Indicator development to determine the state of the (South-West) delta

Designing, testing and evaluating an indicator development method





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Deltares
Enabling Delta Life

Universiteit Twente
de ondernemende universiteit

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Summary English

Introduction

A purpose of the program “Staat en Toekomst van de Delta” (STD) is to determine the state of the delta by using indicators. This research is a pilot study for this program with the next objective. To get knowledge and insight in indicator development processes and to draft and test a development method of indicators for determining the state of the delta. Urgent societal issues (USI) which are affected by the water and ground system form the perspective of these required indicators. Furthermore, research is carried out to the differences in the way of thinking, interests and view to reality between experts and intended users.

Research method

The first sub-objective is an overview of the theories from scientific literature concerning indicator development processes and to draft a method for developing an indicator set. This method is called the ‘research indicator development method’ (RIDM) in this report. The second one is a test of the usefulness of the RIDM to develop the required indicators by applying the RIDM in a case study, the South-West Delta. The last sub-objective is composing guidelines for future indicator development processes in the program STD. An evaluation of application of the RIDM in the case study forms the basis for the guidelines.

Theory and RIDM

Scientific literature describes five common steps in a indicator development processes. These are formulating the scope, defining quality criteria, analysing the system, formulating indicators and as final step: ‘communicating and/or implementing’. Besides these common steps, literature leaves many degrees of freedom to design an indicator development method that exactly fits the case and the objective of the indicator set. A second relevant dimension is the participation process that determines who are involved in the application of the five processing steps. Choices concern the participation groups, levels and methods necessary to design this process.

The RIDM is developed by elaborating the five process steps to fit the STD context. The participation groups chosen of the RIDM are experts and intended users. They gave input for identifying two sets with USI’s and potential indicators which are processed to a final set. The experts gave input for and checked the system analysis. The interest of the users was the guiding principle.

Case study

The participation group ‘experts’ consists of experts of Deltares. The group ‘intended users’ consists of six politicians of national, provincial and water board level and a journalist. The used participation methods are interview, problem/cause analysis and email.

A main result of the case study is that it shows the need of considering the involvement of both users and experts in developing the required indicators of interest to users. They have a different way of thinking and their own roles and expertises. The involved users show more interest in the effects of the water and ground system on the user functions and integrate horizontally among policy areas and user functions. They are also slower in using new scientific insights than experts. In contrast to the users, the involved experts focus more on causal relations to explain effects in the system.

A second main result is the final indicator set which is a selection of all potential indicators. It consists of the USI’s: ‘safety for flood hazards’, ‘transportation by shipping’ and ‘quality of life’ and ‘water system quality’ divided in seven sub-USI’s like ‘ecological deterioration’ and ‘hindrance of inundation’.

Evaluation

The evaluation shows that the formulation of the objective of the indicator set and the quality criteria has not been clear enough; Deltares does not have a clear picture about how and for what purpose they would like to use the indicators exactly. Consequences are a lack of clarity during the development process and a less good final product.

The participation levels and methods have not been satisfactory. The processing of input from the participation process during case study has most likely introduced considerable noise in the results. Co-production of intended users and experts can probably reduce this noise, so that the final indicator fits better with the interests of users and the system of the expert. This means other participation methods like workshops.

The case study shows that the theoretical choices from literature – the RIDM - determine the design and execution of the indicator development process only partly. Pragmatic factors and considerations also determine a big part of the execution of the process and via this way the final product.

Conclusions

An indicator development method has been developed based on five common processing steps identified in literature. Furthermore, the many degrees of freedom left open by literature have been reduced to match the specific STD context. Application of the RIDM in the case study has resulted in an indicator set that determines the state of the delta. Another result is the acceptance of the hypothesis that the way of thinking, interests and view to reality differ between experts and intended users. Evaluation of the practical experiences with the RIDM during the case study shows that the RIDM scores 'moderate' on process criteria about practicability, satisfaction of the final product and enthusiasm of involved persons from outside Deltares. The RIDM needs various changes to improve subsequent indicator development processes with regard to the process of the case study. The most important changes concern a clearer objective of the indicator set and sharper quality criteria, higher extent of participation and more representative participation groups.

Recommendations

I. Deltares needs to reflect more on what the institute explicitly wants with indicators to determine the state of the delta. This is necessary to formulate a clearer objective and sharper quality criteria.

II. The RIDM is adapted, based on the lessons of its application during the case study. The recommended method for subsequent indicator development is the 'State of the Delta Indicator Development Method'.

III. A research about politicians' way of perception and thinking at larger scale would be interesting, because experts of Deltares have little feeling with and knowledge about this.

IV. More research is necessary to elaborate indicators for quality of life. It is advisable to involve social-cultural or spatial planning expertise in the research.

Summary Dutch

Introductie

Een doel van het programma “Staat en Toekomst van de Delta“ (STD) is het bepalen van de staat van de delta. Dit onderzoek is een pilotstudy voor dit programma met de volgende doelstelling. Kennis en inzicht krijgen in de ontwikkelingsprocessen van indicatoren en een ontwikkelingsmethode voor indicatoren - om de staat van de delta te bepalen - te ontwerpen en te testen. Urgente maatschappelijke vraagstukken (Engelse afkorting: USI) die worden beïnvloed door het water- en ondergrondsysteem vormen het perspectief of deze benodigde indicatoren. Verder is er onderzoek gedaan naar de verschillen in de manier van denken, interesses en de kijk op de werkelijkheid tussen deskundigen en beoogde gebruikers.

Onderzoeksmethode

Het eerste subdoel is een overzicht van de theorieën in de wetenschappelijke literatuur over ontwikkelingsprocessen van indicatoren en het ontwerpen van een methode voor het ontwikkelen van een set indicatoren. Deze methode wordt in dit rapport de ‘Onderzoek-ontwikkelingsmethode voor indicatoren’ (Engelse afkorting: RIDM) genoemd. Het tweede subdoel is een toets van de bruikbaarheid van de RIDM om de benodigde indicatoren te ontwikkelen door de RIDM toe te passen in een case studie, de Zuidwestelijke Delta. Het laatste subdoel is het opstellen van richtlijnen voor toekomstige ontwikkelingsprocessen van indicatoren in het programma STD. Een evaluatie van de toepassing van de RIDM in de case studie vormt de basis voor de richtlijnen.

Theorie en RIDM

De wetenschappelijke literatuur beschrijft vijf gemeenschappelijke stappen in een indicatorenontwikkelingsproces. Deze stappen zijn het formuleren van de scope, het definiëren van kwaliteitscriteria, het analyseren van het systeem, het formuleren van indicatoren en de laatste stap is het ‘communiceren en/of implementeren’. Naast deze vijf stappen laat de literatuur veel keuzeruimte over om een indicatorenontwikkelingsmethode te ontwerpen die precies past bij de case en het doel van de set indicatoren. Een tweede relevante dimensie is het participatieproces dat bepaalt wie wordt betrokken bij de uitvoering van de vijf processtappen. Keuzes over de participatie groepen, -niveaus en –methoden zijn nodig om het participatieproces vorm te geven.

De RIDM is ontwikkeld door het uitwerken van de vijf processtappen die bij de STD context past. De gekozen participatiegroepen van de RIDM zijn deskundigen en beoogde gebruikers. Zij gaven input voor het identificeren van twee sets met USI’s en potentiële indicatoren die zijn verwerkt tot een eindset. De deskundigen gaven input voor en checkten de systeemanalyse. De interesses van de gebruikers was leidend.

Case studie

De participatiegroep ‘experts’ bevat deskundigen van Deltares. De groep beoogde gebruikers bestaat uit zes politici uit de Tweede Kamer, Provinciale Staten en waterschapsbesturen en een journalist. De gebruikte participatiemethoden zijn interview, probleem/oorzaak analyse en email.

Een hoofdresultaat van de case studie is dat het de noodzaak aantoont van het overwegen om zowel deskundigen als gebruikers te betrekken in de ontwikkeling van de benodigde indicatoren die interessant zijn voor de gebruikers. Zij hebben een verschillende denkwereld en hun eigen rol en kennis. De betrokken gebruikers tonen meer interesse in de effecten van het water- en ondergrondsysteem op de gebruiksfuncties en integreren horizontaal tussen beleidsvelden en gebruiksfuncties. Zij zijn ook trager in

het gebruik van nieuwe wetenschappelijke inzichten dan deskundigen. In tegenstelling tot de gebruikers focussen de experts meer op de causale relaties om de gevolgen in het systeem te verklaren.

Een tweede hoofdresultaat is de eindset met indicatoren: een selectie van alle potentiële indicatoren. Het bevat de USI's: 'overstromingsveiligheid', 'transport door de scheepvaart', 'belevingskwaliteit' en 'watersysteemkwaliteit' dat is verdeeld in zeven sub-USI's zoals 'ecologische verarming' en 'wateroverlast'.

Evaluatie

De evaluatie laat zien dat de formulering van het doel van de set indicatoren en de kwaliteitscriteria niet duidelijk genoeg zijn. Deltares heeft geen duidelijke beeld van hoe en met wat voor doel zij de indicatoren precies wil gebruiken. Consequenties hiervan zijn onduidelijkheid tijdens het ontwikkelingsproces en een minder goed eindproduct.

De participatieniveaus en –methoden zijn niet toereikend. Het verwerken van de input van het participatieproces tijdens de case studie heeft zeer waarschijnlijk aanzienlijke ruis in de resultaten gegeven. Coproductie van beoogde gebruikers en deskundigen kan waarschijnlijk deze ruis reduceren, zodat de eindindicatoren beter overeenkomen met de interesses van de gebruikers en passen in het systeem van de expert. Dit betekent dat andere participatiemethoden zoals workshops nodig zijn.

De case studie laat zien dat de theoretische keuzes van de literatuur – de RIDM – maar deels het ontwerp en de uitvoering van het indicatorenontwikkelingsproces bepalen. Pragmatische factoren en overwegingen bepalen ook voor een groot deel de uitvoering van het proces en via deze weg het eindproduct.

Conclusies

Een methode voor indicatorenontwikkeling, gebaseerd op vijf gemeenschappelijke processtappen die zijn geïdentificeerd in de literatuur, is ontworpen. Verder zijn de keuzemogelijkheden uit de literatuur gereduceerd om de methode aan de specifieke STD context aan te passen. Een resultaat van de toepassing van de RIDM in de case studie is een set indicatoren die de staat van de delta bepalen. Een ander resultaat is het accepteren van de hypothese dat de denkwijze, interesses en kijken op de werkelijkheid verschilt tussen deskundigen en beoogde gebruikers. Een evaluatie van de praktische ervaring met de RIDM tijdens de case studie laat zien dat de RIDM matig scoort op de procescriteria over bruikbaarheid, tevredenheid over het eindproduct en enthousiasme van betrokken personen van buiten Deltares. De RIDM heeft een aantal verandering nodig om verdere indicatorontwikkelingsprocessen te verbeteren ten opzichte van het proces van de case studie. De belangrijkste veranderingen betreffen een duidelijker doel van de set indicatoren en scherpere kwaliteitscriteria, hogere mate van participatie en representatievere participatiegroepen.

Aanbevelingen

I. Deltares moet beter overdenken wat het instituut expliciet wil met indicatoren om de staat van de delta te bepalen. Dit is nodig om een duidelijker doel en scherpere kwaliteitscriteria te formuleren.

II. De RIDM is aangepast op basis van de lessen van het toepassen tijdens de case studie. De aanbevolen methode voor verdere indicatorenontwikkeling is 'State of the Delta Indicator Development Method'.

III. Een grootschaliger onderzoek naar de beleving- en denkwereld van politici zou interessant kunnen zijn, omdat deskundigen van Deltares hiervan weinig feeling en kennis hebben.

IV. Meer onderzoek naar het uitwerken van indicatoren om belevingskwaliteit te duiden is nodig. Het advies is om expertise op het sociaal-culturele- of ruimtelijke ordeningsgebied te betrekken in het onderzoek.

Preface

I finish my master Water Engineering and Management of the study Civil Engineering at the University of Twente in Enschede with this research. The latter was a valuable experience for me. I learnt about indicator development and I experienced the importance of a sharp objective and quality criteria. I got knowledge about the urgent societal issues, problems and the physical processes of water and soil system in the South-West Delta. Furthermore, the experience and discovery of the differences in way of thinking and looking at reality between experts and politician are also very interesting. It was nice to meet various politician and to learn about the things that are important in their work as decision-makers.

It was my pleasure to do my Master Thesis at Deltares. I like the possibility to have a look of a research institute and to learn something about the projects, activities and knowledge of Deltares. It was interesting to join in the meetings of the department Strategic Studies and Innovation Management, to contribute to the Delta Water Award and a number of workshops about the state and future of the delta.

I would like to thank my supervisors Jurjen van Deen, Maarten Krol and Rianne Bijlsma for their useful support, discussions, suggestions, feedback and correction of my English texts during the research. I also want to thank a number of experts from Deltares who were involved in my research: Willem Bruggeman, Bert van Eck, Harriette Holzhauer, Ies de Vries, Theo Prins, Judith Ter Maat, Maaike Bos, Herman Wilmer, Perry de Louw, Roelof Schuurman, Nicky Villars, Joost Stronkhorst, Henriette Otter, Henk Wolters and Sonja Karstens. Furthermore, my thank goes to the department Strategic Studies and Innovation Management for being welcome in their midst. I also thank other employees of Deltares who I met and who told interesting information or gave good advice.

I would like to thank the (former) decision-makers and journalist for their participation in my research, too. They are the

gentlemen Koppejan, Robesin, Van der Burgt, Bruil, Van der Hoef, Boot and Persson. Last but not least, I thank my loving wife Lidia, my family and friends for their support during my Master Thesis and my whole study Civil Engineering and Management.

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Glossary of terms and abbreviation

Glossary of terms

State of the delta	The extent to which water, ecology and soil facilitate the different user functions like agriculture, transportation of goods, drinking-water supply, recreation and nature
Indicator	A parameter (modelled or measured) that reflects an aspect of the state of the system
User-function	An activity that depends on the presence of water in the right quantity and quality for its success.
Urgent societal issue	An issue that surpass individual user-functions, because it affects more functions or it is a dominant function.
Participation	The act of taking part or sharing in something.
Intended users	Person who is part of the purpose group of the indicator set.
Expert	Person who has much expertise of (a part of) a particular scientific discipline.
Potential indicator	A possible indicator that is suggested during interviews with intended users or is based on the system analysis.
System analysis	The process of mapping and analysing the important processes of the water and soil system and translating those to conceptual models with quantities and relations.
Quality criterion	An aspect that represents a requirement of the (set of) indicators.
Final indicator set	The set of indicators that is selected from the list with formulated potential indicators.
Expert-USI's	The set of urgent societal issues identified by the experts.
User-USI's	The set of urgent societal issues identified by the intended users.
Expert-indicator set	The set of potential indicators designated by the experts.
User-indicator set	The set of potential indicators designated by the users.

List of abbreviation

USI	Urgent societal issues
STD	Program "Staat en Toekomst van de Delta"
RIDM	Research Indicator Development Method (method based on the theory)
SDIDM	State of the Delta Indicator Development Method (guidelines future indicator development)

1. Introduction

"Deltares has the (societal) task to make knowledge about the functioning of delta areas accessible and transparent. This concerns knowledge about the state of the delta, about the consequences of changes in the delta and about the possibilities to solve bottlenecks or create changes" (Deltares, 2008a).

This is a citation from 'Onze Delta, Staat en Toekomst van de Delta 2008', the first publication of the program "Staat en Toekomst van de Delta". This research is part of that program. The first chapter introduces the problem context and objective of the research. Upon that a brief description of the research method is given. The chapter finishes with a reading guide of this report.

1.1 Problem context

Deltares is an independent research institute with the societal task to enable delta life (Deltares, 2008c). The program "Staat en Toekomst van de Delta" is a way to implement this societal task. It started in 2007 with the first step on the road to an adult "Staat en Toekomst van de Delta" (STD) (Deltares, 2008a). Deltares published the first version with the title "Onze Delta" in 2008. It is a collection of knowledge about the Dutch delta system to feed the societal discussion about the physical planning of the delta (Deltares, 2008a). A second volume of 'Onze Delta' will be published in 2009. It discusses actual societal themes, like water safety, water level management of the IJsselmeer, transportation and the ecological problems in the South-West Delta.

The program has two purposes. The first purpose is to provide knowledge about the water and soil system in the delta in an accessible way for a wide audience. The main audience consists of decision-makers and interested citizens (who do not have a technical background). Deltares carries this first purpose through with the publications of "Onze Delta" in 2008 and 2009.

The second purpose is to determine the state of the delta. This concerns the questions: how is life in the delta area? To what extent does the situation of water, ecology and soil facilitate the different user functions like agriculture, transportation of goods, drinking-water supply, recreation and nature? The problem statement of this research relates to the second purpose.

Indicators can be used to determine the state of the delta in a quantitative way. Deltares prefers that these indicators are at a high aggregation level that fit with the broad urgent societal issues of STD. Helpful indicators have to be developed for specific use in specific situations (Jackson et al, 2000; Garcia et al, 2000). The state of the delta is a new concept for Deltares and for The Netherlands as well, therefore indicator sets are not available.

When useful indicator sets are not available, they have to be composed or developed. Deltares however has identified a gap in the knowledge about indicator development methods and procedures to compose or develop an indicator set. Which steps are important? Which things should be taken into account during a development process?

1.2 Research objective

This research contributes to the above-mentioned knowledge gap about indicator development. The research objective is to get knowledge and insight in indicator development processes and to draft and test a development method of indicators for determining the state of the delta. An important framing is that the state of the delta has to be determined from the perspective of urgent societal issues which are affected by the water and soil system. In this research the definition of an indicator is a parameter (modelled or measured) that reflects an aspect of the state of the system. Furthermore, a hypothesis is set up that is formulated as: the way of thinking, interests and view to reality differ between experts and intended users. The research has three sub-objectives.

1. An overview of the theories concerning a research indicator development method (RIDM). This method consists of the relevant steps to compose an indicator set for an application such as determining the state of the delta by Deltares. The overview is based on an inventory of scientific literature and experiences of some Deltares-experts about this subject.
2. Testing of the usefulness of the RIDM to develop an indicator set to determine the state of the delta by applying the RIDM in a case study. The case is the South-West Delta in The Netherlands. Deltares-experts and intended users of the indicator set are separately involved in the process to give input and contribute to the different process steps.
3. Guidelines for future indicator development processes in the program “Staat en Toekomst van de Delta” based on an evaluation of the case study. The experiences of the case study are used to learn from and as a basis for recommendations concerning how to develop indicators.

1.3 Reading guide

The report continues with a description of the research method in chapter 2. The literature about indicator development and the identified three sub-objectives are elaborated in chapter 3 to 6. The third chapter discusses the common steps from literature of an indicator development process and the degrees of freedom to design the process to a specific case. The fourth and fifth chapter describe the process design of the case study and the results of the process respectively. Chapter 6 gives an evaluation of various method choices and experiences of the case study. The final chapter consists of the conclusions and recommendations. The intermediate products of the courses with the experts and intended users are discussed in the appendixes A en B respectively. The third appendix (C) discusses the assessment of potential indicators. Appendix D gives the guidelines for subsequent indicator development.

2. Research method

This chapter describes the research method. It starts with a brief discussion of the mutual relations among the three research parts. The other three paragraphs - 2.2 to 2.4 - discuss the research method followed and the information sources used to satisfy the three sub-objectives.

2.1 Overview research method

This research starts to fill the knowledge gap about indicator development for determining the state of the delta. The research method is organised according to the sub-objectives described in the previous chapter. Figure 1 shows a picture with the research steps in chronological order. The broken arrows mean that the three parts are subject of reflection during the evaluation of the case study.

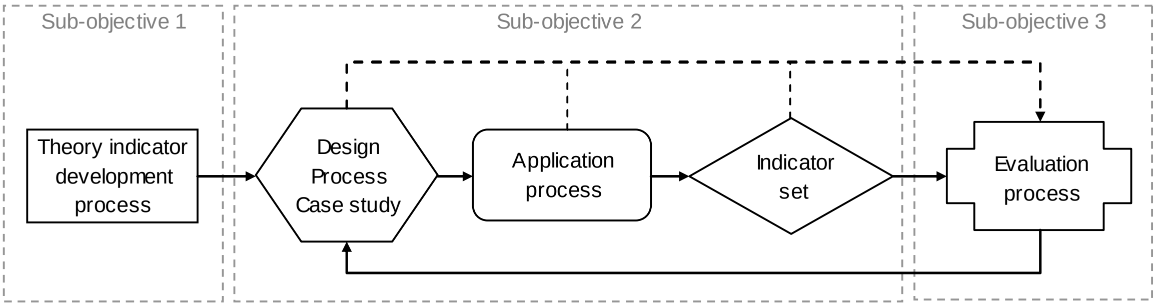


Figure 1: An overview of the research method. The unbroken arrows show the sequence of research steps. The broken arrows mean that the three parts are subject of reflection during the evaluation.

2.2 Theory indicator development method

The first sub-objective is an overview of the theories concerning indicator development processes that are relevant fro the development of an indicator set for determining the state of the delta and to draft a method for doing so. This method is called the 'research indicator development method' (RIDM) in this report. The first step is a review of literature about indicator development. The second step is to design a RIDM.

Literature about indicator development is diverse. Indicators are used in a wide range of disciplines, such as sustainable development, mining, forestry, management of cities and health care. The content of the articles also differs. Some articles focus on the methods, or give guidelines or an evaluation of dealing with indicators. Others describe case studies concerning indicator development. This literature is used with the exception of health care, because the indicators of this scientific discipline are specific signs of the human body, which differ much from indicators used in water management.

The common elements and the differences in literature concerning indicator development processes are listed. The common elements refer to main steps in a process. The differences result from different objectives and characteristics of the indicator sets, extent of stakeholder participation and different cases. These indicate the degrees of freedom to design the development process for a specific objective and characteristics of the indicator set and a specific case(study).

The extent of stakeholder participation is also a relevant choice. Participation literature is therefore involved to map the possibilities for designing a participation process. Especially, the report of HarmoniCOP (2005) is used which contains practical guidelines for designing a participation process and an inventory of participation methods.

The last information source for indicator development is the experiences of Deltares-experts (dr. H.S. Otter, dr. J. Stronkhorst and M.T. Villars M.Sc.). During conversations, they told about their experiences and the issues which are important to take into account concerning indicator development.

The starting-point is a general inventory of what scientific literature says about indicator development methods and processes. A number of 'research choices' are made to focus the theory on the specific situation of this research: looking for an indicator set that measure the state of the delta. The research choices concern the characteristics of the indicator set and some choices about participation. The result is the 'research indicator development method'. The choices that are specific for a particular case are left open in the RIDM. They are called 'case choices' in this report. Figure 2 gives a schematic picture of the framing process in this research. It starts with a broad analysis of indicator development literature. From below to above the choice possibilities are framed in two steps that finally results in the process of the case study. The two steps are making the research choices and making the case choices.

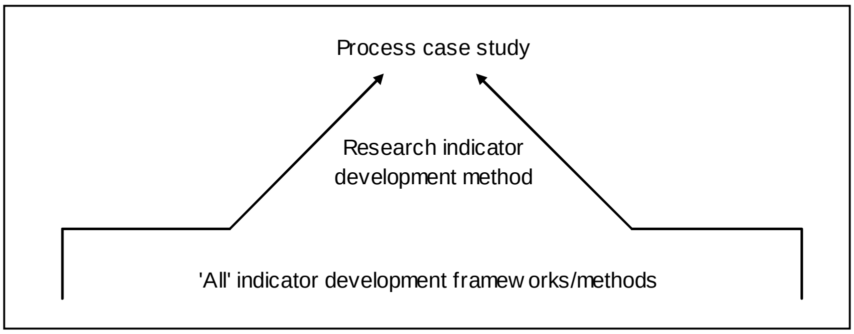


Figure 2: A scheme of the framing process in this research.

2.3 Case study: indicator set for the South-West Delta

The second sub-objective is testing the usefulness of the RIDM to develop an indicator set to determine the state of the delta by applying the RIDM in a case study. Such study puts the theoretical method in practice to acquire experiences with the method. An additional reason is that Deltares desires a concrete indicator set as start of further indicator development. Only one case is chosen, because an indicator development process takes a lot of time. The case is the South-West Delta. The reason to choose the South-West Delta as case is pragmatic.

The South-West Delta is the area the consists of the province Zeeland, the islands of the province South Holland and the western part of the province North Brabant. Three international rivers flow through the South-West Delta into the North Sea: the Scheldt, Meuse and Rhine. The area consists of the shipping routes to and from the harbours of Rotterdam and Antwerp, the world-famous Delta Works and suffers from water quality problems (Ministerie van Verkeer en Waterstaat, 2008).

The case study starts with designing the indicator development process for the specific case. This means that the case choices are made, which the RIDM left as degrees of freedom for the case. Thereupon application of the process follows and the final product is an indicator set to measure the state of the South-West Delta.

The information sources in the case study are literature, interviews and problem/cause analyses with Deltares-experts and intended users. The literature consists of information about water management and water, ecology and soil processes in the South-West Delta. Deltares-experts are involved to give input during interviews or doing problem/cause analysis. They give a technical-scientific argumentation of the indicators that are embedded in the water and soil system well. In addition, intended users (decision-makers of different governmental levels and a journalist) participate in the process by giving input during interviews. They help to make the indicator set user-friendly and useful for their daily work, because they have another way of thinking, other interests than experts and they have often a non-technical background. Two sets with potential indicators are composed and assessed by using quality criteria. The output of the assessment is used to select the final indicator set. During the case study, the opinion of the user is guiding on the condition that it fits with the system or knowledge of the experts.

Chapter 4 describes and discusses the design of the indicator development process deeper. The chapter also gives some descriptions of the practical execution of the process during this research.

2.4 Evaluation case study

The last sub-objective is composing guidelines for future indicator development processes in the program “Staat en Toekomst van de Delta”. An evaluation of application of the RIDM in the case study forms the basis for the guidelines. The experiences of the case study are used to learn from indicator development and form the basis of the recommendations.

The evaluation is organised according to four process criteria which are discussed below. The evaluation includes an assessment of the process and the final product by the process criteria. A methodological disclaimer is that the input of the process criteria mainly consists of experiences and estimations of the researcher. These are used, because material for comparison is not available. The process criteria are discussed below.

1. Practicability - executability and intermediate results RIDM: to what extent is the RIDM executable and does it provide useful intermediate results (USI’s, system analysis, potential indicators)? The experiences with process steps, intermediate results, methods and tools during the case study are input for assessing executability and the intermediate results.
2. Practicability - coherence RIDM: how big is the coherence among the process steps of the RIDM? The experiences with the RIDM during the case study form the input for assessing this process criterion. The different with criterion 1 is that the focus is on the coherence of the method.
3. Satisfaction final product: to what extent is the desired final product achieved? This question is answered by asking the core team of the program ‘Staat en Toekomst van de Delta’ and intended users for their assessment of the final product.
4. Enthusiasm: to what extent does the indicator development process generate enthusiasm by persons involved from outside Deltares? Input for this process criterion is the experiences with collaboration of the approached persons and their enthusiasm during the interviews.

The evaluation forms the input for the formulation of guidelines for subsequent indicator development which includes the good RIDM aspects and recommendations for changes concerning the things that are going less well or bad.

3. Theory indicator development process

This chapter discusses the theory concerning a research indicator development method (RIDM). This method consists of the relevant steps to compose an indicator set to determine the state of the delta. This chapter gives an overview, an analysis and a discussion of the indicator frameworks in scientific literature. The frameworks are ordered by five common process steps which are:

1. *formulating the scope;*
2. *selecting quality criteria;*
3. *analysing the system;*
4. *formulating indicators;*
5. *communicating and/or implementing.*

Per process step the belonging elements or aspects are grouped which are important according to a number of authors. Every sub-paragraph discusses an element or aspect. It starts with the similarities and differences. The differences result in definitions of research or case choices. Research choices are independent on the case, while case choices are specific for a case. Thereupon the research choices are made. They form the RIDM together with the research choices of the participation process. Figure 3 shows an overview of the common aspects and the participation process of the RIDM. This scheme is a reading guide for this chapter.

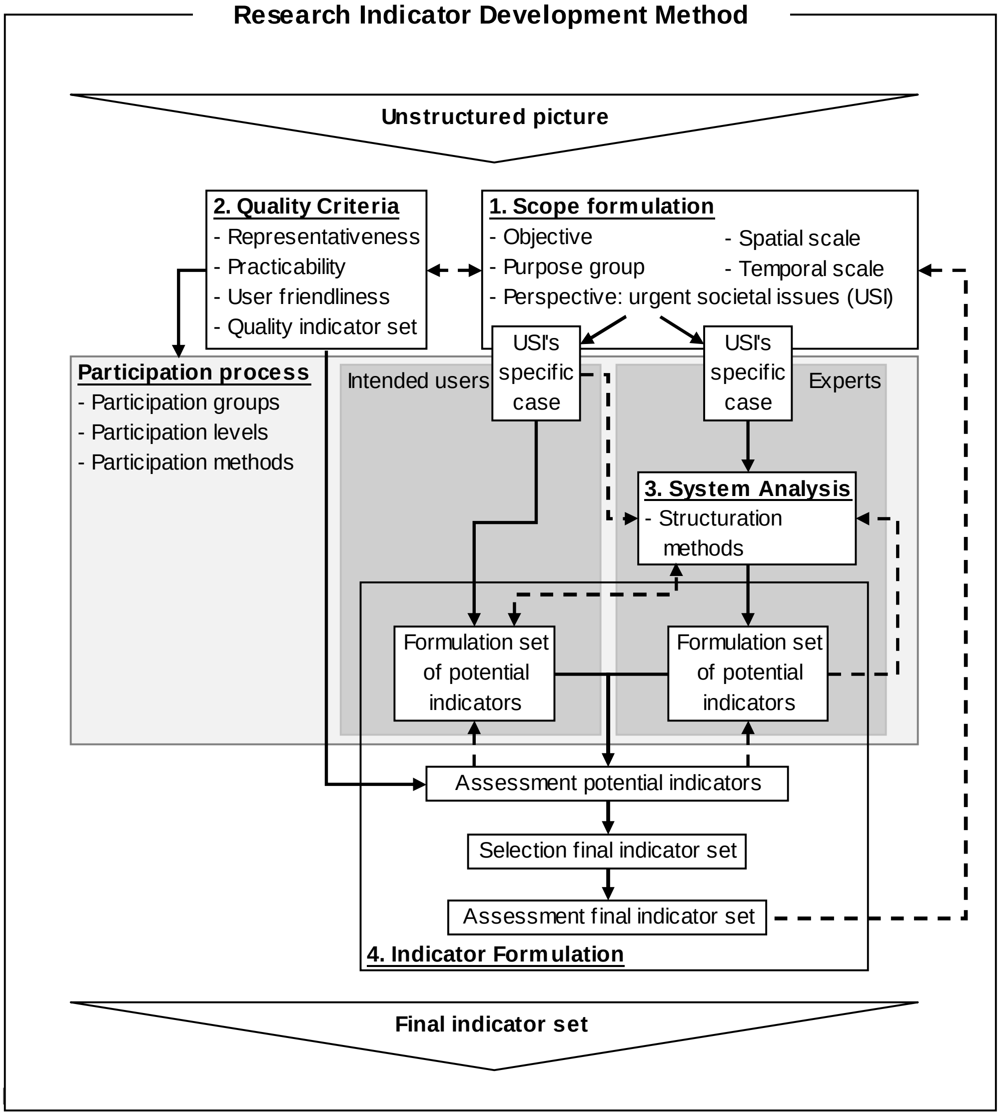
The first two paragraphs discuss the first two process steps: formulation of a scope and selection of quality criteria. The third paragraph elaborates the participation process, because this affects how the other process steps are worked out. The chapter continues with the other three process steps and finishes with showing an overview of the RIDM.

