Research Proposal: Methodology for Assessment Frameworks in Large-scale Infrastructural Water Projects

Enschede, 23 August 2005

Ir. Saskia Hommes

Faculty of Engineering Technology,
Civil Engineering,
University of Twente
P.O. Box 217,
7500 AE Enschede, The Netherlands.
tel: +31 (0) 53 489 2821
fax: +31 (0) 53 489 5377

Contents

1 Applicant

Name, title: Ir. Saskia Hommes
Department: Civil Engineering
Group: Water Engineering & Management
Position: Ph.D. Candidate
Telephone number: +31 53 - 489 2821

2 Title of the Project

The title of the project is: *Methodology for Assessment Frameworks in Large-scale Infrastructural Water Projects* (in Dutch: Methodologie voor beoordelingskaders in grootschalige infrastructurele water projecten)

3 Composition of the Research Group

The composition of the research group is as shown in Table 1.

	Name, titles	**Position**	**hrs./week**	**To the account of**
Proposed researcher	Ir. S. Hommes	Ph.D. Candidate	40	VICI
Promotor	Prof. dr. S.J.M.H. Hulscher	Professor	1	VICI
Daily supervisor	Dr. H.S. Otter	Assistant Professor	2-3	VICI
Supervisor	Dr. J.P.M. Mulder	Guest Researcher	1	RIKZ

Table 1: Research group

4 Short Project Description

Water management is a central and ongoing issue in the Netherlands. Large infrastructural projects are being carried out and planned in a number of water systems. These initiatives operate within a complex web of interactions, between short- and long-term, economic costs and benefits, technical feasibility, environmental impact, national and international policy and regulations, and general public interest. In this PhD-project, we aim at assisting decision-makers in large-scale infrastructural water projects through the complex web of interactions by providing a *methodology* required to develop and use *assessment frameworks (AF's)* for decision-making.

In formulating such assessment frameworks we distinguish between *process* and *contents* of a framework. The process part describes the process surrounding the development and use of assessment frameworks, where as the contents part of an assessment framework focuses on the (scientific) knowledge and other information that is used in decision-making for water management. The expected result from this PhD-project is a *methodology* for development and use of AF's for decision-making in large-scale infrastructural water projects. We aim at providing a *tool* or *a set of guidelines* (in Dutch: stappenplan, richtlijnen) for the process as well as the contents of AF´s.

5 Relevance to the Civil Engineering Department

5.1 Mission Statement

The Civil Engineering Department operates at the interface of Civil Engineering, Business Management and Public Administration. It acquires qualitative and quantitative knowledge on all phases of the lifecycle of civil engineering systems and objects, in a societal and environmental context.

5.2 Water Engineering & Management group

The Water Engineering & Management group (WEM) of the Civil Engineering Department deals with management of large, mainly natural, surface water bodies, such as rivers, estuaries and seas. In the WEM research two distinct lines of investigation can be distinguished: physics of water systems and analysis of the management of such systems. This PhD-project will mainly contribute to the latter research line, in providing a tool for the management of large-scale infrastructural water projects.

6 Location and Collaboration

6.1 Location of the Project

This PhD-project is embedded in a NWO VICI-project, entitled *Roughness modelling for managing natural shallow water systems* or simply *Rough Water*. Bed roughness in natural water systems has traditionally been studied extensively, since roughness strongly affects the large-scale morphodynamics of a river or seabed. Current roughness models are insufficient for predicting water motion in rivers, estuaries and along coasts. Therefore, a better insight in bed roughness is crucial for policy making in lowland countries like The Netherlands, where protection along coastlines and rivers is of vital importance. The central research question of the *Rough Water* project is the following:

How can we incorporate essential physical (sedimentary, vegetation and biological) influences in roughness models so that water management measures can be sufficiently evaluated in advance?

This central question splits into three research themes:

- Theme A: sedimentary and biological factors that influence roughness;
- Theme B: factors that hinder evaluating water measures in advance;
- Theme C: benefits from improved roughness models for water management.

The project is split into nine subprojects, which are covered by seven PhD-projects, one Postdoc-project and one project by Prof. dr. Suzanne Hulscher, the project leader of the *Rough Water* project. The subprojects and researchers are given in Table 2.

Theme	Subproject	Researcher
A1	The effects of bedform stochastics upon bed roughness in rivers and seas	Ir. Rolien van der Mark
A2	Dune stochastics in river morphodynamics	Dr. Ir. Astrid Blom
A3	Appropriate modelling of vegetation roughness for river management purposes	Drs. Frederik Huthoff
A4	Influence of meso scale biogeomorphological interactions on the macro scale sediment balance of the Wadden Sea	Ir. Mindert de Vries
B1	Uncertainty analysis of roughness modelling in rivers	Ir. Daniëlle Noordam
B2	*Integrated assessment framework for large-scale infrastructural water projects*	*Ir. Saskia Hommes*
C1	Dynamic roughness in rivers during floods	Ir. Andries Paarlberg
C2	Roughness and large-scale morphology	Drs. Arjan Tuijnder
C3	Water management applications	Prof. dr. Suzanne Hulscher

Table 2: Research group of the Rough Water project

This PhD-project (theme B2) will contribute to the central research question of the *Rough Water* project by exploring the integrated assessment of decisions in water management. The focus is on methodological aspects of assessment frameworks and the role of (scientific) knowledge and other information in the decision-making about water management measures. Results from this PhD-project will continuously feed back into the other VICI projects by providing input about the role of (scientific) knowledge, in particular on roughness, in decision-making for water management. The focus of this PhD-project is further described in Section 7.

6.2 Research Institute

This PhD-project is placed in the *Institute for Governance Studies (IGS)*. IGS supports multi-disciplinary research and graduate training in the fields of governance, management and innovation studies. In this institute, issues of co-ordination, steering and the operation of (networks of) institutions in both public and private sectors are core research foci, based on a multi-level, multi-actor perspective.

6.3 Collaboration with Third Parties

6.3.1 User group

A user group for the *Rough Water* project is formulated in the project research proposal (Hulscher 2003). This commission consists of end-users from the following institutes or companies: HKV Consultants; WL Delft Hydraulics; Royal Haskoning; Institute for Inland Water Management and Waste Water Treatment (RIZA); National Institute for Coastal and Marine Management (RIKZ); Netherlands Institute of Applied Geoscience (TNO-NITG); and Directorate North Sea of the Directorate-General for Public Works and Water Management (RWS-DNZ). During the VICI-project, a mini-symposium will be held every year in order to provide a platform for interaction between the VICI researchers and the end-users. The VICI researchers will present scientific progress and utilization possibilities will be discussed in-depth during discussion workshops.

In addition to the user group described above, also a smaller, more specific user group for this PhD-project will be formed. This user group will meet every six months, to discuss and comment on the research progress. Current members of the commission are: Bianca Peters (RIKZ) and Ad Stolk (RWS-DNZ). In a later stadium, we might approach other persons to join the user group.

6.3.2 Case study contacts

In this PhD-project, three case studies of large-scale infrastructural water projects will be analysed to collect the required data. We have already started with two case studies: *Dike shift Lent* and *Project Mainport Rotterdam (PMR)*. Both cases are carried out in collaboration with third parties. For the case *Dike shift Lent* we have contacts with:

Marnix de Vriend Royal Haskoning Barbarossastraat 35 P.O. Box 151 6500 AD Nijmegen Phone: +31 (0)24 3284176 Fax: +31 (0)24 3605438 m.devriend@royalhaskoning.com	Josan Tielen Directorate-General for Public Works and Water Management Directorate East Netherlands (RWS-DON) P.O. Box 9070 6800 ED Arnhem Phone: +31 (0)26 3688449 Fax: +31 (0)26 3688734 j.a.l.w.tielen@don.rws.minvenw.nl

As part of the case study PMR, Saskia Hommes will spend 1 day/week at RIKZ for a period of 6-9 months, starting from end of March 2005. In this period, she will actively cooperate with the so-called core team, which was established to repair the Core Planning Decision (PKB+) of PMR after the negative judgement of the Council of State this January (Raad van State 26 januari 2005). Contacts for the case *PMR* are:

John de Ronde and Rien van Zetten National Institute for Coastal and Marine Management (RIKZ) P.O. Box 20907 2500 EX Den Haag Phone: +31 (0)70 3114311 Fax: +31 (0)70 3114321 J.G.dRonde@rikz.rws.minvenw.nl	Bas Hoogeboom Project Mainport Rotterdam (PMR) p/a P.O. Box 20907 2500 EX Den Haag Phone: +31 (0)70 3114311 Fax: +31 (0)70 3114321 b.hoogeboom@rikz.rws.minvenw.nl

7 Extended Project Description

7.1 Problem context

Water management is a central and ongoing issue in the Netherlands. Large infrastructural projects are being carried out and planned in a number of water systems. Such projects are designed to achieve (water) management goals, like: increase protection against flooding, improve environmental quality or stimulate the local or national economy. These initiatives operate within a complex web of interactions, between short- and long-term, economic costs and benefits, technical feasibility, environmental impact, national and international policy and regulations, and general public interest. Uncertainties of different types and magnitudes play an important role (Otter and Capobianco 2000), and social and political processes determine whether new knowledge indeed plays a role in the decision-making process (Peters and Hulscher 2003).

