An integrated Decision Support Tool for long term strategic water planning in The Netherlands

In search of the magic wand

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by

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Executive summary

The future of the Dutch delta is challenged by the wicked problem (Ritter& Webber, 1973) of climate change characterized by sea level rise and extreme weather changes (IPCC, 2021) as well as land subsidence (Deltares, 2017) and the uncertainty (KNMI,2023) pertaining to these processes. This makes well-considered policy decisions a sought-after endavour (Deltares, 2023). To provide a long-term view of how the Dutch delta behaves under future conditions and how this may be influenced by solutions from different domains, Deltares initiated an exploration into the need for a ”Deltaverkenner”, a national-scale decision support tool to collect, integrate, improve, and visualize insights from disciplinary research. Decision support tools (DSTs) are developed to support decision-makers in decision-making processes by providing frameworks and models to assist in making informed decisions. According to Newman et al. (2017) the benefits of DSTs can be plentiful. However, according to Cash et al. (2002) for information to successfully transfer the boundaries between science and policy it needs to be salient, credible and legitimate. This is exemplified by recognition from Watson (2005), Chong et al. (2017) and Lemos et al. (2012) regarding the dilemmas between the usability for political stakeholders and the credibility desired by scientists.

Therefore, this thesis aims to explore, synthesize and evaluate co-produced designs for a decision-making support tool for water governance contributing to climate change adaptation in the Netherlands that best fits the needs of the stakeholders involved. Consequently, this thesis aims to answer the following research question:

“What do stakeholders perceive as a fit for purpose design for a water governance decision support tool contributing to climate change adaptation in the Netherlands?”

To do so, it takes an informed, iterative co-production approach (Norström et al., 2020), meaning possible designs for the DST are co-designed based on stakeholders’ needs in collaboration with stakeholders and experts. Subsequently, the potential designs are evaluated by the stakeholders. This process is informed by lessons learned from the application of previous decision support tools at the water governance science-policy interface. Additionally, the findings are analyzed in comparison to a literature-based theoretical framework regarding the requirements for successful DSTs and the trade-offs to consider at the science-policy interface.

The findings show that there is consensus on the need for a quick and aggregated tool, preferably a conceptual model like a system dynamics model or a reservoir model. This tool should be able to provide insight into the impacts (both water engineering related and societal impacts such as nature, agriculture and economics) of strategies like the ’voorkeursstrategiën’ for the Delta program. It is also clear there is no desire for a computationally detailed model. There seems to be enough information available; the challenge is to find a way to aggregate this into a quick, easy to use, informative tool that offers significant interaction opportunities in the form of dialogue between different users, as well as feedback between users and the tool based on system knowledge.

The findings were analyzed using a theoretical framework that identifies important considerations for a successful decision support tool that capable of bridging the science-policy interface. Most of the findings of this thesis align with the framework especially regarding the content and use elements for a DST. Regarding the goal and process elements, the findings and the framework are also in agreement, however more research is needed to further specify the needs from stakeholders.

While the findings offer interesting insights into the perception of stakeholders on fit for purpose designs of the ’Deltaverkenner’, they also highlight several areas where more research is necessary to further

concretize the need and offer a staring point for potentially developing an approach for the 'Deltaverkenner'. Specifically the 5 W's have to be elaborated and specified. Who should the 'Deltaverkenner' be for, why the need for a 'Deltaverkenner', what should it be able to do and where and when (timing, resources, process) should in be developed.

To further concretize the need for a 'Deltaverkenner' and to ensure all elements of the theoretical framework are considered for successful decision support tools at the science-policy interface, the recommendation is to develop a meta model detailing the design of the process for developing the 'Deltaverkenner'. This framework should include criteria derived from co-production, boundary object, and decision support systems design processes. Additionally, the literature on impact pathways can inform the types of knowledge, types of research orientations, types of interactions, and the beneficiaries to ensure an effective impact on the decision making process.

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1 Introduction

Good water governance is an underlying objective of most sustainable development goals of the UN for prosperity for people and the planet, now and into the future (Lusigi, 2021). Whether directly, for instance in the goal "Clean water and Sanitation" or indirectly in goals like "Zero hunger", "Good health and well-being" and "Industry, innovation and infrastructure". Indirect consequences of water governance for agriculture, nature and shipping (Deltares, 2017) show the far-reaching influence of decision-making in the water domain. PBL, the Dutch Environmental Assessment Agency, concluded that integrated water governance is a key issue for the Dutch Delta Program (PBL, 2014). Additionally, a measure might have conflicting effects on different goals where achieving better conditions for one problem hinders the other. For example a decision to increase local water retention to reduce either the oxidation of peat meadows or salination, complicates the already stretched fresh water distribution issue, with the additional feedback loop of increased the water evaporation in the summer (Deltares, 2017). Due to the interconnectedness of the water issues mentioned above, it is hard to make comprehensible the entire range of impacts on all significant indicators of a certain intervention or absence thereof. Adding to this are the complexities of the wicked problem (Rittel & Webber, 1973) of climate change adaptation (CCA), driven by sea level rise, projected extreme weather changes (IPCC, 2021), and land subsidence (Deltares, 2017). These challenges and the uncertainty (KNMI, 2023) pertaining these processes, makes well-considered policy decisions a sought-after endeavor (Deltares, 2023).

Decision support tools (DSTs) have been developed to support decision-makers in decision-making processes providing frameworks and models to assist in making informed decisions. According to Newman et al. (2017) the benefits of DSTs can be plentiful. They can support relevant questions, focus on long term and strategic issues, facilitate group interaction, incorporate intuitive interfaces, operate on different temporal and spatial scales and resolutions, adequately capture system dynamics including feedback loops, and be built using flexible and modular software systems that can be efficiently maintained, extended and adapted to similar case studies. Most importantly, they can facilitate effective decision outcomes in complex, poorly-structured or wicked decision problems, which involve many actors, factors and relations and are characterized by high or unknown uncertainties and conflicting interests among actors. However, Newman et al. (2017) also point out there is little evidence of successful use of DSTs for long-term strategic planning. This is in contrast with experience in the field of flood warning DSTs which are applied successfully in many instances (Maaten et al., 2007). Additionally, according to Cash et al. (2002) for information to successfully bridge the boundaries between science and policy it needs to be salient, credible and legitimate. This is exemplified by acknowledgment from Watson (2005), Chong et al. (2017) and Lemos et al. (2012) of the dilemmas between usability for the political stakeholders and credibility desired by the scientists.

To provide a long-term view of how the Dutch delta behaves under future conditions and how this may be influenced by solutions from different domains, Deltares initiated an exploration into the need for a "Deltaverkenner", a national-scale decision making support tool to collect, integrate, improve, and

visualize insights from disciplinary research. The exploration aims to determine if there is a need for and, if applicable, the functional requirements of such a tool in the multi-actor environment of stakeholders within the water governance domain and the adjoining domains essential for CCA. The research presented in this thesis is a preliminary component of the exploration by Deltares.
This thesis aims to explore, synthesize and evaluate designs for a decision-making support tool for water governance contributing to climate change adaptation in the Netherlands that best fits the needs of the stakeholders involved. To do so, it takes an informed iterative co-production approach (Norström et al., 2020), meaning possible designs for the DST have been co-designed based on stakeholders' needs in collaboration with stakeholders and experts. Subsequently, the potential designs have been evaluated by the stakeholders. This process was informed by lessons learned from the application of previous decision-making support tools at the water governance science-policy interface. Additionally, the findings are analyzed in comparison to a literature-based theoretical framework regarding the requirements for successful DSTs and the trade-offs to consider at the science-policy interface.

This thesis is exploratory and the results are of qualitative nature and have a limited sample size. Moreover the results have bias as they are influenced by which actors have been approached and the context provided to them. Therefore, the objective of the thesis is not to draw definitive conclusions. Instead, this thesis aims to improve the understanding of the need for a tool like the 'Deltaverkenner'. These results are relevant in addressing current perceptions of the stakeholders regarding the issue and advising future research on designing a decision-making support tool for water governance contributing to climate change adaptation in the Netherlands.

In summary, Deltares wants to explore the development of a national-scale decision making support tool to collect, integrate, improve, and visualize insights from disciplinary research to provide a long-term view of how the Dutch delta behaves under future conditions and how this may be impacted by solutions from different domains. However, this is complicated by the tension between actors at the science-policy interface, especially regarding the dilemma between usability for political stakeholders and credibility desired by scientists, and the challenges in developing successful DSTs. Therefore, the research described in this proposal will explore, synthesize and evaluate co-produced designs for a decision support tool for water governance contributing to climate change adaptation in the Netherlands according to the needs of the stakeholders involved. Consequently, this thesis aims to answer the following research question:

"What do stakeholders perceive as a fit for purpose design for a water governance decision support tool contributing to climate change adaptation in the Netherlands?"

The sub questions are as follows:
1. What examples of decision support tools are, or have been, used at the science policy interface of the Dutch water governance and climate change adaptation domain and how were they used?
2. What do stakeholders need in a water governance decision support tool contributing to climate change adaptation in the Netherlands?
3. What designs are possible for a water governance decision support tool contributing to climate change adaptation in the Netherlands?
4. Which design for a water governance decision support tool contributing to climate change adaptation in the Netherlands is preferred by stakeholders?

The remainder of this thesis is structured as follows. Chapter 2 elaborates on the theoretical background supporting this thesis. Chapter 3 describes the research design and the methods used to answer the research questions, including the multiple research activities that explored, synthesized and evaluated the diverse design concepts. The results from these research activities are presented in chapter 4 after which they are analyzed and discussed in chapter 5. The thesis is concluded in chapter 6, including the limitation, and scientific and practical recommendations for future research and the 'Deltaverkenner' respectively.

2
Theoretical background

This chapter addresses the theoretical background that supports this thesis. First, the usage of Decision Support Tools (DSTs) for water management and CCA and the requirements and or challenges they face will be elaborated. Next, the concept and challenges of the science-policy interface (SPI) are discussed and subsequently how to navigate it.

2.1. Decision Support Tools

As illustrated in the introduction, integrated water management and CCA are complex fields that require the consideration of various environmental, social, and economic factors. Decision support tools (DSTs) have been developed to aid in this process, providing frameworks and models to assist stakeholders in making informed decisions. There are many different definitions and names (e.g. decision support system) for DSTs. This section provides a background on the usage of DSTs in water management studies and CCA in particular and highlights requirements and challenges that DSTs face according to the literature. This section does not aim to provide an all-encompassing review of all known state of the art DSTs.

According to van der Most et al. (2018) the original goal of DSTs was to support decision-makers in decision-making processes. However, the actual use of most DSTs falls short of these ambitions. Additionally they refer to Newman et al. (2017) who present a comprehensive review of DSTs for natural hazards risk reduction including 101 papers which indicated there was little evidence of successful use of DSTs in practice or of the actual participation of stakeholders in development and application of the DST. This sentiment is echoed by reviews from GWP (2013) and Mysiak et al. (2005). van der Most et al. (2018) note that the goal of DSTs has gradually shifted to enhancing stakeholder engagement for better informed and societally supported decisions. The paper was inspired by the use of the Planning Kit for Room for the River which is considered a very successful DST with many applications in policy development and stakeholder engagement. The success, according to the authors, was attributed to:

- The Room for the River planning kit was relatively easy to use and – most important – provided a quick response to user interaction; hence it facilitated learning
- The Room for the River planning kit comprised a complete overview of measures with their impacts; together with the wide distribution of the planning kit this created a common information and knowledge base on the effectiveness of possible measures, and
- The Room for the River planning kit had a clear focus on relevant policy issues: what objectives to be pursued, what measures were possible/needed and what were the impacts of these measures

The authors define requirements for DSTs from various perspectives. From a use(r) perspective the DST should facilitate the learning process of stakeholders. To this end the DST should be *transparent* and *easy to comprehend* including a user interface with an intuitive look and feel, disclosing the scope and functionality of the DST, aligned with the frame of mind and approach of the intended use(r)s. Moreover, it should provide an (almost) *immediate response to user interaction*(feedback on choices made) and offer the capability to easily *compare cases or strategies* that have been defined by the user. Additionally, from a systems perspective, the DST should support the development of strategies, meaning it should be able to assess the impacts of combinations of measures including *synergy in impacts* and *allow the inclusion of new measures* within the time phasing of the planning process. Furthermore, from a technological perspective, the DST should enable a varying group of participants to engage. This requires *flexible access* which also implies that the most recent version of the tool is available. Measures are often spatially distributed and maps are a common tool for visualization which requires a *geographical orientation*.

The authors note that it is hard, if not impossible, to meet all these requirements in one system and in practice different types of DSTs have been and are being developed, dedicated to a particular subset of requirements. Subsequently, they note that the decision situation at hand, with its associated stakeholders should be leading in the choice of DST set-up as it defines the requirements for a DST from a use(r) perspective. Additionally, a good tool performance alone will not be sufficient. A DST should be easy to use and tuned to the available understanding of the problem at hand. Lastly, the paper concludes that to make the best use of the potential of DSTs, adequate time and resources are needed, that the steps in the planning process are properly tuned to the information requirements of the analytical activities and that it will be a flexible approach, in which the DST is extended based on experiences and feedback from its users.

de Kok & Wind (2003) present six case studies that focus on different aspects of the design and application of DSTs for integrated water management aiming to answer in what respect and how the design and applicability of DSTs can be improved, and which limitations are to be expected. They define a number of essential conditions for a successful design:

- a solid analysis of the problem from an integrated point of view
- active involvement of end users from the beginning of the design
- a clear statement of purpose of the DST
- presentation of results in a form tuned to the needs of the users, and
- a flexible design that can deal with changing demands.

However, they note that experience teaches us that even if all these conditions are met the applicability of a DST in the practice of water management is not guaranteed. Additionally, de Kok & Wind (2003) highlight that a DST can serve as a platform for discussion when multiple stakeholders with conflicting interests are involved. A DST is well suited to take into account different points of view on an equal basis, meaning it can assume a support-oriented function. When there is a general lack of agreement on the nature of the problem, the objectives to be met and the tentative solutions, the creation of support should be given a higher priority than modeling the outcomes of strategies. Furthermore, they highlight that DSTs are particularly suitable to describe integrated systems, while allowing users to intervene by changing scenarios and measures, provided it is well designed. However, they note the difference in purpose of interacting models that capture the behavior of the integrated system best is overlooked. As both policy makers and researchers are better acquainted with models and data pertaining to a single aspect of a problem, this results in the development of models that describe every field in the best way to that corresponding process. To combat this challenge, the authors define the concept of internal consistency of the system. Internal consistency of a decision-support system is achieved when the network of interacting process models is the simplest needed to rank the proposed strategies according to the objectives of end users.

Indeed, van der Most et al. (1998) state that a DST is only successful when it fits the decision making process. According to them, for a DST to be able to support a decision making process it is required to be:

- process oriented; the steps in the planning and decision making, and the information supply with the DST are seen in cohesion
- participatory; all relevant actors are involved

- incremental; the DST development is seen as a shared learning process and not as a technical implementation project

Volk et al. (2010) analyzed four DSTs for landscape and river basis management. Based on this analysis they formulated four crucial criteria for success. First, *system quality* the quality of the models, model coupling, calibration and validation. *User support and user training* as well as *perceived usefulness*, referring to the way information is structured or how workflows are organized. *User satisfaction*, depending on an easy to use and easy to learn interface which allows a proper management of results as well as an easy generation of reports.

Moreover, Mysiak et al. (2005) affirm multiple of the aforementioned requirements for successful DSTs. They found that involvement of end users is an important success factor for DSTs. Especially when future users have difficulty in defining comprehensive requirements for a DST at the beginning of the development process. Additionally they mention the development of intuitive and easy to understand interfaces, appropriately defined system requirements and evolutionary system development as important factors for success.

Furthermore, building upon McCartney (2007), Giupponi (2014) states modern DSTs should be seen as tools assisting in the structuring of problems and the decision-making processes, with a specific role in supporting the analysis of the system, and facilitating the exploration of the consequences (including trade-offs) of possible choices, with efficient communication means.

The previous section explored the challenges DSTs face in successfully supporting decision making. Section 2.3 elaborates further on the tensions and factors to consider in developing DSTs that will be taken into account in this thesis.

2.2. The Science-Policy Interface

Next to the requirements for decision support tools themselves described in the previous section, it is valuable to look into the context in which they are used. The science-policy interface has been defined by (van den Hove, 2007) as ”social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making”. This section elaborates on the challenges identified for the SPI.

As mentioned in the introduction, Cash et al. (2002) state that for information to successfully transfer the (SPI) boundaries (Guston (2001); Jasanoff (1987); Gieryn (1995); Sokolovska et al. (2019)), it needs to be salient, credible and legitimate. They describe salience as “how relevant information is to decision making”, credibility as “authoritative, believable, and trusted information” and legitimacy as “how fair an information producing process is and whether it considers appropriate values, concerns, and perspectives of different actors”. According to the authors there are numerous examples of (the output of) information systems that actors deem as having high levels of two of the attributes but an insufficient level of the third, and therefore are unsuccessful in influencing decision making.

Cash et al. (2002) argue that “tensions often exist between the three attributes such that efforts to bolster one attribute will often adversely impact another”. Figure 2.1 from Cash et al. (2002) shows how the attributes influence each other positively or negatively illustrating the trade-offs. Cash et al. argue that the most successful efforts connecting knowledge to action are those that have favorable perceptions of the three attributes and are effective at balancing trade-offs among them ensuring that no attribute will trigger the rejection of information or the resistance to recommended action.

Attempts to increase…	influence salience	influence credibility	influence legitimacy
salience	-	↓ by "tainting" science with politics; ↑ by including "place-based" knowledge	↑ or ↓ by increasing the inclusion of different decision makers
credibility	↓ by isolating the science and removing decision maker input; ↑ by including different scientific disciplines who ask different questions	-	↓ by limiting participation and thus decreasing process legitimacy; ↑ by increasing inclusiveness of expertise from formally excluded groups
legitimacy	↓ by changing the focus of the resulting information and therefore its usefulness to defined users ↑ by increasing inclusiveness ∴increasing participation of decision makers	↓ by "tainting" science with politics ↑ by increasing the inclusion of different knowledges	-

Figure 2.1: How efforts to increase saliency, credibility and legitimacy influence each other from Cash et al. (2002).

More trade-offs are identified by Sarkki et al. (2014) who identified four key trade-offs based on empirical research. The first is *Clarity-Complexity trade-off*, which involves communicating research through simple, strong, clear messages (relevance) versus thorough treatment of uncertainties and systemic dimensions (credibility, legitimacy). The second, *Speed-Quality Trade-off*, involves timely and rapid responses to policy needs (relevance) clashing with time-consuming quality assessment (credibility) and/or consensus building (legitimacy). The third is the *Push-Pull trade-off*, which concerns the demand for strongly following policy needs (relevance) versus more supply-oriented research strategies to enable the identification of emerging issues or the development of innovative solutions (credibility, legitimacy). The last trade of concerns the *Personal Time* of researchers and policy makers. This trade-off relates to the main task of the researchers (publishing peer-reviewed research) and policy makers (carry out policy work), where science-policy work can be seen as time consuming and a distraction from their main task. Dinesh et al. (2021) identified lessons to be learned from unsuccessful science–policy engagement. In addition affirming the previously discussed considerations from Cash et al. (2002) and Sarkki et al. (2014), Dinesh et al. distinguish the role of intermediaries and knowledge brokers which affect the iterative nature of engagement processes as a factor for success.

According to Cash et al. (2002) salience, credibility, and legitimacy being attributed and interpreted differently on different sides of the science-policy boundary is often a source of dissonance. This is exemplified by Gooch & Stålnacke (2010) who attribute the tension to different perspectives where scientists feel that policymakers and managers do not take into account the knowledge generated within their disciplines. Conversely, from the policymakers' perspective, the complaint is that scientists do not provide the kind of knowledge necessary to solve day-to-day problems (saliency). Another example of tension in the science-policy interface identified by Chong et al. (2017), is the trade-off between scientific complexity (credibility) and usability of scientific knowledge (saliency). Similarly,Watson (2005) & Lemos et al. (2012) identify a gap between what scientists understand as useful information and what users recognize as usable in their decision-making.

