# Integrated water management strategies for the Rhine and Meuse basins in a changing environment

## Final report of the NRP project 958273

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NRP project 958273
IRMA-SPONGE project 3/NL/1/164 / 99 15 183 0

NCR Netherlands Centre for River Studies

IRMA

Contribution to the CHR

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# Preface

The present study has been carried out within the framework of the Dutch National Research Programme on Global Air Pollution and Climate Change (NRP) - phase 2, 2nd tranche. The project forms a continuation of a previous NRP project on the implications of climate change for the Rhine basin and water management in the Netherlands (NRP project 952210). The project was carried out in the period August 1999 - June 2001. This report also contributes to the IRMA-SPONGE project nr. 3/NL/1/164 / 99 15 183 0.

Institutes that collaborated in the project:
Faculty of Geographical Sciences - Utrecht University
Institute of Inland Water management and Wastewater Treatment - RIZA
WL|delft hydraulics
International Centre for Integrative Studies – ICIS – Maastricht University
Carthago Consultancy
Royal Dutch Meteorological Institute - KNMI

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CHR is acknowledged for their co-operation in previous studies on the Rhine basin, which formed the basis of the present study, and for providing various types of data from the Rhine basin enabling the development of the RHINEFLOW-2 model.

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## Contents

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# Summary

Key issues for water management in the Netherlands include the integration of the water system's functions for ecology and society, their sustainable development, a river basin approach, and increasing the natural 'resilience' of the water systems. These should lead to the achievement of well-managed water systems in a complex environment in which the future is surrounded by large uncertainties. Climate change and the hydrologic response are major causes of uncertainty, as they may affect water availability. Uncertainties also depend on various unknown socio-economic and agro-economic developments (such as population growth, industrial expansion, land use changes, and use of different crop types), that will affect water demand. These factors together determine possible futures that are envisaged, and can be coloured according to different perspectives ('world views') people may have. Depending on the perspectives of the future, different water management strategies may be adopted. The question that rises is then: which is, given the uncertain future, the best water management strategy?

The objective of this project was to provide an integrated framework for decision making in water management in the Rhine and Meuse basins under increased uncertainty due to climate change. Existing socio-economic, demographic, land use and climate change scenarios as well as existing water management strategies have been structured using the Perspectives method. Using these results in combination with the results of a stakeholder workshop a set of consistent integrated scenarios has been developed. These represent future changes in demand and supply for the Rhine and the Meuse, as well as the according water management policies. The scenarios make up a matrix with combinations of management styles and world views, both where these match (utopias) and mismatch (dystopia). Using a suite of existing models, the hydrological and socio-economic consequences for the water systems in the Netherlands were assessed for each management styles against each scenario. Based on the model results in the utopia-dystopia matrix, and an interactive evaluation of the implications of each management style with stakeholders, the explored management strategies were analysed. From the results, recommendations were made concerning the robustness of present-day water management, and on options for adaptation of the management style with regard to uncertain future conditions.

## Samenvatting

Sleutelbegrippen in het huidige Nederlands waterbeleid zijn de integratie van water-gerelateerde funcies, duurzaam waterbeheer, de stroomgebiedsbenadering en het vergroten van de natuurlijke veerkracht van de watersystemsn. Dit dient te leiden tot een uitgebalanceerd en geintegreerd waterbeheer, dat in staat is om te gaan met onzekerheden voor de toekomst. Klimaatverandering is een van de belangrijke oorzaken van deze onzekerheden voor het waterbeheer, omdat dit van grote invloed is op het wateraanbod. Onzekerheden zijn echter ook gerelateerd aan een grote verscheidenheid aan mogelijke sociaal- en landbouw-economische veranderingen (zoals bevolkingsgroei, industriele ontwikkeling, landgebruiksveranderingen, gewaskeuze), die met name betrekking hebben op de toekomstige water behoefte. Samen bepalen deze factoren de mogelijke toekomsten de we tegemoet kunnen zien. Deze zijn gekleurd al naar gelang het perspectief ('wereldbeeld') dat mensen van de wereld hebben. Afhankelijk van het perspectief dat men heeft, zal men een verschillende strategie willen kiezen in het waterbeheer, om zo goed mogelijk op de toekomst voorbereid te zijn. De vraag die dan rijst is: wat is, gegeven de onzekerheden omtrent de toekomst, de beste strategie in het waterbeheer?

Het doel van dit project was om een geïntegreerde onderbouwing te verschaffen voor beleidskeuzes in het waterbeheer voor de Rijn en de Maas, gegeven de onzekerheden voor de toekomst, met name als gevolg van klimaatverandering. Reeds bestaande scenario's voor veranderingen in klimaat, landgebruik, en socio-economische ontwikkelingen, evenals voor strategieën in waterbeheer zijn geanalyseerd en gestructureerd op grond van de Perspectieven methode. Tesamen met de resultaten van een stakeholder workshop zijn hieruit integrale scenario's opgesteld, die toekomstige veranderingen in water aanbod en watervraag voor de Rijn en de Maas beschrijven, evenals hiermee samenhangende strategieën voor waterbeheer. De scenario's zijn weergegeven in de vorm van een matrix, die de combinaties van waterbeheersstrategieën en wereldbeelden van mogelijke toekomsten omvat. Hierbij bevinden zich zowel combinaties waarbij de waterbeheersstrategieën in overeenstemming zijn met de toekomstige situatie ('utopia's') als waar dit juist niet het geval is ('dystopia's'). Met behulp van een keten van bestaande modellen zijn de hydrologische effecten van deze combinaties, evenals de gevolgen voor de verschillende water-gerelateerde sectoren in Nederland geanalyseerd. Op grond van de resultaten in de utopia/dystopia matrix, en een interactieve evaluatie met stakeholders zijn de verschillende strategieën onderling vergeleken. Hieruit zijn aanbevelingen opgesteld omtrent de robuustheid van het huidige waterbeheer, en zijn mogelijke opties voor aanpassingen in de wijze van beheer bediscussieërd met het oog op de onzekerheden voor de toekomst.

# 1 Introduction

Rivers and inland water systems fulfil important functions for the Netherlands' economy, society and environment. This may seem a cliché, but as put forward in the Fourth National Policy Document on Water Management in 1997, it is a true and actual issue for the Netherlands. Following this document, we distinguish Safety, Navigation, Ecology and Fresh water supply. The rivers Rhine and Meuse primary function is to discharge water sediment and ice, without the risk for the hinterlands to be flooded. Secondly, the rivers and their floodplains are areas of high ecological potential. They constitute elongated zones that reach beyond national boundaries, and form the backbones of the Netherlands Ecological Network. The rivers are major waterways between the port of Rotterdam and the hinterland. River water is needed to prevent salt intrusion on the lower river delta, to flush the polders, for agriculture for industrial use and for the production of drinking water. The rivers Rhine and Meuse form an important boundary condition for the regional freshwater system within the Netherlands. Key issues for water management in the Netherlands include the integration of the water system's functions for ecology and society, their sustainable development, a river basin approach, and increasing the natural 'resilience' of the water systems in view of uncertainties in future. Various water management measures for flood prevention, drought reduction and increase in ecological potential have been initiated in recent years.

Under the present day conditions discrepancies exist between water supply and demand. For example, during dry periods the water level in the river channels becomes low so that ships can take less cargo; during high flow periods water levels in lake IJssel often exceed the target level, meaning that drainage of the surrounding polders is hampered. In future, this water balance is obviously controlled by changes in both water supply and demand. International socio-economic developments will affect in the first place the water demand. It can be envisaged that the demand will increase because of economic development in Western Europe and changes in physical environment, demography, lifestyle, agriculture, and so forth. Agriculture needs water of better quality and 'just in time management' means that inland shipping transport becomes more and more sensitive to fluctuating river water levels. The supply side will also be affected by international developments on a global scale. Previous studies (Kwadijk, 1993; Parmet et al., 1994; Grabs et al., 1997; Middelkoop, 2000, Middelkoop et al., 2001) have demonstrated that climate change may have considerable impact on water availability in the Rhine and Meuse basins. Measures taken in the upstream area of both basins have impact on the amount of discharge downstream during low flow periods as well as on the water levels during extreme floods (IKSR, 1995; 1997).

Although it is clear that demand and supply will change, these developments are surrounded with considerable uncertainties. These uncertainties originate from different sources and result from a number of unknown or partly known social, economic and environmental processes at different scale levels. In spite of these uncertainties policy makers have to formulate effective and robust strategies for future water management. Scenarios can be helpful tools in developing, analysing and evaluating future strategies. However, many different scenarios already exist in the above fields of economy, demography, lifestyle, agriculture, physical environment and climate change. All these scenarios differ in terms of underlying assumptions and perspectives. For integrated assessment studies in the Rhine and Meuse basins, therefore, methods are required to structure and interrelate various categories of future developments into integrated and consistent sets of scenarios.

### 1.1 Previous climate-impact studies in the Rhine basin and the Netherlands

Over the past decade several studies have been carried out that focused on climate change impacts on the Rhine basin. In the early eighties, a comprehensive study was undertaken in the Netherlands to assess the Impacts of Sea Level Rise on Society (ISOS) (Rijkswaterstaat, 1988). This study showed that the implications for the lower River Rhine branches and the large fresh water lake IJsselmeer are considerable, especially with respect to safety. However, the scenario changes for peak flows of the Rhine were not based on hydrological models, and alternative safety measures for dike rising methods were hardly considered. Research carried out in the framework of the International Commission for the Hydrology of the Rhine Basin (CHR) (Kwadijk, 1993; Parmet, 1995; Grabs et al., 1997, Middelkoop et al., 2001) has shown that due to higher temperatures the river Rhine is expected to change from a combined rain-fed/snow-fed river towards a rain-fed river. Consequently, winter discharge will increase, with possible consequences for safety. The frequency and duration of low flows during summer increases, which together with higher temperatures will affect the river and floodplain ecosystems. Low flows will reduce water availability for economic functions such as inland navigation, agriculture, cooling water, public water supply and recreation. Furthermore, salt-water intrusion in the lower delta may increase, which affects agriculture.

Within the framework of NRP-II, theme 2, the sensitivity of the Rhine basin to climate change and global change has been studied extensively by the Utrecht University and RIZA. The NRP-II studies described the impacts on the functions and the consequences for water management. Similar studies are presently undertaken for the Meuse basin (MEUSEFLOW project of RIZA, 1997-1998). In NRP I these studies focused on the response of the individual physical sub systems such as sediment transport, erosion and water supply to global change. The NRP-II project addressed the response of the whole physical system in the Rhine basin by linking different sub-systems. In NRP-II we also incorporated the requirements of some of the river-related functions (Middelkoop, 2000). These previous studies enabled the identification of the vulnerability of major water system's functions to climate change. They pointed to bottlenecks and priorities for water management under various climate change scenarios, and to some extent paid attention to mitigation and adaptation strategies.

Outside the Rhine and Meuse basins, by far most studies that consider water and climate focus only on changes in water supply. Only few studies take changes in water demand into account. Studies that are most related to the project proposed here are The Great Lakes - St Lawrence project (Mortsch, 1998), the WaterGap (Döll, et al., 1998), and the AQUA study (Hoekstra, 1998). The Great Lakes – St Lawrence project evaluated existing plans for future water management in the Great Lake region under a changing climate regime. WaterGap focuses on annual water availability in different river basins in the world, where water supply is climate driven, while demand is mainly a function of population growth. Within the AQUA study (as part of the TARGETS project) the perspectives methodology was applied to future water resources management on a global level and on the Zambezi river basin (Hoekstra, 1998). A large study to future water resources in the EC estimated the response of the hydrological system under various climate change scenarios, using different models (Arnell, 1998).

The previous NRP Rhine basin studies did not address climate change against a background of socio-economic developments, nor evaluated possible strategies for future water management in an integrated way. Also the study to the water resources in the EC did not focus on different ways of managing water resources. The application of AQUA on a catchment scale is limited to the Zambesi river basin, while the model has not been applied for an intensively measured and managed river system as the Rhine basin. The advantage of such an application is that all tools and data exist to simulate changes in water supply, and that existing plans and strategies for adaptation to changes can be included in the evaluation. The WaterGap study surveyed water availability and demand on a global scale, not including seasonal differences in demand and supply, demands from different sectors and adaptation strategies. Most close to our proposed project is the study of Mortsch (1998). They however did not analyse future developments from different management styles' point of view; neither did they take into account risks belonging to different management styles.

### 1.2 Problem definition

Key issues for water management in the Netherlands include the integration of the water system's functions for ecology and society, their sustainable development, a river basin approach, and increasing the natural 'resilience' of the water systems. These should lead to the achievement of well-managed water systems in a complex environment in which the future is surrounded by large uncertainties. Climate change and the hydrologic response are major causes of this uncertainty, as they may affect water *availability*. The uncertainties also depend on various unknown socio-economic and agro-economic developments (such as population growth, industrial expansion, land use changes, and use of different crop types), that will affect water *demand*. These factors together determine possible futures that are envisaged, and can be coloured according to different perspectives people may have. Depending on the perspectives of the future, different water management strategies may be adopted. *The question that rises is then: which is, given the uncertain future, the best water management strategy?*

### 1.3 Objectives

The aim of the project is to provide an integrated framework for decision making in inland water management in the Rhine and Meuse basins under uncertainty. For this purpose the following objectives are formulated:
1. Identification of consistent integrated scenarios of socio-economic and environmental changes in the Rhine and Meuse basins, and associated water management policy strategies,
2. Analysis of the hydrological changes that may result from different scenarios and management strategies and the consequences for the user functions of the water systems,
3. Assessment of the robustness of different strategies under different possible futures.
Since there is no ready-made approach available to achieve this, the project not only addresses issues concerning content: the project is also clearly a methodological exercise.

### 1.4 Rhine and Meuse basins - hydrological setting

The drainage basin of the river Rhine covers about 185.000 km² and stretches from the Swiss Alps to the river mouth in the North Sea (Figure 1.1). Two thirds of the basin are located in the Federal Republic of Germany. The Alpine countries, Switzerland, Austria, and Lichtenstein, form 20% op the total area. Other areas that are part of the drainage basin are France, Luxembourg, Belgium and the Netherlands. At Basel, where the River Rhine leaves Switzerland, the river has a typical snow melt driven regime, with high discharges in summer and relatively low flows during the winter period. The hydrological response of the Alpine basin section is largely determined by the existing lakes that damp the flash floods from the mountains. Flowing to the North the regime becomes more and more dominated by the annual course of precipitation and evapotranspiration (Figure 1.2). Under the current conditions the River Rhine at the German-Dutch border has a combined rainfall-snow melt driven river regime. This means that discharge is relatively equally distributed over the year. The winter season shows the largest discharges originating from precipitation in the German and French parts of the basin. Summer discharge originates mainly from melting snow in the Swiss Alps when evaporation surpasses precipitation in the lower regions.

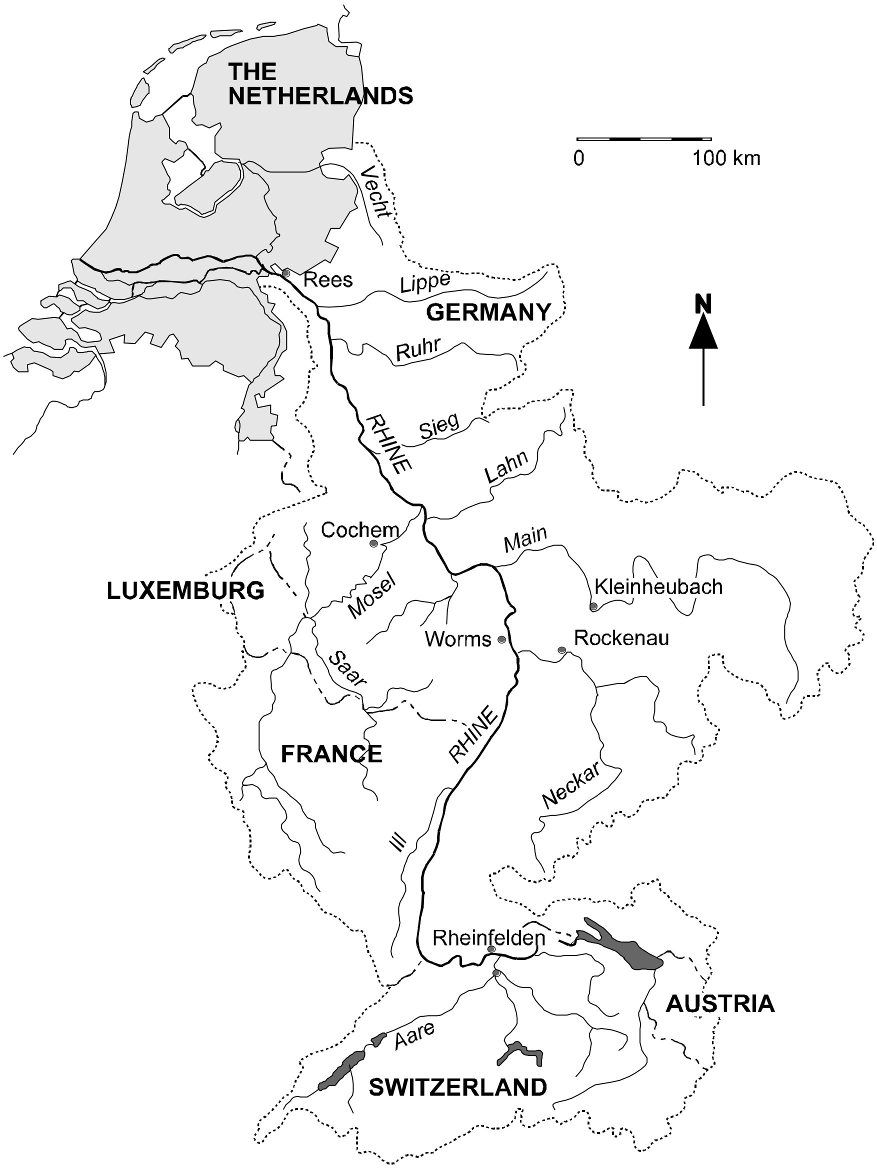


Figure 1.1 The Rhine basin

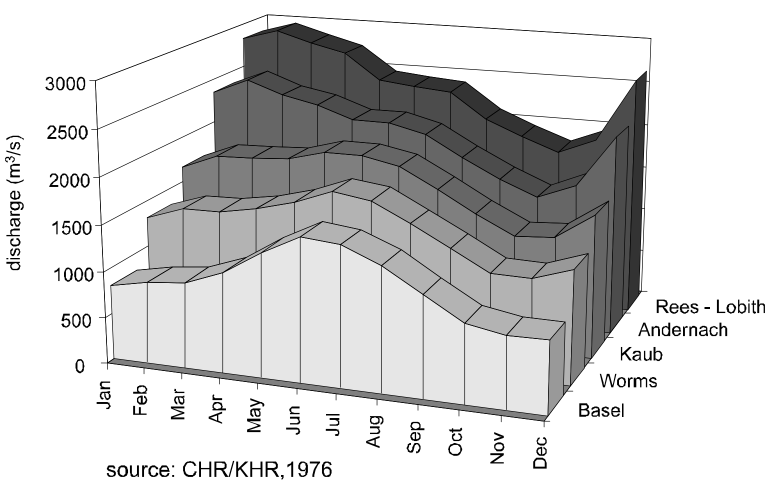


Figure 1.2 Hydrographs for different gauging stations along the Rhine

The basin of the River Meuse covers an area of approximately 33,000 km² (Figure 1.3). The Meuse is entirely rain-fed, usually showing high discharges in winter and very low discharges in the summer period (Figure 1.4). Although the character of the river is entirely rain-fed, there are differences in river behaviour within the basin. These differences are mainly due to spatial differences in the amount of precipitation, geomorphology and geology of the sub-surface. The upper part of the basin, located in France is long and narrow, with small gradients. The valley sides are gentle. The river flows through alluvial deposits underlain by calcareous rocks. In its central section the river Meuse has cut its way through the Ardennes in Belgium. Gradients here are steeper than in the upper section. The valley sides are steep upward, leading to an undulating landscape. Due to the steeper gradients, flow velocities are high resulting in small travel times in both the main river and the tributaries.

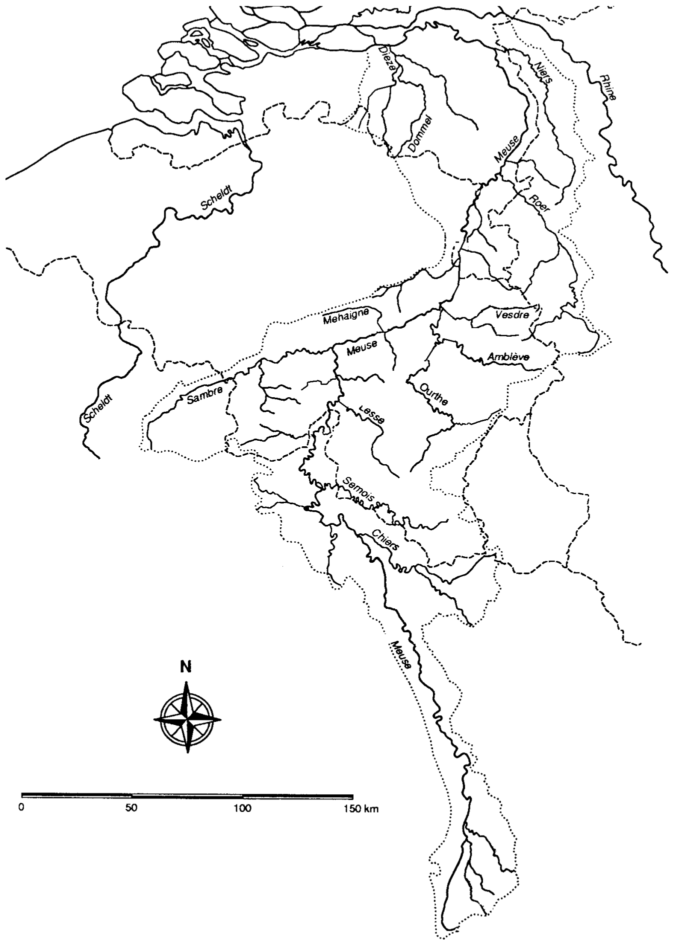


Figure 1.3 The Meuse basin

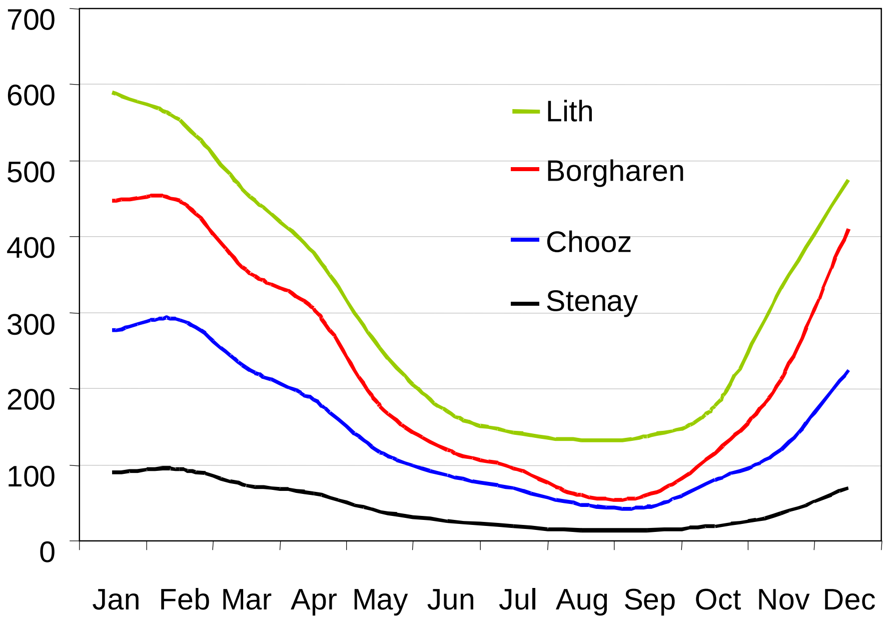


Figure 1.4 Hydrographs for different gauging stations along the Meuse (after De Wit et al., 2001)

### 1.4.1 Water systems in the Netherlands

The lower river Rhine branches and their estuary, the IJsselmeer area and the regional water systems form a dense interconnected network of water systems (figure 1.5). River water enters through the rivers Rhine and Meuse and several smaller rivers such as the Overijsselse Vecht. Rhine water is distributed primarily over the large river Rhine distributaries and subsequently it is distributed over a great part of the country through a dense network of watercourses. Precipitation, river discharge and sea level determine water levels, discharge, and salt intrusion within the Rhine-Meuse estuary and the Lake IJsselmeer. Precipitation excess in the higher terrestrial areas in the eastern part of the Netherlands is drained through smaller watercourses into the rivers. To maintain the water levels in the low lying polder areas precipitation and seepage water is pumped from the polders into storage canals ('boezems'). In dry periods, water may be transferred into the opposite direction from the storage canals into the polders. Lake IJsselmeer plays a key role in the water management of the northern Netherlands.

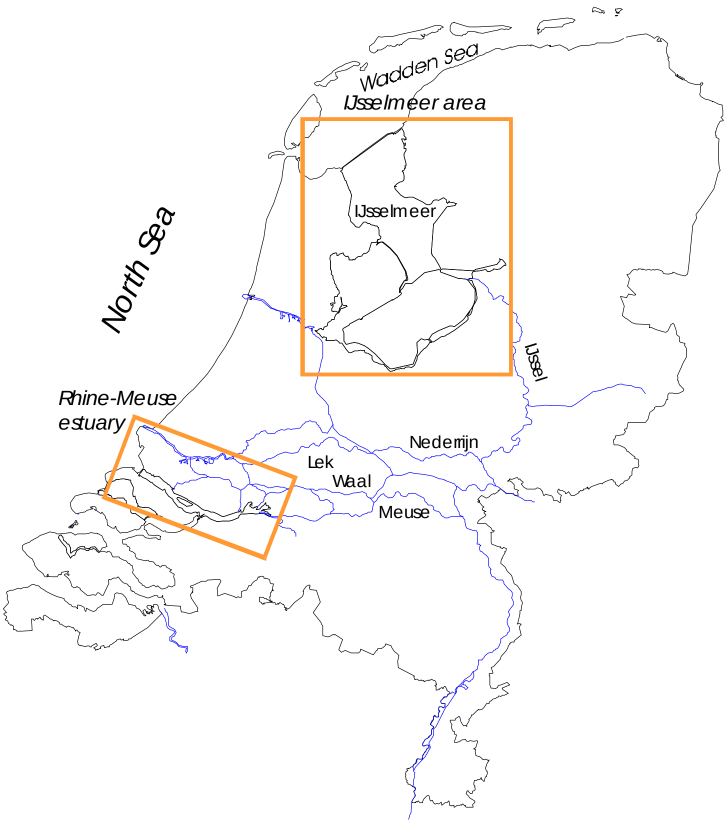


Figure 1.5 Water systems in the Netherlands. The regional water systems are not indicated separately

### 1.4.2 Lower rivers Rhine and Meuse

The average discharge of the Rhine at the German-Dutch border is about 2,300 m³/s. In the Netherlands, the river Rhine divides in three distributaries. The largest is the river Waal, which carries about 2/3 of the total Rhine discharge, the other distributaries are the Nederrijn-Lek (about 2/9 of the Rhine discharge), and the IJssel (1/9 of the discharge). The Meuse discharges on average 230 m³/s water at the Belgian-Dutch border. The Dutch Meuse is 250 kilometres long and has a drop of about forty-five metres from the Dutch-Belgian border to the North Sea. Between Eijsden and Maastricht (nine kilometres) and between Borgharen and Stevensweert (forty-seven kilometres), the Meuse forms the border between the Netherlands and Belgium. From Maastricht to Maasbracht, the Meuse meanders over shallow gravel banks; this stretch is uncanalized, fast-flowing and virtually unnavigable. There is consequently no shipping along this part of the river, and barge traffic goes via the parallel Juliana Canal. Further downstream to Lith, the water levels in the Meuse are controlled by weirs.

Along with water, both rivers carry large amounts of sediments, nutrients, pollutants, such as heavy metals, organic micropollutants and pesticides from the river basin into the lower delta. For example, the Rhine carries each year about 400,000 $m^3$ of sand and gravel, and about 2,000,000 $m^3$ (which is 3.1 Mton) of fine suspended sediments into the Netherlands. In addition to this discharge function, the rivers fulfil important other functions for the Netherlands:

**Safety**
The land along the lower Rhine and Meuse branches is protected from river flooding by embankments. Safety standards for the areas bordering the Rhine in the Netherlands are based on a 'failure probability' of the primary embankments equal to 1/1250 per year. The associated design discharge for flood protection is 16,000 $m^3/s$ for the Rhine and 3,800 $m^3/s$ for the Meuse river.

**Ecological functions**
The rivers and their floodplains form an important interconnected network that provides ecological corridors for plants and animals. The Rhine Action Programme has resulted in a considerable improvement of water quality of the Rhine over the past decades. In the context of nature development projects, opportunities are being created for the return of plant and animal species that lived in and around the river in large numbers before mankind intervened.

**Water supply**
Rhine water amounts about 60% of the annual input in the water balance of the Netherlands. It therefore is an important water supply for agriculture, industrial use, drinking water, and, in the lower parts of the Netherlands, for maintaining polder water levels and to prevent the intrusion of salt from the North Sea. Rhine water is also used as cooling water for industry and power plants. Three weirs in the Lower river Rhine have been built controlling water flow, enabling to divert a sufficient amount of water into the Lake IJsselmeer during periods of low discharge. When the Rhine discharge is between 2300 $m^3/s$ and 1400 $m^3/s$, the weirs ensure that the IJssel discharge does not become lower than 285 $m^3/s$. At lower Rhine discharge, the weirs are adjusted to preserve a minimum discharge equal to 25 $m^3/s$ through the Nederrijn. The river Meuse water is used for the production of drinking water both in Belgium and the Netherlands.

**Inland navigation**
The Rhine is the busiest river for navigation in Western Europe. In the Netherlands, the River Waal is the most important route. The number of ships passing Lobith amounts up to 170,000 a year. In 1990, the total transport over the Rhine along Lobith was 143 million tons. For the forthcoming decades a substantial growth of transport via inland navigation is foreseen. The Meuse forms a major South-North axis for inland navigation. The river has been regulated with weirs between Borgharen and Lith.

**Recreation**
The Rhine and Meuse fulfil many recreational functions, such as recreational boating, fishing, swimming, hiking and camping.

**Raw materials**
In the Netherlands, gravel is extracted from the upper river reaches (Meuse) and sand is mainly extracted from the lower reaches. Clay is excavated from the floodplains for the brick industry and for reinforcing river dikes. A lot of sand extraction takes place from the floodplains as well. The province of Gelderland, in the Netherlands, is one of the most important suppliers of sand for concrete and masonry sand. The resulting sand and gravel pits are predominantly used for recreation.

### 1.4.3 Lake IJsselmeer area

The IJsselmeer area contains the inter-connected lakes IJsselmeer, Markermeer and Randmeren (Figure 1.6). The lakes are shallow with an average water depth of 4 meters. This freshwater inland lake is mainly fed by the IJssel branch of the river Rhine. In winter the surrounding polders drain their surplus water towards the lake. The lake itself drains mainly towards the Wadden Sea in the North and through the North-sea canal and the Amsterdam harbour into the North Sea. Water is also exchanged between the lake and the Amsterdam-Rhine Canal. In summer water from the lake is flushed to the polders and water evaporates from the lake.

The basis of the water management in the IJsselmeer area are decisions about so-called 'target' water levels, and agreements between water authorities. The lake target levels in the IJsselmeer and Markermeer are NAP -0.40 m (NAP = Dutch Ordnance Datum) in winter. This low level is to achieve a sufficiently large storage capacity for excessive water from the IJssel during periods of high river discharge, and from the surrounding polder areas, without risking too high water levels. During summer, the target level is NAP -0.20 m. This higher level is maintained to enable a larger amount of fresh water stored in the lake to fulfil the high water demands from the surrounding land during periods of a net precipitation shortage. The discharge into the surrounding area occurs generally by gravity. Therefore the level in the IJsselmeer area has to be higher than in the surrounding area. Further a minimal head loss is necessary in order to get enough capacity. Since extremely high lake levels (e.g. due to peak flows of the IJssel River) do not occur during summer, this higher level has no adverse effects on safety. The target levels in the border lakes are slightly higher than in the IJsselmeer. In the summer season the lake target levels can be easily maintained. During winter, however, the lake levels are systematically higher than the target level. This is because at target level the discharge capacity of the sluices in the Afsluitdijk is lower than the average total discharge into the lake. Particularly unfavourable weather conditions, mainly the wind speed and direction, and fluctuations in the river IJssel discharge cause lake levels exceeding the target levels. Because the other lakes discharge their water into the IJsselmeer, their lake levels are influenced by the level in the IJsselmeer. The target level in Amsterdam-Rijnkanaal/Noordzeekanaal is at NAP -0.40 m throughout the year. In practice this is a mean value. The water level normally fluctuates between NAP -0.5 m. and -0.3 m.

The ability of maintaining these target lake levels thus strongly depends on sea level and wind, as the IJsselmeer drains by gravity into the Wadden Sea. Water quality in the lake mainly depends on the quality of the River Rhine water and on the residence time of the water in the lake.

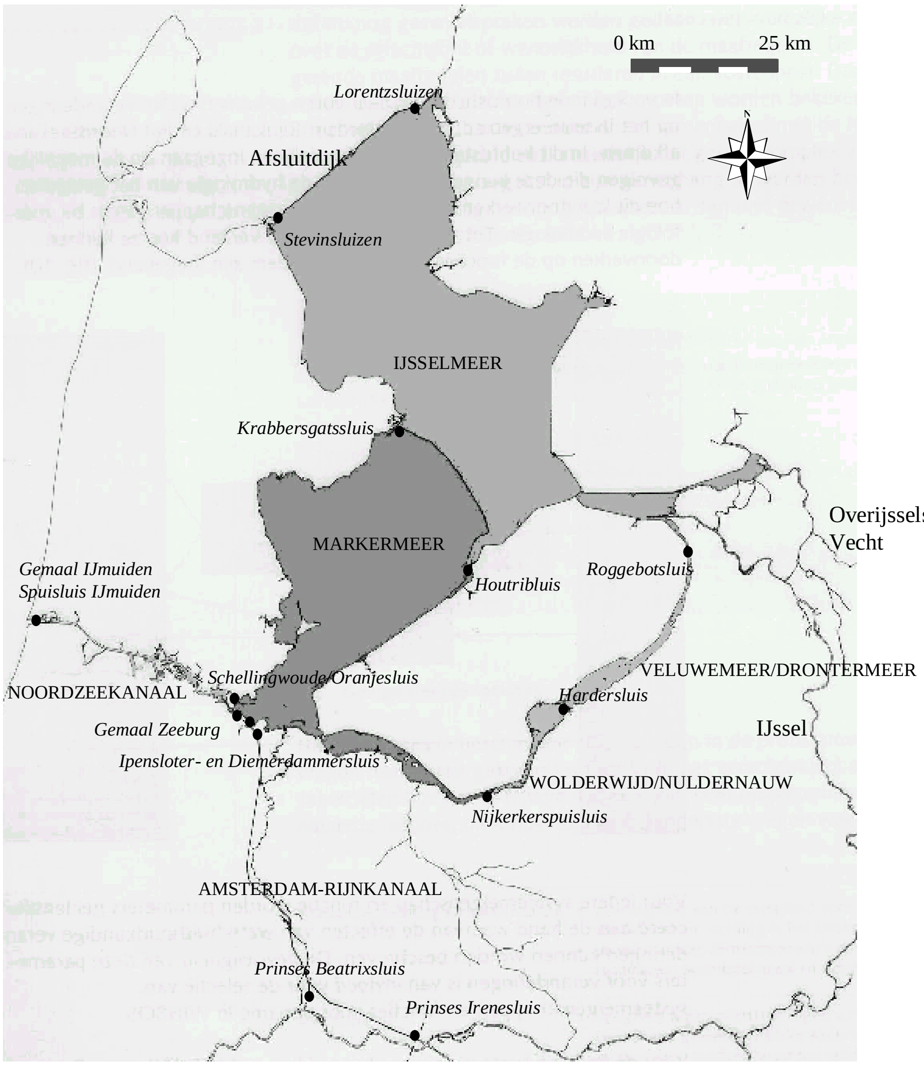


Figure 1.6 The IJsselmeer area

### 1.4.4 Terrestrial water systems

The terrestrial areas in the Netherlands cover the lower areas consisting of Holocene fluvial and marine deposits (clay, peat and silt) and higher areas underlain by Pleistocene glacial deposits, mixtures of clay and gravel, fluvial sands and gravel and wind blown sands. The relatively higher regions are groundwater infiltration areas, with ground water levels up to several meters below the surface. These areas receive fresh water mainly from precipitation. In summer when evaporation exceeds precipitation, water is extracted from the groundwater reservoir. These higher areas drain through the groundwater and small creeks to the lower terrestrial areas. The lower areas receive water from precipitation and partly from upward groundwater flow from the higher regions. Here, groundwater levels are artificially maintained at the surface or several tens of centimetres below it. Excess water in the polders must be drained by pumping stations and drainage canals to storage reservoirs ('boezems'). They drain towards the rivers, the IJsselmeer area or directly into the sea. During dry summer periods, fresh water must be conducted from the rivers and Lake IJsselmeer into the polder areas to control the polder water levels and to prevent the intrusion of saline groundwater.