In large-scale infrastructural projects several alternatives are developed to achieve management goals. To enable a decision to select a certain alternative an *integrated assessment* of all ecological, physical, technical, economic, social and institutional aspects is needed. A broad definition of integrated assessment is the following: *a structured process of dealing with complex issues, using knowledge from various scientific disciplines and stakeholders, such that integrated insights are made available to decision-makers* (Rotmans 1998). Integrated Assessment distinguishes itself form intuitively based processes through the usage of formal frameworks, systematic procedures and scientific knowledge. It is distinct from interdisciplinary research by its a-priori decision-support ambition. Integrated Assessment is particularly useful for analyses of real world problems that are complex, operate at different levels in time and space, are immersed in uncertainty and for which stakes are high (Rotmans and Van Asselt 2001; Van Asselt 2000).

The need for assessment frameworks has increased in the Netherlands in the last decade. Graveland et al. (2002) appoint several causes: citizens participate more; knowledge is accessible for participants; available space decreases, causing more conflicts among user functions; more insight in cause-result relationships and more monitoring data are available; legislation has changed, with more participation and more specific goals; and the growing attention for efficiency of legislation and regulations.

However, there are several problems arising with the use and development of assessment frameworks in water management. These problems comprise aspects like: incomplete or non-existing assessment frameworks; indistinct objectives; abusive assessment criteria; different stakeholder perspectives; and the gap between science and decision-making. In addition, it may be the case that certain decisions are taken on other grounds, e.g. political motives, this is however not the focus of this project.

7.2 Research objective

In this PhD-project, we aim at assisting decision-makers in large-scale infrastructural water projects through the complex web of interactions by providing a *methodology* required to develop and use *assessment frameworks (AF's)* for decision-making.

In Figure 1, an example is given in which a decision has to be taken between two river broadening alternatives, a and b. The methodology for AF's assists the advisors and the decision-maker to develop and use the AF for the river broadening project. This methodology is basically a tool or a set of guidelines. In the AF an overview of the effects of the two alternatives on different criteria is given. The final decision for an alternative has to be taken by the decision-maker, this is however not the scope of this PhD-project. The objective of this PhD-project is to:

Design a methodology for the development and use of assessment frameworks (AF's) in large-scale infrastructural water projects, by investigating case studies in the Netherlands.

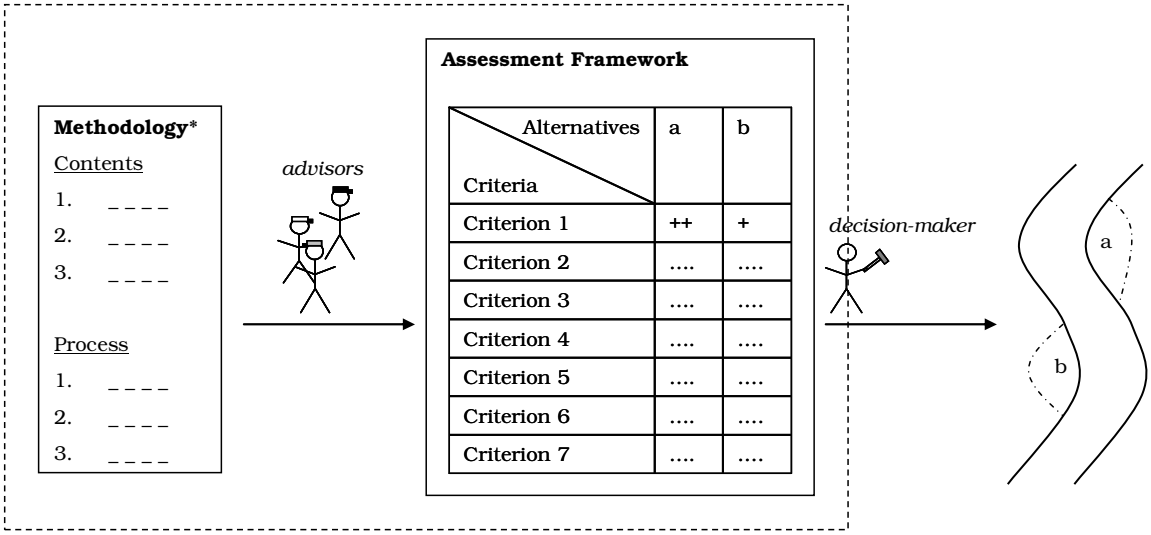

Figure 1: Example of decision-making for river broadening
* Methodology = Tool = Guidelines (= Stappenplan = Richtlijnen)
--- = Research scope

The methodological challenges of an integrated assessment framework lie in the adequate linking of input from natural and social sciences (Otter 2000), linking temporal and spatial scales of the different processes (Van der Veen and Otter 2002) and the interaction between scientists and policy makers (Van Koningsveld et al. 2003).

In formulating such assessment frameworks we distinguish between *process* and *contents* of the framework. This gives a more distinct overview of all aspects that are involved in decision-making for water management. The *process* part describes the process surrounding the development and use of assessment frameworks and contains aspects like: *Who should take the initiative of developing an assessment framework? Which actors should be involved and when? What different stakeholder perspectives are we dealing with?* (see for example: (Rijkswaterstaat 2003; Thompson 1997; Van Asselt 2000)

The *contents* part of an assessment framework focuses on the (scientific) knowledge and other information that is used in decision-making for water management. This contains aspects like: the use of (scientific) knowledge; (the formulation of) assessment criteria; the effects of human interventions (economical, physical, ecological, etc.); and the ranking of alternatives.

7.3 Research scope

In this PhD-project, we assume that scientific knowledge plays *a* role in the Dutch decision-making process, despite how big or small this role may be. This approach is known as (new-style) policy analysis (Adviesdienst Verkeer en Vervoer 2003; Van de Riet 2003). Furthermore, we investigate on the use of scientific knowledge in assessing alternatives, as solutions to problems in water systems.

We assume that a methodology for AF's, as designed in this project, is most necessary for so-called complex, unstructured problems (Figure 2, Type 4). These problems have multiple objectives and stakeholders; stakes for the project are high; sequential decisions have to be taken; and there are many uncertainties present (de Boer et al. 1999b; Funtowicz and Ravetz 1993; Goodwin and Wright 1992; Van Asselt 2000). Therefore, we focus on large-scale infrastructural water projects, which possess all these aspects.