Dunn & Laing (2017) observed the CRELE (credibility, relevance (saliency), legitimacy) triad does not fit the most important and frequently raised issues based on more than seventy interviews with policymakers, politicians, industry figures and boundary spanners. They argue CRELE places too much emphasis on issues that are not the highest priority for policymakers, as it takes a primarily intra-scientific perspective. Taking a politic perspective they note that credibility and legitimacy were low priorities and judged very differently by the policy and decision-makers compared to the research community. Salience, however, was of such overwhelming importance that it required further elaboration. To do so, Dunn & Laing (2017) identified key elements for saliency: accessibility, comprehensiveness, timing and applicability, see Table 2.1 for elaboration. These factors can be considered an addition to the CRELE triad, together encompassing both scientific and political perspectives.

Table 2.1: ACTA elements from political perspective SPI in addition to CRELE triad, from Dunn & Laing (2017).

Key element	Description
Accessibility	- Usable knowledge needs to be developed with the end-user in mind - Communicate effectively (e.g., succinct and clear messaging-draw out the key message; use analogies, imagery and sound bites)
Comprehensiveness	- Decision-makers need broader interdisciplinary perspectives of issues (rather than narrow and highly-specialised) - Contextualise (and advance) ideas within the broad range of considerations that decision-makers are likely to face this includes risks (pros and cons) and a range of options - Incorporate economic and financial impacts of research
Timing	- Align with the cycle of government and business decision-making - When windows of opportunity arise research needs to be readily available and promoted
Applicability	- Scientific evidence needs to be applicable and usable for the problems current decision-makers are facing - Offer solutions rather focusing solely on problems - Guide implementation as well as concepts - Tailor to the specific problems and variables (e.g. temporal and scalar relevance)

2.3. Theoretical framework

Accordingly, the most relevant requirements for a successful DST and trade-offs to consider from the SPI are summarized in Table 2.2. Many of the requirements for DSTs and the considerations deriving from the SPI overlap each other. This is not surprising, as a DST that is able to transfer the SPI successfully is likely to be a successful DST. It is important to note as mentioned in section 2.1, that it is impossible for one DST to excel in all requirements at once. Most importantly, the choice for the design of the DST has to fit the decision making situation in which it is involved. The table below will serve as theoretical framework on which the findings of this thesis can be compared, analysed and discussed. This will be done in Chapter 5. The table divides the tensions/factors to consider into different categories pertaining to the tool. *Process* relates to the process or the development behind the tool. *Content, goal and use* consider the tool substantially.

Table 2.2: Theoretical background of requirements for DSTs and considerations from the SPI used for the analysis of this thesis.

	Related tensions/factors to consider	reference
Process	• adequate time and resources • planning process is tuned to information requirements analytical activities/ cycles of decision-making (timing) • participatory, active and early involvement of (end) users from the beginning of the design • take into account different points of view on an equal basis • process is seen as a shared learning • balance trade-offs among saliency, credibility and legitimacy (see 2.1). • speed-quality: timely and rapid responses to policy needs vs. time-consuming quality assessment and/or consensus building • have a clear statement of purpose of the DST	(van der Most et al., 1998), (Mysiak et al., 2005), (van der Most et al., 2018), (de Kok & Wind, 2003), (Volk et al., 2010), (Cash et al., 2002), (Sarkki et al., 2014), (Dunn & Laing, 2017)
Content	• include objectives, measures and impacts of these measures from a integrated point of view (comprehensiveness) • assess and compare the impacts of combinations of measures including synergy in impacts (comprehensiveness) • geographical orientation • internal consistency; simplest model needed to be able to produce desired analysis • able to deal with changing demands, varying participants, or include new measures • based on experiences and feedback from its users • clarity-complexity: simple, strong, clear messages vs. thorough treatment of uncertainties and systemic dimensions • applicability: usable information tailored to the specific problems and variables	(van der Most et al., 2018), (de Kok & Wind, 2003), (Volk et al., 2010),(Mysiak et al., 2005), (Sarkki et al., 2014), (Dunn & Laing, 2017)
Goal	• facilitates learning • enhances stakeholder engagement • is process oriented • create common information and knowledge base	(van der Most et al., 2018), (de Kok & Wind, 2003)
Use	• easy to comprehend, presentation of results in a form tuned to the needs of the users and transparent (accessibility) • flexible access for varying users • immediate response to user interaction • user support	(van der Most et al., 2018), (Volk et al., 2010), (Dunn & Laing, 2017)

2.4. Navigating the science-policy interface

The challenge of bridging the SPI described in the previous section is not a new phenomenon. Consequently, there exist an abundance of literature aiming to structure, support or integrate the engagement of actors in the science-policy interface in order to effectively influence decision making. This section reviews some of this literature on concepts relevant to this thesis.

Cash et al. (2002) argue that achieving salience, credibility, and legitimacy, and balancing trade-offs between them, is achieved through institutional mechanisms (rules, procedures, norms, etc.) such as establishing dual accountability across the boundary; using “boundary objects”; establishing participation from both sides of a boundary; actively mediating to establish “selectively permeable” boundaries; translating across boundaries; and coordinating complementary expertises. Additionally, Watson (2005), Chong et al. (2017) and Lemos et al. (2012) all suggest to use coordinated or integrated strategies to overcome this SPI tensions with an important role for boundary objects (Liu et al. (2008); Leigh Star (2010), Argent et al. (2009)) to deepen scientific understanding, while concurrently supporting key management, policy and planning decisions. Furthermore, van den Hove (2007) identified 15 normative requirements for science–policy interfaces providing guidance for the design, implementation, and evaluation of real-life science–policy interfaces. The requirements are shown in Table 2.3.

Cash et al. (2003) suggest that when stakeholders are involved in knowledge production, they are more likely to view the resulting knowledge as credible, salient, and legitimate and also more likely to adopt such knowledge for implementation. This together with the insights mentioned above, suggest engaging relevant stakeholders and integrating knowledge from different disciplines and is an important strategy for navigating the SPI (Young et al., 2014). One of these approaches is co-production or co-creation. Co-creation and co-production involve collaborative processes where stakeholders work together. Co-production is defined by Armitage et al. (2011) as “the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-oriented understanding of that problem”. Both co-production and co-creation encompasses working iteratively, interactively and transdisciplinary toward collaborative learning, shared understanding, and co evolution of common purpose and action. Norström et al. (2020) propose four general principles that contribute to high quality co-production: (1) context-based: situating the process in a particular context, place or issue, (2) pluralistic: explicitly recognizing the multiple ways of knowing and doing (3) goal-oriented: articulating clearly defined, shared and meaningful goals that are related to the challenge at hand and (4) interactive: allowing for ongoing learning among actors, active engagement and frequent interactions. Additionally, boundary work has been suggested as a strategy for managing the SPI tension as it promotes uptake of research through facilitating meaningful participation of relevant stakeholders in issues framing and knowledge co-production (Nel et al. (2016); Guston (2001)). According to Nel et al. (2016) a key aspect of boundary work is the creation and use of boundary objects, which establish a shared understanding of knowledge for action across multiple knowledge domains. Where boundary objects are defined as ”co produced outputs that are adaptable to different viewpoints yet robust enough to maintain identity across them”. Another approach from literature to effectively influence decision making is impact pathways (Muhonen et al., 2020). Impact pathways are structured sequences of events or processes linking interventions or burdens to their outcomes or impacts, often involving stakeholder engagement. Muhonen et al. (2020) characterized different kinds of pathways, with different types of knowledge, research orientations, interactions, different kinds of beneficiaries. Accordingly they showed the variety of mechanisms and conditions that encourage social impact.

As mentioned in sections 2.1 and 2.2, it is important to take into account different points of view on an equal basis of different actors since they have different perspectives. According to Karstens (2009) when many actors are involved it results in many different views resulting in too great a diversity in viewpoints to draw conclusions. To gain a better understanding of how different actors are involved in a policy analysis process, the different perspectives they have and the ways they may react, Karstens identified four actor archetypes; the political actor, the commissioner, the policy analyst and the researcher. These can be used to navigate the challenges of multiple perspectives in the SPI. See Figure 2.2 and Table 2.4 for the explanation and definition of the archetypes.

Table 2.3: Normative requirements for science-policy interfaces from van den Hove (2007).

Theoretical problems	Normative requirements/challenges for science–policy interfaces
Ouputs	
Complexity, uncertainty, indeterminacy	To bring about communication and debate about assumptions, choices and uncertainties, and about the limits of scientific knowledge. To allow for articulation of different types of knowledge: scientific-, local-, indigenous-, political-, moral- and institutional knowledges. To provide room for a transparent negotiation among standpoints (participatory processes)
Issue-driven vs. curiosity-driven science	To allow for balancing issue- and curiosity-driven science and their articulation in knowledge for decision-making processes
Roles of scientific explanations and predictions	To allow for a reemphasis of the role of scientific explanation for understanding the issue, exploring options for action, and building justifications
Processes	
Fuzzy frontiers between science and policy	To allow for recognition of the existing dependencies between the scientific and the social systems and how they influence the knowledge that is exchanged in the interface. To allow for continuous creation and dynamic exchange of different knowledges across the frontiers of science and society (dynamic processes)
Prioritising and organising research	To include a reflection on research priorities and research organisation
Scientific quality	To allow for critical assessment of scientific outputs in light of users needs and other knowledges.
Educating scientists	To allow for education and training of scientists in communication, translation and mediation
Role of scientific networks	To engage in a transparent manner with existing scientific networks
Inputs and roles of social sciences in science-policy interfaces	To allow for genuine interdisciplinary interactions between social and natural sciences. To recognise the potential of social scientists as designers, implementers and evaluators of science-policy interfaces, and their potential role as translators, mediators or facilitators.
Actors	
Non-neutrality of scientists and possibility of objective knowledge	To render explicit the values, ethics and interests of knowledge holders and allow for their articulation with (objective and subjective) knowledge
Context	
Responsibility of knowledge holders and technology developers (scientists)	To allow for scientists to exercise their responsibility

Table 2.4: Summary of actor archetypes descriptions as defined by Karstens (2009).

Actor archetype	Description
Political actor	Political actors focus on the outcome of the analysis and are expected to have a political rationality. Meaning the political actor is apt to see an issue in terms of advocacy or efficiency, or in terms of its impact on the quality of life. They will act opportunistically in such a way that their own interests or the values they represent are served best.
Commissioner	The commissioners are situated in between the problem situation and the analysis. The commissioner is expected to have a combination of a managerial rationality and a political rationality, since they often are the client of a policy analysis, act similar to the political actors they represent, but they also want the objective of the study to be achieved because they are accountable.
Policy analyst	Policy analyst are a kind of broker between the political actors and the researchers and are positioned in between the problem situation and the analysis. Their role perception is determined strongly by their position within the spectrum (see figure below), e.g. if the policy analyst is more oriented to support the debate in the policy process, they shift to the left in the spectrum towards a facilitating role. If the policy analyst wants to provide the commissioner with information, they shift to the right. Policy analysts designers are often not both designer and executor of the study and are therefore expected to have a dominating design rationality whilst taking into account the other rationality's as well.
Researcher	Researchers focus on the content of the analysis and the learning effect it has on people involved and are therefore expected to have a scientific rationality. They aim to conduct research that is scientifically valid, and of interest to them, for example because it involves investigating new phenomena or building more sophisticated models of conventional phenomena.

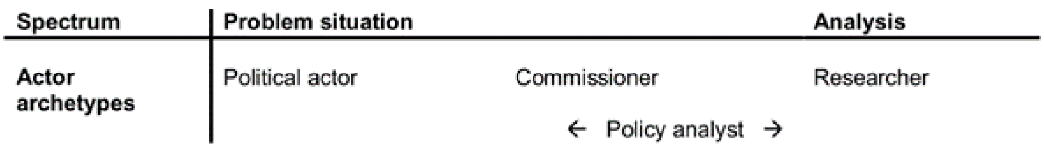

Figure 2.2: The actor archetype spectrum between problem situation and analysis from Karstens (2009).

This section provides theoretical background to navigating the SPI. Some concepts described in this section are used the methods of this thesis as well as the discussion and recommendations. In particular the principles of co-production, co-creation and the actor archetypes of Karstens (2009) informed the methodology, see sections 3.3 and 3.4. Moreover, the boundary objects and impacts pathways concepts informed the discussion and recommendation of this research, see section 6.3.

3 Methods

3.1. Research design

This chapter elaborates on the methods used to answer the research questions discussed in Chapter 1. First, the overall design is presented with an overview of all phases and activities included in this thesis. Figure 3.1 depicts the research flow diagram developed for this thesis. The research design is composed of five phases; Formulation, Context, Needs and Design, User validation and Analysis.
The project formulation started with the identification of the societal problem mentioned in the introduction. From the topic relevance discussion the knowledge gap was synthesized with complementary research design. These steps were iterated leading to the present research design.

The sub-research questions are conform the research cycles for design science described by Hevner (2007). These cycles are the *rigor*, *relevance* and *design* cycles. The rigor cycle provides grounding theories and methods along with domain experience and expertise from the foundations knowledge base into the research and adds the new knowledge generated by the research to the growing knowledge base. This cycle is supported by sub-question one. The relevance cycle, which incorporates input requirements from the contextual environment into the research and introduces the research artifacts into environmental field testing, is supported by sub-question two. Lastly, the central design cycle, which supports a tighter loop of research activity for the construction and evaluation of design artifacts and processes, is supported by sub-questions three and four.

After the Formulation phase was concluded with a research proposal, the research started with the Context phase. The accumulated knowledge from the Context phase was applied in subsequent Needs&Design phase. Together these phases provided insights for the User validation phase. Within these three aforementioned phases four research activities were carried out in total: Expert consultations, Stakeholder interviews, a Design workshop and a User workshop. Additionally, these phases have intermediate outputs and answer sub-research questions. Detailed descriptions on these phases, their activities and outcomes will be explained in the next sections. Subsequently, the research was concluded with the Analysis phase in which the accumulated data and findings are evaluated using the theoretical framework presented in the previous chapter. This chapter concludes with an overview of the participants involved in each phase of the research.

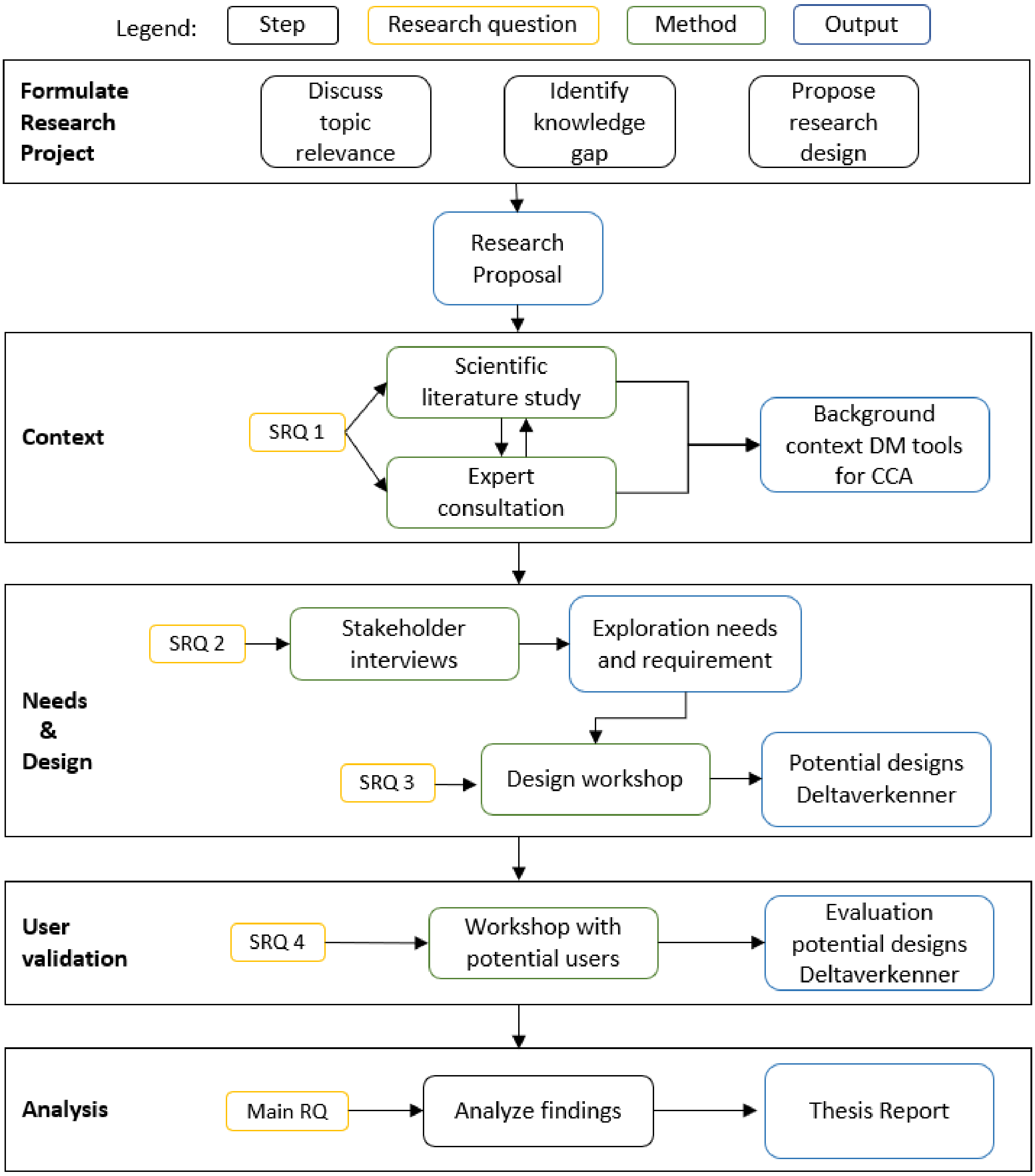

Figure 3.1: Flow diagram of research design of this thesis.

3.2. Context phase

The goal of the Context component of the research is to further scope the scientific context of this research. The sub-research question to be addressed in this section is; "What examples of decision support tools are or have been used in the science policy interface of the Dutch water governance and climate change adaptation domain and how were they used?". Two methods are used to answer this question; Expert consultation and Scientific literature study, which informed each other. The output of this phase is an understanding of the relevant scientific context on DST for climate change adaptation in the Netherlands.

This exploration phase focused on DST used in the water domain developed for CCA purposes and which have an integrated element, e.g. are not of singular focus. Key focus of the exploration is to gain a deeper understanding of what tools have been successful or unsuccessful and for what reasons and why, where and how they were used at the science-policy interface. The emphasis is on gaining understanding of the scientific context where the 'Deltaverkenner' will be an addition to and drawing lessons learned from it, rather than attempting to assembling a complete and extensive review of all relevant tools globally. Furthermore, this phase provides the required background knowledge for both workshops as well as the lessons learned from the application of previous and current DSTs helping to evaluate the potential designs in this study.

3.2.1. Expert consultation

Three experts were consulted on their closely involved experiences with an integrated, CCA contributing, Dutch, water governance DST. The tools chosen are described below. To be consider for the consultation, the tool had to qualify as a Dutch CCA attributing tool that, most importantly, dealt with integral problems. The planning kit for room for the river, for example, is excluded as it is a one issue tool dealing only with water levels. Additionally, the choice for the tools is influenced by network proximity.

- **PAWN study:**
  The PAWN (Policy Analysis for Water Management in the Netherlands) study (Rijkswaterstaat, 1980) was a research project conducted between 1976-1982 in collaboration between Rijkswaterstaat, Delft Hydraulics Laboratory (a predecessor to Deltares) and Rand, a corporation from America, with the main goals to develop a methodology for assessing the multiple consequences of water management policies and develop alternative water management policies for the Netherlands. To this end several models where developed and used to asses policies. Based on the findings of the study the second Nota Waterhuishuiding (Ministerie V&W, 1994) was informed.
- **IRM study:**
  IRM (Integrated River Management (Programma Integraal Riviermanagement, 2024)) is a ongoing Dutch government program in collaboration with multiple ministries, Rijkswaterstaat and the Delta program looking into future-proofing the rivers. To this end a integrated study using multiple models and tools (Asselman, 2023) was done on the consequences of policies on the river, (morphology and hydraulics), navigability for shipping, fresh water availability, nature and flood protection compared to a zero-alternative.
- **The Delta model:**
  The Delta model (Ruijgh et al., 2015) is a model suite developed in 2010 by Deltares to support the policy analysis of the Delta program for flood risk management and fresh water supply. The goal was to develop a multi-disciplinary modeling system that allows for climate and socio-economic scenario analysis as well as exploration of possible adaptation strategies in order to be able to perform comparable calculations in the entire country and to integrate the results in the national policy analysis.