## 1.5 General outline of the project

**Concept**

The basic concept in the project was to produce a limited set of integrated scenarios. That means that the underlying assumptions, preferences and choices must made transparent and consistent among different sectors, problems and scales. This requires a clustering of the various selected scenarios into a small set of integrated scenarios. For this purpose, the so-called Perspectives method derived from the Cultural Theory[1]. In Van Asselt and Rotmans (1995), Rotmans et al. (1996), and Hoekstra (1998) the Cultural Theory, has been used for the first time in scientific research to explicitly deal with divergent interpretations of uncertainty. In this project, we continue to build on this experience.

The basic rationale underlying the Perspectives method is that inherent uncertainty provides room for different valid interpretations of how social, economic and environmental processes are currently evolving and will evolve in the future. The approach now chosen is to relate subjective interpretations of salient uncertainties to a limited number of perspectives. The different perspectives are reflected by different choices concerning structural uncertainties throughout the whole cause-effect chain of social, economic and physical changes in a river basin as a result of human interventions. A perspective is a consistent description of the perceptual screen through which people interpret the world, and which guides them in acting. A perspective comprises both a world view (i.e. how people interpret the world) and a management style (i.e. how they act upon it), focusing either on *control* (Hierarchist), *environment* (Egalitarian) or *economy* (Individualist) (Figure 1.7). In the present project we firstly analyse scenarios where the world view coincides with the management style (which means that at last, the future will have turned out to be in accordance with the a-priori expectations) - this situation is referred to as 'utopia'-scenario. In addition, we analyse situations where there is a mismatch between the management style and world view, which is the case when future conditions (e.g. climate change) may turn out differently from the a-priori expectations - a 'dystopia' scenario. By analysing not only the utopia scenarios but also considering the dystopias for different management styles, the robustness of these styles for different (or uncertain) futures can be assessed.

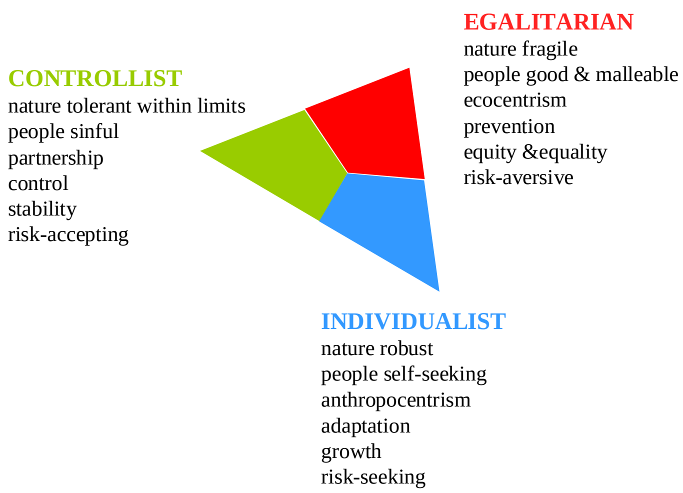


Figure 1.7 Perspectives and their view on the world

**Approach**

[1] Important sources about the Cultural Theory are (Douglas, 1969), (Douglas, 1982), (Rayner, 1984), (Rayner, 1991), (Rayner, 1992), (Schwarz, 1990) and (Thompson et al., 1990).

The integrated assessment was carried out in a step-wise scientific approach, which consists of the following steps (compare van Asselt, 2000):

1. The first step was the identification and selection of salient uncertainties through expert knowledge, the analysis of existing water-related studies and policy reports and stakeholder participation. Subsequently, the salient uncertainties were used for a qualitative interpretation of uncertainties according to different perspectives.
2. Next, perspective-based assumptions were defined in a quantitative manner to present a range of possible future developments with regard to economic growth, population growth and structure, consumption patterns, transport, land use and climate change. For the identification of parameters and input variables representing the perspective-based assumptions, we used bandwidths from the scholarly literature and expert judgement of the modellers. Climate change scenarios were developed by the Dutch KNMI, related to the emissions of greenhouse gases as part of the socio-economic scenarios. The perspective-based utopian sets of assumptions sketch the major driving forces behind future changes in water supply and demand. Each set of assumptions furthermore includes a specific water management strategy.
3. The set of perspective-based assumptions was fed into a suite of interconnected models, which calculated the impacts on the Dutch water system (Figure 1.9). Two different types of models were used in this study. First the numerical models that calculate the physical (hydrological) response on environmental change, as denoted in Table 1.1. As input these models use climate data based on measured time series or output from climate models, as well as geographical data such as land use, soil type and channel dimensions. The models calculate changes in runoff, evapotranspiration, water availability and groundwater flow. Examples include the models RHINEFLOW, BEKKEN and NAGROM.
4. The next set of models, the ‘function models’, transfer this output into variables relevant for a specific river function and compare the output with the demands of this function (see Table 1.2). Examples of these models are the Landscape Planning Decision Support Systems (LPR-DSS), SHIPS@RISK and DEMNAT. The model calculations provided the basis for utopian and dystopian images of 2050. An integrated perspective-based scenarios thus involve the combination of the set of underlying assumptions, combined with the associated image of 2050 derived from model calculations.
5. Then, an evaluation of all utopia and dystopia situations of the scenarios was carried out. To that end the images of 2050 were clustered into 3 scenario families (the Hierarchist, the Egalitarian and the Individualist scenario family) in which the external context is constant and the management varies. Dystopian images can then be considered as bifurcations of the utopian outlook. A number of stakeholders were asked to reflect on the scenarios in terms of consistency, coherency and relevance.
6. Finally this approach resulted in an integrated assessment of the robustness of various water management strategies under different futures. This yielded recommendations for decision-makers on how to act in a dynamic environment involving global climate change.

Step 1 consitutes phase A of the project; steps 2, 3 and 4together are phase B, and steps 5 and 6 form phase C of the project. A schematic representation of the project outline is given below and will be thoroughly described in Chapter 4.

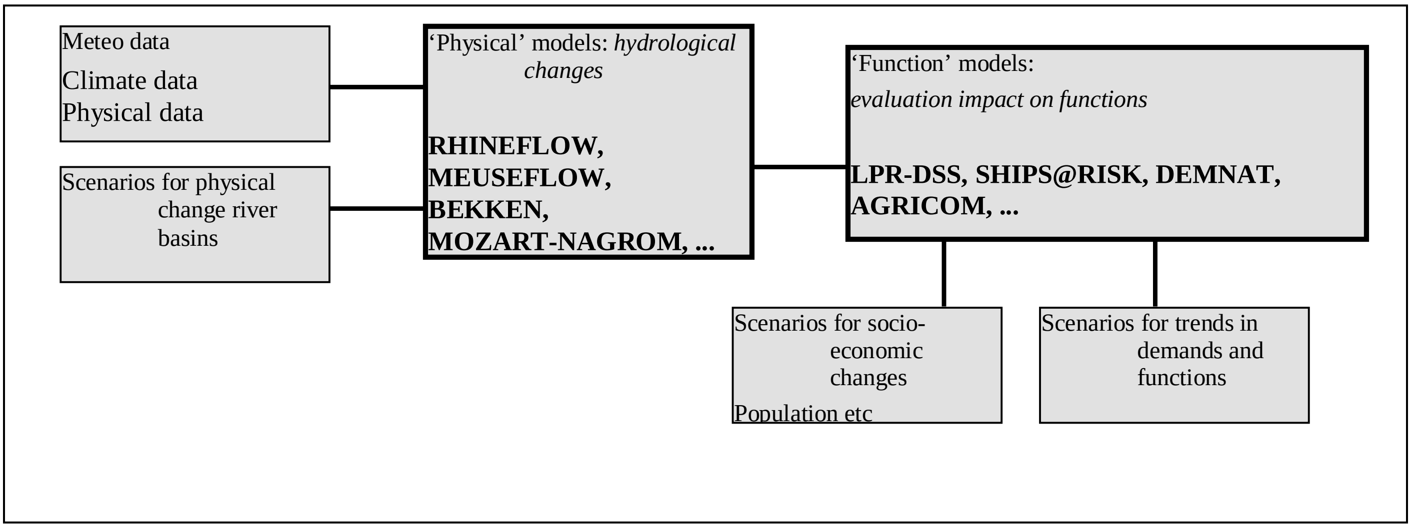


Figure 1.9 Suite of models used in the project

### 1.6 Outline of the report

The general methods and the establishment of integrated Perspective-based scenarios are described in a separate report (Phase A of the project) (Van Asselt et al., 2001c). Also, the detailed model results are presented separately (Phase B of the project, Buiteveld et al., 2001). The present report is the final report of the project, and addresses the interpretation of the scenario result for all utopias and dystopias (Phase C of the project). First, the general concepts of the Perspectives method and the PRIMA approach as used in the project are outlined (chapter 2). In chapter 3 the existing policy documents related to fresh water management in the Netherlands are analysed and placed within the Perspectives' framework. Chapter 4 describes the path that was followed to achieve the set of integrated scenarios for the present study. Here, the uncertainties are identified and put into perspective, based on the analysis of existing studies and policy reports, expert meetings and participation of stakeholders. Subsequently, the selection of perspective-based experiments for the modelling is presented. Chapter 5 presents the utopian sets of assumption with regard to the water systems and their implementation in the modelling instruments. In chapter 6, the images of 2050 are evaluated in terms of the hydrological situation and the consequences for the user functions. This is done through expert judgement and informed by stakeholder input. The main conclusions are drawn in chapter 7 and finally listed in chapter 8.

Table 1.1 A. Data flow for linking scenarios and hydrological models in the upstream basins of Rhine and Meuse

| Input | | Method / model | Output |
|---|---|---|---|
| Source/model | Data | | |
| *Upstream basin* | | | |
| Climate | climate variables | RHINEFLOW MEUSEFLOW | 10-daily river discharge<br>water availability |
| Soil type | water storage capacity | INTERREG-models | peak flows |
| DEM | elevation | | |
| Land use | evaporation/crop factors | | |
| Scenarios | climate change | | |
| Scenarios | land use change | | |
| Plans/scenarios | landscape planning measures | | |

B. Data flow for linking scenarios and models for the water functions of Rhine and Meuse

***B1 Rivers Netherlands***

| Driving data | | Method / model | Result |
|---|---|---|---|
| Source/model | Data | | |
| RHINEFLOW<br>MEUSEFLOW<br>INTERREG-models | river discharge | SOBEK<br>RvR | water levels |
| Plans/scenarios | land use high-water bed rivers | | |
| Plans/scenarios | landscape planning measures high-water bed rivers | | |

***B2. Water distribution Netherlands***

| Driving data | | Method / model | Result |
|---|---|---|---|
| Source/model | Data | | |
| RHINEFLOW<br>MEUSEFLOW | 10- daily river discharge | National Distribution Model (DM) | Water distribution over open water channels in the Netherlands |
| MOZART-NAGROM | area discharge | | |
| *IJsselmeer area* | | | |
| RHINEFLOW | 10- daily river discharge | BEKKEN | water levels Lake IJsselmeer |
| Sea level | Sea level | | |
| Scenarios | Sea level rise | | |
| National Distribution Model (DM) | area discharge | | |

***B3. Terrestrial systems***

| Driving data | | Method / model | Result |
|---|---|---|---|
| Source/model | Data | | |
| Climate | climate variables | MOZART-NAGROM | groundwater levels<br>ground water upwelling/seepage<br>ground water salinity<br>area discharge |
| Scenarios | climate change | | |
| DEM | elevation | | |
| Land use | transpiration / crop factors | | |
| National Distribution Model (DM) | river discharge | | |

Table 1.2 Linking hydrological changes (water availability) and scenarios (water demand) to functions

| Function | output | Source data: demand | Source data: supply | model |
|---|---|---|---|---|
| *Upstream basin* | | | | |
| Water availability | Potential net water availability | Population growth, projections for agricultural developments | RHINEFLOW MEUSEFLOW | GIS analyses |
| Safety | Q-recurrence times for major tributaries | Policy on safety standards, retention areas, measures to reduce flood damage | RHINEFLOW MEUSEFLOW | Statistical downscaling |
| Inland navigation Rhine | Transport capacity river | Economic scenarios, projections for transport developments | RHINEFLOW | Ships@Risk |
| *Netherlands* | | | | |
| *Rivers* | | | | |
| Safety | Peak flow recurrence times, design discharge | Policy on safety standards, retention areas, measures to reduce flood damage | RHINEFLOW MEUSEFLOW | Statistical downscaling |
| Inland navigation | Navigation cost | Economic scenarios, projections for transport developments | RHINEFLOW MEUSEFLOW | PAWN - instrument |
| Drinking water | River water supply | Population growth, economic scenarios | MEUSEFLOW | MEUSEFLOW |
| Agriculture, ecology, cultural heritage, raw materials, floodplain landscape | Landscaping plans | Landscape planning measures and planning variants | RHINEFLOW MEUSEFLOW | RvR |
| *IJsselmeer area* | | | | |
| Safety | Water levels IJsselmeer, MHW | MHW, Policy document, sluice management programs, WIN-study | BEKKEN Wind scenarios | Statistics |
| Ecology | Boundary conditions ecology | WIN-study | BEKKEN | WIN DSS |
| Water supply regional areas | Net water availability | Land use scenarios, WIN-study | BEKKEN DM | WIN DSS |
| *Terrestrial areas* | | | | |
| Ecology | Composition and distribution terrestrial ecosystems | Landscape planning variants, RPD scenarios | MOZART | DEMNAT |
| Agriculture | Agriculture damage | Projections for agricultural development | MOZART | AGRICOM |

# 2 PERSPECTIVE-BASED UNCERTAINTY MANAGEMENT

## 2.1 Dealing with uncertainties

The climate problem is surrounded by large uncertainties. There is discussion concerning the explanations of the observed changes and, therefore, the extrapolation of the changes to the future: the rate, magnitude and regional variability. Causes of these uncertainties lie in the variability of the climate system and our limited knowledge of the most important feedback mechanisms. The most important components of the climate system, i.e. the atmosphere, oceans, ice masses and biosphere, show non-linear behaviour, so that relatively small changes can have large effects. Therefore, there is also large uncertainty concerning the consequences of climate change. Consequently, as we do not know how fast climate will change and what the precise regional impacts will be, the future of the Rhine and Meuse is uncertain.

Researchers and policy makers are always confronted by uncertainty when carrying out research into these complex problems. The lack of data and information is, however, not the only source of uncertainty. There is also social uncertainty. Human behaviour is unpredictable and, therefore, the behaviour of social actors, society and its policy are also uncertain. Technical innovations and the perception of these innovations by the users may also have a large influence on our world, which will, as a result, become more complicated and, therefore, more difficult to predict.

Uncertainty is, thus, inherent in scientific research concerning water management and produces a number of different problems:

- Society expects science to solve, or at the very least, reduce uncertainty;
- Politicians expect policy supporting and scientific advice in the short-term;
- Politicians expect advice to support their policies that is unambiguous, but this is not possible due to the inherent uncertainty;
- Scientists are required to provide a certain degree of accuracy, which they are not able to do due to the inherent uncertainties.

Additionally, uncertainty is difficult to define, which further complicates communication between science, society and policy makers. In scientific literature uncertainty is often defined using classification. A way to classify uncertainty is to research the various sources of uncertainty. Van Asselt (2000) has developed a taxonomy of the sources of uncertainty which enables us to distinguish between uncertainties and to communicate about uncertainty in a more constructive manner (Figure 2.1). Two sources of uncertainty can be distinguished at the highest aggregate level:

*Variability* is defined as an uncertainty due to the fact that a system can behave in various different ways or is valued differently. Variability is linked to the following types of sources:

- The unpredictability of nature;
- Different standards;
- Unpredictable human behaviour;
- Unpredictable social events;
- Unforeseen technological developments.

*Limited knowledge* is a characteristic of the analysts who carry out the research and/or of the general level of knowledge. Lack of knowledge can be divided into different levels:

- Inaccurate information (‘We know more or less’);
- Lack of measurements (‘We could have known’);

- Practical immeasurable: the information can be measured in theory, but not in practice, it takes too long or is too expensive ('We know what we do not know');
- Conflicting information: differing sets of information are available, but the observations give room for different interpretations ('We do not know what we know');
- Reducible ignorance: there may be different processes or interactions between processes which we cannot observe or reason, but we may discover it in the future ('We do not know what we currently do not know');
- Indeterminacy: there may be processes which cannot be determined by humans ('We cannot know it');
- Non-reducible uncertainty: there may be different processes or interaction between processes which we cannot observe or reason ('We cannot know it').

The first three forms of the limited knowledge are called unreliability and the last four are called structural uncertainties.

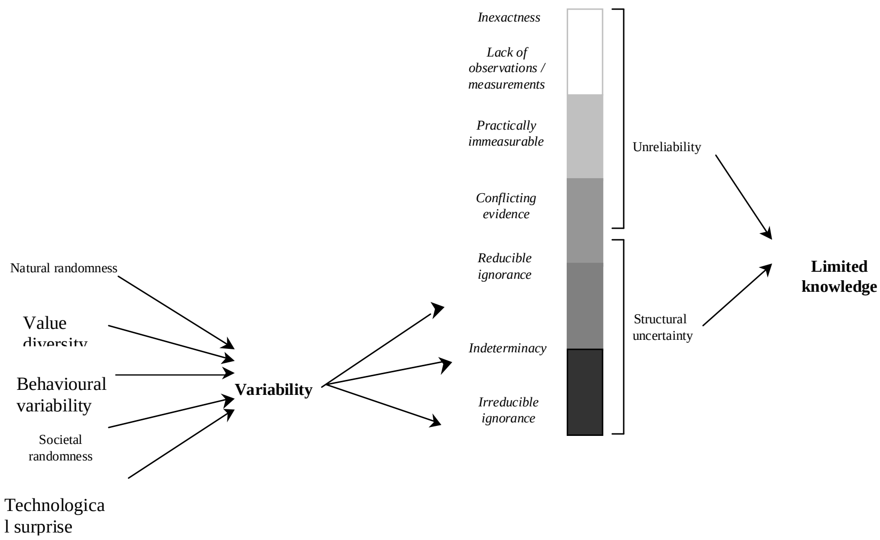


Figure 2.1 Typology of the sources of uncertainty

The taxonomy covers uncertainties due to unreliability and the more fundamental uncertainties. Uncertainties, which can be classified in the category of unreliability, can be measured or calculated in the sense that they generally result from systems or processes that we understand. This implies that these uncertainties, in principle, can be described as being quantitative. *Structural uncertainties*, on the other hand, are difficult to estimate. These uncertainties generally exist as a result of conflicting information, ignorance, indeterminacy and uncertainty due to variability. With regard to complex subjects, such as the water management of the Rhine and Meuse, the most important uncertainties are probably structural.

Uncertainty management aims to facilitate the search for robust alternatives. If an unequivocal, optimal solution cannot be produced, the alternative is to try to find and develop robust strategies. Robust strategies are strategies which lead to a favourable future, which appear to avoid undesirable futures and which are flexible enough to be altered or reversed if new developments come to light (Van Asselt, 2000). The aim of this project is to produce robust strategies for water management for the Rhine and Meuse rivers in a changing and uncertain environment. There is no ready-made approach available to achieve this. This implies that, the project not only addresses issues concerning content: the project is also clearly a methodological exercise.

### 2.2 Perspectives

As argued by Van Asselt (2000), complexity and uncertainty stimulate pluralism, which means that different perspectives are legitimate and viable. These biased individual perceptions can only be understood if the concept of uncertainty is regarded as a social construct (Douglas and Wildawsky, 1982). Social constructivism claims that both private, subjective perception and scientific knowledge are closely connected to culture, shared values and beliefs, hereby challenging the positive claim that knowledge can be produced according to purely rational, cognitive factors. Social constructivism, therefore, recognises a strong and mutual interdependency between perception of the world and the socio-cultural positions.

Dealing with various interpretations of uncertainty requires a typology of perspectives, which sufficiently covers the pluralistic character of value systems. It is, therefore, explicitly not the intention to view an infinite number of individual preferences. The Cultural Theory[2] offers a framework to investigate the complexity of different value systems systematically, as well as at a general level.

Thompson et al. (1990) describe Cultural Theory as a theory about socio-cultural viability which explains how ways of life maintain (or fail to maintain) themselves. Cultural Theory distinguishes between myths of human and physical nature as two integrated aspects of four cultural biases, based on distinctive patterns of social relations, beliefs and values. The roots of the cultural theory lay in the anthropological research of Mary Douglas (1970), who introduced a group-grid typology of cultures as a way of classifying an individual's social context. She argues that different social context can be described along two axes: group and grid. 'Group' is defined as 'the experience of a bounded social unit', and 'grid' refers to the 'rules that relate one person to others on an ego-centred basis'. By distinguishing two positions on each dimension – strong and weak – she generates four types social relations.

The group-grid typology has been further developed in the Cultural Theory, where the four types of social contexts are called ways of life. These ways of life are described as the Hierarchist (strong group boundaries and binding prescriptions), the Individualist (weak group boundaries and little prescribed roles), the Egalitarian (strong group involvement and minimal regulation) and the Fatalist (excluded from group membership and binding prescriptions). In addition to these four key orientations a fifth one is added, namely the Hermit, representing the autonomous and ineffectual way of life (Thompson, 1999). The first three perspectives can be characterised as the active ways of life, whereas the latter two are passive.

The major strength of the cultural perspective as a whole is its recognition of the fact that individuals and social groups behave differently under similar circumstances because of the differences in their underlying beliefs and values. On the other hand, we realise that Cultural Theory does not represent social science as a whole. We also recognise that it is a rather rigid scheme and that it cannot fully take account of the real world variety of perspectives.

In the current project we use the Cultural Theory as a rationale in explaining historical developments and exploring possible futures. In the project we limit ourselves to the three active perspectives, i.e. the Hierarchist, the Egalitarian and the Individualist, which have been used as stereotypes to develop multiple model routes that represent fundamentally different, but legitimate perspectives. The three perspectives are considered as extremes: the resulting spectrum that these extreme stereotypes define comprises a variety of less extreme, or rather hybrid, world views and management styles. The heuristic rules shown in sequence of priority in Table 2.1, turned out to be critical in interpreting uncertainties according to the Cultural Theory perspectives.

[2] Important sources about the Cultural Theory are (Douglas, 1969), (Douglas, 1982), (Rayner, 1984), (Rayner, 1991), (Rayner, 1992), (Schwarz, 1990) and (Thompson et al., 1990).

**Box 2.1 Cultural Theory's typology of perspectives**

In the ***Hierarchical perspective***, people are sinful by nature. However, people can be controlled (and educated) by good institutions. Management must ensure that large problems are prevented. Regulation of the system requires a large degree of control. This management style can be characterised by an attitude of accepting risks. In this perspective, nature is robust within certain limits: nature is able to repair small disturbances. However, crossing the limits causes serious dangers for the way in which nature functions. The hierarchical perspective can be associated with an attitude towards the relationship between humans and nature where the mutual dependence between both parties is emphasised. In this perspective, an attempt is made to guarantee this balance.

In the ***Egalitarian perspective***, it is assumed that people are, in principal, good, but that they can be easily influenced. Although humans can be negatively influenced by bad influences, they can also be guided positively by means of intimate relationships with nature and other people. Self-development lies more in spiritual growth rather than consumption of goods. The Egalitarian world view implies an attitude of risk avoidance. The management style belonging to this can, therefore, be characterised as being preventive. The Egalitarian perspective advocates drastic and structural social, cultural and institutional changes in the current capitalistic economic system. Nature is extremely vulnerable and small disturbances can have catastrophic consequences. Nature is, therefore, in a delicate balance. Human activities, which can effect the natural environment, must, therefore, be prevented.

In the ***Individualistic perspective***, human nature is based on selfishness. In this perspective, people are considered as rational, self-assured actors who try to satisfy their material needs. Changes and uncertainties form a challenge and can, in principle, be solved. This perspective is characterised by a large amount of trust in the market mechanisms and technology. The management style of this perspective can, therefore, be characterised as being adaptive. In the Individualistic perspective, nature is extremely robust and is able to survive a few knocks. Anthropogenic disturbance, even if large, results in mild and harmless disruption. In this perspective, people are considered the centre of the world. The natural resources are at the service of people and can be exploited.

Table 2.1 Characteristics of the cultural perspectives

| Perspective Heuristic rules | Individualistic | Hierarchical | Egalitarian |
|---|---|---|---|
| Heuristic rule 1 | Free market mechanism and anti-regulation; economic growth and technical development equal progress. | Stability through regulation, hierarchy and standards; regulation of nature and the environment; acceptance of differences. | Nature is vulnerable and environmental risks are avoided; prevention is better than cure. |
| Heuristic rule 2 | Individual development and material self-interest are motives for action; success is a personal responsibility. | Avoiding risks and against changes; easy does it, otherwise you'll break the line. | Equity. |
| Heuristic rule 3 | Problems can be solved; risks produce opportunities and challenges. | Authority through expertise and experience. | Economy as a means and not as an objective; conscious consumption. |
| Heuristic rule 4 | | Power and esteem are the motives for action. | People have solidarity and behave as such; collective interest. |

We define a perspective as a consistent and coherent description of how the world functions and how policy should be carried out (Van Asselt, 2000). In accordance with this definition, a perspective has two dimensions: a world view and a management style. The world view is a coherent description of how the world functions and the management style is a coherent set of preferred policy options. If the world view and management style coincide, then we speak of a utopia (Figure 2.2). When this is not the case, then there is dystopia.

WORLD VIEW

MANAGEMENT STYLE

| | Hierarchical | Egalitarian | Individual |
|---|---|---|---|
| **Hierarchical** | *UTOPIA* | *DYSTOPIA* | *DYSTOPIA* |
| **Egalitarian** | *DYSTOPIA* | *UTOPIA* | *DYSTOPIA* |
| **Individual** | *DYSTOPIA* | *DYSTOPIA* | *UTOPIA* |

Figure 2.2 Utopia and dystopia

In philosophical tradition, dystopias (or anti-utopias) describe terrifying visions of the future. In terms of our dichotomy, dystopias describe what may happen if the world functions according to a perspective different to the perspective on which the policy strategy is based. Or vice versa, where reality functions in line with one's favoured world view, but opposite strategies are applied. Thus, in terms of scenario development and model experiments, dystopias are future pathways involving 'mismatches' between world view and management style. In reality, there are often dystopias due to the interplay of forces between actors.

In Van Asselt and Rotmans (1995), Rotmans et al. (1996), and Hoekstra (1998) the Cultural Theory, has been used for the first time in scientific research to explicitly deal with divergent interpretations of uncertainty. Within the scope of RIVM's research project 'Global Dynamics and Sustainable Development' that involved the development of the Integrated Assessment model TARGETS, which is an acronym for Tool to Assess Regional and Global Environmental and health Targets for Sustainability. The model uses multiple (perspective-based) model routes for demography, human health, economics, energy, food, land, elements cycles and water. In this project, we continue to build on this experience.

### 2.3 Methodology: From uncertainty towards robust strategies for the Rhine and Meuse

This project uses various methods and techniques to identify crucial relevant to integrated assessment of the Rhine and Meuse basins. In this project we propose to combine two classes of methods, i.e. analytical (scenario and models) and participatory methods. Analytical and participatory methods are used in a mutually complementary way: models are used as tools to develop and evaluate scenarios and, on the other hand, the scenarios are the result of participatory processes. The current project reasons from the PRIMA approach (**P**luralistic f**R**amework for **I**ntegrated uncertainty **M**anagement and risk **A**nalysis) (Van Asselt, 2000) in which analytical and participatory methods are combined. The PRIMA approach will be used in this project as a scheme of steps, which enables us to systematically explore the uncertainties pertaining to the future of the Rhine and Meuse. The PRIMA approach takes uncertainty and pluralism (i.e. more than one perspective) as the starting point. The essence of this method is that uncertainties in a participatory process, which are indicated as being crucial with regard to the development of a strategy, are *coloured in* according to different perspectives. Figure 2.3 shows the most important steps of the PRIMA approach. Below, the general steps to deal with uncertainty and perspectives in assessment endeavours are outlined as well as the application of these steps in the current project.

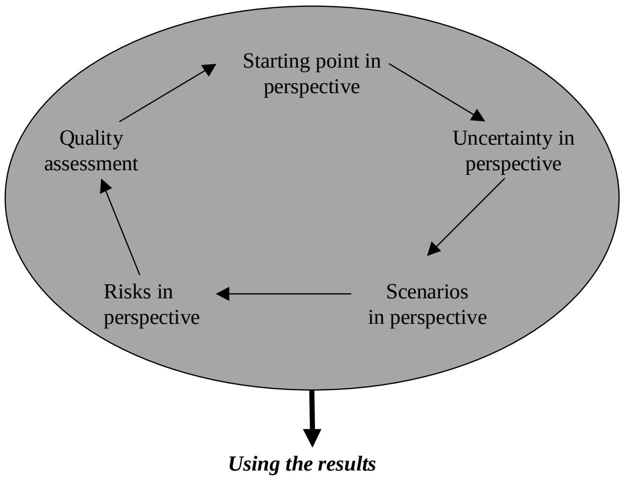


Figure 2.3 Schematic representation of the PRIMA approach

**Step 1: "Starting point in perspective"**

In the first phase, Starting point in perspective, it has to be decided how to perform the various phases in a way that is adequate to the topic under concern and the context of the study (Van Asselt, 2000). In this step it is determined which perspective is adopted with regard to pluralism and which dilemma will be researched in order to be consistent with this perspective during the assessment process. There are four crucial choices that are dependent on the choice for the pluralistic stand:

- The type of uncertainties included in the pluralistic analysis;
- Whether a demand- or a supply-driven approach is advocated;

- Portfolio of methods for uncertainty analysis;
- The perspective framework used.

Pluralism means that different perspectives are legitimate and viable, also within science. This implies cultivating a diversity of perspectives, without necessary slipping into an indifferent relativistic tolerance of all viewpoints. Pluralism fundamentally conflicts with the positivist, singular, paradigm, because in this latter paradigm different explanations are accepted in the sense of necessarily provisional: in the long run 'pluralism' will disappear.

The consequence of pluralism is that we have to realise that in exploring a pluralistic approach we, either explicitly or implicitly, take up a certain perspective on pluralism. Table 2.2 considers perspectives on pluralism in relation to the type of perspective. In the "observation-in-perspective"- perspective only scientific frameworks are accepted as legitimate perspectives, while the "theory-in-perspective"- perspective acknowledges different scientific paradigms. In the "science-in-perspective"- perspective a typology of socio-cultural perspectives is welcomed. The "reality-in-perspective"- perspective recognises those perspectives that are observed in actual networks or societal fields. The latter viewpoint would never accept an a-priori classification of perspectives, because it holds that knowledge and interpretation are embedded in social interaction patterns.

Table 2.2 Perspectives on pluralism in relation to the type of perspective

| **Perspectives on pluralism** | Observation - in - perspective | Theory – in – perspective | Science – in – perspective | Reality – in - perspective |
|---|---|---|---|---|
| **Types of perspectives** | Scientific hypotheses | Science paradigms | Socio-cultural perspectives | Observed in actual networks |

The perspective on pluralism that underlies the methodology of perspective-based model routes comes close to both the "theory-in-perspective"- perspective and the "science-in-perspective"- perspective. Both views have it that observation and interpretation is perspective-dependent. Cultural perspectives are related to social and economic uncertainties, i.e. uncertainties occurring in the human system and addressing scientific uncertainties which arise from the degree of unpredictability of long-term developments and which are inherently 'unknowable' and in practice unpredictable (Rotmans, 1994). In this view on perspectives, a clear distinction is made between science and non-science, which are considered as separate, independent domains. The starting point of the current project thus closely corresponds with the 'theory-in-perspective'- perspective and will, therefore, be chosen as a meta-perspective.

**Step 2: "Uncertainty in perspective"**

In the second phase of the PRIMA-approach, *Uncertainty in perspective*, the brainstorming session, the selection and the interpretation of uncertainties based on the perspectives are the key issues. To arrive at perspective-based interpretations of uncertainty and associated assumptions a stepwise approach was adopted:

- Surfacing water-specific assumptions from existing studies and policy reports and identify them in terms of perspective;
- Role-play like articulation, in which experts were asked to put themselves in the shoes of the various perspectives (cf. Van Asselt et al., 2001a);
- Participatory workshop with stakeholders:
  a. Identification of perspectives and associated assumptions from free-format output (brainstorm, storylines);
  b. Role-play in which societal actors were asked to put themselves in the shoes of the various perspectives.

Participation is related to pluralism. Participation is necessary if the required variety of perspectives extends beyond scientific points of view. Participation is required to a greater or lesser extent in case one of the following descriptions apply (Van Asselt, 2000):

- The controversy / dilemma involves complex issues;

- The salient uncertainties are due to value diversity, behavioural variability and societal randomness;
- The salient uncertainties are related to psychological, socio-political and cultural risk factors;
- The adopted perspective on pluralism transcends the distinction between the world of science and the social world (i.e. the "science-in-perspective"- perspective and esp. the "reality-in-perspective"- perspective);
- The aim of the decision-support endeavour is to deliver normative judgements;
- The decision-support endeavour intents to provide recommendations that bear on public support.

The process of integrated uncertainty management is not per definition participatory, although from the above it can be expected that in the majority of cases participation is highly recommended or even indispensable. The nature of integrated water management and the ambitions in the project, is seems conceivable that the development of integrated scenarios for the Rhine and Meuse has to be not only an expert exercise, but also a participatory endeavour.

One of the ways of interpreting uncertainties according to different perspectives is, thus, to involve societal actors, covering different viewpoints (Van Asselt, 2000) and (Van Asselt et al., 2001a). In order to stimulate this process of divergence we organised an expert meeting and a stakeholder workshop. In both sessions we choose for a creative, but structured brainstorm about uncertainties and perspective-based interpretations of uncertainties with regard to the future of the Rhine and Meuse.

The scenarios receive certain *richness* through the involvement of various individuals. The knowledge, expertise and creativity of both science experts and stakeholders from different backgrounds can provide the following output for the development of scenarios:

- The most important themes and associated uncertainties are articulated through a plenary brainstorming session;
- The uncertainties considered most important are interpreted from various perspectives. Storylines are then sketched based on this;
- Scenario themes emerge from the analysis of storylines.

Five interested parties are, therefore, identified as target groups for our project:

- Scientific experts, who provide the necessary scientific and technical information. (In this project, an attempt is made to extract the knowledge and expertise of the participants through a creative, but structured process);
- Politicians and policy makers, who take decisions concerning the future of the Rhine and Meuse;
- Inhabitants of the Rhine and Meuse river basins;
- Representatives of relevant commercial sectors, such as agriculture, shipping, recreation and the drinking water supply;
- Representatives of other interested parties, such as the representatives of environmental NGOs.

The stakeholder workshop was partly based on the scenario method developed by SHELL (Anastasi, 1997; Van Asselt et al., 2001b) (which is also known as the envisioning workshop, and which distinguishes itself by a free brainstorming session where anything is allowed and no idea is considered to be too extreme) and partly on the PRIMA method (Van Asselt, 2000). In the European VISIONS project, the *envisioning* method was applied for the first time in heterogeneous groups in which politicians, policy makers, business men and other social actors participated (Rotmans and Van Asselt, 2000; Rotmans et al., 2001; Rotmans, 2001). This project builds on this experience and the methodological lessons learned.

For envisioning, we used the storyline methodology. Storylines are sequences of events, which are logically and consistently related to each other. A storyline is a sequence of events, linked in a logical and consistent manner (Van Asselt et al., 2001b). When developing storylines, it is not important what will take place, but rather what could take place. Characteristics of storylines include:

- A storyline contains at least three events;
- The events included in a storyline are causally related;
- A storyline follows logically and consistently from a series of events;
- Branching-off can occur in a storyline, actually resulting in a ‘family’ of storylines.

The storyline methodology used in the current project consisted of 5 different steps:

*1: Brainstorming about important events*
During the first step, a participative brainstorming session was held over events and uncertainties in the future relating to the Meuse and Rhine. This usually gives reason for a lively and creative discussion, in which the most remarkable ideas about the future are postulated.

*2: The development of storylines*
It is possible that the participants of the brainstorm place only one event as the central event and develop a storyline from there, which then describes event after event. An alternative is that the participants simultaneously place more than one event as being central and then build the storyline by threading the different events together like beads on a string. This project also explicitly developed storylines from different perspectives. Each group had to place themselves in a perspective so that they could then develop a storyline.

*3: Dating the events*
When the participants have described a series of events, they have to position these events in time. They have to consider at what period of time the events appear to be plausible. The time axes that are central in this project cover the period up to the year 2050. For the final period, it will mainly be the global lines that are indicated.

*4: Connection between storylines*
After dates have been assigned to the different events, the participants will work out whether the developed storyline is coherent and logical. Questions that can be asked are: Do the events contradict each other? Are the connections plausible?

*5: Improving the storylines*
In the last step of the development of the storylines, the participants can supplement the storylines with additional information.