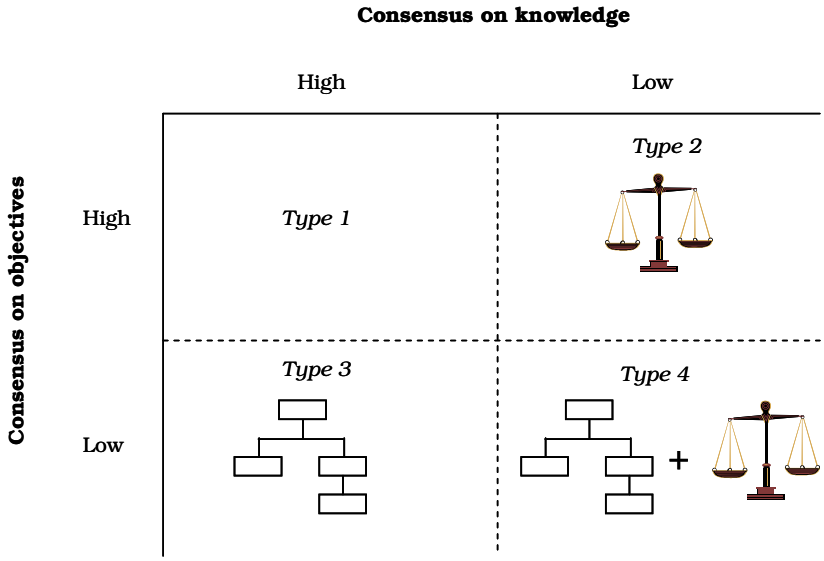

Figure 2: Problem types (de Boer et al. 1999a)
Type 1 = structured problem;
Type 2 = moderately structured problem;
Type 3 = badly structured problem;
Type 4 = unstructured problem.

The development of AF's, on which we focus in this project, takes place in a policy context. The Dutch and European policy and regulations form the boundary conditions from which large-scale infrastructural water projects are planned and implemented. This policy context is dynamic and (sometimes) unstructured. An AF is part of this dynamic policy process. Furthermore, in a policy cycle we can distinguish a strategic level and an operational level (Figure 3). We aim at evaluating alternatives for large-scale infrastructural water projects at an operational level *in advance*, in order to support decision-makers in their decision. We do not focus on strategic objectives, e.g. National spatial planning policy, water management policy.

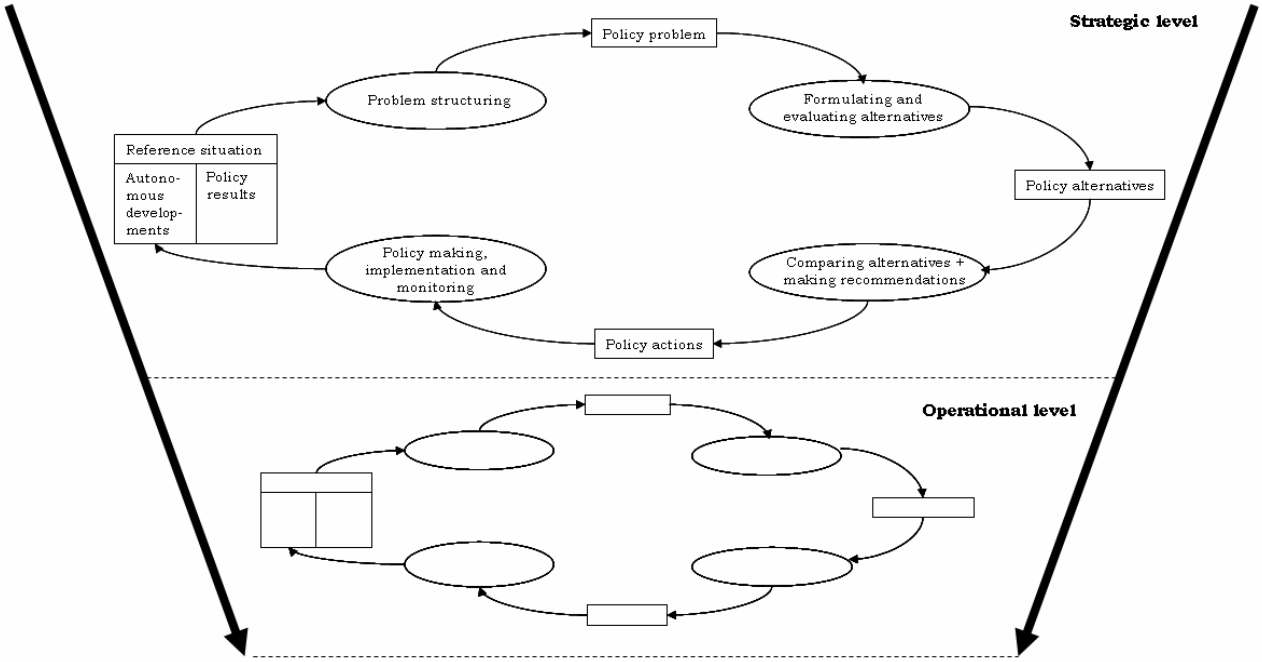

Figure 3: "Funnelmodel" (de Boer et al. 1999a)

7.4 Scientific and Societal Relevance

The innovative aspect of this PhD-project lies in the improvement and scientific embedment of the methodology for integrated assessment frameworks. These improvements can focus on the process as well as the contents of assessment frameworks.

By the use of case studies this renewed methodology will be implemented and validated in practice. Therefore, the results of this project will be useful in future large-scale infrastructural projects like *Space for the River (PKB Ruimte voor de Rivier)*, the measures in the Scheldt estuary and the activities foreseen in the North Sea (such as wind energy parks, aquaculture, sand extraction and artificial islands).

7.5 Research approach

7.5.1 Phase 1 – Theoretical framework and Case studies

Phase 1 of the project consists of a *theoretical framework* (part A) and the analysis of two *case studies* (part B). Research question A guides the literature survey (Hommes 2005a) and results in theoretical methodologies for the development and use of AF's. These *theoretical methodologies for AF's* form the frame of analysis for the case studies (Figure 4, part B). Documents, semi-structured interviews and workshops with a range of stakeholders (i.e. scientists, policy makers, water managers, non-governmental organizations) will be used to collect the required data. The theoretical framework assists in formulating questions for the semi-structured interviews and gives the researcher a perspective to analyse documents. This theoretical frame of analysis together with research question B forms the case study protocol for this project.

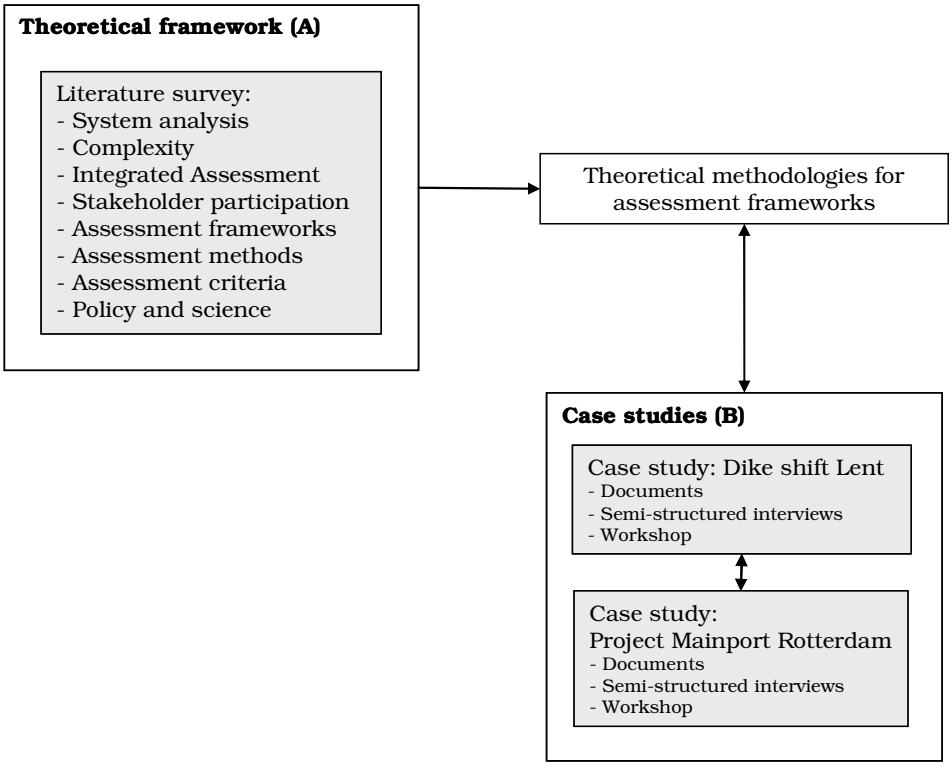

Figure 4: Research model, phase 1

A. *How do decision-makers take a decision to select a certain alternative in large-scale infrastructural projects?*
   - A.1. What basic principles, concepts, tools and methods from literature can support the decision-making process? (top-down approach)
   - A.2. What types of assessment frameworks, methods and criteria exist in literature?
   - A.3. What role does scientific knowledge play in the decision-making process? (bottom-up approach)
   - A.4. What role do hydraulic models play in the decision-making process? (feedback to other VICI projects)