3.1 RIDM: phase model

The RIDM fits the best with the phase model, because indicator development is “represented in terms of a number of distinct stages” (Teisman, 2000). The method consists of two courses with successive phases which lead to a final indicator set. Every phase finishes with a result that is the input for the next phase. The method does not fit with the stream or rounds models, because it does not consists of separated streams of problems, solutions and politics. Furthemore, the RIDM also does not have different decision-making rounds (Teisman, 2000), but the method is relative straight forward with some feedback loops.

3.2 Step one: formulating the scope

In literature a scope - in the broad sense of the word - is a common component of every indicator framework, but the specification of the scope differs. Opschoor & Reijnders (1991) define the scope as selection of dimensions. Others specify it as formulation of overall purpose, human activities, issues and geographical boundaries (Garcia et al, 2000). Azapagic (2004) defines the scope as formulation of issues and processes in relation with what mining companies face. This paragraph discusses several important aspects of a scope, which are ‘objective, purpose group, perspective, spatial and temporal scaling. The different aspects have many mutual connections. For example, when the choice of the objective changes then the purpose group, perspective and dimensions can also change.



discussed in chapter 3. The unbroken arrows show the order and the broken arrows represent feedback among steps.

3.2.1 Objective of the indicator set

Above all, the three Deltares-experts emphasize that a clear objective of the indicator set is important for its success. Erftemeijer et al. (2002) distinguish two main purposes of indicators for marine and coastal management. These are ‘measuring the state of the system´ and ´measuring the effectiveness of management’. The specific objective of an indicator set in a particular case context determines which purpose.

Research choice: objective

The purpose of the indicator set is ‘measuring the state of the system’. This follows from the objective of the indicator sets in the program ‘Staat en Toekomst van de Delta’: to determine the state of the delta from perspective of urgent societal issues which are affected by the water and soil system. The purpose measuring the effectiveness of management is not chosen.

3.2.2 Purpose group

Definition of a purpose group is important according to Braat (1991), because ‘effective indicators have a format which is designed with an explicit target group in mind’. He distinguishes three groups: professional analysts and scientists, policy-makers and public. These groups differ from each other by two features: decreasing total quantity of information and increasing condensation of data from scientists to public. Decision-makers (politicians) are also part of the group ‘public’ concerning features like non-technical background. Another categorization can be the scale. Policy-makers, public and decision-makers can focus on local, regional (provincial) or national scale, which depends on their responsibilities and interests.

Research choice: purpose group

The purpose group of the indicator set is the same as the main audience of the program ‘Staat en Toekomst van de Delta’. The main audience consists of decision-makers (politicians and top executives from the governmental sector) of national, provincial and water board level, and interested citizens. This group is a choice of Deltares. The purpose group is often called intended users (group) in this report.

3.2.3 Perspective

Perspective is the way of seeing the reality. It determines how people are looking to the reality and which relations and picture they see. Figure 4 is an example of how different perspectives shows different pictures. The perspective affects in the information that people want to know. Therefore, the perspective strongly relates to the purpose group.

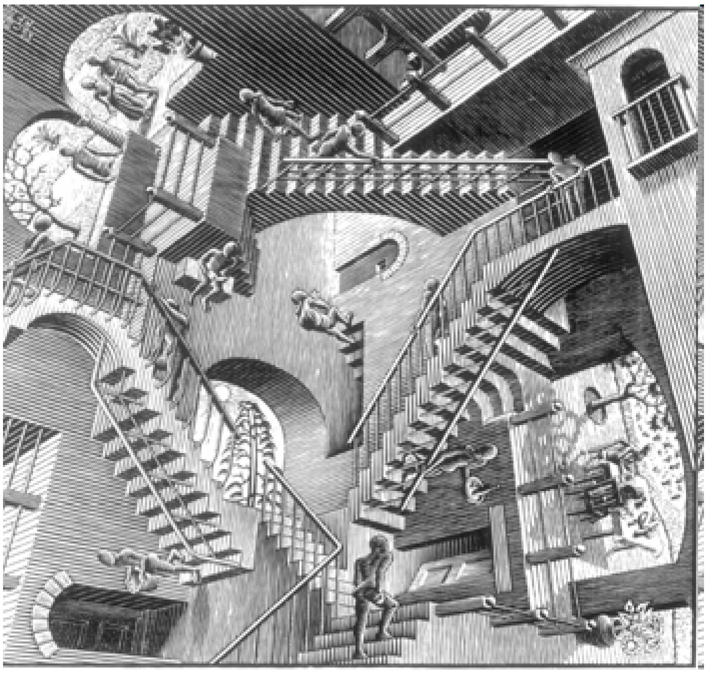


Figure 4: A drawing 'Relativity' of M.C. Escher (1953). Different perspectives show different pictures.

Literature distinguishes two main (group) perspectives that can be leading for developing indicators. The first one takes the total physical system as perspective and select the representative parameters as indicators. It focuses on the processes and relations of the natural-physical system (Reed et al, 2006; Azapagic, 2004; Lorenz et al, 2001). The second main group perspectives consists of relevant societal- or user functional-, policy- or fundamental interest issues (Stronkhorst, 2008; Garcia et al, 2000; Erfemeijer et al, 2002; Bossel, 1999). This group frames the issues (and parts of the system) that are interesting for the users. The difference between societal- and user functional issues is that societal issues surpass individual user functions, because the societal issue affects more functions or it is a dominant function. Fundamental interests concern the interests that are essential for human beings.

One perspective (group) can be leading, but that does not mean that the other group is not taken into account. A possibility is that an indicator development process consists of some iteration steps between the system and the demand of users. This is necessary to get an indicator set that is representative for the system and that fits with the demands of users (Garcia et al, 2000).

The choice which perspective to take depends on the objective of the indicator set and purpose group. It determines to the extent of user participation. Experts will mostly reason from the system parameters, while stakeholders will think earlier about societal or policy issues (Reed et al, 2006).

Research choice: perspective

The perspective of the RIDM is urgent societal issues (USI). This fits with the line of approach of Deltares is that the state of the delta has to be determined "…from perspective of urgent societal issues" (see objective, paragraph 3.2.1).

3.2.4 Spatial scaling

Literature shows two different main ways to spatially scale a system or a project, i.e. the study area. Reed et al. (2006) distinguishes two contexts that can be the guiding principle: a physical system or a social/institutional context. They give the first one an indication as a top-down and the second one as a bottom-up approach. According to Reed et al. (2006) researchers and policy-makers often define physical system boundaries. Social boundaries are the main principle by community-based (almost full participation) projects.

Karstens (2009) distinguishes features of larger and smaller scales to choose the size of the study area. These features have to be taken in mind in choosing the spatial boundaries. Examples are the involved number of issues, processes and actors, complexity, time and manageability. All these aspects concern a specific case with its own characteristics. The choice of the study area is therefore characterised as a case choice.

The next issue concerning spatial scaling is the spatial aggregation of the indicators. The indicators should have the same spatial aggregation scale to determine the state of the delta. Indicators can have different aggregation scales. For example, an indicator for water safety will have a dike ring as spatial scale, because the Dutch law defines the safety standards per dike ring. The spatial scale of an indicator about shipping however will consist of particular shipping routes. Those two examples have different spatial scales.

Research choice: spatial aggregation scale

The choice is made to use the study area as highest spatial aggregation scale. This fits with the purpose of STD to determine the state of a particular delta area.

3.2.5 Temporal scaling

The temporal scale is a choice. It depends on the objective of the indicators (Erftemeijer et al, 2002). The temporal scale has two aspects, which are the frequency of reporting and the time horizon. Karstens (2009) helps to choose these two temporal scales by distinguishing features for larger and smaller temporal scales. Examples are the sense of urgency (both aspects), predictability (both), action ability (both) and taking into account of uncertainties (time horizon). The adaption time of natural-physical processes also determine which frequency of reporting is useful.

The frequency of reporting also depends on the data availability. Ewert et al. (2006) relate the spatial scale with the temporal scale, because the size of the area determines the practical availability of data per time period.

Concerning the time horizon, Reed et al. (2006) and Fraser et al. (2006) finally warn that "indicators need to evolve over time as communities become engaged and circumstances change". This implies a restriction of the maximum functional time of indicators. On the other side, a minimal measurable period is necessary to be able to observe progression or declination and to formulate trends (Reed et al, 2006).

Research choices: time horizon and reporting frequency

The processes with the slowest significant changes are morphological processes. Their temporal scale is in order of decades. The time horizon of the indicators should therefore be at least one decade to be able to use the monitoring function of the indicator set well.

The frequency of reporting is chosen of 1 year, which is a choice of Deltares. This frequency fits with the natural societal cycle of years. In addition, data is probably available per year from existent monitoring programs. Furthermore, it is high enough to show changes over time of the most indicated processes. A disclaimer is that is frequency is less useful for morphological processes.

Box 1	**RIDM: formulating the scope**
√	Objective of the indicator set: *to assess the state of the delta from perspective of urgent societal issues which are affected by the water and soil system.*
√	Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens
√	Perspective: urgent societal issues
√	Spatial aggregation scale: the study area
√	Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year
?	*Case choice: study area (spatial scale)*

3.3 Step two: selecting quality criteria

3.3.1 Scientific literature

Quality criteria reflect the aspects which are important for an indicator (set). In other words, they determine when the customer is satisfied. The quality criteria are used to select potential indicators or assess an indicator set. Literature shows various lists of quality criteria. The criteria can mainly be divided in three groups:

1. Criteria that guarantee the representativeness or practicability (Braat, 1991; Opschoor & Reijnders, 1991; Bossel, 2001).
2. Criteria that guarantee a high extent of user-friendliness of the indicators (Garcia et al, 2000; Reed et al, 2006).
3. Criteria to assess the set of indicators as a whole (Bossel, 1999; Garcia et al, 2000).

Table 1 shows the various quality criteria that are mentioned in the indicator development literature. The criteria are arranged into the above mentioned groups. Besides literature, a number of Deltares-experts are also asked to mention quality criteria for indicators. These are handled in the last column that consists of ‘yes’ for mentioned and ‘no’ for explicitly mentioned as no relevant criteria. Empty cells mean not mentioned at all. The remaining paragraph defines the quality criteria.

Representativeness and practicability

- *Amount of change in time:* the indicator must be able to change significantly in time (Opschoor & Reijnders, 1991).
- *Sensitive to change across space:* the indicator must be able to change significantly across space (Opschoor & Reijnders, 1991).
- *Representative measure or computation:* data that feeds the indicator must be a representative measure (or observation) or computation by a model (Braat, 1991; Liverman et al, 1988).

Table 1: Quality criteria that are mentioned in indicator development literature. References are Liverman et al, 1988/Opschoor & Reijnders, 1991 (1), Braat, 1991 (2), Garcia et al, 2000 (3), Reed et al, 2006 (4), Bossel, 2001 (5).

Quality criteria	Literature	Deltares	Quality criteria	Literature	Deltares
Representativeness and practicability			*User-friendly*		
Amount of change in time	1,3,4	Yes	Simple	1,3,4	yes
Sensitive to change across space	1		Communicable	2,3,4	yes
Representative measurable or computable	1,2,4	Yes	Interesting for users	2,3,4	yes
Representative the chosen processes or effect	2,3,4,5	Yes	Value-free	1,2,3,4	yes
Controllable	1,2,4	Yes	*Criteria for set of indicators*		
Data availability	3,4	No	Complete	1,2,3,5	yes
Cost-effective	3,4		Be limited in number	3,4,5	yes
Long-period measurable	1,4	Yes	Scientific valid	2,3,4,5	

- *Representative for chosen processes or effect*: an indicator should be representative for particular process(es) or the effect on the user-functions (Braat, 1991; Reed et al, 2006).
- *Controllable*: the system parameter that is used as indicator should be reasonably controllable by interventions regarding to external factors which are not controllable (Reed et al, 2006; Opschoor & Reijnders, 1991).
- *Data availability:* data is already available in databases (Garcia et al, 2000).
- *Cost-effective:* data is cost-effective to collect (Garcia et al, 2000; Reed et al, 2006)
- *Long-period measurable:* a minimal measurable period is necessary to be able to measure trends (Reed et al, 2006).

User-friendliness

- *Simple:* the indicator should be easy to understand for the users without extensive explanation (Reed et al, 2006).
- *Communicable:* presentation and documentation of information should be adequate in an attractive format for the users (Reed et al, 2006; Garcia et al, 2000).
- *Interesting for users:* the information has to be interesting for users' work or the society (Reed et al, 2006).
- *Value-free:* the indicator should be factual and not contain explicit or implicit normative judgements (Braat, 1991).

Criteria for final set of indicators

- *Complete:* the indicator set should give an indication of all relevant issues and perspectives (Bossel, 1999)
- *Be limited in number*: to keep the indicator set manageable the number of indicators should be as low as possible (Reed et al, 2006)
- *Scientific valid:* systematic error of the conceptual model of the system analysis should be minimal (Bossel, 1999; Garcia et al, 2000).

3.3.2 Research choice: not chosen quality criteria

Table 1 shows the quality criteria that are mentioned in the literature. Six criteria however are not chosen for the RIDM. This paragraph discusses which quality criteria and the reasons for this research choice.

- Sensitive to change across space is not a relevant criterion in this case study, because the (highest) spatial (aggregated) scale of this study is equal to the study area (see sub-paragraph 3.2.4).

- Controllable is especially relevant for indicators which measure the effectiveness of management. This is not the objective of the indicator set in this research; therefore controllable is not a relevant criterion.
- Data availability and cost-effectiveness are considered less in this phase of research to indicator development by Deltares.
- Communicable is mentioned in literature as important quality criterion, but communicability depends on the presentation of the information. It does not depend on the indicator itself. This criterion is therefore not taken into account in this study.
- Scientific valid is discussed in literature as criterion, but the focus is on the effect on the USI in this research. The scientific validity of the system analysis does not have influences on the selection of the final indicator set.

3.3.3 Research choice: chosen quality criteria and working-definitions

This paragraph gives (working-)definitions of the quality criteria and discusses the arguments for choosing. The purpose of the criteria for potential indicators is assessing the potential indicators of the expert- and user-indicator set. The result is input for selection of the indicators which form the final indicator set. The purpose of the criteria for the set of indicator set is to assess the success of the indicator set. Deltares discriminates the quality criteria between a need and a nice. A need means that one negative score is not allowed. Nice means that the score should be as high as possible.

Criteria to assess potential indicators concerning representativeness and practicability

1. *Amount of change in time:* the indicator must be able to change significantly in time in order of years (see paragraph 3.2.5). Otherwise, the indicator is useless to monitor the state of the system, because trends cannot be observed. This criterion is a need.
2. *Representative measure or computation:* data that feeds the indicator must be a representative measure (or observation) or computation by a model for the quantity. This criterion is also a need.
3. *Representative for the effect on the USI:* an indicator has to be representative for the effect on the USI. The quality criterion is characterised as a need.
4. *Long-period measurable:* information should be measurable for at least a period of one decade, because this is chosen as the time horizon of the indicators (see paragraph 3.2.5). A minimal measurable period should be practical (nice) to be able to measure trends.

Criteria to assess potential indicators concerning user-friendliness

5. *Simple*: the indicator should be easy to understand for the users without that extensive explanation is necessary. This criterion is characterised as nice, because it is very preferable, but it is not decisive according to Deltares.
6. *Interesting for intended users*: the information have to be interesting for users' work or the society and it should fit to the perception of the users. When information does not satisfy these two requirement, then they will probably not use it. Therefore, this criterion is a need.
7. *Value-free*: the indicator should be factual and not contain explicit or implicit normative judgements. This is in order to prevent that some political or pressure groups abuse the data for their own ends. This quality criterion is characterised as nice.

Criteria for the final indicator set

8. *Complete*: the indicator set has to give an indication of the effects on all relevant urgent societal issues which are affected by the water and soil system. All relevant interests (perspectives) have to be taken into account. Therefore, this criterion is a need.

9. *Limited number of indicators*: to keep the indicator set manageable the number of indicators should be as low as possible. A guideline is that a maximum of three indicators per USI is a need and one indicator per USI would be nice.

Box 2	RIDM: selecting quality criteria
Quality criteria to assess potential indicators:	*Quality criteria to assess the set of indicators:*
√ Amount of change in time	√ Complete
√ Representative measure or computation	√ Limited number of indicators
√ Representative for the effect on the USI	
√ Long-period measurable	
√ Simple	
√ Interesting for intended users	
√ Value-free	

3.4 Participation process

3.4.1 Participation in indicator development literature

A general definition of participation is "the act of taking part or sharing in something". A synonym is involvement (Dictionary.com, 2008). The involvement of stakeholders or users differs in the indicator development literature. Some scientists discuss explicitly the importance of participation (Fraser et al, 2006; Bossel, 1999, Azapagic 2004; Reed et al, 2006), while others do not even mention participation (Schoor & Reijnders, 1991).

Innes & Booher (1999) describe a lesson from experience that "it matters how the indicators are produced. Both anticipated users and participants in the production must be involved in the design (…), if the indicators are to be influential". They argue that indicators' main influence is not primarily after developing, but during the course of their development. Because the process shapes the stakeholders thinking about policies. Erfemeijer et al. (2002), Villars (2008) and Stronkhorst (2008) underline that involvement of users is important to develop an indicator set that will be useful for them. Indicators do often not link well with objectives or human acts, because indicators are often developed out of a scientific perspective that does not match with the needs of users.

Because literature about indicator development is not clear about the level of participation and methods to participate, information is searched in participation literature.

3.4.2 Participation level and groups

According to literature about participation, there is a wide range of the extent of stakeholder participation. HarmoniCOP (2005) and Jonsson (2005) distinguish three theoretically different levels of participation in river basin management:

1. Information (co-knowing): providing access to information and propagating information actively.
2. Consultation (co-thinking): public can react to governmental proposals.
3. Active involvement (co-operation): more involved role for the public in the wide range from discussions with the authorities to fully responsible for river basin management.

Edelenbos and Klijn (2005) distinguish five main levels of participation: informing, consulting, advising, co-producing and co-deciding. This latter is actually a specification of the former classification. Participation in literature often concerns the involvement of stakeholders in policy-making or design of solutions or decision-making (Edelenbos and Klijn, 2005). The general definition (paragraph 3.4.1) indicates that participation is broader than these domains. In this research, participation means the involvement of the purpose group and experts in the indicator development process.

The level of participation depends on the objective of the project (HarmoniCOP, 2005), i.e. in this research the indicator set. The categorisation of the participation levels is based on the classification of HarmonicOP (2005), because this book relates usefully the participation levels with the methods and tools (see methods and tools, paragraph 3.4.3). An addition is that no stakeholder participation is also an option, therefore zero participation is defined as the fourth level.

The participation levels can also differ per group of stakeholders. It is often not necessary to involve all the stakeholders at the same way and intensity. Therefore, it is firstly needed to define the participation groups, before it is possible to define of the participation level per group.

Research choice: participation groups

For the RIDM the choice is made to use two participation groups using participation in the widest sense of the term. The two groups are the experts and the intended users. The second group consists of politicians of the national, provincial or water board parliament and journalists who are representative for the interested citizens.

The reason for involving experts is to guarantee representativeness and practicability. Participation of intended users will guarantee that the set of indicators is the user-friendly. The participation process should be designed in such a way that the (set of) indicators satisfies the quality criteria as much as possible. The reason for using two separated groups is to check the hypothesis (See chapter 1) and to analyse the differences in their way and level of thinking, perspectives and interests.

Research choice: participation level

The participation level of the expert group is chosen between consultation and active involvement. Co-thinking is only necessary to receive input for formulation of the urgent societal issues (USI), the perspective of the RIDM. A modest form of active involvement is chosen to do the system analysis, because more interaction and discussion is necessary to analyse the relevant processes and parameters per USI. A high level takes more time and that can discourage experts to involve.

The choice of the participation level of the user group is consultation. They give input once by telling their view on water and soil management issues and their ideas for possible indicators. The reason for choosing consultation is practical. Consultation is the minimal participation level that should be satisfied, because their input is necessary. A higher level could put off decision-makers to participate in this research, because it takes more effort and time. During this research could be checked if the minimal participation level – consultation - is sufficient to develop an indicator set that is interesting for the users.

3.4.3 Participation methods and tools

There are many methods available which can be used during a participation process for different participation levels (HarmoniCOP, 2005). This paragraph gives a list of methods and tools that are interesting for application in indicator development processes. Some methods and tools are left, because those are suitable for development of spatial planning or water management plans with a wider audience than necessary for indicator development. Examples are public hearing, citizen's jury, planning kit and website.

The list shows per method a short definition and a specification of applicability per participation level, which are both taken over from HarmoniCOP (2005). The letters and symbols mean [Information – (low), Consultation o (medium), Active Involvement + (high applicability)]. Which methods are manageable and applicable in a particular case depends on the motivation and available time of persons that are involved. The choice concerning participation methods and tools is therefore characterised as a case choice.

Methods and tools:

- Brainstorming: workshop setting focused on the collection of a large number of ideas on a specific subject (I -, C o, AI +).
- Group model building: facilitated session in which participants build a model to improve their understanding of the issue (I o, C +, AI +). This is a specific session for the system analysis.
- Interviews: discussions, usually with open questions and the possibility of extensive answers (I +, C +, AI o). Interviews are useful for getting input from users and experts about USI's and possible indicators.
- Problem/cause analysis: in-depth analysis of causal network which is behind a problem (I o, C +, AI +). This is also a specific session for the system analysis.
- Reframing workshop: workshop setting which allows participants to explore different analytical frameworks and refine their problem perception (I -, C o, AI +). This method can be used to combine the definitions of USI's with a system analysis.
- Review session: workshop setting to monitor progress, keep momentum, discuss lessons learnt and evaluate steps taken so far (I -, C o, AI +). This session is may be interesting for evaluation of a case study with the participants.
- Questionnaire: list of written questions for one-way information gathering (I -, C +, AI +). This is a tool that can be used during interviews or by emails.
- Letter/mailing: tool for sharing of information

Box 3	RIDM: participation process
√	Participation groups are experts and intended users
√	Participation levels: consultation and a modest form of active involvement for experts; consultation for the users.
?	*Participation methods and tools*

3.5 Step three: analysing the system

An analysis of the system with the essential physical and socio-economic elements is the basis for a conceptual understanding of the total system (Bossel, 1999). It helps in identifying the relevant processes and aspects to realise a technical-scientific basis for formulation of potential indicators. In scientific literature different methods to structure a system analyse can be found. This paragraph lists five different approaches, which are OECD, system approach of Bossel, Layer model, functionalist approach and some other system approach.

The *OECD* introduced the Pressure State Response concept and the EU developed the approach further in Driver Pressure State Effect Response (DPSIR), which also includes socio-economic effects and driving forces (Koningsveld, 2003; Erftemeijer et al, 2002).

Bossel (1999) however discusses that this approach neglects the systemic and dynamic nature of processes and feedback loops. The author therefore introduced a different integrated *system approach*. It identifies and divides the essential sub-systems and their contribution to the total system. He distinguishes six sub-systems and dimensions: individual development, social system and government system (together human system), economic system and infrastructure system (together support system), and the environmental and resource system (natural system).

The *Layer model* is introduced by the Dutch Spatial Explorations 2000 and the 'Nota Ruimte' (policy spatial planning) as method to analyse and manage spatial developments (De Vries, undated). The approach has three physical planning layers with differences in dynamics and vulnerability:

1. Base layer consisting of soil, water and ecology; low dynamic and large vulnerability.
2. Network layer consists of connections and junctions which form the infrastructure; intermediate dynamic and vulnerability.
3. Occupation layer consisting of the physical pattern of human activities like housing, working and recreating; high dynamic and lower vulnerability.

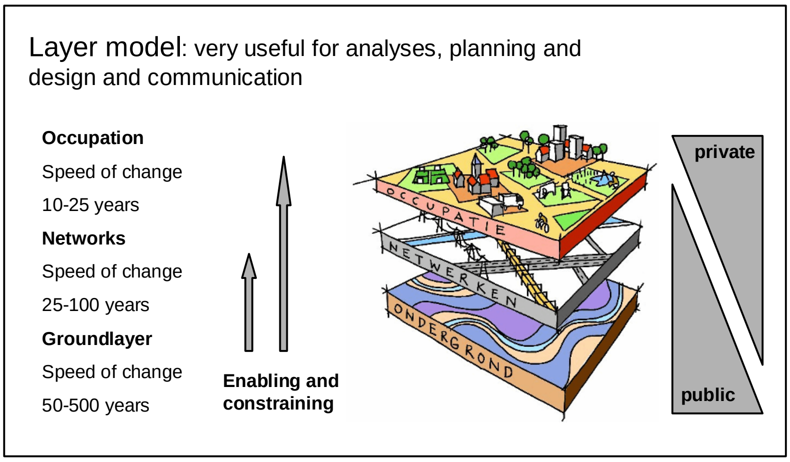


Figure 5: An overview of the Layer model. Source: De Vries (u.d.)

It is characteristic for the layer approach that the possibilities and limitations of the underlying layers are the starting-point of the analysis. The base layer creates and sets the conditions for the network and occupation layers (De Vries, u.d.; Senternovem, 2008).

Ertemeijer et al (2002) mentions the *functionalist approach* that is based on the functions that environmental, social and economic systems have to satisfy human needs. Indicators can be perceived from these functions to monitor the state of such functions.

Garcia et al. (2000) also mention *some other system approaches*. One approach is the 'general sustainable development framework' that consists of a human and environmental sub-system. The method of FAO distinguishes the sub-systems resources, environment, technology, institutions and people. This method is however mainly applicable for agricultural and fishery contexts.

Garical et al. (2000) put the importance which structuring method is used into perspective. "In practice, it is not critical which framework (structuring method) is adopted as long as it encompasses the scope and purpose (...). In many cases different frameworks will lead to the same or similar sets of indicators".

The structuring methods also need a tool to model the processes inside and among the sub-systems. A tool that is often used for this purpose is the Causal Relation Diagram (CRD) (Enserink et al, 2003). The tool drafts positive or negative relations among parameters. It helps to structure processes and forces the researcher to think about which parameters are relevant and how they affect each other.

Research choice: structuring method

The method 'Layer model' is chosen to structure the system analysis. It is a systematic method that works from low dynamic to high dynamic processes and from big vulnerability to little vulnerability by starting in the base layer, followed by the network and occupation layers. It starts with the processes and capacity of the water, soil and ecological system. These systems create the conditions for their use for infrastructure and by various user functions.

The system approach of Bossel (1999) does not consist of this structure very apparently. In addition, this approach is more detailed because of the six subsystems and that makes it more complex and less surveyable to work with it. The functionalist approach would set the focus too much on satisfaction of user functions and too little at the capacity of the natural system. Finally, the dividing in human and environmental sub-systems lacks the support/infrastructure sub-system that increases the extent of structure in the analysis.

Box 4	RIDM: analysing the system
√	Structuration method: Layer model with CRD as processes modeling tool.

3.6 Step four: formulating indicators

The step indicator formulation concerns the process to define the final indicator set. Additional aspects are the formulation of reference values, the aggregation levels and some choices about used data types and sources.

3.6.1 Process to define the indicator set

The scope frames the issues and the system analysis designates the parameters that could be potential indicators, but “there may still be a large number of potential indicators that could be used” (Garcia et al, 2000). Many formulated potential indicators can have various reasons. These are the use of longlists with system parameters, different perspectives or dimensions or different participation groups (Garcia et al, 2000; Azapagic, 2004; Lorenz et al, 2001; Innes &Booher, 1999; Reed et al, 2006).

An evaluation of the potential indicators is necessary to select the indicators that form the final indicator set. Assessment of the potential indicators by using quality criteria can help to select a limited number of effective indicators (Garcia et al, 2000; Lorenz et al, 2001). The quality criteria that have been used in various literature are already discussed in paragraph 3.3.1.

Research choice: potential indicators and assessment

The choice is made to develop two sets with potential indicators in this research. The sets are based on inputs of experts and users respectively. This is a specification of the choice to involve these two participations groups like argumented in paragraph 3.4.2. The sets are called expert-indicator set and user-indicator set in this report. The different participation groups could probably have different insight that results in different indicators.

Therefore, the potential indicators are assessed with help of the chosen quality criteria for potential indicators (see paragraph 3.2.3). The assessment of the potential indicators forms the input for the selection of the final indicator set.

3.6.2 Reference values

Reference values are strongly linked to the indicators. The definition of these values is an essential step, because changes in indicators (e.g. over time) cannot be meaningfully interpreted without having a basis for the comparison (Garcia et al, 2000; Reed et al, 2006). Literature mentions three bases for comparison: reference levels, targets or thresholds. Reference levels can be the situation of a particular year or a zero-measurement. Targets and thresholds are related to policy-making and decision-making respectively.

It depends on the nature and the objective of the indicator which type is suitable (Opschoor & Reijnders, 1991). Erftemeijer et al (2002) warn after evaluation of decades of indicator development for the North Sea, for the value-sensibility of targets, because of their financial consequences. In practice it seems that experts take this too little into account.

Research choice: reference values

The choice is made to use only reference levels which are zero-measurements or –computations. Targets or thresholds of the indicators are a political questions and ask political choices. Deltares is an independent research institute, therefore it does not want to make these choices. The reference years are chosen from the current period which consists of the last decade and nowadays, because the program 'Staat en Toekomst van de Delta' focus on current state of the delta with a look in the future.

A remaining aspect is the choice concerning the specific year that depends on factors as data availability and natural noise. These aspects are however not taken into account in this research (see paragraph 3.2).

3.6.3 Aggregation methods

To reduce the number of indicators to a manageable set, it is essential to condense the indicator set as much as permissible without losing essential information (Bossel, 1999). This means that choices about aggregation have to be made. Opschoor & Reijnders (1991) and Bossel (1999) distinguish several methods (including the definitions) to condense an indicator set:

- Aggregation: use of the highest level of aggregation as possible.
- Condensation: locate an appropriate indicator representing the ultimate cause or effect of a particular problem without bothering with indicators for intermediate systems.
- Weakest-link approach: identify the weakest links in the system and define appropriate indicators.
- Basket average: if several indicators representing some different aspects of an issue, all should be considered in an index.
- Representative indicator: identify a variable that provides a reliable information characteristic of a whole complex situation.