Stakeholder participation and envisioning is important in order to have both a view of crucial uncertainties and a water specific interpretation of the world views and management styles associated with the general perspectives adopted in this project. The perspective method is used in this study as a kind of benchmark framework and heuristic to evaluate plurality by addressing subjective judgements in scenario-development and modelling efforts. The perspectives are, then, used to explore coherent pathways into the future. This requires the identification of coherent chains of uncertainty, coloured with the bias and preferences of a certain perspective. A perspective can, therefore be described as a chain of biased interpretations of the crucial uncertainties. We intend to use the typology of perspectives in order to describe consistent choices at the crucial points in the scenarios and models where subjective judgement is required. The development of qualitative descriptions of interpretations of the future for the Rhine and Meuse and of the inherent uncertainties of this future is an important input for the development of perspective-based integrated scenarios.

**Step 3: “Scenarios in perspective”**
The next phase looks at which scenarios are possible and plausible. This is achieved by investigating the future using various perspectives. This phase can, therefore, be characterised as *Scenarios in perspective*. Scenarios are a way of structurally thinking about uncertainty and possible developments. This makes scenarios an aid in anticipating an uncertain future. For the present study, scenarios are defined as:

*Hypothetical descriptions of alternative images of the future and of causally related processes, events and actions which lead to these images of the future, where a final situation is sketched from a starting situation (usually the present situation)* (Rotmans, 1998).

A scenario is not the same as a vision of the future. A vision of the future is a cross section of time (a snapshot of any given moment, or, in other words, a photograph). A scenario, on the other hand, describes as it were, a film of the future, which explains step by step what may take place in the future and what the consequences of this may be. Scenarios must not be regarded as predictions, but as *what-if* analyses, which reflect the state of knowledge. This makes scenario development the translation of uncertainties into possible developments and events. There are many definitions of a scenario: Most definitions share the following characteristics:

- Scenarios are hypothetical and describe possible future developments;
- Scenarios describe processes and represent a succession of events over a certain period of time;
- Scenarios consist of situations, events and acts, which share a causal relationship.

A scenario must also be consistent and plausible. It must have a narrative character, which is both recognisable and challenging and which contributes to the participation of important stakeholders and policy makers.

Scenarios can be classified in different ways. For example, a distinction can be made between forecasting and back-casting scenarios. Forecasting scenarios explore future developments starting from the present situation, with or without desirable or expected policy actions. Back-casting scenarios start from a desired future situation and give a number of different policy actions, which may lead to this situation.

Scenarios, which operate at different spatial levels, can be developed in two different ways. Firstly, by means of a top-down approach, where a scenario is developed at a high level, for example, the entire river basin, and steps are taken to generate results at a lower level, for example, the regional level. And secondly, a bottom-up approach, that starts from a lower level and works up to a higher level. When results generated by both approaches confront each other, insight is produced into the tensions between choices, priorities, preferences and values at different levels. These tensions produce ideas about the possibilities and impossibilities, as well as the scope of policymaking available.

In view of the different sources of uncertainty, which play a role in designing water management strategies with regard to climate change, it is necessary to have integrated scenarios available. Integrated scenarios have to meet several requirements (Van Asselt et al., 1998; Van Asselt, 2000; Rotmans and Van Asselt, 2000; Rotmans et al., 2000; Greeuw et al., 2000):

- Complex issues lie across the intersection of many disciplines, i.e. they have an economic, environmental, socio-cultural and institutional dimension. Therefore, integrated scenarios have to address these various socio-cultural, economic, environmental and institutional developments in a balanced way (*multi-domain*).
- Complexity legitimates different interpretations of uncertainty. It is, therefore, necessary to consider multiple perspectives in decision-support on complex societal issues. Integrated scenarios, therefore, should reflect different legitimate perspectives, and should be developed through participation of relevant stakeholders (such as different national departments, provinces, water boards and recreation organisations, local councils, pressure groups, companies and private citizens). Integrated scenarios are, therefore, not only *expert based*, but also take explicit account of the knowledge and expertise of stakeholders (*multi-perspective & multi-actor*).
- Uncertainties with regard to the complex relationships between various dimensions make it very difficult to assess what is likely to happen if a particular event or a concurrence of circumstances comes about. Underlying processes do not only interact on different domains, but on different scale levels (local, regional, national, continental and global) and on different temporal scales. Integrated scenarios, therefore, should integrate various

processes that interact on different scale levels and on different temporal scales *(multi-scale).* In the current project we distinguish between three scale levels: the global scale level (climate change), the national scale level and the water system scale level. We will primarily focus on the Dutch part of the Rhine and Meuse river basins. In the IRMA-SPONGE project the entire river basins will be taken into account.

- The past teaches us that complex societal developments are not linear, which implies that current trends can not be extrapolated to the future. Figure 2.4 visualises examples of non-linearity in long term developments, starting from a historical or the current situation, extending till the chosen time horizon. Therefore, integrated scenarios should, ideally, integrate surprises and trend breaks, in order to break with old stereotypes. However, many existing scenarios have a 'business as usual' character, assuming that current trend conditions will continue to exist for decades, which is highly implausible (Rotmans and Van Asselt, 1997).

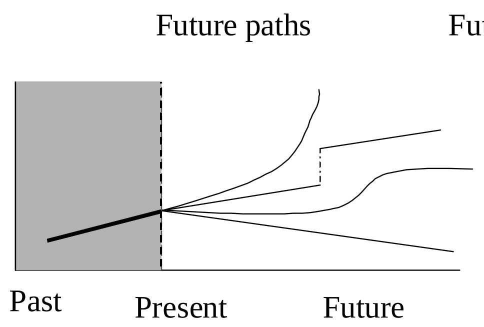


Figure 2.4 Non-linearity in long-term developments

In sum, integrated scenarios should comprise the following characteristics:

- <u>Multi-domain</u>. The issue lies across or the intersection of many disciplines, i.e. it ahs an economic, socio-cultural, environmental and institutional / political dimension;
- <u>Multi-perspective and multi-actor</u>. Complex issues involve multiple stakeholders and legitimate different perspectives;
- <u>Multi-scale</u>. Underlying processes interact on various scale levels (local, regional, national, continental and global) and on different temporal scales.

The project *Integrated Water Management Strategies for the Rhine and Meuse Basins in a Changing Environment* aims to develop new perspective-based integrated scenarios according to the above interpretation of 'integrated'.

**Step 4: "Risk in perspective"**

The previous stages can be considered as a phase in which divergence was a key principle. In the present step, convergence is the ambition. The next phase is the risk assessment, which involves providing general insights relevant for decision-making that are valid regardless of the preference for a certain perspective.

This step implies that various scenarios (and thus images of the future) are assessed in terms of 'riskiness'. Such an analysis of the scenarios can be done either quantitatively or qualitatively. In the current project, the risks are assessed semi-quantitative. A qualitative way of evaluating the 'riskiness' of strategies is to evaluate outlooks of the future in terms of the following risk questions:

- What might happen?
- How plausible?
- Imaginable consequences?

- How likely?
- What can we do about it?

These questions were leading in the second stakeholder workshop (April 26th, 2001) in Phase C of the current project. In this workshop draft scenarios were presented to the stakeholders for review and evaluation. Based on this interactive stakeholder dialogue, first insights were gained into the robustness of various policy strategies.

8 June 2001, a second expert meeting was organised in Maastricht. The aim of this session was to evaluate the scenarios. This evaluation resulted in a first estimation of the robustness of the various water management strategies under different futures.

**Step 5: "Quality assessment"**
It is important to assess the quality of the robust insight by looking back at the previous phases. This implies that the uncertainties and risk factors, which are relevant for the conclusion, must be evaluated to see whether they have been included correctly. This *quality assessment* closes the PRIMA circle. The entire process, with all of its intermediate steps, should produce results, which can then be used as recommendations for policy makers and as priorities for the scientific research agenda.

The PRIMA approach has been explored in the context of the RIVM's Environmental Outlooks (Van Asselt, 2000; Van Asselt et al., 2001a). The current application builds on theses first experiences with the PRIMA approach. It is important to realise that this approach is still in the phase of development and that neither a unifying theory nor clear recipe for integration is available. Therefore, the choice of a method or a combination of methods is crucial to any integrated assessment of a complex problem. In the present project, scenarios were developed in a participatory manner. This implies that interested parties and stakeholders (such as authorities, NGOs and citizens) were involved in the development process.

In the next chapter we will test the variety and, therefore, the *scope* of existing studies and policy report that appeared over the past few years. In addition, we will analyse the integration level of the studies in terms of scale levels, themes, dimensions and temporal scales.

# 3 Existing studies and policy reports in perspective

The floods of 1993 and 1995 have illustrated that the threat of flooding is a reoccurring phenomenon in the Netherlands. It has not only made clear that many people are dependent on the water, but also that the river seems to need more space. Flood protection, reduction of flood risk and adaptation to floods have become major issues of interest in present-day water management. Just as is the question of how solutions can be found in the entire river basin that take into account the natural processes and the different claims relating to the different river functions. For this reason, a large number of reports concerning water management have appeared over the last few years. In our project, we used these studies and policy reports as a starting point.

### 3.1 Inventory

Our first objective of the analysis of existing studies and policy reports was to explore whether a sufficiently varied set of integrated scenarios could be derived from existing material. For this purpose we have searched for studies that a) deal with water management in a broad sense, which means that they must take into account economic, socio-cultural, institutional, as well as the nature and environmental aspects; b) relate to the long-term and, therefore, sketch at least one picture of the future and c) deal with the Dutch parts of the Rhine and/or Meuse river basins.

An inventory has been made of the studies by obtaining information from water experts (both within and outside the project) in a number of rounds. From the collection of 20 studies and policy reports (see appendix 1), it turned out that a lot of studies refer to each other or are follow-up studies. The result of this is that there is much overlap. Furthermore, four studies have not been included in the analysis for other reasons. The examples ‘Action Plan High Water Meuse’ (‘Actieplan Hoogwater Maas’) and ‘Action Plan High Water Rhine’ (‘Actieplan Hoogwater Rijn’) only analyse the high water problem and the available safety measures. These studies included no other themes and, apart from the aspired high water levels, did not sketch any future images. The ‘Rhine Basin Study’ and ‘Wirkungsabschätung von Wasserrückhalt im Einzugsgebiet des Rheins’ both deal with the entire Rhine basin and did not say much explicitly about the Dutch sections of the Rhine and Meuse. These two studies will be included at a later stage in the IRMA-SPONGE project . The literature search was from August 1999 to May 2000, implying that studies and policy reports that appeared in the course of the project (such as ‘Water management for the 21st Century’ ) have not been used in the analysis. This study is, therefore, limited to 16 studies (Table 3.1). The selected reports cover a time period of nine years (1992 - 2000). Most reports were drawn up by, or under the authority of, the Directorate-General for Public Works and Water Management (Rijkswaterstaat). Besides the national government, the following governments and sectors are also represented in this selection: provinces and district water boards, agriculture (countryside service (Dienst Landelijk Gebied), Centre for Agriculture and the Environment (Centrum van Landbouw en Milieu (CLM)) and nature and the environment (Dutch Forestry Commission (Staatsbosbeheer), World Wildlife Fund).

Table 3.1 List of investigated reports and documents on water management policy

| STUDY | YEAR | INSTITUTE(S) |
|---|---|---|
| 1. Living Rivers (Liv. Riv) – Levende Rivieren | November 1992 | World Wildlife Fund |

| | | |
|---|---|---|
| 2. Landscape planning for the Rhine (LPR) – Integrale Verkenning inrichting Rijntakken (IVR) | May 1996 | RIZA, WL |
| 3. Aquatic Outlook; the Future for Water memorandum (WSV) – Nota Toekomst voor Water | November 1996 | RIZA |
| 4. From Worrying About the Meuse to Caring for the Meuse (Meuse) – Van Zorgen om de Maas naar Zorgen voor de Maas | November 1996 | WL |
| 5. The Future for Agriculture and Water Management (Agri) – Toekomst van Landbouw en Waterbeheer | March 1997 | RIZA / Centre for Agriculture and the Environment |
| 6. Definition Study of the Set of Instruments for Water Management in the Wet Heart (WIN) – Definitiestudie Instrumentarium Waterhuishouding in het natte hart | October 1997 | RIZA, H+N+S |
| 7. WSV target group study: Inland Fishing Industry (Fish) – WSV Doelgroepstudie Binnenvisserij | June 1998 | RIZA |
| 8. The Rhine in Time (Rhine) – De Rijn op termijn | 1998 | WL |
| 9. Action Plan High Water Rhine (AHR) – Actieplan Hoogwater Rijn | March 1998 | ICPR[1] High Water Project Group |
| 10. Sparkling Water, Perspectives for Water Management (Sparkling) | April 1998 | PBW[2] |
| 11. Agriculture in the Floodplains (Flood) – Landbouw in de Uiterwaarden | December 1998 | DLG[3] / LEI[4] / Dutch Department of Public Works |
| 12. Water in Pictures (Pictures) – Water in Beeld | 1999 | Integral Commission for Water Management |
| 13. Space for the Rhine Branches (RvR) – Stand van Zaken Ruimte voor Rijntakken | 1999 | RIZA |
| 14. Future for a Sandy River (Sand) – Toekomst voor een Zandrivier | January 1999 | Buro Stroming |
| 15. Natural Safety, Vision or the Rhine branches in the perspective of flowing storage (Safe) – Natuurlijke veiligheid | September 1999 | Dutch National Forestry Commission/WWF |
| 16. Vision for the Rhine (Visions) | March 2000 | RIZA |

[1] International Commission for the Protection of the Rhine
[2] Sparkling Water Project Group
[3] National Countryside Service
[4] Institute of Agriculture and the Economy

A similar inventory of existing studies was carried out by the RIZA and WL/Delft Hydraulics (Claessen and Dijkman, 1999) under the authority of the Water Management in the 21st Century project team. The study entitled *'Starting points of Recent Studies of Water Management'* (*'Uitgangspunten recente studies waterbeheer'*) is an inventory of assumptions, starting points and scenarios, as these have been and are used in national and regional water management involving various studies and large projects in the field of national and regional water management. The study is based on projects at various spatial scales, including *'Space for the Rhine Branches'* ('Ruimte voor Rijntakken'), *'Landscape Planning of the Tidal Rivers'* ('Integrale Verkenning Benedenrivieren'), *'Landscape Planning of the Meuse'* ('Verkenning Verruiming Maas'), *'Water in the Wet Heart'* ('Water in het Natte Hart'), *'Fourth Water Management Memorandum'* (4e nota Waterhuishouding), NRP II project *' Impacts of climate change on the Rhine basin and implications for water management in the Netherlands'* (Middelkoop, 2000) and regional studies *'Sparkling Water'* ('Buisend Water') (1998), *'Living Storage'* ('Levende Berging') (1998).

The main conclusions from this evaluation study were that a great deal of similarity between starting points, assumptions and the vision year with regard to climate changes and soil subsidence, but that there are only small differences relating to hydrology and water management and that spatial development receives relatively little attention. Furthermore, the authors conclude that the time horizon is relatively short (15-20 years) with regard to the spatial assumptions. According to the authors, for the second half of the century, no starting points have been formulated or assumptions made in the analysed studies, except for climate change (including the increase in sea level) and soil subsidence.

The inventory made by the RIZA and WL/Delft Hydraulics distinguishes itself from the present project by placing the emphasis on water management in general. The current protect is specifically aimed at studies for the Rhine and Meuse. Moreover, the current inventory further distinguishes itself by taking pluralism (more than one perspective) and uncertainly as starting points and by using the insight obtained from the existing studies as building blocks for integrated scenarios. In other words: what do existing studies and policy reports yield with regard to relevant aspects of water management, the considered uncertainties and assumptions and envisioned futures?

### 3.2 Analysis of existing studies and policy reports

A detailed description of the investigated studies is given in Van Asselt et al. (2001c), and is summarised in Appendix 2. For all studies it was assessed to which extent uncertainty was addressed and what types of uncertainties were considered. Subsequently, it was determined whether these existing studies provide all the necessary building blocks to establish integrated scenarios. For this purpose, integration and variation are the key concepts.

*Integration*
The integral character of the existing studies and policy reports was evaluated using the following four dimensions (cf. Van Asselt et al., 1998; Greeuw et al., 2000).

- Integration of spatial scale levels, subdivided into Rhine, Meuse, European scale and Other;
- Integration of temporal scales, i.e. the time horizon;
- Integration of themes; i.e. recreation, agriculture, nature, transport, safety, water quality, cultural history, housing / working, extraction of raw materials;
- Integration of dimensions; i.e. environmental and nature, economic and socio-cultural dimension

*Variation*
Variation deals with the question of whether sufficient legitimate interpretations of uncertainty (i.e. multiple valid perspectives) are considered. The existing studies and policy lines describe

various measures and scenarios. In order to gain insight into the range of scenarios that can be distilled from the whole set of studies and reports, we have investigated to what extent the scenarios from different studies can be considered to form scenario clusters that share the same critical assumptions with regard to the functioning of the system (world view) and policy option (management style). The Future of Water (WVS, 1996) gives four variants upon which other studies - explicitly or implicitly- elaborate. These were analysed to assess whether the previous studies include sufficient variation and different legitimate interpretations of uncertainty.

### 3.2.1 Integration

*Central themes*

We have extracted 9 different water-related themes from the various studies: safety, nature, agriculture, transport, water quality, cultural history, recreation, housing/working and extraction of raw material. Table 3.2 shows which of these are considered in each of the studies.

Three themes are central in almost all of the studies: *safety*, *nature* and *agriculture*. All the studies take the sustainable preservation of safety as the central starting point. Two policy variants can be identified within the water debate: the first is based on the '*water is guiding'* principle and the other on the '*water follows'* principle (it should be noted that intermediate variants are also conceivable). The studies link the choice of a solution variant to the consequences for the layout of the river bed and, in particular, for agriculture and the development of nature. If a strategy is chosen where *water guides*, a lot of agricultural land must be sacrificed and the development of nature within the embanked floodplains will receive a strong impulse. If a choice is made for a *water follows* strategy, there the main strategy is based on technical measures, such as dike raising and strengthening, river normalisation, damming and construction of weirs.

Only three studies consider all themes in their policy vision. These are the '*Future for Water'* memorandum, '*From Worrying About the Meuse to Caring for the Meuse'* and '*Water in Pictures'*. The latter, however, only has the Meuse as its area of study. This study is also the only study, where starting points for future spatial developments are made concrete. The studies '*Future for Agriculture and Water Management'*, '*WSV Professional Fishing Industry'* and '*Agriculture in the Embanked Floodplain'* integrate the smallest number of themes.

Table 3.2 Analysis according to themes

**TABEL 3.1 LOS TOEVOEGEN!!**

### 3.2.2 Spatial extent

There are 7 studies, which pre-eminently deal with the Rhine, and 2, which deal with the Meuse (Table 3.3). There are a further 6 studies which deal with both the Rhine and the Meuse. Of all the studies, there are three, which also consider the European level. Finally, there are 8 studies, which also consider other water systems apart from the Rhine and/or Meuse. The table shows that none of the studies, which were examined, consider the Rhine, the Meuse and the European level (i.e. the entire river basin).

Table 3.3 Spatial extent of the investigated studies

| **STUDY** | **SPATIAL SCALE** | | | |
|---|---|---|---|---|
| | Rhine | Meuse | European level | Other |
| Liv.Riv | * | * | | |
| IVR | * | | | |
| WSV | * | * | | - Water in general |
| Meuse | | * | * | |
| Agri | * | * | | - Water in general |
| Fish | * | * | | - Fishing on the IJsselmeer versus inland waters |
| WIN | | | | - Wet Heart |
| Rhine | * | | | - IJssel |
| AHR | * | | * | |
| Foaming | | | | - Province of South Holland |
| Flood | * | | | - Plus the branches of the Rhine |
| Pictures | * | * | | - International role of the Netherlands |
| RvR | * | | | |
| Sand | | * | | |
| Safe | * | | * | |
| Visions | * | | | |

**Time horizon**

The time horizons considered in each study are given in Figure 3.1. Two studies offer policy recommendations without explicitly examining the future (*Agriculture in the Flood plains* and *Natural Safety*). The time horizon of the other studies varies from 5-10 years to 100 years. The majority, however, describe a time horizon from now until the year 2050. Four studies also offer a view of 2100, namely '*Sparkling Water'*, '*Future for a Sandy River'*, *'From Worrying About the Meuse to Caring for the Meuse'* and '*The Rhine in Term'*.

Apart from the description of the central scenario, five studies also give a view further into the future ('*Action Plan High Water Rhine', 'Sparkling Water', 'Water Management in the Wet Heart', 'Future for Water'* and '*Lanscape Planning of the Rhine*'). '*Action Plan High Water Rhine', 'Sparkling Water', 'The Future of Water'* and *'Landscape Planning of the Rhine'* have the farthest view into the future (to 2100).

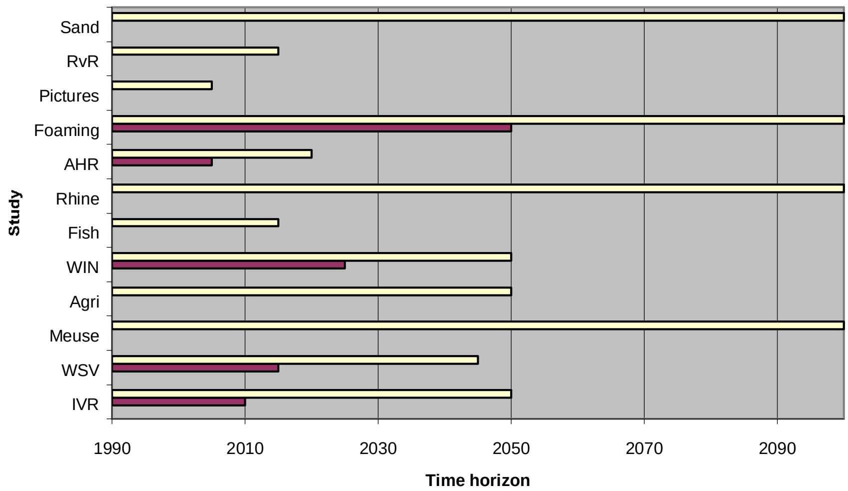


Figure 3.1 Time horizons considered in the investigated studies. Different bars indicate that different time horizons are considered in the same study

*Dimensions*

Table 3.4 shows the dimensions considered in each study. The analysis showed that only '*Living Rivers'* and '*Space for the Rhine Branches'* satisfy this criterion of integrating all dimensions.

Table 3.4 Analysis according to dimensions

| **STUDY** | **Dimension** | | |
|---|---|---|---|
| | *Environmental and nature* | *Economic* | *Socio-cultural* |
| Liv.riv. | * | * | * |
| IVR | * | * | |
| WSV | * | * | |
| Meuse | | | |
| Agri | * | | |
| Fish | * | | |
| WIN | * | * | |
| Rhine | * | * | |
| AHR | * | * | |
| Sparkling | * | | * |
| Flood | | * | |
| Pictures | * | * | |
| RvR | * | * | * |
| Sand | * | | |
| Safe | * | | * |
| Visions | * | | * |

### 3.2.3 Uncertainties

The most often explicitly mentioned uncertainties in the investigated studies concern climate change, sea level rise and soil subsidence. In most studies, climate change is mentioned as an important uncertainty concerning the future of water. Only few studies ('*Landscape Planning of the Rhine*' (Silva and Kok, 1996), '*The Rhine in Term'* (WL, 1998), '*From Worrying about the Meuse to Caring for the Meuse'* (WL, 1996) and '*Water Management in the Wet Heart'*) a statement is made on uncertainty associated with the change in climate. These estimates reason from the IPCC figures and the interpretation of these figures for the Dutch situation

(Können, 1999). Just as with climate change, the figures for sea level rise are based on global temperature rise. Estimates for soil subsidence are obtained from the Haasnoot et al. (1999).

The studies '*The Future of Agriculture and Water Management'* (CLM, 1997), '*Landscape Planning of the Rhine'* and '*Space for the Rhine Branches'* also question the reliability of the models. In a number of studies, social factors are identified as an important source of uncertainty, such as human behaviour, social support and the change of standards and values ('*Integral Examination of the Rhine Branches*', '*Definition Study of the Set of Instruments for Water Management in the Wet Heart*', '*The future of water*', '*Visions for the Rhine', 'From Worrying about the Meuse to Caring for the Meuse*', '*The Rhine in Term*'). In the studies '*Space for the Rhine Branches'* and '*Landscape Planning of the Rhine'* (Silva & Kok, 1996), the limited knowledge of the complex river system and the methods used are also mentioned as important sources of uncertainty.

*'Landscape Planning of the Rhine'* (Silva and Kok, 1996) is the only study explicitly stating that a way must be found to deal with future uncertainty. This project indicates that additional research, pilot projects and management strategies may reduce the uncertainties. No study explicitly addressed uncertainty management in their assessment of water management issues in the future.

The images of the future sketched in the studies and policy reports can, therefore, not be considered as systematic interpretations of uncertainties. Furthermore, partly as a consequence the studies reason from one set of assumptions and do not explore alternative interpretations of uncertainty in the system (i.e. uncertainty related to the world view). In doing so, the margins of uncertainty are diminished into a central estimate.

### 3.2.4 Variation

The existing studies and policy reports describe various measures and outlooks in terms of snapshots of a certain part in time. The '*Future for Water'* report (WSV, 1996) gives four variants upon which other studies and policy reports then, explicitly or implicitly, elaborate. These variants are:

- Current policy: the policy as formulated in the 3rd Water Management memorandum (V&W, 1989);
- Use: the policy in which facilitating economic growth has the priority;
- System: policy in which nature values have priority;
- Radical Change: the policy where a change in societal lifestyles leads to a natural balance between the economy and the environment.

These variants reason from the point of view of policy and, implicitly, from world view. In-depth analysis of the outlooks presented made clear that these variants can be considered as the core of four scenario clusters. In the following sections the scenario clusters emerging from the different outlooks will be discussed in more detail.

**'Current policy' scenario cluster**

The *current policy* scenario cluster sets *safety* as an uncompromising priority.

World view: In this cluster, it is assumed that by continuing traditional water management, it is possible to continue to meet the demands and desires of the user. In doing so, it is assumed that more is possible the further technology advances. This perspective, however, does not believe in revolutionary breakthroughs in technology.

Management style: This cluster includes measures that have already been decided upon. The measures, which are central in this cluster, are targeted towards achieving a better or faster discharge of water to the sea. Other utility functions and activities are secondary to this. The hierarchy of societal functions and spatial development is determined by the (national) government. This scenario cluster is devoted to adopt international agreements regarding water management and to taking preventive measures in potential flood areas.

Possibilities for the development of nature are taken into account, but this is not a primary starting point for the management style. Where possible, space will be given back to the river, if this is beneficial to prevent problems of flooding and drought. Short-term, primarily economic, interests remain more important than long-term environmental interests. In this variant, large-scale technical interventions (such as structures and dike raising) are applied to achieve and maintain the desired conditions. A consequence of this approach is a further compartmentalisation and separation of water-bound functions along the river.

In this cluster, all measures are targeted to prevent or limit the damage caused by flooding, as well as drought resulting from drainage problems. The hierarchical perspective is mainly characterised by risk avoidance behaviour. Having and maintaining control is central in the hierarchical perspective. All measures are orientated towards controlling safety. The assumption made in this cluster that short-term economic interests are more important than long-term environmental interests could also be characterised as being Individualistic. It can, however, also be conceived as the maintenance of the hierarchical status quo. In general, we can conclude that the current policy scenario cluster represents the hierarchical utopia.

**Underlying studies:**
Integral Examination of the Rhine Branches (IVR)
The Future of Water (WSV) – “Current policy”
Professional Fishing Industry (Fish) – “Current policy”
Visions for the Rhine (Visions) – “BAU-scenario”
Sparkling water (Sparkling)- “Water follows”
From Worrying about the Meuse to Caring for the Meuse (Meuse)

**‘Use’ scenario cluster**

World view: In this cluster, strong emphasis is put on economic growth. High prosperity and the creation of jobs are important for society. This scenario cluster holds that more economic and technological developments will offer solutions for reducing flood risk and environmental problems. An important assumption is that the money available for water and environmental problems grow along with economic growth. The traditional role of government will be taken over by the private sector and the free market. Multinational and other large industrial companies will deal directly with the governments and develop into a strong European lobby group.

Management style: The development of nature will be increasingly based on economic motives. Water quality will get worse in this scenario, but the development of high-tech cleaning techniques will ensure that there will be no health problems. This cluster particularly aims at solving bottlenecks for the economic functions. Risks are not avoided; they are looked upon as challenges. Insurance companies will play a larger role in the policy on flooding. In this scenario cluster, measures with the highest cost efficiency are chosen based on cost-benefit analyses. Short-term economic gains are more important than long-term solutions.

Confidence in economy and technological developments is a characteristic of the Individualistic perspective. The large influence of private companies and the declining (traditional) role of the government also fit within the Individualistic perspective. In this cluster, nature is increasingly seen as an economic good. The solution to environmental and waters problems will be increasingly looked for in the mitigation of effects (such as health and economic effects).

The hierarchical perspective is still present in this cluster, but it also shows Individualistic characteristics in terms of both world view and management style. The description of *WINb*-scenario particularly shows a combination of hierarchical and Individualistic characteristics. In this scenario, spatial planning will be made instrumental in the protection against flooding. The other functions are secondary to this aim. National government determines the spatial planning. These are typical characteristics of the hierarchical management style.

Underlying studies:

- Watermanagement in the Wet Heart (WIN) – "The space to be used"
- Watermanagement in the Wet Heart (WIN) – "The public utility"
- The Future of Water (WSV) – "Use"
- Professional Fishing Industry (Fish) – "Use"
- Visions for the Rhine (Visions)– "TEC"

**'System' scenario cluster**

World view: Restoration and further development of nature has priority in this cluster. A growing societal support for nature is assumed. Social interaction is based on respect (for each other and for nature) and solidarity. Ecological sustainability is a more important motive than economic gain. Consumption patterns change and people are prepared to invest more into ecologically responsible products. Knowledge plays an important role in the creation of durable solutions. For the river systems, this implies that there will be more space for water. Human activities are secondary to this.

Management style: In this variant, the main issue is to solve the system's bottlenecks and to utilise the ecological potential of the water systems as quickly as possible. Strict boundaries are placed around the playing field of human activities. In certain areas, functions of use with adverse effects have limitations enforced on them or are even banned. The principle of flowing storage is central here. This implies that an attempt is made to give the river its natural course back.

The management style in the *system* scenario as described in the Aquatic Outlooks (Watersysteemverkenningen, V&W,1996) is also clearly hierarchical. The citizen gladly leaves administration duties to experts and appreciates control and periodic assessment. Rules are issued from the top down (in particular from the EU). Plans are made at an international level for water management for the continental shelf, the North Sea and Wadden Sea and the river basins of the Rhine, Meuse, Eems and Scheldt.

However, *Sparkling Water* (*water guides*), which is also a part of this scenario cluster, is a combination of Egalitarian and hierarchical measures. This vision assumes that water guides the spatial planning and that the planning of functions, such as living, working and recreation, are adapted to the water system. By adapting the allocation and spatial planning to the physical conditions and natural processes, fewer measures are needed to guarantee sustainable use and safety. More space is, therefore, given to the river, so that conditions are created for strengthening and developing a natural water system. On the other hand, the safety principle takes a dominant position in this vision as well. That is why measures aiming at achieving a better flow of water to the sea, such as widening the riverbed, deepening the summer bed, moving the dykes further away from the river and diverting extreme peak flows are proposed. By placing strong emphasis on the controllability, this vision of *Sparkling Water* also has strong Hierarchical characteristics.

The *system* scenario cluster can be described as a hierarchical cluster with elements from the Egalitarian perspective. Within this scenario cluster, however, there is an area of tension between world view and management style. This scenario is, therefore, more dystopian.

Underlying studies:

- Watermanagement in the Wet Heart (WIN) – "The sactuary"
- Watermanagement in the Wet Heart (WIN) – "The blue heart"

- The Future of Water (WSV) – "System"
- Professional Fishing Industry (Fish) – "System"
- Visions for the Rhine (Visions) – "VAL"
- Sparkling water (Foaming) – "Water guides"

**'Radical Change' scenario cluster**

World view: *Radical change* is described starting from a future situation and assumes a radial reversal in the preferences of society, which is characterised by a strong environmental awareness (implying strong societal support for nature) and an altered production and consumption pattern. There is a dynamic balance between humans and nature.

Management style: The water policy is this cluster is characterised by prevention and adaptation as leading principles. Hard measures are set for the recovery of nature, including large-scale development of side channels in the entire river area. This is intended to stimulate the development of biotopes and to recover the river's ecosystems. The idea is to breathe new life into nature in the Netherlands and to offer an ecological sustainable solution to the danger of flooding. The consequence is that the agricultural land in the water meadows must be abandoned.

The vulnerability of nature is strongly emphasised in this cluster. A *limit on growth* policy is striven for, because the earth's capacity is physically limited. This cluster is characterised by a recovery of the natural system. Considerable societal changes are necessary to realise this, such as an increase in solidarity and a radical change in lifestyle. This scenario cluster is the most extreme, Egalitarian variant of the Hierarchical scenario clusters.

Underlying studies:

- The Future of Water (WSV) – "Radical change"
- Living Rivers (Liv.riv)
- Professional Fishing Industry (Fish) – "Radical change"

**General**

The *current policy* scenario cluster most strongly represents the hierarchical utopia. The policy framework for the river area is primarily based upon the 3rd and 4th Memoranda for Spatial Planning (1974, 1988), the National Environmental Policy Plan (1989, 1998) and the 3rd and 4th Memoranda for Water Management (1989, 1998). All these studies have safety as an uncompromising priority. The idea of safety as the main concern and the demand for research from dominant institutional frameworks are important characteristics of the Hierarchist perspective.

Figure 3.2 shows the position of the four clusters within the Perspectives triangle. The *Radical change* scenario cluster covers the Egalitarian perspective, starting from a limit to growth policy and radical changes in lifestyle. The basis of the Egalitarian perspective is, however, relatively small. Firstly, because only few studies and scenarios include Egalitarian assumptions and secondly, because these studies are not as much elaborated as the Hierarchist outlooks. This can be explained by the fact that the *Radical change* scenario cluster explores in general a longer time span. Due to the exploratory character of the trend break scenarios, this cluster provides only few building blocks for the development of integrated scenarios.

The Individualistic domain is the least represented. This could partly be explained by the fact that water is, by definition, not an important subject for Individualists, since it is discussed mainly from the safety (Hierarchical) and the environment (Egalitarian) aspect in the current debate. Except for the 'Radical change' scenario cluster, all scenario clusters can be categorised as

*Hierarchist*. However, the scenario clusters *system* accommodates more Egalitarian elements, such as the focus on nature values and sustainability. The scenario cluster *use* includes more Individualistic assumptions, such as the focus on economic functions and technical solutions. In order to express these nuances, we have further specified the three Hierarchist-dominated clusters in terms of world view and management style.

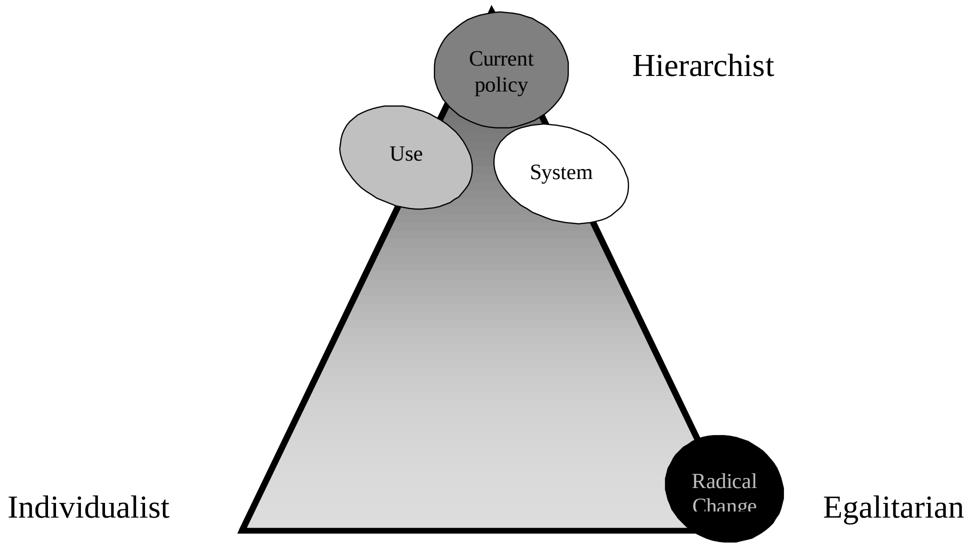


Figure 3.2 Clustering according to perspectives

There are 4 combinations of world views and management style (i.e. 4 cells in the matrix) which are not represented in the analysed studies and policy reports (Figure 3.3):

1) Hierarchical world view with Egalitarian management style;
2) Individualistic world view with Egalitarian management style;
3) Individualistic world view with Hierarchical management style;
4) Egalitarian world view with Individualistic management style.

Furthermore, few studies represent a dystopia. The *system* scenario cluster is, in that sense, the most dystopian. There are also dystopian elements within the *use* cluster.