During the in person consults with the experts the following questions were asked to gain insight into their experiences with the tool. It is important to note these conversations where not an interview, rather they were a discussion about the experiences of the experts guided by the talking points brought up in the following questions.

> **Talking point questions for expert consult**
>
> Q1) Can you paint a picture of the situation in which the development of the tool came about? Was there an assignment or research program involved? Where did the demand come from?
>
> Q2) Were the requirements of the users gathered and if so how? Which users were identified and were certain requirements prioritized?
>
> Q3) Did the the eventual results match with the (original) requirements?
>
> Q4) Was the usage of the tool as it was envisioned beforehand? Were the users the same as the ones identified beforehand and were the results and products as envisioned?
>
> Q5) Did any issues come up during the development of the tool in regards to the interaction with users?
>
> Q6) Are there any papers or other secondary materials that should be examined pertaining the previously discussed?

The insights gained from these conversations were synthesized and used in the later research activities and provide a background context for the 'Deltaverkenner'. Some of the dilemmas that came forward during the consults were used to inform the questions and methods in the Stakeholder interviews and Design workshop later in the research.

3.2.2. Literature study

During the conversation with the experts, a starting point for the accompanying literature study was requested. Subsequently, more materials where found through snowballing and consulting public government databases as these aforementioned studies and accompanying tools are owned by or commissioned by government agencies. The gathered materials of interest were selected for further reading if they provided more information on the questions in the previous text box. The goal of studying these materials was to gain more understanding on the reasons and why, where and how the tools were used at the science-policy interface and if and why they have been (un)successful.

3.3. Needs and design phase

The Needs&Design component of the research was aimed to answer sub-research questions two and three, see Figure 3.2 for highlighted Needs&Design segment of flow diagram. This phase of the research focused on aggregating the needs and requirements from stakeholders for the tool and consequently developing multiple potential design concepts to be evaluated by stakeholders later in the research.
To answer sub-question number two; "What do stakeholders need in a water governance decision support tool contributing to climate change adaptation in the Netherlands?", structured interviews were conducted with several stakeholders. The goal of each interview is to further clarify the needs and aggregate corresponding functional requirements for a DST that supports water governance in the context of CCA in the Netherlands.
Additionally, the third sub-question was addressed in the Need&Design component; "What designs are possible for a water governance decision support tool contributing to climate change adaptation in the Netherlands?". To this end the Design workshop was organized with the objective to synthesize at least four different tool designs that fulfill (part of the) the needs and requirements identified in the stakeholder interviews.
The Needs&Design phase was informed by co-production principles outlined by(Norström et al., 2020) in section 2.4. The phase concluded with two outputs. First, a comprehensive aggregation of needs and requirements for a CCA DST for the Netherlands derived trough the multiple interviews with stakeholders. And secondly, multiple potential design concepts for the aforementioned tool, collaboratively

created in a workshop with multiple experts.

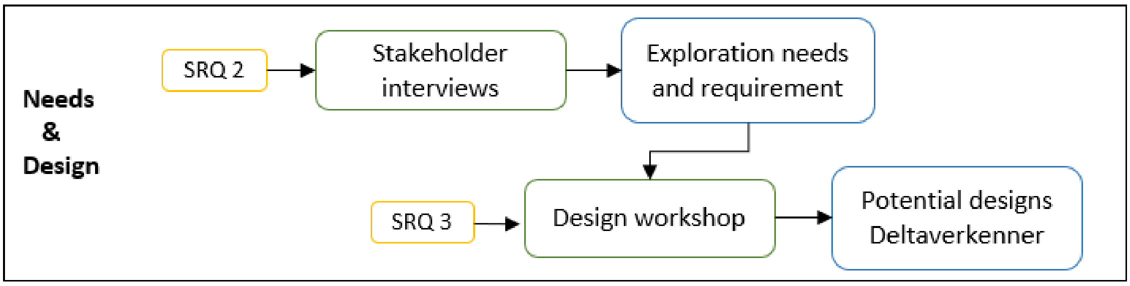

Figure 3.2: Flow diagram of research design Needs&Design phase.

3.3.1. Stakeholder interviews

Many stakeholders can be identified for the 'Deltaverkenner' due to its integrated nature. To get a comprehensive view that represents the whole stakeholder spectrum of the needs, structured interviews were conducted with multiple experts with different actor archetypes from Karstens (2009), see section 2.4. For this study the political actor is omitted for practical reasons. At this point in time, in the exploration phase of the 'Deltaverkenner' project, it is not relevant or concrete enough to involve prominent political actors, e.g. the top ranks of the ministry of Infrastructure and Water management (IenW, particularly at Directoraat-Generaal Water en Bodem (DGWB)). Nevertheless, government officials of IenW are a critical stakeholder and will be involved in study. However, these officials are presumably of the commissioner archetype as they represent the higher officials in the ministry and additionally are intended clients of the 'Deltaverkenner' project. Therefore, at this point in time the political actor archetype is assumed to be represented by the commissioner archetype.
At least two structured interviews were conducted per archetype, with a cumulative of seven in total. Collectively, the interviews give a comprehensive articulation of the stakeholders' needs due to the structured nature of the interviews and the inclusive spanning of the stakeholder spectrum.
As for the commissioner archetype, interviews were conducted with two potential clients for the 'Deltaverkenner' project from staf Deltacommissaris and DGWB. The policy analyst archetype interviews were conducted with expert experienced with policy analysis for integrated water problems in the Netherlands. The researchers approached for the interviews are experienced with modeling and researching the aforementioned integrated water problems.
The one on one interviews were conducted in person or online through video call and were recorded for reference. The (Dutch) questionnaire used for the interviews is shown in appendix section A.1. The questionnaire has two parts. The first part focused on substantial functional requirements defining the policy question(s), scenarios, output and other details the tool needs to encompass. This is based on the methods described in Enserink et al. (2022). The second part of the interview concentrates on requirements for the use of the tool e.g. runtime, ease of use, etc.. The following text box shows a summary of the questionnaire used during the stakeholder interviews.

Summary of questionnaire Stakeholder interviews

Substance requirements

Q1) What integrated policy question for the coming 100 years do you anticipate for CCA in the Netherlands?

Q2) Which corresponding measures* should we be able to test with the 'Deltaverkenner'?

Q3) Which corresponding scenarios* should we be able to test with the 'Deltaverkenner'?

Q4) What output/data* should the 'Deltaverkenner' be able to generate?

Q5) Which physical and social processes should be included in the 'Deltaverkenner'?

Q6) Is there anything else that should be covered in the 'Deltaverkenner'?

*note: for these question components the required level of detail (time/space) was inquired.

Use requirements

Q1) What are requirements for the use of such a DST when assisting in the aforementioned policy question? Think about:

- * The configuration of the output
- * The interface options
- * Runtime
- * etc.

Q2) Who should use the DST and in what kind of settings?

Q3) Is there anything else that should be mentioned about the use of the DST?

The interview answers were compiled, anonymized and summarized. The twofold requirements were used to inform the subsequent research activities. Additionally, any lessons to be learned and or noteworthy similarities and contradictions were remarked.

3.3.2. Design workshop

Two categories of experts were invited to participate in this workshop. The first group consisted of experts with experience in modeling or DSTs for policy analysis of integrated water issues in the Netherlands. The seconds group included experts in conceptualizing and designing DSTs, with the goal of stimulating and broadening the design thinking process during the workshop.
The primary goal of the workshop was to explore the ”design space”, which refers to the range of possible designs for a water governance decision support tool contributing to climate change adaptation in the Netherlands. Thus, rather than focusing on finding and elaborating on one definitive design for the 'Deltaverkenner', the emphasis was on creating multiple and diverse designs concepts .At least four designs were required to ensure that the workshop covered a broad spectrum of potential solutions within the design space. This approach allows for identifying any particular preferences that users may have in the next phase of the research.
The PowerPoint presentation used to inform the context and the proceedings of the workshop can be found in Appendix section B.1.1. The workshop included three challenges for the participants to address. These challenges, along with the methods behind them, are elaborated in the following sections. Next to the collection of direct outputs from the challenges, the workshop was recorded for reference.

Challenge 1

The first challenge of the design workshop was to define the design space concretely. In order to do this, a coordinate system was proposed, as illustrated in Figure 3.3. This coordinate system provides dimensions that differentiate the designs. Before tackling this challenge, participants were informed about the research context and presented with various dilemmas related to designing DSTs that emerged earlier from the expert consults or stakeholder interviews. Participants were then asked to reflect on these dilemmas, confirm their relevance, and contribute additional insights to include for diversifying the design space. The specific challenge posed to the participants is outlined in the text box below.

Challenge 1: Defining the design space

- What do you think about the aforementioned dimension?
- Are there other dimensions to consider?
- Choose the two axes on which to span the design space.

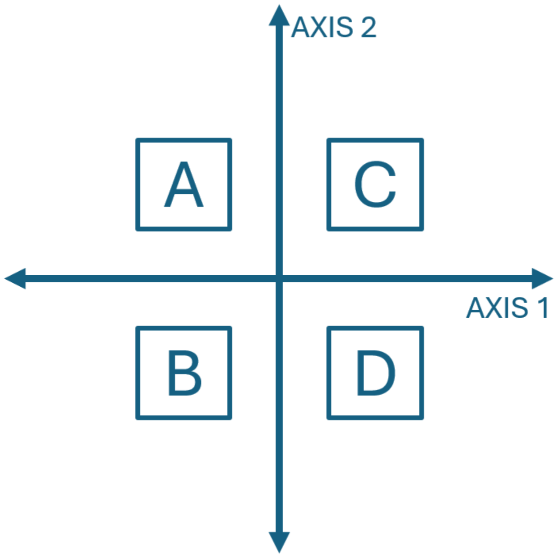

Figure 3.3: Coordinate system used to define design space design workshop.

Challenge 2

Once the axes were defined, the four corners of the design space can be defined each being a combination of the extremes of the axis, again see Figure 3.3. The participants were divided into two groups, with each responsible for two of the design space corners. Their task was to create a schematic concept of a design that aligned with the designated corner of the design space. To assist them, the substantial functional requirements gathered in the stakeholder interviews were provided to the groups as background material. Additionally, the groups were instructed to complete 'properties tables' (see Table 3.1) that outlined the features of their concepts. The properties included in these tables were derived from the functional requirements pertaining the use of the tool in the Stakeholder interviews and the Expert consultations. The specific challenge posed to the participants is detailed in the following text box.

Challenge 2: Designing tool concepts

- Divide in 2 groups: 1 TU Delft expert, 3 Deltares experts
- 2 designs per group, each corner of the design space explored
- Make a schematic representation of the design concept that fits that corner's description
- Use table 3.1 to describe the concept's properties
- Think about functional requirements from table 4.2
- 45 min total

Table 3.1: Properties for table used in Design workshop to describe the design concepts.

Properties
Level of detail
Computation time
Interaction possibility
Ease of use (knowledge background required)
Goal/application
Other noteworthy comments

Challenge 3
After the previous challenge was completed, the developed design concepts were explained and discussed between the groups. In the last challenge of the workshop, the participants were asked individually to reflect on the concepts made. The participants were asked to vote for their favorite designs and explain their reasoning. Subsequently, it can be observed if the participants have a preference for one concept and why. The votes and reasoning were anonymized and summarized. The third challenge, as posed to the participants, is displayed in the following text box.

Challenge 3: Voting

- You get 10 votes: 7 positive + 3 negative
- Vote for your favorite designs. Use either positive or negative votes per design, how many is unrestricted
- Explain your reasoning on a post-it note

Post Design workshop the developed design concepts were further elaborated and made schematic to make them concrete and applicable for the next step; User validation. Furthermore, any lessons to be learned and or noteworthy similarities and contradictions that have come up in during the workshop are remarked.

3.4. User validation phase

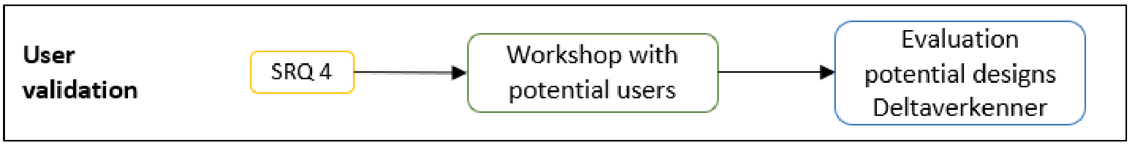

Figure 3.4: Flow diagram of research design User validation phase.

The last sub research question to be addressed before answering the main research question, is sub-question four; “Which design for a water governance decision support tool contributing to climate change adaptation in the Netherlands is preferred by stakeholders?”. The objective of this phase was to collect the perspectives of the users on the different design concepts for the tool made in the previous phase, which is also the output of this phase. As part of the process of the ’Deltaverkenner’ project a workshop was hosted by Deltares which will include intended stakeholders/users of the ’Deltaverkenner’. A segment of the workshop was dedicated to the research of the thesis. The method and criteria of the evaluation of the stakeholders was informed by the research in the context component of the study. See Figure 3.4 for highlighted User validation section of research design.

3.4.1. User workshop

The workshop included 24 participants with different backgrounds within the Dutch water sector from organizations like Rijkswaterstaat and the Delta program. As mentioned above the segment dedicated to this thesis was part of a longer workshop. Before the segment the participants were introduced to the problem identification and the context of the 'Deltaverkenner'. With this in mind, the participants were given a form and a hand-out, both can be found in Appendix C section 1. The different design concepts from the design workshop were presented, explained and described with the aid of the schematic representations and the properties tables which were summarized on the hand-out. Subsequently, the participants were asked for their opinions about the concepts via the form. Additionally, the form invited general opinions on the functionality of the 'Deltaverkenner'. For a summary of the questions asked in the form, see the text box below.

Overview form User workshop

About the concepts

- To what extend does this concept enrich your work environment?
  1) Give a grade from 1 (no enrichment) 5 (much enrichment)
  2) Are there (one or more) properties that appeal or deter you?
- Rank the concepts from most appealing to least appealing

In general

- Where in the design space coordinate system do you think lays the most potential for a 'Deltaverkenner'?
- What functionality do you think is most important for a 'Deltaverkenner'? [short run time, high accuracy of data, ease of use]
- What goal is the most important to achieve with the 'Deltaverkenner'? [gain system knowledge, learning as a user of the tool, generate exact data on measures and or scenarios, creating a equal discussion space for different users]
- Is there anything else you want to comment about the 'Deltaverkenner'?

The answers were collected and analyzed to see if there are any clear preferences or dislikes from this user group and or any interesting connections within the data.

3.5. Content and Process elements

This thesis includes multiple policy analytic activities defined by Thissen & Twaalfhoven (2001) as "specific analytic effort delimited in time and scope and oriented towards a specific policy issue". Their conceptual structure, shown in Figure 3.5, can be used to evaluate these activities (McEvoy (2019), d'Hont (2020)). Thissen & Twaalfhoven make a distinction between process elements of the activity and content elements. Content elements relate to the substance of the activity, such as knowledge or information that is shared and used. Process elements relate to how an activity is organized and plays out, including, for example, the interaction and communication between participants. Furthermore, the direct outcome of an activity is defined as results. The effects of an activity come from two sources, via the use of the results and directly form the activity itself.

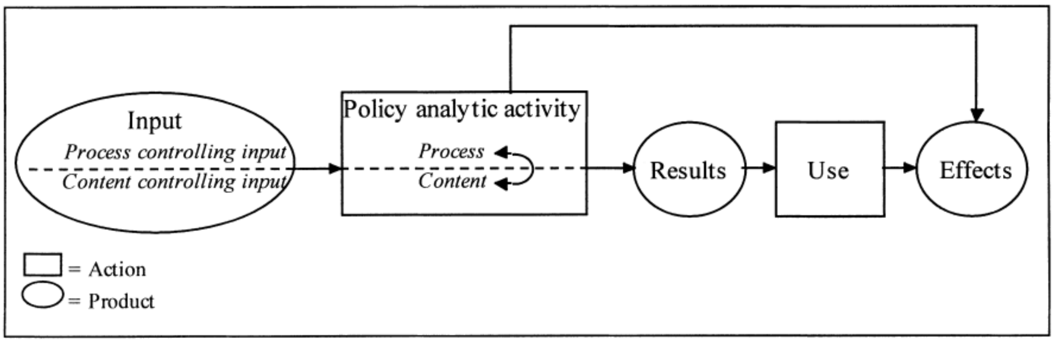

Figure 3.5: Conceptual structure for criteria to evaluate policy analytic activities from Thissen & Twaalfhoven (2001).

This concept is used in this thesis to take into account and analyze content and process elements of the research activities and not only the direct results. As any supplementary experience, remark or requirement might be valuable to the analysis of the thesis these relevant observations were noted during all four research activities. The recordings of the Stakeholder interviews and the Design workshop as well as the additional comments inquiries of the User workshop provided account for these observations.

3.6. Participants

During this research multiple participants from varying organizations and varying expertise's are involved in multiple research activities. This section provides an overview of the type of experts involved in each research activity in Table 3.2. Additionally these participants are assigned a code for reference in the results, these can be found in the last column of the table.

Table 3.2: Overview of the participants involved in each research activity. For each research activity a description on the expertise of the participants is given with the total number per activity and the format of interaction. The last column indicates the reference codes used to refer to a participant, where x would be the individual's serial number.

Research activity	Description of experts	Total	Reference code
Expert consultation	Experts within Deltares with experience on integrated, CCA contributing water Decision support tools	3	EC-PAWN, EC-IRM, EC-Deltamodel
Stakeholder interview	Three actor archetypes (see table 2.4 for definitions) ; 1) Commisioner: e.g. DGWB and staf Deltacommissaris 2) Policy analyst: Deltares, RWS 3) Researcher: Deltares	7	1) SI-C-x 2) SI-PA-x 3) SI-R-x
Design workshop	Two types of experts: 1) Experts that have experience in policy analysis of integrated water problems in the Netherlands, Deltares 2) Experts in designing decision making support tools, TU Delft	8	DW-x
User workshop	All intended users of the 'Deltaverkenner', e.g. Ministerie I&W (DGWB), staf Deltacommissaris, Rijkswaterstaat, Programma managers Deltaprogrammas, Deltares	+/- 25	UW-x

Except for the project team, repeat appearances in multiple research activities were prevented, where possible, to mitigate bias in the research.

To protect the privacy and professional opinions of the participants, the TU Delft Human Research Ethics Committee (HREC) application has been submitted and approved. The application includes a Data Management Plan, the checklist for human research and informed consent forms that have to be signed by participants to be included in the research. In the application several risks have been identified and mitigated ensuring safety and anonymity of the participants. Most notably, all research data in this thesis obtained by research activities including participants is anonymized. Individual anonymous codes are used to refer to participants when necessary. Additionally, the access to raw unanonymized data is limited to the research team.

4

Results

This chapter discusses the results from the research activities that have been elaborated in the previous chapter. Each section presents the data accumulated in that research activity plainly. The analysis of these results and the subsequent conclusions that can be drawn from them will be discussed in the next chapter. First, relevant field experiences are elaborated in Expert consultations including additional remarks or observations made by other research participants. Then the needs and design for the 'Deltaverkenner' are discussed in the Stakeholder interviews and the Design workshop. Finally the designs are evaluated in the User workshop.

4.1. Expert consultation

This section presents the experiences of three experts that were closely involved with a decision support project for integrated, CCA attributing policy plans for the Dutch Delta. The projects and tools of the PAWN study, the IRM impacts study and the Deltamodel are described in section 3.2.1. In these conversations, the experts were asked about their experiences with the tool(s) and especially the interactions with users, demands and or requirements and the project process surrounding the tool (see section 3.2.1 for list of questions asked). The following elaborates on the relevant experiences, challenges, learning points that where derived from the discussions in these conversations with the experts. Moreover, where possible, these experiences are complemented by relevant corroborations or additions found in the accompanying literature on these tools.