B. *How are assessments in large-scale infrastructural projects made?*
   - B.1. Which type of AF is used?
   - B.2. Why is an AF used?
   - B.3. What methodologies are used to develop these AF's?
   - B.4. Who develops these AF's?
   - B.5. When, in the decision-making process, is an AF developed and used?
   - B.6. How is an AF used?
   - B.7. Who uses the AF's?
   - B.8. What role does scientific knowledge, and specifically hydraulic models, play in the decision-making process? (feedback to other VICI projects)
   - B.9. How is scientific knowledge used to distinguish between alternatives?
   - B.10. How are uncertainties, in scientific knowledge, dealt with in the decision-making process? (link with VICI-project B1)
   - B.11. Which stakeholders are involved in the project and when?
   - B.12. How do different perspectives of initiators, government and other stakeholders influence the decision-making process?

7.5.2 Phase 2 – Designing methodology for AF's

In the second phase of this PhD-project, we aim at designing a methodology for the development and use of AF's (Figure 5, part C). Research question C guides the design phase of the project. This phase results in a methodology for AF's in large-scale infrastructural water projects.

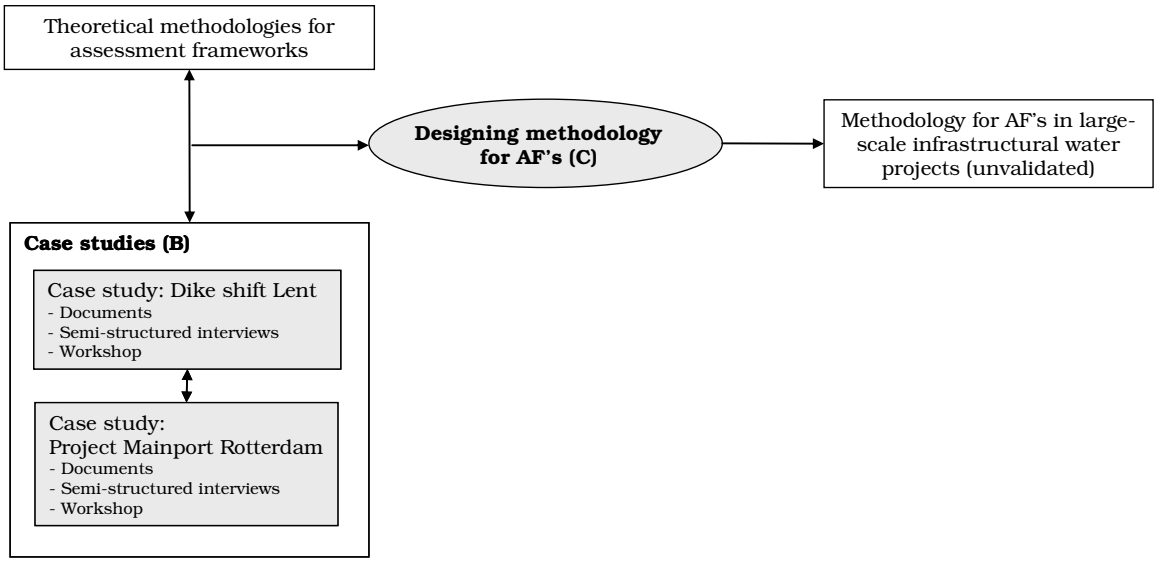

Figure 5: Research model, phase 2

C. How can we design a methodology for AF's in large-scale infrastructural water projects?

- C.1. What are the differences between theoretical (methodologies for) AF's and (methodologies for) AF's used in practice, in the case studies?
- C.2. How can these differences be explained?
- C.3. How can these differences be removed by renewing theory or formulating practical guidelines?
- C.4. What successes appeared in practice in applying AF's?
- C.5. What bottlenecks appeared in practice in applying AF's?
- C.6. How do the observed successes and bottlenecks add or correspond to theory on AF's?
- C.7. What adjustments to theory or practical guidelines have to be made?
- C.8. Which steps are necessary to develop and use a consistent AF?
  Who should take the initiative for the development of an AF? And in what stage of the decision-making process?
  Which stakeholders should be involved in the project and when?
  How do different perspectives of initiators, government, scientists and other stakeholders influence the decision-making process?
  How can scientific knowledge be used to distinguish between alternatives?
  How can uncertainties, in scientific knowledge, be dealt with in decision-making? (link with VICI-project B1)
  What are successes and bottlenecks in the development and use of an AF?

7.5.3 Phase 3 – Testing methodology for AF's

In the last phase of this PhD-project, we test the designed methodology for AF's for large-scale infrastructural water projects (
Figure 6, part D). Research question D guides the testing phase of the project. The result of this phase and thus of the project, is a validated methodology for AF's.

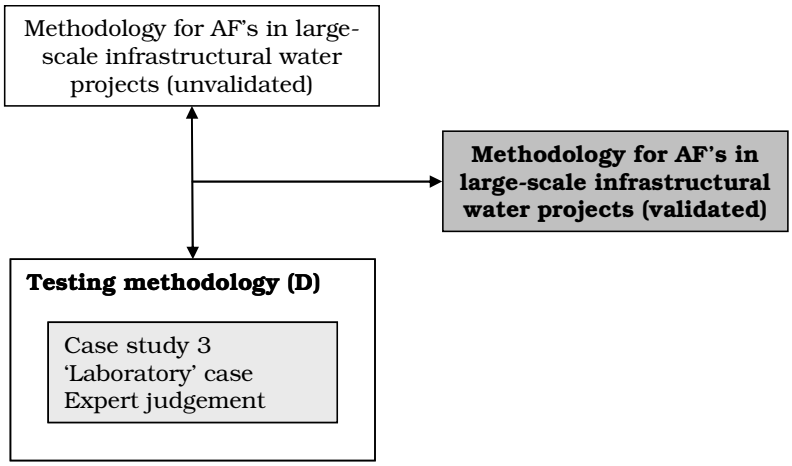

Figure 6: Research model, phase 3

D. Is the designed methodology for AF's in large-scale infrastructural water projects an improvement for practice?

- D.1. When is the designed methodology for AF's successfully used? What is the reference?
- D.2. How is the designed methodology for AF's used by experts and/or in practice?
- D.3. What further improvements can be made in the methodology, based on expert judgement and findings in practice?

7.6 Case studies

7.6.1 Preconditions and Selection criteria

Three case studies will be analysed in depth in this PhD-project. We formulated four preconditions for the case studies. They must comprehend the following characteristics:

i. Large-scale: impact on national level (spatial) and long-term (temporal);
ii. Infrastructural: real-estate facilities like roads, waterways, airports, harbors, etc.;
iii. Intervention in water system: river, estuary or sea;
iv. Multiple objectives and stakeholders: due to other spatial developments, e.g. house building, nature development

To further select case studies, we formulated three selection criteria:

1. Phase of the project (decision-making process);
2. Access to information (documents, actors);
3. Contacts with third parties.

The first criterion describes the phase of a project, which phases have been finalised (research phase; design phase; final/decision phase). The first two case studies will be 'historical' cases, meaning that the projects must be in the final/decision phase and that the research and design phase have been finalised. The third case study is supposed to be a running project or a 'laboratory' case and will be selected further on in the project. The second and third criteria are mainly for practical reasons, to ensure (easy) access to information needed to analyse the case studies.

7.6.2 Potential Case studies

We made an inventory of case studies that could be used as case studies in this PhD-project. These are the following projects:

Flyland project
Research programme initiated to determine whether an airport island would be an alternative for the current Schiphol airport location in the long term. This project started in 1999 and was frozen in 2002 (Flyland 2003).