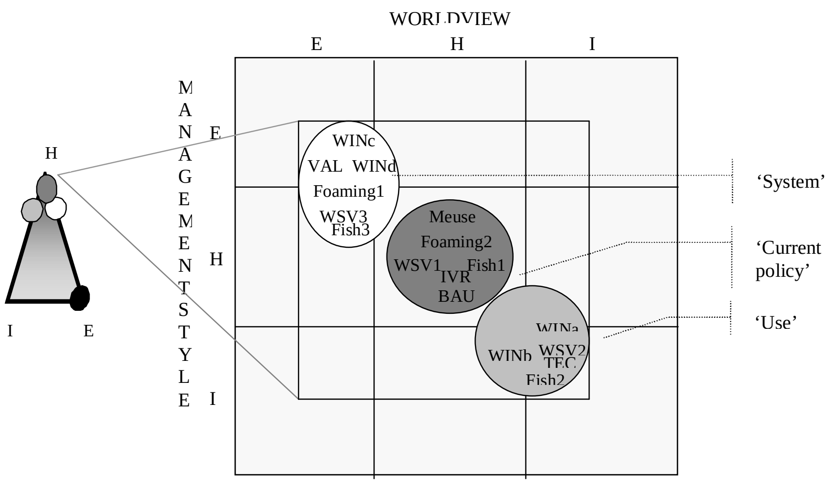


Figure 3.3 Variants within the Hierarchist perspective

### 3.3 Evaluation and conclusions

*Integration*
On the basis of the analysis carried out, the following can be concluded with regard to the intrinsic side of the existing studies and policy reports:

- The studies and policy reports are all expert based and are not developed through participation (with input from stakeholders);
- The studies are dominated by backcasting scenarios. This implies that the future is examined from target information and target objectives;
- There are no, or very few, surprises. The studies mainly offer visions. This is not the same as what we describe as scenarios (Van Asselt, 2000; (Kahn and Wiener, 1967; Anastasi, 1997). A future vision is a cross-section through time (a snapshot in time, or a photograph). A scenario, on the other hand, is a film of the future, which describes, step by step, what may occur in the future and what the consequences of this could be;
- Uncertainties are not, or hardly, examined. Although they are mentioned, they are not systematically included in the scenario analysis.

It is important that different dimensions are considered in a balanced manner and in relation to each other. Water management is a theme in which many economic, socio-cultural, as well as nature and environmental factors play a role. The analysis demonstrated that this complex character is not, or hardly, reflected in the existing studies and policy reports (cf. Van Asselt et al., 2001). The studies with a longer view are, in general, the least integrated and the most general.

We therefore conclude that to date, no integrated scenario studies have been carried out for the Rhine and Meuse. Nevertheless, the existing studies can be used as building blocks for new scenarios.

*Variation*
The investigated studies all adapt similar system assumptions. Consequently, the set of studies and reports only provides a narrow, bounded variety of possible futures. The studies and reports differ with regard to assumptions concerning policy (i.e. uncertainty in management style). However, because the studies aim to provide solutions for the same challenges reasoning from similar outlooks, also this variation does not yield fundamentally different assessments of the future. In other words, there is little variation in the futures sketched for the Rhine and Meuse. We, have, therefore, good reasons to doubt that the broad range of legitimate interpretations of the salient uncertainties is covered by the existing studies. Without the requisite variety, assessment of the future does not offer sufficient basis for developing robust policy strategies.

The analyses indicated existing scenario studies are characterised by insufficient pluralism. Therefore, this material alone does not provide a solid basis for the development of robust strategies, which is crucial in view of structural uncertainty. Nevertheless, the existing studies and policy reports do provide building blocks for examining different perspectives with regard to the water management of the Rhine and Meuse.
It is, therefore, necessary to develop integrated scenarios for water, which involve a wider set of assumptions, so that there is the sufficient variety necessary to develop robust strategies. The aim of the current project '*Integrated Water Management Strategies for the Rhine and Meuse in a Changing Environment'* is to develop such scenarios. In the following chapter we will describe how, apart from indicating the need for perspective-based scenarios, the assessment of existing studies and policy reports provides input to the project.

# 4 TOWARDS PERSPECTIVE-BASED INTEGRATED SCENARIOS

This chapter focuses on how the second and third steps of the PRIMA approach have been applied in the current project. The central issues in the second step - *uncertainty in perspective* - are identifying uncertainty, selection of salient uncertainties and perspective-based interpretation of the salient uncertainties. In this way, this step yields perspective-based interpretations of crucial uncertainties. In step 3 these interpretations will be used to systematically develop perspective-based scenarios. A schematic representation of how the project has been carried out in various phases is given in figure 4.1.

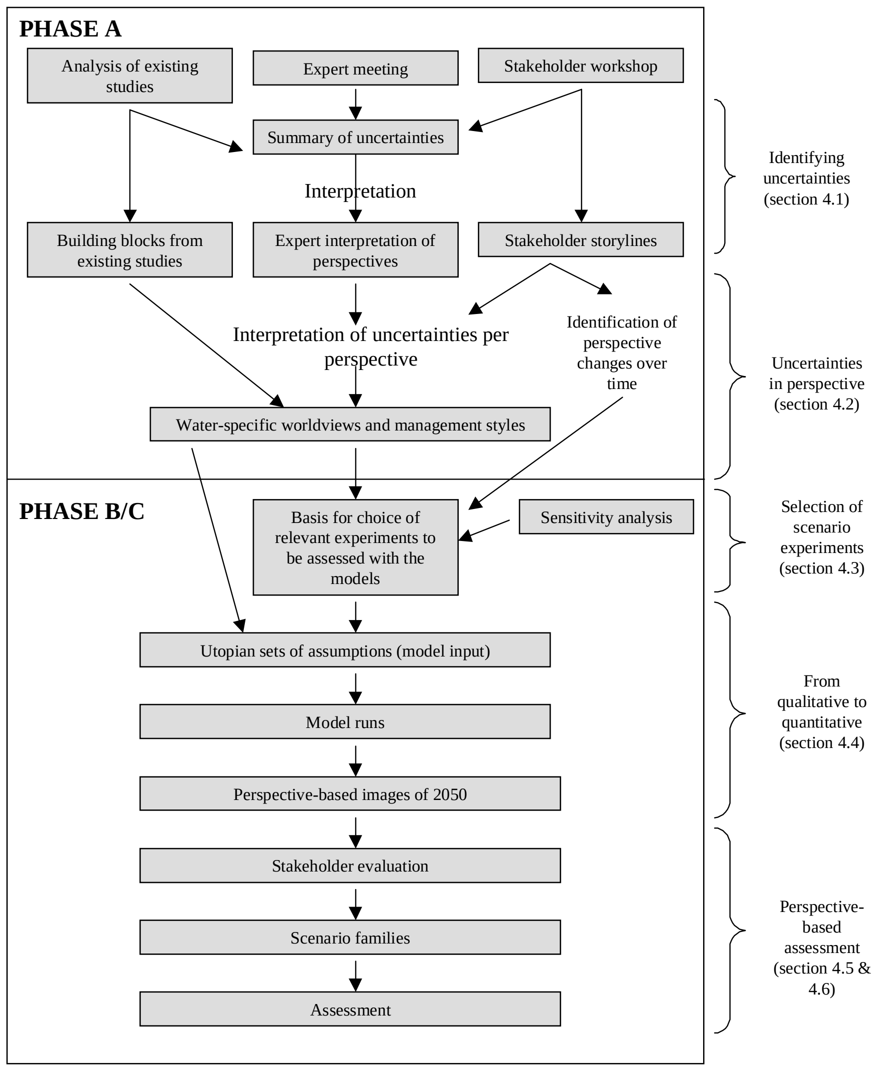


Figure 4.1 Project methodology

For the identification of uncertainties with regard to the future of the Rhine and Meuse, three sources of information were used to articulate salient uncertainties, i.e. expert knowledge, contextual knowledge and experiential knowledge. The output from the existing studies and policy reports, the output from the meeting of experts and, analysis of the results of the stakeholder workshop served as input for the identification and selection of uncertainties.

Subsequently, the three sources of information were used for the interpretation of uncertainties according to different perspectives. For the development of perspectives for water, we synthesised the interpretation of uncertainties derived from the stakeholder workshop and the expert interpretation of perspectives, thereby using the identified building blocks from the previous studies (see chapter 3) mainly to describe the Hierarchist perspective.

Building upon the storylines developed in the stakeholder workshop and a sensitivity analysis were the major input to the selection of relevant utopian and dystopian experiments. Furthermore qualitative descriptions of the water specific world views and management styles in view of the models' reach and limitations informed the choice for experiments to be meaningfully assessed with the models.

The next step was to translate the qualitative water perspectives to values for model parameters and inputs. To that end, utopian sets of assumptions have been developed which provides the basis for quantitative estimates. In estimating values for socio-economic parameters and inputs ranges derived from existing scenario studies have been used as benchmark. In this way, for each of the models used perspective-based input sets have been defined.

The models have been run with these perspective-based inputs to perform the selected utopian and dystopian experiments. The model outcomes and the qualitative descriptions of the perspectives on water were used to sketch utopian and dystopian images of 2050. In other words, the models were used to reason through the perspective-based assumptions into the future, especially pertaining to associated water-related effects, which are expressed in quantitative terms. The outlooks have been clustered into scenario families, i.e. clusters in which the world view and external context are shared. This implies that three clusters are distinguished, i.e. an Egalitarian scenario family, a Hierarchist scenario family and an Individualist one.

A stakeholder workshop was organised to review and evaluate the scenarios from the perspective of water use and users. The participants were asked to reflect on the scenarios in terms of consistency, coherency and relevance.

The final step was to evaluate the three scenario families in terms of the hydrological situation (the Rhine and Meuse basins, the IJsselmeer area and the terrestrial areas), the consequences for the user functions (safety, nature, agriculture and transport / shipping) and the characteristics of the water system (investments / costs, economic benefits and reversibility). This was done through expert judgement informed by the stakeholder input. This perspective-based assessment of water-related issues pertaining to the Dutch Rhine and Meuse river basins has been used to explore recommendations for policy.

In the following the various steps and associated outputs will be described in more detail (see also van Asselt et al., 2001c). The results of the steps i) identifying uncertainties (section 4.1), ii) uncertainties in perspective (section 4.2) and iii) selection of scenario experiments (section 4.3) are discussed in the current chapter (see also van Asselt et al. (2001c) for a more detailed discussion). The results associated with the following steps –forming the core of the project- are described in detail in the remaining chapters.

### 4.1 Identifying uncertainty

#### 1. Existing studies and policy reports

To identify uncertainties and perspectives we used the analysis of the existing policy variants and studies as building blocks for storylines of the future. Insight into uncertainties can be obtained in two different ways. Firstly, uncertainties are explicitly mentioned in the reports. Secondly, uncertainties can be derived from the assumptions used in the associated explorations of the long-term in the following way: if significantly different assumptions are used in different scenarios, this implies that uncertainty exists with regard to the underlying topical issue. See also Van Asselt (2000), where it is argued that controversy implies that opposite interpretations of uncertainty are viable. Different arguments and interpretations can, thus, be used to identify uncertainty. Since the studies are mainly written from one perspective (see chapter 3), uncertainty is likely to be veiled. This implies that the set of studies only reflects a limited number of possible interpretations of uncertainty, because similar assumptions are used. The analysis of the existing policy documents is, therefore, not enough to gain sufficient insight into uncertainty.

In the previous chapter we concluded that the existing studies mainly represent the hierarchical perspective. Nevertheless, some elements useful for the description of two other perspectives can be derived from the existing studies (see section 3.3).

**2. Meeting of experts part 1**

An "*uncertainties-in-perspective"*- brainstorming session to articulate expert knowledge was organised with the researchers gathered in the project (Maastricht, February 2000). The aim of this session was to obtain insight into the relevant uncertainties and various interpretations, evaluated as legitimate by the experts. The first part of the meeting consisted of a brainstorming session surfacing important uncertainties for the long-term future in view of the management of the Rhine and Meuse river basins. The results of this brainstorm are summarised in table 4.1.

Table 4.1 Output of experts-meeting part 1

| | Hierarchist | Egalitarian | Individualist |
|---|---|---|---|
| European Union | Top-down, strong co-operation | Democratic character, the environment as goal | Monetary Union |
| Water | Is part of spatial planning | Space for water | Water has economic function |
| Spatial planning | Top-down zoning schemes. Exchange between functions | Water and environment is guiding in spatial planning | Market-driven |
| Relationship nature-economy | Win-win situations | Nature has priority | Economy has priority |
| Agriculture | EU-regulated | Small-scale, nature friendly | Market-driven |
| Shipping | Strong regulations. Multi-functional | Clean, small and flexible ships | Market-driven |
| Industry | Strong regulation and legislation | Small-scale and clean. Work from home | Market-driven |
| Water demand | Decreased through introduction of 'grey' water and recycling | Is a matter of mentality / life style | Market-driven |
| Design discharge | Based on expert-judgement, safety first | Space for water, environment has priority | Based on cost-benefit analysis |
| Risk | Overcome through norms based on expertise and experience | Is unavoidable. Prevention is required | Risks provide opportunities. Confrontation yields solutions |
| Climate Change | Long-term issue. Research required for future policy | Major problem | May eventually become an economic problem, Technical solutions will be found eventually |

**3. Stakeholder workshop part 1**

A first stakeholder workshop was held on 12th April 2000 (for the full report, see Van Gemert and Van Asselt (2000)), with 23 people present from the following sectors: government, water management, agriculture, science, fishing and recreation. The shipping sector was also invited, but no representative of this sector participated in the workshop (see appendix 2). A plenary session was held, in which the participants were requested to brainstorm freely about events and uncertainties related to the Rhine and Meuse in the Netherlands until the year 2050. For inspiration, the participants were provided with the list of uncertainties surfaced in the expert meeting held prior to the workshop.

This session resulted in 294 *post-its* referring to events and uncertainties. The events included (compare Schneider, 1997):

- Certain surprises (such as extreme flooding)
- Imaginable surprises that are probable (strong economic fluctuations
- Imaginable surprises that are improbable (change in the Atlantic Thermohaline Circulation)
- Unimaginable surprises (the Netherlands as a whole inundates)

The surprises included events with regard to nature, climate (flooding / drought), pollution and terrorism (Table 4.2). The events and uncertainties brought up by the stakeholders were subsequently clustered according to uncertainties in various domains, namely *nature and environmental*, *economic*, *social and cultural* and *institutional* (cf. Van Gemert and Van Asselt, 2000: App. 5). In Table 4.2 it is also indicated how often a particular uncertainty was mentioned.

Table 4.2 Clustering of uncertainties according to dimension

| Economic | Nature and environmental |
|---|---|
| - *General economic developments (5x)* | - *Dykes (3x)* |
| - *Use of land (5x)* | - *High water (6x)* |
| - *Insurance (4x)* | - *Low water (5x)* |
| - *Agriculture (11x)* | - *Climate (12x)* |
| - *Infrastructure measures (9x)* | - *Sea level (5x)* |
| - *Gravel (4x)* | - *Water infrastructure (18x)* |
| - *Increase/decrease in shipping (13x/11x)* | |
| - *Demand for (drinking) water (9x)* | |

| | |
|---|---|
| - *Water as an economic good (12x)* | |
| **Social cultural** | **Institutional** |
| - *General social tendencies (12x)*<br>- *Population (11x)*<br>- *Living/working (16x)*<br>- *Drinking water (4x)*<br>- *Tourism (15x)*<br>- *Acceptance and safety (9x)* | - *Government composition (4x)*<br>- *Future of the EU (13x)*<br>- *Legislation and policy (25x)*<br>- *Regional (4x)*<br>- *International (9x)* |

#### 4.2 Uncertainty in perspective

The output resulting from the analysis of studies and policy reports, the meeting of experts and the stakeholder workshop was processed and integrated through using the taxonomy of sources of uncertainty as clustering device (Van Asselt, 2000) (see chapter 2 of this report; Table 4.3).

Table 4.3 Clustering of uncertainties according to sources of uncertainty

| **Limited knowledge** | |
|---|---|
| - Lack of observation / measurements | Rainfall |
| - Practically immeasurable | River flow<br>Sedimentation<br>Retention capacity |
| - Conflicting evidence | Climate change<br>Sea level rise<br>Resilience of ecosystems |
| **Variability** | **Uncertainty** |
| - Natural randomness | Climate change<br>Sea level rise<br>Soil subsidence<br>Rainfall<br>Flooding |
| - Value diversity | Standards<br>Societal support for nature policy<br>Acceptance of risks<br>Safety standards |
| - Behavioural variability | Lifestyle<br>Efficiently in water use |
| - Societal randomness | Prosperity<br>Population growth<br>Land use<br>International relations |
| - Technological surprise | Transport<br>Energy supply<br>Water technology |

The next step was interpreting these uncertainties and assumptions according to the different perspectives.

**1. Meeting of experts part 2**
The experts placed themselves in the shoes of the various perspectives during the second part of the meeting (Maastricht, February 2000). Furthermore, the experts studied the literature of perspective-based modelling, especially through the work of Rotmans and De Vries (1997) and Hoekstra (1998) and thereby got acquainted with the various perspectives associated with Cultural Theory. The heuristic rules (see chapter 2, and Table 4.4) and key statements were furthermore used to facilitate the application of the scheme of perspectives in the expert

meeting. Table 4.5 summarises the results in terms of assumptions per perspective (world view and management style) considered most critical by the experts.

Table 4.4 Key statements per perspective

| **Egalitarian** | **Hierarchist** | **Individualist** |
|---|---|---|
| Nature is vulnerable and no environmental risks.<br>Prevention is better than cure.<br>Equality and fraternity.<br>Economy as a means and not an aim.<br>Conscious consumption.<br>Humans stand by each other and behave in a solidary fashion. Collective interest. | Stability through rules, hierarchy and standards.<br>Regulation of nature and the environment.<br>Acceptance of differences.<br>Risk avoidance and anti-change.<br>Easy does it, otherwise you'll break the line.<br>Authority through expertise and experience.<br>Power and respect are the motives for action. | Free market mechanism and anti-regulation.<br>Economic growth and technological development is progress.<br>Individual development and material self-interest.<br>Nature is not vulnerable, but tough.<br>Problems can be solved.<br>Risks offer opportunities and challenges. |

Table 4.5 Water in perspective

| | Hierarchist | Egalitarian | Individualist |
|---|---|---|---|
| WORLDVIEW | Strict standards and top-down legislation is necessary<br>Research and expertise is important.<br>Safety above everything else<br>Water follows<br>Climate change is a long-term matter.<br>Research offers solutions for the future policy.<br>Shipping is multifunctional | Nature has priority<br>The demand for water can be decreased: is a question of a change in mentality<br>Risks are part of our world. We must deal with this in a preventive manner<br>Climate change is a pressing problem: prevention as guiding principle | Economy has priority<br>Free market<br>Economy is guiding principle in spatial planning<br>Water follows<br>Risks are opportunities, confrontation leads to solutions<br>If climate change one day will become an economic problem; solutions will be found |
| MANAGEMENT STYLE | Top-down legislation from the EU<br>Strong European co-operation<br>Win-win situation<br>Water is a part of spatial planning<br>Strict standards for industry and shipping<br>Maximum high water level is based on expertise<br>Risks are overcome by standards | EU has a democratic character<br>The environment as objective<br>Space for water: water as guiding principle in spatial planning<br>Environmental value has priority over function<br>Nature is always valued over economy in decision making | EU is characterised by monetary union<br>Water is an economic good.<br>Spatial planning is market regulated<br>Economy is leading in decision making<br>Agriculture, shipping, industry and the demand for water are market regulated<br>Design discharge is determined by cost-benefit analysis |

**2. Stakeholder workshop part 2**

Prior to the first workshop (held on April 12th 2000) (Van Gemert and Van Asselt, 2000), the participants were asked at the workshop to fill out a perspective questionnaire[3]. By means of this questionnaire we aimed to create insight in the variety of perspectives held by the workshop participants. After the plenary brainstorming session, the participants were divided into three heterogeneous work groups with the assignment to develop storylines.

This was achieved by first selecting a *starting event* from the brainstorming session and then continuing the discussion from how this event may lead to developments up to the year 2050. It was emphasised that these storylines were not about what *should* happen, but what *might* happen. One or more storylines were developed by each group according to this method. The creative process of imagination from their experience and backgrounds led to five storylines.

In the same story line exercise the participants were asked to place themselves in the assigned one of the three perspective and to develop a story line from there. The assigned perspective was explained to the groups using four key statements for each perspective (see table 4.4 and Van Asselt, 2000). The groups started again from a *starting event* and thought about the developments from the perspective of an Egalitarian, an Individualist or a Hierarchist. This sometimes resulted in a story line (groups 2 and 3), however, the largest amount of working time was taken up by brainstorming about and understanding the perspective.

[3] This questionnaire was developed in the context of the TARGETS project (Hilderink et al, 1998) with input of Cultural Theory experts Rayner, Thompson and Grendstad.

The workshop led to 5 concrete storylines. The discussions were furthermore kept through minutes of the workshop (Van Gemert and Van Asselt, 2000). After the workshop, the storylines were analysed and characterised in terms of the perspectives by analysing the action-reaction patterns and underlying assumptions. This resulted in:

- Perspective-assumptions;
- Insights into the combinations of world view and management styles that the stakeholders identified with.

As an illustration, below we will describe story line number 1 (Table 4.6) as developed by one working group during the first stakeholder meeting. The other storylines are described in more detail in the workshop minutes (Van Gemert and Van Asselt, 2000).

Table 4.6 Story line 1

| ***Year*** | ***Event/development*** |
|---|---|
| **2000 - 2005** | As a result of constant flooding, the Dutch government decides to no longer do anything about flooding. The consequence is the depopulation of the Netherlands.<br>This results, on the one hand, in more space for water and, on the other, in a change to the Dutch economy. Together with the good economic situation of the relatively rich Netherlands, the changes in the landscape and the appreciation of nature above agriculture promote recreation in the Netherlands. |
| **2010** | The Netherlands changes into a varied river landscape where water, nature, agriculture and cultural history are divided in a balanced way. The Netherlands becomes small-scale and recreation becomes an important economic driving force. |
| **2020** | Economic collapse.<br>Recreation and nature receive less appreciation, whilst the economically strong functions are stimulated. |
| **2025** | A technological society is created.<br>Safety and shipping become more important. |
| **2048** | Space for water.<br>No space for water. |
| **2050** | High water:<br>Economic stagnation |

The storylines represent various possible action-reaction patterns, thereby giving insight into different interpretations of uncertainty (what *can* happen in the future and what is *plausible*) and possible surprises.

The workshop led to 5 concrete storylines and the numerous discussions and minutes of the workshop provided very practical material. Elements of story line 2 and 5 were used to substantiate interpretation of the Hierarchist water perspective. The other separate storylines had sufficient internal logic and consistency. It was noticeable that these were not linear, but were characterised by action-reaction patterns. This gave time-periods a different character, which were subsequently analysed on the basis of the perspective scheme. We used the heuristic rules (see chapter 2, table 2.1) to characterise the storylines or episodes in the storylines in utopia and / or dystopia terms. In this way, the various observed perspective changes could be characterised in terms of world view and management style (see Figure 4.2).

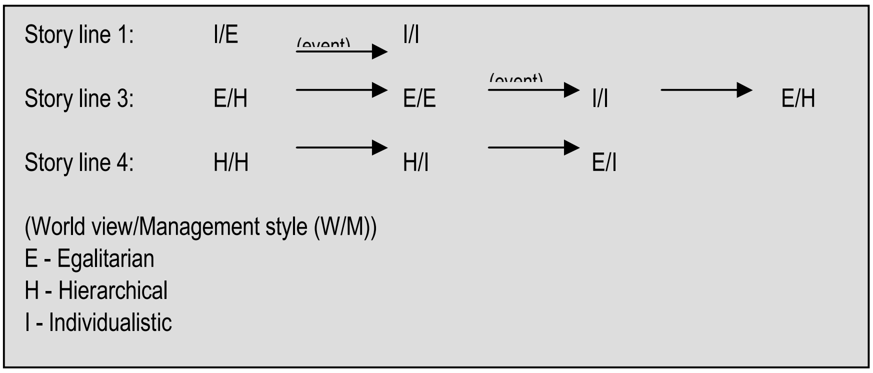


Figure 4.2 Storylines with changes

Below we will shortly illustrate the action-reaction pattern and our assignment of perspective-based world views and management styles per period by using story line 1 as an example case:

- 2000: The starting event in this story line is continuous flooding.
- 2000-2020: In response to this event more space is given to water, which is an Egalitarian policy measure. The world view in this period is, however, predominantly Individualistic as significant economic growth is assumed and a central economic function for the recreation sector [I-E].
- 2020: Event.
- 2020-2050: Due to economic collapse, nature receives less appreciation and economic functions are further stimulated. By the year 2025 a technological society is created. These characteristics coincide with an Individualistic utopia [IND-IND].

This analysis of the storylines indicates that it is possible and appealing to introduce bifurcations by using different combinations of world view and management style for different episodes. These three storylines could be developed further so that they could be examined using models. However, it turned out to be an intellectual challenge to use existing models to represent such non-linear scenarios (see also chapter 7). For that reason, we concentrated first on developing linear integrated perspective-based scenarios. What we have done is to use the storylines to further develop water-specific interpretations of the three perspectives. Together with the input from existing studies and the expert input for each perspective a water specific world view and management style could be established as is summarised in Table 4.7. This table provided the basis for further use of the perspectives in the project. In structuring and detailing the water-specific assumptions per perspective use was made of Hoekstra (1999). This table provided the basis for further use of the perspectives in the project.

**Observations**

During the first stakeholder workshop three heterogeneous discussion groups were formed, the Hierarchist, the Egalitarian and the Individualist group, consisting of stakeholders from various disciplines and professional backgrounds. As these groups were formed, it was felt that heterogeneity and confrontation between different perspectives would stimulate discussion, in such a way that deviating standpoints would come to the fore. However, this choice turned out to have also three major drawbacks:

- First, there was a problem of identification: as some people in the group we asked to empathise with, for them, unfamiliar assumptions and arguments. In some cases empathising a deviating perspective turned out to be problematic.
- Second, because some people were asked to empathise with an unfamiliar perspective, they felt like being in a disadvantaged position and not able to defend their own interests in the discussion with other stakeholders in their group.
- Third, as a result of the heterogeneity of the group, the extremes were flattened out, rather than made more explicit.

From this experience, we learned that in stakeholder workshops with a heterogeneous group of perspectives such a role-game type of perspective exercise is not advised. Compare experiences with more homogeneous groups (i.e. Van Asselt, 2000, Van Asselt et al., 2001c) where such exercises did work. In case such perspective role-play are used it is to be preferred that the syndicate groups are selected according to perspective, so that the subgroup empathise with the assigned perspective. As the second stakeholder workshop experience indicates, such an approach seems to be possible and fruitful.

Table 4.7 Description of water-specific world view and management style per perspective

**OVERDWARS, los inleggen**

### 4.3 Selection of scenario experiments

Ideally, the whole utopia/dystopia matrix (i.e., all possible combinations of world view and management style) should be worked out, but for practical reasons, this is not possible. The model experiments (particularly the connected set of rural hydrological models (Haasnoot et al., 1999)) require too much calculation and analysis time to do so within the time-scale of the project. Therefore, a *light version* of the rural hydrological models has been developed which can be used to reduce the representation of the Netherlands from 130,000 plots to 20 plots. The properties of these plots have been chosen so that they are representative for a certain type of (hydrological) area in the Netherlands. In this way, we are able to perform a larger number of calculations.
Secondly, we learned that not all experiments were interesting, since translating the complete set of assumptions to the models was not possible, which would result in identical model outputs for different scenarios. The Rhineflow calculations, for example, showed an overlap between combinations EGA/IND and IND/EGA in terms of effect of measures on discharge. This can be explained as follows: in the Egalitarian perspective, land use changes (in terms of Rhineflow input this should be interpreted as 'extra forest') helps to store water. In combination with the Individualistic management style, however, this has no effect, as these forests are not built. In de Individualist perspective, forests are built, while land use change has no effect on water storage.
Thirdly, some combinations of assumptions would lead to parameter values outside the scope of the models. This would lead to unreliable or unrealistic model results, or aborted model runs. Therefore, we decided to assess whether and how the number of calculations could be reduced without violating the aims of the project.

We developed the following criteria building upon discussions with the project team:

- The most extreme scenarios should be calculated so that sufficient variation is maintained.
- We prefer not to reinvent the wheel: the Hierarchist scenario has been extensively described in existing studies and policy reports. The decision has, therefore, been made to draw the hierarchical utopia from the existing studies and policy reports. No new model calculations will be made for the hierarchical utopia; instead we will use the calculations from 'The impact of climate change on the river Rhine and the implications for water management in the Netherlands (NRP-2)' (Middelkoop, 2000).The workshop material will be used to gain insight into which combinations appear to be important for the societal debate and decision-making processes. Analysis of the stakeholder workshop output shows that the following combinations were not mentioned in the workshop: i) a Hierarchical world view with an Egalitarian management style, ii) an Egalitarian world view and hierarchical management style, iii) an Individualistic world view and a hierarchical management style and iv) the three combinations of the Egalitarian world view in a wet variant. The combinations touched upon in the stakeholder workshop are marked as 'WS' in figure 4.3.
- It is expected that some distinct cells in terms of model inputs and thus in terms of output of the calculations do not differ.

Experiments with a hierarchical world view and an Egalitarian or Individualistic management style will not be included further in the process of scenario examination. Firstly, because these combinations were not mentioned in the workshops and, secondly, because the combinations are not interesting from a model point of view as they are in between the extremes of Egalitarian and the Individualistic perspectives.

In the Egalitarian world view, a distinction is made between a dry and a wet variant. In the dry variant temperature and precipitation are uncoupled (cf. Commissie Waterbeheer 21e eeuw, 2000). It is assumed in this scenario that the frontal precipitation amount decreased by 10%, combined with the high estimate of the temperature. These extreme bandwidths are enhanced by considering an imminent change in the Atlantic thermohaline circulation (Können, 2001). As the Egalitarian considers the largest bandwidth of climate change, both extreme wet and dry situations are in accordance with the Egalitarian perspective. For that reason, it was argued that the two variants of the experiments considering the Egalitarian world view have to be distinguished.

Based on the criteria above, the following cases appeared to be interesting to simulate with the models.
Case 1: Perspective: Individualist, Management style: Individualist
Case 2: Perspective: Individualist, Management style: Egalitarian
Case 3: Perspective: Egalitarian-wet, Management style: Egalitarian
Case 4: Perspective: Egalitarian-dry, Management style: Egalitarian
Case 5: Perspective: Egalitarian-wet, Management style: Individualist
Case 6: Perspective: Egalitarian-dry, Management style: Hierarchist
Case 7: Perspective: Egalitarian-wet, Management style: Hierarchist
Case 8: Perspective: Egalitarian-dry, Management style: Individualist

Subsequently, a distinction was made between simulations to be calculated using the entire model and scenarios that will be calculated using the light version.

The cases were simulated in the above order. While the results of the Rhineflow runs became available, some very clear patterns emerged. In the analysis of the results of case 1 to 6, it became clear that the hydrological regime as simulated by the Rhineflow runs is very sensitive to changes in world views, but hardly any sensitivity to changes in management style could be distinguished. Given these considerations, it seemed superfluous to simulate case 7 and 8. For the further analysis in the project, the results of Rhineflow for Case 7 are considered the same as for Case 5, and Case 8 is considered the same as Case 6. However, one should realise that this simplification is only legitimate when analysing the hydrological regime at Lobith, but this is not necessarily true when analysing local situations with time-series instead of hydrological regime analysis.

We also decided not to calculate all the cases with the Winbos model. The results of cases 2, 6, 7 and 8 are based on the results of the other cases and on results of other calculations which were done in the WIN-project (Hebbink and Breukers, 2000). For the IJsselmeer regime the water levels are predominantly influenced by sea level rise. The Rhine discharge is of minor interest compared to sea level rise for the IJsselmeer hydrology. Because sea level rise is an exogenous factor and, therefore, outside the sphere of influence of the water manager, the differences between different management styles are relatively small. This is true when the discharge capacity of the sluices at the Afsluitdijk is the same. The perspective-based interpretations of the model parameters of Winbos show that in the Hierarchist and the Egalitarian management style the sluice capacity is doubled, whereas in the Individualist management style the sluice capacity increases by factor 1.5. Therefore, the outcomes of case 7 (Egalitarian-wet world view combined with a Hierarchist management style) could be interpreted from case 3 (Egalitarian-wet world view combined with an Egalitarian management style); and case 8 (Egalitarian-dry world view combined with an Individualist management style) could be interpreted from case 6 (Egalitarian-dry world view combined with a Hierarchist management style). The resulting choices concerning model experiments are summarised in Figure 4.3.

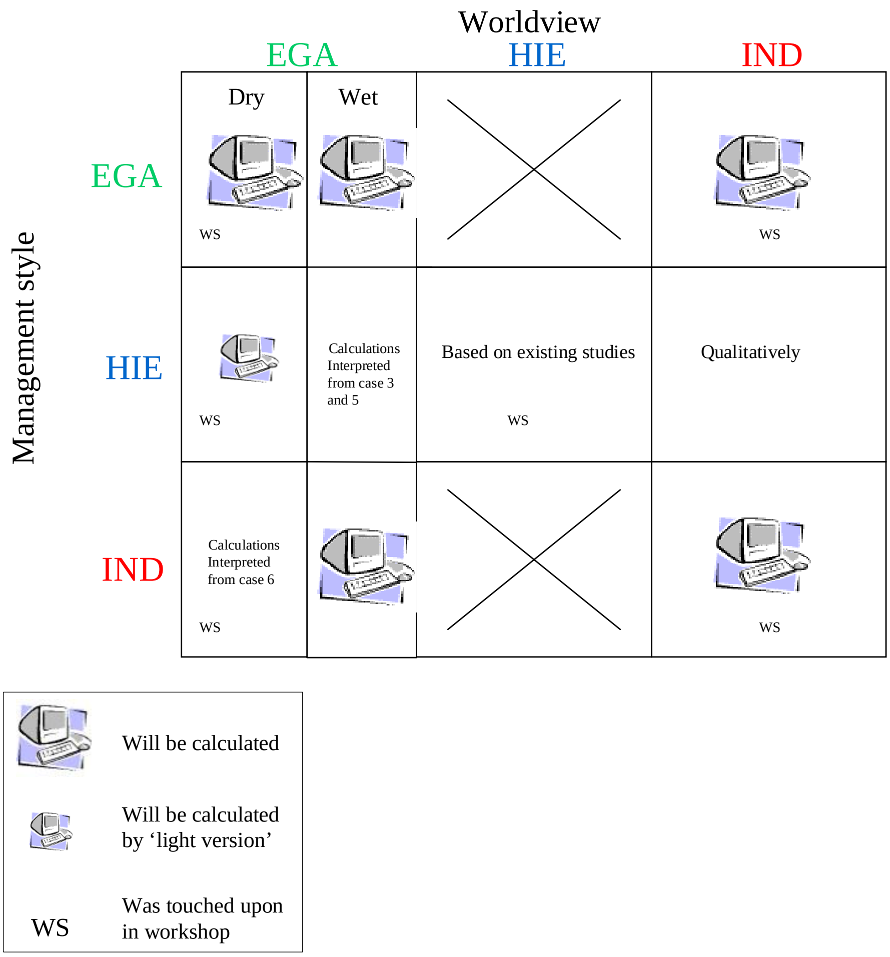


Figure 4.3 The utopia / dystopia matrix

### 4.4 From qualitative to quantitative

The second phase of the project was devoted to quantification of the perspective-based input and calculation. The model calculations are used to quantitatively assess and illustrate future developments for each set of perspective-based assumptions, whether utopian or dystopian. The qualitative descriptions and the associated images for 2050 which are derived from model outcomes were presented to stakeholders for review and evaluation in a second stakeholder workshop (the 26th of April 2001).

**The second stakeholder workshop**

The workshop started with a general introduction to the project, followed by a presentation of the three scenario families. Each scenario presentation was followed by a discussion. The Egalitarian scenario family was discussed in a group session and the other two families were discussed in a plenary session. During the second half of the workshop, the scenarios were discussed in terms of policy strategies and favourable policy options. Building upon our experiences from the first stakeholder workshop (see section 4.1.2) more or less homogeneous working groups were formed: the first representing the Hierarchist perspective, the second the Egalitarian and the third the Individualist perspective. The workshop output was used to improve the consistency and plausibility of the scenarios.

Before the workshop sessions, the workshop, the participants were again assigned to fill out a perspective questionnaire (see also section 4.2). After the workshop the participants were asked to fill out a questionnaire through which they could express their feelings about the organisation of the workshop and the project in general.

