.0 ▶(red)	1.0 ▲(red) ▲(green)	2.1 ▲(red)	0.8 ▲(green)

The assessment for the A1 scenario results in increased preference for the acceptance of flooding, building of piers and breakwaters and coastline retreat for water storage. The preference for raising dykes stabilises. Due to the focus on environmental issues in the B1 scenario, the assessment for this scenario shows large preference for accepted flooding and managed coastline retreat.

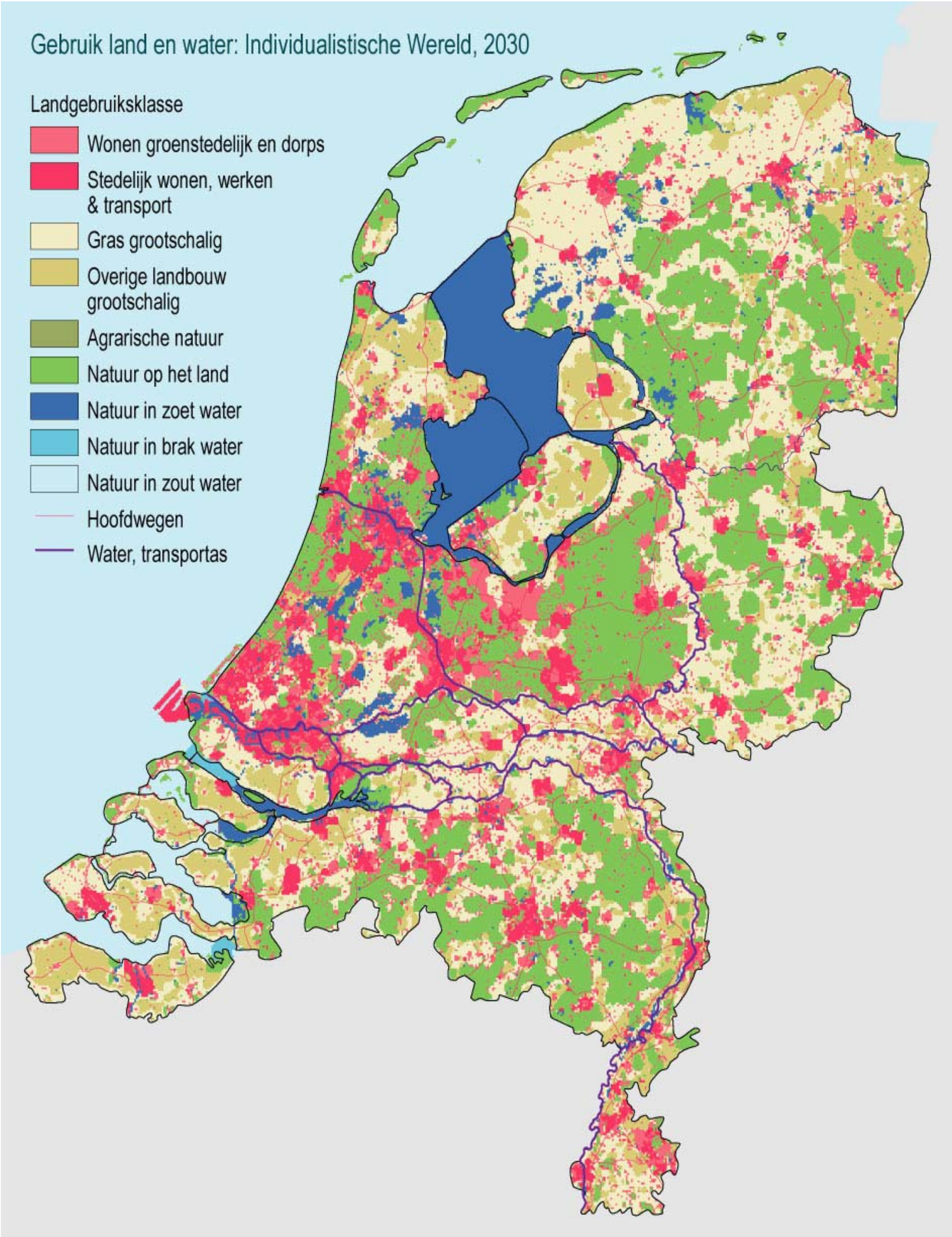

Figure 9: Land and water use in the Netherlands in 2030 for the A1 scenario (taken from the National Nature Outlook2. 2000-2030. Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2002.