Scheldt estuary
In 2001, the *Long Term Vision Scheldt Estuary (2030)* was established and discussed by the Dutch and Flemish government and their parliaments. In 2004, the *Scheldt Estuary Project Development Plan 2010*, based on the Long-term Vision, was formulated. This plan focuses on three ambitions: safety against flooding; accessibility of Flemish and Dutch Ports in the region; and naturalness of the delta. The Flemish and Dutch governments will decide which measures and projects have to be implemented to reach the goals of the long-term vision (2030) for the Scheldt estuary (Website ProSes October 2004).

Project Mainport Rotterdam (PMR)
The Dutch Government aims to reinforce the Rotterdam mainport by solving the anticipated space shortage for port and industrial activities; and to improve the quality of life in Rijnmond by utilising the opportunities afforded by solving the shortage problem. The decision process concerning PMR takes place via a Core Planning-plus Decision Process (PKB+). In January 2005, the Council of State gave a negative judgement, destroying the specific policy decisions ('concrete beleidsbeslissingen') in the Core Planning Decision (PKB+) of PMR (Raad van State 26 januari 2005). In April 2005, the Minister presented a plan to repair the PKB+.

Core Planning Decision (PKB) 'Space for the River'
In 2000, the Dutch Cabinet decided on 'space for the river' as a new approach to flood protection. In stead of further heightening and strengthening of the dikes, possibilities to give the river more space are investigated. Excavation of floodplains; shifting of dikes; or creating reservoirs are examples of measures. In 2002, the starting note for the Environmental Impact Assessment (Projectorganisatie 'Ruimte voor de Rivier' 2002) was formulated.

Dike shift Lent
The bed of the river Waal is very narrow near the city of Nijmegen. This 'bottleneck' causes serious problems in case of extreme large water discharges. The primary objective of the project is to find a sustainable solution to abolish the pushing effect of the 'bottleneck' at Nijmegen, in such a way that the safety against flooding is guaranteed. Secondly, the spatial consequences of the interference in the river system should fit the environment; the solution must be of good spatial quality. In 2003, the starting note for the Environmental Impact Assessment (Ministerie van Verkeer en Waterstaat 2003) was formulated. In fall 2004, the Project note/EIA was planned to be finalised, based on which the minister takes a decision. However, so far this document has not been finalised and the decision by the minister was postponed in April 2005.

Emergency reservoirs (ER's)
In 2003, the Committee for Emergency Reservoirs ('Commissie Luteijn') presented their results to the Dutch Cabinet. The Committee concludes that emergency reservoirs are necessary to protect the Rhine and Meuse catchments from flooding on the long-term (Commissie Luteijn 2003). The Dutch Cabinet followed the advice of the Committee and pointed out three potential area's for emergency reservoirs: Rijnstrangen; Ooijpolder; and Beersche Overlaat (Ministerie van Verkeer en Waterstaat and Ministerie van Binnenlandse Zaken en Koninkrijksrelaties 2003). However, in March 2005 it was decided that Rijnstrangen and Ooijpolder are no longer reserved as emergency reservoirs.

'Weak links' along the Dutch coast
In 2003, the process plan for eight 'weak links' along the Dutch coast was formulated. Based on this plan, the involved Provinces carry out design studies for each 'weak link', aiming at both safety against flooding and spatial quality. In each design study, three alternatives for strengthening are investigated: seawards; inland and a combination (consolidate). The design studies must be finished in 2006 (Website Kustzonebeleid 2005).

Western Scheldt Container Terminal (WCT)
In 1997, an exploration of the possibilities for a large container terminal in the Province of Zeeland was executed. In 2002, the Provincial State agreed on modification of the regional plan, which made the construction of the WCT possible. However, in July 2003 the Council of State destroyed the revised regional plan, because the economic importance of the WCT had not been proved and alternative solutions to stimulate employment in Zeeland were insufficiently investigated. After the statement by the Council of State, the Province of Zeeland decided to carry out a feasibility study for a new procedure. By now, extra studies have been carried out to try and find alternative locations for the WCT, come up with other possibilities to create more jobs, think up solutions to hinterland problems, and provide a better fitting in of the WCT with the Western Scheldt's protected bird and habitat guidelines (Website Port of Zeeland 2005).

7.6.3 Selection Case studies

In Table 3, the potential case studies, described in the previous section, are judged on the three selection criteria. We only select case studies that score 'good' on every criterion.

Project / **Selection criterion**	Flyland	Scheldt estuary	**PMR**	**Dike shift Lent**	ER's	Weak links along the Dutch coast	WCT
State of the project	-	+/-	**+**	**+**	-	+/-	-
Access to information	+	+	**+**	**+**	?	+/-	+/-
Contacts with third parties	+	+	**+**	**+**	?	+	+/-
Total	No	Not yet	**Yes**	**Yes**	No	Not yet	No

Table 3: Selection Case studies
+ good; +/- moderate; - bad; ? unknown

Note that selected case studies do not have to be *identical* to be *comparable*, because we focus on the methodology for AF´s (process and contents) that is used in the projects.

7.7 Theoretical framework

In the literature survey (Hommes 2005), we focus on the following topics: system analysis; complexity; Integrated Assessment; assessment frameworks, methods and criteria; policy and science; and stakeholder participation. The state-of-the-art of every topic is described briefly in this section.

7.7.1 System analysis

The DPSIR (Driving forces Pressure State Impact Response) model, Figure 7, has initially been developed by the OECD (Organisation for Economic Co-operation and Development). According to this systems analysis view, social and economic developments exert *Pressure* on the environment and, as a consequence, the *State* of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to *Impacts* on human health, ecosystems and materials that may elicit a societal *Response* that feeds back on the *Driving forces*, or on the state or impacts directly, through adaptation or curative action (EEA 1999; OECD 2003).

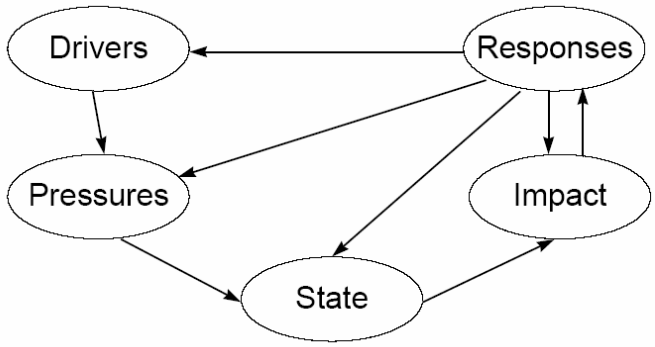

Figure 7: DPSIR model (EEA 1999)

A Global Unified Metamodel of the BiOsphere (GUMBO) was developed to simulate the integrated earth system and assess the dynamics and values of ecosystem services. It is a 'metamodel' in that it represents a synthesis and a simplification of several existing dynamic global models in both the natural and social sciences at an intermediate level of complexity. In GUMBO five distinct modules or "spheres" are considered: the *Atmosphere*, *Lithosphere*, *Hydrosphere*, *Biosphere*, and *Anthroposphere* (Boumans et al. 2002).

The Netherlands Ministry of Spatial planning, Housing and the Environment (VROM) uses the so-called *layer approach* to picture land use in the Netherlands. In this approach, land use consists of three layers: surface (water, soil and the flora and fauna in those environments), networks (all forms of visible and invisible infrastructure) and occupation (spatial patterns due to human use). Each layer influences the spatial considerations and choices with respect to the other layers. In the planning stage, the processes in the different layers need to be considered more in relation to each other. This can prevent conflicts between different users of the same land, as well as creating greater coherence in the measures to be taken (Ministeries van VROM et al. 2004).

7.7.2 Integrated Assessment

Integrated Assessment (IA) is the practice of combining strands of knowledge to accurately represent and analyze real world problems of interest to decision-makers. Portraying and translating real world problems can be done from a plurality of perspectives. There is no "right" way to represent and analyze the world, therefore a diversity of methods and approaches to IA are needed, ranging from model-based methods to participatory methods. In general, IA models attempt to portray the social, economic, environmental and institutional dimensions of a problem in question.