4.1.1. Consult with expert EC-PAWN

PAWN (Rijkswaterstaat, 1980) was the first integrated cost-benefit study on water allocation in the Netherlands, primarily focused on freshwater supply. It was conducted before stakeholder engagement became a standard approach, and thus little needs and requirements were not asked in advance. The study featured an unusual setup where Rand, an external American company with limited knowledge of the Dutch water system, was hired by Rijkswaterstaat to conduct the analysis. This external perspective proved beneficial; thinking from within the system can sometimes lead to entrenched viewpoints, and Rand's lack of involvement in domestic conflicts of interest—such as those between Dutch ministries—allowed them to approach the study impartially. Trust in Rand's capabilities was already well established based on a previous, successful study on the Oosterschelde, which made them a trusted partner for this analysis. The PAWN study produced highly technical results, leading to discussions of the findings primarily among regional directors within Rijkswaterstaat rather than with decision-makers. While the primary purpose of a decision support tool is often to serve as an educational communication tool, PAWN was not designed as a decision support tool. Its calculations were performed in the United States and delivered pre-prepared to the Netherlands. Throughout the project, there was ongoing discussion between technical researchers and policy actors regarding the appropriate level of detail required for effective decision-making.

4.1.2. Consult with expert EC-IRM

The impact assessment study conducted by Deltares for the Integrated River Management (IRM) program (Asselman, 2023) did not rely on a single model or model suite, rather, it used a combination of models applied in sequence to assess the effects of various scenarios and measures. This analysis was performed by a team of experts following an initial baseline study (Asselman et al., 2022). The results of these analyses were intended to inform the PoW (Programma onder de Omgevingswet) Integrated River Management. One challenge during the analysis was determining which impacts to consider and at what level of detail. Subject-specific experts were consulted to help identify these impacts, which led to discussions between these experts and policy analysts about the appropriate level of detail needed. Careful selection of experts aimed to ensure a comprehensive representation of expertise, though some distrust persisted regarding the decision-making process for identifying key impacts. A second challenge arose due to misalignment in the timing of the analysis. Before the impact assessment results were finalized, a preferred strategy for the PoW had already begun to take shape, based on preliminary findings from other studies and initial insights. When the impact assessment results failed to support this preferred strategy, the study became a political issue, leading to criticism of both the stakeholder engagement process and the overall credibility of the study.

4.1.3. Consult with expert EC-Deltamodel

The Delta Model (Ruijgh et al., 2015), commissioned by Rijkswaterstaat (RWS) and developed by Deltares, was an attempt to organize and unify the various flood risk management and freshwater supply models used by different departments within the Delta Program. It was created to support national policy analysis and intended to be a long-term tool for use by Delta Program stakeholders, though these stakeholders did not initially express a need for the model. Each Delta Program had its own models and showed limited interest in being involved in the development process, despite being the intended users. The Delta Model was effective in standardizing and aligning boundary conditions and connecting the various components into a unified suite. However, instead of simplifying these individual components, they were further detailed and improved, leading to an increase in computational complexity. Although efforts were made to reduce computation time over the years, it remained less than optimal. The level of detail in the Delta Model was significantly greater than what was technically necessary for policy analysis. This high level of detail, while enhancing accuracy, also resulted in longer computational times and increased uncertainty—especially for long-term projections, which raised questions about the model's efficiency. Nevertheless, the accuracy and detail contributed to a general acceptance of the data provided by the model.

4.1.4. Process and content elements

In addition to the previously discussed expert experiences with DSTs, there are additional remarks or observations made by other research participants before, after or during the other research activities that can be valuable to the analysis of this thesis (see section 3.5). The code indicates the participant and at which activity the remark was made.

UW-5: ”The development of a tool is not the goal. The goal is to connect to (new) target groups.”

UW-6: ”The tool is only an instrument, everything depends on what you want to do with it/who you want to connect with.”

UW-10: ”Eventually it is not about the one concept, but the combination of multiple concepts.”

UW-12: ”You need to define the problem clearly for which the ’Deltaverkenner’ will be the solution. From black box models to communicating key variables and system knowledge and quickly make options insightful to a broader target group. ”

UW-18: ”First the goal and target group and application (specific program) need to be defined and after an appropriate model or procedure can be devised.”

UW-20: ”The ’Deltaverkenner’ should be a combination of A&B, where the actual ’Deltaverkenner’ is A which is fed by B.”

SI-C-2 : "The timing of decision making process is important. You don't want decisions being made at different times and places.

SI-C-2 : "The data is very complex, but in the end the question is always the same: what will this decision mean?"

SI-C-1 : "Ownership is important as well"

UW-15: "The crux is insight."

From this section it is evident the process surrounding the tool is very important to the success of the tool and not only the achievement of the substantial requirements of the tool. Additionally, the level of detail required for decision making is a repeated issue in the experiences of the experts.

4.2. Stakeholder interviews

In total 7 interviews were conducted with the three different actor archetypes; commissioner (2), policy analyst (3) and researcher (2) (see Table 3.2 for description of interviewees). The interviews aimed to accumulate the needs and requirements for a CCA attributing integral decision support tool for long-term policy plans for the Dutch delta. The next sections summarize the requirements mentioned during these interviews. For an overview of the questions asked and responses see section 3.3.1 and Appendix A.2 respectively. The requirements can be summarized in two separate categories; 1) substantive requirements considering the measures, scenarios and output the tool must comprise and the level of detail in them and 2) the requirements regarding the use of the tool, the kind of setting it would be useful in and how it should be used (e.g. the interface). Table 4.1 shows an overview of the long-term policy questions that were central to the succeeding discussion of the requirement of the tool to support in answering these questions.

Table 4.1: Stakeholder interview responses on current long-term policy questions.

Which integral policy question do you anticipate for the next 100 years in the Dutch delta?	Interviewee
What is the optimal water division over the main water branches for low and high discharges?	SI-C-2
What are the total effects of closing the Dutch delta?	SI-C-2
What is the most optimal strategy for the IJsselmeer in the future with regards to flood risk, fresh water availability and nature goals?	SI-PA-2
What strategies are there for transitioning to an open, semi-open or closed Rijn-Maasmonding (focusing on the developments during the transitions)?	SI-PA-3
What are the effects of different spatial planning strategies regarding agriculture, nature and housing?	SI-R-1
What are the costs and benefits of possible climate adaptive strategies for ensuring livability on the Wadden?	SI-R-2
What is the best strategy for replacing the Maeslantkering?	SI-C-1
What is the best strategy for replacing and or elaborating the Volkeraksluizen considering shipping, salt intrusion and ecology and biodiversity?	SI-PA-1
What are the future perspectives of agriculture in the low-lying areas of the Netherlands?	SI-PA-1

4.2.1. Functional requirements: substance

The interviewees were asked to specify the associated measures, scenarios and output required to gain the necessary insights for decision making on the aforementioned policy questions. See Figure 4.1 for reference of the schematic representation of the system diagram approach these questions where based on. The responses of the interviewees were summarized and are displayed in Table 4.2. The responses are in no particular order and are unweighted even though some were mentioned multiple times. Additionally, when applicable the scales that were mentioned for the scenarios and or outcomes are also listed. Notably, not all elements listed in the table are or should be compatible or comparable.

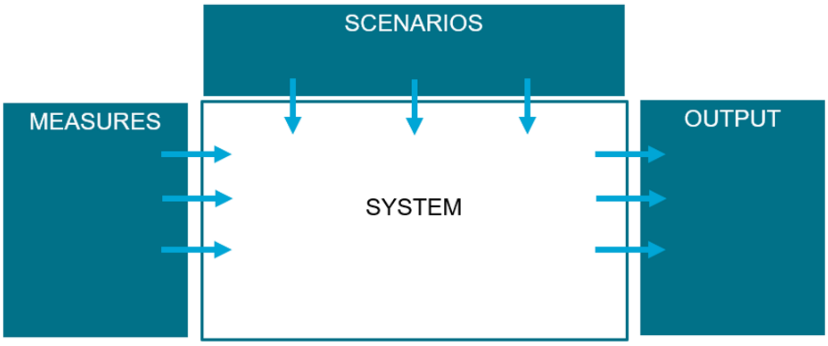

Figure 4.1: Schematic representation system diagram approach from Enserink et al. (2022) used for substance functional requirements.

4.2.2. Functional requirements: use

The requirements for the use of the tool, all participants mention and unanimously agree on that it should have a short runtime. Additionally, most of the interviewees (R-2, C-1, PA-1, PA-2, PA-3) prefer visualization in the form of maps. Info-graphics were also mentioned as way of knowledge transfer. Furthermore, half the interviewees (PA-1, PA-2, C-1) say the information should be coarse at first showing the broader picture. However, if desired, more details can be explored.
Three out of seven (C-1, PA-1, PA-2) interviewees think the tool should be used during interaction between expert and user, where they see the tool plus expert as one package. One interviewee (C-1) specifically mentions they don't think a political actor will interact with the tool at all if it is a model on a laptop. Another interviewee (R-2) sees the tool being used at the place where the decisions are being made, for example in the boardroom where policy makers are discussing a course of action. Three interviewees (R-2, R-1, PA-2) see two versions of the tool, one for the experts and one for users with less expertise. Two interviewees (C-1, R-1) think it is important the tool fits the context where it will be used in, however they don't know specifically which context this will or should be.

Table 4.2: Summary of all measures, scenarios and outcomes needed for answering the long-term policy questions mentioned during the stakeholder interviews in random order, see A.2. The measures described in the measures column are system aspects that can be altered. The scenarios are divided into two types of scenarios: water related or not water related outcomes. Scales relate to the different time and spatial scales that were mentioned.

Measures	Scenarios	Outcomes
Altering ….	**"Water" scenarios** KNMI '23 scenario's	Water division, min/max runoff
Water division	Non-extreme scenario's	Water availability
Buffer capacity	Deltascenarios	Buffer capacity and location
Water levels	Kennisprogramma Zeespiegel (sea level rise)	Concentrations (salt and other)
Concentrations (salt and other)		Flood risks
Risks acceptance ∼safety laws ∼relocation	**Other scenario's** Combi-events, cascade events	Dikes (space, height, reinforcement)
In general: dikes and locks	What if scenario's or land use scenarios (PBL, Deltascenarios) (e.g.)	Embankment and locks (safety, space, open frequency)
Specifically: closing or (semi) open zuidwestelijke delta, harbor Rotterdam		Flood protection (fatalities, costs)
	Economic scenario's (shipping)	Land use ∼ Water use
Land type/use (agriculture, nature, housing, peat), waterbodemsturend	Material availability	Nature/eco goals and impacts
	Demographic and migration	Groundwater level
Nature/eco goals		"Kwel en flux"
Water usage	**Scales** Series	Economic opportunity (of land)
Groundwater levels	Shocks	Costs - investment and impact
Maintaining current strategy	Event frequency (1/10, 1/100, 1/1000)	Resilience (time till repair)
Sand depletion/replenishing		Durability (tipping point)
		"Kosten en baten"
		Tidal action
		Agricultural profit
		Scales Nationally: economics, Regional: impacts
		Trendline or years (e.g. 2030/2080/2130)
		Drought: months/years vs Flooding: daily/weekly

4.3. Design workshop

This section presents the results from the Design workshop. The participants and the challenges used in organizing the results are described in the methods section 3.3.2.

4.3.1. Challenge 1: coordinate system design space

The first challenge was to choose two axes on which to differentiate the potential design that would be created and place them in a coordinate system that would then represent the design space. From the previous phases of the research, the expert consultation and the stakeholder interviews, some dilemmas came forward on which to differentiate the designs. These were:

- Level of detail
- Phase of decision making process (learning/exploring in the beginning, insights/facts/detail in the end)
- True to reality or realism
- Type of user (political actor, commissioner, policy analyst, researcher, citizen)
- Interaction (only known combinations of inputs, making new combinations)

The participants were asked to reflect on these axes. To help start the discussion the *detail* and *phase* axes were proposed as axes of the design space. The *detail* axis was soon reformulated to level of aggregation. With a low level of aggregation meaning a detailed tool and high level of aggregation meaning a conceptual tool. On the second axis, *phase*, there was less concordance. One participant raised the point of interaction or participation being critical for trust in a tool or model. It was added that interaction and participation would look different depending on the individual involved. Where experts, political actors and citizens all interact at different levels with a tool and require different things from a tool. However, they all have in common that interaction and or participation with the tool can help build trust in it. This point was supported by the insight that the 'Deltaverkenner' deals with multiple interest and goals from multiple groups that might operate at different levels. Therefore it was concluded to define the second axis as *explorative vs predictive*. Where explorative offers engagement with the tool to learn and explore more options. And predictive provides (rigid) information and predictions. The resulting coordinate system is shown in Figure 4.2.

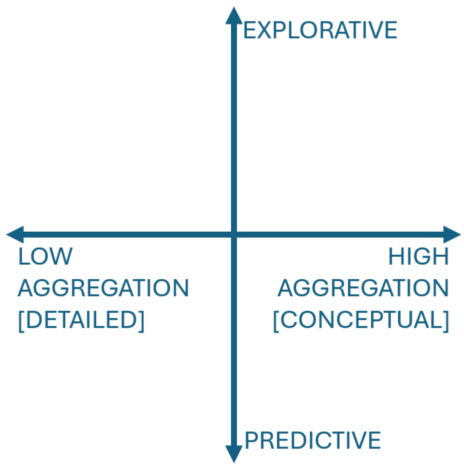

Figure 4.2: Axis design space for Design workshop.

4.3.2. Challenge 2: designing concepts

This section presents the results from the second challenge in the design workshop where concept designs for the tool were made according to each corner of the previously elaborated design space.

Figure 4.3 shows the layout of the design numbers across the design space, group 1 tackled concepts A&B and group 2 concepts C&D. The resulting concepts will be elaborated in the following. The schematic representations of the concept are extracted from the drawings made during the workshop. These drawings can be found in section B.2.2 in Appendix B. Additionally, the participants were asked to fill in the properties table (Table 3.1) to provide additional information on their concepts. These can be found in Appendix section B.2.1.

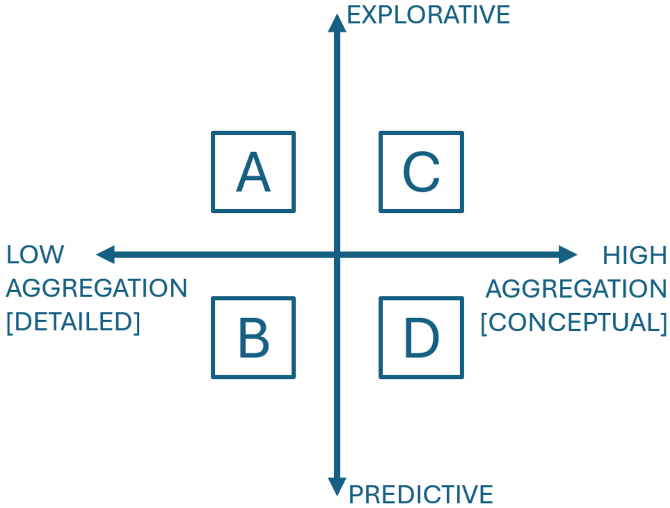

Figure 4.3: Layout of the concepts located in design space coordinate system for Design workshop.

Concept A

Concept A is in the left upper corner, meaning it is detailed and explorative. The schematic representation in shown in Figure 4.4. The concept was duped 'het bakjes model' as it is based on a simple reservoir model spanning the whole Netherlands main water system (0 Dimensional) from one body of water to the next including hydraulic structures along the way. The model interacts with a group of researchers with multiple and diverse disciplines. In an iterative process the model can be updated or expanded by the researchers to include more features, like new measures, based on the needs from the user group. To validate the results from the model it will have to be compared to results from a more detailed (3D) model.
In the properties table, the model is described as follows. The computational time is low as it is a simple 0D model. It is quite comprehensive, describing flood risk, water availability, ecology and shipping from which indicators can be extracted like an integrated assessment model. For goal/application, it is mentioned the concept is especially suited to test a multitude of (structural) measures for a user like for example Rijkswaterstaat. Furthermore, it offers possibilities to explore bottlenecks where the multidisciplinary researchers group can learn from each other. The model is not accessible for laymen as it is complex, especially the interpretation of the outcomes is not evident. It is suggested a portal could be added to increase the ease of use if desired.

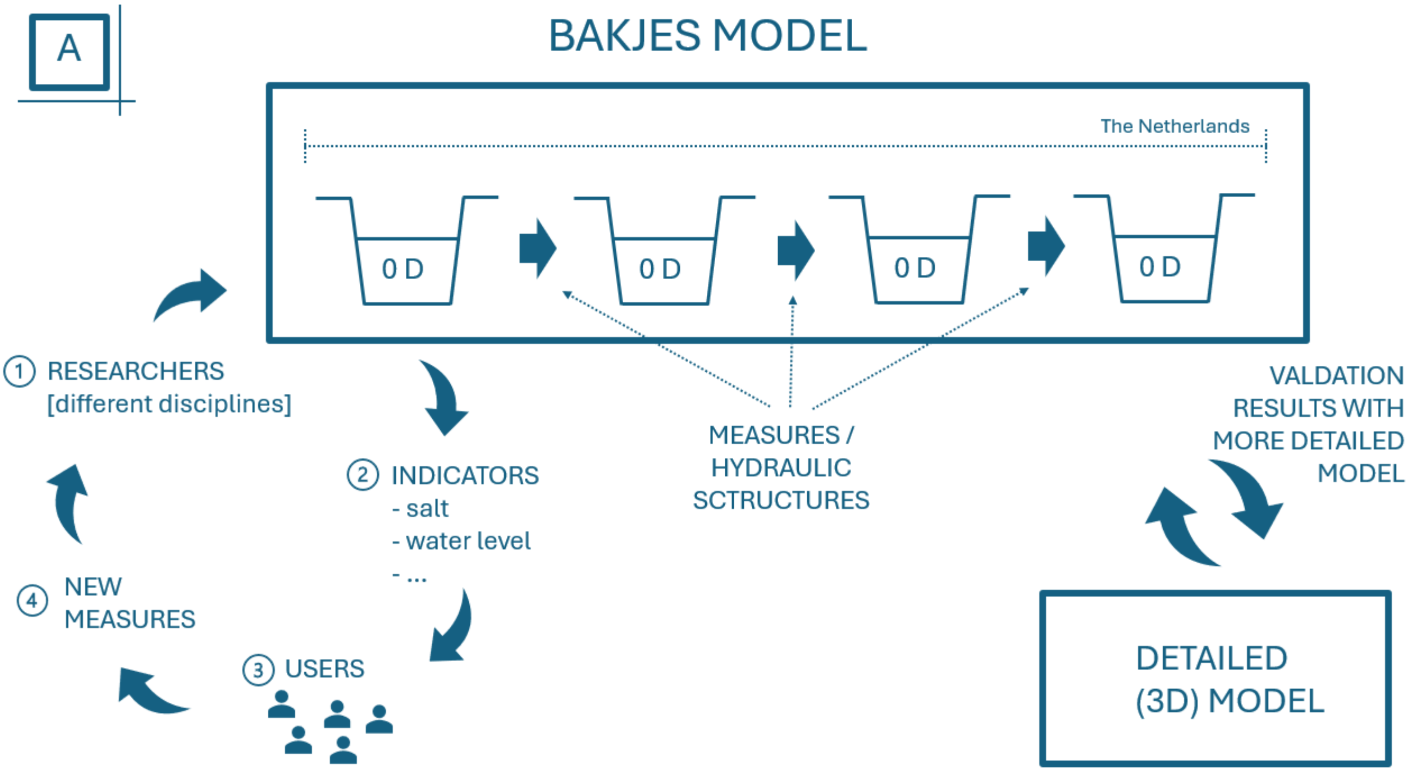

Figure 4.4: Schematic representation of concept A; the 'bakjes model'.

Concept B

Figure 4.5 depicts the schematic representation of concept B, the detailed and predictive combination in the bottom left corner of the design space. The concept is based around a noticeably detailed and extensive (2D+3D) model that produces regional (e.g. Rhine-Meuse delta) data on impacts like salinity, temperatures, water levels and inlet window similar to a model like Delft 3D. It is able to run a predefined set of scenario's and measures. The outcomes require post processing and can be used for impact studies with an impact model. A group of expert modellers can use and modify the model. The users can access the data via a portal that is maintained by the same group of expert modellers. Accordingly, they can communicate their needs back to the expert modelers for new input for the model.
As can be expected from a detailed predictive concept, the computation time is long e.g. days to weeks. Additionally, interaction possibilities are not flexible. There is a separation between the data and the users. Furthermore, the ease of use is describes as only for experts who post process the data for users. Such a concept can be used to obtain detailed insights in impacts of for example sea level rise and variations in discharge in a certain region.