In order to translate the qualitative perspective-based assumptions to quantitative model input, we had to determine which assumptions relate to which inputs and parameters in the model (Middelkoop et al., 2000). Ideally, the perspectives in the scenarios are to be reflected in the choices made regarding parameters, variables, model structure and equations (Rotmans and De Vries, 1997), (Van Asselt and Rotmans, 1996; Hoekstra, 1998, 1999). In this project, however, the perspectives are translated into the models through inputs and parameters. Alternative equations would have required re-modelling, which was beyond the scope of the project. The aim of the project was to explore what insights perspective-based assessments with existing models would yield. Such an exercise would yield limitations and drawbacks of existing models, which could then motivate a next modelling endeavour. If the project had focussed on models, the experience teaches us that then not enough time would have been spend on designing and selecting model experiments nor to the assessment of the experiments. The current project had the explicit ambition to focus on coherent perspective-based set of assumptions as a basis for a more systematic and integrated assessment of the salient uncertainties associated with water management of the Rhine and Meuse in a changing environment and an uncertain future.

**External context**
Ideally, we would have developed scenarios for the external context in a thorough manner, i.e. in close collaboration with experts on the various subjects (such as economy and demography), in line with state-of-the-art scholarly literature and through use of the most advanced models in the relevant fields. However, the development of such sophisticated external context scenarios was beyond the capabilities and the expertise of the project team and beyond the time frame of the current project. Therefore it is fair to characterise the current project as nothing more and nothing less than a first step towards broader and more integrated scenarios for the Netherlands.

Eight (exogenous) context variables were perspective-based interpreted:

- Climate change
- Soil subsidence due to the exploitations of natural gas
- Economic development
- Agriculture
- Urbanisation
- Population growth
- Water demand
- Shipping and navigation

Below we discuss for each of the context variables how estimates for each perspective have been derived.

Climate change

The figures for climate change are derived from estimates by the Royal Dutch Meteorological Institute (KNMI) - based on the IPCC estimates (IPCC, 1995) and applied to the Dutch situation (Können, 2001). These figures are similar to the scenarios developed in NRP-2 (Middelkoop et al, 2000)), WB21 (Commissie Waterbeheer 21ste eeuw, 2000), the 4th Memorandum of Water management (NW4, 1998) and previous greenhouse scenarios formulated by KNMI. The lower and higher estimates being +1 ºC - +4ºC respectively in the year 2100. The IPCC Third Assessment Report (TAR) (IPCC, 2000) estimates global warming 1.2ºC higher than the high Second Assessment Report (IPCC, 1995). According to Können (2001), although the IPCC widened the range of global warming, there are no reasons to change the range for Europe accordingly[4]. Four reasons are advanced:

- The inherent large uncertainty of regional climate projections combined with the fact that the temperature response of region Europe to global warming is small with respect to other regions.
- Downscaling of the output of extreme GCMs to precipitation may produce less realistic results than those of moderate GCMs.
- Downscaling using the empirical temperature-precipitation relations requires an extrapolation for outside the domain of this relation.
- An extrapolation of the precipitation scenario based on the temperature-precipitation relation to a 5.8ºC temperature rise would lead to an increase in precipitation that is outside the range in the regional IPCC projections for Europe.

In line with the above its was decided to adopt the +1ºC - +4ºC range for our scenarios (cf. Appendix 3).

The range given for precipitation is based on WB21 and varies from + 4% to -10% in summer and from +25% to –10% in winter in the year 2100. The value ranges associated with evaporation are based on (Haasnoot et al., 1999) and (Kors et al, 2000). The evaporation range varies from +4 % to +16 % in the year 2001. The figures for sea level rise are based on the IPCC estimates, supplemented with the natural trend and subsidence of the Netherlands. The range given varies from +20 cm to +110 cm in 2001 (see appendix 3).

Soil subsidence

The figures for soil subsidence for the year 2050 in the Netherlands are derived from the NRP-2 study (Haasnoot et al., 1999). Three major causes of land subsidence in the Netherlands are identified:

- Oxidation and settlement of Holocene deposits, especially peat soils, due to intensified drainage conditions
- Mining activities, especially due to gas
- Tectonic movements

The figures for oxidation and settlement are based on figures from the Provincie Friesland (1997). For the polders the southern Flevoland extrapolated measurements made by DRIJP (Van Dooremolen et al., 1996) have been used. In this area a stronger land subsidence occurs due to the riping process of the soil. The most important mining activities of gas are those in the northern Groningen and Friesland provinces. Estimates for land subsidence caused by mining activities originated from data from NAM (the Dutch Petroleum Company). For the year 2050, land subsidence figures up to 35 cm. are foreseen. Tectonic movements have the least severe effects on soil subsidence. It was derived by interpolating 40 measure points funded on the Pleistocene deposits (Lorenz, 1991). The effects of the different types of land subsidence have

[4] During a meeting about the TAR, organised by IPCC (Amsterdam, April 2001), the speakers repeatedly pointed out a need for studies on the impact of a temperature rise of 6 ºC. Also after the presentations, several participants (representing nature organisations and research institutes) asked us to adjust our maximum estimation of climate change from 4 ºC to 6 ºC in 2100. However, KNMI advised against a scenario of 6 ºC for the Netherlands for the four reasons mentioned above. In future exercises, broader ranges may be applied.

been quantified for the year 2050 and the effects have been summed to a estimated overall land subsidence for 2050. The given range varies from subsidence more than 60 cm to land rise more than 2 cm in the year 2050.

Economic development & population growth

In the Netherlands, the CPB-scenarios (CPB, 1992; 1996) are the dominant source of economic and population growth. An analysis of the scenarios developed by CPB in the context of a review of European scenarios (Van Asselt et al., 1998 and Van Asselt, 2000) indicated that the variety expressed by the set of scenarios is quite limited. First of all, the scenarios propose a linear relationship between economic growth and technological development. The postulated relationship implies that a lower economic growth is associated with fewer funds for technology, and thus less "eco-technology". The consequence is that low-economic-growth future is associated with a relatively high physical growth of the economy. This means that none of the scenarios developed by CPB involves a future in which economic growth is not a condition for technology improvement, but in which a more environmental-friendly lifestyles are adopted, and available technology innovations are applied on large scales. Due to the rigid assumptions with regard to the relation between economic growth and technological innovation and the consumption-driven calculation of production trends, the CPB-scenarios can be characterised as rather extrapolative. In view of the ambitions of the current project, these scenarios seem to cover too little variety. However, on the other hand there are no better authoritative and qualified outlooks for the economic development and population available. So, notwithstanding the recognised limitations, the CPB scenarios have been used to associate quantitative numbers with the qualitative descriptions pertaining to economy and population.

The percentages for economic growth are based on the CPB-scenarios (CPB, 1996). The CPB ranges for economic growth vary from 1½ % a year to 3¼ % a year. For our model calculations we used round figures, in order not to assume precision. Therefore, we adopted a range for our scenarios from 1% to 3 % a year. The estimates for population developments are based on the CPB-scenarios (CPB, 1996). Ranges derived from this study are 0.2 % – 0.6 % / year.

Urbanisation

In estimating future urbanisation trends, we build upon the public debates around the 5th Memorandum of Spatial Planning (Ministry of Spatial Planning, Housing and the Environment, 2000) and (Commissie Waterbeheer 21e eeuw, 2000). In the public debates the ranges varied from 0 (due to an expected condensation policy) to 225.000 ha (the sum of 70.000 ha reserved for housing and 155.000 for economic activities).

Agriculture

The ranges for agriculture are derived from the public debates around the 4th Nature and Environmental Plan (NMP4). The ranges varied from – 7% to –20% in the year 2030. These ranges were extrapolated and rounded to respectively –10 and –30% in the year 2050. In the 4th Nature and Environmental Plan (published June 2001), it is assumed that in 2030 the Dutch life-stock will decrease by 50% due to autonomous developments and governmental policy. Furthermore, it is assumed that 200.000 to 300.000 ha of the agricultural acreage will suffer from wetter grounds (due to more natural groundwater levels in the EHS areas.

Drinking water

For the interpretation of the demand for drinking water we were not able to find adequate scenarios. The Dutch Water Company provided prognoses, in which a 10% increase of water demand was assumed in the year 2015. The increase of 10% was extrapolated to 20%, building upon the following assumptions:

- Flattening of the decreasing water use;
- Decrease of the average house occupation;
- Increase of water use per person, per day;
- Introduction of different kinds of water (such as grey-water);

- Decreasing water use by bulk-consumers.

To explore the range, we coupled water demand to ranges for economic growth. In this way, we estimated a maximum increase of 30% and a minimum of 0%.

We realise that the variety of the ranges that derived from existing scenario studies may be still limited. In using these ranges as benchmark, the perspective-based interpretations are bounded. Nevertheless, in this pragmatic but transparent manner we derived motivated quantitative estimates for each context variable.

**Utopian sets of assumptions**

In Chapter 5 we describe in detail the set of utopian assumptions that provide the basis for the further quantification of the perspective-based scenarios. Utopian sets of assumptions involve the a priori expectations concerning functioning of the system (world view) and policy (management style). The utopian sets of assumptions are subdivided in three parts: external context, national scale level and water system scale level. The *external context* includes the exogenous variables (i.e. input variables outside the sphere of influence of the management style) (see above). The *national scale* involves the following water-related inputs and parameters:

- spatial development
- surface water management / natural storage
- groundwater management
- These variables cover the inputs and parameters included in the rural hydrological models. The *water system* level include variables pertaining to:
- river measures
- retention areas
- sluice management

The quantitative ranges identified from existing scenario studies, scholarly literature and through expert judgement from the experts involved in the project serve as benchmarks for the quantification of the qualitative perspective-based assumptions so that they can be handled by the models.

***Model runs***

The selected 7 combinations of world views and management styles as identified in the utopia / dystopia matrix (3 utopias and 4 dystopias) will be further assessed resulting in 5 utopian and dystopian model experiments. The models used in this exercise involve Rhineflow, Meuseflow, WINBOS and NAGROM-MONA-MOZART-DEMNAT-AGRICOM (the rural hydrological model chain). See Box 4.1 for a short description of the characteristics and type of model output. The model runs are extensively documented in (Buiteveld et al., 2001). In Chapter 6, we limit ourselves to a summary of the main output.

**Box 4.1 Short model descriptions and output**

RHINEFLOW and MEUSEFLOW
Rhineflow and Meuseflow are a GIS-based water balance model for the Rhine and Meuse catchments respectively (Kwadijk, 1993) (van Deursen, 1995). The models use standard meteorological input variables of temperature and precipitation, and geographical data on topography, land use, soil type and groundwater flow characteristics. These parameters are stored in a raster GIS with a spatial resolution of 1x1 km². The aim of the models is to give detailed information about the hydrological response of the Rhine and Meuse catchments to climate change scenarios.

*Model output*
- Discharge statistics
- Impact on frequency of flooding (after statistical downscaling of the results)
- Impact on safety standard of the design of river dikes in the Netherlands

LPR-DSS: landscape planning of the embanked floodplains
Decision support System developed for Landscape Planning of the Rhine. Using this DSS, implications of various landscape planning strategies and measures for the embanked floodplains have been tested on their effects on water levels, nature, agriculture and resilience.

*Model output*
- flood water levels
- areas with nature, agriculture
- cost

WINBOS
The effects of climate change on the IJsselmeer area are calculated using models of the so-called WINBOS instrument. Winbos is a decision-support system that consists of several couples models, developed for WIN –study (Water Management in the central part of the Netherlands (Iedema & Breukers, 1998; Oosterberg et al, 1998)) to study the effect of alternative water management strategies and changing climate on the IJsselmeer area.

*Model output*
- Lake water level statistics
- Length of dikes where dike rising is required (km)
- Costs of dike rising
- Length of extra shallow forelands (km) and costs
- Drainage (cubic(s) / costs)
- Water availability (cubic (s) / costs)
- Birds statistics as parameter for nature

NAGROM-MONA-MOZART-DEMNAT-AGRICOM
The nation-wide impacts of climate change, land subsidence and changes in land use have been determined with a comprehensive set of eco-, agro- and hydrological models (RIZA, 1997) (Haasnoot, 1999). The hydrological results in groundwater levels, discharge, amount of upward see page and infiltration. This output is used to calculate change in nature conservation value with DEMNAT and the costs and benefits for agriculture with AGRICOM. The input parameters, like soil characteristics and water management variables are mainly based on GIS maps of 500 x 500 m.

*Model output*
- Impact on the hydrological system
- Groundwater levels
- Upward and downward seepage
- Salt loads in surface water
- Discharge
- Externally supplied water

Impact on water system functions
- Change in nature conservation values
- Costs and benefits for agriculture

### 4.5 Scenario families

The model runs yield a set of perspective-based images of 2050. These quantitative outlooks have been combined with the qualitative descriptions to sketch utopian and dystopian images of 2050. In other words, the models are used to reason through perspective-based assumptions into the future, especially in terms of associated water-related effects. The sets of images of 2050 enable us to evaluate the perspective-based assumptions in terms of expected discharges, groundwater tables, reversibility, investments and economic gains. The model outcomes associated with user functions sketch agricultural gains or damages, nature values, shipping developments, social values (i.e. quality of life) and safety. An integrated perspective-based scenario is then defined as the combination of the set of underlying assumptions (Chapter 5) combined with the associated image of 2050 derived from model calculations (Chapter 6).

The future outlooks have been clustered into three scenario families. The clustering criterion involved shared world view and external context. In this way, in each family the underlying system assumptions (external context, national scale and water system) are similar. This implies that a utopia and the associated management-style dystopias form one scenario family. So world view and external context are similar over the clustered scenarios and the management styles vary. A family is clustered around the utopian image. This led to three scenario-families: the Egalitarian, Hierarchist and the Individualist family. Each scenario-family, starts with the utopian description and is followed by the associated dystopian combinations (see figure 4.4). In the Hierarchist scenario family only the utopia is described, because the other combinations have not been investigated (see selection of experiments, section 4.3).

The dystopian images can be considered as bifurcations to the utopian outlook. In doing so, the scenarios are presented as branching 'what-if' assessments of the future (compare (Rotmans et al., 2001)). The pitfall of any scenario exercises is to classify one of the scenarios as the most likely scenario or best-guess scenario. In this way the output of scenario analysis then masks inherent uncertainty, which was originally the starting-point of the analysis (Van Asselt, 2000). Through our presentation of future outlooks through scenario families this pitfall is avoided.

| | | ***Hierarchist family*** | ***Individualist family*** |
|---|---|---|---|
| ***External context*** | 1 | 2 | 3 |
| ***Evaluation 2050 Utopias*** | EGA (wet + dry) | HIE | IND |
| ***Evaluation 2050 Dystopias*** | ↙ HIE (wet + dry) ↘ IND (wet + dry) | | ↙ EGA ↘ HIE |

Figure 4.3 The three scenario-families

### 4.6 Perspective-based assessments

As an intermediate step towards an integrated assessment of the scenarios, the water experts in the project have evaluated the three families of scenarios. The statement structured the evaluation involved: 'water management according to perspective X results in….'. In doing so conclusions were drawn for each perspective and associated management style. In this way risks associated with management styles can be assessed. As a next step, the utopian and dystopian scenarios were evaluated in terms of functions that were identified in the beginning of the project (see Middelkoop et al., 1999 and chapter 1) and which were refined during the last expert meeting in Maastricht, June 8th 2001.

The functions are evaluated for the river basins Rhine and Meuse, the floodplains, IJsselmeer and the terrestrial areas. The evaluation of the *floodplains* is based on the NRP-2 final report (Middelkoop, 2000) of the project 'The impact of climate change on the river Rhine and the implications for water management in the Netherlands' and Termes et al. (1998) and Termes et al. (1999). The evaluation criteria for the *river basins* are applied on the upstream of Lobith and Borgharen. It focuses on the effect of the water supply to the main channels. It does not include measures in the flood plain. The outcomes of the *terrestrial* indicate effects on nature, agriculture and quality of life. In addition, the effects of management style on the economy in terms of costs and the reversibility of measures is considered.

The evaluation criteria were defined as follows:

- *Safety* is considered as the probability that a catastrophic (in terms of risk impacts for humans) flooding of the river polders may occur. For the river basins this is the probability that extremely large discharges at Lobith or Borgharen occur.
- In the river basin models '*nature'* is defined as forested area. Forests evaporate more than agricultural areas and in forests more water can infiltrate. Both effects should reduce the flood peaks. For the floodplain area nature is defined as the total area occupied by 'nature', which may be floodplain forest, wetlands or grasslands (not used for grazing/agriculture). Floodplain forest is hydraulically rough, and causes groundwater levels to rise. Wetlands and grassland are smoother. During dry periods in summer, groundwater tables in the floodplain may become low, which is unfavourable for ecology, particularly for small ponds. Nature values for the IJsselmeer are mainly determined by the length of shallow foreshores along the lake's dikes. In the terrestrial models nature is considered as the terrestrial ecosystem in the Netherlands. In particular the terrestrial and aquatic vegetation. In this study an expansion of nature is always positive. More unique ecotopes (mainly growing in wet areas) and areas with a high biodiversity are valued higher. In general, high groundwater levels and a good water quality are favourable for nature. In contrary, dryer periods will lower nature conservation value, especially when this occurs in summer.
- *Agriculture* is primarily the area occupied by agriculture, main land use in meadows, with some scattered arable fields. Floodplain lowering (needed to increase the discharge capacity of the high-water bed) will lead to higher groundwater tables and increased flooding frequency. Both are undesired from an agricultural viewpoint. In the evaluation of the terrestrial areas it is further taken into account that more precipitation and/or reduced artificial drainage will increase groundwater levels, which will diminish agricultural yields. Increase of the total agricultural area is considered as positive for agriculture.
  In general there are two counteracting effects that determine the sign (positive or negative) of the impact of agriculture. These are:
  - Change of the total area of agriculture in the Netherlands. Less agriculture means less damage on a national scale, but also less economic profits.
  - Climate change. An increase of the precipitation results in more water logging damage.

  In most scenarios agricultural acreage decreases as the urban or nature areas expand. As a result, the total costs summed for the Netherlands decrease. The spatial distribution of the water logging damage may show different effects. On this scale a larger climate change will result in more precipitation and water logging damage. To indicate the counteracting effects of land use changes and climate change, the results of the model

AGRICOM are presented in terms of total costs summed for the Netherlands as a whole, and changes in drought and water logging damage in a map with a grid on a scale of 500 by 500 m. In the evaluation table we present the effects for the individual farmer. A '+' represents an increase of the total amount of agricultural area and a higher yield per square metre.

Agriculture in the northern part of the Netherlands depends on the water supply from the IJsselmeer area. Problems occur when the lake levels are lower than the target levels for longer periods. Due to the sea level rise the lake levels increase. Referring to WINBOS calculations there are hardly any problems to be expected for agriculture seen from the water supply from the IJsselmeer.

- For *transport/navigation* three evaluation criteria were identified (see also Middelkoop and van Deursen, 1999): transport costs, the storage volume needed to tide over periods of decreased cargo capacity (e.g. due to draughts with decreased discharge) and reliability. In the IJsselmeer area, because in general an increase in lake level is expected, there are no negative effects on navigation.
- *Investments* are the costs of the measures taken. For the river basins investments are the costs of spatial planning measures in the river basin (e.g. buying areas to restore nature, raising dikes, infra structural measures). Within the embanked floodplains, these are cost of measures such as removal and sanitation of clay from the floodplain surface, dike raising digging side channels. The level of investment is judged qualitatively by the experts building upon their extensive knowledge of water management measures.
- The valuation of *economical benefits* depends on the definition of 'economic' sectors. Agriculture is considered a separately. For the river basins economy / benefits are considered as how much area can be potentially used for economic activities. Main river-bound economic sectors within the floodplain area are recreation, brick production and shipyards. All will benefit from a reduction in floodplain inundation, but the benefits are low and insignificant when comparing to other criteria. For the *terrestrial areas* economy is considered as the possibility to have economic goods. Simplified, an increase of the urban areas will provide more space for economy, industry and recreation. Consequently, this is considered as positive for the economy.
- *Flexibility / reversibility* is the ability of the water system to adapt to the continuously changing conditions (climate, implementation of retention measures upstream), without having taken irreversible measures, such as digging away floodplain surface (expressed in area) and dike rising (in km dike length). For example, it is easier to change a nature area into an urban area than the other way around. On the other hand, some measures are very expensive to carry out, like removing and constructing drainage tubes to facilitate discharge. Flexibility / reversibility is judged qualitatively, informed by model output. Reversibility does not only apply to reversibility of measures, but also to reversibility of management styles in general, i.e. the ability to change from one management style to another.
- *Quality of life* is a complex and ambiguous notion. It is beyond the scope of this project to come up with adequate definition. The amount of nature, the possibilities for recreation and type of cultural values are used as rough indicators for quality of life.

The assessment of the perspective-based scenario families in terms of the above evaluation criteria provided the basis for informed policy recommendations. These lessons for water management involve both strengths, weaknesses and risks of each management style and general insights relevant to water management of the Rhine and Meuse in a changing environment and an uncertain future.

# 5 PERSPECTIVE-BASED UTOPIAN SETS OF ASSUMPTIONS

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In this Chapter the three sets of utopian sets of assumptions are described. These sets are informed by the general characteristics of the Cultural Theory perspectives, the expert interpretations, the stakeholder interpretations and the analysis of existing studies as described in the previous Chapter and summarised in Table 5.1. The utopian sets of assumptions involve perspective interpretations of uncertainties pertaining to world view and management style. We further differentiate between external context, national scale and water system level.

### 5.1 Water as vulnerable ecosystem

***The Egalitarian set of utopian assumptions***
*The Egalitarian utopian set of assumptions describes a world in which priority is given to the restoration and strengthening of the water system as ecosystem. Vulnerability of ecosystems is emphasised. The Egalitarian management style is characterised by a strong plea for the recovery of natural (water) systems. A limit to growth policy is pursued, because the earth's capacity is assumed to be physically limited. Traditional measures to control the water are considered to be not effective enough to protect the ecological qualities of the water system. The utopian set of assumptions thus features a water management strategy that differs fundamentally from traditional Dutch water management: the Egalitarian management strategy aims at 'following', instead of 'fighting' the water.*

**External context**
For the interpretation of the uncertainties concerning the development of the external context in the period 2000-2050, the following characteristics of the Egalitarian perspective are important:
- nature is fragile
- human nature is malleable
- ecocentric attitude
- equity as ideal

According to the Egalitarian myth of nature, minor human-induced changes will have a major influence on the behaviour of the environmental system. Egalitarians fear that nature is increasingly disrupted by the growing pressures on the environment. They argue that adaptation of natural systems to new situations is not or only partly possible. Egalitarians also expect environmental problems to be aggravated by amplifying (positive) feedbacks, although acknowledging that dampening feedbacks may delay serious disasters. Speculative positive feedbacks with possibly catastrophic impacts are considered, even if they are at present strongly disputed within the scientific community.

Climate change and its associated effects are perceived as a serious problem for the near future. The Egalitarian alerts that there are serious reasons to belief that climate change is already happening. Potential positive feedbacks are stressed in this risk-aversive worldview. According to the Egalitarian worldview, large changes must be expected and the largest bandwidth of climate change should be seriously considered. This belief stems from the Egalitarian assumptions that climate is very sensitive and that emission reduction will not be effective before the year 2050. According to the Egalitarian view, climate change may cause either wetter or drier conditions in the next 50 years. This implies that the Egalitarian assumes that periods of reduced water depth will occur more frequently and may last longer, while extremely high floods occur more frequently.

According to the Egalitarian, ecological sustainability and human well being are more important than economic benefits. Environmental quality and protection of ecosystems prevail. Social interaction is based on solidarity and respect (for each other *and* for nature). According to the Egalitarian assumptions, compared to the present situation, public awareness of nature's vulnerability will increase significantly in the future, resulting in growing support for nature. The votes shifting to green parties of the Dutch citizens and the significant support for environmental NGOs in the first decades of the 21st century are used as illustration of the change in preferences. The Egalitarian thus assumes a structural change in the preferences of society, characterised by altered production and consumption patterns towards ecologically sound products. According to the Egalitarian, people are willing to pay more for and to invest in green products and service. Water scarcity is regarded as a problem caused by water demand and pollution. The solution to this problem is sought in the management of human needs and desires. Water pricing is not considered as a solution, since everyone should have free access to water to fulfil *basic* needs.

The Egalitarian associates a further increase in population with environmental problems such as environmental degradation and resource depletion. In the Egalitarian utopia, the tolerable limit of population levels is coupled to ecological carrying capacity. In the Egalitarian sets of assumptions, it is therefore assumed that the Dutch population does not increase significantly over the next 50 years.

Economic growth rate is expected to be relatively low. The Egalitarian is not against economic growth, but criticises the direction into which the global economy seems to develop, especially because the increasingly materialistic character of the economy with its global transport schemes is at the expense of nature and the environment. If the future develops according to the Egalitarian perspective, the Dutch economy evolves into a society in which a larger proportion of services reflects that social and ecological values are more important than economic gains. European regulations to reduce greenhouse gas emissions might cause some pain for certain businesses, but that is considered to be acceptable in view of larger sustainability aims. Furthermore, an Egalitarian economy would feature small-scale industries: small ICT and eco-technological research companies are assumed to pop-up and flourish. The remaining large-scale industries would be characterised by maximum process-integrated recycling structures. Eco-recreation sector is assumed to become one of the key economic sectors. Information and communication technology (ICT) enables homework, which in an Egalitarian utopia would contribute to a decrease in mobility. Furthermore, local production and local consumption are assumed to increase, causing the volume of transport to further decline. Transportation over water is preferred as way of transporting goods: the ideal is small, clean and flexible ships adapted to the part of the river where they operate navigating the rivers. The Egalitarian thus assumes that by 2050 the economic situation in the Netherlands has changed significantly compared to today. Agriculture is assumed to be dominated by small-scale biological-dynamic farms. According to the Egalitarian management style, initiatives for nature and landscape management will be subsidised and farmers will be not merely agricultural producers, but primarily guardians of the landscape. The environment-oriented attitude and lifestyles combined with a rather stable population number and limited economic growth implies that according to the Egalitarian utopian assumptions it is not necessary that urban and industrial areas further expand at the expense of nature.

In the Egalitarian perspective, it is assumed that the Netherlands continues to extract natural gas as complement to renewable energy resources, because gas is less $CO_2$-intensive than coal and oil and nuclear energy is no option in this perspective, because of the associated waste and risk problems. Gas extractions lead to soil subsidence, which should be avoided as much as possible according to the Egalitarian perspective. For that reason water management measures in polder areas aiming at the prevention of further soil subsidence due to peat oxidation and settling are advocated.

We realise that the Egalitarian external context may seem inconsistent at first glance. It features the lowest economic development and population growth, usually associated with the lowest $CO_2$ emissions. However, as was first demonstrated in Rotmans and de Vries (1997), if the uncertainties pertaining to the climate system are interpreted according to the Egalitarian idea of vulnerability of the system, temperature and associated precipitation patterns can change significantly in the next 50 years. The latter even in a situation in which future $CO_2$-emissions are curbed significantly compared to the present level. The quantitative interpretations of the uncertainties used for the description of the Egalitarian view of how the climate system functions used in this global assessment of Egalitarian assumptions are legitimate in view of state-of-the-art science (see Den Elzen *et al.* 1997 for detailed motivations).

The Egalitarian considers water quality as an environmental problem caused by increased water demand and pollution during the 20th century. The de-materialisation of lifestyles in the early 21st century as assumed in the Egalitarian utopia is also reflected in the water demand. Compared to the present level, no further increase in water demand is assumed. According to the Egalitarian, it is a matter of mentality to be efficient and economical with water. Applying small-scale water-saving and re-use technology can lower water-use intensities in all sectors. According to the Egalitarian management style, environmental impacts should be reflected in an environmental tax. According to the Egalitarian worldview, the fragile dynamic equilibrium of the water balance is easily disturbed by human activities. Intensive water use, human-induced climate change and deforestation may considerably affect precipitation, stable fresh-water availability and the sea level. Long term solutions, such as reducing water demand through water conservation and efficiency measures and the use of treated wastewater, are needed according to this perspective.

**Box 5.1 Model inputs - external context**

The qualitative descriptions have been translated to values for input-variables for the different models:

- In our model calculations for ***climate change*** we take into account both an extreme warm-dry and an extreme warm-wet climate variant, with an upper margin of 2 ºC in 2050 and 4 ºC in 2100. In the wet scenario for 2050 precipitation increases by +2% in summer and by a +12 % in winter. The dry scenario envisages precipitation decrease by –10% in winter and in summer. Evaporation intensifies by +8% and sea level rise by 45 cm.
- The Egalitarian assumes a maximum degree of ***soil subsidence*** due to gas extraction. Soil subsidence in polders and peat areas due to excessive drainage is tempered by maintaining more natural surface water levels.
- For the Egalitarian interpretation the ***GNP-growth*** in the period 2000-2050 increases by 1% annually. This percentage is based the low economic growth estimates as described in the Divided Europe-scenario of the Central Planning Office (CPB) (CPB, 1996).
- For the model input in terms of ***population*** numbers, we used again the CPB scenario Divided Europe which is said to be a low population number scenario: i.e. a growth of 0.2 %.
- In this scenario no further increase in ***water demand*** is assumed.
- In this scenario no increase of urban areas is assumed: ***urbanisation*** is characterised by condensation, rather than by enlargement.
- ***Inland navigation*** is characterised by small ships and an increase of freight supply.

**National scale level**

In the Egalitarian utopia, spatial planning aims to improve environmental values: functional planning is secondary to environmental planning. The Egalitarian is not in favour of solving environmental problems with large-scale high-tech interventions. In this scenario the Ecological Main Structure (EHS) is implemented at the expense of area available for agriculture. Water guides regional planning, and landscape changes should fit in the natural environment: the Egalitarian thus assumes that water will guide future spatial planning and that the planning of functions, such as housing, working and recreation, are adapted to water circumstances. Environment-oriented water management can imply that people have to move to other places, or that they should accept potential flooding. This is not a problem since in this Egalitarian utopia people strongly support the ideal of giving more space to nature. The Egalitarian assumes that the rivers will get more space so that conditions are created for strengthening and developing into a more natural water system. According to the Egalitarian, by adapting the allocation more to the physical circumstances and natural processes, fewer measures are required to guarantee sustainable use. Moreover, infiltration and groundwater recharge will increase due to a reduction of artificial drainage and the extension of nature areas. The Egalitarian set of assumptions is, therefore, characterised by more natural surface water levels and increase possibilities for nature development. In the Egalitarian management style, areas will be reserved for water retention and for 'green rivers' (strips of land along the river that are designed to carry water during extreme peak flows) along the rivers.

Continued and excessive artificial drainage of polders, peat areas causes soil subsidence, which is regarded to become a major problem, especially in the Western part of the Netherlands. According to the Egalitarian the ground water table in the agricultural areas of the higher regions with sandy soils is no longer allowed to be lower than 60 cm to prevent desiccation of nearby nature areas. As a result, there will be more polders with a more natural water level. In the Egalitarian utopia, the largest part of the embanked floodplains is returned to nature and for enlarging the discharge and storage capacity of the river, at the cost of agriculture. Consequently, it is assumed that there will be an increase of nature areas surface from the current 11% to 23% in the year 2050.

According to the Egalitarian utopia, the Netherlands is assumed to slowly transform into a varied river landscape in which water, nature, agriculture and cultural history are well balanced. The Egalitarian believes that people are able to find a sustainable equilibrium between economy and ecology. An illustration of such dynamic balance between humans and nature might be the construction of swamps used to decompose all kinds of (natural) waste matter. The Egalitarian will try to realise the ideal of closed water systems. In cities the sewer system will be separated from the rainwater discharge system by constructing underground water reserves in order to diminish desiccation and sewer overflow. In response to water shortages ‘grey’ (B and C) water and closed water systems in cities will become strongly subsidised. In the cities, the Egalitarian management style will involve the building of an extended water network of ditches, ponds, and other watercourses (like underground and aboveground water reservoirs) to store waste, rain and groundwater.

***Water system scale level***

According to the Egalitarian, the fragile dynamic equilibrium of the water system is easily disrupted by human activities. Intensive water use, human-induced climate change and deforestation are serious pressures on the water system, in terms of affecting water availability and sea level rise. In view of these pressures, the Egalitarian no longer uses the concept of ‘design discharge’ (in Dutch: maatgevende afvoer), but is more interested in the occurrence of extreme discharges.

In the Egalitarian management style, nature and environment are central in water management. The key issue for the Egalitarian is to utilise not more than the ecological potential of the water systems and to give the rivers their natural course. The Egalitarian management style thus involves putting strict boundaries on the playing field of human activities. In certain areas, functions of use with adverse effects might be strictly regulated or even banned. Hard measures will be set to stimulate the recovery of nature. The principle of flowing storage is central in the Egalitarian management style. One of the central preferred measures is increasing the discharge and storage capacity of the rivers, in combination with the development of ecotopes in order to recover the river’s ecosystems. The Egalitarian idea is to breathe new life into nature in the Netherlands as well as to offer a long-term solution to flooding and to droughts. For the river systems, this implies that there will be more space for a more natural (water table) course and that floods are allowed in most areas. The Egalitarian management style aims at ecological recovery plans; to that end agricultural land will converted into natural habitat, promoting greater exchange of water and sediment between the main river channels and the flood plain, re-establishment of riverine forest, secondary channels and natural river banks.

It is envisaged that sea level rise and changes in amounts of river water entering the lake will increasingly affect Lake IJsselmeer. Egalitarian water management of the IJsselmeer will aim at achieving more natural lake level fluctuations, and seeks for sustainable solutions for flood protection. This means that the discharge capacity of the Afsluitdijk sluices will be increased. Along the dikes surrounding the lake, shallow foreshores will be established. These are expected to reduce the wave-impact, and hence peak levels threatening the dikes.

**Box 5.2 Implementation hydrological models**

RHINEFLOW/MEUSEFLOW

- The Egalitarian rejects the concept of ***design discharge.*** In this scenario it is implemented as a very high value (may be higher than 18.000 m³/s at Lobith).
- The Egalitarian has a high expectation of the ***retention capacities*** of forests. In the Egalitarian utopia nature (including forests) increases by 50%, which has a positive effect on the retention capacity. For the interpretation of the Egalitarian utopia we adopted the most optimistic variant of 1000m³/s peakflow decrease as a result of retention measures (based on the retention effect from IKSR (1997) and the RvR-study (Dijkman and Silva, 2000)): 1000 m³/s in 2030 and 2000 m³/s in 2050).

WINBOS (Lake IJsselmeer)

- For the Egalitarian interpretation for the Lake IJsselmeer no ***design discharge*** is assumed.
- WINBOS uses the ***monthly discharges*** at Lobith as derived from the Rhineflow calculations for the Egalitarian wet and dry variant and sea level rise in the Waddensea.
- The volume of ***water discharge from the surrounding polders*** into the Lake IJsselmeer does not change for the wet variant and decreases by –10% for the dry variant. (The Egalitarian aims to retain the water. Depending on the increase in precipitation this will result in an increase of sluice water to the Lake IJsselmeer).
- In this scenario the ***sluice water*** to the Lake IJsselmeer increases by 8%. The sluice capacity of the Afsluitdijk is increased by factor 2. There is no need for additional pumping capacity, to discharge water from the region to the Ijsselmeer.
- ***Water demand*** due to land use changes decreases by 25%

River management measures that are advocated in the Egalitarian perspective include:

- Removal of obstacles, such as artificial heights and road embankments within the floodplain areas;
- Removing minor embankments within the floodplain;
- Lowering the floodplain surface;
- Digging side channels;
- Widening the floodplain by dike replacement.

In the Egalitarian utopia it is assumed that all measures can be implemented relatively fast. All these measures aim at giving the water more space. Other measures include the removal of weirs and sluices. In the Egalitarian utopia most of the weirs are removed which influence nature development negatively. In other cases, sluices may be used exclusively to regulate the river water tables for nature development. Weirs will be removed from the lower-Rhine, and ships are forced to navigate over the Waal and the Amsterdam-Rhine Channel, (which remain important transport routes for small, clean and flexible ships). The weir at Driel remains operational. Also the weirs and sluices in the Meuse are removed and inland shipping moves to the canals. In any case, no investments in the improvement of the river channel solely for the sake of transport are made. Finally, retention areas are designated and green rivers are established, as the Egalitarian is very optimistic with regard to the water holding capacity of upstream water conservation and retention areas. The designated polders with nature water management include: Horstermeer, Mijdrecht, Weerribben, Bethune, Giethoorn and Ooijpolder.

### *5.2* Safety as guiding principle

***The Hierarchist set of utopian assumptions***

*This Hierarchist utopia describes a world in which safety is an indisputable priority. The ideal of control is emphasised. This ambition touches upon all aspects of the Hierarchist water management. This set of assumptions features a world that is not much different of today, although some climate change is assumed.*

**External context**

Three Hierarchist principles have been central in the description of the set of assumptions, i.e.:

- nature is robust within limits;
- the water system (and related systems) is sensitive to authoritative incentives;
- stability is the major driving force underlying the Hierarchist management style.

Hierarchists, perceiving nature as fairly tolerant, consider that disturbances such as climate change will alter the hydrological cycle to some extent. According to the Hierarchist the climate will not significantly change. These disturbances can be assimilated as long as they do not reach critical levels. As the Hierarchist has no eye sensitivity for non-linear relationships not established by scientific evidence, the complexity of climate issues may be underestimated.

According to the Hierarchist, systems are malleable. The Hierarchist has a preference to control, assuming that rules and legislation can regulate people behaviour. The Hierarchist, for example, assumes that measures such as child allowances and taxes can control population growth. The Hierarchistic utopia features a moderate population growth in line with current trends.