Research choice: aggregation methods

A choice concerning aggregation methods is not made during this research. This implies that all methods can be applied within the RIDM.

3.6.4 Data

All frameworks mention data collection as point of interest in relation with the formulation of indicators. The first aspect is the type of data: quantitative or qualitative. Another aspect linked to the this aspect is the source of data: models, measurement or observation.

According to Hellendoorn (2001) quantitative means expressed in numbers or percentage and qualitative means expressed in hierarchy (for example, A scores better than C). Experts of physical background often use only quantitative data, while communities collect both quantitative and qualitative data (Reed et al, 2006). Other scientists discuss that indicators should be both quantifiable and qualifiable from models and (qualitative) measurements, while Opschoor & Reijnders (1991) and Braat (1991) think that indicator information should be only quantitative model data. New scientific insight about participation during the time can maybe clarify this difference. An example that illustrates this is the rise of Participatory Rapid Appraisal that turns around community participation in, for example, agricultural or water management projects.

Research choice: type and source of data

The choice is made to leave open all possibilities concerning data, because restriction of data use is considered less relevant in this research according to Deltares. So, both quantitative and qualitative data are possible and the data source can be models as well as measurements and observations.

Box 5	RIDM: formulating indicator
√	Development of two sets with potential indicators based on respectively experts and user input.
√	Assessment of potential indicators by using the quality criteria for potential indicators
√	Selection of a final indicator set
√	Reference values are levels which come from the current period that consists of the last decade and nowadays
√	All possibilities are left open concerning data and aggregation methods

3.7 Step five: communicating and/or implementing

The fifth step is a collection of steps to communicate the indicator set to the users, or implement the set in a management cycle.

The information and interpretation need to be presented in a form which is easily understood by the user to access the indicators to them (Garcia et al, 2000; Erftemeijer et al. 2002; Braat, 1991). Stronkhorst (2008) mentioned that the indicators have to be brought close to the professional daily acts and activities of the users. This is especially the case when the purpose of the indicators is to measure the effectiveness of management (see scope, paragraph 3.2).

Presentation is not a part of every framework (Reed et al, 2006; Fraser et al, 2006). It is not very well possible to derive a good reason for this from literature. Maybe, it is implicitly assumed or because communication is not seen as final piece of the developing process. This is especially the case, when implementation of the indicators in the management cycle (to monitor effects of policy) is the final part of the process (Fraser et al, 2006; Reed et al, 2006).

Research choice

This research does not consist of extra steps after the fourth step, indicator formulation. The choice is made to pay no attention to presentation and communication of the indicators, because this lies outside the scope of the assignment of Deltares. Besides this, implementation in management cycles is also not part of this research.

Box 6	RIDM: communicating and implementing
√	Communication and implementation are not taken into account in the RIDM

3.8 Overview of research indicator development method

Box 6 Research indicator development method

Step 1: formulating the scope

- √ Objective of the indicator set: to assess the state of the delta from perspective of urgent societal issues which are affected by the water and soil system.
- √ Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens
- √ Perspective: urgent societal issues
- √ Spatial aggregation scale: the study area
- √ Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year
- ? *Case choice: study area (spatial scale)*

Step 2: selecting quality criteria

Quality criteria to assess potential indicators:

- √ Amount of change in time
- √ Representative measure or computation
- √ Representative for the effect on the USI
- √ Long-period measurable
- √ Simple
- √ Interesting for users
- √ Value-free

Quality criteria to assess the set of indicators:

- √ Complete
- √ Limited number of indicators

Step 3: analysing the system

- √ Structuration method: Layer model with CRD as processes modeling tool.

Step 4: formulating indicators

- √ Development of two sets with potential indicators based on respectively experts and user input.
- √ Assessment of potential indicators by using the quality criteria for potential indicators
- √ Selection of a final indicator set
- √ Reference values are levels which come from the current period that consists of the last decade and nowadays
- √ All possibilities are left open concerning data and aggregation methods

Step 5: communicating and implementing

- √ Communication and implementation are not taken into account

Participation process

- √ Participation groups: experts and intended users
- √ Participation levels: consultation and a modest form of active involvement for experts; and consultation for users.
- ? *Case choice: participation methods and tools*

4. Case study ‘South-West Delta’: process

This chapter describes the indicator development process that is designed for the case study about the South-West Delta of The Netherlands. The process is determined by the RIDM, some case choices and the execution of the methods in practice.

The chapter starts with an area description of the South-West Delta. Paragraph 4.2 discusses the case choice study area. Thereupon the paragraphs 4.3 to 4.5 describes a case choice about the participation methods and the process in practice concerning quality criteria, participation process and indicator formulation. The chapter finishes with a theoretical overview of indicator development process of the case study.

4.1 Area description

The area description of the South-West Delta is mainly taken over from the area description of the Ontwerp Nationaal Waterplan (Directoraat-Generaal Water, 2008).

The South-West Delta is the area that is bordered by the ‘Nieuwe Waterweg’, Biesbosch and the Scheldt-estuarium. It is an area with many large water bodies with their own characters: from fresh to salt and from stagnant to flowing. Three international rivers flow into the North Sea: the Scheldt, Meuse and Rhine. It is a blue-green area between high industrialised and densely populated areas. Many national water bodies are nature areas, which have been designated as Natura2000-areas (protected nature areas). The Eastern Scheldt and the Biesbosch are National Parks.

The ‘Zak van Zuid-Beveland’, Western ‘Zeeuws-Vlaanderen’ and the ‘Hoeksche Waard’ are National Landscapes. Each area has its own characteristics, but consists of a common presence of dunes, dikes, creek remnants and terps as sign of the continuing fight against water. The area is world-famous because of the Delta-constructions, a collection of dams in diverse water bodies to increase the flood safety during storm at the North Sea.

Figure 6: A map of the Dutch South-West Delta. Source: Provincie Zeeland, 2003b.

The economy in the area is strongly related to water, for example the world seaports of Rotterdam and Antwerp. These ports are connected with each other via the Rhine-Scheldt Corridor, an important inland shipping route for container transport. The Western Scheldt and the 'Nieuwe Waterweg' are the direct connections to the sea for Antwerp and Rotterdam respectively. Harbours like Moerdijk, Vlissingen, Terneuzen and Gent also profit of this water infrastructure.

The economic importance of water recreation is big and the expectations are that this sector will grow. Another water-related sector is the shellfishery in the Eastern Scheldt and the Grevelingenmeer. It is a strong regional sector producing for the international market.

The largest part of the land is used for agriculture. The polders of South-Holland, Brabant and Zeeland with high-quality cultivation of vegetables and fruit profit of the good logistical connections and they have an internally strong competitive position.

In the South-West Delta area, many power plants and companies are present which use process- and cooling-water. The reservoirs in the Biesbosch provide drinking water for Rotterdam, the Drecht-cities and the province Zeeland. Drinking water for Goeree-Overflakkee and Schouwen-Duivenland are withdrawn from the Haringvliet. In addition, the soil water from the 'Brabantse Wal' is a drinking water source for Zeeland and West-Brabant.

4.2 Step one: formulating the scope – case choice study area

Box 8	RIDM: formulating the scope
√	Objective of the indicator set: *to assess the state of the delta from perspective of urgent societal issues which are affected by the water and soil system.*
√	Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens
√	Perspective: urgent societal issues
√	Spatial aggregation scale: the study area
√	Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year
?	*Case choice: study area (spatial scale)*

Characteristic for the governance of the South-West Delta area is the number of governmental levels and boundaries (Various national ministries, 3 provinces, 3 water boards and tens of municipalities). In 2003 a common integral vision for the Dutch Delta Waters is developed. This governmental cooperation is necessary, because the problems across institutional borders (Provincie zeeland, 2003c).

Directoraat-Generaal Water (2008) defines the South-West Delta as is the area that is bordered by the 'Nieuwe Waterweg', Biesbosch and the Scheldt-estuary. This means that institutional borders are not chosen, but that the physical system is chosen at a pragmatic way.

This definition is followed in this research with some exceptions. The number of issues and

Figure 7: The study area: the South-West Delta without Rotterdam and Antwerp.

involved actors that are taken into account in this case study are restricted to reduce the complexity. The cities of Antwerp and Rotterdam are therefore not taken into account, but they are considered as important external factors for the study area because of their interests and power concerning good connections with the North Sea. A part of Flanders is taken into account, because the flood safety of Zeeuws-Vlaanderen depends on the coastal defence of Flanders. Figure 7 shows the study area. The area consists of the Delta Waters, the polders among the Delta Waters and a small coastal zone (some kilometres).

4.3 Step two: quality criteria in practice

Box 9	RIDM: selecting quality criteria
Quality criteria to assess potential indicators: √ Amount of change in time √ Representative measure or computation √ Representative for the effect on the USI √ Long-period measurable √ Simple √ Interesting for users √ Value-free	*Quality criteria to assess the set of indicators:* √ Complete √ Limited number of indicators

This box shows the quality criteria of the RIDM. In the case study the criteria for potential indicators are used to assess and integrate the two sets with potential indicators. Table 2 shows the graduation that is applied during this assessment. It shows per quality criterion the type and graduation. The criteria that are characterised as need are basis conditions. A negative score [-] for these criteria means dropping out of the potential indicator. The table also shows the graduation per criterion in qualitative or quantitative terms. Appendix C works out the assessment. It shows an overview of the scores and discusses the argumentations of the scores per quality criterion. The quality criteria to assess the set of indicators are used to select a final indicator set that satisfy these criteria (see paragraph 4.5.3).

Table 2: The graduation per quality criterion that is applied to assess the potential indicators.

Quality criterion	Type	Graduation			
		-	0	+	++
Amount of change in time per year	Need	Order of 1%	Order of 10%	Order of 100%	
Representative measure or computation	Need	Weak correlation	Well correlated but not measuring the same thing	Good measure	Exact measure
Representative for the Effect on the USI	Need	Part of the effect	Biggest part of the effect	Whole effect	
Interesting for users	Need	Not interesting	Moderate	Interesting	
Long-period measurable	Nice	0-10 year	10-20 year	> 20 year	
Simple	Nice	Hard	Moderate	Easy	Very easy
Value free	Nice	Not value free		Value free	

4.4 Participation process

Box 10	RIDM: participation process
√	Participation groups are experts and intended users
√	Participation levels: consultation and a modest form of active involvement for experts; and consultation for the users.
?	*Participation methods and tools*

4.4.1 Participation groups in practice

The two participation groups of the RIDM are experts and intended users. During the case study, the selection of experts and users is based on their knowledge about problems and (physical) processes or responsibilities and interests in the South-West Delta respectively. Both groups are involved to give different input, because they have different characteristics.

Experts

The involved experts are employees of Deltares with some common characteristics. They have scientific knowledge about the water- and soil system and policy. They often have a scientific-technical perspective on society and its issues and problems. The most involved experts have less feeling with politics than policy- and decision-makers.

Four experts are involved to give input for designation of the expert-USI's. Another six experts are selected to draft and discuss (a part) the system behind a USI. The selection criterion for the first group is a broad overview of issues which play a role in the South-West Delta. The criterion of the second group is their professional expertise. Besides these selection criteria, the experts are adviced by other employees of Deltares, because of their knowledge about the study area or their expertise with physical processes (in the area). The input of experts in the case study is as following.

Figure 8: The gap in way of thinking and interests between experts and citizens. Source: doglegs.net

- Designating of urgent societal issues by four experts with a broad overview of the issues which play a role in the South-West Delta and relevant quality criteria.
- Describing of processes per USI. Drafting with and discussing of specific parts of the system analysis according to their scientific discipline and knowledge.
- Designating of or mentioning of (possible) indicators related to the USI's.

Intended users

The user group consists of six decision-makers and a journalist. They are involved in politics, directly by managing the different interests of various parties, or indirectly by writing and reporting about the issues going on. The decision-makers often do not have much scientific knowledge about the water- and soil system, but they know how to deal with the different interests of stakeholders and how to look for political solutions for societal problems. The journalist plays another role. He looks for problems and promises that are not fulfilled to write about.

The politicians have a particular political philosophy. Therefore, during the selection of potential interviewees their political party is taken into consideration. An additional selection criterion is that the three governance levels (national, provincial and water board) and different provinces and water boards are involved. The user group consists of 1 national, 3 different provincial and 2 different water board decision-makers. Their input is as following.

- Designating of urgent societal issues by decision-makers of three governmental levels and a journalist.
- Designating of interesting indicators for their daily work as representative or journalist.
- Explaining of their way of thinking in terms of user functions or societal issues to check which one fits better with the intended users.

4.4.2 Case choice: participation methods

The features of the participation groups and their intended input must be taken into consideration in the participation method choices. Besides this, the methods have to be manageable, which means that the method takes the least effort and time from the involved persons. The chosen participation methods are listed firstly. The next three paragraphs discuss the methods in practice.

1. The participation method for the four ‘broad experts’ is an individual interview; defined as discussions with open questions and the possibility of extensive answers.
2. The method for the system analysis and indicator formulation is a problem/cause analysis; defined as in-depth analysis of the causal network that is behind a problem.
3. The participation methods for the user group are individual interviews (over the telephone); followed by email to ask feedback about the user-, expert- and final indicator set.

4.4.3 Interviews with experts in practice

The basis of the interviews with the experts with a broad view on the South-West Delta are open questions. Questions about which urgent societal issues plays a role in the South-West Delta, possible indicators and important processes. The interviewer firstly gives the interviewee the possibility to answer the questions with a open mind, without steering into a particular direction. Next, the expert is asked why he or she did not discuss USI’s that are mentioned by other experts or in policy documents.

Processing results of interviews concerning USI’s

The author worked out the input of the experts and formulated five USI’s (expert-USI’s, see paragraph 5.1.1). Appendix A discusses the output of the interviews and the formulation of the expert-USI’s.

4.4.4 Problem/cause (system) analysis in practice

The following step in the case study is an analysis of the system behind expert-USI’s. Five problem/cause analyses are applied to draft four conceptual models of the important processes and factors behind the USI’s. The importance of a factor or process has been determined from literature and the insights of various specialists of Deltares which are gathered during the analysis. Per USI one or two experts are involved. In case of two experts they complement each other. This method does not facilitate the possibility that experts disagree about causal relations between quantities. This is also not occurred during the analysis.

The problem/cause analysis starts with a conversation (over the telephone) with a specialist about processes of (a part of) the water and soil system and potential indicators. Next, the author draws and structure a Causal-Relation Diagram (CRD) in the three layers of the Layer model : base, network and occupation layer. Finally, the specialist checked the diagram and gave feedback (eventually including some discussions). The feedback is used to improve the system diagram. The author completes the system analysis with a textual discussion of the important processes and parameters and the formulation of potential indicators. The described organisation of the system analysis process should guarantee a high credibility of the conceptual models.

The interviews with the users reveal some gaps in the input of the involved experts concerning the USI's and meeting processes. An example is desiccation of nature areas caused by dropping of the groundwater level. These USI's and processes are added to the system diagrams after those interviews. Paragraph 6.1.6 discusses the reasons for the gaps.

4.4.5 Interviews with intended users in practice

The interviews with the intended users consisted of open questions. The first question was: what are urgent societal issues/problems in the South-West Delta related to water, ecology and soil? So they could discuss issues and problems that are important for them without being steered in a particular direction. The answers often left some USI's unmentioned which the experts or other users discussed earlier. The interviewer went on by asking their opinion about these USI's.

Other questions concern possible indicators per USI and an interesting frequency of reporting. In addition, their perspective in their daily work as parliamentarian or journalist is asked. Do they think about user functions or societal issues?

During the face-to-face interviews, the last part was asking their opinion of the expert-indicator set. The interviews finished with the appointment to give feedback the results of the interviews per email: the user-USI's and user-indicator set. Some interviewees very briefly respond with positive feedback. Furthermore, a provincial and a water board decision-makers were asked to give their view on the final indicator set.

Processing results of interviews concerning USI's

The author structured the input of the users at a manner so that their way of thinking is mainly reserved, without mixing with the expert way of thinking. During the interviews seem that politician thinks integral. They quickly connect issues and problems with each other. This is especially the case with societal issues which belongs to water system quality. Therefore, the mentioned USI´s that can fit with the term `water system quality´ are grouped together. The input of the users concerning USI's results in four USI's and seven sub-USI's (the user-USI's). Appendix B discusses the output of the interviews and the formulation of the user-USI's.

4.5 Step four: formulating indicators

Box 11	RIDM: formulating indicators
√	Development of two sets with potential indicators based on respectively experts and user input.
√	Assessment of potential indicators by using the quality criteria for potential indicators
√	Selection of a final indicator set
√	Reference values are levels which come from the current period that consists of the last decade and nowadays
√	All possibilities are left open concerning data and aggregation methods

4.5.1 Formulation of potential indicators in practice

An aspect concerning the formulation of potential indicators is the way of composing the indicator sets based on the input of expert and intended users. The guiding principle in this case study is using the suggestions of the involved users as the most important and leading source.

The experts discussed possible indicators or designated interesting parameters in the system diagrams per USI during the interviews and problem/cause analyses. The author adopt their suggestions and compose the expert-indicator set that covers the expert-USI's. These indicators logically follow from the system analysis. Appendix A discusses the expert-indicator set.

During the interviews, the intended users are asked to discuss which information – parameters- is interesting concerning determination of the state of their delta. The indicators of the users are not necessarily the same as those of the experts, even if they agree on the USI. The users mainly discuss the state of processes or problems as indicators for a USI, which fit with their perception. These are the things that they can experience or observe.

Table 3: An example of structuring the input of the users concerning indicators.

(Sub) urgent societal issue	Indicator layer 1: perception/concept	Indicator layer 2: operational
Ecological deterioration	Algal growth	Chlorophyll-a content

Therefore, the input of users concerning indicators is worked out in two indicator layers. Table 3 gives an example. The first indicator layer fits with the problems and processes that users mentioned like algal growth. The water looks green and smell during the summer. The second layer is an operationalisation of the first layer. It consists of measurable indicators and fit in the system description or measurement method of the experts. In the example, this is the chlorophyll-a content of water, which is a scientific method to indicate algal growth.

The second-layer indicators are partly mentioned by the users during the interviews and for the remaining part their operationalisation is done by the author. These indicators are made operational by using indicators of the expert-indicator set. This is also done by parameters that are a representative measure for 'perception indicator' from the system analysis or scientific knowledge that was not taken into account by the involved experts. Because the users show some gaps in the input of the experts concerning USI's and processes. Figure 9 shows a scheme with the positioning of the two indicator layers in the system. The operational indicator is only an operationalisation of the perception indicator when necessary. This can be a parameter that indicates a cause of the effect, but it can also be a certain measurement method. Appendix B discusses the user-indicator set and making the perception indicators operational.

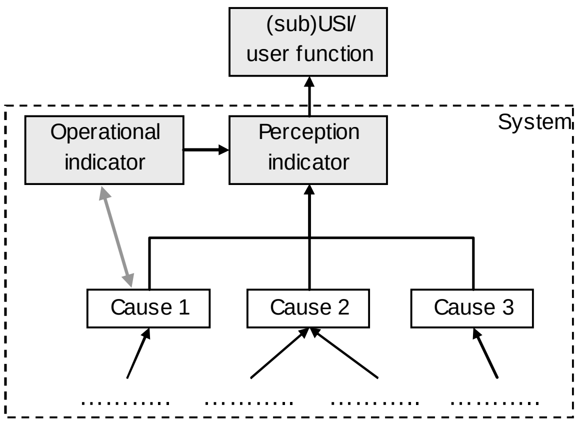


Figure 9: Positioning of the two indicator layers in the system.

4.5.2 Selection of the final indicator set in practice

The potential indicators are assessed by using the elaborated quality criteria for potential indicators (see paragraph 4.3). The assessment is the input for the selection of the final indicator set. One guiding principle for the selection is the structure of the user-USI's and meeting interests to satisfy the quality criterion complete. Another guiding principle is to limit the number of indicators as much as possible (QC limited number).

In order to satisfy this criterion, the author firstly try to select one indicator per layer per (sub-)USI. When the best scoring indicator of layer 1 is not representative for the effect on the USI, then a second indicator is selected. So, the combination of two indicators is representative for the effect on the (sub-) USI. The same method is applied for selection of operational indicators, which have to be a representative measurement or computation for the perception indicators. All selected perception/conceptual and operational indicators forms together the final indicator set.

4.6 Overview indicator development process of the case study

Box 12 **Research indicator development method**

Step 1: formulating the scope

- √ Objective of the indicator set: to assess the state of the delta from perspective of urgent societal issues which are affected by the water and soil system.
- √ Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens
- √ Perspective: urgent societal issues
- √ Spatial aggregation scale: the study area
- √ Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year
- √ *Case choice: study area is the Dutch South-West Delta without the harbours of Rotterdam and Antwerp*

Step 2: selecting quality criteria

Quality criteria to assess potential indicators:

- √ Amount of change in time
- √ Representative measure or computation
- √ Representative for the effect on the USI
- √ Long-period measurable
- √ Simple
- √ Interesting for users
- √ Value-free

Quality criteria to assess the set of indicators:

- √ Complete
- √ Limited number of indicators

Step 3: analysing the system

- √ Structuration method: Layer model with CRD as processes modeling tool.

Step 4: formulating indicators

- √ Development of two sets with potential indicators based on respectively experts and user input.
- √ Assessment of potential indicators by using the quality criteria for potential indicators
- √ Selection of a final indicator set
- √ Reference values are levels which come from the current period that consists of the last decade and nowadays
- √ All possibilities are left open concerning data and aggregation methods

Step 5: communicating and implementing

- √ Communication and implementation are not taken into account

Participation process

- √ Participation groups: experts and intended users
- √ Participation levels: consultation and a modest form of active involvement for experts; and consultation for users.
- √ *Participation methods and tools: interviews, problem/cause analysis and email*

5. Case study 'South-West Delta': results

Chapter 4 discussed the process of the case study. This chapter continues with the results of the case study. The first paragraph presents the intermediate results which are two sets of USI's and potential indicators based on the input of the experts and intended users. The second result is an analysis of the differences in way of thinking between decision-makers and experts. Paragraph 5.2 discusses the comparison of sets with USI's and potential indicators. The third result is the final indicator set for determining the state of the South-West Delta. Paragraph 5.3 discusses the final indicator set and gives a brief elaboration of the set.

5.1 Intermediate results

5.1.1 Urgent societal issues discussed by experts and intended users

Box 13 lists the two sets with USI'. It is noticeable that the arrangement of both lists differs. The experts separate fresh water availability as an apart USI, while the intended users relate this issue to water system quality. Furthermore, the users add two sub-USI's to water system quality with regard to the experts. These are desiccation of nature and hindrance of inundation. Appendixes A and B give a further elaboration of the expert- and the user-USI's respectively.

Box 13 — Set of urgent societal issues

Identified by expert:

- safety for flood hazards;
- water (system) quality including
  - (ecological deterioration of the Delta Waters)
  - (salinization of polders)
  - (possibilities for marine fisheries and aquaculture)
  - (water pollution for recreation);
- fresh water availability;
- transportation by shipping; and
- quality of life.

Identified by intended users:

- safety for flood hazards;
- water system quality divided in:
  - ecological deterioration in the *whole* delta
  - possibilities for marine fisheries and aquaculture
  - fresh water availability
  - salinization of polders
  - desiccation of nature
  - water pollution for recreation
  - hindrance of inundation;
- transportation by shipping;
- quality of life.

5.1.2 Sets with potential indicators according to experts and intended users

The input of experts and users is used to develop two sets with potential indicators. Table 4 shows these two sets. The guiding principle of the RIDM is the users' view. The arrangement of the indicator sets follows this principle in table 4. Appendixes A and B also give an argumentation of the the expert- and user-indicator set respectively. The RIDM consists of two courses with both participation groups to compare the ways of thinking, perspective and interests. The remaining of the paragraph describes the similarities between the results of both courses, which are the USI's and potential indicators. Paragraph 5.2 discusses the differences. The indicators in table 4 are split up in three groups. These are 'similarities', 'addition of users relative to experts' and 'addition of experts relative to users'.

Table 4: An overview of potential indicators of both sets with the USI's and indicators according to the users as starting-point.

Urgent societal issue	Indicator layer 1: Perception/concept	Indicator layer 2: operational *Users*	*experts*
Water system quality			
Ecological deterioration in the ***whole*** *delta*	Aquatic biodiversity	Number of and per species: (shell)fishes & seals	
	Algal growth / eutrophication	Chlorophyll-a content	Nutrients content
	Erosion of sand banks	Surface area of sand banks	
	Extent of tide	Tidal range	
	Salt content surface water	Chloride concentration	
	Refreshment		Replacement time
	Photosynthesis		Oxygen-concentration
	Water bed pollution	Amount and location of hazardous substances	
Possibilities for marine fisheries and aquaculture (MFAC)	Presence of suitable conditions for marine fisheries and aquaculture		Ecotope (salinity, acidity, nutrients content)
Salinization polders	Suitability to grow particular crops	Chloride concentration groundwater	
Fresh water availability	Availability of fresh water for different functions regard to use by the functions	Discharge available fresh water per regard to use by user-function per source	
Desiccation of nature	Terrestrial biodiversity	Groundwater level (linked to kinds of plants)	
Water pollution for recreation	Safety swimming water	% swimming waters that satisfy the EU-standards	
	Algal growth / eutrophication	Chlorophyll-a content	
Hindrance of inundation	Extent of hindrance	Frequency	
		Inundation height	
Safety for flood hazards	Condition of the flood defence structures	Flooding probability	
	Risk approach		Flood prob. & effects
Transportation by shipping	Use of shipping	Volume of goods	
		Accessibility of water routes for particular ships	
			Travelling time loss
	Shipping accidents risk	Shipping movements per water route	
		Effect of accidents	
Quality of life	Perception of the water	Quality of the water system	
	Favour of living nearby water	Price of real estate nearby water	

Legend: Similarities | Addition of users relative to experts | Addition of experts relative to users

The users and experts agreed (black letters) on almost half of the indicators. This concerns indicators of the sub-USI's of water system quality, flood disaster safety and quality of life. The users also add two (sub)-USI's and a number of indicators (30%) of the second indicator layer with regard to the experts (blue letters). These indicators belong to the USI water system quality and flooding. The last group of indicators (white letters) are disagreements between the users and experts, which can be found by the (sub)USI's ecological deterioration of Delta Waters, flood disaster safety and transportation by shipping.

The perception indicators which the users discussed – within the framing of the water and soil system – are related to threats of the physical system for the user-functions. Furthermore, they also mention positive developments concerning user-functions like the increasing use of shipping for transportation. The intended users interest in indicators which are representative for the effect on the USI. The experts however recommend indicators which indicate important system processes.

5.2 Differences in way of thinking between decision-makers and experts

The next step is analysis of the specific differences between the results of the two courses. The differences between users and experts in way of thinking and perception concerns six aspects. Table 5 gives an overview of the differences and gives examples from the sets. The six aspects are discussed below.

- *The issues that are taken into account:* expert looks for problems at significant scale, like the fresh water supply for agriculture, but the users also looks for smaller scale problems like drinking-water and process water with a less significant volume. This is also affected by the choice of the involved experts.
- *The focus on which water bodies:* the experts focus on the Delta Waters, but the decision-makers of the water board and the province of North-Brabant also take into account the water bodies in the polders. A possible cause of this different is the restricted choice of experts and focus during the interviews and problem/cause analyses.
- *The focus on causes or effects of problems:* the user is more interested in the effects (effects) of the system on user-functions. For example, they want to know the extent of algal growth (the effect of eutrophication) and the expert (also) looks to the causes of algal growth: the abundance of nutrients or the long replacement time of water in the water body. The consequence of this different is the parameter choice.
- *The parameter choice:* the users ask for indicators that are directly related to problems or threats for functions, while experts suggested to use parameters that indicates important processes of the system. For example the expert advices the indirect indicators replacement time and oxygen-concentration to determine the ecological state of the system.
- *The extent of integral thinking*: politicians quickly integrate the various problems and interests of different policy areas or user functions that interact with each other (horizontal integration), whereas experts look more isolated to separated problems and interests per system (vertical integration). For example, politicians see shipping as a way to relieve the road, because it is an alternative of road transport (they said during the interviews). The involved expert use the perspective of the shipping company and captains.
- *The use of new scientific insights (paradigm shifts).* Experts use new scientific insights earlier than users do. An example is that decision-makers use flood probability as standard, while the risk approach is more embraced by the experts.

Table 5: An overview of the differences between the users and experts in way of thinking concerning six aspects.

Differences	Politicians/journalist	Experts	Example from sets
Issues taken into account	All (problematic) issues	Significant problems	Users include functions drinking-water and process industry by fresh water availability
Cause or effect	Focus on effects	Causes and effects	Users suggest the presence algal growth experts use abundance of nutrients
Parameter choice	Parameters directly related to problems or functions (demand-driven)	Parameters that indicates important processes of the system (supply-driven)	Experts include replacement time and oxygen-concentration
Integrality	Horizontal integration among policy areas or user functions	Vertical integration among user functions and system processes	Users see transportation by shipping as alternative for road transport
Use new scientific insights	Slow use of new scientific insights	Fast use of new scientific insights	Risk approach (experts) or flood probability (users)

5.3 Final indicator set

The 'final indicator set' is the final product of the case study. Figure 10 shows the final indicator set for determining the state of the South-West Delta. The columns from left to right are the (sub)-urgent societal issues, related user-functions, perception indicators and the operational indicators. The final indicator set is the final set of this research. It is a start for developing of the intended indicators. Further elaboration of the indicators is necessary concerning spatial aggregation, data collection and specification of the operational indicators. An example of the latter is the choice concerning the species as indication for the aquatic biodiversity.

The final indicator set is organised according too the set user-USI's, which consists of 'safety for flood hazards', 'transportation by shipping', 'quality of life' and ''water system quality'. The latter is divided in seven sub-USI's like 'ecological deterioration', 'desiccation' and 'hindrance of inundation'. The other three USI's are not divided. This can cause some visual unbalance among the USI's.

5.3.1 Aggregation methods

The RIDM leaves all aggregation methods open. Choices concerning these methods still have to be made. A choice is the spatial aggregation of the indicator. When maps are used as communication method then one choice concerns the size of the grids, e.g. 500m x 500m, 1000 x 1000m or a dike ring. A second choice concerns the data that is determined for the study area, South-West Delta, e.g. extreme value (minimum or maximum) or average value. An example of a choice is that the dike ring with the largest flooding probability is indicative for the 'safety for flood hazard' in the whole South-West Delta, because a flood hazard is a very abrupt event with large consequences. A good consideration of these choices for every indicator of the final set takes time. This time is not available in this research. Therefore, these choices are passed through to subsequent research.