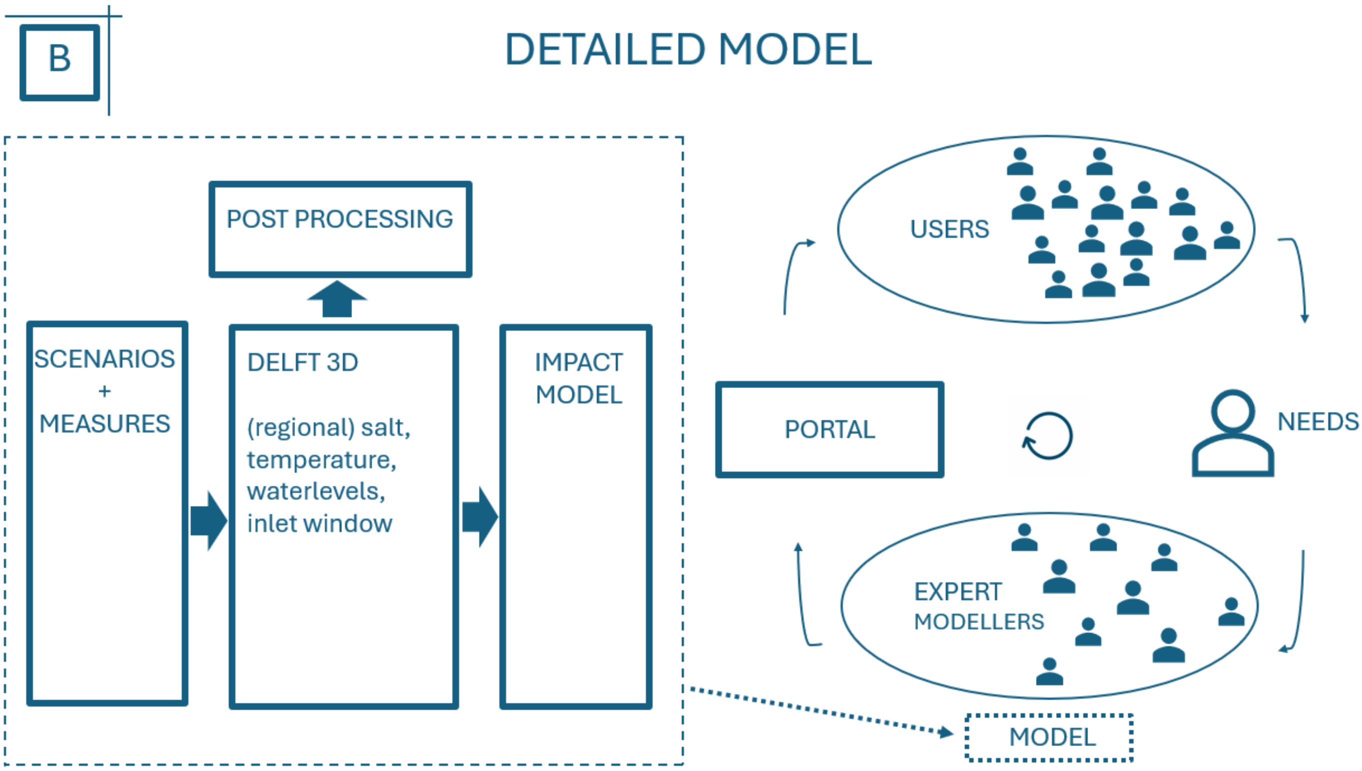

Figure 4.5: Schematic representation of concept B: the detailed model.

Concept C

Figure 4.6 depicts the schematic representation of the conceptual explorative right upper corner concept C. The idea of concept C is a game with cards that is played by the users. The procedure of the game would be to have the players represent certain actors in the system or problem. The main player(s) makes a move e.g. imposes a measure, and the physical systems reacts accordingly to this move. Likewise, other actors that might have opposing goals react to the move. With the new situation resulting from the previous reactions, the central player makes a new move. The data (e.g. moves, reactions) have to be generated and or validated by a detailed model. The game creates insight into trade-offs and dependencies in the system. Additionally, not yet considered measures might arise from the evolution of the game. These can be used as input for the detailed model as new research questions to implement. Potentially, the whole process can be repeated to have multiple installments of the game over a longer time period.

The game is particularly suited to focus on trade-offs or dependencies and human interaction (between humans and or between humans and the system). There is no computational time excluding the preparation time between rounds of the game. The interaction possibilities are very high, since the game offers immediate feedback from the other players and the physical problem system. The goal of the game is more focused on gaining understanding of the system and the human interactions and the effects of different measures and can be used by layman and experts alike.

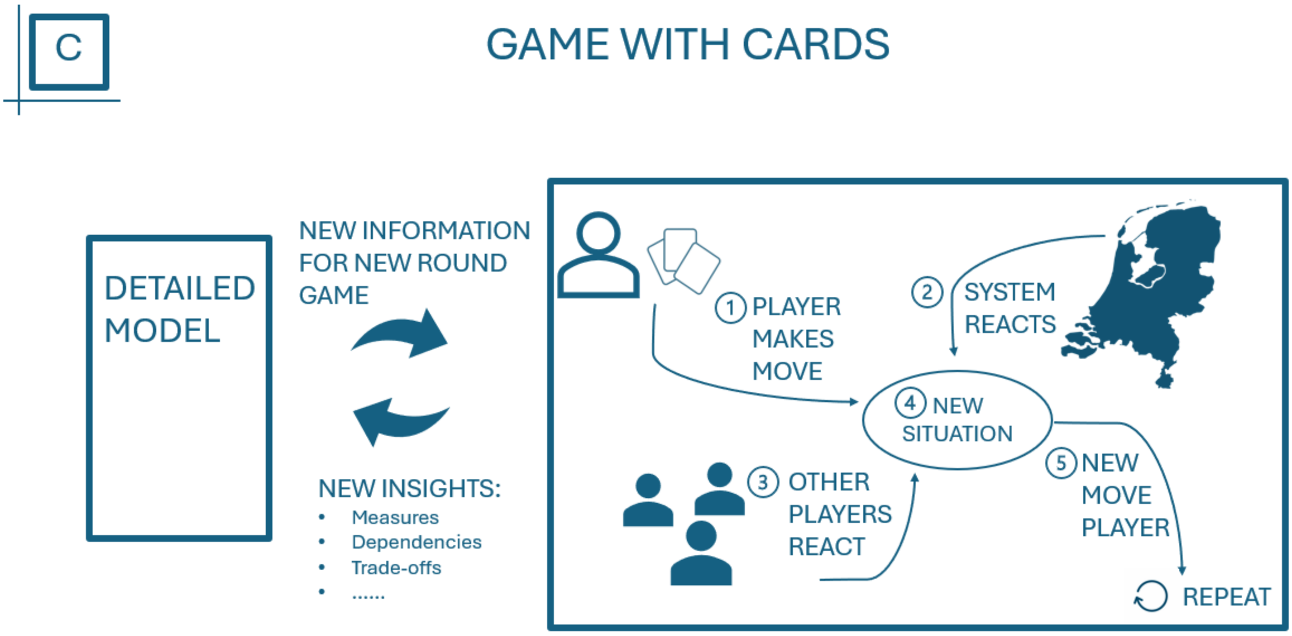

Figure 4.6: Schematic representation of concept C: game with cards.

Concept D

The last concept made during challenge 2 of the design workshop is concept D (see Figure 4.7). Concept D, located in the lower right corner, is conceptual and predictive. For this concept a system dynamics (SD) model was suggested. A system dynamics model is a considerably more sophisticated version of a reservoir model. The basis is stocks and flows, reservoirs and in/outflow respectively. However, this principle is extended with capabilities like delays, changing rates in time or space, feedback, etc. Furthermore, it can accumulate other matters like land area, population, economics, shipping, etc. analogous to water in the reservoir model. The SD model is based on a causal loop diagram which is an aggregated depiction of the system that includes all causal dependencies. The output of the model is especially suited to explore patterns in outcomes and gain system understanding trough the dependencies and feedback that the system displays as effects of measures. In contrast it is less suited to produce exact data on exact locations at exact times. Additionally, validation of the results with a detailed (3D) model is required.

The computation time for this model is short ($\sim$ minutes). The interaction possibility is fairly high as there is opportunity to easily adapt measures, scenarios variables and re-simulate. Additionally, an interface is easily build, making this concept suited for exploration and what if scenarios. Furthermore, it gives insights at an aggregated level into the physical system and its processes as well as human decision making.

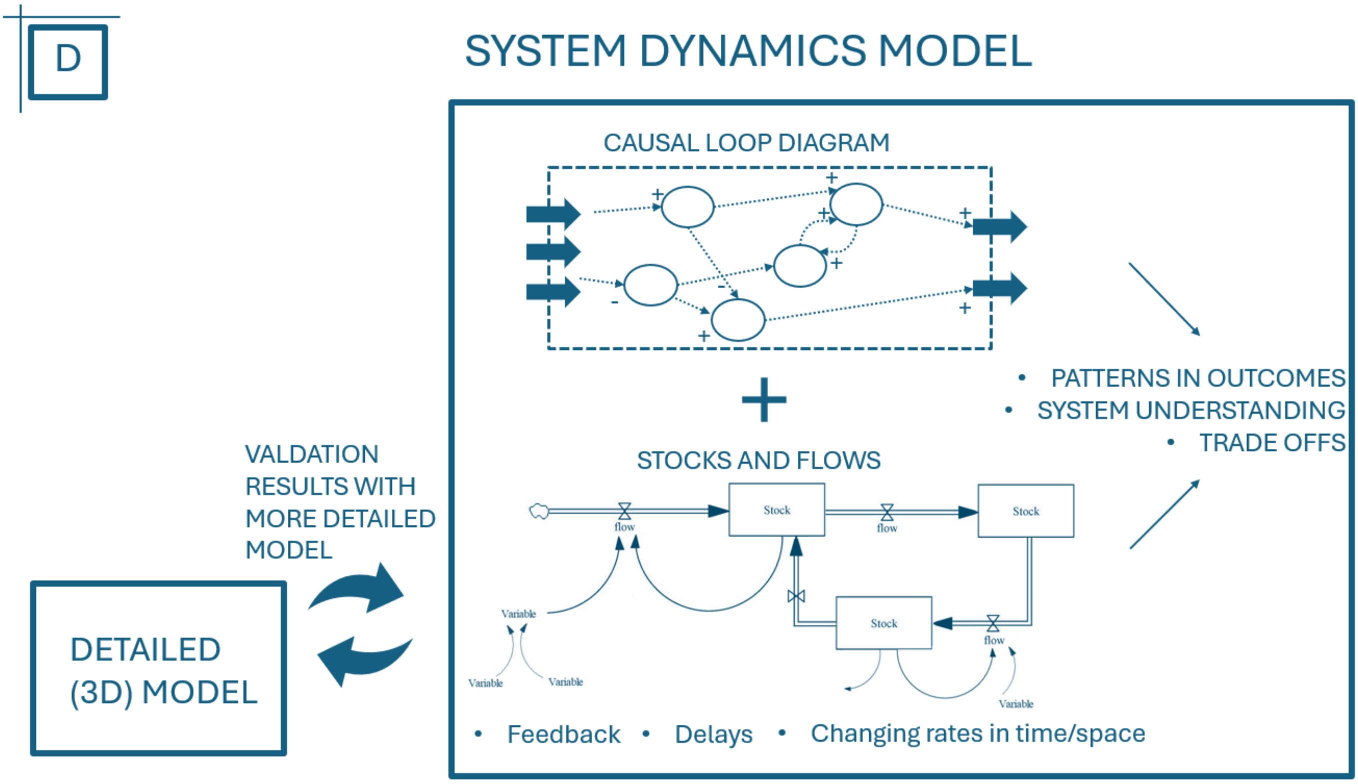

Figure 4.7: Schematic representation of concept D: the system dynamics model.

Additional concept
During the workshop group 1 responsible for designs A&B, the left side of the quadrant, noted their concept A: "the bakjes model" was rather aggregated as it is a conceptual representation of the Netherlands. Therefore they argued the concept is closer to the middle as opposed all the way to the left on the aggregation axis ranging from detailed (l) to conceptual (r). In the subsequent discussion it was suggested to add a fifth concept that would be more detailed. Figure 4.8 shows the modified design space including the adjustment of concept A and the addition of concept E.

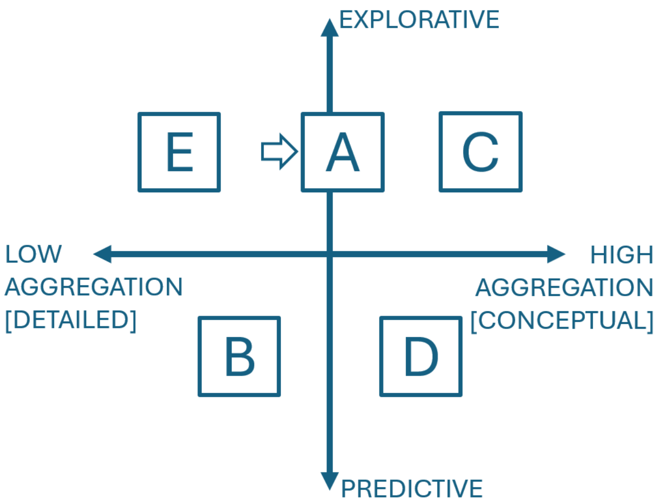

Figure 4.8: Design space with concept E.

Concept E

Concept E is detailed and explorative meaning the user has a substantial opportunity to explore in detailed information. Therefore an extensive web portal was proposed giving the user opportunity to explore through the material provided through the portal in a structured way. A schematic representation of the concept is shown in Figure 4.9. The materials available would be a collection of output produced by studies including detailed models (like Delft 3D) and other research that can be validated with detailed models. Additionally, one could also think of an overview and description of relevant models that are currently or have been used and similar knowledge bank subjects that add to the shared expertise that exists in the Netherlands. Accordingly users have a library of relevant, organized and detailed materials. However, there is no interaction between these materials and the users will require considerable background knowledge to understand the relations or lack thereof between the materials amidst and between the materials and the problem analysis they are conducting. To complement the properties table used for the other concepts, the computational time would be zero as the material are readily available through the portal.

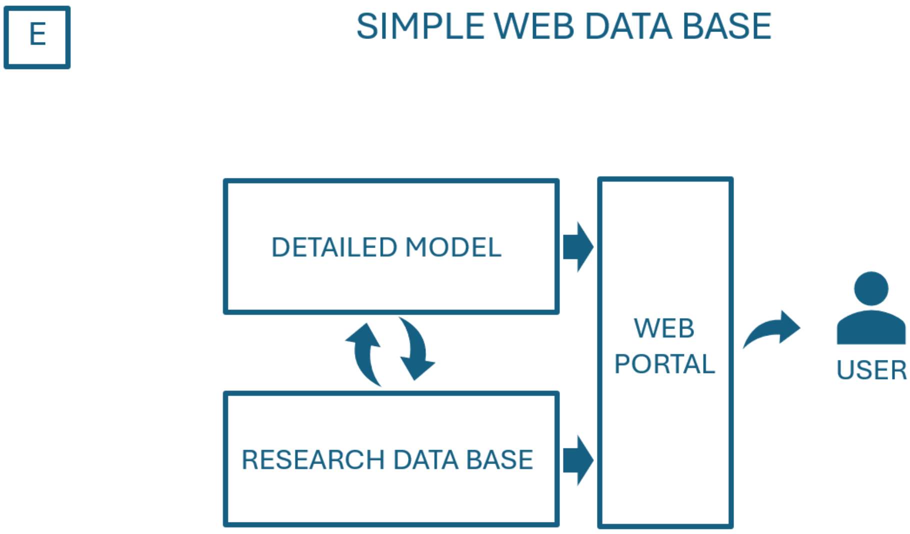

Figure 4.9: Schematic representation of concept E: wab database.

4.3.3. Challenge 3: reflection

The workshop concluded with the reflection on the design space and it's potential for a 'Deltaverkenner' by the participants. Figure 4.10 shows the rewarded votes to the concepts. Evidently, the right side of the coordinate system is favored over the left side. Furthermore, the participants seem to agree on the left upper corner being the least adequate concept space for the 'Deltaverkenner'. In the motivation behind the votes participants note the detailed&explorative combination seems very hard to accomplish and additionally it is noted such a tool would not add much when tools from all the other corners are available. Many of the participants motivate their positive votes for the bottom left, the detailed&predictive corner, because they see it as a prerequisite to tools on the right side of the coordinate system. They note it is needed for trust and call it a "basic need" stating you first need to understand the system before you can aggregate it.

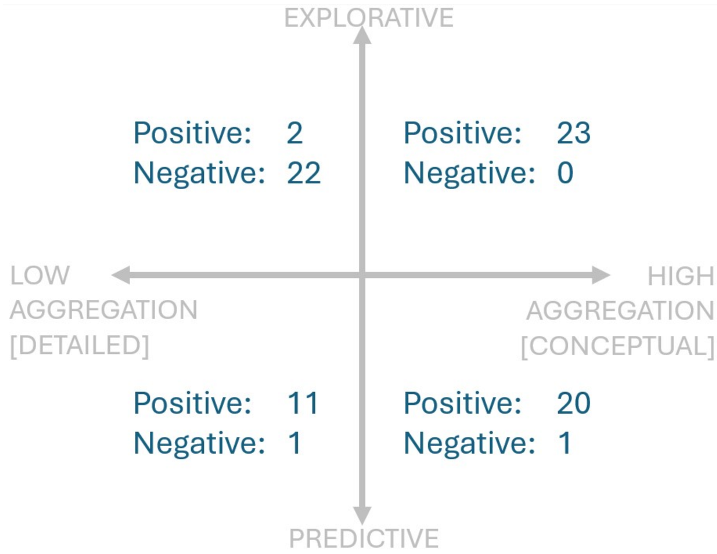

Figure 4.10: Votes for favorite concepts by the design workshop participants.

4.4. User workshop

In the User workshop the different design concepts from the previous section were presented. Subsequently the participants were asked for their opinions on them. As described in the methods section 3.4.1 the participants were given a form with which they could indicate their preferences on the designs made in the design workshop. This section presents the results from these forms. There where 20 form responses in total. Unfortunately, not every form was completely filled out as some participants chose to not answer every question. No forms where omitted, since most results are averages or give an indication on the opinion of a participant independent of other responses. The following results are thus an overview of all the responses that where filled out.

Associated fields of expertise
The first question on the form asked with which discipline the participant has the most affinity with the option of choosing from fresh water, flood safety, ecology& water quality, spatial adaptation and other. Of the 20 responses, 12 participants selected fresh water, 9 for flood safety, 6 for ecology & water quality and 3 for spatial adaptation. Those who selected the other category commented ”model-based decision-support”, ”economy” and ”integrated water management (including shipping)” as (additional) expertise. Prior to the workshop, in response to the invitation to the workshop, 5 respondents identified themselves as a researcher, 20 translate research to policy and 3 identify as decision makers. This gives an indication of the proportions of actors types present at the workshop.

Concepts
Regarding the various concepts, the form asked the participants to indicate what appeals to them or what deters them considering the concepts and with a grade from 1-5 to what extend the concept enriches their work environment. The following Tables 4.3 through 4.7 show the responses per concept.

Table 4.3: Summary of user workshop responses on concept A.

Concept A: The 'bakjes model'		
Property	**Appeal**	**Deter**
Detail level	8	2
Computational time	16	0
Interaction level	14	2
Goal/Application	6	2
	Average grade:	4.06

Table 4.4: Summary of user workshop responses on concept B.

Concept B: Detailed model		
Property	**Appeal**	**Deter**
Detail level	11	2
Computational time	0	12
Interaction level	0	12
Goal/Application	6	2
	Average grade:	2.78

Table 4.5: Summary of user workshop responses on concept C.