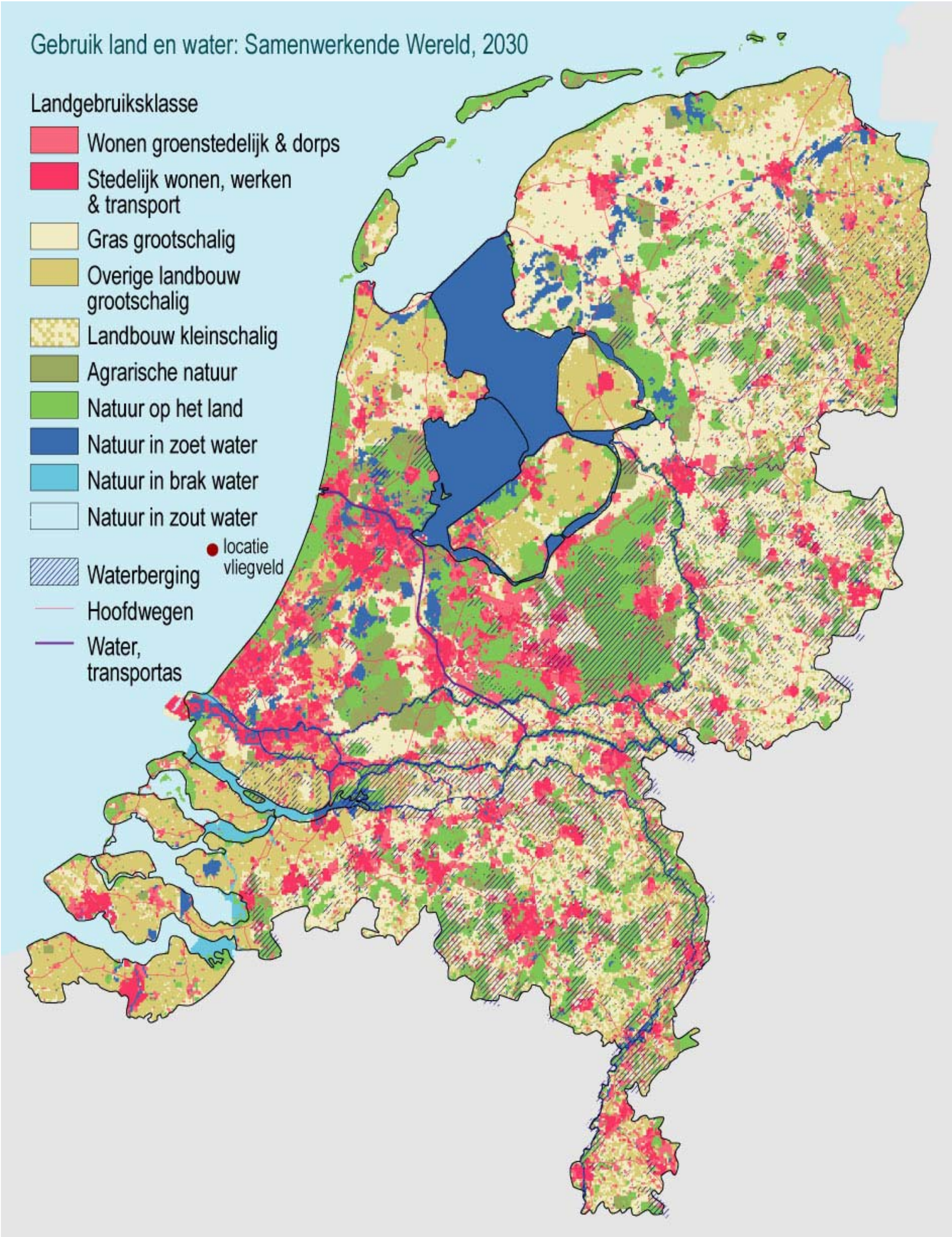

Figure 10: Land and water use in the Netherlands in 2030 for the B1 scenario (taken from the National Nature Outlook2. 2000-2030. Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2002.

5. Conclusions

The case study clearly shows that economic and cultural values differ considerably, and the value chosen may depend on the purpose of the assessment. Across the Netherlands, different compartments are sensitive to different threats. But overall, the biggest threats are river and sea level flooding. Land use differs strongly between compartments, and this is reflected in the differing sensitivity of sectors across compartments. If the likelihood of catastrophic flooding is incorporated based on the dyke heights, this strongly increases the sensitivity of certain compartments. Climate forcing will be higher under SRES scenario A1 relative to B1 and this will cause increased sensitivity to flooding in the Netherlands. The conclusion of assessing current adaptive capacity and trends for the A1 and B1 scenarios is that the Netherlands have a high adaptive capacity for all scenarios studied, but that adaptation strategies would be different under the two scenarios.

The approach presented here provides the basis for a management tool to explore the differing sensitivity of service sectors in different parts of the Netherlands. The underlying data can be modified to incorporate changes in the baseline (current) situation, or to take into account input from different stakeholders.

Appendix

How the group approached the vulnerability assessment process

According to Schröter et al. (2003, submitted) the assessment process can be considered as a sequence of eight steps, in which both stakeholders and scientists are involved in defining the components of vulnerability. In this case study genuine stakeholder involvement was not possible, so we decided to focus on water management in the Netherlands and on this basis we defined the principal stakeholders affected. Within a stakeholder role-play (prime minister, local citizen, ecologist, water manager, spatial planner, transport representative, tourist manager) we then discussed the sectors involved and their sensitivity. A first decision was made on focusing on the Netherlands as a whole region and on coastal and inland water management as a vulnerable sector. Defining the vulnerability factors of exposure, sensitivity and adaptive capacity we felt to be too abstract on the national scale, so we had to restrict the definitions to a smaller region or even local system. As a simplified model we then considered a very local human environmental system close to the dykes with water input and output. Elaborating on this we decided to take the four risk compartments as a planning basis and thus started the vulnerability assessment and developed our scenarios. In conclusion, the eight-step approach was roughly followed – however, not exactly step by step. We used an iterative approach in the vulnerability assessment.