5.3.2 Data types and sources

The RIDM also leaves the choice for all possibilities concerning data types and sources open. The type of data is a characteristic of the indicator. All indicators of the final set are quantitative with the exception of one indicator. This is the 'score of water system quality' as indication for 'the perception of water'. The indicator only gives an indication of the perception of the water situation, because the relation is as followed. When the score of water system quality increase or decrease, then the perception of water will probably also be more positive or negative respectively.

The sources of data are mostly measurements with the exception of some indicators. The main source of these indicators is model computations or reasoning. These indicators are flood probability, effect of accidents with ships and quality of the water system. The latter is reasoning because it is a qualitative indicator.

State of the South-West Delta

Urgent societal issue (USI)	Sub-USI	User-functions	Indicator layer 1: perception/concept	Indicator layer 2: Operational
Safety for flood hazards		All functions	? Condition of the flood defence structure	? Flooding probability [1/number]
Water system quality	Ecological deterioration	Nature Housing Recreation	? Situation of aquatic biodiversity	? Number of and per species: (shell)fishes & seals [idem]
	Possibilities for MFAC	Marine fisheries and aquaculture	? Suitable conditions for marine fisheries and aquaculture	? Ecotope marine fisheries and aquaculture [ha]
	Fresh water availability	Agriculture Drinking-water Process industry	? Availability of fresh water for functions regard to their use	? Discharge fresh water per and regard to the use of the function per source [m3/s per period]
	Salinization polders	Agriculture	? Suitability to grow crops because of salinization	? Chloride concentration of groundwater [g Cl^-/L]
	Desiccation	Nature Agriculture Drinking-water	? Situation of terrestrial biodiversity because of desiccation	? Groundwater level (linked to plants) [m below surface level]
	Water pollution for recreation	Recreation (swimming)	? Safety swimming water ? Algal growth	? Percentage swimming waters that satisfy EU-standards [%] ? Chlorophyll-a content
	Hindrance of inundation	Housing, industry recreation agriculture	? Extent of hindrance of inundation	? Inundation height [m above surface level] ? Frequency [# (if >#m) per period]
Transportation by shipping		Maritime sector Industry	? Use of shipping ? Shipping accidents risk	? Volume of goods [#ton per year] ? Number of accidents [# per year] ? Effect of accidents [€ and people]
Quality of life		Housing Working Recreation	? Perception of water	? Quality of the water system [increase or decrease]

Figure 10: The final indicator set to determine the South-West Delta. It is a start for developing of the intended indicators. Further elaboration of the indicators is necessary.

5.3.3 Assessment of the final indicator set

Complete

The definition of this quality criterion is that the indicator set has to give an indication of the effects on all relevant urgent societal issues which are affected by the water and soil system. All relevant interests (perspectives) have to be taken into account in the indicator set. Figure 10 also shows the user functions that are connected to the various urgent societal issues. The observation is that nature, agriculture, marine fishery and aquaculture, maritime sector, industry, recreation, housing and drinking water are taken into account in the USI's and the indicator set which is representative for the effect of the physical and socio-economic system on the USI's. This means that the set is complete to determine the state of the South-West Delta.

Limited number of indicators

The restriction of the number of indicators is primarily governed by the criterion of communicability. From that perspective, the total number of indicators concerning the case should be perceptible 'in one view'. This means that the total number should be restricted to about a dozen at the most. If the final indicator set consists of too many indicators depends on its application in a publication. A possibility is to use the whole set every year. Another one is to vary every year with another theme, i.e. urgent societal issue. The final indicator set of figure 10 has fourteen operational indicators, while some indicators still have to be split up in more indicators like 'number of and per species' in further elaboration. The final set exceeds the dozen. This could be difficult from perspective of communication for the first possibility, but this does not matter in the second application because the set is divided in parts per USI. The discussion shows that a 'limited number of indicators' is relative. It depends on the use of the indicator set. A clear picture of the use is necessary to formulate the maximum number of indicators.

6. Evaluation of application RIDM by the case study

The two former chapter discussed the process and results of applying the RIDM during a case study about the South-West Delta. The experiences provides lesson for subsequent indicator development for determining the state of the delta. This chapter gives a reflection on the process and products of the case study by using four process criteria. The paragraphs 6.1 up to 6.4 firstly reflects the practicability of the RIDM separated in 'executability and results' and coherence and then the criteria, satisfaction final product and enthusiasm.

6.1 Process criterion practicability: executable and results RIDM

To what extent is the RIDM executable and does it provide useful intermediate results (USI's, system analysis, potential indicators)?

6.1.1 Scope: objective indicator set and purpose group

The formulation of the objective is to determine the state of the delta from perspective of urgent societal issues which are affected by the water and soil system. Chapter 3 discussed that a clear objective is very important. The above objective seems clear, but the case study showed that it is less clear and too general.

An unclear aspect concerns the choice if the indicator set has to cover the effect on USI's or indicate the important processes of the system or both? This choice remained open during the case study. A quality criterion was finally formulated as representative for the effect on the USI, which means that the indicators have to cover the effect on the user functions. The choice relates to the intended use of the indicator set. When the indicators would have to cover both aspects, then the set would probably have to be expanded.

Another aspect that has a lack of clarity is that the choice concerning spatial aggregation of the indicators was not made clear. Spatial aggregation has a strong relation with the communication methods like maps or only core numbers of the study area. This affects the data collection for the indicator. Communication by core number about an issue for the whole study area needs only some computations, but maps need many data to fill the grids. Spatial aggregation can also affect the choice of indicators when the representativeness of an indicator for the effect on an USI depends on area specific characteristics. An indicator can be representative for particular sub-systems, but it is not representative for other sub-systems. So, different indicators should be desired. This is not a problem for a map, but it is for a core number of the whole area, because then a certain aggregation is necessary with the different indicators.

Choices concerning spatial aggregation also depends on the purpose group. An interested citizen would like to know information of his personal environment represented most specifically in a grid from 500m by 500m, for example. While a national parliamentarian is probably interested in information about the whole area. The purpose group of the RIDM is broad, especially at spatial scale. The group consists of national, provincial and water board decision-makers and interested citizens. Therefore, more focus on a particular group is necessary to make apparent choices about spatial aggregation. An option is to choose for one governance level or citizens as guiding in the purpose group when involvement of the other levels is still desired by Deltares. Another option is a narrow purpose group with one governance level or interested citizens.

6.1.2 Scope: perspective urgent societal issues

The definition of USI's which are relevant in the South-West Delta helped to focus. It framed the number of issues for which indicators have to be looked for. USI's are issues where decision-makers - who have responsibilities in this area – have to deal with in their daily work. Definition of urgent societal issues can therefore be characterised as demand-driven framing.

Three aspects need more attention. The first one is the strong relation between user functions and USI's, but they fit better with the perspective from politicians and interested citizens or policy-makers. When a problem concerning an user function is pointed out, then the function is used to get the problem on the political agenda. An issue often becomes an USI when a number of user functions are affected by the same problem, e.g. bad water quality (Koppejan, 2009). This is especially interesting for policy-making to solve the problem, because then the mechanisms are important, which also affect other user functions. Therefore, a choice is if the main concern of the state of the delta from perspective of user functions or urgent societal issues, which is related to the focus on politicians and interested citizens or policy-makers respectively. Anyway, the relations between an USI and the user-functions have to be communicated very well.

The second aspect of attention is that USI's have to be defined for a specific area, like the South-West Delta. Otherwise, issues that play in other areas could also be taken into account. Examples from the case study are the USI's subsidence and spatial pressure. These issues especially play in the Randstad, but they do not play in the South-West Delta. Something is only an USI when it contains a problem, otherwise it does not get attention from decision-makers and citizens.

The third aspect that needs attention is that definition of USI's means artificial separation of issues and physical processes that are strongly related to each other. A certain arrangement has to be chosen to keep it manageable and clear. One big system diagram is visually useless, because it should consist of too many relations (see paragraph 6.1.8). Making a choice to separate issues is difficult at times. An example is the overlap of water system quality (including ecology) with estuarine conditions for marine aquaculture and fresh water availability. A second example is that the experts and intended users separate the USI water system quality differently. The experts separate water system quality from fresh water availability, while the users see fresh water availability as part of water system quality.

6.1.3 Scope: Minimal time horizon (temporal scaling)

The choice concerning the minimal time horizon was one decade. A longer minimal time horizon would probably imply a drop of some indicators of the final set during the assessment of potential indicators. These indicators depend on a particular paradigm of legal standards, which can change when new scientific insights will be found. Whether or not these potential indicators should be dropped depends on the graduation of the quality criterion, but the indicators have an uncertainty concerning continuity of measuring or computation. At this moment, it is hard to estimate the duration of a concept as flood probability or EU-standards for swimming water quality.

6.1.4 Result process step scope

A number of choices are not explicitly made with the result that the formulation of the objective of the indicator set is less clear. Briefly, a clear objective for the indicator set needs clear choices concerning:

- what do the indicators have to cover: effect on functions, processes of the system or both?
- more focus in the purpose group
- spatial aggregation

The perspective urgent societal issues help to focus on and structure the societal issues that play in the study area. The question is however if user-functions do not fit better to the way of thinking of decision-makers and interested citizens than USI's. Formulation of expert-USI's made it possible to compare these USI's with the user-USI's.

6.1.5 Quality criteria and assessment

Deltares is searching for a way to deal with the indicators to determine the state of the delta. They do not have a clear picture about how to use the indicators. This did not only give indistinctness about the objective of the indicator set, but it also did for the quality criteria. The precise formulation of the quality criteria was point of discussion during the whole process. Their formulation changed diverse times. An additional point was the unclearness of the definition of a quality criterion and the way of measuring the criteria. An apparent picture about these aspects and the use of the indicators is also necessary to formulate the quality criteria sharply.

The overall requirement of the indicators is that they have to be user-friendly, manageable and fit in the system description of the experts. The scientific literature discusses this and it is a requirement of Deltares. The precise formulation of the rough quality criteria from literature is much more difficult. Besides this, the case study shows that the rough quality criteria (the aspects they deal with) are useful to assess the indicators (set). In the case study, the next elaboration of the overall requirement in various quality criteria is used.

One aspect is the representativeness of the measurement for the perceptional and conceptual indicators and the representativeness of the former for the effect on USI's. A second aspect is practicability that concerns *amount of change over time* and *long-term measurable*. The third aspect is user-friendliness. The criteria *interesting for users*, *value-free* and *simple* make this important aspect operational.

The graduation of the quality criteria that is used for the assessment gives a good structure to score the potential indicators. The assessment is mainly qualitative, so that space for interpretation is present. This may make a number of scores subjects of discussion. It is however very questionable if (artificial) quantification will make the assessment more objective.

A quality criterion concerning the cost-effectiveness of data collection is left outside of the consideration of the RIDM, but the financial side of a program is often very important and even decisive. A next research could probably consist of an extra step to make the final set further operational. An aspect of further operationalisation is collection of data, so that the costs have to be taken into consideration.

The quality criteria to assess the final indicator set were useful guiding principles for selection of the final set. Using them as guiding principles helped to select a final indicator set that satisfies these quality criteria, so that the objective of the indicator set could be satisfy (as much as possible).

6.1.6 Participation process: groups and levels

The consequences of the overall practice during the case study

One person did the whole indicator development process of the case study. The author did all interviews and used their output to formulate urgent societal issues and potential indicators. Furthermore, the author did the interviews and mail sessions (problem/cause analyses) with the experts to get input for the system diagrams and descriptions. The input of experts was used to draft the diagrams and descriptions. The most experts also checked these afterwards.

The author processed the input of the involved persons and formulated USI's or indicators based on their input. This practice can give a lot of noise between what an interviewee says and how this is interpreted and used to formulate USI's, indicators and system analysis. Subtle details and nuances that are indicated in an interview are lost. A manner to reduce the noise has been to ask the interviewee's to check the results. The experts and intended users however have not always been critically about the (final) results and how their input is used, so that all noise is not taken away.

A way to prevent the noise described above is to increase the participation level and contribution of the experts and intended users. Consideration of their views with nuances is probably better possible when they are co-producer of the USI's, system analysis and indicators. Therefore, the participation level should be co-production (active involvement) for both groups with workshops to draft USI's, system analysis and indicator sets. The disadvantage is that this takes more effort for both groups, but a high participation level can also incite more motivation, because they have more influence. A second disadvantage is that another kind of noise can be occur during the group process, which is that particular subjects get too much attention.

Participation group experts

The involved experts in the case study are employees of Deltares, who focus on the Delta Waters and large scale problems. They have a professional background in the water and soil system or in policy-support. Experts with a social-cultural background or researchers of other institutes were not involved. Next, the consequences of the choice for this group of experts are discussed.

The case study shows that the selected experts do not cover the knowledge of all USI's which exists according to the intended users. These two USI's - desiccation and hindrance of inundation – are common problems in The Netherlands. A reason for lacking the knowledge can be the focus on the Delta Waters and not on the area behind the dikes (polders). Another reason can be that experts forget these issues during the meetings and mailing. A third option is that they do not know all issues that plays in a specific area. Therefore, the choice of the experts and the practical situation during the participation sessions can also give noise.

Besides this, the involved experts do not have much overlap concerning their expertise. This is the result of the selection process in the case study in order to gather an overall view of the water and soil system within the limited time. The assumption was made that the involved experts - whose expertise is acknowledged by others - are able to give a good overview of the processes in the water and soil system in the study area. When this is not the case, then the credibility of the system analysis is in doubt. A consequence of involving one expert per expertise field is that the system diagrams and descriptions are only verified by one expert and not validated (see paragraph 6.1.8). This leaves the possibility open that divergences of view exist about some relations in the system diagram.

Figure 11: A photo of a workshop with experts for the program STD.

The case study proved that it is difficult to work out the USI quality of life. The Deltares-expert gave a method to determine an expert-judgement of the quality of life in the area that has to be determined by a number of experts during a workshop. Furthermore, she told which things are important. This was however not sufficient to work out indicators which gives an indication of quality of life and can be measured every year. The difficulty is the presence of perception/values in quality of life. It could probably be interesting to involve experts from a research institute with social-cultural expertise, because they might have other knowledge and ways to find useful indicators for quality of life.

Participation group intended users

The group with intended users was broad. It consisted of decision-makers of three governmental levels of diverse provinces and water boards. An additional feature of the group is that it had a broad political spectrum with a socialist, Christian-democrate, liberal, member of a specific provincial party (Partij voor Zeeland) and two independent water board representatives. The group also consisted of one journalist of the Volkskrant. During the case study, it was difficult to interview journalists, because they did not respond to letter or email.

The interesting question is how representative the involved politicians were for the decision-makers in the study area? The optimal situation concerning representativeness is to involve the whole political spectrum per level of government (water board, province or national parliament). This was however not practically feasible within the scope of this research. It turned out during the case study that it was sometimes difficult that only one politician with a particular political background per province is involved. The USI's which the politicians discussed are coloured by their political programs. Therefore, it could be better to involve decision-makers of different sides of the political spectrum per province or national parliament.

During the interviews, it proves that the decision-makers can discuss the urgent societal issue well. It is however much more difficult to mention potential (operational) indicators as indication of the USI's. The politicians cover with their input the effect side of the system diagrams. They are better aware of direct socio-economic indicators for the USI's than technical (operational) indicators. This varies per decision-maker and it is probably caused by their professional background. The assumption concerning the intended users is made that they have a good overview and knowledge of the societal issues related to the water and soil system in their governance area. When this is not the case, then the credibility of the USI's and indicators is doubtable. These can however also be checked with literature.

6.1.7 Participation process: methods

Interviews

Face-to-face interview was a good method to gather input from intended users and experts. The interviews over the telephone were a worse method for asking input about USI's and indicators. These subjects are probably too difficult to communicate them well over the telephone. The amount of useful information from interviews over the telephone is much less than the face-to-face alternative. The advice is to try to do face-to-face interviews only. The problem is however that some persons only want to give an interview over the telephone, because that takes less time.

Problem / cause analysis

The problem/cause analysis was an useful method to execute the system analysis. This method is however not very strictly defined, so its organisation depends on the researcher. The organisation of the method during the case study was an interview, processing of output and comparing with literature, drawing of a system diagram and the expert checked the diagram and give suggestion for improving.

Email

The experience of the case study with email as communication tool is that it gets little response of people from outside Deltares. Only one interviewee replied via email. The other persons have to be ringed, before they give an answer on the question if they want to collaborate with this research. Only two persons responded the feedback mail to the intended users with the result of the interviews: the user-indicator set. Learning from this, an email was sent to two intended users with the question to give feedback on the final indicator set. Thereupon, they are contacted over the telephone to gather their responses some days latter.

6.1.8 System analysis

Causal relation diagram

The tool to visualize and structure the parameters and relations of relevant processes was the Causal Relation Diagram. This tool helped to structure the processes during the system analysis. It forced the author to think about which parameters are relevant and how they affect each other.

Layer model

The Layer model was used as second structuring-method to carry out the system analysis. The Layer model focuses on the spatial-physical planning. However, issues like legislation and perceptions of people do not have a physical character, but they were relevant to take into account in the system diagrams, because they shape the physical environment.

The power of the Layer model was the systematic structure by layers. It starts with the supply of the water-, soil and ecological system in the base layer. Thereafter, the use of the base layer follows by respectively infrastructure and occupation. The method forced the researcher to think about the features of a parameter. The consequence of this method is that a system analysis is supply-driven. The method starts with the question: what can the system offer (De Vries, 2008). Due to this, the indicators of the expert-indicator set are also system-supply-driven within the borders of the urgent societal issues that are firstly defined.

A difficulty is that some issues are not only situated in one layer, but in two or three layers. Safety for flood hazards for example has physical elements in the base layer that determine the flood probability, e.g. dunes and water levels, but the effects are found in the occupation layer, e.g. inundated buildings and evacuation. The situation of dikes and dams is still a point of discussion amongst scientists. Should this infrastructure be situated in the base layer or network layer? It is infrastructure, but flood defence also has an existential character that fits better in the base layer (De Vries, 2008).

The Layer model is only a way to structure the system analysis. The method viewed apart did not affect the content of the system analysis. The author estimates that it does not matter for the content with system-like method is used to structure the analysis. Garcia et al. (2000) also underline this by “it is not critical which framework (structuring method) is adopted as long as it encompasses the scope and purpose (...). In many cases different frameworks will lead to the same or similar sets of indicators”.

Detail level and communication of system diagrams

The urgent societal issues are broad subjects at a high aggregation level. They affect many natural-physical processes which can make the system analysis extensive. The system diagrams and descriptions however have to be manageable and conveniently arranged, too. A consideration had to be made between conveniently arranged and complete during drafting of the system diagrams. In the system diagrams, the researcher tried to account for all entities (processes) and causal relations that are relevant according to the expert, but not more then strictly necessary. In order to draft complete system diagrams it is difficult to be consistent in detail level. This is especially the case by water system quality, which is a very broad and complex system. When all relevant processes of this system are drafted at a consistent detail level then the diagram becomes a muddle.

Another aspect that needs attention is the limited usefulness of the system diagrams for communicating the system to experts in the case study (see in appendix A). Drawing the diagrams helped to structure the processes, but the water and soil system is complex. A complete diagram has many quantities and causal relations. This makes the diagram cluttered.

Verification and validation

One specialistic expert per issue has been involved to draft the system analysis in this research. The experts were asked to check the system diagrams after drafting those based on the experts input and literature. The match between literature and the expert input and checking of the result – the system diagrams – should guarantee a high credibility of the conceptual models. This was sufficient in this research, because the system analysis does not have much influence on the final indicator set (see paragraph 6.2.1).

When the indicators have to indicate important processes of the system, a validation of the system analysis can be desirable. Experts can have personal views and their fads and fancies about causal relations among parameters. They do not give a value-free system description by definition. Therefore, it can be important to validate the system description in future indicator development. Other experts with different views from other scientific schools should check the system diagrams to discover the scientific discussion points and fads and fancies of individual experts.

6.1.9 Indicator formulation: potential indicators

The expert-indicator set indicates the important processes of the water and soil system. The most important quantities - according to the involved experts - of the drawn system diagrams are indicators.

Mentioning of potential indicators was more difficult for intended users (than for experts), so that the user-indicator set is not only based on their own input. The decision-makers were able to mention the issues about which they would like to get information. These issues are perceptional and/or conceptual, but they are often not measurable or computable. Therefore, a first indicator layer was drafted as a brigde between the USI's and the operational indicators. An extra processing step was necessary to make the mentioned issues/indicators operational. A disclaimer is that the main source for the user-indicators is the output of the interviews with seven intended users. When they forgot urgent societal issues or possible indicators, then these were not taken into consideration.

6.1.10 Indicator formulation: selection of the final indicator set

The quality of the evaluation of the potential indicators affected the ease of selecting the final indicator set. The quality increases when the quality criteria cover the requirements well. Furthermore, the output of the assessment is the most useful when the formulation of the quality criteria is sharp and the assessment is consistently done. A pitfall of an assessment is that it can be subjective. The potential indicators can be scored so that the assessment results in the selection of a (the) desired indicator set. A way to prevent this pitfall is to define per criterion the graduation and the guidelines of scoring well. During the case study, the author tried to define the graduations well to prevent subjectivity as much as possible. The bad thing was that the evaluation and selection of indicators is changed some times, because the formulation of the quality criteria changed. This took much time to adapt the evaluation every time and it increased the possibility of errors.

6.1.11 Indicator formulation: reference levels, data and aggregation methods

The reference levels fits with the current state that is characterised for the program STD. These could affect the indicators when data availability is important. The availability of data was however not taken into consideration in the RIDM. All possibilities concerning data were left open. This was the same for aggregation methods. Paragraph 6.1.5 already discusses data availability.

Various aggregation methods were used in the case study. When a sharper picture exists about the objective of the indicator set, then a choice concerning aggregation methods was probably also necessary. Some methods can maybe fit better with the objective than others.

Assessment process criterion practicability: executability and results RIDM

The RIDM is executable, but the method has disadvantages, so that a number of changes can improve the RIDM. These changes concern a clearer picture of the intended use of the indicators, so that the formulation of the objective and quality criteria can be sharper. Only one course can be necessary in which intended users identify the USI's, experts analyse the system, and both groups formulate potential indicators and select the indicator set. Another improvement is a better representativeness of and a bigger role for the participation groups. The experts and intended user should become co-producers of the various (intermediate) products instead of co-thinkers. This can probably reduce the noise of processing of the input from the participation process during the case study

6.2 Process criterion practicability: coherence RIDM

How big is the coherence among the process steps of the RIDM?

6.2.1 Process steps and courses

The scope and the quality criteria formed the basis of the RIDM. The other process steps – system analysis and indicator formulation (and communication and/or implementation) - build further on this basis. The unclear formulation of the objective and quality criteria is already discussed above. This worked through the whole indicator development process. The final consequence can be that the indicator set satisfies the formulated objective, but that it does not satisfy the expectations. Deltares does however not have apparent expectations (see paragraph 6.1.1).

The sequence of formulating the scope, defining quality criteria and designing the participation process, followed by system analysis and formulating the indicators turned out to be useful. The scope and the quality criteria formed the basis for designing the participation process. This determined how and with who the process steps system analysis and indicator formulation is applied.

A comment concerning the system analysis is its use. For defining the quality criteria and selecting the final indicator set, the view of the intended users was guiding in this research. They are interested for indicators which are representative for the effect on the USI's. This was also possible without system analysis with a marginal role for experts to make the perception indicators operational. A system analysis is only useful when the indicators have to give an indication of the important processes of the system, because the system analysis forms the argumentation for the indicators. Realising this, the circle is round again to the scope and quality criteria. Does the indicator set have to cover the effect on USI's or indicate the important processes or both? The choice determines which groups, composition of the groups and the participation levels. 'Indication of important processes' asks a valid system analysis. 'Representative for the effect on USI's' needs a representative group of intended users.

A point of concern is that the same person processed the input of experts and intended users. Although, the course with the experts is done firstly, followed by the intended users' course, the strictly distinction between their input lacked. The process with the expert has probably already shaped the view and knowledge of the author when he started with the process with the users. It is questionable if the results (USI's and potential indicator sets) would be the same when two different persons did a course with everyone a participation group.

Another aspect concerning the coherence of RIDM is that the definition of expert-USI's seems unnecessary besides the user-USI's in subsequent indicator development, when the user view is chosen to be guiding for the final indicator set yet. The user-USI's division was therefore used to structure the final set in this research. The expert-USI's were defined in the RIDM to research the differences in way of thinking between experts and users. A result of the case study is showing that such differences exist, so that it is advisable to involve both in future indicator development. Identification of USI's (or urgent issues of user-functions) by only users takes less effort and the structure of the system analysis can fit better with the user-USI's (or user-functions).

6.2.2 Role pragmatic factors and considerations

The RIDM formed the framework of the indicator development process of the case study. The progress and filling in of the development process did however not depend on the RIDM only. An important case choice was the participation methods which determine the process for an important part. Paragraph 6.1.6 already discussed that using interviews as participation method and the output to formulate USI's or indicators did give noise. The experiences, expertise, analysis and communication talents of the researcher and the attitude and empathy of the involved persons were determinants for success of the RIDM. Another factor is the specific execution of the participation methods. It concerns the questions that were asked during the interviews and the way of interviewing: face-to-face or over the telephone.

These examples show that the theoretical choices that are identified from literature determine the usefulness of the RIDM for a part. The other part concerns pragmatic factors and considerations like the given examples. An explanation of this is that scientific literature only describes indicator development processes at main lines. Anyway, the author did not discover extensive reports about all ins and outs.

Assessment process criterion practicability: coherence RIDM

The coherence of the RIDM is good concerning the sequence of process steps. Important is a clear and sharp definition of the scope and quality criteria. The system analysis played a marginal role in the development op the final indicator set, because the potential indicators only have to cover the effect on the USI. The sequence of the two courses with experts and users done by the same person could have influenced the final indicator set. Theoretical choices limited affect the development process and pragmatic factors and considerations do also play a role.

6.3 Process criterion satisfaction final product

To what extent is the desired final product achieved?

Three member of the core team of the program Staat en Toekomst van de Delta are asked to give their opinion about the final indicator set. Their reactions are listed below.

- J.K. van Deen said that he is pleased. The final indicator set is not an immense long list with indicators. It is a nice set at the aggregation level of societal issues that he expected.
- H. Wolters said that he likes that the view and demand of the intended users is mapped. He thinks that the operationalisation of the indicator layer perception/concept is too narrow. Wolters mentioned some indicators that he misses like the period of inundation (USI hindrance of inundation). He sees a challenge to converge the abundance of information from current monitoring to useful for decision-makers. The monitoring is done for policy programs like Water Framework Directive, Natura2000 and GGOR. He also misses the own input of experts concerning how important processes of the (physical) system work, e.g. processes of water quality.

- S. Karstens like the indicator set. She notes that the subdivision of USI's seems unbalance considering the visual aspect. Water system quality is divided in seven sub-USI's, while the other USI's are not divided. She is also curious if the indicators to determine the state of the delta gets enthusiasm from outside Deltares and what its added value can be.

Two intended users are also asked to give their opinion about the final set.

- C.H.M. van der Burgt (province) is especially pleased with the subdivision of the USI's and the USI water system quality in sub-USI's. It makes clear which societal issues play in the South-West Delta. He said that he misses the energy supply from wind and waterpower as USI. Van der Burgt is less apparent about his opinion about the perception and operational indicators. He only said that he thinks that the indicator set consists of the important aspects of the USI's.
- G. Boot (water board) said that he could agree with the indicator set. He discussed that he likes that the set consists of measurable indicators, but he misses the link with project proposals and legislation. Boot also thinks that more obliged indicators can be used concerning the WFD. Furthermore, he misses the costs(-effectiveness) as indicator for the effectiveness of interventions for realising a particular (legal) state.

Assessment process criterion satisfaction final product

The overall reaction is that the final product is a good step in the right direction. The above persons suggest various improvements. The first improvement concerns the operationalisation of the perception indicators which is to narrow according to Wolters. Another one is that the set USI's is not complete, e.g. energy is missed. The third improvement is more visual balance in the USI's. The fourth one is that the indicator should also consist of expert input to indicate the important system processes. The last two improvements are the link with project proposals and legislation (targets) and the addition of cost-effectiveness according too Boot.

6.4 Process criterion enthusiasm

To what extent does the indicator development process generate enthusiasm by involved persons from outside Deltares?

Enthusiasm of intended users can be measured from the willingness to collaborate and their attitude and things they say during the interviews. The willingness to collaborate is high of most approached persons want to collaborate by giving an interview (over the telephone) or they refer the researcher to colleague with more expertise concerning the water and soil issues.

One provincial and one water board decision-maker explicitly said that they have doubts about the added value of an extra program that gives information about the state of water-related issues. The reason is that there already exist reports of planning offices and of provincial and water board governments. Van de Hoef (2009) and Bruil (2009) think that these reportages give sufficient information for the work as decision-maker.

Other interviewee's think along with the researcher, but their attitude can be featured as 'we have to wait and see'. They are not directly negative, but they are not very enthusiast, too. They mention two aspects concerning indicators that are important for them.

1. Indicators have to show future perspective for user functions (Koppejan, 2009).
2. Indicators are especially interesting when they show the progress of projects or results of interventions, like improvement of the ecological quality (Boot, 2009; Van der Burgt, 2009).

Assessment process criterion enthusiasm

The observation is that the involved people from outside Deltares are not very enthusiast about indicators that measure the state of the delta. A critical question is: does Deltares not artificially create urgency that does not exist? What is the surplus of determining the state of the delta regard to several existent reportages?

7. Conclusions and recommendations

7.1 Conclusions

Indicator development processes in scientific literature have five common processing steps. Besides those steps, literature leaves many degrees of freedom to design an indicator development method that exactly fits the case and the objective of the indicator set. The first common step is 'formulating the scope' with various options concerning purpose of the indicator set, purpose group, perspective and scaling. The second step is 'defining quality criteria'. The third step is 'analysing the system' with various options concerning structuring methods. The next common step is 'formulating indicators' and the final step is 'communication and/or implementation'. A complementary relevant dimension is the participation process that determines who are involved in the application of the five processing steps. The design of this process involves important choices about the participation groups, levels and methods.

In this research, a 'Research Indicator Development Method' (RIDM) is composed to develop an indicator set that determines the state of the delta and to check the hypothesis. Requirements of the STD-program define important choices concerning scope and participation process. These choices are: the purpose of the indicator set (determining the state of the system), purpose group (decision-makers of different governmental levels and interested citizens), perspective (urgent societal issues) and participation groups (experts and intended users).

The RIDM was tested in a case study about the South-West Delta in the Netherlands, which gives two main results. The first one is acceptance of the hypothesis that the way of thinking, interests and view of reality differ between experts and intended users. The case study shows the need of considering the involvement of both users and experts in developing the required indicators of interest to users. They have a different way of thinking and their own roles and expertises. The involved users show more interest in the effects of the water and ground system on the user functions and integrate horizontally among policy areas and user functions. They are also slower in using new scientific insights than experts. In contrast to the users, the involved experts focus more on causal relations to explain effects in the system.