In the Hierarchist world view, short-term (economic) interests are in practise more important than long-term environmental interests, although the latter are not ignored. The hierarchies assumes that Dutch government and business continue to be on friendly terms. Government positively approaches industry as long as the sectors continue to reduce risks (e.g. environmental pollution or disasters) and turn out to be good employers contributing to a healthy labour market. Good working conditions and enough jobs are considered as an important precondition for societal stability. Nevertheless, private companies are confronted with strict regulations pertaining to safety. Subsidy is another important means used by the Hierarchist to guarantee stability and control. In line with the rather business-as-usual attitude with regard to the economic structure, the Hierarchist utopia assumes that the Netherlands will continue to extract natural gas. As a result the peat areas bed down. In nature areas, soil subsidence is partly addressed through some water management measures.

The increase of freight transport over water is assumed to be moderate. In the Hierarchist utopia, the shipping sector is dominated by governmental policy: norms and legislation control the allowed degree of river pollution resulting in some boundaries on transport. Toll collection in various parts of the Rhine and Meuse is one of the options a Hierarchist management style would feature to decrease river pollution if needed. As a result of legislation and moderate economic growth in this scenario freight transport over water increases moderately. The Hierarchist invests primarily in waterway improvement in order to stimulate the transport modality and much less in the water transport means. Without incentives, it is expected that the future shipping sector is characterised by little technological innovations. The Hierarchist assumes that climate change will impact the transporting capacity and the transport reliability. Continuity in water levels is considered important in view of minimising logistic costs; changes will thus effect the economic performance of the shipping sector. Problems related to navigation constraints are most relevant for the inland-shipping sector. Nevertheless, no severe modal shift from rail, road to water or vice versa is assumed nor stimulated.

Hierarchist will extract drinking water from surface water in case stable ground water reservoirs do not supply enough water to satisfy the demand. It is furthermore assumed that average economic growth will result in an increase of water demand per capita. The Hierarchists are in favour of more efficient water use, as long as the associated measures do not result in socio-economic constraints. The Hierarchist utopia therefore assumes some incremental efficiency improvements, but large-scale and innovative efficiency techniques are neither developed nor introduced. The Hierarchist thus favours system optimisation above system innovation.

The Dutch Hierarchists, being responsive to higher-level authority, realise that agriculture has become the responsibility of the EU. Central planning of agriculture policy, together with subsidies, have created a stable agricultural system in the Netherlands. However, due to the assumed reform of the agricultural policy of the EU (especially downsizing of subsidies), the Hierarchist assumes that the Dutch agricultural area will autonomously decrease, but not completely disappear. It is assumed that by 2050 about 10% of the agricultural area will have been disappeared.

**Box 5.3 Model inputs - external context**

- Concerning ***climate change***, for the Hierarchist utopia, we assume a moderate temperature increase of 1 °C in the year 2050. Also precipitation increases with 6% in winter and 1% in summer. Evaporation intensifies by + 4% and sea level rise is estimated at +25 cm.
- ***Soil subsidence*** is in accordance to the NRP-2 project (Haasnoot et al, 1999), except for a few polders.
- The ***Gross National Product*** will increase moderately with 2% a year, based on the European Co-ordination (EC) scenario (CPB, 1996).
- ***Soil subsidence*** is extrapolated from current trends, see Haasnoot et al. (1999)
- ***Population*** figures are derived from the CPB-scenario Global Competitions (GC) in which the GNP-growth is estimated at +2% for the year 2050.
- ***Urbanisation*** increases with 150.000 ha in 2050. In this scenario agricultural and urban areas are increasingly interlaced.
- ***Water demand*** in the Hierarchist utopia increases moderately, but the total extraction remains the same.
- ***Inland shipping*** is characterised by a moderate increase of freight transport, which develops in line with the current trend (WVS-scenario Global Shift). No change in fleet compositions is assumed.

**National scale level**

The Hierarchist management style is responsive to international / EU agreements addressing flood risks. The precautionary principle fits with the ideal of control. The Hierarchist would support the creation of an Integral River Commission, which has the task to create a single safety norm in the EU. According to the Hierarchist perspective, this norm should comply with two principles: no human life should be exposed to danger and measures should not be too expensive. In the Hierarchist utopia, government will make agreements with institutions that provide information to standardise calculations and information formats. Regarding policy making in uncertainty, the Hierarchist will aim at gathering as much knowledge as possible and will attempt to quantify uncertainty through classical risk analysis (probability times effect). The Hierarchist strongly believes in science's ability to solve problems. In the case of water management, substantial funds are, therefore, reserved for research. The Hierarchist ideal is that authoritative science or scientists provide legitimacy for large investments and the imposition of strict norms.

According to the Hierarchist, government is entitled to impose strict safety standards, based on thorough research and consultation. The time-horizon of planning varies, depending on the function (10-50 years). The Hierarchist tends to avoid ad hoc measures and regulation: policy should be well deliberated and gradually implemented.

In the Hierarchist world view, nature is perceived to be robust but just within limits. In line herewith, the Hierarchist assumes that nature can be managed by defining adequate standards. Policy measures are either preventive or mitigation oriented, in terms of limiting the damage caused by both flooding and drought resulting from drainage problems. Which attitude is preferred depends on which measures are most easy to implement in view of the whole range of interests. With regard to water, the Hierarchist perspective can be best characterised as risk-avoiding and safety-oriented. Water management is first and for all considered as an issue to be regulated by governments rather than by the free market, due to the public character of water. Situations in which human life is unnecessarily exposed to danger due to flooding are unacceptable. Risks due to flooding should be reduced by the imposition of norms based on expertise and experience. In the Hierarchist utopia, citizens gladly leave administration duties to experts and appreciate control and periodic assessment. Water management in this utopia is assumed to be top-down. Taking into account that water can best be controlled at the level of the full river basin, the Hierarchist prefers that plans are made at an international level concerning water management for the continental shelf, the North Sea and Wadden Sea and the river basins of the Rhine, Meuse, Eems and Scheldt.

Also spatial planning is characterised as top-down: the government primarily determines the hierarchy of the area's various social functions, and derives the associated layout and management. According to the Hierarchist, spatial planning is above all the result of negotiation between various functions aiming at win-win situations. In case of conflict between different spatial functions the government will deliberately decide, after thorough research, what the purpose or allocation should eventually be. Taking into account the assumed population and economic growth, the Hierarchist assumes that urban area will expand. A consequence of this type of spatial planning, this utopia can best be characterised by compartmentalisation and function integration in the river basin based on the various requirements relating to water quantity and quality.

The Hierarchist utopian assumptions involve that land use develops according to the current trend (see also 'Current Policy' variant in the Aquatic Outlooks (WSV) and Middelkoop (2000)). In line with the above, this implies that it is assumed that due to EU regulation the current surface area for agriculture reduces by nearly 7% in 2030 and 10% in 2050. Agricultural land is replaced by nature and urban area. Areas with historically valuable landscape will be preserved as much as possible.

***Water system scale level***

Safety is the utmost priority. The Hierarchist water management style uses the current design discharge as norm for safety measures. In view of the Hierarchist, traditional water management has always been able to satisfy the various demands and requirements. The Hierarchist, furthermore, assumes that there is no actual crisis in the Rhine and Meuse basin, neither will there be under utopian conditions in the next 50 years. In this utopian set of assumptions, it is assumed that technological developments will create new possibilities in the future, however, Hierarchists do not believe in revolutionary breakthroughs in technology.

For the Hierarchist, water management involves negotiations between different interest functions and win-win solutions. The Hierarchist view of the water system can be characterised as instrumental. The water system should fulfil in the protection against flooding, drainage of the hinterland and large-scale water supply for agriculture, industry and drinking water. The flood measures, central in this management style, aim in principle at a better or faster flow of water to the sea. As second option, water conservation and storage in the river basin are advocated. Large-scale technical interventions (especially dikes and dike reinforcement) are applied to achieve and maintain the established norms. Space will be given (back) to the river, if this is needed to control risks associated with flooding. The Hierarchist is moderately positive with regard to retention capacity and its effectiveness in reducing peak flows. For the interpretation of the Hierarchist utopia a peak decrease of 1000 m³/s in 2050 (based on IKSR scenarios (IKSR, 1997) is assumed. Retention areas are designated in Rijnstangen en Ooijpolder.

The possibilities for the development of nature are taken into account, but this is not a primary starting point for policy. The ideal of creating win-win situations implies that substitution is accepted in nature policy. The Hierarchist assumes that nature development will be carried through the realisation of the Ecological Main Structure (EHS).

In the Hierarchist utopia, the water management in the Lake IJsselmeer area is strongly driven by so-called established water target levels. This perspective envisages moderate increase of sluice water discharge out of the Lake IJsselmeer. Therefore, the sluice capacity of the Afsluitdijk is increased. In the summer, water levels sometimes drop below the established target level. Therefore, the Hierarchist will create additional pumping capacity to regulate water levels in winter and summer. In this Hierarchist management style some shallow forelands will be constructed along the most threatened dikes of the Lake IJsselmeer.

In order to create win-win situations, measures taken within the embanked floodplains should serve several purposes at the same time. For example, lowering the flood plain does not only reduce flood water levels, but also allows wetlands to develop. Another consequence of the principles adopted in this management style is that digging secondary channels and additional lowering the floodplain should compensate for increasing flood water levels possibly resulting from reallocation of floodplain forests. The Hierarchist considers the following landscaping measures for the embanked floodplains:

- removing obstacles of the water flow;
- removing minor embankments;
- lowering the floodplain surface;
- digging secondary channels;
- lowering groins;
- dike displacement.

**Box 5.4 Model implementation hydrological models**

RHINEFLOW/MEUSEFLOW

- The design discharge of the Rhine and Meuse increase respectively by about 5% and 10%.
- For river basins the relative expansion of urban area is assumed to be the same as is assumed for the Netherlands as a whole in the 5th Memorandum for Spatial Planning.
- Agriculture will decrease by nearly 10% over the next 50 years.
- In the river basins the effect of water conservation is estimated to be close to the established separation coefficient. The average estimate of effectiveness of retention along the Rhine on peak flow reduction are derived from IKSR scenarios (= 500 m³/s at Lobith in 2030 and 1000 m³/s in 2050). There will be no retention measures along the Meuse.

WINBOS (Lake IJsselmeer)

- For the Hierarchist interpretation it is assumed that target levels are similar to the current norms. They are allowed to increase.
- The discharge capacity of the Afsluitdijk sluices is doubled.
- Shallow forelands will be constructed along the lowest dike sections.
- The Hierarchist favours local dike raising.
- Due to the decrease in agriculture the associated water demand decreases by 10%.
- The water supply from the IJsselmeer to the region increases with the increase in evapotranspiration.
- No extra pumping engines are installed at the Afsluitdijk. Additional pumping capacity will be installed to discharge water from the region into the IJsselmeer.

MOZART-NAGROM (Terrestrial areas)

- Urban areas is assumed to expand by 150.000 ha in 2030 and 225.000 ha in 2050. Cultural and historic valuable areas are preserved.
- Agricultural area reduces by 7% in 2030 and 10% in 2050. Landscape planning is based upon existing plans.
- Groundwater recharge increases by factor 1.5 in new VINEX areas. No changes assumed outside these areas.
- The drainage resistance increases for primary and secondary watercourses.
- For the Hierarchist interpretation a reduction of drainage density in nature areas is assumed due to an intensity decrease of artificial drainage.
- A small reduction of groundwater extraction is assumed in the Netherlands (based on 'current policy' in Aquatic Outlooks).
- Retention areas are designated in Rijnstangen en Ooijpolder.

### 5.3 Water as economic good

***The Individualist set of utopian assumptions***

*The Individualist utopia describes a world in which the forces of liberalisation and technology create an environment in which nature is made subordinate to economic interests. As a result priorities in spatial planning are set according to market forces and water management decisions are increasingly based on cost-benefit and cost-effectiveness considerations alone. The underlying assumption is that the natural system is robust and society can adapt to changes.*

**External context**

The following general assumptions are important in the Individualist interpretation of uncertainties:

- nature is robust;
- human nature is self-seeking;
- economic growth and a dominant role of the market are the Individualist's driving forces;

- high expectations of human ingenuity, especially related to technological progress.

In the Individualist world view, the environmental system is robust: it has the ability to adapt and evolve if changes or even disturbances occur. Individualists do not believe that human activities cause irreversible environmental catastrophes. The environmental system itself is able to cope with the fluctuations and humans are ingenious enough to find solutions. Accordingly, the Individualist emphasises dampening feedbacks, even if they are speculative from a scientific point of view. Consequently the climate is considered to be resilient and self-regulating, and, therefore, providing fairly stable climate conditions. The Individualist is thus not convinced that Kyoto emission targets are necessary. The Individualist estimates damage / risk probabilities (by means of cost-benefit analyses) for climate events (like accidental flooding) extremes, but this perspective sees no need for a long-term climate policy. Driven by market processes, the Individualist has a relatively short time horizon (10 years).

Economic growth is valued. The Individualist considers material prosperity and the creation of work opportunities important assets for society. It is assumed that economic and technological developments will eventually offer necessary solutions, also for high water and environmental problems. Risk is calculated in terms of cost-benefit analysis. An important presumption is that the money available for technological solutions to water and environmental problems only as the economy grows. The management style of the Individualist involves an increasing influence of private companies and declining (traditional) role of governmental authorities. In the Individualist perspective, nature and water are valued as economic goods, to be exploited for economy and recreation.

In the Individualist utopia, there are no principle limits to population growth nor to the length of the human life span. So population growth is not considered a problem: intelligent solutions will be found to be economic and efficient with space. The Individualist assumes that the economic favourable and safe climate in the Netherlands attracts people from the poorer part of the world. As a consequence, the population growth in the Individualistic utopia will be in line with current trends. Increased population numbers will lead to a pressure on the housing market due to the law of economic mechanisms associated with scarce items. The Individualist assumes that people who can afford it want to leave the crowded cities and opt for luxury houses in the open space and small villages in the Netherlands. As a result, the Dutch landscape, especially former agricultural area and nature reserves, will become increasingly cultivated; natural areas without buildings will become scarce. The Individualist believes in the free market mechanism, competition and the ‘survival of the fittest’. The Individualist society of winners and losers will feature relatively large differences between rich and poor, which is not considered as a problem but as a natural and even necessary consequence of a competitive market society.

From the economic sectors, the traditional agricultural sector is assumed to become the biggest losers in the Individualist utopia. Subsidising is considered too expensive and structural subsidising is anyway considered as interfering with market-mechanisms. If the Dutch agriculture cannot compete, for example with East European countries, it will and should fade away. In the Individualist utopia it is assumed that only the large-scale high-productive agro-businesses will survive. The Individualist in not in favour of maintaining the agricultural sector in the Netherlands. In the agricultural sector the cultivation with the largest profit margins, such as bulb growing and greenhouse products increase. Uneconomic agriculture yields its place for urbanisation. Around cities, nature areas are preserved for recreation. In line with current market prospects, in the utopian setting the Individualist expects an increase of freight transport over water and in line herewith a significant increase of (international) container ships, which will be faster, lighter, bigger, and likely more efficient with regard to fuel use (the latter in order to decrease costs).

Due to economic growth and luxury lifestyles accompanied by an increase in population numbers domestic and industrial water demand is assumed to increase. For the amount of water extracted by industry, it is for example assumed that the increase will be in line with the assumed economic growth of 3% (CPB scenario ‘Global Competition’).

**National scale level**
The Individualist management style implies that governmental control is weak in the Individualist utopia; governments just play the role of supervisor. The government's responsibility is to provide the boundary conditions and to act as a mediator where it concerns issues that exceed the interests of companies, such as education and welfare. Society functions according to the rules and the mechanisms of the private sector and the free market; the Individualistic utopia can thus be characterised as a free market society. In the Individualist utopia a large share of traditionally important parts of governmental responsibilities – energy, water, transport – will devolve to the market with minimum regulation. A logical consequence in this utopia would be that the ministry of Housing, Spatial Planning and the Environment (VROM) and the ministry of Transport and Communications (V&W) reside under the authority of the ministry of Economic Affairs. The Individualist assumes that multinational and other large industrial companies will deal directly with governments and develop into a strong and dominant (European) lobby group. European integration as especially valued as economic and monetary integration yielding a competitive European market. The Individualist management style aims at exploiting potential economic chances and solving actual bottlenecks for the functions of use. Risks are interpreted as challenges.

**Box 5.5 External context and model implementation**

- In the Individualist utopia it is assumed that climate changes are minor. ***Temperature*** is assumed to increase with 0.5 ºC in 2050 and 1 ºC in 2100. Annual ***precipitation*** is assumed to increase with 1.5% and ***evaporation*** by 4%. Accordingly, s***ea level*** is expected to rise by at maximum 10 cm in 2050.
- With regard to the Individualist utopia it is assumed that the ***economic growth*** rate is high. The increase in GNP is interpreted to increase with 3%, based on the CPB scenario 'Global Competition'.
- In this utopia it is assumed that the Netherlands continues to extract natural gas causing enhanced ***soil subsidence*** in the Northeast of the Netherlands. The degrees of land subsidence are adopted from the NRP-2 study.
- Building upon the CPB scenarios, the ***population*** figures of +0.6 (European Co-ordination) are adopted to estimate population developments in line with the Individualist assumptions.
- Increase of ***urban area*** by about 225.000 ha in 2050 (WB21 (2000) and on the public debates around the Fifth Memorandum of Spatial Planning (2000)) at the expense of agriculture and nature.
- The Individualist utopia involves an increase of domestic and industrial ***water demand***, which is estimated to be 30% higher in 2050 compared to the present levels. We should note that because the models do not allow direct incorporation of water pricing policy, this estimate reflects an unconstrained growth. According to the Individualist, water pricing should be applied in case of water scarcity (which is currently not considered the case for the Netherlands); market theory then has it that pricing is likely to result in the development and application of high-tech water-saving technology and more efficient water use. In that way the increased water demand can be satisfied with lower supply and extraction.
- ***Inland shipping*** is characterised by large ships and a strong increase of freight transport. Cheap and reliable transport modalities are preferred.

**Water system scale level**

In this utopia risks associated with water can and will be calculated: the assessment in terms of costs and probability enables the Individualist to identify cheap options and topical areas for investment and research programmes. Cost-benefit analyses and economic risk assessment thus guide water management: in the Individualist management style, measures with the highest cost efficiency are chosen. This will lead to, for example, privatisation of water and water-related sectors. In the Individualist utopia short-term gains are more important than long-term solutions.

In the Individualist point of view, water is an economic good and should be managed in that way. Extensions of the stable runoff through reservoirs or the increase of the resource base through desalination are considered as options. If ground water is the cheapest resource, in the Individualist utopia it should and will be used to satisfy the demand. Water demand is determined by the price mechanism: higher prices as a result of increased scarcity will lower demand and stimulate the development of more efficient technology. Subsidisation of water is rejected and an active policy in public water supply and sanitation is not needed because economic development will adequately increase water supply and sanitation coverage. It might be that entrepreneurs decide to develop natural areas for recreation or as means to increase the economic value of real estate property, but the development of nature in the river basins as such is not considered an aim in itself.

In line with the perception of nature as being robust, Individualists tend to consider possible disturbances of the hydrological cycle as of minor importance. If intensive water use, deforestation or temperature change will have some effect on the hydrological cycle, the Individualist assumes that either the changes will be slow enough or human beings fast enough to adapt and that technological innovation will provide new solutions.

The Individualist attitude to water management can be characterised as adaptive and will mainly involve technological interventions. The Individualist anyway only intervenes in case economic interests are seriously threatened, and then preferably locally and implemented on a project basis. The cheapest set of measures is chosen. However, in the Individualistic utopia little effort is anyway envisaged, since it is assumed that the discharge does not increase. In the Individualist utopia, insurance companies play a large role in the management of flooding risks. The Individualist, for example, expects that insurance companies might purchase retention areas in order to decrease damage payments. The Individualist furthermore expects that people who prefer to live in flood-prone areas will adapt their style of living, for example, they might construct houses that put primary functions at the second or third floor or they pay high insurance premiums. Nevertheless, on the basis of cost-benefit analyses, the Individualist would also opt for some water management measures, of which some are not directly focussed on flood prevention, but might have a positive spin-off effect, such as the dredging of the channels to improve shipping routes also increases the discharge capacity. Furthermore, the Individualist assumes that such measures will be implemented through market mechanisms, such as limited lowering of the floodplain beds, which should be cost-neutral by selling excavated clay and sand. Some other water management measures that fits with the Individualist utopia are removing high-water free areas in the Rhine and Waal, dike raising and increasing dike crests.

The Individualist prefers technological, engineering solutions, and expects that technological innovation will provide solutions to new problems if they materialise. The Individualist has low expectations of the effects of retention capacity, and this perspective anyway does not see the need for constructing new water retention areas. This kind of storage measures is anyway considered to be too expensive, because every square meter has or can have an economic function as the prices of land in the Netherlands indicate.

**Box 5.6 Model implementation hydrological models**

RHINEFLOW/MEUSEFLOW

- The *design discharge* for the Rhine and Meuse will not change in the future (remains 16.000 $m^3/s$ in Lobith).
- The Individualist has low expectations of the *water holding capacity* (sponge-effect) of reforestation or a major effect of *retention basin.* The most pessimistic variant for peak flow decrease is 250 $m^3/s$ in 2050 (based on IKSR and RvR studies) is attached to the Individualist utopia.
- The Individualist assumes that *evaporation* is not influenced by the effects of $CO_2$ on plants.
- For flood reduction in the floodplain area, the cheapest set of measures is chosen. However, little effort is envisaged, since the design discharge is not assumed to increase.
- In order to improve inland shipping, substantial resources are invested in channel adjustments, which has also some spin-off effects in terms of flood management.

WINBOS (Lake IJsselmeer)

- For the Individualist utopia the *water surplus* to the Lake IJsselmeer is estimated at +4%.
- The lake levels are assumed to be similar to the present situation.
- No *shallow forelands* are constructed in this utopia.
- The *sluice capacity* of the Afsluitdijk is increased by factor 1.5.
- *Water demand* associated with land use does not substantially change.
- If lake levels can no longer be maintained, extra *pumping engines* are installed at the Afsluitdijk. Also additional pumping capacity will be installed to discharge water from the region to the IJsselmeer.
- Dike crests are increased.

MOZART-NAGROM (Terrestrial areas)

- Cities will grow significantly. *Urbanisation* increases by nearly 40% (225.000 hectares) until 2050 (based on the public debates around the Fifth Memorandum of Spatial Planning (2000)), In this scenario we assume the maintenance of buffer zones with nature around urban areas and so called 'VINEX' locations. Also the urban areas of the new map of the Netherlands were implemented.
- The *agricultural* acreage decreases by 10% due to expanding urbanisation.
- Current *nature areas* will remain unchanged, and are increasingly used for recreational functions, especially the areas near the cities.
- *Ground water management* is directed towards the optimisation of economic use of the soil. This implies that the groundwater levels are adjusted if needed. It is further assumed that new techniques are developed to manage groundwater levels.
- The Individualist is pessimistic with regard to the capacity of *retention.* Moreover, retention is perceived as too expensive. Nevertheless, it is assumed that current retention areas remain.

### 5.4 Summary

Table 5.1 and 5.2 summarise the main exogenous (external context) and endogenous parameters and model inputs associated with the three perspectives as derived from the qualitative descriptions. In order to facilitate utopian and dystopian experiments, worldview variables and management style variables are distinguished with regard to the endogenous model settings. Assumptions with regard to external context usually refer to the perspective's world view.

Table 5.1: Main model input external context (for detailed description see Appendix 4)

| **External context**<br><br>**Assumptions** | **IND** | **HIE** | **EGA**<br>**Wet Dry** | | **Input in models** |
|---|---|---|---|---|---|
| Temperature | +0.5 ºC | +1 ºC | +2 ºC | +2 ºC | All models |
| Precipitation summer (s) and winter (w) | s) +0.5%<br>w) +3% | s) + 1%<br>w) +6% | s) +2%<br>w) +12% | s) –10%<br>w) –10% | All models |
| Evaporation | + 2% | + 4% | +8% | 8% | All models |
| Sea level rise | + 10 cm | + 25 cm | + 45 cm | + 45 cm | All models |
| Soil subsidence | Based on NRP-2 and WSV-Friesland | | | | Rural models |
| Economic development | + 3% GNP | + 2% GNP | + 1% GNP | | Rural models |
| Population | + 0.4 % | + 0.6 % | + 0.2 % | | Rural models |
| Urbanisation | + 225.000 ha | + 150.000 ha | + 0 ha | | All models |
| Agriculture | 0 | -10% | - 30% | | All models |
| Water demand | + 30% | +20% | + 0% | | Rural models |
| Inland navigation | - Increase in transport volume<br>- Larger vessels<br>- Adaptation of navigation channel where necessary | - Moderate increase of load<br>- No change in fleet composition<br>- Some bottle-necks in channel alleviated | - Increase of transport<br>- Small vessels<br>- No adaptation of navigation channels<br>- Weirs removed from Meuse: navigation moves to Willems Canal | | Shipping module |

Table 5.2: Main model input hydrological models

| ***Model implementation*** <br><br> ***Assumptions*** | ***IND*** | ***HIE*** | ***EGA*** |
|---|---|---|---|
| River basins | | | |
| **World view variables** | | | |
| Design discharge | No change | Increases by 5-10% | Rejects concept of design discharge, is implemented as a high value |
| 'Sponge' effect | No effect | Moderately effective | Very effective |
| Peak flow decrease | No effect | Moderate effect | Most optimistic variant (result of retention measures) |
| Direct runoff | Increases moderately due to expansion of urban area | Decreases moderately | Decreases, due to increased water holding capacity of forests |
| **Management style variables** | | | |
| Retention basins | No retention basins are constructed | Some retention basins are constructed | Many retention basins are constructed |
| IJsselmeer | | | |
| **World view variables** | | | |
| Water demand due to land use changes | 0% | - 10% | - 25% |
| Water supply from IJsselmeer region | Present level | Increase due to increase in evapotranspiration | Decreases due to land use changes which decreases agricultural water demand |
| **Management style variables** | | | |
| Lake levels | Present | Present. Lake levels are allowed to increase | Seasonal lake levels |
| Increase discharge capacity sluices Afsluitdijk | Increases by factor 1.5 | Increases by factor 2 | Increases by factor 2 |
| Shallow forelands | No shallow forelands | Along lowest dike sections | Along 14 dike sections |
| Increase dike crest | Yes | Yes | No |
| Pumping station at Afsluitdijk | Yes | No | No |
| Terrestrial areas | | | |
| **World view variables** | | | |
| Drinking water extraction | Increase by 30% | Increases by 20% | Suspended in highly valuable nature areas |
| Industry water extraction | Increases by 3% | Increases by 2% | Suspended in highly valuable nature areas |
| **Management style variables** | | | |
| Water level management | - | Water levels are allowed to increase in some areas | Natural: no surface water uplift in summer |
| Retention areas | No extra retention areas | Some retention areas are designed | Re-wetting certain polders and retention areas |
| Wadi's | No | In new VINEX areas | Yes |
| Groundwater recharge | No measures | Increases by a factor 1.5 in new VINEX locations | Increases by a factor 1.5 |
| Drainage resistance | No measures | Increases for primary and secondary watercourses | Increased for primary and secondary watercourses |

# 6 PERSPECTIVE-BASED OUTLOOKS

The present chapter describes the images of 2050 associated with the selected utopias and dystopias informed by the model runs. The results of the models experiments have been described in detail elsewhere (Buiteveld et al., 2001). To allow an integrated assessment of the scenarios, the results have been analysed qualitatively through expert judgements in order to yield insights for water management. The selected combinations of worldviews and management styles are assessed vertically (i.e. by keeping the external context and worldview constant and varying the management styles) and horizontally (i.e. by keeping the management styles constant and varying the worldviews). In this way risks associated with management styles can be evaluated.

The utopian and dystopian scenarios are evaluated in terms of functions that were identified in the beginning of the project (see Middelkoop, 1999 and chapter 1) and which have been refined during the last expert meeting in Maastricht, June 8th 2001. We assessed the following aspects associated with integrated water management, i.e.: the hydrological situation (the Rhine and Meuse basins, the IJsselmeer area and the terrestrial areas), the consequences for the user functions (safety, agriculture, nature and transport/shipping) and the state of the water system (reversibility, economic gains and investments/costs). The evaluation involved expert judgement informed by the stakeholder input, who evaluated the scenarios in terms of consistency, coherency and relevance. This perspective-based assessment of water-related issues pertaining to the Dutch Rhine and Meuse river basins provides a basis to explore recommendations for water management policy.

The perspectives have been abbreviated here as follows:

- Egalitarian = EGA
- Individualist = IND
- Hierarchist = HIE

Scenarios are indicated by a combination of worldview - management style. For example EGA(dry) - IND means: the external conditions and worldview settings according to the Egalitarian perspective, with the dry variant of climate change, while an Individualistic management style has been applied.

### 6.1 AN EGALITARIAN IMAGE OF 2050

*What if climate change in the Egalitarian utopia will manifest itself through extreme wet or extreme dry conditions…*

| Utopian images of 2050: EGA (wet/dry) - EGA |
| --- |

**Characteristics of the water systems**

The Egalitarian has put a great effort on expanding nature, and making the river systems more resilient. Large-scale renaturalisation, together with a reduction of agriculture land and no further expansion of urban areas has been achieved. Along the rivers large areas have been reserved for floodwater retention. Within the embanked floodplains major changes have occurred: floodplain forests have been restored, while at many places the floodplain surface has been dug away to a depth of 1 to 2 m below the original surface. Large wetlands have developed here, and agriculture has completely disappeared. River dikes have not been reinforced. Major areas behind the river dikes have been appointed as retention basin, and several green rivers have been established. In both areas, no economic development takes place. The embanked floodplains form the backbone of the Ecological Main Structure (EHS) that has been almost completely implemented in the Netherlands, at the cost agriculture. Drinking and industry water exploitation is brought to a halt in highly valuable nature areas. Ground water extraction has been greatly reduced. Water management in the terrestrial areas has led to higher ground water levels in the higher Pleistocene parts of the Netherlands. This is very favourable for wet nature, but limits agriculture as it prevents access to the fields by heavy machines in early spring. Here too, water conservation is enhanced by reducing artificial drainage, re-establishment of nature areas and renaturalisation of brooks. Drainage from several peat areas and low-lying polders the western part of the Netherlands has become less intensive, resulting in more natural - higher - levels, so to prevent further subsidence of these areas. In general, water and nature occupy large areas, preventing wide expansion of industrial and urban areas. The IJsselmeer is still drained by gravity to the Wadden Sea, but now through much wider sluice gates. Also there are no longer target levels maintained. Instead water levels are allowed to demonstrate more natural fluctuations with higher levels in winter and lower levels in summer. Shallow foreshores along the dikes have been established for protecting the dikes against wave action. Because it is an environmentally friendly mode of transportation, inland navigation is promoted, in spite of a reduction in the total flow of goods. Navigation in this scenario is characterised by many, but small-size ships. Navigation on the Meuse is not possible during several months in summer, because the weirs have been removed. Inland navigation to Liege and the Belgian Meuse takes place along the South-Willems Canals.

**Hydrological changes**

In the Egalitarian wet utopia, climate change has increased (natural) fluctuations in discharge increase. Summer discharge has decreased, while winter discharge has increased. Discharge peaks of the Rhine and Meuse have become higher. However, he river system is well accommodated to these changes. River flooding occurs more frequently, but does not cause significant damage, because of the larger discharge capacity of the riverbed and the efficient use of retention areas. The terrestrial areas experience larger amounts of precipitation, leading to higher ground water levels, and larger discharges of regional water systems. The IJsselmeer experiences a considerable sea level rise (about 45 cm). Together with a management style that is based on natural lake level fluctuations, average levels of the lake have increased by several dm. In the western part of the Netherlands, the capacity of storage canals is exceeded more frequently due to increased precipitation. Consequently, some polders are needed for retention of excess water.

The situation in case of the Egalitarian-dry utopia is quite different. River discharge considerably reduces, together with peak flows. Nevertheless, sea level rise is the same as under the wet scenario, still leading to a rise of the IJsselmeer water level. While this will decrease flood risk, water shortage for agriculture and to prevent salt intrusion will become more serious during summer periods.

*Rhine and Meuse*

The model calculations for the Egalitarian-wet case show a significant increase in high discharge volumes (Table 6.1). The maximum discharge, Q95 and mean discharge all show a remarkable increase. This is mainly caused by the changes in precipitation. Furthermore, it can be noticed that the minimum discharges are only slightly higher than in the current situation.

The Egalitarian dry scenario is characterised by a significant decrease in discharge volumes due to a significant decrease in precipitation, together with an increase in temperature. The total input of water into the catchment is in this situation significantly less than in the current situation, resulting in decreased mean and minimum flows. The Meuseflow calculations show a similar pattern for the Meuse discharge. Therefore, the calculations for the hydrological situation of the Rhine, as presented below, can be considered as representative for the Meuse.

Table 6.1 Discharge characteristics of Rhineflow runs (10-daily average discharges in m³/sec)

| | Current situation | EGA wet situation 2050 | EGA dry situation 2050 |
|---|---|---|---|
| **Maximum** | 8300 | 11500 | 9000 |
| **Minimum** | 800 | 800 | 600 |
| **Q95** | 4600 | 5200 | 4000 |
| **Q05** | 1000 | 1100 | 800 |
| **Mean** | 2300 | 2500 | 1900 |

*IJsselmeer*
Due to sea level rise, lake levels will be on average higher than in the present situation. Lake levels show a natural variation during the year; there are no target levels maintained. The discharge capacity of the Afsluitdijk sluices has been increased. In the wet scenario, it has become more difficult to drain excess water from the surrounding polders into the IJsselmeer. In addition to larger sluice gates, shallow forelands along the dikes reduce peak water levels, so maintaining safety against flooding.
In the Egalitarian-dry scenario the lake levels are somewhat lower than in the Egalitarian-wet utopia due to a decrease in precipitation, but generally rise along with sea level rise. Due to the decrease in rainfall, no additional measures are needed for water discharge. Due to the higher lake levels there is sufficient water available for agriculture during dry summers, even in the dry scenario.

*Terrestrial areas*
Increased precipitation in the EGA(wet) results in a more intensive ground water flows, as well as higher groundwater levels. In contrast, the EGA(dry) scenario results in a reduction of ground water levels and regional discharges. Extensivation of artificial drainage reduces the adverse effects of the dry scenario.

**Consequence for the user functions**

*Safety*
The model results indicate that the effect of land use changes and renaturalisation on peak floods of the Rhine and Meuse as a whole is small. However, retention along the Rhine is effective, and reduces peak flows by about 2000 m³/s. Within the Netherlands, the large discharge capacity of he high-water bed of the rivers, together with additional retention areas and green rivers adequately nullify the rise in flood water levels that would result from the changed climate conditions. If necessary, the Egalitarian proposes retreat, so the safety problem is avoided. In the Egalitarian-dry utopia safety is optimal due to an enormous increase of space for water, but a reduction in winter discharge and lower peak flows. The extra measures implemented in this scenario to reduce peak flows were costly and not necessary.

In this scenario nature is restored in large areas of the basin to improve the ‘sponge’ effect of the river basin. While the effects at the scale of the entire Rhine and Meuse seem insignificant, renaturalisation, reducing artificial drainage and land use changes considerably increase water conservation at the local scale. This is also the case for the terrestrial areas in the Netherlands. In spite of the higher IJsselmeer lake levels, the shallow foreshores adequately reduce the impact of peak levels and waves on the dikes.

*Nature*
Nature primarily benefits from the expansion of nature areas by implementation of the EHS, and the reduction of artificial drainage and ground water extraction, which is part of the Egalitarian management style. Nature in the embanked floodplains is characterised by maximum floodplain lowering, in combination with retention, large wetlands and regular flooding which is beneficial for wetland vegetation. Existing floodplain forests are preserved; new floodplain forests are

developed. Also, nature in the IJsselmeer takes profit of the new conditions. This is firstly due to shallow forelands that are constructed along 14 dike segments. This is more than is required from a safety point of view. The more natural water levels are beneficial for ecology. The reduced residence time of the water in the lakes is small and this is advantageous for water quality in summer as it may decrease the seasonal algae growth. The climate conditions with increased precipitation of Egalitarian 'wet' utopia will have further positive effects on nature conservation values. Desiccation will be reduced largely because of the higher groundwater levels. The dry scenario, in contrast, will reduce the ecological quality of the nature areas, as it may cause desiccation of vegetation during summer. Extreme dry weather conditions may be unfavourable for wetland nature and small ponds. In the Egalitarian-dry utopia nature benefits from the measures taken by the Egalitarian, but still suffers somewhat from dry summers.

*Agriculture*
Large areas of agriculture land have made way for water and nature. In this utopian scenario agriculture completely disappears from the floodplain. This greatly reduces the total benefit from this sector. The increase of precipitation in the EGA-wet scenario results in more water logging damage in the remaining agricultural areas. In combination with the most extreme wet climate conditions for agriculture, this scenario is most unfavourable for agriculture compared to other scenarios. In the Egalitarian-dry utopia climate conditions are more favourable for agriculture. However, during dry summers there may be a shortage of water for agriculture.