One of the problems of IA is that of aggregation versus disaggregation. The level of aggregation refers to the spatial and temporal resolution and the level of complexity used in IA models. Another key issue in IA modeling is uncertainty due to various reasons. First of all IA modeling is confronted with the inherent uncertainty and lack of knowledge that the disciplinary sciences face. Secondly, IA models have to deal with a variety of types and sources of uncertainty that have to be structured and combined in one way or another. And finally, IA models are prone to a accumulation of uncertainties, because their ambition to cover the whole cause-effect chain of a particular real world problem (Rotmans and Van Asselt 2001).

We used GUMBO, the layer approach and the template of an IA-model to schematize the complex world we are dealing with in this PhD-project. This schematization is shown in Figure 8.

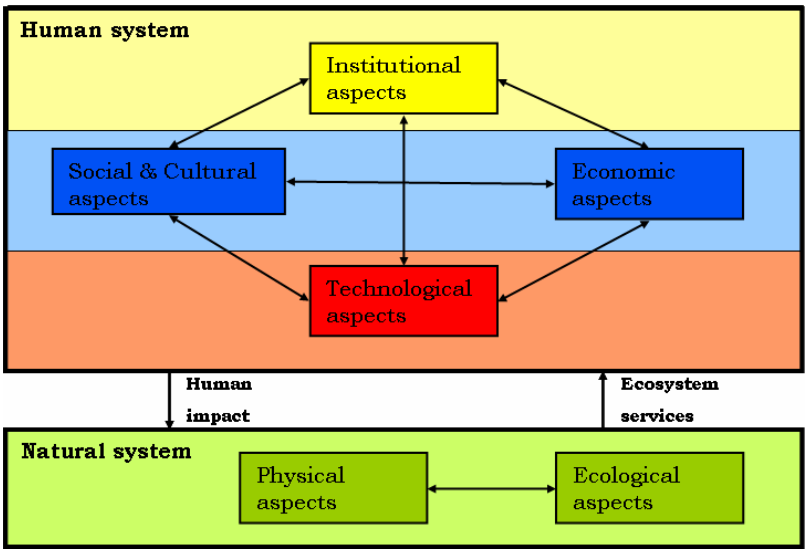

Figure 8: Schematized world view (Hommes et al. 2005a)
green = surface layer;
red = networks layer;
blue = occupational layer;
yellow = institutional layer.

7.7.3 Complexity

A system is complex when the relevant aspects of a particular problem cannot be captured using a single perspective (Functowicz et al. 1999, O'Connor et al 1996, Rosen, 1997, in: (Munda 2004).

A decision-making issue is complex, if it satisfies the following characteristics (Van Asselt 2000):

- There is not one problem, but a tangled web or related problems (multi-problem).
- The issue lies across or at the intersection of many disciplines, i.e. it has an economic, environmental, social-cultural and institutional/political dimension (multidimensional).
- The underlying processes interact on various scale levels (local, regional, national, continental and global) and on different temporal scales (multi-scale).

7.7.4 Assessment Frameworks

De Boer et al. (1999) state that in a lot of projects, alternatives are assessed on their effects without the construction of a consistent assessment framework. This causes indistinctness in the choice for a certain alternative. Constructing an explicit assessment framework can help in the decision-making process and gives more insight in the assessment. In the methodology from the *Guide for Assessment Frameworks* (de Boer et al. 1999) an assessment framework consists of objectives, sub-objectives and criteria, which form the basis of the assessment. In this assessment framework, an overview of the effects of the alternatives of a (large-scale) project on the objectives can be given, enabling the decision-makers to compare the alternatives systematically. In Figure 9, the phases of a project and the assessment framework (Phase B) are shown.

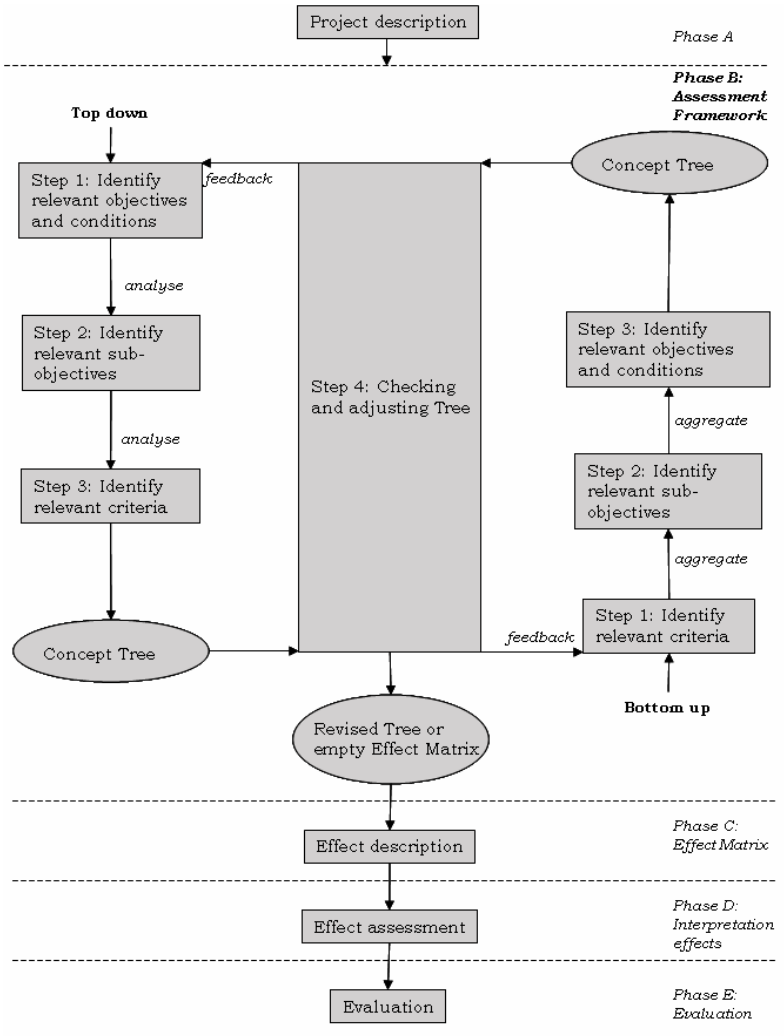

Figure 9: Assessment Framework in a project (de Boer et al. 1999)

7.7.5 Assessment Methods and Criteria

Assessment methods are *tools* to assist a choice between alternatives based on the effects of the alternatives. Frequently used assessment methods are: multi-criteria analyses (Hellendoorn 2001) and cost-benefit analyses (Eijgenraam et al. 2000).

Assessment criteria are the elements forming a decision. Each criterion requires one or more indicators for its description. An *indicator* comprises a variable or some aggregation of variables, describing a system or process such that it has a significance beyond the face value of its components. It aims to communicate information on the system or process. An *index* is a mathematical aggregation of variables or indicators, often across different measurement units so that the result is dimensionless. An index aims to provide compact and targeted information for management and policy development. The problem of combining the individual components is overcome by scaling and weighting, processes which will reflect societal preferences. Figure 10, represents the difference between variables, indicators and indices (Lorenz 1999).

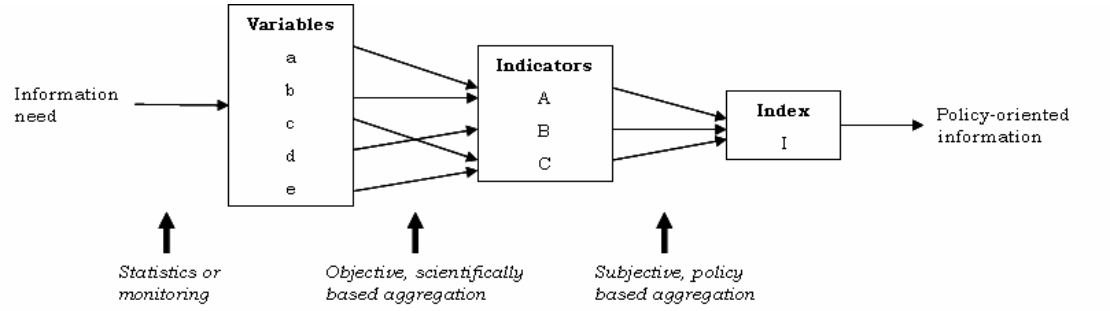

Figure 10: Translation of an information need into policy-oriented information via variables, indicators and indices (Lorenz 1999)

7.7.6 Policy and science

A well structured problem is characterized by consensus on the goals as well as on the means and methods for reaching the goals. In this case, policy is highly expert driven. In the case of unstructured problems no consensus exists on either goals or solutions. Policy development can become an interactive and participatory process, which includes scientists and stakeholders with different perspectives on the problem. Like unstructured problems, in the case of badly structured problems there is no consensus on the policy goals. Decision makers will try to pacify or depoliticize potential conflict and seek compromise. In those cases science can accommodate the policy process. Such an accommodating role for science suggests under-critical acceptance of science (Collingridge and Reeve 1986). An important pacifying strategy is to produce vague or symbolic policy and to use shared concepts.

