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

Designing, testing and evaluating an indicator development method

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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.
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 pilotstudie 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 participatie groep ‘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 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 indicatorenontwikkelingsprocessen 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 representatieve 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 belevenis- 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.

- Indicator development to determine the state of the (South-West) Delta -
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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SD 2A Fresh water availability and desiccation.
SD 3A Water system quality.
SD 4A Transportation by shipping.
SD 1B Safety for flood hazards and hindrance of inundation (representative for the effect on the USI).
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## Glossary of terms

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

<table>
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<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>USI</td>
<td>Urgent societal issues</td>
</tr>
<tr>
<td>STD</td>
<td>Program &quot;Staat en Toekomst van de Delta&quot;</td>
</tr>
<tr>
<td>RIDM</td>
<td>Research Indicator Development Method (method based on the theory)</td>
</tr>
<tr>
<td>SDIDM</td>
<td>State of the Delta Indicator Development Method (guidelines future indicator development)</td>
</tr>
</tbody>
</table>
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.](image)

2.2 Theory indicator development method

The first sub-objective is an overview of the theories concerning indicator development processes that are relevant for 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.](image)

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. Furthermore, the RIDM also does not have different decision-making rounds (Teisman, 2000), but the method is relative straightforward 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.
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.

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](attachment: RIDM.png)

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

- **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.

<table>
<thead>
<tr>
<th>Box 2</th>
<th>RIDM: selecting quality criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quality criteria to assess potential indicators:</strong></td>
<td><strong>Quality criteria to assess the set of indicators:</strong></td>
</tr>
<tr>
<td>✓ Amount of change in time</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>✓ Representative measure or computation</td>
<td>✓ Limited number of indicators</td>
</tr>
<tr>
<td>✓ Representative for the effect on the USI</td>
<td></td>
</tr>
<tr>
<td>✓ Long-period measurable</td>
<td></td>
</tr>
<tr>
<td>✓ Simple</td>
<td></td>
</tr>
<tr>
<td>✓ Interesting for intended users</td>
<td></td>
</tr>
<tr>
<td>✓ Value-free</td>
<td></td>
</tr>
</tbody>
</table>

### 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 0, AI +).
- **Group model building:** facilitated session in which participants build a model to improve their understanding of the issue (I 0, 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 0). 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 0, 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 0, 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 0, 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

<table>
<thead>
<tr>
<th>Box 3</th>
<th>RIDM: participation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>√</td>
<td>Participation groups are experts and intended users</td>
</tr>
<tr>
<td>√</td>
<td>Participation levels: consultation and a modest form of active involvement for experts; consultation for the users.</td>
</tr>
<tr>
<td>?</td>
<td>Participation methods and tools</td>
</tr>
</tbody>
</table>

### 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.

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.

<table>
<thead>
<tr>
<th>Box 4</th>
<th>RIDM: analysing the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Structuration method: Layer model with CRD as processes modeling tool.</td>
</tr>
</tbody>
</table>

### 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 argued 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.
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; Erfemeijer 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.

<table>
<thead>
<tr>
<th>Box 6</th>
<th>RIDM: communicating and implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Communication and implementation are not taken into account in the RIDM</td>
</tr>
</tbody>
</table>
### Overview of research indicator development method

<table>
<thead>
<tr>
<th>Box 6</th>
<th>Research indicator development method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: formulating the scope</strong></td>
<td></td>
</tr>
<tr>
<td>✓ 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.</td>
<td></td>
</tr>
<tr>
<td>✓ Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens</td>
<td></td>
</tr>
<tr>
<td>✓ Perspective: urgent societal issues</td>
<td></td>
</tr>
<tr>
<td>✓ Spatial aggregation scale: the study area</td>
<td></td>
</tr>
<tr>
<td>✓ Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year</td>
<td></td>
</tr>
<tr>
<td>? Case choice: study area (spatial scale)</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2: selecting quality criteria</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Quality criteria to assess potential indicators:</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Amount of change in time</td>
<td>✓ Simple</td>
</tr>
<tr>
<td>✓ Representative measure or computation</td>
<td>✓ Interesting for users</td>
</tr>
<tr>
<td>✓ Representative for the effect on the USI</td>
<td>✓ Value-free</td>
</tr>
<tr>
<td>✓ Long-period measurable</td>
<td></td>
</tr>
<tr>
<td><strong>Quality criteria to assess the set of indicators:</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Complete</td>
<td></td>
</tr>
<tr>
<td>✓ Limited number of indicators</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3: analysing the system</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Structuration method: Layer model with CRD as processes modeling tool.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4: formulating indicators</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Development of two sets with potential indicators based on respectively experts and user input.</td>
<td></td>
</tr>
<tr>
<td>✓ Assessment of potential indicators by using the quality criteria for potential indicators</td>
<td></td>
</tr>
<tr>
<td>✓ Selection of a final indicator set</td>
<td></td>
</tr>
<tr>
<td>✓ Reference values are levels which come from the current period that consists of the last decade and nowadays</td>
<td></td>
</tr>
<tr>
<td>✓ All possibilities are left open concerning data and aggregation methods</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5: communicating and implementing</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Communication and implementation are not taken into account</td>
<td></td>
</tr>
<tr>
<td><strong>Participation process</strong></td>
<td></td>
</tr>
<tr>
<td>✓ Participation groups: experts and intended users</td>
<td></td>
</tr>
<tr>
<td>✓ Participation levels: consultation and a modest form of active involvement for experts; and consultation for users.</td>
<td></td>
</tr>
<tr>
<td>? Case choice: participation methods and tools</td>
<td></td>
</tr>
</tbody>
</table>
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