*Transport and navigation*
The shipping sector may occasionally suffer from high water periods when navigation is not allowed (EGA-wet). Under the EGA-dry scenario navigation will increasingly be confronted with long periods of low flow. The fleet composition with small ships has made the sector less sensitive to this change. Prolonged low flow periods in the Meuse are avoided by sailing through the South-Willems canals. This however, increases the travel time and thus navigation cost.

**Other characteristics**

*Investments*
All these far-reaching measures are very costly, as they concern changes in the landscape over large areas, both within the upstream basins and within the Netherlands. The costs of floodplain lowering (and sanitation of polluted clay) are high. For the IJsselmeer area the costs are specified in Table 6.1. In case of the EGA-wet scenario, additional costs are needed for the discharge of excess water from the polder areas.

*Economic benefits*
As less room is available for economic activities (as space is taken by nature and less room is available for economic activities) most economic activities disappear from the floodplain. In the Netherlands as a whole, the urban area remains the same. Therefore, growth of industry and other economic activities have to concentrate on the existing space. There will be a high claim (high costs) for space in the urban areas. Perhaps more functions have to be combined in the same area with more expensive technical solutions (for example higher and underground buildings). All these effects are mainly due to the Egalitarian management style, and are not influenced by the changed climate. In general the Egalitarian utopia is considered negative for economy.

*Reversibility*
Reversibility indicates to what extent applied measures can be re-converted to the original situation. Reversibility of floodplain lowering is low, as it for ever destroys the original landscape and the natural soil archive. The appointment of retention areas, on the other hand, can be taken back without affecting the area (perhaps except for constructing additional polder dikes around the retention area).

The Egalitarian generally applies far-reaching landscaping measures. Within the upstream basins and the terrestrial areas in the Netherlands, large agriculture areas are converted to nature, while removing artificial drainage and re-naturalising first order river channels. Once this has happened, it will be difficult to re-cultivate these areas. Large-scale floodplain lowering has resulted in drastic and irreversible changes of the high-water bed of the rivers. Once this is done, the landscape is changed and no return to the original state is possible. This will destroy the natural archives within the floodplain sediments and cultural-historic landscape patterns of the floodplain. Valuable historic sites, however, have been preserved. Also the removal of weirs cannot be cancelled without high cost. The same holds for the shallow foreshores in the IJsselmeer.

### 6.1.1 Egalitarian Dystopias

***What if*** *a different strategy is applied than the Egalitarian management style? To what kind of future would this 'mismatch' of worldview and management style lead? Is it really a dystopia, or does it yield positive developments? The following two bifurcations describe a world in which the Egalitarian worldview is linked to an Individualist and Hierarchist style of management, respectively.*

Dystopian image of 2050: EGA(wet/dry) - Individualistic management style

***And what if*** *a market-oriented management style is applied while climate change is more extreme and ecosystems much more vulnerable than anticipated?*

Individualistic water management particularly has aimed at solving bottlenecks for the functions of use and the exploitation of potentials. Agriculture has been re-structured, abandoning non-profitable areas, and a major industrialisation of the sector has occurred. Agricultural acreage diminishes because other functions are considered to be more beneficial for economy. Nevertheless, this decrease is relatively small, compared to the other management styles. The extraction of natural gas has continued, which has caused intensified land subsidence in the northern part of the Netherlands. The Individualist has taken no measures in the river basin to provide room for the river or to increase retention of the headlands, as they are too expensive and use space that can be economically beneficial. The Individualist has carried out the cheapest measures for flood protection, leaving as much as possible space for other users that are economically more efficient. Flood protection is obtained through structures, weirs, dikes, etc. (favouring high-tech solutions if problems occur). Urban areas have expanded, and no nature development has taken place. In view of possible sea level rise, the sluice gates of the Afsluitdijk have been enlarged by 50%. The shipping sector is characterised by many large-sized ships.

#### Hydrological changes

In the EGAwet dystopia situation, climate changes much more than the Individualist has anticipated. In general, the few measures that were taken were inadequate to cope with the changing conditions, and rapid, ad-hoc technical measures must be applied to withstand the great hydrological changes. In contrast, there are fewer problems under the EGA-dry scenario, but this still has adverse effects on the water-related functions.

*Rhine/ Meuse*
The hydrological situation in the Rhine and Meuse in this EGA (wet)-Individualist dystopia is similar to the EGA-wet EGA utopia. Both scenarios are characterised by a significant increase in the high discharges (Table 6.2). For the EGA-dry scenario, the hydrological effects in the river basins are the same as under the EGA management style.

Table 6.2 Discharge characteristics of Rhineflow runs for the EGA(wet)-IND dystopia (10-daily averages, in m³/sec)

| | Current situation | Situation 2050<br>EGA (wet) - IND |
|---|---|---|
| Maximum | 8300 | 11000 |
| Minimum | 800 | 800 |
| Q95 | 4600 | 5200 |
| Q05 | 1000 | 1100 |
| Mean | 2300 | 2400 |

*IJsselmeer*
Surprisingly rapid sea level rise has led to higher water levels of the IJsselmeer. Peal levels also have increased. Consequently, additional pumping stations have to be placed at the Afsluitdijk, and the lake's dikes have to be reinforced. In the IJssel and Vecht delta additional measures are needed to maintain safety. Due to the higher lake levels it becomes more difficult to discharge water to the IJsselmeer, requiring additional pumping capacity.

*Terrestrial areas*
Increased precipitation in the EGA(wet) results in a more intensive ground water flows, as well as higher groundwater levels. Regional discharge is not retarded by water conservation measures. In contrast, the EGA(dry) scenario results in a reduction of ground water levels and regional discharges.

**Consequences for the user functions**

*Safety*
Safety is strongly reduced under the EGA(wet) scenario that results in large peak flows. No water conservation and retention measures have been taken in the upstream basin, so that large volumes of water must be discharged by the lower Rhine branches. Since no space has been reserved for retention and green rivers, solutions must be found within the high-water bed. This results in large scale dike raising to prevent the surrounding are from flooding. Also in the IJsselmeer area insufficient measures are implemented to intercept the consequences of climate change. Overall, flood protection of the IJsselmeer area is far inadequate in this scenario, raising the need for placing additional pumping stations at the Afsluitdijk and dike reinforcements along the lake.

*Nature*
In the wet scenario there are favourable climate changes for nature. Despite the favourable climate conditions, the ecological gains are limited. This is because nature areas have not been expanded, and are mainly used for recreation. Also in the river basins no extra nature areas are developed, and most of the forest must be cut to reduce water levels along the river. No ecological benefits are found in the IJsselmeer, where no natural shores have been established, and water quality reduces during warm summers. In the EGA(dry) scenario, there are no benefits for terrestrial nature.

*Agriculture*
Though the Individualist has aimed at an efficient, agro-business, the wet conditions of the EGA(wet) scenario lead to high damage cost. In contrast, under the EGA(dry) scenario, there is water shortage in summer.

*Transport and navigation*
In the EGA(wet) scenario there are more frequent periods of high-discharge, when navigation is not allowed. Periods of low flow in summer, particularly under the EGA(dry) scenario lead to

major restrictions for the large ships. Therefore, major works have to be carried out to improve waterways, such as deepening and widening of the channels.

**Other characteristics**

*Investments*
Investments are initially low, as the Individualist favours those measures with the highest cost-efficiency. However, technical measures required in case of the wet scenario will be very costly.

*Economic benefits*
Economic benefits increase, because much room is created for economically beneficial activities (urban, industry), and agriculture is increasingly becoming an industry. Nature is increasingly exploited for recreation. In the wet scenario however, the risk of flooding has increased, leading to higher insurance premiums.

*Reversibility*
The Individualist primarily has taken few measures, thus leaving reversibility high. However, in case of the EGA(wet) scenario, rapid adaptations by technical means (including dike raising) must be applied to prevent the collapse of the water system. These measures are expensive and cannot reversed easily. In case of the dry scenario, few measures were needed.

Dystopian image of 2050: EGA(wet/dry) - Hierarchist management style

***And what if** a Hierarchist management style is applied while climate change is more extreme and ecosystems more vulnerable than anticipated?*

Generally, the Hierarchist has developed a water system that serves most functions at the same time, while it has been attempted to provide a major impulse to nature. This has led to a complex and time consuming phase of planning, followed by expensive implementation. Within the upstream basins and the terrestrial areas of the Netherlands, urban areas have moderately grown, while nature has expanded, both at the cost of agriculture. Several areas have been reserved for water retention, but no large-scale water conservation has been undertaken in the headwaters of the rivers. Within the embanked floodplains, a combination of nature development, floodplain lowering and, at few sites, dike raising has been carried out. Meanwhile, some (extensive) agriculture has remained within the floodplain area, and most historically valuable areas have been preserved. Water levels in the IJsselmeer are still under strict regulations guided by of targets. In view of sea level rise, the discharge capacity of the Afsluitdijk sluices has increased. The discharge capacity at the Afsluitdijk has been doubled, while safety is to be maintained by a combination of shallow forelands and reinforcement of dikes. Shallow forelands have been applied at locations were they could easily be realised. Inland navigation has little changed in transport amounts and fleet composition.

**Hydrological changes**

*Rhine/ Meuse*
The discharge regime of the Rhine and Meuse under the EGA(wet) scenario with the Hierarchistic management style very are similar to those under the Egalitarian management style. In both cases average and maximum discharges increase. However, due to the smaller retention capacity in the upstream basin, peak flows are higher than under the Egalitarian management. The model calculations of the EGA(dry) – HIE dystopia are similar to the EGA(dry)-EGA utopia. Both regimes are characterised by a significant decrease in discharge volumes.

Table 6.3 Discharge characteristics of Rhineflow runs for the EGA(dry)-HIE scenario (10-daily averages, in m³/sec)

| | Current situation | Situation 2050<br>Ega (dry) - Hierarchist |
|---|---|---|
| Maximum | 8300 | 8900 |
| Minimum | 800 | 600 |
| Q95 | 4600 | 3900 |
| Q05 | 1000 | 800 |
| Mean | 2300 | 1900 |

*IJsselmeer*

The doubled discharge capacity of the Afsluitdijk is not sufficient to maintain the 2000 target lake levels. Instead, the Hierarchist has adapted to the new situation that is caused by sea level rise by establishing new target levels, where lake levels are higher in winter than in summer. To prevent all dikes from flooding, the existing foreshores are not sufficient. Therefore, several dike reaches have been reinforced. . In this case a very small increase of dike crest is necessary, because on most locations shallow forelands can be applied.

*Terrestrial areas*

Increased precipitation in the EGA(wet) results in a more intensive ground water flows, as well as higher groundwater levels. Regional discharge is retarded by water conservation measures only in a few areas. Nature areas (i.e. wet ecosystems) have expanded. In contrast, the EGA(dry) scenario results in a reduction of ground water levels and regional discharges.

**Consequences for the user functions**

*Safety*

Peak flows have under the EGA(wet) scenario more increased than anticipated. Since only a limited number of retention basins have become operational, additional measures within the embanked floodplains are required. Here, the landscape planning has been the result of negotiations between various functions, but drastic additional measures (in particular further floodplain lowering, dike raising) are required. In the headwaters and terrestrial areas urban runoff has increased, while renaturalisation measures are only locally effective. Overall, safety has decreased. The EGA(dry) scenario has led to an increase of safety, since peak flows have been reduced, while flood reduction measures have been implemented.

*Nature*

In the river basin and floodplains larger areas are reserved for nature development. Although the targets of the EHS have not been fulfilled, nature areas have considerably expanded. The wetter climate of the EGA(wet) scenario increases the value of these nature areas. Also in the IJsselmeer area nature conservation values improve due to the construction of shallow forelands. However, due to the dry summer periods (particularly of the EGA(dry) scenario) the improvement of nature is sub-optimal.

*Agriculture*

Agricultural area has been reduced, but less than in the Egalitarian utopia. Existing agriculture suffers from summer drought.

*Inland navigation*

Navigation in this dystopian scenario is characterised by medium-sized ships, which may occasionally suffer from high water periods when navigation is not allowed. The fleet is not well adapted to the low flow conditions caused by the EGA(dry) scenario, resulting in a lower transporting capacity, higher cost and a reduction in the reliability.

**Other characteristics**

*Investments*
Investments are expensive, because of the complex planning process and measures that must be adopted to local demands of all functions. The dystopian wet scenario has resulted in a situation where costly measures have been implemented that are still inadequate to cope with the changed conditions. The dry scenario is characterised by costly and unnecessary measures taken for reducing flood risks. Moreover, there are no economic gains. In the river basin the economic gains are even negative, because less area is reserved for economic activities. Initially 'win-win' situations may turn in losses for several functions if the complex and integrated designs collapse under the pressure of additional measures for flood protection.

*Economic benefits*
Economic benefits increase, because room is still preserved for economically beneficial activities (urban, industry) and agriculture. Also the designs that serve different functions at the same time are economically beneficial. Under the EGA(dry) scenario these benefits become true, but under the stress applied by the wet scenario, the benefits of agriculture and economic sectors near the rivers may reduce.

*Reversibility*
The reversibility is relatively high, because there has not been large-scale landscape changes, and because of the 'win-win' strategy applied. Along the rivers floodplain lowering and dike raising were initially limited. Furthermore, nature near the rivers can be used for other purposes. However, to cope with the major changes in discharge under the EGA(wet) scenario, considerable (irreversible) additional measures have been undertaken.

### 6.2 An Individualist image of 2050

**What if** the world turns out to in accordance with the a priori Individualist expectations?

| A utopian image of 2050: IND-IND |
| --- |

#### Characteristics of the water system

Individualistic water management has been guided by cost-efficiency, aimed at solving bottlenecks for the functions of use and the exploitation of potentials. Agriculture has been re-structured, abandoning non-profitable areas, and a major industrialisation of the sector has occurred. Agricultural acreage diminishes because other functions are considered to be more beneficial for economy. Nevertheless, this decrease is relatively small, compared to the other management styles. The extraction of natural gas has continued, which has caused intensified land subsidence in the northern part of the Netherlands. The Individualist has taken no measures in the river basin to provide room for the river or to increase retention of the headlands, as they are too expensive and use space that can be economically beneficial. The Individualist has carried out the cheapest measures for flood protection, leaving as much as possible space for other users that are economically more efficient. Flood protection is obtained through structures, weirs, dikes, etc. (favouring high-tech solutions if problems occur). Urban areas have expanded, and no nature development has taken place. In view of possible sea level rise, the sluice gates of the Afsluitdijk have been enlarged by 50%. The shipping sector is characterised by many large-sized ships.

#### Hydrological changes

This scenario has hydrological characteristics similar to the current situation (cf. Table 6.4). The Individualist perspective did not give any reasons to expect a totally different rainfall or temperature regime and so the input into the hydrological system has remained unchanged in the utopia situation. Slightly higher maximum and Q95 values can be expected due to a large increase in urban area, which decreases infiltration and increased direct runoff.

Table 6.4 Discharge characteristics of Rhineflow runs for the HIE-HIE utopia scenario (10-daily averages, in m³/sec)

| | Current situation | Situation 2050 |
| --- | --- | --- |
| Maximum | 8300 | 8600 |
| Minimum | 800 | 800 |
| Q95 | 4600 | 4800 |
| Q05 | 1000 | 1100 |
| Mean | 2300 | 2400 |

*IJsselmeer*
The discharge capacity in the IJsselmeer has been increased in this scenario by a factor 1.5. This is sufficient to maintain the lake levels as they were in the year 2000. Maximum levels have not increased. Also in other sectors, such as water supply and the discharge water into the IJsselmeer area, no additional measures are needed.

*Terrestrial areas*
Little changes have occurred in the terrestrial areas. Continued soil subsidence has required intensified artificial drainage of the polders. Cities have expanded, and agriculture has become more efficient, and only occasionally suffers from very wet springs or dry summers. Nature

areas have not become larger and are intensively used for recreation. Ground water tables are artificially maintained at low levels for the benefit of agriculture.

**Consequences for the user functions**

*Safety*
The present state is adequate for flood protection. Some measures have been carried out to solve a few bottlenecks. Hydraulic obstacles have been removed, and a few dike sections have been reinforced.

*Nature*
Climate conditions have not significantly changed in this scenario. The overall implications of the management style have been negative for nature. The area of nature has not changed, while industrial and urban expansion put a high pressure on nature. Low groundwater tables for agriculture has negative effects for nearby (wet) nature areas. Many nature areas are intensively used for recreation. In the terrestrial areas large growth of population and economy results in a large increase of domestic and industrial water demand. This will decrease the groundwater levels and may stimulate water use of low quality water from the rivers.

*Agriculture*
Some agricultural land has been occupied by urban and industrial areas. The remaining area has been intensively used by profitable agriculture. Within the embanked floodplains the agricultural acreage remains the same. The sector is not affected by a climate change.

*Inland navigation*
Inland navigation is characterised by many and large-sized ships. The occurrence of low flow periods is a calculated and relatively easily predictable risk.

**Other characteristics**

*Investments*
The Individualist has been guided by making low costs. Since no surprises have occurred, the low costs have resulted in high benefits.

*Economic benefits*
In this scenario most possibilities for economic activities in terms of space increase. Also nature areas are considered as an economic good and are used for recreational and tourism purposes. In the floodplains there is a small increase of economic benefits as more restaurants and recreation areas are built.

*Reversibility*
In this utopia water management is characterised by few measures, thus leading to a high reversibility in general. However, although no measures are taken, the Individualist allows economic beneficial activities in potential retention basins. It is both difficult and expensive to remove these economic activities if, for example, peak flows will be much higher than expected.

### 6.2.1 Individualist dystopias 2050

***What if*** *a different strategy is applied than the Individualist management style? To what kind of future would this ‘mismatch’ of worldview and management style lead? Is it really a dystopia, or does it yield positive developments? The following two bifurcations describe a world in which the Individualist worldview is linked to an Egalitarian and Hierarchist style of management.*

Dystopian images of 2050: IND-EGA and IND-HIE

These dystopias include the external world according to the perspective of the Individualist, in which Egalitarian and Hierarchist management styles were applied. The characteristics resulting from each of these two management styles have been described previously in their utopia scenarios. Here, the consequences under an Individualistic world view are summarised. In general, climate has very little changed, which means that the changes in the water systems are largely associated with the applied management styles. In line with the definitions given in chapter 4, we assume that in these IND-dystopias urban and industrial areas have expanded, prohibiting the Egalitarian and Hierarchist to fully implement their measures.

**Hydrological changes**

*Rhine and Meuse*
The inputs into the hydrological system have little changed. Runoff of the Rhine and the Meuse are similar to the present (year 2000) situation. Slightly higher maximum and Q95 values can be expected due to a large increase in urban area, which decreases infiltration and increases direct runoff (Table 6.5). Nevertheless, peak flows in the Rhine have been reduced by about 2000 $m^3$/s due to the retention measures in the IND-EGA dystopia, and by about 1000 $m^3$/s in the IND-HIE dystopia.

Table 6.5 Discharge characteristics of Rhineflow runs for the HIE-EGA dystopia scenario (10-daily averages, in m³/sec)

| | Current situation | Situation 2050 |
|---|---|---|
| Maximum | 8300 | 8600 |
| Minimum | 800 | 800 |
| Q95 | 4600 | 4800 |
| Q05 | 1000 | 100 |
| Mean | 2300 | 2300 |

*IJsselmeer*
Water levels in the IJsselmeer have remained unchanged because the discharge capacity of the Afsluitdijk sluices has been drastically increased, while sea level rise was only 10 cm. In the IND-HIE dystopia, target levels can be maintained most of the year. The large investments (shallow shores, natural levels) made by the Egalitarian (and to a lesser degree by the Hierarchist) have been unnecessary for safety, and mainly serve nature.

*Terrestrial areas*
The Hierarchist and Egalitarian have partly failed in fulfilling their objectives concerning nature restoration and preventing the expansion of urban and industrial areas. The changes carried out under the Egalitarian and Hierarchistic management styles have to some extent resulted in conditions comparable to their utopias, while the climate boundary conditions are less wet during winter and spring. In general there has been a large pressure on space by urban and industrial interests. Cities have expanded, and agriculture has become more efficient, and only occasionally suffers from very wet springs or dry summers. However, agriculture locally suffers from too high ground water tables that aim at increasing ecological values of nature areas. Soil subsidence of the polders has been reduced. Water demand by industry and for public water has not been reduced.

**Consequences for the user functions**

*Safety*
As the climate changes are small, resulting in no significant changes in the river discharges, this scenario does not lead to lower safety. Moreover both management styles even have increased the discharge and retention capacity of the rivers.

*Nature*
In IND dystopias there have been no unfavourable climate changes for nature. The small climate change and because the total nature area has somewhat increased (in spite of the expanding urban areas), both have resulted in a positive effect. Also, because of the unexpected low increase in peak flows, there is still space for floodplain forests along the rivers.

*Agriculture*
In the IND-EGA dystopia there are small negative effects for agriculture, because of the decrease in space available for agricultural activities.

*Inland navigation*
The Egalitarian management style has led to a fleet with relatively large numbers of small ships, which has slightly reduced the efficiency during periods with sufficient water flow. Also the route through the South-Willems Canal is less efficient. The Hierarchistic style has not led to any changes compared to the present-day (year 2000) situation.

**Other characteristics**

*Investments*
The investments have been high, and have appeared unnecessary for maintaining safety, while the Egalitarian has not fulfilled his targets concerning nature.

*Economic benefits*
Economic benefits have been lower that in the IND-utopia. This is because agriculture has been dealing with higher ground water tables, and inland navigation was less efficient under the Egalitarian management style. Urban and industrial areas have expanded, thus resulting in some economic benefits.

*Reversibility*
Where the Egalitarian measures have been carried out, the reversibility is similar to in Egalitarian utopia. Under the Hierarchistic management style, the reversibility is higher than under the Hierarchistic utopia, because fewer measures had to be implemented for flood protection.

### 6.3 A Hierarchist image of 2050

***What if*** *the world turns out to be in accordance with the a priori Hierarchist expectations?*

| Utopian image of 2050: HIE - HIE |
|---|

The Hierarchist utopia is reflected in the scenario results for the central estimate in 2050 in the preceding NRP study (Middelkoop et al., 2000). This scenario represented the ‘best guess’ future development, extrapolated from existing policy documents. The implementation of the Hierarchist utopia has therefore been derived from these modelling results.

**Hydrological changes**

*Rhine and Meuse*
Climate change has resulted in an increase in winter discharge and a reduction in summer flow, though less than in the Egalitarian scenario. By the year 2050, peak flows in the Rhine have increased by about 5% while those in the Meuse by about 10%.

*Lake IJsselmeer*
Sea level rise has been about 25 cm, while discharge of water through the IJssel has increased. Consequently, the mean winter lake level in the IJsselmeer has become about 15 cm higher, and target levels anno 2000 cannot be maintained. Extreme levels would have increased by about 25 cm., but due to the enlarged discharge capacity of the sluice in the Afsluitdijk, this is now in the order of 20 cm. In summer, due to a reduced water inflow from the IJssel and an increased demand from the polders, periods of water shortage in summer will increasingly occur. As a result, summer lake levels may often drop below the target level. Generally, sea level rise will result in a more natural lake level regime with winter levels higher than summer levels. Due to the higher lake levels, the drainage capacity of excess water from the surrounding polders had to be increased by placing additional pumping stations. In summer discharges of the River IJssel into the lake has decreased and the demand for water for the surrounding polders had risen due to the increased temperature and intensified evapotranspiration.

*Terrestrial areas*
Geographically, the ongoing subsidence and climate change has enhanced the present-day differences between the higher Pleistocene areas in the SE part of the country where infiltration is accelerates, and the low lying polder areas in the W part where upward seepage flows intensify. This has resulted in a lowering of groundwater levels in infiltration areas and higher groundwater levels in seepage areas. Ongoing soil subsidence demands an intensification of current water management measures in the polder areas.

**Consequences for the user functions**

*Safety*
Peak flows have increased. In the river basins the effects of increased nature are small, which causes a small decrease of safety. Within the upstream basins, some retention basins have become operational, which lead to a reduction in peak floes (for the Rhine nearly 1000 $m^3/s$). Along the lower Rhine and Meuse rivers, various landscaping measures have been carried out, including floodplain lowering, removal of hydraulic obstacles, and digging side channels. Some dike stretches have been reinforced, to allow the preservation of historically valuable areas, mainly along the IJssel River. Also, two retention polders have been appointed. Due to these measures, the safety levels have not reduced. The larger sluice gates in the Afsluitdijk, together with some shallow foreshores and local dike reinforcements have been applied to preserve the safety standards.

*Nature*
The area of nature has increased. In the terrestrial areas the spatial distributions show both areas with losses and gains of nature conservation values. These changes can be attributed to either changes in mean spring groundwater level or changes in upward seepage. In general, nature conservation values have increased in the peat areas. In areas adjacent to areas with land subsidence and in brook valleys nature conservation values have decreased due to upward seepage and groundwater level decreases. Nevertheless, wetter climate conditions have largely counteracted these adverse effects. However, although the wetter climate conditions may alleviate desiccation problems in most nature conservation areas, the rise of groundwater levels has been reached only in a small part of the desiccated nature reserves. Along the rivers, nature benefits from ecological restoration plans, and intensified flooding. Shallow foreshores also enhance the nature values of the IJsselmeer.

*Agriculture*

The area of agriculture land has somewhat decreased. Hydrological changes will influence the costs and benefits for agriculture. During summer, the water deficit will increase due to enhanced evapotranspiration. At the same time, there will be less water available from the Rhine for agricultural use in the Netherlands. During dry summer periods, the water demand from the IJsselmeer for agricultural use may exceed the inflow of fresh water through the IJssel River. The effects on a regional scale may be different from the overall average due to spatial differences in hydrological conditions and climate effects on the one hand, and due land us changes and the application of new crop varieties on the other hand. The largest damages are foreseen for the northern and eastern parts of the Netherlands.

*Inland navigation*

Changes in river discharge have affected inland navigation to a minor extent. During summer, low flow periods occur more frequently, which has put an additional pressure on the flexibility of the inland navigation sector in terms of navigation schemes and storage capacity.

**Other characteristics**

*Investments*
The investments made in this scenario to create safety are high because of the complex planning processes and measures that had to fulfil the local demands of all functions.

*Economic gains*
The Hierarchist scenario features limited economic gains. Retention areas can no longer be used for economic activities, but the 'win-win' strategy has allowed some expansion of urban and industrial areas, and did not affect transport negatively.

*Reversibility*
The reversibility of the measures in the river basins is moderately high, since no large-scale landscaping measures have been carried out. Retention areas are considered as reversible. Measures applied within the floodplain were based on a strategy of 'no-regret', resulting in limited floodplain lowering and only some dike rising. Also for the IJsselmeer, the application of various different measures, each at a limited scale has resulted in a relatively high reversibility.

### 6.4 Qualitative evaluation of the management styles

The anticipated effects for the various evaluation criteria - the hydrological situation (the Rhine and Meuse basins, the IJsselmeer area and the terrestrial areas), the consequences for the user functions (safety, agriculture, nature and transport/shipping) and the state of the water system (reversibility, economic gains and investments/costs) - have been estimated by each water expert in the current project by means of a 5 point scale: very negative (--) (i.e. unfavourable), negative (-), neutral (0), positive (+) and very positive (++) (i.e. favourable). The judgements were based on the model outcomes, knowledge of the models, interpretation of the modelling result and the stakeholder evaluation. The various judgements have been compared and in a Delphi-type exercise the experts have been confronted with striking differences in their judgements (see Table 6.1).

As a consequence, evaluations have been re-interpreted or adapted, for example, especially with regard to reversibility. In this iterative way, consensus has been achieved in terms of whether the impacts were estimated as positive or negative (i.e. consensus on the signs) and with regard to the degree (i.e. consensus on the number of plusses or minus). The results of this Delphi-type of qualitative expert valuation exercise are summarised in Table 6.2. The abbreviation 'N.A.' is used to indicate that a function was not applicable to a particular focus area.

Table 6.1 Input to second round of expert evaluation

| Management style | World view | Evaluation criteria | Range of expert judgements |
|---|---|---|---|
| Egalitarian | Egalitarian - dry | agriculture | [--, ++] |
| Egalitarian | Egalitarian - dry | reversibility | [--, ++] |
| Egalitarian | Egalitarian - wet | agriculture | [--, +] |
| Egalitarian | Egalitarian - wet | reversibility | [--, ++] |
| Egalitarian | Hierarchist | agriculture | [--, +] |
| Egalitarian | Hierarchist | reversibility | [--, +] |
| Egalitarian | Individualist | reversibility | [--, ++] |
| Hierarchist | Egalitarian - dry | reversibility | [-, ++] |
| Hierarchist | Hierarchist | reversibility | [-, ++] |
| Hierarchist | Individualist | reversibility | [-, +] |
| Individualist | Hierarchist | reversibility | [-, ++] |
| Individualist | Hierarchist | investment/ costs | [-, +] |
| Individualist | Individualist | investment / costs | [-, ++] |
| Individualist | Egalitarian - dry | reversibility | [-, ++] |
| Individualist | Egalitarian - dry | investment / costs | [-, ++] |
| Individualist | Egalitarian - wet | investment / costs | [-, +] |

Table 6.2 Qualitative evaluation of the effects associated with the various utopias and dystopias

| | | EXTERNAL CONTEXT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | EGA-dry | | | | EGA-wet | | | |
| MS | | Rhine / Meuse | IJssel-meer | Flood-plains | Terrestrial areas | Rhine / Meuse | IJssel-meer | Flood-plains | Terrestrial areas |
| EGA | Nature | + | ++ | + | 0 | ++ | ++ | ++ | ++ |
| | Agriculture | -- | 0 | -- | - | -- | 0 | -- | -- |
| | Safety | + | + | ++ | N.A. | - | + | + | N.A. |
| | Reversibility | - | -- | -- | - | -- | -- | -- | + |
| | Investment/ money | - | -- | -- | - | -- | -- | -- | -- |
| | Economy/ benefits | - | -- | -- | -- | -- | -- | -- | -- |
| | Transp / navigation | N.A. | 0 | - | N.A. | N.A. | 0 | + | N.A. |
| | Quality of life | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| HIE | Nature | 0 | + | 0 | - | + | + | + | + |
| | Agriculture | - | 0 | -- | 0 | - | 0 | - | -- |
| | Safety | + | 0 | ++ | N.A. | - | - | - | N.A. |
| | Reversibility | 0 | 0 | ++ | + | - | - | 0 | + |
| | Investment/mon ey | - | - | - | - | -- | - | -- | -- |
| | Economy/ benefit | - | - | - | 0 | - | - | -- | 0 |
| | Transp./ navigation | N.A. | 0 | - | N.A. | N.A. | 0 | 0 | N.A. |
| | Quality of life | + | + | + | + | + | + | + | + |
| IND | Nature | -- | 0 | -- | -- | -- | 0 | 0 | + |
| | Agriculture | 0 | 0 | - | 0 | 0 | 0 | - | - |
| | Safety | + | -- | ++ | N.A. | -- | -- | -- | N.A. |
| | Reversibility | ++ | + | ++ | ++ | -- | + | 0 | -- |
| | Investment/mon ey | ++ | + | ++ | ++ | - | + | + | N.A. |
| | Economy/ benefit | ++ | 0 | + | ++ | ++ | 0 | - | ++ |
| | Transp. / navigation | N.A. | 0 | - | N.A. | N.A. | 0 | + | N.A. |
| | Quality of life | -- | 0 | 0 | - | -- | - | -- | -- |

Table 6.2 Qualitative evaluation of the effects associated with the various utopias and dystopias - continued

| | | EXTERNAL CONTEXT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HIE | | | | IND | | | |
| MS | | Rhine / Meuse | IJssel-meer | Flood-plains | Terrestrial areas | Rhine / Meuse | IJssel-meer | Flood-plains | Terrestrial areas |
| EGA | Nature | + | ++ | ++ | + | + | ++ | ++ | + |
| | Agriculture | -- | 0 | -- | - | -- | 0 | -- | - |
| | Safety | - | ++ | ++ | N.A. | 0 | ++ | ++ | N.A. |
| | Reversibility | - | -- | -- | + | - | -- | -- | + |
| | Investment/money | - | -- | -- | - | - | -- | -- | - |
| | Economy/ benefits | - | - | -- | -- | - | - | -- | -- |
| | Transp. / navigation | N.A. | 0 | 0 | N.A. | N.A. | 0 | 0 | N.A. |
| | Quality of life | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| HIE | Nature | + | + | + | + | + | + | + | 0 |
| | Agriculture | - | 0 | - | - | - | 0 | - | - |
| | Safety | 0 | 0 | 0 | N.A. | + | + | + | N.A. |
| | Reversibility | + | 0 | + | + | + | 0 | + | + |
| | Investment/money | + | - | - | + | + | - | - | + |
| | Economy/ benefit | - | 0 | - | 0 | - | - | - | 0 |
| | Transp. / navigation | N.A. | 0 | + | N.A. | N.A. | 0 | + | N.A. |
| | Quality of life | + | + | + | + | + | + | + | + |
| IND | Nature | -- | 0 | 0 | 0 | -- | 0 | - | - |
| | Agriculture | 0 | 0 | + | 0 | 0 | 0 | + | + |
| | Safety | -- | - | - | N.A. | 0 | 0 | 0 | N.A. |
| | Reversibility | + | + | ++ | -- | ++ | + | ++ | -- |
| | Investment/money | + | + | + | + | ++ | + | ++ | ++ |
| | Economy/ benefit | ++ | 0 | 0 | ++ | ++ | + | + | ++ |
| | Transp. / navigation | N.A. | 0 | - | N.A. | N.A. | 0 | + | N.A. |
| | Quality of life | -- | 0 | 0 | - | -- | 0 | 0 | 0 |

In order to provide a basis for the assessment of the management styles, the expert judgements have been further processed. This was done by a row-wise comparison of the qualitative evaluation of each management style across the different worldviews, in the following ways:
The various scores have been aggregated into minimum and maximum values to indicate the range of estimated effects for each evaluation criterium. Furthermore, in order to get an indication of whether the associated effects are expected to be primarily positive or negative, all scores have been summed up in a qualitative average (see first columns in Table 6.3). In this way per management style it can be assessed what kind of positive or negative effects are associated with this type of policy, and which outlooks are indefinite. In the case of negative effects, it can be concluded that the particular management style is associated with risks.
Furthermore, it was determined to what extent the results for a management style vary with different worldviews and associated external contexts. This has been done for the various focus areas (Rhine and Meuse, IJsselmeer, floodplains and terrestrial area), because of the large variation in effects among the different subsystems. The plusses and minus have been interpreted as numbers (-- as 1 and ++ as 5) to estimate the variance of effects over the various world views and external context. Based on this semi-quantitative evaluation (see Table 6.3 last four columns), it is possible to indicate whether the effects associated with a management style are sensitive to assumptions with regard to world view and external context. If the outcomes in terms of images for 2050 do not vary (i.e. zero or very low variance), the implications of a management style are not sensitive to uncertainties about the future, and the management style may be regarded as robust to the interpretation of uncertainty. The latter implies that firm conclusions can be drawn on whether and which positive or negative effects associated with the management style are expected, irrespective of the assumptions pertaining to external context and the functioning of the water system. In other words, in these cases the uncertainties are not relevant for decision-making, which implies that decision-makers can disagree about the underlying assumptions while still agreeing about the effects associated with the management style. In case significant variance is observed, the underlying uncertainties pertaining to external context and functioning of the water system are relevant to decision-makers. Differences in perspectives do matter to the political debate.

Table 6.3 Qualitative results of the evaluation of management styles

| MS | | 'Average' | Max | Min | Variance Rhi/Mse | Variance IJsselmr. | Variance Fl.pl. | Variance Terr. |
|---|---|---|---|---|---|---|---|---|
| EGA | Nature | ++ | ++ | 0 | a | a | a | a |
| | Agriculture | - | 0 | -- | a | a | a | a |
| | Safety | + | ++ | - | a | a | a | N.A. |
| | Reversibility | - | + | -- | a | a | a | b |
| | Investment/money | -- | - | -- | a | a | a | a |
| | Economy/benefits | -- | - | -- | a | a | a | a |
| | Transp/ navigation | 0 | + | - | N.A. | a | c | N.A. |
| | Quality of life | ++ | ++ | ++ | a | a | a | a |
| HIE | Nature | + | + | - | a | a | a | a |
| | Agriculture | - | 0 | -- | a | a | a | a |
| | Safety | 0 | ++ | - | a | a | b | N.A. |
| | Reversibility | + | ++ | - | a | a | a | a |
| | Investment/money | - | + | -- | c | a | a | c |
| | Economy/benefit | - | 0 | -- | a | a | a | a |
| | Transp / navigation | 0 | + | - | N.A. | a | a | N.A. |
| | Quality of life | + | + | + | a | a | a | a |
| IND | Nature | - | + | -- | a | a | a | b |
| | Agriculture | 0 | + | - | a | a | b | a |
| | Safety | - | ++ | -- | c | a | c | N.A. |
| | Reversibility | + | ++ | -- | c | a | a | c |
| | Investment/money | + | ++ | - | c | a | a | b |
| | Economy/benefit | + | ++ | - | a | a | a | a |
| | Transp / navigation | 0 | + | - | N.A. | a | b | N.A. |
| | Quality of life | - | 0 | -- | a | a | b | a |

a – choice for management style is for focus area not sensitive to assumptions in world view and external context, i.e. robust to interpretation of uncertainty
b – management style is for focus area moderately sensitive to assumptions in world view and external context
c – management style is for focus area very sensitive to assumptions in world view and external context

Irrespective of the uncertainty associated with the changing environment and an uncertain future, inspection of Table 6.3 yields that the following conclusions can be drawn with regard to the effects associated with the *Egalitarian* management style:

- positive effects on nature and safe in view of flood risks, though upstream land use measures (in Germany for the Rhine and in Belgium and France for the Meuse) turn out not to significantly reduce the peak values; as a consequence the Egalitarian management style is associated with a higher quality of life;
- negative impacts on agriculture, both in terms of the areal extent of agriculture and damage associated with high ground water levels;
- high investment costs and low economic benefits.