In the case of moderately structured problems, a certain degree of consensus exists on the policy goals but not on how to reach those goals. Use of knowledge is strategic in that it will be used or rejected depending on the interests at stake. Willingly or unwillingly, science becomes part of the debate, as the different sides tend to strengthen their position by the use of scientific arguments. Collingridge and Reeve's (1986) overcritical model can be recognized here. In short, depending on the type of problem at hand, science takes on a different role and knowledge takes a different shape (Turnhout 2003).

7.7.7 Stakeholder Participation

In the past, water resource management was characterized by clearly defined problems and was largely shaped by an engineering approach. The nature of the problem as well as the approach in dealing with them has changed. Nowadays, high levels of uncertainty, undefined problems, and absence of clearly defined cause-effect relationships ask for the development of integrated approaches to problem solving and to include stakeholder perspectives (Pahl-Wostl 2002). The methods for stakeholder participation will be further explored.

7.8 Expected Results

The expected result from this PhD-project is a *methodology* for development and use of AF's for decision-making in large-scale infrastructural water projects. We aim at providing a *tool* or *a set of guidelines* (in Dutch: stappenplan, richtlijnen) for the process as well as the contents of AF´s. The process part focuses on aspects like: the initiative for an AF; steps in the development and use of an AF; the involvement and perspectives of stakeholders. The contents part contains: the use of scientific knowledge; (the formulation of) assessment criteria; the effects of human interventions (economical, physical, ecological, etc.); and the ranking of alternatives. Note that an AF is (partly) dynamic and thus evolves and changes during the decision-making process.

The final product will NOT be a generic AF, because we state that an AF is different for every project. Furthermore, it will NOT be a blueprint on how to develop and use an AF, because this is also project dependent. Finally, this PhD project is a *design process*. Therefore, it is hard to tell in the beginning of the project what precisely the final product will be.

8 Planning

8.1 Starting date and duration

Starting date: June 2004
Duration of the project: 4 years

8.2 Research planning and Deliverables

In Table 4, a broad overview of the planned research activities and deliverables is given. A more detailed overview of the activities that have been carried out in the first year and a planning for the next three years can be found in the Appendix.

	Activities	**Deliverables**
Year 1 June 2004-June 2005	Research Proposal Literature survey Courses Case study 1: Dike shift Lent Case study 2: PMR	Research Proposal Literature survey * Paper on Case study 1**
Year 2 June 2005-June 2006	Case study 2: PMR Case study selection	Paper on Case study 2
Year 3 June 2006-June 2007	Case study 3 Framework development	Paper on Case study 3
Year 4 June 2007-June 2008	Framework development Writing dissertation	Paper on framework Dissertation

Table 4: Long-term planning and deliverables
* Hommes (2005)
** Hommes et al. (2005b)

8.3 Educational Plan

In Table 5, the planned and finalised educational activities are shown. In Table 6, the conferences that Saskia Hommes participated in and planned to participate in as well as her contributions are listed.

Course	Hours	Date	Finalised
Integrated Coastal Zone Management (IHE Delft)	16	13, 14 Apr. 2004	X
Systematically searching for information (ITBE, UT)	16	8, 16 Jun. 2004	X
Integrated Assessment for Environmental Management (TIAS)	50	25-31 Jul. 2004	X
Instructional workshop for AiOs (ITBE, UT)	25	7, 8, 14 Sept. 2004	X
Technical Writing & Editing (Peterborough Technical Communications, UT)	100	8-11 Nov. & 6-9 Dec. 2004	X
Case Research Methodology (NOBEM)	50	17-19 Jan. 2005	X
Presentation skills (ITBE, UT)	20	2, 7, 9 Feb. 2005	X
Stakeholder Participation and Model-building in Sustainable Resource Management (TIAS)	100	4-13 July 2005	X
Qualitative Methods of Research (NOBEM)	80	2006	
Course on Policy analysis or Facilating	40	2006	
Total	**497**		277

Table 5: Educational plan

Conference	Contribution	Hours	Date
AQUA international seminar on European Citizenship and water (Italy)	poster [1]	50	9-13 Jun. 2004
Physics of Estuaries and Coastal Seas, PECS (Mexico)	paper presentation [2]	80	19-22 Oct. 2004
EFIEA/TIAS: Challenges for Integrated Assessment in a fast changing world (Germany)	winning poster presentation [3]	40	28 Feb.- 2 Mar. 2005
International Symposium on Flood Defence, ISFD (The Netherlands)	poster presentation [4]	40	25-27 May 2005
National conference		40	planned for 2005
International conference		80	planned for 2006
National conference		40	planned for 2007
International conference		80	planned for 2008
Total		**450**	

Table 6: Conferences and contributions

[1] Hommes et al. (2004)
[2] Hommes & Hulscher (2004)
[3] Hommes et al. (2005a)
[4] Hommes et al. (2005b)

9 Costs

In Table 7, a budget plan for this PhD-project is given. The total budget that is available for this project is €12.000.

Courses	**Location**	**Costs (€)**	**Travel & Hotel costs (€)**
Integrated Coastal Zone Management	IHE Delft	0	0
Systematically searching for information	University of Twente	0	0
TIAS Summer School 2004	Osnabruck, Germany	250	30
Instructional workshop for AIOs	University of Twente	0	0
Technical Writing & Editing	University of Twente	0	0
Case Research Methodology (NOBEM)	Groningen, The Netherlands	230	140
Presentation Skills	University of Twente	0	0
TIAS Summer School 2005	Osnabruck, Germany	250	50
Qualitative Methods of Research (NOBEM)	Barchem, The Netherlands	600	100
Conferences			
AQUA: European citizenship and water	Turijn, Italy	70	200
Physics of Estuaries and Coastal Seas (PECS)	Merida, Mexico	580	770
EFIEA/TIAS	Berlin, Germany	0	50
International Symposium on Flood Defence (ISF	Nijmegen, The Netherlands	200	150
National conference (2x)		600	400
International conference (2x)		1000	2000
Materials			
Books		550	
Other materials			
Voice recorder		190	
Stereo microphone		45	
Other			
Travel costs PMR		1500	
Travel costs Netherlands		500	
Dissertation		1500	
Subtotal		8065	3890
Unexpected costs (10%)		1196	
Total costs		**11955**	

Table 7: Budget plan

10 Funding

This project is embedded in the VICI-project *Rough Water*, and is supported by Technology Foundation STW, the applied science division of NWO and the technology programme of the Ministry of Economic Affairs. All labour costs of the members in the research group are covered. The costs of Jan Mulder are covered by RIKZ. For the rest of the research group, the costs are covered by the VICI-project and additionally WL Delft Hydraulics covers the costs of Henriëtte Otter for six days/year.

Furthermore, within the VICI-project a budget of €12 .000 is available to cover educational costs, conferences, etc. of the PhD-candidate. This budget will be used as described in the previous section.

References

Boumans, R., Costanza, R., Farley, J., Wilson, M. A., Portela, R., Rotmans, J., Villa, F., and Grasso, M. (2002). "Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model." *Ecological Economics*, 41(Special Issue: The Dynamics and Value of Ecosystem Services: Integrating Economic and Ecological Perspectives), 529-560.