The second result of the case study is the final product of applying the RIDM to the South-West Delta: an indicator set to determine the state of the South-West Delta. It concerns the urgent societal issues 'safety for flood hazard', 'transportation by shipping' and 'quality of life' and 'water system quality'. The latter one is divided in seven sub-USI's like 'ecological deterioration' and 'fresh water availability'.

The indicator set consists of two layers with respectively perceptional and operational indicators. The first indicator layer fits the perception of intended users and the second layer is the (scientific) operationalisation.

An ex-post evaluation reflects on the practical experiences with the RIDM during the case study. The process of the RIDM scores 'moderate' on the two process criteria concerning practicability. A number of changes can improve the development process (see below). The final indicator set is a good step in the right direction according to some Deltares employees and intended users (criterion satisfaction final product). They suggest various improvements concerning the set, like more visual balance between the USI's and the indicator set should also indicate the processes. The fourth process criterion 'enthusiasm' scores also moderate, because the involved users are not convinced of the value-added of indicator set on water and soil management issues.

The most important conclusions with regard to the RIDM are listed below:

- The formulation of the objective of the indicator set and the quality criteria has not been clear enough. In that, Deltares does not have a clear picture of how and for what purpose they would like to use the indicators exactly. The purpose group that includes national, provincial and water board decision-makers and interested citizens is too broad. The spatial and process scales differ too much for indicators that are developed for specific use in specific situations.
- Participation levels and methods are not satisfactory. The participation process of the RIDM can generate much noise, because the researcher processes the input of the intended users and experts. More involvement (co-production) of intended users and experts can probably reduce this noise, so that the final indicator fits the interests of users and the system of the expert better. This means other participation methods like workshops.
- More representative participation groups probably increase the support for the indicator set. This means for the intended users more representativeness of the political spectrum per government institute. When an indication of the processes of the system is considered, involvement of a wider range of experts of different scientific schools is desired to validate the system analysis.
- The case study shows that the theoretical choices from literature – the RIDM - determine the design and execution of the indicator development process only partly. Pragmatic factors and considerations also determine a big part of the execution of the process and via this way the final product.

7.2 Recommendations

I. Deltares has to reflect better what it explicitly wants with indicators to determine the state of the delta. What is the additional value of determining the state of the delta in relation to several existing reports like 'Water in Beeld'?

- A suggestion is to show future perspective for user functions by combining the indicator set with future scenarios.

Related questions that need a clear choice are:

1. On which purpose group does Deltares want to focus especially?
2. Which perspective would Deltares like to use? Urgent societal issues (policy development?) or user functions (put on the political agenda?)? Which one does meet the purpose group better?
3. What do the indicators have to cover? The effect of the system on user functions or the important processes of the system or both?
4. Which spatial aggregation is desired? This choice is strongly related to the way of communicating the indicators (by maps, core numbers of the area, diagrams, etc.?). For example, maps needs more data – thus higher costs - than some aggregated core numbers.

Making clear choices concerning these issues will help to formulate a clearer objective for the indicator set. Further, it will help to formulate sharper quality criteria than during the case study of this research.

II. The RIDM is adapted, based on the lessons of its application during the case study. The recommended method for subsequent indicator development for determining the state of the delta is the 'State of the Delta Indicator Development Method'. This method is worked out in the form of guidelines in appendix D of this report.

III. A larger scale research about the politicians' way of perception and thinking is interesting, because experts of Deltares have little feeling with and knowledge about this. Two questions are important to answer. Firstly, which information is really interesting for the decision-makers? Secondly, how should this information be communicated to fit their way of perception and thinking better? This research probably surpasses the scientific discipline borders of Deltares (water and soil system). An example of this is that the success of the user function agriculture does not only depend on the availability of fresh water. Agricultural and socio-economic aspects also affect its success. A component could be an analysis of programs of political parties as an inventory of the (aspects of) user functions that are important to the various parties.

IV. More research is necessary to work out indicators for quality of life. It is advisable to involve social-cultural or spatial planning expertise in the research. This issue has a large interface with the water and soil system, but it also consists of social-cultural elements like perception and appreciation.

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A. Appendix A – Processed input of experts

This appendix consists of the system analysis and the formulation of expert-USI and expert-indicator set. It starts with the formulation of expert-USI's in paragraph A.1. The paragraphs A.2 until A.6 discuss the context per expert-USI, analyse its system and formulate expert-indicators.

The content of this appendix is finally expert input that is added by USI's of intended users. This can make that the arrangement of information seems sometimes illogically. The author did not have the time to re-arrange this appendix. Therefore, the purpose of this appendix is to formulate and discuss the expert-USI's and the expert-indicators. Furthermore, the appendix consists of all processes that are relevant in relation with the expert-USI's and -indicators and user-USI's and –indicators. It is important to keep in mind that the artificially separation of the system diagrams and descriptions - because of practical reason – are parts of one system in reality. The large arrows in the diagrams also show relations among the four diagrams. The last note is that the extra processes discussed by the intended users can be recognised by the indentations in the system descriptions. Table A1 shows the involved experts, their function, expertise, and the main subject of their input.

Table A1: An overview of the involved experts

Expert	Function/expertise	Main subjects
Willem Bruggeman	Strategic advisor, strategic studies	Urgent societal issues
Harriëtte Holzhauer	Morphological ecologist	Urgent societal issues
Bert van Eck	Senior advisor, strategic studies, citizen of Zeeland	Urgent societal issues
Ies de Vries	Senior advisor, citizen of Zeeland	Urgent societal issues, fresh water availability, water system quality
Herman Wilmer	Advisor, former employee of Directorate Persons and Goods Transport	Processes in (water)transportation sector
Judith ter Maat	Researcher/advisor water safety	Safety for flood hazards
Theo Prins	Senior advisor, water quality	Water system quality
Maaike Bos	Senior advisor spatial quality	Quality of life
Roelof Stuurman & Perry de Louw	Advisors groundwater	Groundwater situation and processes

A.1 Formulation of expert-USI's

The research objective sounds "[…] to develop an indicator set from the perspective of urgent societal issues affected by the water and soil system". This means that the indicator set has to focus on the urgent societal issues (USI) in the South-West Delta, i.e. the function of the USI's is framing. Regional and national policy and vision documents are sources that can be useful to denote the urgency of the issues. A hypothesis of urgent societal issues is therefore defined that is based on policy and vision documents. To check the policy hypothesis USI's, four experts are interviewed who have a broad insight in the South-West Delta. The output resulted in the definition of five urgent societal issues.

A.1.1 Policy hypothesis of urgent societal issues

The vision and policy documents are Delta in Zicht (2003b) Zanting and Van Essen (2006) and the National Water Plan (2009). Five USI's are selected that form the policy hypothesis. These are mentioned below including a citation from one of the document to demonstrate its urgency.

- *Safety for flood hazards*: "Veiligheid is een absolute randvoorwaarde voor alles wat de Deltaprovincies willen met de Delta" (Zanting and Van Essen, 2006).
- *Transporation by shipping*: "De Deltahavens [...] Een uitstekende toegankelijkheid en goede verbinding onderling en met het achterland zijn de belangrijkste voorwaarden voor blijvende kracht" (Zanting and Van Essen, 2006).
- *Water system quality*: "Door het wegvallen van de getijdendynamiek en zoet-zout overgangen zijn de waterkwaliteit en de natuurwaarden van veel waterbekkens steeds verder achteruit gegaan" (Directoraat-Generaal Water, 2008).
- *Fresh water supply*: "Het zal steeds moeilijker worden om gebieden in Zuidwest Nederland van voldoende water te voorzien" (Zanting and Van Essen, 2006).
- *Quality of life*: "Samen met het herstel van de ecologische waarden zal dit de ruimtelijke kwaliteit van het Deltagebied versterken. De kwaliteitsslag is nodig wil het Deltagebied zijn functie als voortuin van de omringende Eurometropool behouden" (Provincie Zeeland, 2003b).

Discussion of choice expert-USI's

Table 1 shows an overview of the urgent societal issues and matching user functions in the South-West Delta that are mentioned by the four experts. Chapter 3 discusses the strong relations between user functions and urgent societal issues. The user functions are therefore also given in the table. The third column 'times' shows how many times an USI is discussed by the four experts.

The times an urgent societal issue is mentioned indicates for consensus amongst the experts. They commonly see safety for flood hazards and water system quality as an USI, but subsidence and demography are both mentioned once only

Land subsidence occurs in such extent that relative land subsidence regard to the North sea occurs because of reclaiming polders. Further, the USI is from national perspective (Bruggeman, 2008). Soil modelling shows that land subsidence is not a big problem in the South-West Delta, but it is especially a problem in the 'Randstad' and the Northern provinces (Deltares, 2008a).

Table A2: An overview of urgent societal issues and matching user functions in the South-West Delta that are mentioned by experts.

Urgent societal issue	User functions	Times	Corresponding hypothesis USI
Safety for flood hazards	All	4	Safety for flood hazards
Transportation by shipping	Industry / harbour / navigation	2	Transportation by shipping
Water system quality	Recreation/housing/nature/agriculture	4	Water system quality
Estuarine dynamics	Marine fisheries and aquaculture	3	-
Fresh water supply	Agriculture	4	Fresh water supply
Quality of life/attractiveness	Housing/working/recreation	3	Quality of life
Subsidence	All	1	-
Demography	All	1	-

One expert emphasized that demography is an important issue, because ageing the population leads to a shortage of labour force and vitality reduction of the area. Demography however is not an issue that is affected by the water and soil system. It is therefore not chosen as an USI.

The experts confirm the policy hypothesis during the interviews. They also mentioned an additional issue: the relevance of estuarine dynamics as essential condition for marine fisheries and aquaculture. Estuarine dynamics and water system quality have many overlaps in the physical system. To prevent that things are discussed two times, these two USI's are combined in one USI called water system quality.

A.1.2 Definition of expert-USI's

This paragraph discusses the urgent societal issues in the South-West Delta according to the involved experts. Interesting is the question why are these USI relevant in the delta? The ecological, economical and social aspects of every USI are discussed to structure the answer on this question. The list of expert-USI's consists of:

- safety for flood hazards;
- fresh water supply;
- Water system quality;
- transportation by shipping; and
- quality of life.

Safety for flood hazards as an existential requirement

Limitation of the number of victims, societal, material, ecological and indirect economic damage is an existential requirement for sustainable living in the South-West Delta. It consists of the coastal safety and the safety of upstream cities, like Rotterdam, Antwerp and the so-called Drecht-cities (Zanting and Van Essen, 2006; Deltacommissie, 2008). Water safety affects the functioning of the social, economical and ecological systems in the area.

Fresh water availability for agriculture

The biggest part of the agricultural sector cultivates fresh-water crops. Farmers need sufficient fresh water at the right place at the right time. The economic relevance of agriculture in the area is very low, about 4% contribution to the Gross Domestic Product including fishery and forestry in 2006 (CBS, 2008), but it is an icon of the South-West Delta and the societal support in this area for maintaining and further developing the fresh water dependent agricultural sector is big (De Vries, 2008).

Water system quality for marine fisheries and aquaculture, nature, agriculture, recreation and housing

Characteristic for the delta (of origin) is the presence of estuarine dynamics consisting of river discharge, tidal movement, fresh-salt gradients and morphodynamics (erosion, sediment accretion). A robust water system in the delta shows mixing of nutrients, substantial water motion, a high self-cleaning capacity. This creates the condition for healthy ecosystem (De Vries, 2008; Holzhauer, 2008).

The estuarine conditions are essential for i.e. mussel and cockle culture, marine aquaculture and salty agriculture (WUR, 2009). Healthy ecosystems are essential for a high biodiversity and good water quality is very important for recreation and housing (Bruggeman, 2008; Provincie Zeeland, 2003b)

The robustness and healthiness of delta's water systems especially concerns the ecological aspects, like shown above. It also has economic and social aspects. The marine fisheries and aquaculture are icons of the province Zeeland (Zanting and Van Essen, 2006), and the agenda for a delta program sees future opportunities. The economic contribution of it is low (CBS, 2008). Another newer icon of the delta is water recreation that is of more economic relevance (Holzhauer, 2008).

Transportation by shipping for shipping, harbours and industry

Water routes in the South-West Delta are important for sea shipping and inland shipping. The sea shipping route to the port of Antwerp is the Western Scheldt. This water route is also important for seaports Sloe-area and Terneuzen and the connection with the port of Gent via the 'Kanaal van Gent naar Terneuzen'. The port of Rotterdam is situated at the North side of the South-West Delta. Rotterdam and Antwerp are the two biggest port of Europe. The area also consists of the Scheldt-Rhine-connection from Antwerp to Rotterdam, which is the second inland shipping route in transported goods of the Netherlands after the Rijn-Waal route (CBS, 2008). Accessibility of the harbours does not only affect the shipping-sector, but it affects also the harbour-sector and the industry-sector, which are also dependent from good accessibility (De Vries, 2008; Zanting and Van Essen, 2006). The economic interests of shipping are more international than regional (Van Eck, 2008; Holzhauer, 2008). These sectors contribute up to 40-50% to the regional economy (CBS, 2008)

Contribution to quality of life for housing, working and recreating

Quality of life of an area concerns the attractiveness of that area to live, work and recreate there. It is related to liveability and spatial variation in the area (Bruggeman, 2008; Bosch Slabber, 2008). It determines the imago of an area. The South-West Delta presents itself as the front garden of the Euro-metropolis for which a high quality of live is essential (Provincie Zeeland, 2003b). It is therefore interesting to assess the quality of life of the area.

Quality of live is a broad term. It can consist of the complete physical-spatial layout of an area (H2ruimte et al, 2008). The framing of this research is "[...] urgent societal issues affected by the water and soil system". In this research is therefore looked to the contribution of the water and soil system to increase the quality of live.

A.2 Safety for flood hazards and hindrance of inundation

A.2.1 Context

Safety for flood hazards is a broad term. It can be divided in the coastal safety and river safety for flood hazards. Safety for flood hazards consists of a flood probability and the effects caused by a flood. Dikes, dunes and dams determine the flood probability. The population size and economical value behind the flood defence structures determines the effects. The risk approach as measure for safety is increasingly accepted in policy and decision-making (Provincie Zeeland, 2003b; RWS Waterdienst, 2008; Deltacommissie, 2008). The next system analysis discusses the parameters and processes that play an important role concerning the concept flood risk.

Besides this, the hindrance of inundation is also an USI according to the intended users. A number of relevant quantities that are added to the system description and diagram. The system description starts with the role of the South-West Delta to increase the safety for flood hazards of upstream cities and it follows with the safety for flood hazards inside the area.

A.2.2 System analysis

Safety for flood hazards in the South-West Delta concerns the safety of the region and the (future) safety of upstream cities like Dordrecht and Antwerp. High river discharges can threaten the cities Rotterdam, Dordrecht and Antwerp. River water should be discharged faster to the North Sea to decrease the threat of dike collapsing. This is impossible when high river discharges occur in combination with storms at North Sea. During these events, the flood probability depends on the capacity of retention areas. The fresh river water should therefore be retained in the Delta waters like Kramer-Volkerak, Eastern Scheldt and Grevelingen to reduce the flood probability (Deltacommissie, 2008). An important condition for this retention is that the dikes are high and strong enough to prevent flooding of nearby polders.

In the case that the Eastern Scheldt and the Grevelingen are used for fresh water retention, the fresh water can decay the salt or stagnant brackish water ecology in the salty water basins, because the ecology is not resistant to fresh water. Many scientists and policy-makers see as a solution the restoration of estuarine dynamics in all Delta waters (De Vries, 2008; Holzhauer, 2008; Zanting and Van Essen, 2006). Estuarine dynamics include gradients from salt to fresh water. Then organisms and vegetation adjust to both salt and fresh water conditions. This makes an aquatic ecosystem more resilient. When fresh water retention is necessary the ecosystem has already get used to fresh water and it can better survive large amount of extra fresh water (Holzhauer, 2008; Provincie Zeeland, 2003b).

The second safety for flood hazards issue concerns the safety in the South-West Delta itself. The flooding probability in the South-West Delta depends on the probability of respectively overflowing and collapsing of dikes, dunes and dams (including storm surge barriers). In future, the flooding probability will increase because climate change will probably increase the size of storms (RWS/RIKZ, 2006). Larger storms cause high water levels. The result can be collapsing of the dikes, dunes and dams by various fail mechanism, like piping and damage to revetment. This also depends on the soil characteristics and construction of the dike or dune (Ministerie van Verkeer en Waterstaat, 2005).

A flood can cause a lot of damage and deadly victims. The effect of a flood can be divided in four groups: ecological damage, economic damage, deadly victims and afflicted people. The discussion of the damage starts in the base layer.

The ecological damage is a result of strict separation of salt water from land and fresh water basins. A flood from the North Sea can ravage and saline the terrestrial ecology and the fresh aquatic ecology. The consequence is at least a partly destruction of ecosystem that needs years to restore from the salt-water bath (Holzhauer, 2008).

The economic damage concerns both direct and indirect economic damage. Direct damage is the material damage that is the result of inundation of an area. Indirect economic damage is damage by lack of production or immobility, because the factory, offices or roads are inundated. Suppliers cannot supply because of the customers' production stopped (Ter Maat, 2008b).

The third effect is the threat of deadly victims who drown because of inundation and strong flows. Good evacuation possibilities like refuges, good evacuation plans and evacuation routes with sufficient capacity can decrease the number of people that is threatened during a flood and reduce the number of deadly flood victims (Ingenieur, 2008).

The final effect like the third effect refers to immaterial damage. It concerns people that are afflicted by the flood or experience inconvenience, because they have damaged houses, lost family or friends, damaged factory or office, cannot go to school during a certain period, etcetera. Generally, substantial more people are afflicted by a flood than the actual number of deadly victims. The size of the afflicted population depends on the extent of the flooded area and the population density in that area. The number of afflicted people is an indication of the societal disruption after a flood (Ter Maat, 2008b).

The magnitude of the effects depends on spatial planning of the area (Ministerie van Verkeer en Waterstaat, 2005). For example, a house on a five-meter-high terp is not vulnerable for a flood of three meter high. An important factor, that determines whether people decide to build on a terp or not, is the flood risk perception. People often think that they are safe for hundred percent and the idea that it is impossible to supply safety for hundred percent is not broadly supported (Provincie Zeeland, 2003b). Floods in the past and the occurrence of floods outside the area feed the perception that flood risk exists. A lack of floods decreases this perception (Hoekstra, 2007).

Hindrance of inundation has two causes, which are limited overflowing of a dike or a dam or heavy rainfall. Inundation occurs when the volume of rainfall exceeds the infiltration capacity of soil in rural area or the urban drainage capacity (Deltares, 2008a; N+H+S Landschapsarchitecten et al, 2009). Furthermore, inundation can also occur when the water flows over the dike, but the dike do not collapse. Inundation can cause material damage. The amount of material damage depends on the height of inundation (N+H+S Landschapsarchitecten et al, 2009). Hindrance of inundation has the feature that it does not cause deadly victims and very high material damage, because the inundation height is limited (order of decimetres instead of meters). The extent of hindrance also depends on the frequency of inundation (N+H+S Landschapsarchitecten et al, 2009). For example, free times per year inundation of 0,5 meter give more material damage per year than once per year.

A.2.3 Expert-indicators

The flood probability for the four groups of flood effects is the same, because it is the same dike collapse. The effects however apparently differ from each other. This turns out in the different units: economic damage [€], ecological damage [presence of species], victims [number of dead] and afflicted people [size afflicted population].

Dutch policy-makers recognise the economic damage, victims and afflicted people separately (Ter Maat, 2008a). The project Veiligheid Nederland in Kaart also uses these effects (Floris, 2005; Ter Maat, 2008a). A fourth effect could be ecological damage of fresh aquatic and terrestrial ecosystems that is caused by inundation of salt seawater. It is however difficult to make this effect operational in measurable information (Ter Maat, 2008b).

Using the flood risk concept, the four types of effects and flood probability are chosen as indicators for safety for flood hazards. The first one is the number of victims as indication of the safety of people's life. The second one is the size of the afflicted population as indication of the societal disruption after a flood. Thirdly the economic effect is an indication for the safety of physical infrastructure and buildings and the long-term economic consequences after a flood. Finally, ecological damage as indication of the safety of fresh aquatic and terrestrial ecosystems for salt water inundation.

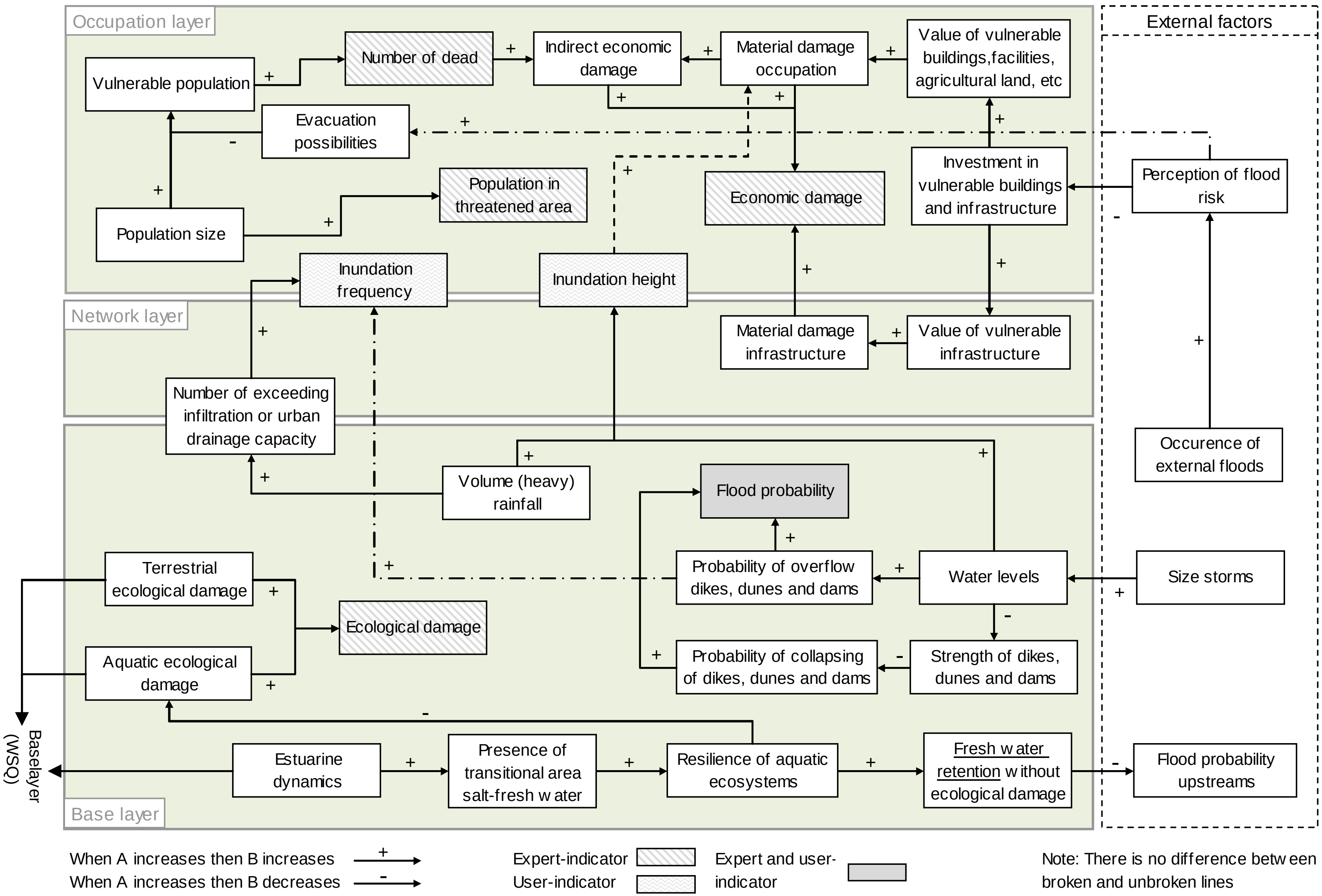
Box A1	Indicators safety for flood hazards
√	Flood probability [1/year]
√	Victims [number of dead]
√	Afflicted population [size afflicted population]
√	Economic effect [€]
√	Ecological effect [?]

A.2.4 Discussion

The five indicators of safety for flood hazards represent with each other the whole system of safety for flood hazards. It consists of the physical-spatial, economic, ecological, hydraulic, social, human and psychological aspects. The risk concept fits with the last scientific insights. There is also an increasing policy and political acceptation of flood probability as new standard for safety for flood hazards.

Definition of legal flood probability standard is possible. Determination of the real flood probability of flood defence structures is much more difficult. There is a lack of knowledge of the strength of dikes and dunes, because it is hard to look into the dike. This gives a lot of uncertainty about the real flood probability. The program ´Veiligheid Nederland in Kaart´ tries to get more knowledge about the strength of dikes to reduce the uncertainty. In addition, it also takes the effects of a flood hazard into account (Ministerie van Verkeer en Waterstaat, 2005).

1A **Safety for flood hazards and hindrance of inundation**



A.3 Fresh water availability for agriculture

A.3.1 Context

The Volkerak-Zoommeer has been a fresh water source for the agriculture for decennia. To tackle the eutrophication problem in this water basin, limited estuarine dynamics consisting of salt water will be restored (Zanting and Van Essen, 2006). Alternatives have to be found for this vanishing fresh water source. This is especially necessary for the areas Sint Philipsland, Tholen, the Hals van Zuid-Beveland and the borders of West-Brabant. The expectation is also that the fresh water need of the agriculture will increase because of developments of European agriculture policy. This aims for a shift to more capital- and labour-intensive crops, which need more fresh water (Provincie Zeeland, 2003b). On the other hand, the Deltaraad will stimulate the development of aquaculture and salty agriculture, which will reduce the need of fresh water (Zanting and Van Essen, 2006).

Desiccation that is introduced as sub-USI by the intended users is also added to this expert-USI. This is because it has relations with the quantities that also affect fresh water availability.

A.3.2 System analysis

The base layer in the South-West Delta provides fresh water by three different sources, which are precipitation, fresh groundwater and surface water. The first source is the precipitation water that can be caught without much effort. The available volume of water on agricultural plots depends on the volume of precipitation per season, water retention capacity of the soil and evaporation that reduces the available volume, especially during summer (Stuurman and De Louw, 2008).

In the South-West Delta, the availability of fresh groundwater is relatively low, but it varies per location. The availability is particular low in the situation on the islands surrounded by salt water. There only thin rainwater aquifers exist above the brackish or salt water. For example, in Noord-Brabant deep fresh groundwater aquifers occur and the fresh water slowly flows in direction of the delta waters (Stuurman and De Louw, 2008). Figure A1 shows a drawing of various groundwater situations in the South West Delta. From left to right is from North Sea to Noord-Brabant. In addition, the chemical quality of groundwater determines the suitability of the fresh groundwater (PLANBUREAU VOOR DE LEEFOMGEVING, 2008).

Fresh surface water is the third source. The available volume depends on the interaction with salt seawater. When the seawater penetrates upstream then the amount of fresh water with a chloride concentration below 150 mg/l (maximum for many crops) is reduced (Stuurman and De Louw, 2008). Besides the salt content other factors determines the suitability of the surface water. A low water quality, caused by for example algal growth, can result in stopping the use of fresh water for irrigation (De Vries, 2008). Evaporation during the summer reduces the amount of fresh surface water. This is especially an issue when the river discharge is very low (Provincie Zeeland, 2003b).

External fresh water sources can be added to the three fresh water sources when they are not sufficient. Those sources can be the Biesbosch or upstream collection points in the Meuse or Merwede (Van der Berg et al, 2004).

Sufficient fresh water is necessary at the right time at the right place. The fresh water is therefore retained and transported - via watercourses and pipes - from the collection points to the agricultural plots and to the storage basin of the greenhouses eventually. In dry years, the need for fresh water from surface, soil or external sources increases, because less precipitation water is available. This results in more pumping of groundwater from aquifers depending on the availability of the volume of suitable fresh groundwater (Stuurman and De Louw, 2008). Legislation protects the physical system. It can restrict the groundwater use in the area to prevent salt intrusion or desiccation.

Desiccation is especially a problem in Noord-Brabant, where pumping of fresh groundwater cause lowering of the groundwater level (Van der Burgt, 2009). A lower groundwater level means that the roots of particular vegetation cannot reach the groundwater (Van Beusekom et al, 1990). This is especially the case in dry periods when subsurface water is already used. The consequence is that particular vegetation is not able to survive in these areas, so that the vegetation evanesces which results in less terrestrial biodiversity Van Beusekom et al, 1990).

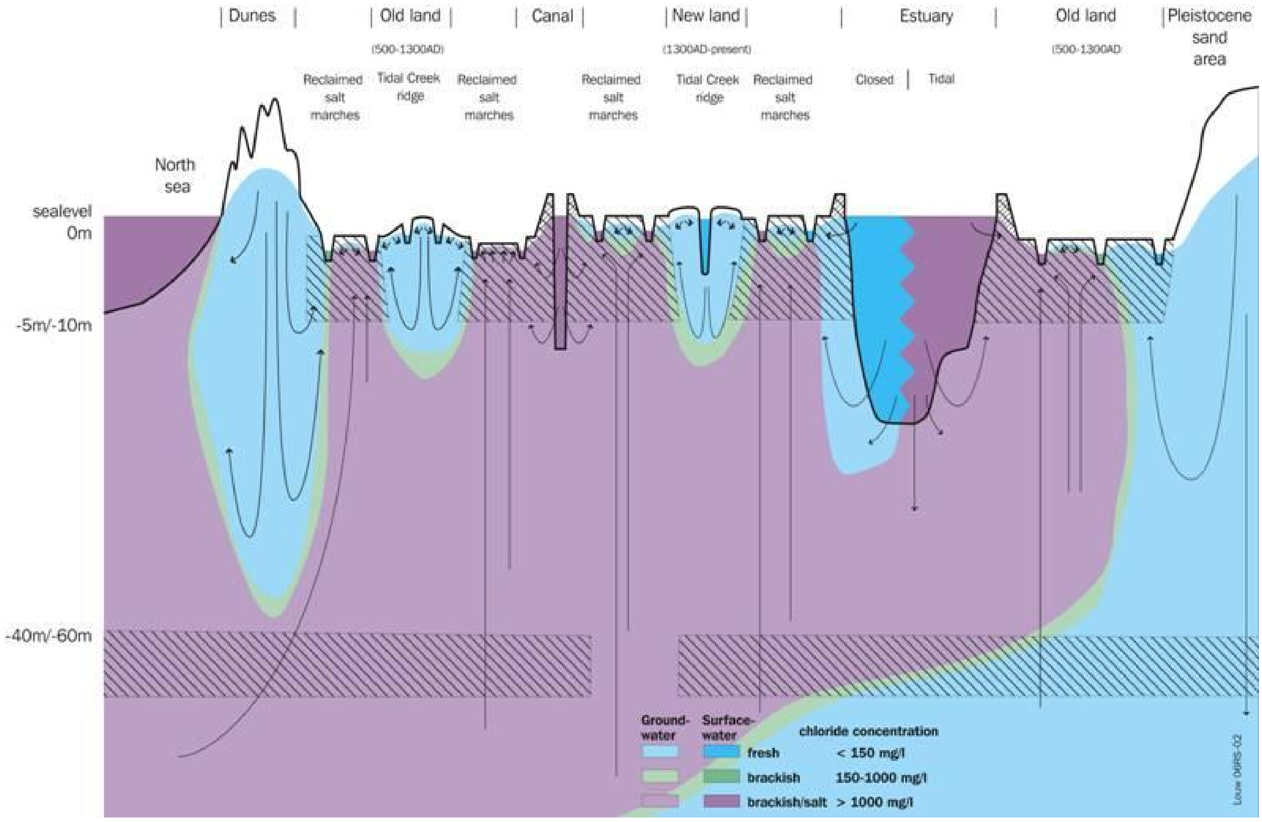


Figure A1: Groundwater aquifers in South-West Delta in various situation (blue = fresh, green = brackish and purple = salt). Source: Perry de Louw, Deltares.