Furthermore, the Egalitarian management style implies such far-reaching changes that in general the reversibility is low, although there are regional differences; it may in some cases be relatively effortless to reconvert natural area in to agricultural area.

With regard to the *Hierarchistic* management style it can be concluded that the Hierarchist management style is associated with some increase in terms of nature values, only in case the Egalitarian interpretations of the uncertainties with regard to external context and functioning of the system holds the outlooks are slightly more negative (HIE – EGA dry). From our assessment we can conclude that water management according to the Hierarchist management style furthermore does yield positive economic benefits. With regard to agriculture it can be concluded that the Hierarchist management style implies a decrease of agricultural acreage and an increase of damage, the latter especially in case the Egalitarian assumptions hold. Compared to the Egalitarian management style, the Hierarchist management style is less safe in terms of flood risks. The level of safety furthermore varies along with the external context and world view. Especially, in case climate change yield more extreme high water events, the Hierarchist management style does not guarantee safety. In other words, with regard to safety, the level of investment and reversibility, the Hierarchist management style is sensitive with regard to the assumptions pertaining to external context and world view. The latter especially holds for the level of investments associated with water management measures implemented in the Rhine and Meuse and the terrestrial area. Compared to the Egalitarian management style, the evaluation results suggest that the Hierarchist management style, even in the most pessimistic case, implies less investments and a higher degree of flexibility with regard to reversing or adapting water management measures.

From the integrated assessment of utopian and dystopian outlooks, the following conclusions can be drawn with regard to impacts associated with the *Individualistic* management style:

- negative impacts on nature;
- economic benefits, provided that no catastrophic flood disasters occur.

The above conclusions hold irrespective the interpretations of uncertainty. In general terms, reversibility of Individualist water management measures is high (also because not so much measures are taken), although this conclusion is violated in view of extreme high waters in the Rhine and the Meuse (Egalitarian interpretation of uncertainty). In the latter case, also the level of investment increases. Further investigation of the evaluation results yield that the impacts in the remaining agriculture areas are affected by climate change, both negatively (dry dystopia) and positively (wet dystopia). Safety values are only acceptable in the Individualist utopia; they are highly variable and reach low values in the dystopias. This implies that the Individualist management style is not robust in case the future will unfold according to Egalitarian or Hierarchist assumptions concerning external context and the functioning of the water system.

**Dystiopas**

More interesting than the utopia scenarios are the dystopias for analysing the management styles. The Hierarchist may encounter two types of dystopia. The first is that climate change is much worse than anticipated. In that case he has spent a lot of effort in developing well balanced, area specific landscaping measures that served as many functions as possible, but now all this effort appears to be inadequate. In case of a disastrous event, there is still a big economic and societal damage, and taking additional measures will seriously affect the achieved objectives, and cause many loss-loss situations. The second dystopia is that there is only little climate change, so there was no great need for costly and deliberate landscaping measures to fulfil all river functions within the narrowing margins enforced by the expected climate change. Nevertheless, there are also benefits in terms of increased safety levels, more resilient river systems, higher nature values, and still most river functions unaffected.
The Individualist's dystopia is a stronger climate change than anticipated. Although the Individualist accepts risk, a true disaster, such as a major calamity flood, may simply result in a bankrupt situation, where it very unclear how such situation will develop after such event. Otherwise, the Individualist may attempt to rapidly implement additional technical measures (since no space has been reserved for water retention) in case he discovers that climate changes much more than anticipated. This at last may lead to high costs.

The Egalitarian's dystopias are situations where climate appears to be less sensitive, emissions have been low and, consequently, climate changes were minor. From the Egalitarian viewpoint, the large investments and far-reaching landscape changes still serve the goals of sustainable development achieving resilient water systems and restoring natural ecosystems. Thus, the investments are not regarded as losses, and reductions in economic benefits are still considered the prize to be paid for this. An Individualistic 'outsider' however, would regard these dystopias much different, as economic benefits have been sacrificed for nature and water, while the need for this has appeared only imaginary.

**Robustness**

Comparing the assessment over the various management styles, we can conclude that the Egalitarian management style is most robust in view of aspirations associated with safety and nature, but it is undisputed that the prize involves high cost and large spatial claims. The Hierarchistic management style fulfils the objectives of integrated (win-win) solutions with nature, safety and reversible measures in most cases. However, in dystopian situations, investment cost will be high without leading to safety in view of flood risks. In case the external context and the water system will evolve according to the Egalitarian wet variant, the applied measures are not adequate, and may lead to loss for nature and other water functions, especially in the floodplains. This management style is thus less robust in view of a changing environment and an uncertain future. From our assessment results, it is clear that the Individualistic management style is adequately characterised as high risk, while cost-efficient, at least in the short term. Positive impacts for all relevant functions (except nature) do only materialise in case the external context develops according to the Individualist assumptions, and when the river basins systems are as robust as the Individualist assumes. In dystopian cases, technical measures have to be applied to counteract the climate-induced changes, which may lead to high cost. The Individualistic management style can therefore be considered as the least robust in view of uncertainties associated with external context and functioning of the water system.

# 7 DISCUSSION

The aims of the project were:

- to develop a set of perspective-based internally consistent scenarios describing future developments with regard to economy, population, consumption patterns, transport, land use, climate change and water management policies.
- to assess hydrological changes in the Dutch part of the Rhine and Meuse basins as well as the consequences for various user functions associated with these scenarios by means of existing hydrological and impact models, i.e. RHINEFLOW, MEUSEFLOW, WinBos, and the model chain MOZART-NAGROM-DEMNAT-AGRICOM
- to assess and evaluate the implications of different water management strategies as basis for policy recommendations concerning the type of water management strategy needed in view of a changing environment and an uncertain future.

In line with the project aims we developed three families of utopian and dystopian scenarios in a participatory manner (i.e. in consultation with experts and stakeholders). The scenarios have been extensively described in the previous chapters. The hydrological changes and the consequences for user functions associated with these scenarios have been assessed by means of existing hydrological and impact models. Different perspective-based assumptions were represented in the model simulations by different model schematisations (e.g. land use maps) adaptation of model parameters (for example, drainage coefficients) and different inputs (such as climate variables). To explore how the models could be used in such an integrative exercise, a sensitivity analysis has been performed to identify relevant parameters and inputs. It was then decided which inputs and parameters could be used to represent the qualitatively formulated assumptions and trends of the scenarios. The output of the model-based assessment of the future has been used to explore the potential range of hydrological changes and the consequences for user functions in a (semi) quantitative manner. Finally, the set of perspectives has been used to evaluate different water management strategies, thereby using the water-specific management styles as associated with Hierarchist, Individualist and Egalitarian perspective as a kind of yardstick.

This integrated assessment of water management for the Dutch Rhine and Meuse basins provides the basis for policy recommendations as well as insights relevant for future research. In this chapter we will focus on what we have learned in terms of:

- the perspective of present-day water management in the Netherlands
- potential implications of different water management styles
- the application of the perspectives concept to this theme
- the role of scenarios and modelling
- participatory processes
- interdisciplinary assessment
- recommendations for further research

### 7.1 Perspectives on water management in the Netherlands

In this project a large number of Dutch reports, which appeared over the last few years, have been analysed. The aim was to explore whether a sufficient varied set of integrated scenarios could be derived from existing material. Secondly it was analysed whether existing studies cover sufficient plurality, in the sense that sufficient legitimate interpretations of uncertainty were considered. From the analysis it could be concluded that no integrated scenarios are available and that most of the investigated studies adopt similar assumptions with regard to future water management, as these studies reason from a Hierarchist perspective in which safety is a leading principle.

### 7.2 Implications of management styles

The project basically evaluated the three scenario families, based on the central statement 'water management according to perspective X results in…'. By confronting each management style with different futures, both utopian and dystopian, overall conclusions could be derived for each perspective and associated management style.

**Hierarchist management style**
The Hierarchist aims at so-called win-win situations. However, our integrated assessment indicates that the Hierarchist avoids real choices, and some of the futures associated with this management strategy run the risk of becoming 'loss-loss' situations. Hierarchistic water management is a time consuming and expensive strategy, but it does not yield firm safety guarantees. Furthermore, the Hierarchist strategy implies regular adjustment, which is a major cause for the high expenses. This management style may be compared to insurance: high premium, but if it goes wrong (floodings due to climate change) it is likely that the system's resilience is not adequate. Because the Hierarchist tries to guarantee all functions in view of scarcity of financial and land resources, it is likely that all functions suffer. If climate change appears to be insignificant, the costs have been for nothing. On the other hand, over time, this compromise strategy of 'running with the hare and hunting with the hounds'[5] has most public support. However, per situation and per point in time no stakeholder is satisfied. This water management strategy can be characterised as reactive, fully 'controlled' by external factors and incidents, as stakeholders interests may change in response to events. The risk associated with this management style is that it gets stuck in conferences and sluggish decision-making, and that only a few measures are actually implemented, among which likely those that are acceptable but not effective. This water management strategy is actually not so much a vision on water policy, but on how to organise water management. The Hierarchist management style actually addresses uncertainty associated with future developments through incrementalism (versus drastic measures) thereby implicitly creating the flexibility to change to another management style.

**Individualist management style**
The Individualistic management style can be characterised as passive, and displaying a short-term vision with respect to water management measures. The Individualist aims at reducing cost, stimulating economic benefits, thereby accepting a relatively high, calculated risk. Measures will be implemented in an adaptive way to changing conditions. However, our assessment yields that real adaptation in case of an unforeseen drastic climate change will not be possible. This is because this management style leaves little physical space for adaptation. Consequently, it will be difficult to change to another management style, for example, because of irreversible damage to natural systems in the flood plains, or potential retention areas have been occupied by other functions. On the short term, this strategy –compared to the others- is relatively cheap. However, there is the risk of amplifying feedbacks if the world develops differently then the Individualist assumes (e.g. materialistic growth inducing further climate change). The world associated with Individualistic management is thus extremely vulnerable for calamities, i.e. low probability events happening. In case of extreme flooding, the economic impacts are larger, because of high economic value and damage potential along the rivers and of the agriculture sector. This strategy of short-term and bottom-up solutions results in few positive side effects. The future associated with the Individualistic management strategy was characterised as wealthy, but even in the utopian case associated with a lower quality of life in the broader sense.  In the case of water management, it is obvious that the Individualistic approach to uncertainty should be really characterised as risk-taking. In sum: little short term costs, but high long-term risks.

[5] In Dutch: de kool en de geit sparen

**Egalitarian management style**

The Egalitarian strategy is focussed on the causes of water-problems, instead of warding off symptoms and effects (Individualist), or focussing on actors (Hierarchist). The approach to uncertainty associated with this perspective can be characterised as aiming at a high resilience of the water system. The Egalitarian water management strategy involves major environmental and landscaping measures, resulting on the one hand in sustainable solutions with resilient water systems for flooding, and major restoration and expansion of nature. On the other hand, the implementation cost involved are high, and other - mainly economic - functions (such as industrial and urban expansion, inland navigation, agriculture) must give way to the protection and expansion of water and nature. The Egalitarian runs the risk of getting prohibitive, and through high water management expenses, for example, sacrificing cost-effective technological breakthroughs in other areas. In dystopian situations, when no calamities happen, the drastic measures and large costs have been to no purpose. The positive side effects involve a large natural area and a higher quality of life in the broader sense, and less in terms of material wealth. The Egalitarian faith is that economic austerity in combination with psychological and socio-cultural well-being will result in a long-term stabilisation or even curbing of climate change, thereby reducing the long term water risks. In other words, this management style seems to lead to futures that are favourable if one does not mind high costs. A negative side effect may be that due to the scarcity of space in the Netherlands, the increasing demands for room for nature and water may indirectly increase the pressure on other nature reserves, such as the Veluwe. Although many landscaping measures are costly and irreversible (digging away floodplains, transforming agriculture areas into nature), it is a strategy more flexible than the Individualist, in the sense that it allows for changing to another water management strategy, if time teaches that the risks are smaller than perceived today.

**Robustness**

Comparing the assessment over the various management styles, we can conclude that the Egalitarian management style is most robust in view of aspirations associated with safety and nature, but it is undisputed that the prize involves high cost and large spatial claims. The Hierarchistic management style fulfils the objectives of integrated (win-win) solutions with nature, safety and reversible measures in most cases. However, in dystopian situations, investment cost will be high without leading to safety in view of flood risks. In case the external context and the water system will evolve according to the Egalitarian wet variant, the applied measures are not adequate, and may lead to loss for nature and other water functions, especially in the floodplains. This management style is thus less robust in view of a changing environment and an uncertain future. From our assessment results, it is clear that the Individualistic management style is adequately characterised as high risk while cost-efficient, at least in the short term. Positive impacts for all relevant functions (except nature) do only materialise in case the external context develops according to the Individualist assumptions and when the river basins systems are as robust as the Individualist assumes. In dystopian cases, technical measures have to be applied to counteract the climate-induced changes, which may lead to high cost. The Indvidualistic management style can therefore be considered as the least robust in view of uncertainties associated with external context and functioning of the water system.

### 7.3 Policy recommendations

This evaluation of water management strategies through assessment of the water-specific management styles associated with the three archetypal perspectives revealed several general conclusions relevant for water management.

The vast majority of current policy plans on water management in the Netherlands falls within the Hierarchist perspective for their management style, and is shifting from Hierarchist to Egalitarian in terms of assumptions pertaining to external context and world view. However, the Hierarchist management style, aiming at win-win situations, is not a-priori the best one in terms of robustness. There is no management style that is superior under all conditions evaluated on the whole set of evaluation criteria - safety, agriculture, nature, transport/shipping, reversibility, economic gains and investments/costs-. In case of a serious climate change (i.e. by the order of 2 °C or more temperature rise in the next 50 years), there may be no longer possibilities for finding win-win solutions for all water functions. Also, the complexity of the planning process of the Hierarchist, may result in a slow response in case of severe climate change. A major difficulty in the 'cost-benefit' assessment is the weighing of advantages against disadvantages, because they are of a different kind. We need to stress that this is not necessarily a generic statement, but specific for the Netherlands.

'Integrative' water management may not necessarily combine all functions at the same place. A firm conclusion from our assessment is that in the Netherlands integrative water management implies area specific ('gebiedsgericht') policy and differentiation of functions. Furthermore, it is clear that 'integrative' implies going beyond the engineering, technical view on water management towards a more societal perspective (compare NLRO, AWT and RMNO, 2000), i.e. taking into account economic, environmental, socio-cultural and institutional dimensions.

Safety versus costs is a real policy dilemma that cannot be solved by using an ingenious water management strategy. Political decisions on water management involve necessary trade-offs on normative grounds. None of the discussed water management strategies is really preferred, because every management style has its own drawbacks and disadvantages.

The main differences between the extreme perspectives Egalitarian and Individualist are their inherent choices on the implementation cost and accepted risk. To illustrate the situations where a choice to a different water management style should be considered, the EGA and IND positions are plotted in Figure 7.1 against cost and risk. The Hierarchist may take an intermediate position. Analysis of previous decision support studies on water (Chapter 3) indicates that the current water management style in the Netherlands can be characterised as Hierarchist. The key question is then whether insights associated with the present project would advocate a different water management style. Building upon our perspective-based assessments we can argue that in case Hierarchist water management would be more expensive than Egalitarian water management, the Egalitarian management style is advocated, because the latter yields more safety and nature at lower costs. In case the Hierarchist management style would appear more risky than the Individualist, the Individualistic management strategy is preferred, because it is less costly, and leaves more room for other functions. On the other hand, the Hierarchist water management strategy is most flexible, in the sense that it is relatively easy to change to another management style. As argued above, if the Hierarchist water management implies that actual measures are postponed or even cancelled due to syrupy stakeholder and decision processes, then the risks associated with the Hierarchist management style increase, probably even beyond the Individualistic level. Furthermore, if the Hierarchist water management style implies pumping the money instead of the water, the Egalitarian management style is likely to be more cost-effective and safer. In other words, too high costs or too high risks legitimate a change of management style. Similar comparisons may be made on the basis of, for example, resilience, ecological values, or the possibility of combining different functions at all places within the water systems.

The current research results do not provide (enough) evidence to advocate that a change of water management strategy is needed. At this point in time, a switch to the Individualistic management style is not advocated, because the scientific knowledge indicate that it would be unwise to neglect the possibility of serious climate change in view of the current level of uncertainty. An Individualistic water management strategy decreases the capability to cope with future climate change. From a safety point of view, it can be advocated to switch to the Egalitarian management style, because it is the most robust strategy, however, it is to be discussed whether society is ready/willing to pay the costs in financial terms and in terms of spatial claims. However, it is clear that it would be a bad policy either to put all eggs in the Hierarchist basket. The Hierarchist water management strategy has to be continuously evaluated in terms of relative risk (compared to the Individualist water management strategy) and relative costs (compared to the Egalitarian water management strategy).

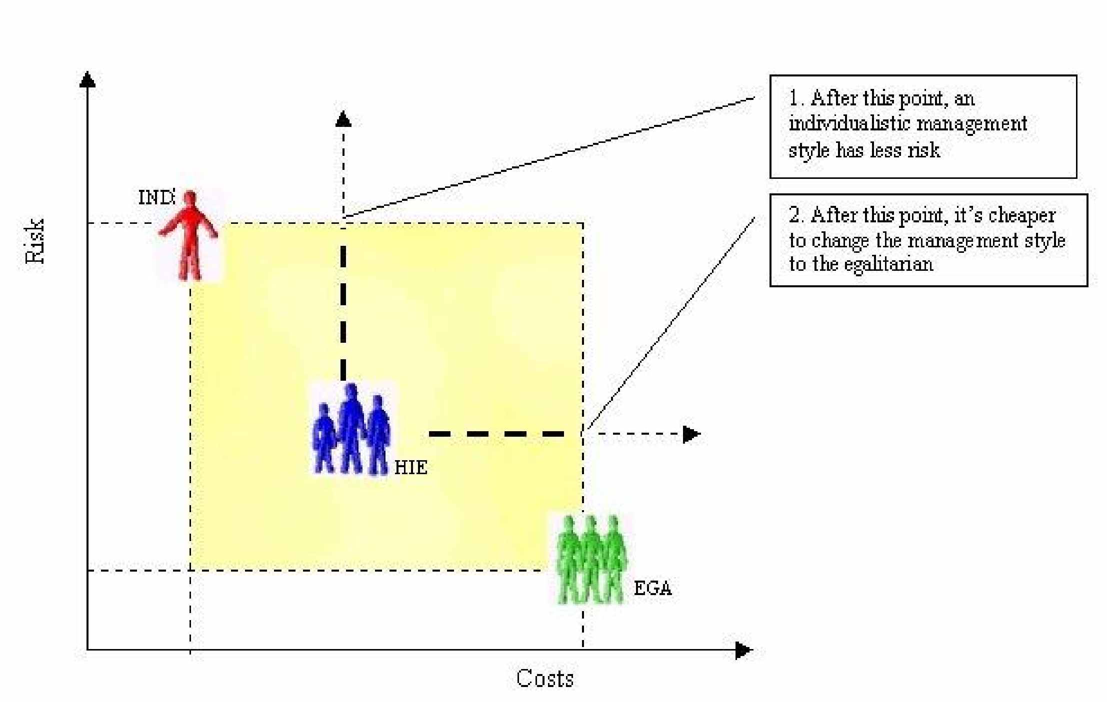


Figure 7.1 Schematic representation of the Perspectives' position against risk and cost

The integrated assessment described in the current report alone does not give enough arguments to abolish the currently practised Hierarchistic management style. Nevertheless, the research results indicate that it is important to evaluate this strategy continuously in terms of safety and costs in view of societal preferences.

Apart from the Hierarchist bias in current water management, a paradigm shift is observed from turning the water ('water keren') to accommodating the water ('water accommoderen'), so from a Hierarchist management style to a more Egalitarian type of water management with still strong Hierarchist aspects. Our research indicates that also following the water is no panacea for water management in the Netherlands, because of spatial conflicts and shifting pressure to other (vulnerable) areas. In other words, the only way forward is to seriously integrate water management and spatial planning, because otherwise spatial claims, tensions and pressures increase which is likely to result in higher risks and higher costs.

This study yields reference material to reflect on the Hierarchist management style, to be aware of the pitfalls associated with this strategy and first insights on why it would be preferred to change to another water management style. In other words, this study does not yield other short-term measures than currently advocated, but it provides recommendations in terms of organisation and evaluation, and reference material for assessment and comparison of long-term options. For example, our insights on the Hierarchist water management style underline the recommendation to select clear guidelines for the stakeholder and decision process (Rathenau, 2000) to avoid risky syrupiness and costly non-decisions. Furthermore, the integrated assessment described in this report emphasises recommendations concerning knowledge production and the process of water management identified by NLRO, AWT and RMNO (2000), i.e. interactive, multi- and transdisciplinary, learning-by-doing, and inclusive of experiential (stakeholder) knowledge. The present project can be considered as a kind of pilot or feasibility for this type of participatory and interdisciplinary knowledge production (see also section on interdisciplinary assessment). However, on the basis of the current research, we can convincingly argue that the Hierarchist water management strategy is reactive, and thus by definition lacks long-term vision. This implies that within this Hierarchist water management regime it is difficult, if not impossible, to follow-up on the ideas associated with transition management (using long-term vision to short-term actions) as advocated by, for example, NLRO, AWT and RMNO (2000), Rathenau (2000), Rotmans et al. (2000, 2001), VROM (2001)).

### 7.4 Methodology and concepts

A major methodological challenge was to explore whether the top-down approach using the concepts and typology of the Perspective-methods (van Asselt and Rotmans, 1996, 1997; van Asselt, 2000) would fit to the 'case' of water management in the Rhine and Meuse basins being the subject of the present study. In the course of the project, and after evaluation by stakeholders it became apparent that most of the present-day studies, policy lines and reports in the Netherlands on water management all fall within the Hierarchist perspective. At first sight, this would suggest that the three Perspectives are not able to discriminate between the different views presented in these studies. However, closer analysis of these studies revealed that these have been produced by related institutes, often involving the same authors, many documents are the product of intensive collaboration between institutes and many reports appear to have the same source. This observation of the 'polder model' style in the development of water management policy in the first place suppresses the development of a broad palette of visions, and in the second place it perfectly matches to the Hierarchist world view and management style, while many existing scenarios were not as broad as the possible range provided by the three Perspectives. Thus, the Perspective-based analysis of these studies well demonstrated the position of current policy in water management in the Netherlands in a wider perspective.

In turn, it was questioned whether it was possible to consider the full spectrum of 'possible' or 'thinkable' scenarios using only three perspectives. From the viewpoint of the stakeholders the three Perspectives indeed do include the extremes in scenario studies:

- The Egalitarian envisages a rather worst case situation in terms of climate change, (both wet and dry extreme events may occur)
- The Hierarchist represents the visions that seek the most plausible scenario, the central estimate, the most likely or most manageable future.
- The Individualist enables to explore the consequences of short-term orientation and a risk-taking attitude. If the Individualist makes the wrong guess, it is a calculated risk, or a bankrupt, after which a new life re-starts.

Nevertheless, our experiences teach that the approach of using archetypes for the perspectives runs the risk of oversimplifying the recognised richness and turning them into caricatures. The typology used does do full justice to the values and motivations associated with actual pluralism among stakeholders and decision-makers.

While previous projects applying the Perspectives method for assessment purposes (i.e. Rotmans and de Vries, 1997; Hoekstra, 1998, 2000) considered the entire world as a closed system, the present project focuses to a specific field of interest (i.e. water management in the Rhine and Meuse basins). The latter research object can be considered as an open system that has to deal with a context (those developments that fall outside the sphere of influence of water management, such as climate change and socio-economic developments). This raised the need for adding a third dimension to  the world view and management style distinction in the scenario analysis. In contrast to the issues comprised in the internal world view, the external contexts comprise those developments that cannot be influenced by the water management and does not touch involve characteristics of the water system itself. The values set for these external context variables are also coloured in accordance with the perspectives. They are the projections of the future of the external world as seen by each of the three perspectives. From a climate perspective, the Egalitarian scenario for the external context can be characterised as pessimistic: a curbing of the emissions, but nevertheless severe climate change impacts for the next 50 years. The Individualist external context can be characterised as rather optimistic: regarding economic growth as beneficial, while there may be little climate change. The Hierarchist's view takes an intermediate position, with regard to most variables, although this context is more pessimistic with regard to population growth and technological developments that the other two.

All management styles were then confronted with the different contexts and associated world views, to determine the sensitivity and hence the robustness of the management styles for varying (uncertain) futures.

#### 7.4.1 Role of modelling in the scenario endeavour

In the present study, large effort was firstly put on a top-down definition of scenarios. This approach provided a scientifically sound basis for the definition of policy relevant scenarios. Also it allowed definition of a limited set of scenarios, represented by the entries in utopia-dystopia matrix, which were to be evaluated with the models. While many other studies tend to carry out large numbers of model runs for lots of different scenarios, our approach provided an intelligent way of selecting relevant hypotheses to be tested using the model runs.

The model results of the present study were completed by modelling results from the previous NRP project (Middelkoop, 2000), from modelling results of related projects (such as the NRP Meuse project (De Wit et al., 2001), the 'Living with Rivers' project carried out within the IRMA-SPONGE project, modelling studies carried out within the framework of the RvR (Landscape Planning for the Rhine) project (Silva et al., 2000), the WIN (Water management in the central Netherlands / IJsselmeer area) study and other projects for water policy assessments. In all cases, models were needed to provide a quantification of the consequences of inputs, measures and parameter estimates for the water systems and water-related functions. These are indispensable for a sound reasoning and underpinning of the scenarios. Also, the models are useful tools to explore the consequences of alternative scenarios in a way that allow for comparison.

The concept of utopias and dystopias enabled to set a step ahead of a detailed comparison of different model results obtained for different climate scenarios. The applied concept firstly provides a cross-sectorial evaluation of different futures, depending on the adopted management style and assumptions with regard to external developments and the functioning of the water system. Secondly, in addition to estimating the sensitivity of the water systems and their functions to changing climate, this approach provided a basis for assessing the robustness of different water management styles under varying future conditions. The model results provided a (semi-)quantitative basis for assessing the hydrological consequences and, subsequently, the potential implications for the water-related sectors.

In the present study, models were applied to assess integrated scenarios in which many boundary conditions and input variables were changed at the same time. Although the models then give insight in the combined effect of these changes, it becomes increasingly difficult to identify the individual contributions of the different factors/measures and their mutual effects on the impacts. Further exploration of these effects might help identifying the key factors in the sensitivity analyses of the water systems, and hence in the scenarios behind these factors. For this reason, it was important that established models have been used, so that previous experiments provided a basis for understanding the model behaviour. Furthermore, it was important that experienced modellers participated in the project, who had the expertise and the skills to adequately interpret model results.

Complex physically-based models (particularly the MOZART-NAGROM models) have been applied in which hydrological processes are calculated at high spatial and temporal detail, but which have huge computing demands. However, the objectives and the result of the study were at a more general level of detail, as we attempted to evaluate general water management strategies for entire river basins. Consequently, during the project it appeared that there was a need for 'lighter' versions of such models, that can be applied many times for the exploration of different scenarios, rather than providing a great level of detail. This may lead to conflicting model demands: one the one hand they should be able to correctly simulate the complex and non-linear relationships that exist within the water systems and account for these in the assessments, while at the other hand simple models are required for exploring various scenarios.

Although simulation models were an important aspect of this study, we should be aware that most models are built around (implicit or explicit) perspectives, which determines the variation of the scenarios that can be assessed using them. The models appeared to be less flexible than expected beforehand. This has some drawbacks for applying these models in a 'perspective-based analysis'. Experts, stakeholders and workshop participants proved to be much more flexible and 'much easier to use' in a perspective-based assessment than the simulation models. However, as discussed above, to create a framework for the quantitative comparison of the different perspectives, the participants can not fully replace the simulation models.

#### 7.4.2 Participatory processes

Participation, also referred to as interactive or deliberative assessment, is increasingly recognised as being essential to decision support on complex issues. However, experience with participatory processes and thorough, systematic evaluation of participation in actual assessment endeavours are at present scarce. Different goals of participation can be identified. In this project, participatory methods were used to map out diversity as tool in decision-supportive assessment / policy analysis. The results of the project indicate that it is useful to organise participatory processes in the context of scenario analysis for the following reasons:

- to identify imaginable events ('surprises') topics that are perceived as uncertain;
- to use experiential and contextual knowledge of stakeholders to test causal logic, both ex-ante through storylines developed by the stakeholders as well as ex-post through stakeholder evaluation of the scenarios;
- to assess potential 'learning effects' that could occur through such an integrated assessment process as well as through its products.

Some experience of the present project may be worthwhile to share in view of the increasing interest in participatory processes as way to involve stakeholders in research:

- There is an overkill of workshops, causing 'workshop tiredness' among invited persons. Furthermore, many workshops organised in the field of water management are more focussed and therefore of more direct interest to the stakeholders than the kind of broad assessment workshops that were needed in our project. An alternative way could be to organise stakeholder sessions for an integrated assessment project as program slot embedded in a single-issue or popular conference or workshop. This implies that collaboration should be sought between the various stakeholder initiatives in 'water-land'.
- It was interesting to note that we had especially difficulties in attracting stakeholders that represent the Individualist perspective. Apparently, the topic water management as such is not an issue among those advocating the Individualistic perspective.
- We learned that using sessions devoted to one perspective in a heterogeneous stakeholder group is difficult, because perspectives are associated with interests and stakes. In the first workshop this resulted in wasted fragmentation. The formation of groups according to stake associated with the assigned perspective in the second workshop turned out to be more effective.

#### 7.4.3 Interdisciplinary assessment

This project is one of the rare examples in water-climate research in which natural scientific water experts collaborated with social scientists. From this perspective, the present project can be considered as a feasibility study for this type of interdisciplinary scenario-analysis. The project experiences yield that this type of research enables to evaluate current thinking and practise, that it provides reference material for critical reflection and that it enables to nuance shared, but never tested, convictions about the future.

Furthermore, the project served as a kind of pilot for integrated assessment in water research, in the sense that difficulties inherent this type of research were identified. One clear lesson was that the vocabularies and the mental maps were notwithstanding the shared commitment to work together so structurally different that it took a serious amount of project time and a number of interesting discussions until the last minute of the project to build the necessary mutual understanding. Due to these efforts, the project partners grew into an interdisciplinary team, through which a basis for further innovative research has been created.

### 7.5 Recommendations for further research

Although major steps were taken in the analyses of water management scenarios for the Rhine and Meuse rivers, we nevertheless consider this project primarily as a first step towards a new type of water assessment. Apart from insights, the project yielded food for thought that can be used to develop new research questions and hypotheses. One spin-off of the project involves research questions pertaining to the international context and possible management style differences in countries and regions along the rivers. Some of these questions are currently addressed in the IRMA-SPONGE project ‘Development of flood management strategies for the Rhine and Meuse basins in the context of integrated river management’, where the emphasis is on flood risk and flood management.

Furthermore, the project made very clear that there is a need for a broader set of reference scenarios. In this project we have made the pragmatic choice to quantify the qualitative trends according to existing scenario studies for Dutch trends, of which the following disadvantages are well-known (cf. van Asselt (2000, Chapter 7), van Asselt et al. (1998) and Greeuw et al., 2000):

- the extrapolative, linear character
- consumption-driven calculations of production trends
- rigid assumptions with regard to relationships between economic growth, population development and technological innovation
- limited discount of radical uncertainty abroad

As a consequence, the existing set of scenario studies quantitatively sketching future developments for the Netherlands in the fields of economic development, population growth and structure, consumption patterns, and land use covers a limited variety of future outlooks in view of the uncertainties involved. In order to perform an issue-specific assessment adequately, there is need for a broader set of scenarios, which can be used as benchmark. It was beyond the scope of this project to develop such scenarios, but our experiences teach that it would be a worthwhile and useful endeavour. Also the stakeholders underlined the value for decision-making and societal debates of such a broader set of context scenarios.

In this project we made use of the archetypal perspectives as proposed by Cultural Theory. This top-down approach runs the risk of not considering actual perspectives of stakeholders. Examples of research questions that could be addressed to facilitate bottom-up articulation of perspectives are:

- Which socio-economic issues do stakeholders define as problems? And in what way do these problem definitions differ from expert views?
- How do stakeholders perceive the future? And what perspectives (in terms of attitudes, beliefs and norms) underlie these interpretations of the salient socio-economic uncertainties?

In this project we explored scenarios in which the management style and world view were kept constant over time. Retrospective analysis of Dutch water management indicate that trend breaks are likely, especially related to events such as an extreme flooding. Also, the output of the storyline workshop with stakeholders surfaced such non-linearities in perspective. During the project, several switches were identifed that are interesting to explore. Conceptually, this project yield insights in how to envision trend breaks and how to structurally identify them by making use of the concepts of world view and management style, and perceiving trend breaks as changes in perspective. There are questions on how such flip-flops can be studied by means of the existing model instrumentarium. Exploring year-to-year developments of scenarios, while considering the role of events, responses and non-linearities herein according to different storylines requires major adaptation of the modelling instruments. Since the models available for the present study are detailed in time and space, and hence require a consederable effort to carry out runs over periods longer than 1 year (MOZART-NAGROM) to 30 (RHINEFLOW, MEUSEFLOW) years, they had to be used to provide a 'snapshot' that characterises the water systems in a specific projection year. Exploring 'transient' and non-linear responses requires more simple and fast 'emulations' of these models. A pressing research question is then what kind of insights (relevant for decision-making) such non-linear perspective-based scenarios can provide.

In the current project we have focussed on the river basins and water quantity. We did not explicitly take into account water quality or interactions between coastal salt water systems and the river systems. Follow-up research could therefore address the future of water quality of Rhine and Meuse (which are different in many aspects), and the Rhine-Meuse estuary (a project proposal in this direction has been submitted to the LOICZ programme).

# 8 CONCLUSIONS

- Current Dutch water management can be characterised as complying with a Hierarchist management style. This type of management runs the risk of becoming an expensive attempt to deal with problems, without actually solving the problems in a view of a long-term vision.
- One alternative is to switch to a more Egalitarian management style. However, this type of water management, guaranteeing safety and protection of nature, runs the risk of becoming too expensive, both in terms of space and direct investments, and indirectly in terms of the loss of potential economic growth and shifting pressure to other natural areas.
- At this point in time, a switch to the Individualistic water management is not advocated, because the current state of science indicates that in view of the current level of uncertainty, it would be unwise to neglect the possibility of serious climate change. Switching to a more Individualistic management style becomes only then favourable in case the Hierarchist management style would turn out to be actually more risky than the Individualist; in that case the Individualistic water management is less costly and leaves more room for other functions.
- No water management strategy is superior in all circumstances. For the Netherlands, no win-win situation can be guaranteed; in other words, water assessment cannot be reduced to an optimisation problem. Safety versus costs is a real policy dilemma that cannot be solved by using an ingenious water management strategy.
- The project results indicate that integrative water management in the Dutch context implies area-specific policy and differentiation of functions. Furthermore, the project indicates that the only way forward is to seriously integrate water management and spatial planning, because otherwise spatial claims, tensions and pressures will increase which is likely to result in higher risks and higher costs.
- Although the use of existing simulation models was an important ingredient of this study, it is should be realised that these models involve restricted and biased assumptions, which constitute drawbacks in a broad perspective-based assessment. The models proved to be more inflexible than expected. Nevertheless, they turned out to be of great help in reasoning through the qualitative sets of assumptions and they provided a framework for comparing the future outlooks associated with the selected utopias and dystopias.
- Expert sessions and stakeholder processes proved to be more flexible tools. We thus conclude that a perspective-based water assessment should involve a conscious combination of expert sessions, participatory processes and model experiments.
- The project actually served as a kind of pilot for integrated assessment in water research through identifying difficulties in real interdisciplinary research. Our experiences yield that even in case of shared commitment to work together and respect for each other's expertise, it takes a substantial amount of project time and intensive discussions and learning to build the necessary mutual understanding.
- At the start of the project it was disputed whether the perspective-approach would yield new and interesting findings relevant for water management. With hindsight the project can be characterised as experimental and challenging. Probably one of the most important results of the project is that it is clear that this type of assessment is worthwhile to further pursue, both from the scientific and the decision-making perspective. The current project provides a conceptual and methodological basis for follow-up research and a more focussed set of research questions and hypotheses.

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