Concept C: Game with cards		
Property	**Appeal**	**Deter**
Detail level	3	4
Computational time	4	1
Interaction level	11	2
Goal/Application	5	2
	Average grade:	2.59

Table 4.6: Summary of user workshop responses on concept D.

Concept D: System dynamics model		
Property	**Appeal**	**Deter**
Detail level	8	0
Computational time	9	0
Interaction level	8	1
Goal/Application	10	0
	Average grade:	4.13

Table 4.7: Summary of user workshop responses on concept E.

Concept E: Web database		
Property	**Appeal**	**Deter**
Detail level	2	4
Computational time	4	1
Interaction level	4	6
Goal/Application	6	2
	Average grade:	2.29

The tables show that concepts A and D, the ”bakjes model” and the system dynamics model, have a high quantity of appeal property votes. In contrast, concept B the detailed model, has a high number of deter votes. Concepts C and E score in both appeal and deter categories however not with very high scores except for the interaction property for concept C with is scored considerably appealing.

The previously mentioned reflections regarding the appeal or deterrence of the concepts is supported by the overall scores for the concepts displayed in Table 4.8 and vizualized in Figure 4.11. This table has two types of grades on the overall concepts. The first grading is the 1-5 grade for work environment enrichment described above that has been given per concept. The second grading is an average of the ranking given for each concept when asked to rank them from most appealing to least appealing. As shown in Table 4.8 concept D: the system dynamics model comes out as favorite, closely followed by concept A: the "bakjes model". Both grading systems give approximately the same ranking order.

Table 4.8: Ranking of all the concepts based on two scores; the overall ranking of all concepts (1=most appealing, 5=least appealing) and a grade (1 to 5) for each concept.

Ranking of the concepts		
Concept	**Ranking** [1=most, 5=least]	**Grade** [average out of 5]
D: system dynamics model	1.74	4.13
A: "bakjes model"	2.14	4.06
B: detailed model	3.40	2.78
C: game with cards	4.00	2.59
E: web database	3.74	2.29

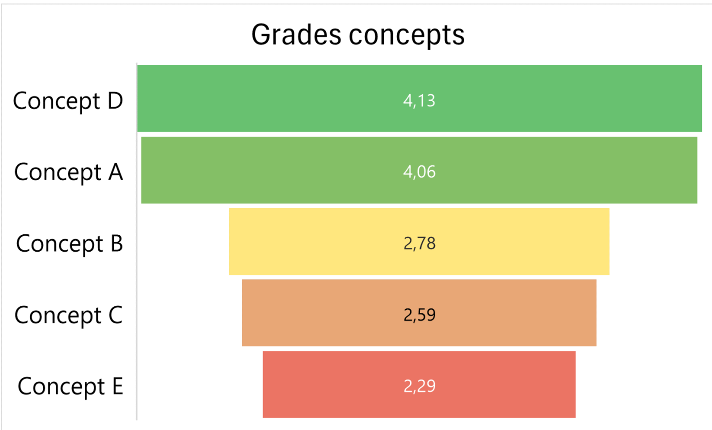

Figure 4.11: Visualization of grading (average out of 5) of the concepts by the user workshop participants.

Additional to the questions regarding the concepts, the form asked general questions regarding the needs for the 'Deltaverkenner'. The participants were asked to rank the potential properties and goals of the 'Deltaverkenner'. The results are shown in Tables 4.9 and 4.10 respectively. For visualization see Figures 4.12 and 4.13. From these results it is clear that *Ease of use* and *Short runtime* are preferred properties over *High accuracy*. Furthermore, *System knowledge* and *Dialogue* are preferred goals over *Learning as user* and *Generate exact data*.

Table 4.9: Ranking of the most important properties', [1=most important, 3=least important].

Property	**Average ranking**
Ease of use	1.44
Short runtime	1.88
High accuracy	2.69

Table 4.10: Ranking of the most important goals, [1=most important, 4=least important].

Goal	Average ranking
System knowledge	1.56
Dialogue	1.94
Learning as user	3.19
Generate exact data	3.31

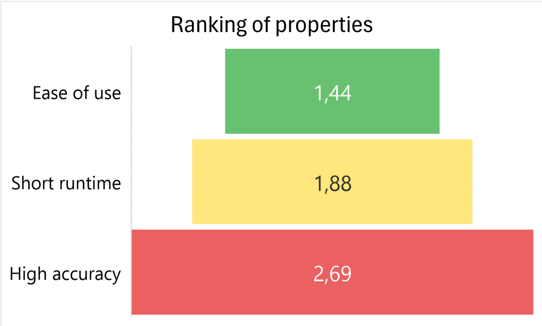

Figure 4.12: Visualization of ranking of the properties [1=most important, 3=least important] for the 'Deltaverkenner' according to the user workshop participants.

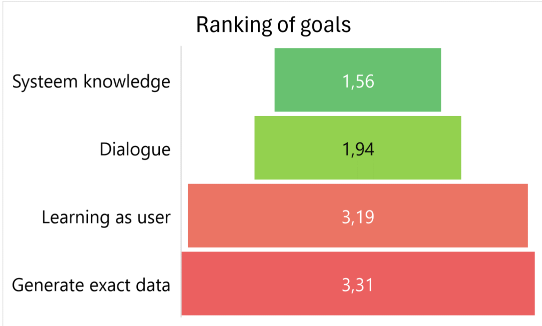

Figure 4.13: Visualization of ranking of the goals [1=most important, 4=least important] for the 'Deltaverkenner' according to the user workshop participants.

Design space

Lastly, the participants where asked to mark a location on the design space axes from the Design workshop at which they think is the most potential for a 'Deltaverkenner'. Important to note is the relation of the concepts to these axis where not disclosed. Thus the participants where asked to mark on a empty coordinate system. The heat map in Figure 4.14 shows an preference for the upper right corner of the design space. The numbers in the heat map indicate the amount marks made by the participants in the coordinate system in that segment. Some participants made two marks, which were counted as two half points, explaining the .5 numbers. Next to the heat map the layout of the concepts in the design space coordinate system is shown again. When compared to the heat map, concept C aligns most with the most favored segment of the design space according to the participants responses.

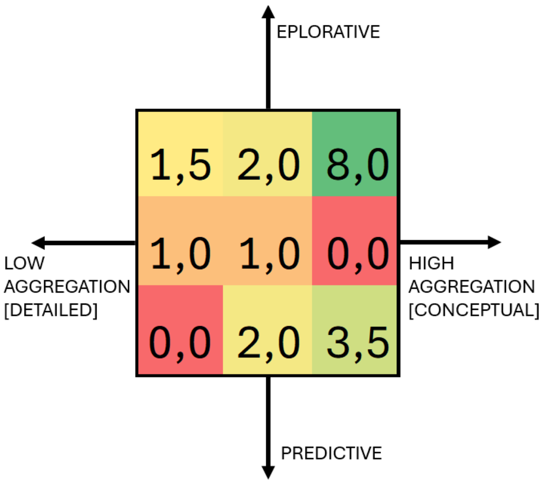

Figure 4.14: Heat map of marks in coordinate system indicating most potential for the 'Deltaverkenner'.

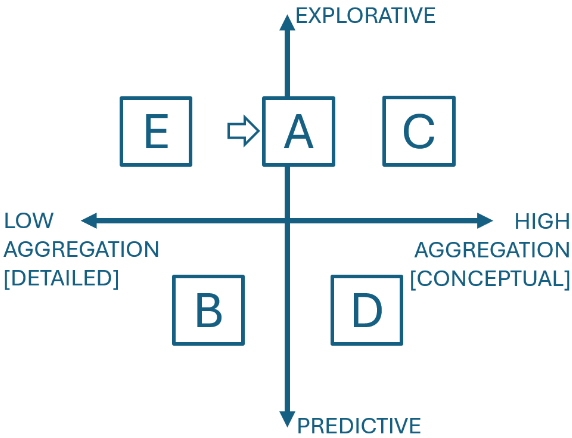

Figure 4.15: Layout of the concepts in the design space coordinate system.

This completes the straightforward presentation of the outcomes of the research. The analysis and discussion follow in the next chapter. To summarize the results presented in this chapter, first, the expert consultation section provided context to the ’Deltaverkenner’ by gathering relevant experiences, challenges and learning points from experts involved with decision support tools for CCA policy for the Dutch delta. Additionally, this section elaborated other relevant remarks or observations from other participants during the research activities.

Next, the stakeholder interviews section elaborated on the needs from a tool like the ’Deltaverkenner’ from three different types of stakeholders, the commissioner, the policy analyst and the researcher. The needs can be divided into two categories. The substantial needs describing the measures, scenario’s and outcomes required to answer long term integral policy questions. The second category, needs for the use of the tool, describe how, by whom and when the tool should be used.

In the design workshop section the results where presented from the three challenges imposed on the participants. In the first challenge the axis of the design space to to diverge the different concepts where decided on. The second challenge was to design different concepts which where reflected upon in the third challenge. The workshop resulted in five various design concepts for the ’Deltaverkenner’; the ’bakjes model’, the detailed model, the game with cards, the system dynamics model and the web data base.

The last section of the results chapter presented the results of the user workshop in which the aforementioned concepts where evaluated. The participants specified for each concept a grade and evaluated what appeals or deters them about the concept. Additionally, the design space in general was evaluated including the optional goals and properties of the ’Deltaverkenner’.

The conclusion that can be drawn from these results will be discussed in the next chapter.

5 Discussion

This chapter provides the analysis and discussion of this thesis using the theory presented in Chapter 2. First, the results obtained trough the research activities, presented in the previous chapter, will be discussed. Next, the findings will be analyzed in relation to the theoretical framework presented section 2.3. The chapter concludes with an evaluation on the aforementioned framework.

5.1. Discussion of results

The results from this thesis are divided in four components based on the previous chapter. For reference to the results discussed see section 4.1 for Experiences, Needs and Design in sections 4.2 and 4.3 respectively and Evaluation in section 4.4.

5.1.1. Experiences

The results present three instances of models being used to inform policy decisions: the PAWN study, an impact analysis for IRM and the Delta model. In each case, through the use of multiple models, the results were used to inform national policy. Though none of these models were designed as quick decision support tools, the experiences using them at the science and policy interface can be valuable to the current challenge at hand for the 'Deltaverkenner'.
The main insight from these experiences is that success of the tool is not necessarily dependent on how well it aligns with the intended substantive specifications. Both the Delta model and the IRM model successfully achieved what they set out to do, to support national policy analysis. However, they both faced issues that reflect more on the process surrounding the tools. The IRM study results did not agree with the conceived idea at that time about the preferred course of action regarding the policy that was already accepted in the preparation of the subsequent policy plan. This timing issue, of the decision process not lining up with the information supply, led to doubts on the legitimacy of the study. The Delta model had acceptance from the stakeholders involved because of its high level of detail. Unfortunately, this made the run time of the model very long making it cumbersome to work with. Additionally, due to the demand for this model coming from the commissioner and not from the intended users, the stakeholder engagement was strained as well. In contrast, the PAWN study had no stakeholder engagement plan, however its process and outcomes were well received. The context and process surrounding the tool and how they add to the credibility, legitimacy and saliency are arguably just as important as the tool itself.
Another shared insight from the experiences with these models is the dilemma of the level of detail. Each conversation about these models had an instance of more detail required by experts versus less detail required by policy actors. Arguably, these are the roles that each of these actors brings to the table in any science-policy interface interaction. However, finding the right balance where the results are sufficient for the analysis without compromising on the use of the tool is a balancing act that decision support tools need to navigate.

5.1.2. Needs

The integral long-term policy questions that were put forward in the stakeholder interviews can be grouped in two categories for this analysis; engineering-focused and social impact-focused. The engineering-focused policy questions aim to answer engineering solutions for CCA issues that the Netherlands is facing. These include the strategies for the Rijnmaasmonding like the (open, semi-open closed) strategies from Knowledge Program Sea Level Rise, replacing and or elaborating hydraulic structures and flood defenses. Furthermore, they include water division strategies for different discharges including the IJsselmeer lake level strategy. On the other hand the social impact-focused strategies aim to synthesize impacts of strategies on livability, housing, nature, agriculture, etc. mostly by changing land-use.
These policy questions resulted in a wide range of functional requirements for the tool, many of which are incompatible with each other, especially when attempting to consolidate them into a sigle tool. Especially regarding the scales in both time and space, the answers span the whole spectrum. This can be expected as the interview protocol was very open and blank to encourage the interviewees to define their own needs for a 'Deltaverkenner' tool without being influenced by the protocol. This shows the need is diverse and can be defined in multiple ways depending on the demarcation of users of regions or issues.
Interestingly, the aforementioned categories impact the associated input and output functional requirements, with input meaning measures and scenarios that have effect on the system and output meaning the outcomes that result from the system. When answering engineering policy questions there was more ease in defining the input elements compared to relating the outcomes to the social impacts. In contrast, the societal impact questions have well defined social impact outcomes but are less sure of the measures and scenario's that are needed for analysis. Additionally, the commissioner type focused most on engineering questions, the researchers on social impact questions and the policy analyst on both. This could be explained with the current need to analyze these engineering questions as these strategies are reviewed in the Delta program with herijking, though the number of participants is too low to draw definitive conclusions from this. Perhaps the overall need and simultaneous complex challenge for the 'Deltaverkenner' is to get more insight into connecting these engineering problems with the social impacts and vice versa.
Regarding the use of the model, the participants all agree on a quick and map-associated tool. There is no consensus on who should be the user of the tool (policy actors, experts, both in combination).

5.1.3. Design

The design workshop resulted in five diverse concepts spanning the design space on the axis of low to high aggregation and predictive to explorative. The workshop was an attempt to make this space more concrete to be able to get users' perspectives on it later on in the research.
An important note that was emphasized in the preliminary discussion to the design assignment was the importance of trust in the tool. Within this discussion trust was expressed in two ways. The first being trust in the outputs (credibility). Possibly, as a result of this notion, all designs include a validation step with a detailed model. In the reflection at the end of the workshop the validation with detailed models was noted and agreed upon by all participants as a vital part of these concepts.
Another requirement for trust mentioned in the preliminary discussion was the importance of stakeholder involvement and or participation to ensure they feel heard. The designed concepts are a combination of a "tool" and a description of the network interaction that accompanies it. In the case of concepts A and D, the 'bakjes model' and the system dynamics model, the tools are quite similar on the aggregation criteria. However, concept A includes an iterative network cycle with user feedback and interdisciplinary discussion between researchers, and is thus assessed to be explorative instead of predictive. This however fuzzies the distinctions of the allocation within the design space a bit, since adding the network cycle to the system dynamics model instead would make concepts A and D interchangeable.
Another possible way of spanning the design space would have been to use one tool idea and expand the concept in multiple ways, with, for example, network interactions to bring it to a position in the coor-

dinate system. However, not every tool is suited for all applications in this design space. For example, to satisfy both a conceptual and a detailed level of aggregation is hard to accomplish with the same tool.
If more time had been available for both workshops, or perhaps in further research, a suggestion would be to have a three-dimensional design space. In this design space it would be possible to put more emphasis on the nuances in the concepts by for example having the exact same tool with different implementations of interaction. The predictive vs explorative axis used in this workshop encapsulated both opportunity for interaction between user and tool to explore more queries and the opportunity for users to learn or be involved. These could be split into two separate extra dimensions.
Regarding the reflection of the participants' on this design space, it is clear they prefer the 'Deltaverkenner' to be on the conceptual side of the used coordinate system provided it is validated with a detailed model from the left bottom corner. This might suggest a combination of two concepts with a detailed model as a basis, with a 'scanning' tool on top of it to explore and learn.

5.1.4. Evaluation

From the results of the user workshop three preliminary conclusions can be drawn. The first conclusion is that a fast and easy to use tool that gives insight into system knowledge and facilitates dialogue is preferred over a tool with high accuracy that enables users to learn or that can generate exact data. Clearly, a(nother) complex and comprehensive tool that takes a long time to compute is not what fits stakeholders needs for this problem. This is backed up by the bottom left corner of heat map of the coordinate system getting the lowest scores. Moreover, the concept that best fits that description, concept B: the detailed model, does not have high scores for the ranking of the concepts. Though it does not have the lowest ranking being the third out of five. This can be attributed to the same reasoning that explains the voting of the of the participants at the design workshop; the detailed model is needed to support any higher conceptualized model. Indeed, the remarks given about the model in the user workshop form say similar things; "good basis for other applications" (UW-5), "is important, but the need lies more in integrated quick impact assessment tools" (UW-1), "together with aggregated model" (UW-2), and so on. The favored properties (quick, easy to use tool for system knowledge and dialogue) are also the properties that got the most appeal votes in the concepts that were ranked highest and also the deterring factors in the ones that were ranked lower.
The second preliminary conclusion is the preference for concepts A: the 'bakjes model' and D: the systems dynamics model. They score highest in the ranking categories, the system dynamics model even more so than the 'bakjes model'. A reason for the system dynamics model scoring slightly higher might be that it is able to include more spatial elements, nature and economics, which is mentioned in the remarks about concept A: the'bakjes model'; "falls short in including spatial adaptation, ecology and nature" (UW-17) and "limited focus on social impacts spatial meaning" (UW-1). Additionally, the remark on concept D: system dynamics model reiterate these: "sounds like an improved version of A, capturing more integration" (UW-14), "Enriched version of A" (UW-17), "because of the feedback between human and system" (UW-19). Both concepts score the same on the detail level property. On computational time and interaction level, concept A: the 'bakjes model' gets more appealing votes. Interestingly, the description of the computational time is exactly the same for both models. The interaction level is higher for concept A: 'the bakjes model', which can explain the higher appealing votes count. Lastly, the goal/application of concept D: the system dynamics model is favored, which is 'exploring system knowledge, relation processes and humans' over 'interaction researchers, exploring building blocks and trade-offs'.
The last preliminary conclusion is regarding the most potential for the 'Deltaverkenner' marks in the coordinate system heat map. As aforementioned, the combination of detailed and predictive (left bottom) has the least potential according to the heat map. The explorative conceptual corner (right top) has evidently the most potential, followed with some distance by predictive conceptual (right bottom) and thereafter explorative detailed (left top). Interestingly, when compared to the allocation of the concept in the design space made in the design workshop this does not correspond to the previous results. In particular concerning concept C: game with cards. Which brings about the outlier in all results from the user workshop. Concept C was the concept designed for explorative conceptual which is the highest scoring corner in the heat map. However, concept C is the lowest scoring concept in the concept ranking scores, and the second lowest scoring on average concept grade. Compared to the other low

scoring concept, concept C actually has quite a lot of appealing votes and average deterring votes. Especially, the interaction property is liked about concept C. Even though concept B: has high deterring votes for both computational time and interaction level, it still scores higher in the ranking than concept C. Two remarks can be made on this anomaly. The general concept of a game with cards might be unfamiliar to the stakeholders especially when compared to the conceptual models that simulate systems (concepts D&A). Secondly, *learning as a user* as goal for the 'Deltaverkenner' tool got a low score in the goals ranking. 'Learning of the system, exploring system and human decisions' is the description of the goal of concept C. Thus the learning component of the goal might have had a deterring effect. However, concept C got 5 appealing votes versus 2 deterring votes for the goal/application category. In the remarks left about the concept two unfavourable comments come up; "you first need a basis with a clear need" (UW-1), "you first need other models" (UW-8) and "only as presentation option" (UW-2), "is expendable" (UW-5). Though a high interaction level is favoured in the properties scores, goals scores and heat map, it seems this interaction is deemed to be needed at the point where conceptualization is happening and not after the conceptualization has taken place.

5.2. Analysis results using theoretical framework

This section analyses the findings with the theoretical framework presented in chapter 2 section 2.3. The framework identifies tensions and factors to consider for a successful, science-policy interface bridging decision support tool and divides them into four categories; process, content, goals and use.