The users of fresh water supply are the floriculture, intensive agriculture, large-scale horticulture and fruitculture (De Vries, 2008; Provincie Zeeland, 2004). The Greenhouse farming in the region does not use soil or surface water in the South-West Delta, because of the low salt resistance of the crops, like tomatoes and paprika. The traditional agriculture is rain-fed and this sector does almost not use other water sources, too (De Vries, 2008; Van der Maas, 2008). Besides the agricultural use, the process industry and drinking water companies also use fresh surface or groundwater (Robesin, 2009).

The question of this urgent societal issue is: do the farmers have sufficient water for irrigation of their crops? The magnitude of the fresh water supply problem depends on the difference between the total volume of fresh water that is available in the area for agriculture, process industry and drinking water and the use of freshwater from these sectors (Van Eck, 2008; De Vries, 2008). The use depends on the need until the maximum volume of water is used. When that border is reached, then the farmers cannot increase their production or they have to change their crop plan. The need for fresh water and an adaptation strategy depend on the economic demand and price for particular crops. It also depends on the possibilities of the alternative of fresh water agriculture, the salty agriculture (Zanting and Van Essen, 2006; De Vries, 2008).

A.3.3 Expert-indicator and discussion

The availability regard to the use of fresh water of sufficient quality is an indicator for the USI fresh water availability. This availability fluctuates with the river discharge and precipitation during a year. The availability will generally be the highest in winter, while the need of fresh water is the highest during summer (De Vries, 2008). It is also not possible to use more fresh water then there is available. Long term, the farmer should change his crop plan to adapt to the available volume of fresh water. Figure 3 shows an example of availability and use curves of fresh water. It illustrates that the use of fresh water has to adapt to the available discharge of fresh water during the summer month when the availability is the lowest.

This indicator covers a large part of the fresh water availability system. It deals with changes in availability by introduction of e.g. retention basins or decrease of river discharge during summer. It also takes into account changes in use by e.g. increase of salty agriculture that gives a decrease of fresh water use or the increase of fresh water use (Zanting and Van Essen, 2006; De Vries, 2008).

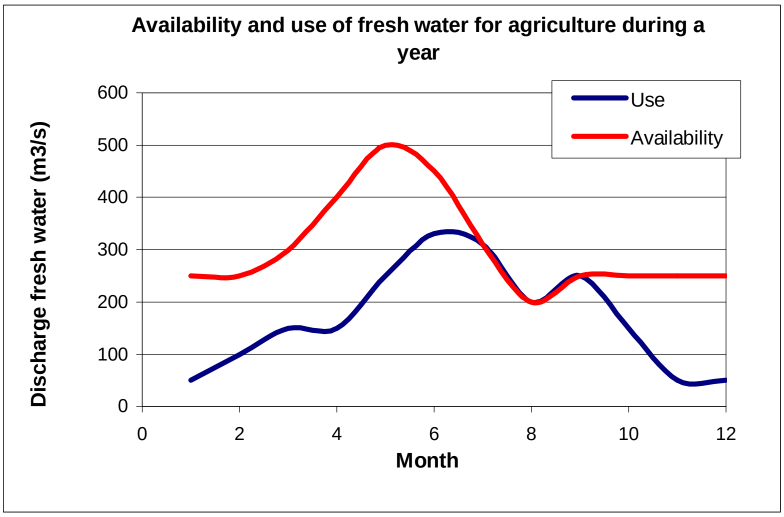
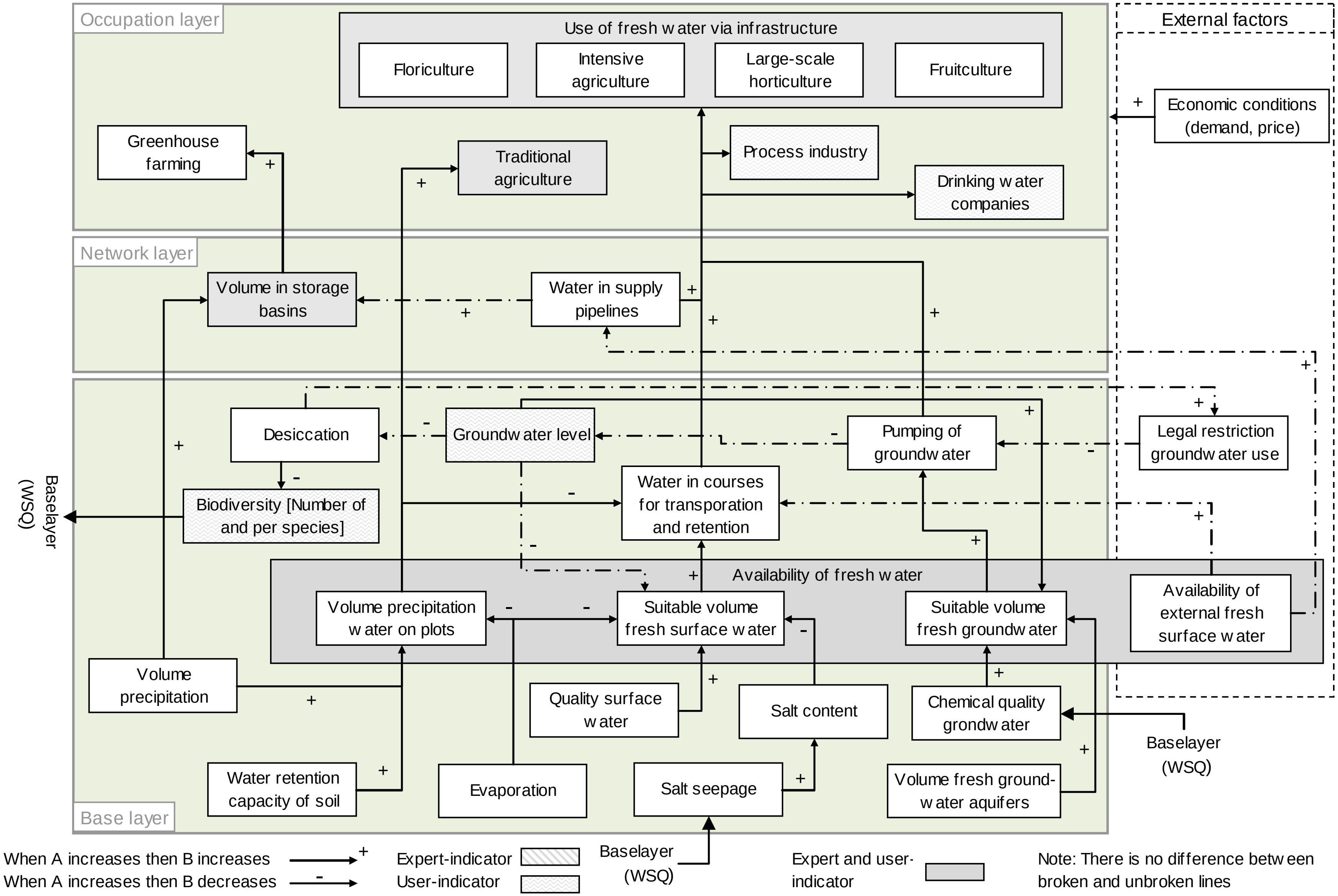


Figure A2: An example of an availability and use of fresh water for agriculture during a year.

Box A2	Indicators fresh water supply
√	Discharge of fresh water (m^3/s) regard to water use (m^3/s) of good quality per function and per source

2A

Fresh water availability and desiccation



A.4 Water system quality for housing, recreation, nature and marine fisheries and aquaculture

A.4.1 Context

The past decennia, dams are built in the South-West Delta to increase the safety for flood hazards. These dams also separate the Delta waters from each other. The Hollandsch Diep, Haringvliet and Volkerak-Zoommeer are fresh water basin without tide, the Grevelingen a salt-water basin without tide and the Eastern Scheldt is a salt-water basin with limited tide. The large interventions in the Delta waters have caused problems, e.g. erosion of tidal flats in the Eastern Scheldt, algae in the Volkerrak-Zoommeer and lack of oxygen in the Grevelingen. A solution for these problems is (partly) restoration of the original natural processes of the delta: de estuarine dynamics by reduction of the fixed borders (dams), i.e. Adaptation of the dams by construction of larger drain structures in the dams (Provincie Zeeland, 2003b). A water system in the delta is robust when it has sufficient self-cleaning capacity, frequently water replacement, mixing of nutrients through the delta and salinization of the Delta Waters (De Vries, 2008).

Another solution strategy to increase the water quality in a water basin is reduction of the contaminated substances like nutrients and heavy metals. This means decrease of the polluted human use of the natural system as deposal depot (Provincie Zeeland, 2003b).

Salinization of the Delta Waters can also influence the salinity of the groundwater in the polders (Stuurman en De Louw, 2009). This affects the suitability of land to cultivate crops with a lower salt resistency.

A.4.2 System analysis

Estuarine dynamics are for the South-West Delta the original natural processes. They are an important factor that influences the water quality (De Vries, 2008). Nowadays, the Western Scheldt and Eastern Scheldt have (limited) estuarine dynamics. The most important processes and aspects that are specific for estuarine dynamics are the presence of salt water and its mixing with fresh river water, tidal movements and building up of estuarine morphology (De Vries, 2008; Open University, 1999). Generally, high oxygen concentrations caused by replacement of water and mixing and dilution of nutrients the water basins are essential for good water and ecological quality conditions. The next parts discuss these processes.

The delta is the transition area between rivers and the sea. The drivers of estuarine dynamics are tide from the sea and fresh water discharge from rivers (Open University, 1999). The tide causes a to-and-fro discharge of salt water into the delta resulting in a variable water level every 12.5 hour. The to-and-fro discharge of salt water and the river discharge together, cause salt, fresh and mixed flows in the delta. This results in a moving fresh-salt gradient at the border of the tidal and river influence (Holzhauer, 2008; Open University, 1999).

The frequent water flows through the (dams in the) delta also take care for the replacement of the water, which has positive influences on the oxygen concentration in the water. Oxygen in the water makes living in the whole water column possible. Water organisms die when the oxygen concentration in the water is (very) low. This is often caused by algal growth or suspended sediment that blocks the sunlight in the water, an essential condition for photosynthesis by water bottom plants and phytoplankton (Augustijn, 2007)

The sufficient strong water flows through the Delta dams should take care for the mixing of nutrients through the whole delta. This result in dilution of the nutrients in Delta waters with a high nutrient inflow.

Low mixing of nutrients through the delta results in accumulation of nutrients in the water and in the bed of a water body (De Vries, 2008; Prins, 2008). For example, this occurs in the Delta water Volkerak-Zoommeer. The agricultural sector in West-Brabant and Belgium has caused a high inflow of nutrient-rich water from the catchments into the Volkerak-Zoommeer for many years (De Vries, 2008; Provincie Zeeland, 2003b).

The tidal waves carry nutrient-rich water from the Voordelta in the North Sea into the (partly) open Delta waters. The tidal flow causes a mixing of this nutrient-rich water with the nutrient-poorer water, so that there is enough food for organisms that use the nutrients to grow in these Delta Waters.

The South-West Delta has from the past salt-brackish water conditions with matching ecology. The effect of the current artificial boundaries between salt and fresh water is that the brackish ecology died and fresh water ecology established. The fresh water in combination with the high nutrient inflow has caused blue algal growth in the Volkerak-Zoommeer. Decaying of algae during the summer results in a dirty smell that reduces the housing and recreation pleasure (Holzhauer, 2008). Nowadays, plans exist to restore a limited estuarine dynamics in the Volkerak-Zoommeer, because salt water should prevent the blue algae to emerge and create again the saline conditions for marine ecology (Zanting and Van Essen, 2006; De Vries, 2008).

The high velocities and flows caused by the tide affect the morphology in an estuary. Deposition and erosion of sediment causes intertidal flats, sandbanks, salt marches and deep and shallow channels. Naturally, there is a balance between deposited area (sandbanks) and eroded areas (channels) (The Open University, 1999). A limitation of tide can disrupt this balance and makes sandbanks move into the deep channels resulting in shallower channels, like the current development in the Eastern Scheldt (Provincie Zeeland, 2003b; De Vries, 2008).

The inflow of wastewater from inside the South-West Delta and inflow from contamination from outside the delta reduce the water system quality a lot. The contamination consists of heavy metals, nutrients, PAC's and organic and toxic substances (Water in Beeld, 2008; Bruggeman, 2008). An additional source of contamination is ships, which loose PACs and metals (Projectgroep IKS, 2004). The presence of all those substances in the water or in the water bottom reduces the chemical water quality (Planbureau voor de Leefomgeving, 2008). Particular metals or other substances (endocrine disrupting compounds) can influences organisms. For example, tributyltin influences snails (dogwhelk and commeon whelk) which transform their gender after contact with the substance. This gender transformation is called imposex (Prins, 2008). Water pollution can also threaten the health of human beings when they swim in the water. Several (in)organic substances like E-Cole, certain heavy metals and blue algae are harmful (EU, 2006; RIVM, 2009).

A healthy ecosystem consists of all the organisms of a food chain. Phytoplankton forms the lowest level and (particular) fishes, birds and seals are the upper level (Prins, 2008; natuurinformatie.nl, 2008). When contaminated substances, the lack of oxygen or high nutrient concentration are present, then some populations will die, because they are not resistant against these threats. This will affect the whole food chain by reducing a food chain level and that mostly results in dying of high food chain organisms like fishes (PBL, 2008a).

Estuarine dynamics gives the essential conditions for marine fisheries and aquaculture (De Vries, 2008). Variable salt and fresh water, water motion, availability of nutrients, tidal range and the presence of estuarine morphology forms the ecotopes that are suitable for marine aquaculture, like mussel and cockle culture, sea crops grow, fishery and salty agriculture (WUR, 2009; Prins, 2008). Salty agriculture is also possible at the inner dike land when this is salt because of salt seepage from an adjacent salt-water body with a higher water level than the polder (De Vries, 2008; Stuurman and De Louw, 2008).

The salinization of groundwater in polders can be a change for salt agriculture, but many farmers see this as a threat for the farm. The salinization of the polders is an increasing autonomous process (Directoraat-Generaal Water, 2008). In the South-West Delta, farmers cultivate crops with a low salt resistance. When the salinization goes deeper into the polder, then less and less agricultural land is suitable to cultivate these crops. The farmers have to change to crops with a higher salt resistance, but which yield less money.

Healthy ecosystems and good water quality have positive effects on housing, recreation and nature. Healthy ecosystems are a prerequisite for biodiversity. Species can better survive or return in the area, because their living conditions are present (Planbureau voor de leefomgeving, 2008). Good water quality means no dirty smell, no green algae areas in the water. This makes it more pleasant to live and recreate in the delta (De Vries, 2008).

A.4.3 Expert-indicators and discussion

This issue is broad and complex to analyse. Another aspect is to deal with the complexity of this broad issue for the purpose group. There are already publications like Water in Beeld and WFD-publications, which discuss the water quality situation in The Netherlands by using technical indicators (Water in Beeld, 2008; PBL, 2008). An ordinary citizen is interested in how boatable, drinkable, swimmable and fishable the water is (Prins, 2008). Some additional demands are houseable, high biodiversity and suitable for marine aquaculture (Bruggeman, 2008; Holzhauer, 2008). To add something to the existing scientific-technical indicators and to focus on the purpose group, indicators are chosen which indicate something about the above-mentioned demands of citizens (and fishery).

The parameters tidal range and Chloride content (salt content) are two important features of a water body in the South-West Delta (De Vries, 2008; Holzhauer, 2008). Extra quality indicators for healthy ecosystems are the replacement time, nutrients concentration through the delta and the oxygen concentration, because the state of these conditions strongly affects the ecology (De Vries, 2008).

(Shell)fishes and seals are chosen to measure the result of healthy ecosystems and good water quality (Planbureau voor de Leefomgeving, 2008; Peeters et al, 2007). Seals and some fishes are at the highest level of the food chain and other species are interesting for the fishability of the water. Fishes are also direct affected by the substances in the water. Seals are also interesting from communication perspective, because the seals are an icon of the South-West Delta.

The above-discussed indicators are parameters at the same level. Another type of indicator is a gathering of parameters, i.e. this is an indicator at a high aggregation level. The indicator is specific for a particular functions and it consists of many criteria or conditions.

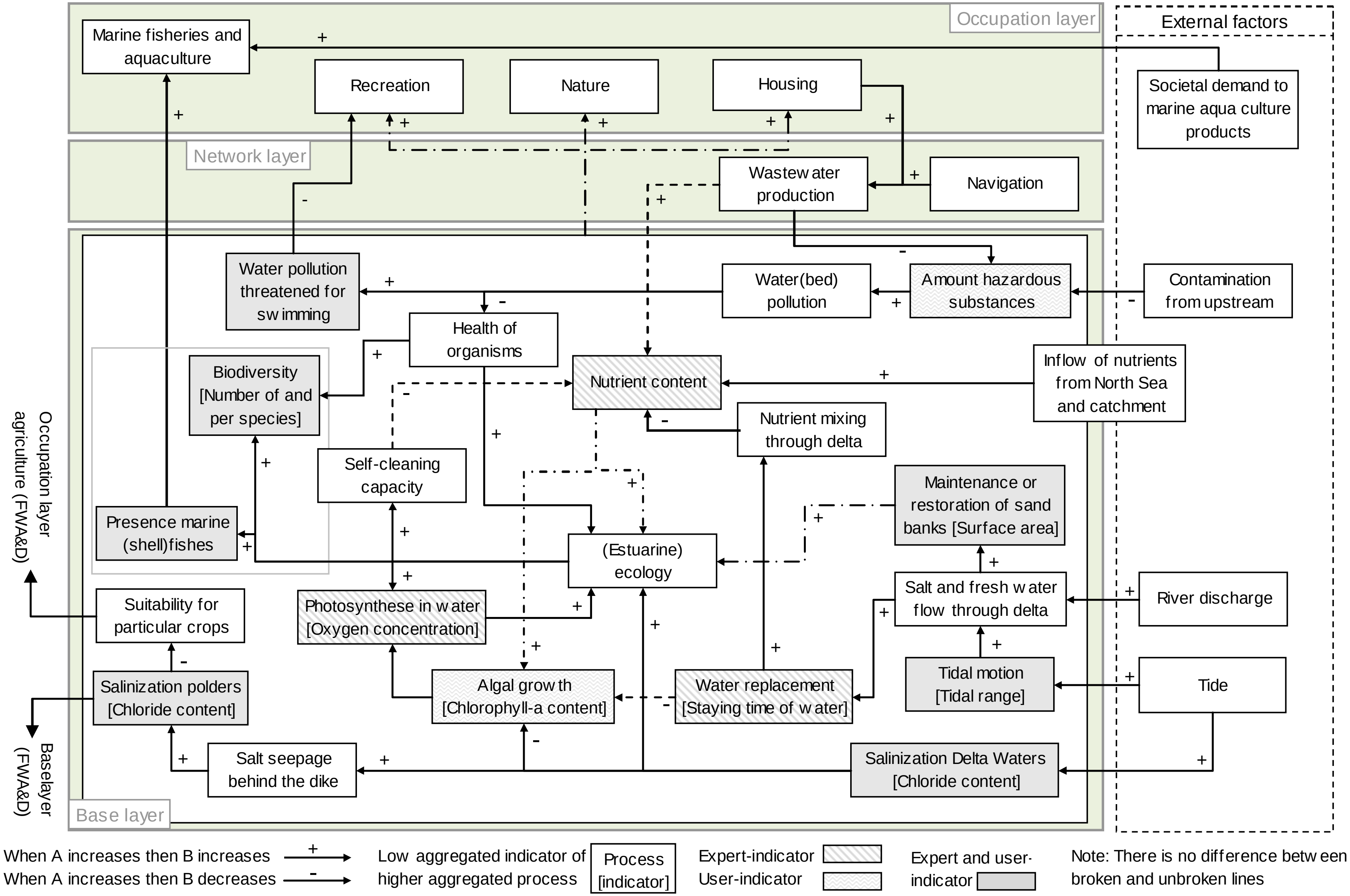
In order to indicate the areas that are suitable for marine aquaculture, the indicator estuarine ecotopes is chosen. The advantage is that ecotopes are specific and they include the morphological aspect. Alterra composed, in cooperation with some other parties, a list of ecotopes based on a number of criteria like salt content and vegetation. An ecotope is a spatial unit that is homogeneous within certain borders considering vegetation structure and its living conditions (Alterra, 2009). The different productions of sea crops, fish and shellfish in the marine fisheries and aquaculture need other conditions, i.e. other ecotopes. The presence of these ecotopes gives an indication of the suitability for particular marine fishery or aquaculture (Van Eck, 2008; Prins, 2008).

Another indicator that is mentioned by the experts is directly related to the function swimability of the water in the delta (Prins, 2008). This indicator is specific for the function swimming (water recreation). The formulation of the indicator is the percentage of the swimming water locations that satisfy EU swimming water standards.

Box A3	Indicators robust and healthy water systems in the delta
√	Tidal range (m)
√	Chloride content of Delta Waters (g Cl^-/l)
√	Chloride content of groundwater
√	water residence time (days)
√	Nutrient concentration (mg N/l and mg P/l)
√	Oxygen concentration (mg O_2/l)
√	Number of and per species: (shell)fishes and seals
√	Presence of estuarine ecotopes for marine fisheries and aquaculture [ha ecotope]
√	Percentage of swimming water locations that satisfy EU swimming water standards [%]

3A

Water system quality



A.5 Transportation by shipping for shipping, harbours and industry

A.5.1 Context

The context of this urgent societal issue is the worldwide transportation sector. The ports of Antwerp en Rotterdam and the smaller ports between them are transfer ports of goods from sea ships for an area consisting of The Netherlands and Belgium, Germany, Switzerland, Austria, Hungary, North Italy and North-East France (Wilmer, 2008). The major transport routes in the South-West Delta are the Western Scheldt route from the North Sea to Antwerp, the Scheldt-Rhine route from Antwerp to Rotterdam and from Vlissingen, Terneuzen and Gent to Rotterdam (Western route). The major transfer locations (excluding Rotterdam and Antwerp) are the ports of Terneuzen and Vlissingen (Zeeland Seaports), Gent, Dordrecht and Moerdijk (Wilmer, 2008; Louisse Consulting, 2005).

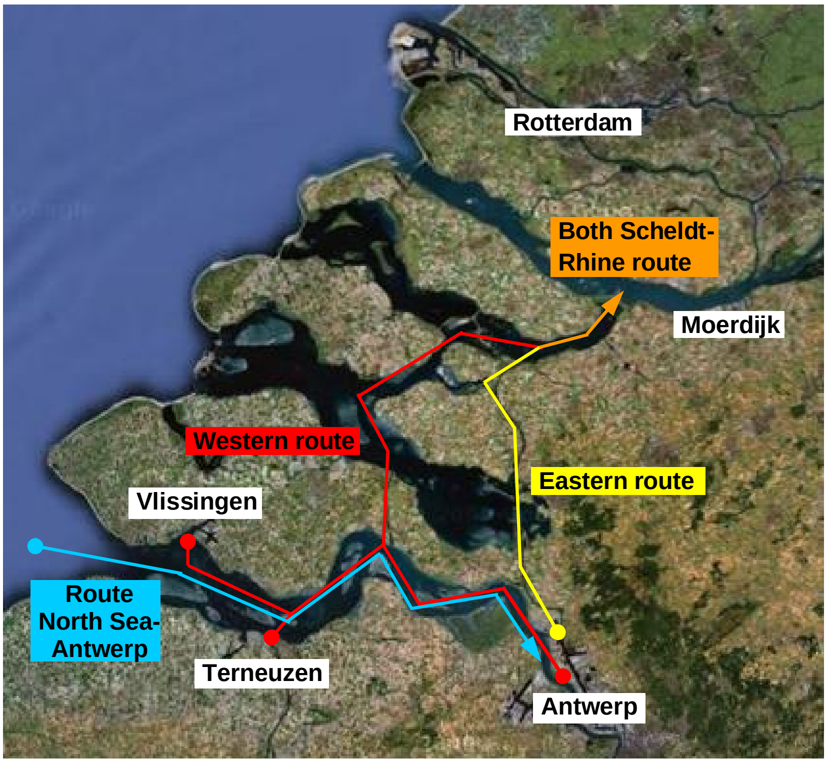


Figure A3: A map of South-West Delta with the most important shipping routes and ports. The points mean origin and destination ports.

The navigation function in the South-West Delta consists of transfer and inland shipping of goods from sea ships to the harbours of Rotterdam, Antwerp or to upstream harbours like Duisburg in Germany and Liege in Belgium. The main requirement for shipping companies is as soon as possible (Wilmer, 2008; Louisse Consulting, 2005). The intended users add an extra aspect of inland shipping and sea shipping through the Western Scheldt: the shipping calamity risk at and around the water routes.

A.5.2 System analysis

The dams in the South-West Delta separate salt or brackish and fresh water basin from each other. To prevent salt intrusion near the locks in fresh water, the Krammer-locks consist of a separation system that prevents mixing. This system however takes more lockage time than ‘normal’ locks. A possible restoration of the estuarine dynamics in the delta makes the fresh-salt separation system unnecessary and results in shorter ship lock passing time. Another possibility is no lockage time at all in the case the lock will be removed completely (Provincie Zeeland, 2003b; De Vries, 2008; Louisse Consulting, 2005).

The passing time of locks depends on the lock operation time, which is affected by the difference in water level, lock operation method and fresh-salt division, and the waiting time before sailing into the navigation lock. The lock capacity determines the latter. The bigger the navigation locks, the more ships can be locked through the same time (Roelse, 2004; Louisse Consulting, 2005).

Another factor that causes delay is the transfer time in the ports. The transfer capacity of the ports strongly affects transfer time (Wilmer, 2008). In this research, the transfer time and the passing time of locks together form the delay time that has to be added to the inland shipping time. The latter depends on the length of the shipping route and the navigation velocity per shipping class (Roelse, 2004; Louisse Consulting, 2005). The navigation velocity depends on the weather conditions. When fog or storms occur the ships have to navigate very slow (Wilmer, 2008). The shipping time and the delay time forms together the total transportation time. When the latter increases, then the transportation cost also increases (Wilmer, 2008; Louisse Consulting, 2005).

The dimensions of the navigation infrastructure (including navigation channels, canals, height of bridges, etcetera) also affect the transportation by shipping. They determine the maximal size of the ships that can navigate through the waterways (Provincie Zeeland, 2003b; Louisse Consulting, 2005). The economic rule is that the bigger the ship, the larger the volume goods, the lower is the marginal transportation cost (Wilmer, 2008). Besides the increase of bulk goods, the amount of container transport in the South-West Delta will increase the next year. 4-layer container ships will often take the Western route in future, because this route does not have limited headroom, like the Scheldt-Rhine route (Louisse Consulting, 2005).

The accessibility and capacity of the navigation infrastructure (including locks) for various ship sizes define the transportation capacity of both Scheldt-Rhine routes in the area. The availability of sufficient capacity of the water infrastructure also influences the behaviour of choice of international shipping companies. The use of the ports of Antwerp, Rotterdam and the smaller ports depend on the water transportation costs, economic situation and the cost of alternative transport modalities like coasters, train and trucks (Wilmer, 2008; Louisse Consulting, 2005).

When the demand for transportation by ships increases and the transportation capacity is sufficient, then the volume of good transported by ships will increase. The number of shipping movements will probably increase, too (Louisse Consulting, 2005). More shipping movements mean that the water routes become busier, which will result in more shipping accidents (Wilmer, 2008). The effect of accidents can be material damage by the involved ships or larger effects when tankers leak oil or gas into the water, or when they burst into flames. The latter case can give ecological damage or cause trouble for people living in the neighbourhood of the water route. The effect of accidents and the number of shipping movements determine the shipping calamity risk.

A.5.3 Expert-indicator

The transportation time is the most important indicator for determining the state of transportation by shipping in the delta according too Wilmer (2008) and Louisse Consulting (2005). Transportation time is indicative for the transportation costs forming the guiding aspect in the transportation sector (Wilmer, 2008).