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

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

<table>
<thead>
<tr>
<th>Box 9</th>
<th>RIDM: selecting quality criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality criteria to assess potential indicators:</td>
<td>Quality criteria to assess the set of indicators:</td>
</tr>
<tr>
<td>✓ Amount of change in time</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>✓ Representative measure or computation</td>
<td>✓ Limited number of indicators</td>
</tr>
<tr>
<td>✓ Representative for the effect on the USI</td>
<td></td>
</tr>
<tr>
<td>✓ Long-period measurable</td>
<td></td>
</tr>
<tr>
<td>✓ Simple</td>
<td></td>
</tr>
<tr>
<td>✓ Interesting for users</td>
<td></td>
</tr>
<tr>
<td>✓ Value-free</td>
<td></td>
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</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Quality criterion</th>
<th>Type</th>
<th>Graduation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of change in time per year</td>
<td>Need</td>
<td>Order of 1%</td>
</tr>
<tr>
<td>Representative measure or computation</td>
<td>Need</td>
<td>Weak correlation</td>
</tr>
<tr>
<td>Representative for the Effect on the USI</td>
<td>Need</td>
<td>Part of the effect</td>
</tr>
<tr>
<td>Interesting for users</td>
<td>Need</td>
<td>Not interesting</td>
</tr>
<tr>
<td>Long-period measurable</td>
<td>Nice</td>
<td>0-10 year</td>
</tr>
<tr>
<td>Simple</td>
<td>Nice</td>
<td>Hard</td>
</tr>
<tr>
<td>Value free</td>
<td>Nice</td>
<td>Not value free</td>
</tr>
</tbody>
</table>

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4.4 Participation process

<table>
<thead>
<tr>
<th>Box 10</th>
<th>RIDM: participation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Participation groups are experts and intended users</td>
<td></td>
</tr>
<tr>
<td>✓ Participation levels: consultation and a modest form of active involvement for experts; and consultation for the users.</td>
<td></td>
</tr>
<tr>
<td>? Participation methods and tools</td>
<td></td>
</tr>
</tbody>
</table>

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 advised 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.

- 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

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

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.

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

<table>
<thead>
<tr>
<th>Step 1: formulating the scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ 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.</td>
</tr>
<tr>
<td>✓ Purpose group: decision-makers of national, provincial and waterboard level, and interested citizens</td>
</tr>
<tr>
<td>✓ Perspective: urgent societal issues</td>
</tr>
<tr>
<td>✓ Spatial aggregation scale: the study area</td>
</tr>
<tr>
<td>✓ Temporal scale: time horizon is at least one decade and the frequency of reporting is 1 year</td>
</tr>
<tr>
<td>✓ <em>Case choice: study area is the Dutch South-West Delta without the harbours of Rotterdam and Antwerp</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: selecting quality criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quality criteria to assess potential indicators:</strong></td>
</tr>
<tr>
<td>✓ Amount of change in time</td>
</tr>
<tr>
<td>✓ Representative measure or computation</td>
</tr>
<tr>
<td>✓ Representative for the effect on the USI</td>
</tr>
<tr>
<td>✓ Long-period measurable</td>
</tr>
<tr>
<td>✓ Simple</td>
</tr>
<tr>
<td>✓ Interesting for users</td>
</tr>
<tr>
<td>✓ Value-free</td>
</tr>
</tbody>
</table>

**Quality criteria to assess the set of indicators:**
- ✓ Complete
- ✓ Limited number of indicators

<table>
<thead>
<tr>
<th>Step 3: analysing the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Structuration method: Layer model with CRD as processes modeling tool.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4: formulating indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Development of two sets with potential indicators based on respectively experts and user input.</td>
</tr>
<tr>
<td>✓ Assessment of potential indicators by using the quality criteria for potential indicators</td>
</tr>
<tr>
<td>✓ Selection of a final indicator set</td>
</tr>
<tr>
<td>✓ Reference values are levels which come from the current period that consists of the last decade and nowadays</td>
</tr>
<tr>
<td>✓ All possibilities are left open concerning data and aggregation methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5: communicating and implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Communication and implementation are not taken into account</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Participation groups: experts and intended users</td>
</tr>
<tr>
<td>✓ Participation levels: consultation and a modest form of active involvement for experts; and consultation for users.</td>
</tr>
<tr>
<td>✓ <em>Participation methods and tools: interviews, problem/cause analysis and email</em></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Identified by expert:</th>
<th>Identified by intended users:</th>
</tr>
</thead>
<tbody>
<tr>
<td>safety for flood hazards;</td>
<td>safety for flood hazards;</td>
</tr>
<tr>
<td>water (system) quality including</td>
<td>water system quality divided in:</td>
</tr>
<tr>
<td>o (ecological deterioration of the Delta Waters)</td>
<td>o ecological deterioration in the whole delta</td>
</tr>
<tr>
<td>o (salinization of polders)</td>
<td>o possibilities for marine fisheries and aquaculture</td>
</tr>
<tr>
<td>o (possibilities for marine fisheries and aquaculture)</td>
<td>o fresh water availability</td>
</tr>
<tr>
<td>o (water pollution for recreation);</td>
<td>o salinization of polders</td>
</tr>
<tr>
<td>fresh water availability;</td>
<td>o desiccation of nature</td>
</tr>
<tr>
<td>transportation by shipping; and</td>
<td>o water pollution for recreation</td>
</tr>
<tr>
<td>quality of life.</td>
<td>o hindrance of inundation;</td>
</tr>
</tbody>
</table>

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.

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

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 advises 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.

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

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.

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

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 Deltaires. 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 apparentpicture 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 perceptual 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.

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 bridge 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 perceptual 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.
8. References


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