Content and use

Let's first consider the content and use categories. The tension and factors to consider in these categories of the framework are recognized and confirmed in the findings of this thesis. In the stakeholder interviews, the needs and requirements for these elements of the 'Deltaverkenner' were inquired. Regarding the substance requirements the obtained results show the need is diverse and can be defined in multiple ways depending on the demarcation of users of regions or issues. However, overall, the needs indicated measures and impacts of these measures tailored to an specific objective from a integrated point of view that could be compared which is in line with the content factors of the framework. Regarding the use of the 'Deltaverkenner', interviewees expressed a need for a fast, easy to use interface tailored to the user in mind that can facilitate immediate response to the users (evolving) inquiries, again in line with the framework. The expert consultations, specifically on the Delta model, recognizes the framework's factor of internal consistency, stressing the stipulation for the simplest model needed for adequate analyses preventing complex comprehensive models with unmanageable long computation time. During the design workshop attention was given to these aforementioned tensions by choosing the axis; explorative vs predictive and low vs high level of aggregation. The first axis was designed to deal with the tension of the requirement to build trust in the tool through interaction and participation, which look different for different types of actors, where 'explorative' offers engagement with the tool to learn and explore options. The latter axis was designed to deal with the tension of complex, exact, comprehensive tools that have extensive computation time (low aggregation) versus quick, flexible, aggregated tools (high aggregation). Participants of both the design and user workshop indicate strong preference for the high aggregation (conceptual) side of the design space for the 'Deltaverkenner'. The preference for explorative over predictive is also expressed by participants in both workshops though less definitive, even more so among the design workshop participants. More specifically, the user workshop participants indicated preference for a fast and easy to use tool that give insight into system knowledge and facilitates dialogue. This preference is compared to a tool with high accuracy that enables users to learn while using it or that is able to generate exact data.

Goal

Now let's consider the goal category from the theoretical framework. According to the framework the goal of the DST should be to be process oriented, facilitate learning, enhance stakeholder engagement and create common information and knowledge base. The findings from the user workshop are that *Obtaining system knowledge (more insight into processes)* and *Creating dialogue space for different users* are the most important goals for the 'Deltaverkenner'. *Generating exact data for new measures*

and scenario's and *learning as user through usage of the tool* are not seen as important goals for the 'Deltaverkenner' according to the user workshop participants. Comparing these findings to the framework indicates foremost that the user workshop participants agree the goal of the 'Deltaverkenner' should be to provide common information and knowledge base as well as to enhance stakeholder engagement. This is backed up by statements from participants during the workshop like "The development of a tool is not the goal, the goal is to connect to (new) target groups" (UW-5). Additionally, another statement indicates the recognition of the process oriented goal; "First the goal and target group and application (specific program) need to be defined and after an appropriate model or procedure can be devised" (UW-18). And similarly, in the stakeholder interviews; "The timing of decision making process is important. You don't want decisions being made at different times and places" (SI-C-2). Where the findings of this thesis on the goal of the 'Deltaverkenner' and the theoretical framework differ is the DST goal to facilitate learning, as the participants in the user workshop rate that in a unimportant goal. On the other hand, the user workshop participants do find the generation of system knowledge important where the framework does see this as a goal for DSTs. There are two possible explanations for this. The first is the participants believe the DST should create more knowledge on the system in order to help support decision making. This is in contrast with was literature has shown. A second explanation is a difference in perception of the word learning, where the stakeholders believe the goal of the DST should not be to have a learning tool that teaches the user. Rather they want it to show and or communicate what they have already learned, which is the system knowledge gained.
The previous discrepancy might also be connected to the different perceptions of actor types. Of the user workshop participants most identified best with the role of translating research to policy. Looking at this participants group as policy analyst gives a new perspective on the findings. As noted by SI-PA-2 policy analyst want to 'play' with model to gain system understanding whilst a higher aggregation level is required for decision makers. This can explain the preference for *obtaining system knowledge* compared to *learning through use of the tool*. Moreover, another discrepancy in the findings of the user workshop might be associated with this actor type perception incompatibility. The preferred tool concept for the 'Deltaverkenner', according to the user workshop findings, is concept D: the system dynamics model or optionally concept A; the 'bakjes' model. Neither of these concepts is described as both explorative and conceptual in the design space which is the most promising area according to the same participants. Again the discrepancy in these finding might be explained by policy analysts preferring a tool that can is suited to give more insight into to system. However, they do realize a tool that facilitates learning and is truly explorative and conceptual is best suited for a decision maker. More research is needed to better understand the needs from decision makers and to better define the needs for the goal of the 'Deltaverkenner'. An important remark is that even though the user workshop participants were underrepresented in the decision maker or political actor types, the group was representative of the policy process domain of the Dutch water sector. Therefore, for the 'Deltaverkenner' to be successful, this group must also see the tool as salient, credible and legitimate since trust is needed from this sector.

Process

The last elements of the framework to consider are the process category. Though this thesis did not actively ask for the process needs and requirement of this tool, a lot of factors noted in the framework were corroborated in the findings. For example; "The tool is only an instrument, everything depends on what you want to do with it/who you want to connect with" (UW-6), "You need to define the problem clearly for which the 'Deltaverkenner' will be the solution. From black box models to communicating key variables and system knowledge and quickly make options insightful to a broader target group" (UW-12), "First the goal and target group and application (specific program) need to be defined and after an appropriate model or procedure can be devised" (UW-18) and lastly, "The timing of decision making process is important. You don't want decisions being made at different times and places" (SI-C-2). More importantly, the expert consultation findings clearly demonstrate the importance of the process factors for a successful DST. As mentioned before, the context and process surrounding the tool and how they add to the credibility, legitimacy and saliency are arguably just as important as the design and substance of the tool itself. Going forward, the process elements that fit this particular decision making process need to be explored further.

Additional dilemma's

The theoretical framework provides a reflection on the findings of this research. Many of the framework considerations and the findings presented in this thesis align. There are some particular dilemmas that appear more urgent in the findings compared to the framework. The first is the dilemma between a quick tool on the one hand and, on the other, the level of detail required or validation with more detailed models to deem the outcomes credible. This 'complexity vs speed' trade-off is a dilemma between credibility (trust in the results) versus saliency (timing and or usefulness of the information). It is also a tension between different roles, where the scientist and policy analyst have different needs and perspectives on the dilemma. The complexity vs speed' trade-off can be added to the framework in the content category to accentuate this dilemma. Additionally, the framework points out that it is important to engage different perspectives and different types of actors possibly with different backgrounds whilst simultaneously tuning the interface to the needs of the users. As is pointed out before, different types of actors have different needs and perspectives and therefore one interface that maximizes the usefulness for all types of users is challenging. This dilemma between flexibility and usability could also be added to the use category of the framework.

6
Conclusions

This thesis aimed to explore, synthesize, and evaluate designs for a decision-making support tool for water governance contributing to climate change adaptation in the Netherlands that best fits the needs of the stakeholders involved. To do so, it took an informed, iterative, co-production approach based on stakeholders' needs in collaboration with stakeholders and experts. Subsequently, the potential designs have been evaluated by the stakeholders. This process was informed by the lessons learned from the application of previous decision support tools from the water governance and climate change adaptation science-policy interface. Additionally, the findings are analyzed in comparison to a theoretical framework based on literature on requirements for successful DSTs and trade-offs to consider from the SPI. The following sections will discuss the answers to the sub- and main research questions and subsequently the limitation and recommendations.

6.1. Answers research questions

6.1.1. Sub-research questions

1. What examples of decision support tools are, or have been, used at the science-policy interface of the Dutch water governance and climate change adaptation domain and how were they used?

The results present three instances of models being used to inform policy decisions; the PAWN study, an impact analysis for IRM and the Delta model. In each case, with the use of multiple models national policy was informed.
The main insight from the experiences of experts involved with these models is the fact that the success of the tool is not only dependent on how well it matched the substantial specifications (content and use of the DST) required by stakeholders. The context and process surrounding the tool, and how they contribute to the credibility, legitimacy and saliency, are arguably just as important as the tool itself.
Another shared insight from the experiences with these models is the dilemma regarding the level of detail, as each of these models had an instance where more detail was required by experts versus less detail required by policy actors. Arguably, these are the roles that each of these actors brings to the table in any science-policy interface interaction. However, finding the right balance, where the results are sufficient for the analysis without compromising on the use of the tool, is a balancing act that decision support tools must navigate.

2. What do stakeholders need in a water governance decision support tool contributing to climate change adaptation in the Netherlands?

The needs for the 'Deltaverkenner', as defined in interviews with multiple stakeholders, are diverse and can be defined in multiple ways depending on demarcation of users of regions or issues. Several integral long-term policy questions were put forward in the stakeholder interviews. These can be categorized in two categories; engineering-focused and social impact-focused. The engineering-focused policy questions aim to provide engineering solutions for CCA issues that the Netherlands is currently facing, while social impact focused questions aim to synthesize impacts of strategies on livability, housing, nature, agriculture, and more. The overall need might be for the 'Deltaverkenner' to provide more insight into connecting these engineering problems with the social impacts and vice versa. The policy questions resulted in a wide range of functional requirements for the tool, which are challenging to incorporate into a single tool. This is particularly true when considering the different the scales in both time and space as the proposed requirements span the whole spectrum. Regarding the use of the model, the participants all agree on the need for a quick and map-based tool. However, opinions are divided on who the primary user of the tool should be - policy actors, experts, or both in combination.

3. What designs are possible for a water governance decision support tool contributing to climate change adaptation in the Netherlands?

While the whole range of designs for a water governance decision support tool contributing to CCA in the Netherlands is limitless, the design workshop resulted in five diverse concepts spanning the design space on the axes of low to high aggregation and predictive to explorative. A low level of aggregation means a detailed tool and a high level of aggregation means a conceptual tool. Explorative offers engagement with the tool to learn and explore more options and predictive provides (rigid) information and predictions. All concepts have validation with (more) detailed models designed into them to ensure trust. In summary the models can be described as follows.
Concept A: the 'bakjes model' is explorative and in the middle on aggregation. It is based on a simple reservoir model. Additionally, the model interacts iteratively with a group of diverse researchers. It is described as quite detailed, low computation time, and offers possibilities to explore multi-disciplinary trade-offs.
Concept B: the detailed model is detailed and predictive. It is based around detailed and extensive (2D+3D) model(s) that produce regional data on a variety of impacts and that are able to run multiple scenarios. It is described as; interaction possibilities are few not and flexible, the computation time is long and the findings are complex.
Concept C: game with cards is conceptual and explorative. The idea of concept C is a game with cards that is played by the user(s) focused on reactions by the system and other players on measures implemented. The game is particularly suited to focus on trade-offs or dependencies in the system and human interaction and has no computation time as it is live.
Concept D: the system dynamics model is conceptual and predictive. It is a more sophisticated version of a reservoir model based on a causal loop diagram of the system that includes all causal dependencies of the system. The computation time is short, and interactions possibilities are fairly high. It is especially suited to gain system knowledge on dependencies and human interaction.
Concept E: web database is detailed explorative. It is an extensive web portal giving the user opportunity to explore through the collection of varieties of different outputs produced by relevant research studies or projects.

4. Which design for a water governance decision support tool contributing to climate change adaptation in the Netherlands is preferred by stakeholders?

From the results of the user workshop, three conclusions can be drawn. The first conclusion is that a fast and easy-to-use tool that gives insight into system knowledge and facilitates dialogue is preferred over a tool with high accuracy that enables users to learn or that can generate exact data. The second conclusion is the preference for concepts A: the 'bakjes model' and D: the systems dynamics model. They score highest in the ranking categories, the system dynamics model even more so than the 'bakjes model' as it is able to include more spatial, nature and economic elements. The last conclusion is the explorative conceptual design space area has the most potential for the 'Deltaverkenner' according to the participants of the user workshop. Interestingly, the previous two conclusions do not support each other, as concepts D and A are not considered conceptual and explorative. Concept C, however is, but it received the second-to-lowest scoring of all concepts. Two remarks can be made on this anomaly. The general concept of a game with cards might be unfamiliar to the stakeholders, whereas they are familiar with and might prefer using models similar to concepts D and A. The second remark has to do with the interpretation of *learning* as goal for the 'Deltaverkenner' where different understandings of how and by whom learning should occur might explain the discrepancy.

6.1.2. Main research question

"What do stakeholders perceive as a fit for purpose design for a water governance decision support tool contributing to climate change adaptation in the Netherlands?"

By answering each of the four sub-questions, the main research question can now be addressed. The findings show a consensus for a quick and aggregated tool, preferably a conceptual model like a system dynamics model or a reservoir model. This tool should be able to provide insight into the impacts (both water system related and societal impacts, such as nature, agriculture, and economics) of strategies like the 'voorkeursstrategiën' for the Delta program. It is also clear there is no desire for a computationally detailed model. There seems to be enough existing knowledge. The challenge is to find a way to aggregate and integrate this knowledge into a quick, easy-to-use, informative tool that offers considerable interaction opportunities in the form of dialogue between different users as well as feedback between users and tool while providing system knowledge.
Perhaps this could be fulfilled by the concepts D: the system dynamics model or A: the 'bakjes model' described in this thesis. However, there are two remarks that should be noted. First, a detailed model is required for validation and for informing the conceptualized tool and building trust in the data. Additionally, there seems to be interest in more explorative elements that offer interaction in the forms of dialogue and feedback, and system knowledge. These elements could be elaborated into tool concepts like D or A, or the solution could be an additional level in an overarching tool.
The findings where analyzed on the basis of a theoretical framework that identifies important considerations for a successful decision support tool able to bridge the science-policy interface. The framework includes dilemmas and factors to consider on the content, use, goal and process of decision support tool. Most of the empirical finding of this thesis are in agreement with the theoretical framework, especially regarding the content and use elements of the framework. For each of these categories an additional dilemma is suggested based on the findings of this thesis. The 'complexity versus speed' dilemma could be added to the content category of the framework, describing the trade-off between the level of detail or validation needed for trust in the results (credibility) versus speed of the tool to ensure adequate timing and usefulness of the information (saliency). Moreover, the trade-off between taking into account different perspectives and different types of stakeholders whilst also tuning the interface to the needs of users called the 'flexibility versus usability' dilemma, could be added to the use category of the framework. Regarding the goal and process elements the findings and the framework are in agreement, however more research is needed going forward to further specify the needs from stakeholders in these regards.

6.2. Limitations

The research and its overall methods also have limitations, which are elaborated in this section. First of all, this is an initial step in exploring the need for a tool like the 'Deltaverkenner' and what that need entails. This means no definitive conclusions for the design of the 'Deltaverkenner' can be derived from the results since they are not comprehensive. Additionally, the data collected in this thesis is limited to the opinions and expertise of the participants approached, as well as the context provided to them. In particular, the participants in this research were all from the water sector. When considering the impacts of decision-making in the water system on social elements like nature, spatial adaptation and land use, more actors have stakes in the issues, as they will be impacted by the decisions. Moreover, this research has a strong Dutch focus, as experiences from neighboring countries or internationally have not been considered. Furthermore, the type of actors involved in the study were drawn more heavily from the researcher or policy analyst categories. More perspectives from the commissioner and, importantly, policy actors are required to get an all encompassing perspective of the science-policy interface. However, the results represent a step forward in concretizing (1) whether there is a need within the closely associated water sector, and (2) what that need looks like. Moreover, the results offer a deliberate advice for future research to further clarify the need and potentially develop an appropriate approach for the 'Deltaverkenner'.

6.3. Recommendations

This thesis has explored the need for a national-scale decision support tool to collect, integrate, improve, and visualize insights from disciplinary research in order to provide a long-term view of how the Dutch delta behaves under future conditions and how this may be impacted by solutions from different domains. While the findings offer interesting insights into these needs gathered through multiple research activities, they also highlight several areas where further research is necessary to further concretize this need and offer a starting point for developing an approach for the 'Deltaverkenner' moving forward. Below are recommendations for future research directions. In particular, the 5W's (who, why, what, where and when) and 1H (how) need to be elaborated and specified. This is, and should be, an iterative process.

Practical recommendations: Who, Why, What, Where & When

The first aspect to clarify is *who*. Who should the 'Deltaverkenner' be for? Which decisions processes should the 'Deltaverkenner' support, and who is the owner of these processes and or decisions? Though clarifying this question is an ongoing process, which has already been started with the user workshop and is dependent on the other W questions, one recommendation can be made by reflecting on the research presented in this thesis. The problems that need to be solved in the future of the Dutch delta are not solvable solely in the water system (van der Brugge & de Winter, 2024), and the impacts of measures in the water system extend further than only the water domain. Therefore, other sectors need to be involved, such as sectors like agriculture, shipping, nature and housing. There already exist extensive calculations with detailed models. However, the strength of a decision support tool is to make insightful what the impacts are of all the choices considered. Additionally, early engagement of stakeholders and including different points of view on an equal basis are important requirements according to the theoretical framework presented in this thesis. Therefore, additional parties that are impacted by the decision-making should be engaged (early) in the process as well.

The second aspect is *why*. This thesis shows obtaining system knowledge and creating dialogue between users are important goals. Additionally, the framework indicates the facilitation of learning and viewing the process as shared learning are important goals for successful DSTs. Going forward, more emphasis can be placed on these factors.

What deals with the content of the tool. The findings show a quick, easy to use aggregated tool like a system dynamics model or reservoir model is preferred by users in the stakeholder workshop. Additionally, they see potential in a tool that is conceptual and explorative. However, to further conceptualize design possibilities and preferences, the design space needs to be elaborated. This can be done by adding additional axes to the ones used in this thesis or by differentiating different aspects in one base design. Furthermore, the perspectives of the commissioner and policy actors types have not been adequately considered, which refers back to the recommendation made in the "who" section.

Where and *when* are not discussed in this thesis. These factors consider the process aspects of the tool, such as timing, resources and structure. This thesis has found that the process factors are just as, or even more, important then designing a competent easy-to-use tool. Even a well-developed tool can be unsuccessful when it does not consider the other elements that ensure credibility, saliency and legitimacy. Further research is needed going forward to specify the needs of stakeholders in this regard.

Scientific recommendations: How

Based on the previously mentioned recommendations, a recommendation for future research is as follows. To further concretize the need for a 'Deltaverkenner' and to ensure all elements of the theoretical framework for successful decision support tools in science-policy interfaces are considered, the recommendation is to develop a meta-model detailing the design of the process for developing the 'Deltaverkenner'. This framework should include criteria from co-production, boundary objects, and decision support systems design processes. Furthermore, the literature on impact pathways can inform the types of knowledge, types of research orientations, types of interactions, and beneficiaries to ensure effective impact on the decision making process.

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A

Appendix A Stakeholder interviews

This Appendix provides details on the materials used and the results of the stakeholder interviews. First, the questionnaire used for the interviews is displayed. Next, the responses to these questions are presented per interviewee.

A.1. Materials stakeholder interviews

A.1.1. Questionaire stakeholder workshop

Interview: Commissioner/Policy Analyst/Researcher

Naam Naam - Datum

Informed consent form laten ondertekenen

Opname aanzetten

Introductie (context en focus klimaatverandering)
We willen een integraal water assessment tool maken dat kan dienen als een beslissingsondersteunend instrument voor het verkennen van adaptatiestrategieën voor Nederland de komende 100 jaar en daarna:

"De Nederlandse delta staat voor veel uitdagingen in de komende 100 jaar en daarna, gerelateerd aan klimaatverandering veranderingen in landgebruik, socio-economische ontwikkelingen, etc. die mogelijk leiden tot een verhoogd overstromingsrisico, kans op wateroverlast, droogterisico en verslechtering van de waterkwaliteit. Onze samenleving moet zich op deze uitdagingen voorbereiden met geïntegreerde oplossingen op verschillende tijd- en ruimteschalen.

Er wordt en is veel onderzoek gedaan om de onderliggende hydrologische, morfologische en waterkwaliteitsprocessen (inclusief verzilting van oppervlaktewater en grondwater) van het huidige watersysteem te begrijpen en te kwantificeren. Het integreren van deze uitdagingen en de vertaling ervan in lange termijn strategieën is echter zeer complex en, mede daarom, niet of nauwelijks gedaan.

Deltares wil het voortouw nemen in de ontwikkeling van een beslissingsondersteunend instrument op nationale schaal om inzichten uit disciplinair onderzoek (overstromingen, droogte, verzilting, …) te verzamelen, integreren en verbeteren, zodat verschillende partijen samen een lange-termijn visie kunnen ontwikkelen voor de Nederlandse Delta. Het gaat daarbij in eerste plaats om het inzicht bieden in de effecten van veranderingen en maatregelen op primaire doelstellingen van het Deltaprogramma: waterveiligheid en zoetwaterbeschikbaarheid. Echter, effecten op andere functies (biodiversiteit, scheepvaart, economie, landbouw, …) zijn ook voorzien als onderdeel"

Het doel is dus om lange termijn systeem keuzes inzichtelijk te maken ten behoeve van adaptatie aan zeespiegelstijging/klimaatverandering in de Nederlandse delta. Om zo'n instrument goed te laten aansluiten bij de behoefte en wensen van beoogde gebruikers richt mijn onderzoek zich specifiek op het in kaart brengen van deze behoefte en ontwerpen van een bijpassend instrument.