Collingridge, D., and Reeve, C. (1986). *Science speaks to power : the role of experts in policymaking*, Pinter, London.

de Boer, J., Bueno de Mesquita, H., Dekker, R., Langerak, L., Sol, V. M., and Aiking, H. (1999). "Gids voor beoordelingskaders (GBK) - Eindrapportage Project Generiek Beoordelingskader Productgroep Interactieve Planvorming - Module 6." *LWI rapportnummer PD2-S99.028/1*. in Dutch.

EEA. (1999). "Environmental indicators: typology and overview."

Eijgenraam, C. J. J., Koopmans, C. C., Tang, P. J. G., and Verster, A. C. P. (2000). "Evaluation of Infrastructural Projects; Guide for Cost-Benefit Analysis." CPD Netherlands Bureau for Economic Policy Analysis, Netherlands Economic Institute.

Funtowicz, S. O., and Ravetz, J. R. (1993). "Science for the Post-normal age." *Futures*, 25(7), 739-756.

Goodwin, P., and Wright, G. (1992). *Decision Analysis for Management Judgement*, John Wiley & Sons Ltd, West Sussex, England.

Graveland, J., Dauwe, B., and Kornman, B. (2002). "Waardering voor de Westerschelde-Voorstel voor beoordelingscriteria gebaseerd op inventarisaties van de ecologische toestand, gebruik, beleid en beoordelingsmethoden." *Rapport RIKZ 2002.053*, RIKZ, Middelburg. in Dutch.

Hellendoorn, J. C. (2001). *Evaluatiemethoden ex ante : een introductie*, Sdu Uitgevers, Den Haag. in Dutch.

Hommes, S. (2005). "Literature survey: Integrated Assessment Framework for Large-scale Infrastructural Water Projects - *Concept*." University of Twente.

Hommes, S., and Hulscher, S. J. M. H. (2004) "Inventory of Mathematical Models for Large-scale Sand Extraction on Ridges Offshore of the Netherlands." *Physics of Estuaries and Coastal Seas (PECS)*, Merida, Mexico.

Hommes, S., Otter, H. S., and Hulscher, S. J. M. H. (2004) "Integrated Assessment Framework for Water Management." *AQUA: European citizenship and water*, Turijn, Italy.

Hommes, S., Otter, H. S., and Hulscher, S. J. M. H. (2005a) "Integrated Assessment Framework for Water Management." *EFIEA/TIAS Conference*, Berlin, Germany.

Hommes, S., Otter, H. S., and Hulscher, S. J. M. H. (2005b) "What kind of integrated assessment frameworks are used in large infrastructural water projects?" *International Symposium on Flood Defence*, Nijmegen, The Netherlands.

Hulscher, S. J. M. H. (2003). "Research proposal: Roughness modelling for managing natural shallow water systems." NWO, VICI scheme.

Lorenz, C. M. (1999). "Indicators for sustainable river management," Vrije Universiteit, Amsterdam.

Ministerie van Verkeer en Waterstaat. (2001). "Summary Environmental Effect Report, Project Mainport Rotterdam."

Ministerie van Verkeer en Waterstaat - Directie Oost-Nederland. (2003). "Startnotitie M.E.R. Dijkteruglegging Lent, Ruimte voor de Waal, Ruimte voor Veiligheid." in Dutch.

Ministeries van VROM, LNV, VenW , and EZ. (2004). "Nota Ruimte - Ruimte voor ontwikkeling / National Spatial Strategy." in Dutch.

Munda, G. (2004). "Social multi-criteria evaluation: Methodological foundations and opertational consequences." *European Journal of Operational Research*, 158, 662-677.

OECD. (2003). "Environmental Indicators - development, measurement and use."

Otter, H. S. (2000). "Complex Adaptive Land Use Systems - An interdisciplinary approach with agent-based models," University of Twente, Uitgeverij Eburon, Delft.

Otter, H. S., and Capobianco, M. (2000). "Uncertainty in integrated coastal zone management." *Journal of Coastal Conservation*, 6, 23-32.

Pahl-Wostl, C. (2002). "Participative and Stakeholder-Based Policy Design, Evaluation and Modeling Processes." *Integrated Assessment*, 3(1), 3-14.

Peters, B. G. T. M., and Hulscher, S. J. M. H. (2003). "Large-scale offshore sand extraction: What could be the results of interaction between model and decision process?" *Ocean and Coastal Management*, submitted.

Raad van State. (26 januari 2005). "Uitspraak zaaknummer 200307350/1." Afdeling Bestuursrechtspraak. in Dutch.

Rijkswaterstaat. (2003). "Meervoudig (be)schouwen - Vier manieren om tegen vraagstukken bij beleidsvorming en -uitvoering aan te kijken." Adviesdienst Verkeer en Vervoer, Rotterdam. in Dutch

Rijkswaterstaat, Provincie Gelderland, Waterschap Rivierenland, Gemeente Nijmegen, Knooppunt Arnhem-Nijmegen (KAN), and Ministerie van VROM. (2004). "Standpunt Stuurgroep t.a.v. alternatiefkeuze Dijkteruglegging Lent." in Dutch

Rijkswaterstaat Directie Oost-Nederland, Gemeente Nijmegen, Polderdistrict Betuwe, and Provincie Gelderland. (2000). "De flessenhals bij Nijmegen - Quick scan naar nut, noodzaak en mogelijkheden voor rivierverruiming bij Nijmegen, voor de lange termijn." in Dutch

Rotmans, J. (1998). "Methods for IA: The challenges and opportunities ahead." *Environmental Modeling and Assessment*, 3, 155-179.

Rotmans, J., and Van Asselt, M. B. A. (2001). "Uncertainty in integrated assessment modelling: A labyrintic path." *Integrated Assessment*, 2, 43-55.

Thompson, M. (1997). "Cultural Theory and Integrated Assessment." *Environmental Modeling and Assessment*, 2(3), 139-150.

Turnhout, E. (2003). "Ecological indicators in Dutch nature conservation - Science and policy intertwined in the classification and evaluation of nature," Aksant Publishers, Amsterdam.

Van Asselt, M. B. A. (2000). *Perspectives on Uncertainty and Risk - The PRIMA Approach to Decision Support*, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Van der Veen, A., and Otter, H. S. (2002). "Scales in space." *Integrated Assessment*, 3(2-3), 160-166.

Van Koningsveld, M., Stive, M. J. F., Mulder, J. P. M., de Vriend, H. J., Ruessink, B. G., and Dunsbergen, D. W. (2003). "Usefulness and effectiveness of coastal research: A matter of perception?" *Journal of Coastal Research*, 19(2), 441-461.

Appendix: Planning

Planning year 1	Apr-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Total (weeks)
Research activities														
Research Proposal														7,5
Literature Survey														11,0
Case study Dike Shift Lent:														
Preparation phase														8,0
Interviews experts														2,0
Case study Project Mainport Rotterdam:														
Preparation phase														6,0
Education														
Integrated Coastal Zone Management (IHE Delft)														0,4
Systematically searching for information (ITBE)														0,4
TIAS Summer School (Germany)														1,3
Instructional workshop for AIOs (ITBE)														0,6
Technical Writing & Editing (UT)														2,5
Case Research Methodology (NOBEM)														1,3
Presentation skills (ITBE, UT)														0,5
Conferences														
AQUA international seminar on European Citizenship and water (Italy)														1,3
Physics of Estuaries and Coastal Seas, PECS (Mexico)														2,0
EFIEA/TIAS (Germany)														1,0
International Symposium on Flood Defence, ISFD (The Netherlands)														1,0
														46,7

Planning year 2	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06
Case study Dike Shift Lent:												
Interviews												
Preparation workshop												
Workshop												
Case study Project Mainport Rotterdam												
Interviews												
Preparation workshop												
Workshop												
Writing/reporting												

Planning year 3	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07
Case study Dike Shift Lent:												
Writing/reporting												
Framework development												
Case 3												
Selection phase												
Preparation phase												
Interviews												
Writing/reporting												
Preparation workshop												
Workshop												

Planning year 4	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08
Case study 3													
Writing/reporting													
Dissertation													
Writing													
Feedback supervisors													
Feedback PhD-committee													
Printing dissertation													
Defence													

Submission concept thesis to supervisors

Submission thesis to PhD-committee