Transportation time includes shipping time and delay time caused by passing locks and transfer. The shortest transportation time consists of the shortest possible route length, highest navigation velocity, shortest transfer time and shortest passing time of locks, i.e. the lowest transportation cost nowadays. The actual transportation time is the real time that it takes to get goods from:

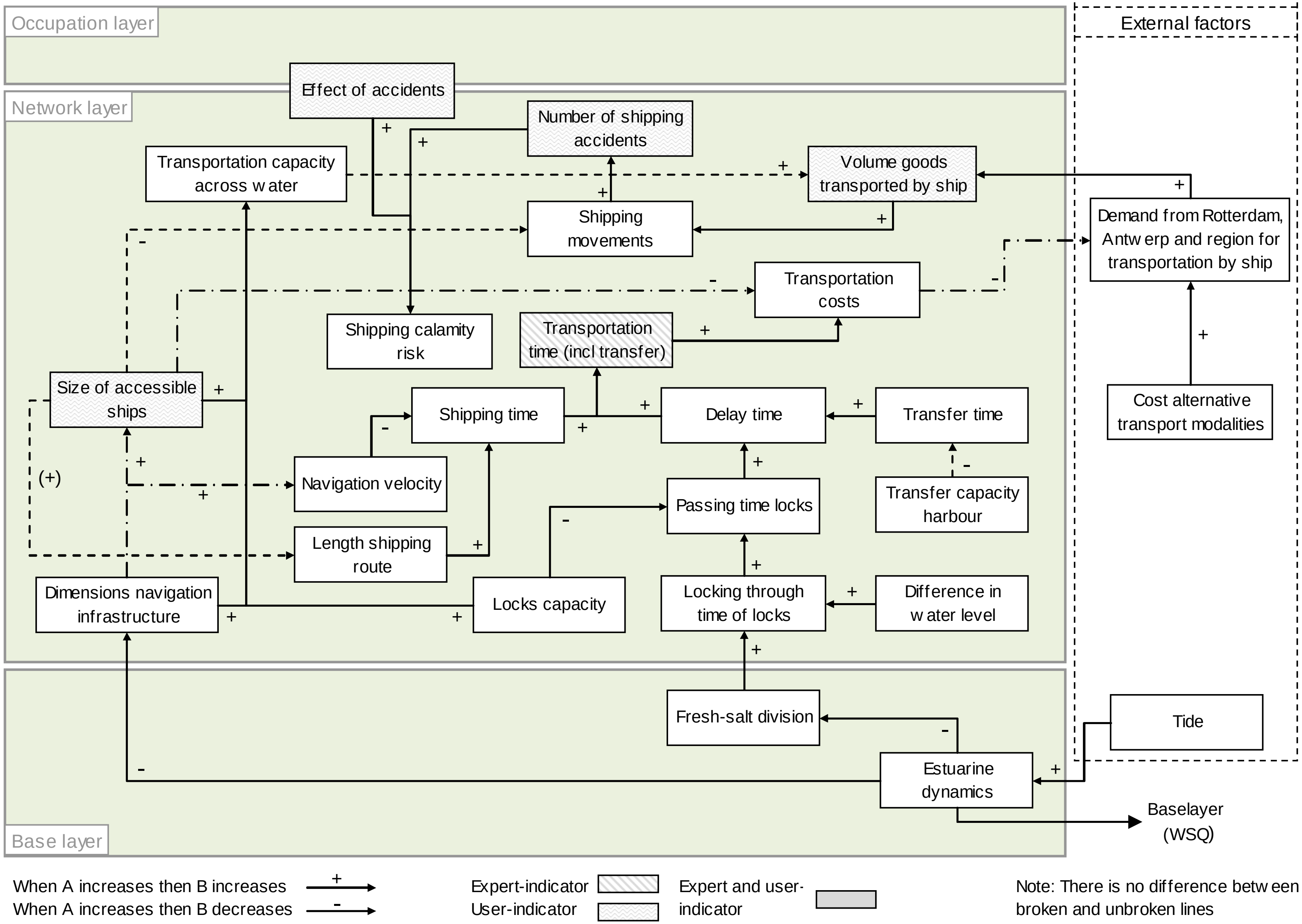
- The North Sea to Antwerp and visa versa via the Western Scheldt
- Antwerp to Rotterdam and visa versa (using the Scheldt-Rhine route for bulk good ships and Western route by 4-layer container ships);
- Terneuzen/Gent and Sloe-area to Rotterdam or Antwerp (using Western route or Western Scheldt) (Louisse Consulting, 2005).

Box A4	Indicators transportation by shipping
√	Travelling time loss (=Actual transportation time [minutes] regarding to shortest transportation time [minutes])

A.5.4 Discussion

This indicator has an economical point of view, due to the economical way of thinking in the transportation sector. The principle target of shipping companies is profit, which requires cost reduction as much as possible. The indicator does not take into account the ship size that has access to the navigation infrastructure. This is less interesting for the shipping companies then the travel time according to Wilmer. Another noticeable aspect is the shipping companies form the perspective of this indicator. Other persons also have interests concerning shipping. For example, residents of the neighbourhood of a water route have more interest in safety. In that case, the shipping calamity risk is important.

4A Transportation by shipping



A.6 Contribution to quality of life for living, working and recreating

A.6.1 Context

Quality of life is a combination of observation and appreciation concerning respectively features and qualities (Bos, 2008; Provincie Zeeland, 2003). The physical-spatial manifestation of an environment or object determines the observation. The subject, personality and senses affect appreciation (Provincie Zeeland, 2003). Figure 5 shows the elements that determine the appreciation of an object or environment.

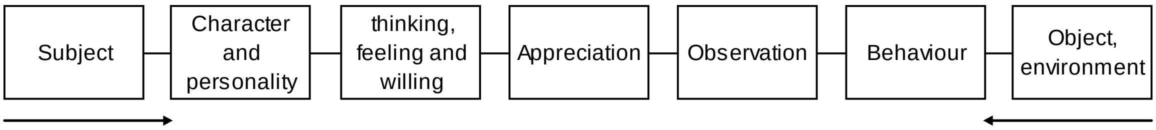


Figure A4: The relation between the subjective and objective world (source: Provincie Zeeland, 2003a)

Because there are different appreciations of an area or object, quality of life has therefore a big subjective component. Some methods exist to handle the subjectivity. One method is an expert-judgement, the so-called Spatial Quality Assessment, which is developed for the project Room for the River (Bos et al, 2004). Another method is to list from policy documents (and some interviews with key-persons) the vision about which strategy and/or interventions improve the quality of life in an area. The remaining chapter discusses these two methods further.

This USI does not consist of a system analysis like the other USI's, because it concerns more the perception of the visual appearance of the system. Furthermore, quality of life is a difficult subject that needs (social-cultural) expertise that the author does not have. Therefore, only two methods are given and the second one is briefly worked out.

A.6.2 Method 1: Spatial quality assessment

This method is an integral method that is used to assess the spatial quality of alternatives in the program 'Room for the River'. It divides spatial quality in three parts: use quality, quality of life (belevingskwaliteit) and future quality (Bos et al, 2004). Every part consists of various questions about different aspects of its quality and one list with questions concerns the balance and sustainability of the three kinds of quality. The aim of the method is to determine an expert-assessment of the quality in a current area or an area after spatial interventions. Experts of various disciplines apply a so-called Spatial Quality Assessment (SQA) during workshops (Bos et al, 2004). Actually, the expert-judgement answers the question if the architecture of the landscape is correct from perspective of various perspectives (Bos, 2008).

The website of www.ruimtexmilieu.nl of different Dutch ministerial departments supplies a similar method to assess the spatial quality. This method adds an extra dimension in comparison with the SQA by assessing the three qualities to ecological, economical, social and cultural aspects (H2ruimte et al, 2008).

This research looks for the contribution of the water and soil system to increase the quality of life. Therefore, an expert-judgement could be made about one part of the SQA, which is the quality of life. The indicators that are used in the Spatial Quality Assessment can be found in Bos et al. (2004). For determining the state of the delta, this method could be practiced by organising a workshop with experts of various disciplines to do a SQA every (number of) years. This method does not provide direct useful indicators for publication like the indicators of other USI's. Another or supporting method is to conduct a survey of residents of the study area to inventory and analyse the quality of life.

A.6.3 Method 2: Gathering appreciation from policy

The second method starts with an inventory of the appreciation of elements of water, ecology and soil in the area from policy and vision documents. The result consists of facts that are interesting to monitor during a period, so that indicators can be formulated.

In this research, it is tried to apply this method on the South-West Delta to get some indicators to measure the contribution of water, ecology and soil to the quality of life. Some citation from a discussion- and a vision document give an impression of the aspects that increase the quality of life:

From research seems that a majority of the Dutch population prefers natural shapes and materials (Provincie Zeeland, 2003).

"Zeeland wordt gekenmerkt door de Deltakarakteristieken: eilanden, zout en zoet water, dijken, schorren, kreken, polders, branding, getij, etc." (Provincie Zeeland, 2003a).

"Natuurlijkheid en de zichtbaarheid van de natuurlijke processen – hier in de vorm van het getij en de branding – vergroten de belevingswaarde van het gebied" (Provincie Zeeland, 2003b).

"Aansluiten bij natuurlijke processen betekent zoveel mogelijk aansluiten bij de kenmerken en karakteristieken van de ondergrond" (Provincie Zeeland, 2003b).

"Er is een evenwicht nodig tussen cultuur en natuur door versterking van de natuurlijkheid" (Provincie Zeeland, 2003b).

"De harde grens tussen land en water, de dijk, is hier en daar wat zachter gemaakt" (uit aquarel, een eindbeeld, uit Provincie Zeeland, 2003b).

"Herstel van de estuariene condities biedt een oplossing voor de ecologische problemen van de Deltawateren. Dit zal niet alleen de natuurwaarde van de Deltawateren verhogen, maar ook ten goede komen aan de economie en belevingswaarde" (Provincie Zeeland, 2003b).

A supplement of this citation is: "De kwaliteitsslag is nodig wil het Deltagebied zijn functie als voortuin van de omringende Eurometropool behouden" (Provincie Zeeland, 2003b).

"De dammen en de Oosterscheldekering geven een gevoel van veiligheid, bereikbaarheid en overwinning op de grillen van de natuur" (Provincie Zeeland, 2003a).

The above citations give an indication of the appreciation of the physical-spatial manifestation of the environment and some objects. The assumption is made that this citations from the two documents are representative for the appreciation of the majority of the population and involved people in the South-West Delta. The citations provide therefore the possibility to draw some careful main conclusions:

1. Naturalness of the water system gets a high appreciation.
2. Natural processes increase the quality of life. This is especially the case for estuarine dynamics.
3. The presence of hydraulic engineering constructions like dams provides a feeling of safety in the South-West Delta.
4. Nature value of the Delta waters is highly appreciated.
5. The ambition of the delta area is to conserve the function as front garden of the surrounded Euro-metropolis. Good environmental qualities are an essential condition for this to be attractive for living and recreation (Zanting and Van Essen, 2006).

A.6.4 Expert-indicators of method 2

The citations and the above main conclusions form the basis for the facts that are interesting to monitor, because they should improve the quality of life. At least the next five aspects are important.

- The water should be clean to be attractive for living and recreation (5).
- To monitor the nature value of the Delta waters the presence of flora and fauna should be monitored, i.e. the biodiversity in the area (4).
- Natural transitions from water to land increase the experiences of naturalness of the water system (1) (Provincie Zeeland, 2003a).
- The natural process in the delta is estuarine dynamics (2). Important for experiencing adventurous water is motion and dynamics. This is especially the case for water sports like surfing (Holzhauer, 2008).
- Finally, a feeling of water safety increases the quality of life (3). The presence of famous Delta-constructions would increase the feeling of safety (Provincie Zeeland, 2003a).

The last step is to choose indicators that give an indication of these five aspects. Box... shows a possible set of indicators. It is noticeable that this set has a large overlap with the expert-indicators of water system quality. As simplification is derived that the state of water system quality is a measure of quality of life. This is with the assumption that when the water system quality increases then the quality of life will also increase and visa versa. The 'score of water system quality' is therefore used as indicator for quality of life.

Box A5 **Indicators of method 2 to indicate quality of life**

Clean water
- √ Transparency of water [m]
- √ Percentage of swimming water location that satisfy the EU-standards [%]

Presence of flora and fauna
- √ Abundance of fishes [presence and population size]
- √ Abundance of birds [presence and population size]
- √ Abundance of sea seals [presence and population size]
- √ Abundance of salt-resistance vegetation [presence and population size]

Natural transition from water to land
- √ Length of banks with natural transition from water to land [km]

Presence of estuarine dynamics
- √ Tidal range [m]
- √ Flow velocity [m/s]
- √ Surface of outer dike area above N.A.P. [ha]

Feeling of safety
- √ Presence of safety for flood hazards construction icons [number and description]

A.6.5 Discussion

During the case study turns out that Quality of life is a relevant USI to taken into account by determining the state of the South-West Delta. The case study does however provide satisfying results. Useful indicators are not found. Besides this, a method is inventoried of which application was not feasible during this research. A quick application of a second method does not provide distinguishing indicators. This USI was to complex to handle as a (small) part of the case study that was done by a researcher with little knowledge about quality of life. Less effort was therefore put into this USI further. The recommendation is to do more research to indicators for determining the quality of life in a delta by someone who has more knowledge about this subject.

A.7 Expert-indicator set

Table A3: An overview expert-indicator set. For comparison with the user-indicators the perception indicators are also added.

Urgent societal issue	Indicator layer 1: perception/concept	Indicator layer 2: operational
Safety for flood hazards	Risk approach	Flood probability & effects
Fresh water availability	Availability of fresh water regard to use by agriculture	Discharge available fresh water per regard to use by agriculture per source
Water system quality	Aquatic biodiversity	Number of and per species: (shell)fishes &
	Algal growth / eutrophication	Nutrients concentration
	Extent of tide	Tidal range
	Salt content surface water	Chloride concentration of Delta Waters
	Refreshment	Water residence time
	Photosynthesis	Oxygen-concentration
	Presence of suitable conditions for marine fisheries and aquaculture	Presence of Marine ecotopes (salinity, acidity, nutrients concentration)
	Suitability to grow particular crops	Chloride concentration groundwater
	Safety swimming water	% swimming waters that satisfy the EU-standards
Transportation by shipping	Use of shipping	Travelling time loss
Quality of life	Perception of the water	Quality of the water system

B. Appendix B – Processed input of intended users

Besides the course with the experts that results in experts-USI and expert-indicator set, a second course with intended users is done. The results are the user-USI's and user-indicator set. This appendix describes the development of the user indicator set in more detail. The methodology of the research and selection of intended users has been elaborated in paragraph 4.4 of the main report. Paragraph B.2 discusses the inventory of the user-USI's and functions. The second paragraph gives formulations of the user-USI's. The last paragraph discusses the user-indicator set. Table A4 shows the involved users and their function.

Table A4: An overview with the intended users who participate in the case study.

Intended user	Function
A.J. Koppejan	National parliament (CDA)
J.C. Robesin	Provincial parliament Zeeland (Partij voor Zeeland)
C.H.M. van der Burgt	Provincial parliament Noord-Brabant (VVD)
B. Bruil	Provincial parliament Zuid-Holland (PvdA)
B. van der Hoef	Water board parliament Zeeuwse Eilanden (resident)
ir. G. Boot	Water board parliament Hollandse Delta (resident)
M. Persson	Science journalist of newspaper the Volkskrant

B.1 Inventory of user-USI's and functions

B.1.1 Structuring input of interviews

Table 1 gives an overview of the urgent societal issues (USI). A number of issues, summarized in "Water system quality" is a main point of concern for most of the interviewees. The intended users – who are interviewed - look more integral to the broad USI water (system) quality than the experts do.

When discussing this USI, they often started with the fresh-salt discussion. The distribution of salt and fresh water affects the water and ecological quality, salinization and the drinking/irrigation water availability. Koppejan notes that water quality is a societal issue affecting nature, ecology, drinking water. Clean water affects economical objectives like recreation, fisheries and agriculture.

The decision-makers have different perceptions on the connections among societal issues, functions and parameters among themselves and the experts. This is probably the result of other perspectives, knowledge, professional background and looking from other sides to the system.

The involved politicians quickly connect the societal issues which belong to water system quality (includes water quantity and quality). The mentioned USI's that can fit with the term 'water system qualiyty' are therefore grouped together.

B.1.2 Analysing input of interviews

The information in table 1 shows that the interviewee's agreed on the USI's ecological deterioration of the Delta Waters, salinization and flood disaster safety. A majority also discussed fresh water availability, flooding, transportation by shipping and quality of life as urgent societal issues. It is further worth noting that they distinguish between hindrance of inundation and safety for flood hazard (dike collapse with causalities).

Another noticed fact is the relation between the level of governance of which the interviewed person is involved in and the kind of USI´s they mentioned. Water board decision-makers do focus on local issues and the provincial and national politicians on societal issues at respectively provincial and national scales.

A short list with some observations shows this relation:

- All water board and 1 provincial politicians mentioned ecological deterioration behind the dike
- 1 water board and 1 provincial politicians mentioned desiccation as USI
- Only provincial politicians discussed water bed pollution
- Only water board decision-makers did not mention water pollution for recreation, transportation by shipping and quality of life.

Table A5: An inventory of the urgent societal issues by decision-makers (per governance level) and a journalist.

User	Parliament level			Journalist	Total
Urgent societal issue	*National (1)*	*Provincial (3)*	*Water board (2)*		(7)
Water system quality	1				1
Ecological deterioration in the polder		1	2		3
Ecological deterioration Delta Waters	1	3	2		6
Possibilities for marine fisheries and aquaculture	1				1
Fresh water availability	1	3	1		5
Salinization of polders	1	3	2	1	7
Desiccation		1	1		2
Water pollution for recreation	1	1			2
Hindrance of inundation	1	2		1	4
Safety for flood hazards	1	3	2	1	7
Transportation by shipping	1	3		1	5
Quality of life	1	3			4

In order to make an inventory either USI's or user functions fit better with the decision-makers, the question is asked: do you think from urgent societal issues or user functions? The decision-makers describes that there is a strong relation between urgent societal issues and user functions. They try to satisfy the various user functions as much as possible based on their political preferences. Their line of reasoning is practical and it usually starts with user functions. For example, the agriculture organisation tells that it sees a problem. The next step of the politicians can be to broaden this function-problem and relate it to societal themes (Koppejan, 2009; Bruil, 2009). Other interviewee's do not make the link from user functions to USI in their work. Table 2 shows an overview with the user functions that are affected per USI according too the interviewee's.

Table A6: An overview with the relations between USI's and user functions.

Urgent societal issue	User functions
Safety for flood hazards	All
Water system quality	
Ecological deterioration behind the dike	Nature, housing, recreation
Ecological deterioration Delta Waters	Nature, housing, recreation
Possibilities for marine fishery and aquaculture	Marine fishery and aquaculture
Fresh water availability	Agriculture, drinking water, process industry
Salinization behind the dike	Agriculture
Desiccation (verdroging)	Nature, drinking water, agriculture
Water pollution	Recreation
Hindrance of inundation	Housing, industry, recreation, agriculture
Transportation by shipping	Maritime sector, industry
Quality of life	Housing, working, recreation

B.2 Formulation of user-USI's

B.2.1 Safety for flood hazards

Safety for flood hazards concerns a dike collapse with causalities and a large amount of financial and societal damage as a consequence. Safety is therefore an existential condition for life in the South-West Delta. The interviewee's focus is on the conditions and maintenance of the flood defence structures (dikes, dunes and dams).

B.2.2 Water system quality

Ecological deterioration in water of the whole delta for nature, housing and recreation

Improving the ecological quality of the water bodies in the polder and the Delta Waters is one of the urgent societal issues. The water bodies are ponds, small lakes and rivers, creeks and streams. Algal growth and low biodiversity are the main problems. The functions that are mainly threatened are nature, housing and recreation in the polder. The interviewee's identify four main problems in the Delta Waters concerning ecological/water quality. These are the algal growth (in the Volkerak-Zoommeer), erosion of sand banks in the Eastern and Western Scheldt, waterbed pollution and low biodiversity.

Possibilities for marine fisheries and aquaculture

Marine fisheries and aquaculture forms an economic sector in Zeeland by tradition. An essential condition for this sector is estuarine dynamics. Only Koppejan discussed this as USI. Other decision-makers from Zeeland focus on the polder water (water board) or the agricultural and maritime sectors, because of his political program (province). Koppejan underlined that this is a really issue in Zeeland. The possibilities for marine fisheries and aquaculture are therefore still taken as USI into account.

Fresh water availability for agriculture, drinking water and process industry

The interviewees see fresh water availability as one of the most important functions of the water system in the Delta. Sufficient fresh water has to be guaranteed to agriculture, to drinking water companies and to the process industry. Increase of the fresh water availability in the South-West Delta is also an objective of the Delta Works.

Salinization of polders for agriculture

All users mention increasing salinization of the polders behind the dikes as a big problem for the agricultural sector. Crops have a maximum salt resistance. When the salt water penetrates further land inward, then the area that is suitable for particular crops becomes smaller. The interviewees expect that the salinization behind the dikes will increase when current fresh Delta Waters become salt.

Desiccation effects on nature and agriculture

Desiccation is an important issue. Desiccation is caused by the drop of the groundwater level as a result of drinking water extraction from soil water aquifers in the western part of Brabant. The result is that plants in nature die because of a water shortage. Another effect in combination with low river discharges is lowering of the water levels in the ditches, so that less water for irrigation is available.

Water pollution for recreation

Some decision-makers discussed the importance of clean water for recreation and especially swimming. The water quality requirements for swimming are stricter than for other functions (except drinking water), because people come directly in contact with the water, e.g. the presence of bacterial pollution as E.coli and chemical substances. Therefore, this urgent societal issue is separated from ecological deterioration.

Hindrance of inundation

There is a difference between hindrance of inundation and safety for flood hazards (see paragraph 1.4). Hindrance of inundation can be a result of heavy rains or overflowing of dikes and dams. Some interviewee's think the other way round. They call the shortage of water retention capacity (the solution) the problem.

B.2.3 Transportation by shipping

The members of provincial and national parliamentarians mentioned transportation by shipping as urgent societal issue. They discussed it as an alternative to road transport or as a good opportunity to increase the economic activity of the maritime sector in the South-West Delta. They also see threats by an increase of shipping movements. The navigation routes become busier, enhancing the risk on collisions between transport ships, with recreation boats and with dikes. An additional aspect is the increasing pollution of the waterways by ships.

B.2.4 Quality of life

The decision-makers of the provincial and national parliaments think that the quality of life is an important societal issue. A high quality of life is granted for the province Zeeland. Water is very important for the quality of life. When the water system quality is good then the quality of life will also be better. They also relate the quality of life with the favour to live nearby the water.

B.3 User-indicator set

The state of every USI can be made operational by defining indicators. In the interviews, the interviewees are asked to give their view on which parameters are relevant quantities to assess the state of their delta.

In a two-step process the indicators are brought together, reflected in table A7. The first layer in this table fits with the problems and issues that the users mentioned. People can observe and experience these indicators directly. Not all these indicators are measurable. The second layer of indicators is therefore added to the first layer to make the perception indicators operational. These indicators are measurable or computable and they fit in the system description of the experts. An important note is that the operational indicators do not denote the important system processes. It does only make the perception indicators measurable or computable. The operational indicators are partly mentioned by the users during the interviews (white cells). The remaining perception indicators are made operational by the author (grey cells).

The system diagrams and the expert-indicator set - which is operational - are put together with the remaining perception indicators. Below, the way of finding operational indicators and the place in the process-chain is discussed. The latter concerns the representativeness of the perception indicator for the impact on the USI.

It is noticeable that all decision-makers discuss that the only factor for the safety of flood hazards is that the conditions of the flood defence structures have to be good. They think that the flood probability can be zero when the dikes and dams satisfy their maintenance criteria. System diagram 1B shows that flood probability only covers a small part of the system. They do not take the effects after a dike collapse into account.

The perception indicators ‘aquatic biodiversity’, ‘presence of suitable conditions for marine fisheries and aquaculture’ and ‘safety swimming water’ are made operational by expert-indicators. These indicators are ‘number of and per species’, ‘presence of marine ecotopes’ and the ‘percentage swimming waters that satisfy the EU-standards’ respectively. The second one is a combination of nutrient concentration, oxygen and chloride concentration, acidity and water residence time. The system diagram 3B shows that aquatic biodiversity is at the end of the process-chain, so that it is representative for impact on the USI.

The layer-1-indicators ‘salt content surface water’, ‘suitability to grow particular crops because of salinization’ and algal growth are made operational by usual measure methods, which are chloride concentration and chlorophyll-a content respectively

The cause of desiccation of nature that leads to decrease of the terrestrial biodiversity is groundwater level lowering. Although the expert did not consider desiccation, the system diagram of fresh water availability had already starting-points. After the completion of this diagram concerning desiccation, the operational indicator ‘groundwater level linked to the vegetation that can grow at a particular level’ fits in the system. Diagram 2B shows that this indicator is representative for terrestrial biodiversity concerning the water factors.

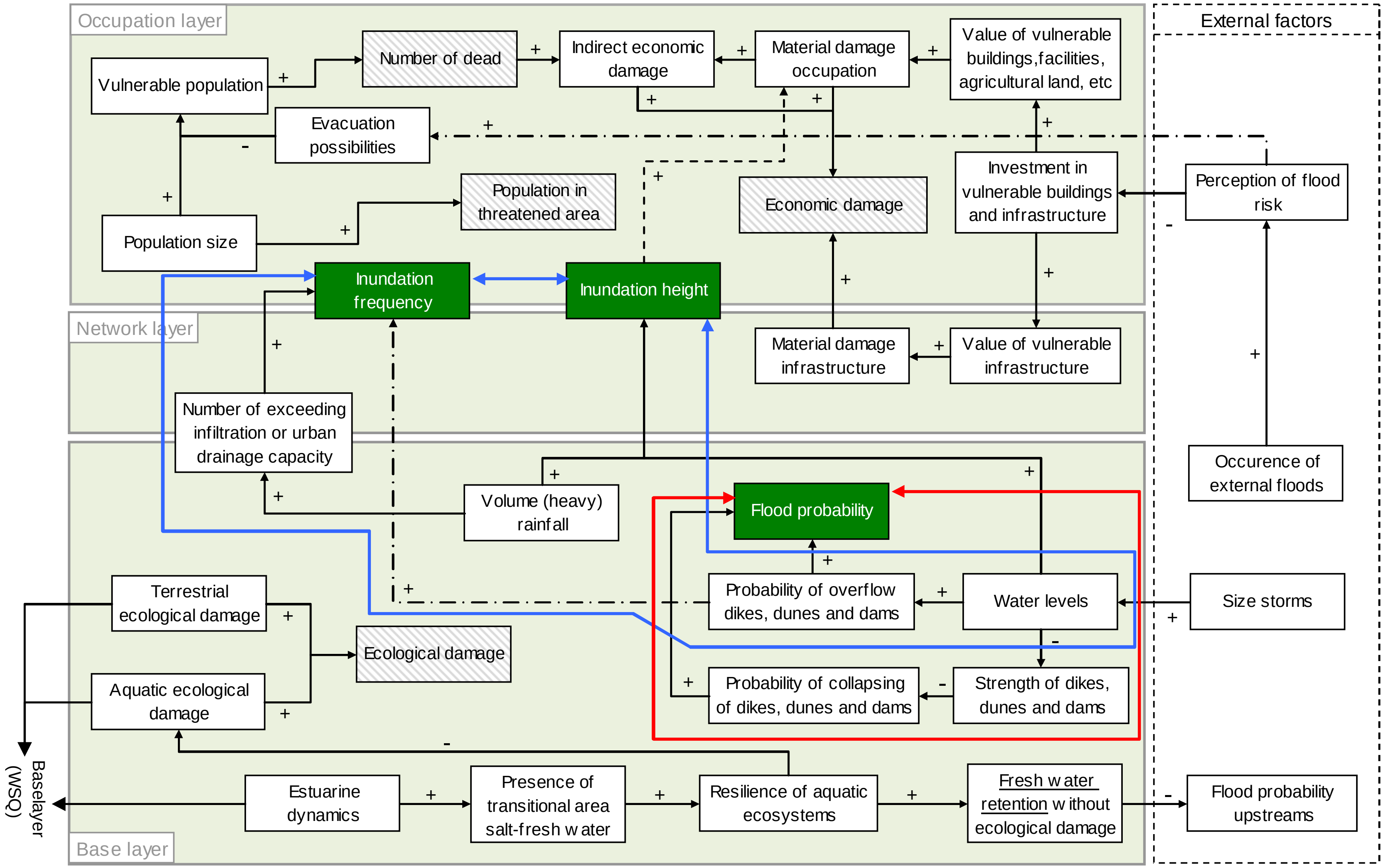
The system diagram 4B shows the places that the operational indicators ‘volume of goods’, ‘accessibility of water routes for particular ships’ and the ‘number of accidents with ships’ and the ‘effect of accidents’ have in the process-chain.

The perception indicator ‘favour of living nearby water’ and its operational indicator ‘price of real estate nearby water is mentioned by two decision-makers. The latter one is however a very economical approach of favour of living nearby water. The indicator ‘perception of the water’ and its operationalisation is the same as one of the expert-indicator.

Table A7: An overview of the user-indicator set. The white cells are mentioned by the intended user. The grey cells are made operational by the author.

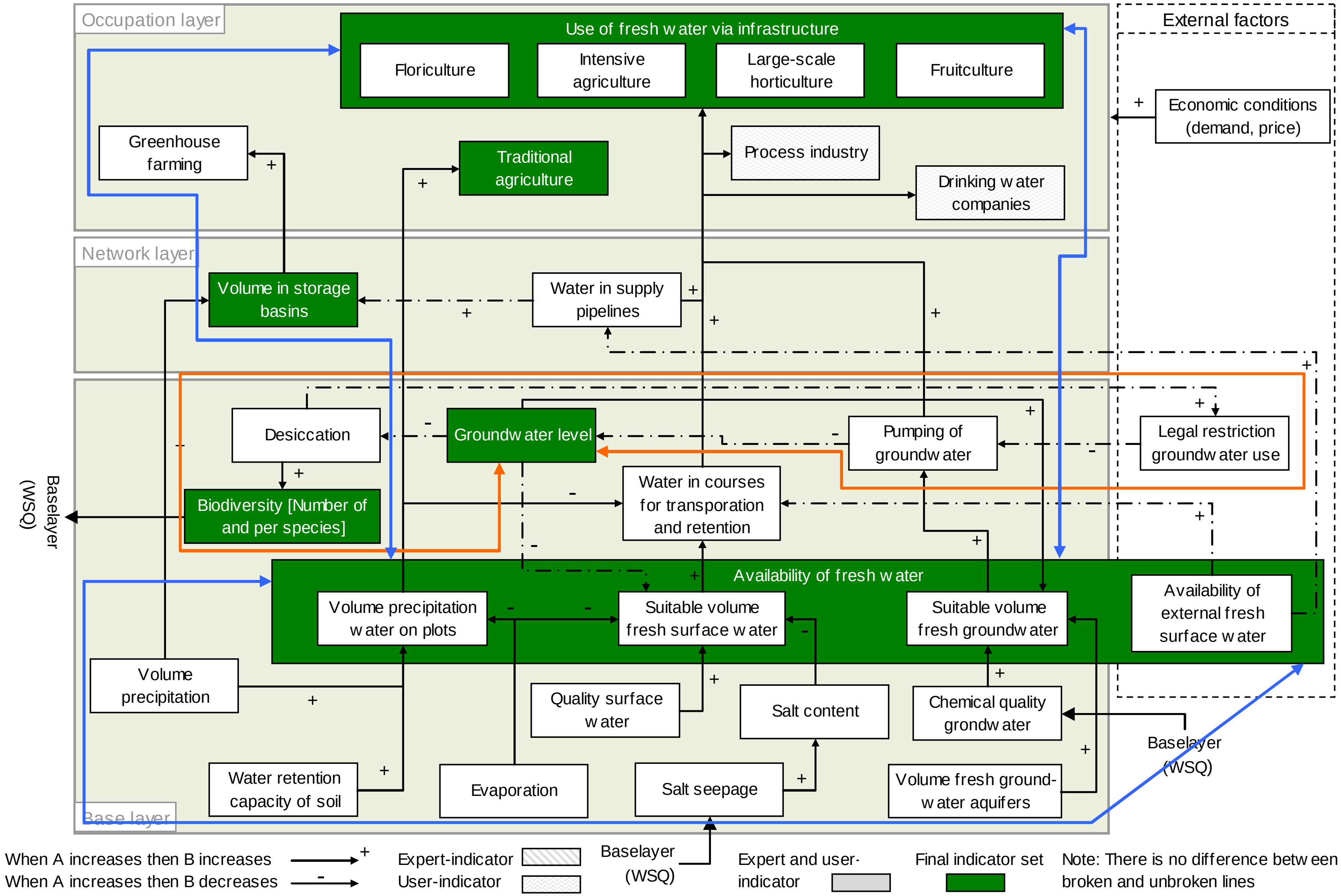
Urgent societal issue	Indicator layer 1: perception/concept	Indicator layer 2: operational
Safety for flood hazards	Condition of the flood defence structures	Flood probability
Water system quality		
Ecological deterioration in water of the whole delta	Aquatic biodiversity	Number of and per species: (shell)fishes & seals
	Algal growth	Chlorophyll-a content
	Erosion of sand banks	Surface area of sand banks
	Tidal flows (water body feature)	Tidal range
	Salt content surface water	Chloride concentration of surface water
	Water bed pollution	Amount and location of hazardous substances
Possibilities for marine fisheries and aquaculture (MFAC)	Presence of suitable conditions for marine fisheries and aquaculture	Presence of marine ecotopes
Salinization polders	Suitability to grow particular crops	Chloride concentration of groundwater
Fresh water availability	Availability of fresh water for different functions regard to use by the functions	Discharge available fresh water per regard to use by user-function per source
Desiccation of nature	Terrestrial biodiversity	Groundwater level (linked to kinds of plants)
Water pollution for recreation	Safety swimming water	% swimming waters that satisfy the EU-standards
Hindrance of inundation	Extent of hindrance	Inundation frequency
		Inundation height
Transportation by shipping	Use of shipping	Volume of goods
		Accessibility of water routes for particular ships
	Shipping accidents risk	Number of accidents with ships
		Effect of accidents
Quality of life	Perception of the water	Quality of the water system
	Favour of living nearby water	Price of real estate nearby water

1B Safety for flood hazards and hindrance of inundation (representative for the impact on the USI)

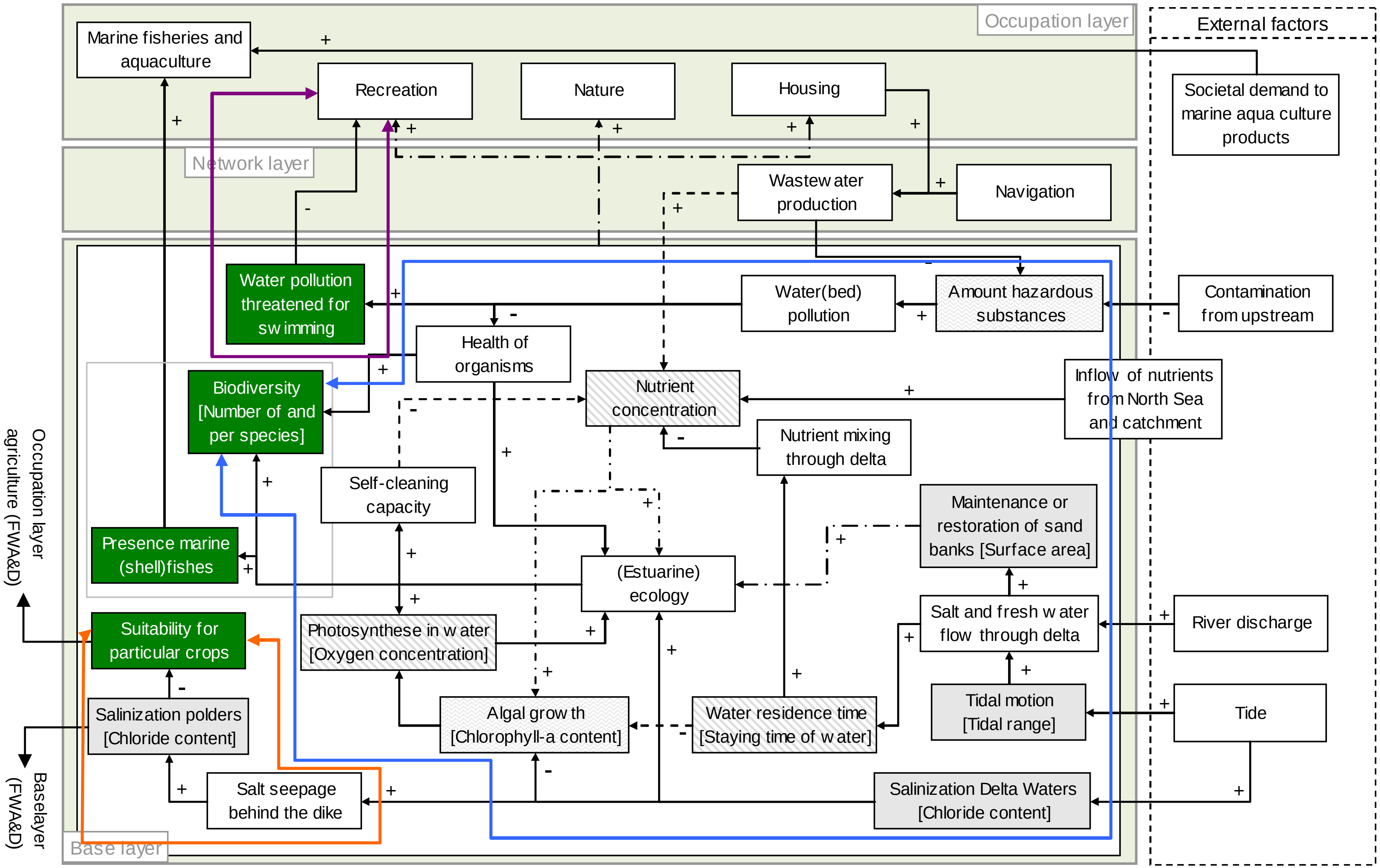


When A increases then B increases +
When A increases then B decreases -
Expert-indicator
User-indicator
Expert and user-indicator
Final indicator set
Note: There is no difference betw een broken and unbroken lines

2B Fresh water availability and desiccation (representative for the impact on the USI)

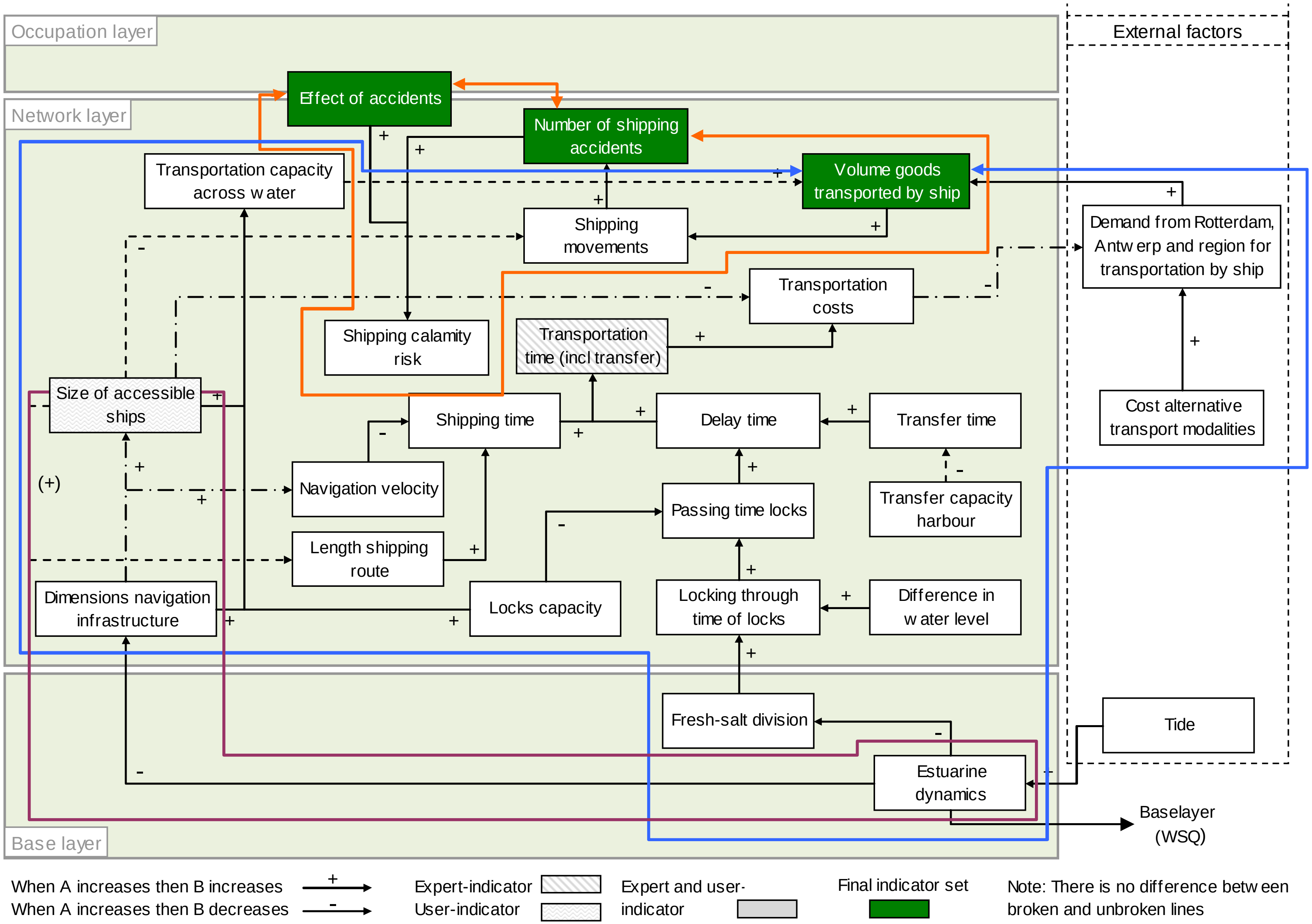


3B **Water system quality (representative for the impact on the USI)**



When A increases then B increases +
When A increases then B decreases -
Expert-indicator
User-indicator
Expert and user-indicator
Final indicator set
Note: There is no difference between broken and unbroken lines

4B **Transportation by shipping (representative for the impact on the USI)**



C. Appendix C – Assessment of potential indicators

This appendix discusses and works out the assessment of potential indicators. The first paragraph presents the scores of the assessment. Paragraph C2 discusses the argumentation of the scores and gives an argumentation for the graduations of the quality criteria.

C.1 Scores of assessment

Table A9 gives an overview of the results of the assessment. The rows show the (sub-) urgent societal issues and the meeting potential indicators. The columns consist of the score per quality criteria for potential indicators (see paragraph 3.3.2). The yellow-coloured columns are the criteria that are a need and the white-coloured ones the nice. The last column shows which potential indicators from the final indicator set (green) and which indicators are dropped (red). Chapter 4 discusses the graduation per quality criteria that is used during the assessment. The table with the graduation is given again to refresh the mind.

Table A8: An overview of the graduation and the type of the quality criteria for potential indicators.

Quality criterion	Type	Graduation			
		-	0	+	++
Amount of change in time per year	Need	Order of 1%	Order of 10%	Order of 100%	
Representative measure or computation	Need	Weak correlation	Well correlated but not measuring the same thing	Good measure	Exact measure
Representative for the impact on the USI	Need	Part of the impact	Biggest part of the impact	Whole impact	
Interesting for users	Need	Not interesting	Moderate	Interesting	
Long-period measurable	Nice	0-10 year	10-20 year	> 20 year	
Simplicity	Nice	Hard	Moderate	Easy	Very easy
Value free	Nice	Not value free		Value free	

The potential indicators with a negative score (-) for one of the four quality criteria 'need' have to be dropped, because they do not satisfy the basis conditions for indicators. These negative scores are coloured grey in table A9. The next paragraph discusses the argumentation of the scores per quality criterion.

C.2 Argumentation scores

Amount of change in time per year

The guiding principle of this criterion is: when indicators do not change in time per year then they are useless, because unchangeable things are not interesting to measure. Two features of the potential indicators are taken into account to score this criterion. The first one is the dynamics of physical-natural processes when that is the case. The processes with a low and high dynamic can change respectively in order of 10% and 100% per year. Change of other indicators is depending on human intervention, the second feature. The big, long-term intervention can change in order of 1% per year. The small and short-term ones can change in order of 10% per year.

Representative measurable or computable

The guiding question of this criterion is: are the measurements and computations representative for the quantity? The graduation is copied from Van der Sluijs and Risbey (2001) for proxy. The lowest score – 'not correlated and not clearly related' – is not used, because these parameters will not receive the status potential indicator. They are already dropped during the composition of the user- and expert-indicator set. A number of potential indicators have a weak correlation with the quantity of layer 1, but in combination with another potential indicators they are well correlated or a good measure. Examples are shipping accidents risk and extent of hindrance of inundation.

Representative for the impact on the USI

The definition of representative in this assessment is that the first indicator layer has to cover the impact of the processes affecting the USI. The view of the users is the main principle and not the view of experts that concerns the quantities that denotes the important processes of a (sub-)USI like ecological deterioration. The users' view only has to fit with the system of the expert.

The system diagrams (see Appendix A) forms the input for the assessment of representativeness for the impact on the USI. The question is: how big is the part of causal relations of a process that the perception indicator covers? When their place is in the middle of the process-chain, then they will not cover the impact of the whole system. However, when they are at the end of the process-chain, then they will likely cover the whole impact on the USI. The assessment turns out that a number of individual indicators only cover a part, but they cover in combination with each other the 'whole' process.

Long-term measurable

The guiding principle of this criterion is if there are reasons that can reduce the measurable period. One reason is the dependency of an indicator on a scientific paradigm or specific standards, because these can change during the next two decades. When this is the case, the measurable period is estimated to 10-20 year. The input of the other indicators is measurements of substances or physical quantities, which are not dependent on paradigm or specific standards. When the current governance and society continue then they will be very probably measured. Therefore, the measurable period of those indicators is characterised as long than 20 years.

Simplicity

The guiding question is: how much explanation is necessary to understand the indicator by a decision-maker or citizen without technical background. In order to score the indicators for this criterion definition of hard, moderate, easy and very easy understandable are made and used. The starting-point for the definitions is that the explanation is communicated at an accessible way. The definitions are:

- very easy: I look to the indicator (visualization) and I understand without explanation;
- easy: I understand the indicator well after some explanation;
- moderate: I do not still understand the indicator well after explanation;
- hard: I do not understand the indicator at all after explanation.

Interesting for users

The input for this criterion is the interviews with the intended users. Various indicators advised by the experts are not interesting for the users. Because they did not mention them or they explicitly discussed that the indicators are not interesting for them, like risk approach, ecotopes and travelling time loss. The interviewee's almost unanimously discussed interesting indicators like flood probability, biodiversity and salt content. Only some users mention other indicators. These are scored as moderate.

Value free

The guiding question of this criterion is: does the indicator (formulation) suggest a particular solution-direction or suggest the indicator (formulation) a narrow-minded definition of the issue or problem? The assessment turns out that some indicators could probably suggest a solution-direction. They are therefore re-formulated, so that the suggestion is moved away and all indicators are value free finally.

C.3 Discussion scores

Table A9 consist of some noticeable scores. The first one is that the potential indicators of the USI 'ecological deterioration in the whole delta' score many minus for the criterion 'representative for the effect on the USI'. These indicators with a minus give an indication of important processes of the system. They are parameters which are somewhere in the middle of the casual chains. Aquatic biodiversity is the only indicator that is at the end of the chains, so that this one is representative for the effect on the USI. The other indicators partly origin from the expert-indicator set, but some indicators also origin from the user-indicator set, like algal growth, erosion of sandbanks and water bed pollution. These three entities are the three biggest problems in the South-West Delta and the intended users are interested in their state. The reasons for dropping these potential indicators are the formulation of the quality criterion and the method of grouping their input in USI's and perception indicators. The formulation of the quality criterion is changed various times, because a clear choice between 'representative for the effect on the USI' and 'indication of important processes was not made.

The two indicators of the USI 'water pollution for recreation' score both positive. They are from incomparable order. The safety of swimming water contains the bacteria that can cause illness after contact during swimming. The algal growth in water concerns more the visual and smell resistance for swimming (besides the threat for illness by e.g. blue algae). They are therefore selected both for the final indicators set.

Table A9: An overview of the assessment of the potential indicators. The light orange columns are needs and the white columns are nice. One minus in the 'need'-columns means dropping of the indicator. The last columns gives a positive or negative final score.

Urgent societal issues / **Indicator layer 1: perception/concept**	**Indicator layer 2: operational** (**Quality criteria for potential indicators**)	Amount of change in time	Representative measurable or computable	Representative for the effect on the USI	Long-period measurable	Simplicity	Interesting for users	Value free	Final set
Water system quality									
Ecological deterioration in the whole delta									
Algal growth	Chlorophyll-a content	+	+	-	+	+	+	+	×
	Nutrients content	0	0	-	+	0	0	+	×
Aquatic biodiversity	Number of and per species: (shell)fishes + seals	+	+	+	+	++	+	+	√
Erosion of sand banks	Surface area of sand banks	+	+	-	+	+	+	+	×
Extent of tide	Tidal range	+	+	-	+	+	0	+	×
Salt content surface water	Chloride concentration	+	++	-	+	++	+	+	×
Water bed pollution	Amount hazardous substances	0	?	-	+	0	0	+	×
Refreshment of water	Replacement time	+	+	-	+	+	-	+	×
Photosynthesis	Oxygen concentration	+	+	-	+	+	-	+	×
Possibilities for marine fisheries and aquaculture									
Suitable conditions for marine fisheries and aquaculture	Presence of marine ecotopes	+	+	+	+	0	0	+	√
Fresh water availability									
Availability of fresh water for functions regard to use	Disch. avail. fresh water per and regard to function per source	+	+	+	+	++	+	+	√
Salinization polders									
Suitability to grow crops	Chloride concentration	+	+	+	+	++	+	+	√
Desiccation of nature									
Terrestrial biodiversity	Groundwater level (linked to vegetation)	+	+	+	+	+	0	+	√
Water pollution for recreation									
Safety swimming water	% swimming waters that satisfy EU-standards	+	+	+	0	++	0	+	√
Algal growth	Chlorophyll-a content	+	+	+	+	+	+	+	√
Hindrance of inundation									
Extent of hindrance	Inundation height	0	+	+	+	++	+	+	√
	Frequency	0	+	+	+	++	+	+	√
Safety for flood hazards									
Condition flood def. structures	Flood probability	0	0	0	0	++	+	+	√
Risk approach	Flood prob. & effects	0	0	+	0	+	-	+	×
Transportation by shipping									
Use of shipping (US)	Volume of goods	0	+	0	+	++	+	+	√
	Accessibility of water routes	-	0	0	+	+	0	+	×
	Travelling time loss	0	0	0	+	+	-	+	×
Shipping accidents risk (SAR)	Number of accidents (NA)	+	0	-	+	+	+	+	×
	Effect of accidents (EA)	0	0	-	+	+	0	+	×
	Combination of NA and EA		+						√
Combination of US and SAR				+					√
Quality of life									
Perception of the water	Scores water system quality	+	0	0	+	+	+	+	√
Favour of living nearby water	Price of real estate nearby water	+	0	-	+	+	0	+	×

D. Appendix D - Manual ‘State of the Delta Indicator Development Method’

The objective of the indicator set is: ‘to assess the state of the delta from the perspective of urgent societal issues which are affected by the water and soil system’. In order to satisfy this objective better, this appendix discusses a number of guidelines based on the evaluation of the application of RIDM during the case study. The guidelines form the State of the Delta Indicator Development Method (SDIDM).

D.1 Essential conditions, disclaimer, note

The applicability and feasibility of ‘State of the Delta Indicator Development Method’ depend on two essential conditions anyway.

1. The objective of the indicator set must be very clear. Point 2 shows the choices that have to be made apparently anyway.
2. Deltares must excite enthusiasm from intended users (and experts) for indicators to determine the state of the delta. They would like to see the usefulness of the indicators before they spend time and effort in this project.

A disclaimer is that the SDIDM is a suggestion based on the experiences of the case study and of workshops for the publication of STD in 2009. The author estimates that intended users and experts are willing to participate in workshops. Especially, when it is communicated to intended users as a try to bridge the communication, interests and knowledge gap between experts and decision-makers.

A note is that the SDIDM assumes that the indicators also have to give an indication of the important processes of the system. For this, the experts have to be involved and a system analysis is interesting.

D.2 Ingredients

For the manual ‘State of the Delta Indicator Development Method’, the next ingredients are necessary for developing an indicator set to determine the state of the delta.

- A case in a delta area
- A group of intended users that is representative for the purpose group in terms of political background (and governance levels). This means involvement of decision-makers from different sides of the political spectrum per province, national parliament or water board, or the interested citizens.
- (A group of experts with expertise about the water and soil system and socio-cultural aspects of different scientific schools).

D.3 Method of preparation

Quick scan case

1. Start with a quick scan about the case study area to get knowledge and a picture of the case. Read information about the area from internet, policy and research documents and study maps and facts.

Scope formulation

2. Formulate a clear objective of the indicator set and take the next choices into account:
    a. purpose of the indicator set: determining the state of the (delta)system
    b. purpose group focussing either one governance level or interested citizens
    c. perspective: urgent societal issues or user functions
    d. demarcation: water and soil system
    e. what do the indicators have to cover: impact of functions, processes of the system or both
    f. picture about how to use the indicator set: communication methods, showing future perspectives for user functions
    g. (spatial) aggregation: is information given in grids on a map or in aggregated core numbers of the whole area.
3. Check the temporal scale choices: time horizon of at least on decade and reportage frequency of 1 year
4. Check the spatial aggregation scale
5. Define the study area

Definition quality criteria

6. Define sharp and explicit quality criteria. Useful rough quality criteria for assessing the potential indicators are:
    - Amount of change in time
    - Representative measurability or computability
    - Representative for the USI
    - Long-period measurable
    - Simplicity
    - Interesting for users
    - Value-free
    - Cost-effectiveness of data collection

  Useful rough quality criteria for assessing the indicator set are:
    - Completeness
    - Limited number of indicators
    - Scientific internal validity

Designing and starting the participation process

7. Make an inventory of potential decision-makers and journalists who could participate in the process.
8. Choose the participation methods that fit the case situation and participation levels. The recommendation is to use the next methods.
    a. Face-to-face interview is a useful participation method to identify the USI's/user functions, because it takes less time for the intended users and they tell their own view without interaction with others. Face-to-face interviews take more time than interviews over the telephone, but they give much better results.
    b. A problem/cause analysis is a good method to draft the system analysis. There are two options to apply the analysis.
        - The first option is to draft the system analysis with one expert per scientific school per USI. Thereupon, let the system description be checked by experts of other schools.
        - The second option is to draft the system analysis per USI with experts of different scientific schools. The author estimates that this option provides a better result, because of the interaction. This one is also worked out hereafter.
    c. Workshop is an useful method to get interaction among intended users and experts to formulate a list with potential indicators and select the indicator set together.

9. Select and approach the decision-makers and journalists by email followed by a telephone call after some days.

Working out perspective (scope formulation)

10. Interview intended users to identify the urgent societal issues (or user functions) in the study area. Furthermore, ask the interviewee's for potential indicators (information) that are interesting for them.
11. Formulate the USI's or urgent issues per user function(s) that take place in the study area. These USI's or user functions form the structure of the system analysis and indicator set.
    (Below, the word 'USI' is exchangeable with 'user function'.)

System analysis

12. Start with a literature study about the case area and important system processes to get knowledge about the water and soil system that affects the USI's.
13. Make an inventory of different scientific schools also from outside Deltares per USI and the expertise (focus) of experts.
14. Choose the structuring methods to draft the system analysis. The recommendation is use the tool Causal Relation Diagram and to try the system approach of Bossel (1999). This method may be taking into account the economical, social and institutional dimensions better than the layers-approach.
15. Select and approach experts of different scientific schools per USI and per expertise. Be sure that all expertises are taken into account to prevent that processes are missed in the system analysis.
16. Organise workshops with experts of different scientific schools who have expertise about the physical (or socio-cultural-economic) system per (group) USI('s). Possible groups are safety for flood hazards, water system quality, transportation by shipping and quality of life. Start the workshop with a free brainstorm to collect all possible important processes. Define the important processes per USI. Next, work out these processes further in smaller groups during the workshop. Finally, discuss the results and map the divergence of views between experts of different schools. The drafted system analysis of the case study South-West Delta can be used as starting-point during the workshop (after the free brainstorm).
17. Draft the system analysis by drawing system diagrams and descriptions. Structure the analysis by the USI's.
18. Optionally organise a second workshop to discuss the divergence of views with the opponents.
19. Ask the experts to give feedback (by mail) on the system diagrams and descriptions. Furthermore, ask them to designate potential indicators. Finally, process the feedback to complete the system analysis.

Indicator formulation

20. Organise a workshop with a number of broad-minded decision-makers, a journalist and a number of broad-minded experts who cover all USI's concerning expertise to formulate a list with potential indicators. Take as starting-point of the workshop the inventory of potential indicators during the interviews with the users and feedback (mail) session with experts. Interaction between experts and intended users is needed to crystallize the list with potential indicators. The experts can help the intended users to understand (better) the idea of indicators and the intended users can hand on their way of thinking and interests to the experts. This will improve the quality of their input.

21. The next step is to assess the potential indicators with help of the formulated quality criteria for potential indicators. This evaluation forms the input for the selection of the indicator set.
22. Organise the final workshop with the same group as the workshop in pt 20 to select the indicator set with the evaluation as starting-point. It is important to take into consideration the formulated quality criteria for the indicator set during the selection process.
23. Finally, assess the set of indicators by the quality criteria for the indicator set.

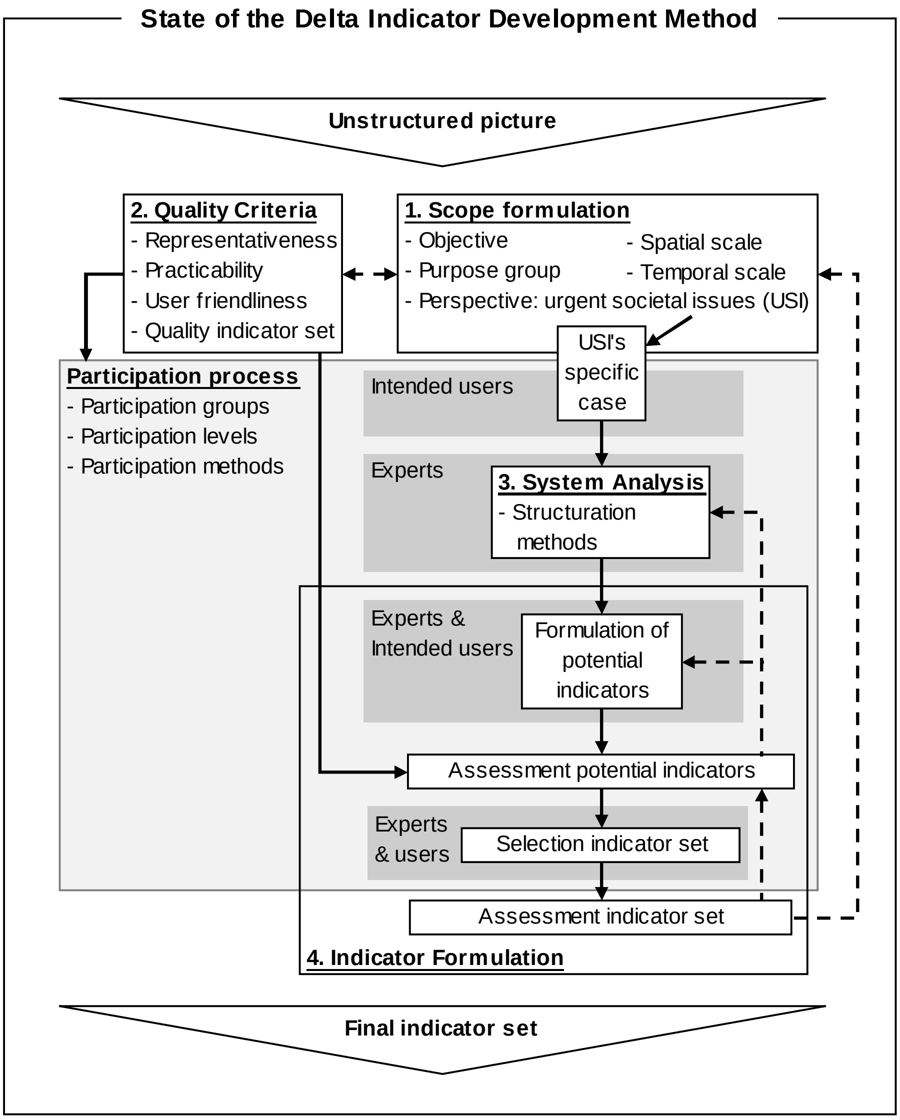


Figure A5: A scheme of the SDIDM. It consists of the process steps and choices that are discussed in this Appendix. The broken lines represent feedback among steps.

Box A6	State of the Delta Indicator Development Method

Step 1: formulation of the scope

- √ Objective of the indicator set: to assess the state of the delta from perspective (of urgent societal issues) which are affected by the water and soil system, including a sharper formulation.
- √ Purpose group: focus on one group from decision-makers of national, provincial or water board level, or interested citizens
- √ Perspective: urgent societal issues (USI) or user functions identified by only intended users
- √ Spatial aggregation scale: the study area
- √ Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year
- ? *Case choice: study area (spatial scale)*

Step 2: selection of quality criteria

Quality criteria to assess potential indicators:

- √ Amount of change in time
- √ Representative measurability or computability
- √ Representative for the USI
- √ Long-period measurable
- √ Cost-effectiveness of data collection
- √ Simplicity
- √ Interesting for users
- √ Value-free

Quality criteria to assess the set of indicators:

- √ Completeness
- √ Limited number of indicators
- √ Scientific internal validity

Step 3: system analysis

- √ Structuring method: system approach of Bossel (1999) with CRD as process modelling tool with experts of different scientific schools to validate the system analysis

Step 4: indicator formulation

- √ Development of potential indicators together with experts and users
- √ Assessment of potential indicators by using the quality criteria for potential indicators
- √ Selection of an indicator set
- √ Assessment of the indicator set by using the quality criteria for the indicator set
- √ Reference values are levels which come from the ‘current period’ that consists of the last decade to today
- √ All possibilities are left open concerning data and aggregation methods

Step 5: communication and implementation

- √ Communication and implementation are not taken into account

Participation process

- √ Participation groups: experts of different scientific schools and intended users (decision-makers of broad political spectrum)
- √ Participation levels: co-producing of experts and intended users
- ? *Case choice: participation methods (face-to-face interviews, problem/cause analysis and workshops)*