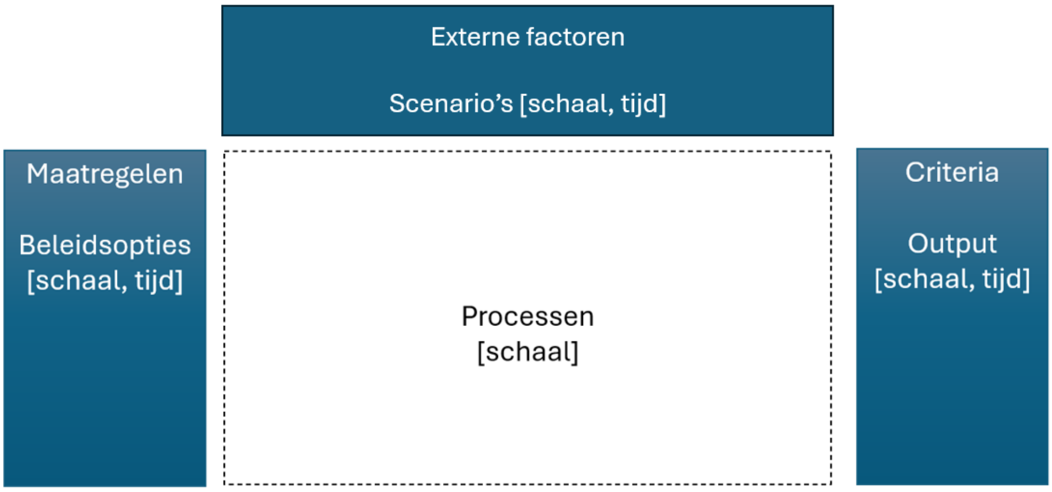
Korte uitleg wat ik met deze input ga doen: Design workshop + stakeholder workshop

Opwarmvragen

1. Kunt u me kort vertellen wie u bent en over uw dagelijkse werkzaamheden?
2. Voor de komende 100 jaar, welke uitdagingen voor het Nederlandse watersysteem ligt u wakker van?

Inhoudelijke vragen
In dit interview wil ik de gebruikersbehoefte inventariseren. Daartoe wil ik voor beleidsvragen van de komende eeuw bekijken welke beleidsopties, scenario's, onderliggende processen en uitvoer nodig is om die vragen te beantwoorden. Daarbij ben ik ook benieuwd naar het niveau van detail voor deze aspecten. Onderstaande figuur bevat een aantal van deze aspecten zoals de keuze voor tijd en

ruimteschaal. Om af te sluiten wil ik ook het gebruik van/interactie met en eigenschappen van het instrument bespreken.



Tijd: denk aan per decennia, per jaar, per maand, per week, per dag, per uur, frequentie
Schaal (resolutie): denk aan per m, per km, regionaal, landelijk of 1D, 2D, 3D

1. Welke integrale beleidsvragen voor de komende 100 jaar voorziet u?

   Voor een (paar) beleidsvraag(en):
2. Welke beleidsopties/maatregelen zouden we dan moeten testen met het integraal beleidsondersteunend instrument?
   -Welke ruimteschaal hoort hier bij? En welke tijdsschaal?
3. Welke scenario's zou het integraal beleidsondersteunend instrument moeten kunnen uiteenzetten?
   -Welke ruimteschaal hoort hier bij? En welke tijdsschaal?
4. Welke uitvoer data zou het integraal beleidsondersteunend instrument moeten genereren om de eerder genoemde beleidsvragen te beantwoorden?
   -Welke ruimteschaal hoort hier bij? En welke tijdsschaal?
5. Welke fysieke en sociale processen moet zou het integraal beleidsondersteunend instrument moeten beschrijven om de eerder genoemde output te genereren?
   -Welke ruimteschaal hoort hier bij? En welke tijdsschaal?
6. Wat zou nog meer onderdeel moeten zijn van een dergelijke model?

BELEIDSVRAGEN	
1.	
2.	
3.	
BELEIDSOPTIES	**DETAIL NIVEAU**
1.	
2.	

3.		
4.		
SCENARIOS		**DETAIL NIVEAU**
1.		
2.		
3.		
4.		
OUTPUT		**DETAIL NIVEAU**
BO nr	**Output**	
1.		
2.		
3.		
4.		
PROCESSEN		**DETAIL NIVEAU**
1.		
2.		
3.		
4.		

Model gebruik en eigenschappen vragen
Laten we 1 beleidsvraag nader bespreken:

1. Hoe zou u zo’n tool willen gebruiken bij het beantwoorden van deze vraag? In wat voor een context wilt u het gebruiken, al overleggend met bestuurders, zelf achter uw bureau? *Mogelijk doorvragen om concreter te worden:*
    a. *In welke vorm ziet u de uitvoer weergegeven worden zodat u er iets mee kan? kaart/tabel/infographics*
    b. *Welke opties moet de uitvoer laten zien? (Maatregelen tov elkaar, 1 maatregel (pakket) vs verschillende scenario’s, gemiddelden of juist trend over de jaren?, mate van interactiviteit (interface aan de voorkant van het model))*
    c. *welke rekentijd is acceptabel? (tijd tussen input erin en antwoord eruit)*
3. Wie zou de tool (ook) moeten gebruiken? Vereist dat nog weer andere functionele eisen?

Afsluiting
1. Wilt u verder nog iets kwijt?

A.2. Responses stakeholder interviews

A.2.1. Substance questions responses

1. Welke integrale beleidsvragen voor de komende 100 jaar voorziet u?	
Interviewee	**Antwoord**
SI-C-2	1) Verdeling van rivierafvoer lange termijn, hoe verdelen bij hoge afvoeren en lage. 2) Afsluiten NL Delta, eerst volgende herijking, afwenteling van keuzes in een deel watersysteem op andere delen.
SI-PA-2	Wat is de meest optimale inrichting van het IJselmeer voor de toekomst, waterveiligheid, zoetwatervoorziening en natuurdoelen incl. waterkwaliteit?
SI-R-2	De verschillende scenarios voor het bewoonbaar houden van de wadden, dit klimaat adaptief te doen zonder hele hoge kosten. Kosten en baten analyse voor
SI-PA-3	Rijnmaasmonding afsluiten open of dicht: Hoe de strategie in de tijd ontwikkeld, overgang van afsluiten open naar dicht.
SI-PA-1	1) Volkeraksluizen, komt snel aan de beurt en wat gaan we met de landbouw doen in het lage deel van nederland. 2) Landbouw laag NL bij de kust waar zoutindrining het sterkt aanwezig is 3) Maaslandkering als ie kapot is, wat te doen?
SI-C-1	1Spannenste is vervanging Maaslandkering, RRG.
SI-R-1	Landbouw en natuur landelijk gebied en oplossing voor wonen. Beweging van west naar oost. Inrichting landelijk gebied.

2. Welke beleidsopties/maatregelen zouden we dan moeten testen met het integraal beleidsondersteunend instrument?		
Interviewee	**Antwoord**	**Opermerkingen detail niveau**
SI-C-2	1) Sturen we meer water naar IJselmeer, meer naar ZWD of nieuwe water weg. Nieuwe verdeling van water, meer of minder, en waar. 2) Optelsom van rijn en maasmonding dicht, IJM peil, ecosystemen ZWD. Ene syteemkeuze en andere systeemkeuzes, verandering in samenhang	Doorwerking in hoofdwatersysteem en de effecten, dan kan je als regio ook bepalen wat de effecten voor jou zijn. Bij exteremere neerslag afvoeren, en hydraulische belasting plannen ontwikkelen. Maatregelen in 2e of 3e laag. Doorwerking op wat betekent het voor functies, diensten en waarde. Dan moet je ook interactie hebben tussen hoofdwatersyteem en regionaalsysteem. Wisselwerking moet beeld van zijn, maar dan moet je randvoorwaardelijk weten hoe grote keuzes doorwerken.
SI-PA-2	1) Zoutconcentratie laten oplopen of gelijkhouden 2) Peilbeheer: meegroeien met zee spiegel stijging of niet, hoger winterpeil, kan ook hoger zomerpeil (meer buffer) 3) De watervraag reduceren, wateraanvoer via IJsel 4) Inrichting watersysteem omligende gebied, dijk ophogen, sluizen (afsluitdijk)	-Voor zoetwater is verschillende types droogte belangijk, niet op dagbasis, maar wel verloop. Piekvraag in augustus, knelpunten hangt dus af van timing. -Van grof naar fijn, eerst WB, dan ruimtelijke differentiatie nodig. Welk schaalniveau precies, niet op grid, maar wel fijner dan waterschapsschaal, dus een paar punten bijvoorbeeld. -Voor drinkwater zijn er wettelijke normen voor ander water zijn het streefwaarde. Voor natuur is gemiddelde zoutconcentratie te weten en pieken/schokken. Je moet dus ook iets in de dynamiek wete, in oppervlakte water met name. -IJzelmeer cloride concentratie, daar moet je ook wel inzicht over hebben. Dat zou apparte module moeten zijn en daaruit doorspoel waarde halen. Kentallen
SI-R-2	1) Status quo houden, we gooien er zand in, huidig beleid 2) Stenen muur bouwen. Dijk neerzetten, karakter veranderen. Groter en hoger 3) Belofte kant, beleidsoptie kan zijn we houden je veilig met duin/dijk maar we gaan niet versterken, veiligheid gaat omlaag richting 1/50. 4) Extreme variant, opgeven. Kans voor natuurlijk systeem. We verplaatsen. Ameland weg is politieke dood.	Tipping point wanneer het te duur wordt is nodig. Details zijn niet nodig, draait meer om bewust wording dus ballpark is genoeg. Het is meer een verhaal/rollenspellen. Wat we niet goed kunnen is de toekomst exact voorspellen. De kaf van het koren scheiden, ongeveer is genoeg. Als je maar het grote process snapt en de orde grote snapt.
SI-PA-3	1) Tussenfase hybride overgang semi-open of dicht. Die periode heb je wel stormvloedkering. Maar dan heb je wel sluizen nodig voor als hij dicht is. 2) Deel opties, waterberging, waar 3) Dicht: mee stijgen binnenkant of pijl laten oplopen en pompen. 4) Afvoerverdeling ook uiteindelijk, ijselmeer of zuidwestelijke delta	Interactieve discussie nodid, dus niet een uur rekenen. Dan krijg je snel een database. Tijd is belangrijker dan ruimtelijke schaal. Feitenbasis moet kloppen, maar goed kijken of het allemaal nodig is. Hoogwater moet fysisch model als basis hebben, laagwater kan je met een boekhoudmodel ver komen, bakjesmodel ook prima. Afhankelijk van het onderwerp heb je een fysische basis nodig en dus meer detail.
SI-PA-1	Volkerrak: 1) Scheepvaart 2) Zoutindringing 3) Vervanging/uitbreiding, hoe komt dat in het grotere geheel, is het alleen de sluizen of meer ----------- Landbouw: 1) Behoud van landbouw zoals nu 2) Aangepaste teelt 3) Stoppen met landbouw in bepaalde delen of reduceren ------------- Measlandkering: Twee opties voor vervangen is nieuwe stormvloedkering of met sluizen, weghalen Afgesloten variant met 2 opties, scheepvaart of niet. Haven buitengraad, overslag buitenschepen/binneschepen Voordat je vervangt kan je ook sluitpeil ophogen-> dus verlengen	1) Niet groot detail, grofstoffelijk, groffe schatting scheepvaart bewegingen. Elke keer schutten, wat betekent dat voor de zoutindringen en sheepvaart en welke kosten zitten daar aan 2) Lokaal wel detail berekeneningen, met eenvoudige bakjes model is voldoende. 3) Ecologie/biodiverciteit niet vergeten. Experts vragen, zoutindrining+getijdewerking moet je dan iets over weten ----------- Percentueel reduceren hoeveel scheelt dat dan in ZW Zee spiegel stijding in de tijd en zoutindrining, zowel kwel en oppervlakte water. Zijn al wel wat berekeningen. Offline kan je hier wel wat berekeningen doen. Die stop je in rekenregel. Vrij grofstoffelijk. Weer bakjes model. Gewoon percentueel/grofstoffelijk is goed. -------------- Jaarlijkse detail is goed.
SI-C-1	1) Afsluiten of (semi)open 2) Afsluiting achterkant, begeleiden water naar ZWD toe. Slimme keuzes van bandbreedte opspant, zinvolle resultaten op hoofdlijnen. Grofstoffelijk de verschillende opties: consortia opties; 3) Ontdiepen, twee stromenland, estuarium oeverlanden. Nu leidingen stelsel 4) Nieuwe water weg	

SI-R-1	1) Huidige strategie (agrarische bedrijven). Duidelijke scheiding landbouw natuur, grottschalig of kleinschalig. Scheiden 2) Inrichting klimaatbestendige landgebruike (vervlechting landbouw met natuur). Verweven 3) Technologish meer of minder	-Vrij kleinschalig, ondersheid moet kleinschalig zijn. Bij zandgronden onderscheid tussen beekdal, dal en vlanken en hogere delen. Bovenstrooms en beneden strooms. Laag nederland heeft weer andere dingen, veen of diepe polders en dijkringen en boezems. -In stappen denken, juiste schaalniveau moet je kunnen laten zien, en dat generaliseren naar landelijke indicatoren. Dat kan niet direct voor alle indicatoren. Heel belangrijk is de kansrijkheid van de nieuwe landinrichting. Dat is eessentieel anders is er geen incentive om mee te werken. -Niet een systeem modeleren dat aan elkaar gekoppeld is. Voorbeeld van WUR is ABCD gebieden landbouw en verdien modellen afhankelijk van ondergrond (verschilende catagorien). Op basis hiervan kan je het over kansen hebben op economisch gebied. Dit soort vraagstukken combineren met gis info en economische kansrijkheid+kaarten van Water en Bodem Sturend. -In de tijd kan je van een generieke afweging naar meer detail gaan. Met die kaarten kan je ook een dynamisch aspect toevoegen, afhankelijkheid van grotere beleidsafwegingen toevoegen. Moet NL exporteur zijn voor alles en iedeer of aleen NL? Willen we daarvoor minder natuur? De doelen moet je eerst scherp hebben voor dat je dan kan kijken wat je waar kan doen. Meer dan aleen schade en landbouw. Dus in de tijd: eerst de doelen, gegeven verschillende doelen wat de balans is tussen de verschillende opties.
3. Welke scenario's zou het integraal beleidsondersteunend instrument moeten kunnen uiteenzetten?		
Interviewee	**Antwoord**	**Opermerkingen detail niveau**
SI-C-2	-De Deltascenario's -Kennis Programma Zee Spiegel Stijging: de 4 strategien -Lange termijn wat als scenarios in zoals in Delta programma gebruikt worden	-
SI-PA-2	1) Deltascenarios, afvoerscenarios 2) zee spiegel stijging 3) Voor Water Veiligheid samenvallen van events (regen regio en afvoer), laag afvoer en lange droogte 4) Vraag kan ook toenemen door landelijkgebied (veenweide, bodemdalign) 5) Keuzes in landgebruik, die eisen watervraag dus ook mee 6) Hoe vegatatie en gewassen reageren op klimaatverandering.	-Resolutie in tijd en bepaald ruimtelijk niveau is belangrijk. -Normale zomer vs extreme zomer, als iets maar eens in de 20 jaar gebeurd vraagt dat een andere oplossing
SI-R-2	1) Zee spiegel stijging 2) Klimaatverandering, hoe snel gaat dat, globaal vertalen. Natter en droger 3) Geopolitiek en waarde systemen: Grondstoffenbeschikbaarheid, Is ook lastig te voorspellen. Migratie, groei, demografie, dit combineren is heel lastig. Landelijkgebied. Als-dan er in brengen. Operationele en politieke besluitvorming. Wat zijn de opties voor de managers en politici	-
SI-PA-3	1) Vooral niet-extremen 2) Volledige bandbreedte 3) Robustheid van verschillende scenarios 4) Prestaties(norm of niet), kosten (maatschappelijk), risicos (wat accepteer je)	1) Beleidscontext: Dagniveau of locatie niet gedetaileerd. Relevante informatie is nodig. Vrij hoog abstractie niveau is prima. Als je het hebt over risico moet je het wel precies weten en dagelijkse neerslag weten. 2) Er wordt doorgeschoten in te veel detail. ls het niet interessant, dan is het niet nodig. Afhankelijk van vraag die je wilt beantwoorden. Dit wordt in zijn ervaring veel te veel gedaan. Tegenwoordig in NHI elke grasspriet doorgerekend, dat hoeft hier niet. Voor landelijke schaal. 3) Blijft een hulpmiddel voor de expert, de interpretatie van het model is belangrijker. Goed model met een slechte expert helpt niet. Degene die ermee werkt moet de materie overzien
SI-PA-1	Volkerrak: 1) Zee spiegel stijging 2) Scheepvaart is ook scenario: economisch Rdam of Adam 3) Droogte wel van belang, droge zomers ------------ Landbouw: ZSS Droge zomer weer doorrekenen met waarschijnljkehid ------------ Measlandkering: ZSS, met schuifje van laag naar hoog Bij gesloten variant wordt piekafvoer scenarios belangijker. Event achtig. Klimaatscenarios	1) ZSS: Snelheid van zss minder direct van belang, absolute scenarios wel en dan flexibel kunnen kiezen welke je kiest met een schuifje. Rate of change voor hydrologische scenarios. Levensduur van sluizen uiteindelijk wel van belang. 2) Scheepvaart: Een aantal socioeconomische scenarios, groot/minder. Wellicht ook schuifje maar is lastiger. 3) Droogte: Aantal scenarios met waarschijnlijkheid droogte, per klimaatscenario veranderd deze. Bepaalde mate van consistentie met ZSS. Niet te complex kwa ruimtelijke differetiatie. Een bepaald tekort, zoveel kuub maar niet heel locaal dus.

SI-C-1	1) Beleidmaken is verstandige optie keizen en weten wat er gebeurd als er iets anders gebeurd. CO2 stabiliseerd, process op ijskappen gaan langer door. Die onzekerheid is typisch voor dit vraagstuk. Bandbreedte van KNMI dus nodig, plus als het sneller gaat. 2) Verschillende type toekomsten (wat als scenario's) de gevolgen zien, houdbaarheid van oplossingen zien. 3) Neiging om meer of minder geloof te hechten aan zware scenarios. Voor bestuurders in het balengrijk die scenarios goed te kiezen. Je moet de juiste verhaallijnen kiezen. Vertaalslag maken is dus goed, maar moet ook niet te ingewikkeld zijn	
SI-R-1	1) inrichtingscenarios: Normatieve scenario's (sluit aan bij PBL), Water Bodem Sturend, status quo, en functie scheidingen 2) Klimaat scenarios: Droogte en wateroverlast. In lage delen van NL ook combi wateroverlast en ZSS. Je moet eigenlijk met klimaat storylines werken. Combi regenval en en zee hoog. Zo'n event kan je opblazen. Combi events die wel eens pijn zouden kunnen doen.	1) Events: Water Veiligheid (WV)- dagen-weken dus 1-14 dagen Zoet Water (ZW) - (droogte) maanden, jaren 2) Voor DP ZW langjaarreeksen en gemiddelde, karakterischisek jaar wordt dan gekozen 1/10 . WV bovenregionale stresstest/waterbom.
4. Welke uitvoer data zou het integraal beleidsondersteunend instrument moeten genereren om de eerder genoemde beleidsvragen te beantwoorden?		
Interviewee	**Antwoord**	**Opermerkingen detail niveau**
SI-C-2	Per functie/dienst nagaan wat de effecten zijn, en welke info heb je nodig om die effecten te bepalen. Watersyteemcondities.Ook mooi als er informatie is over doorwerking van effecten. Impact anlyse indicatoren van KP ZSS zijn goed voorbeeld.	
SI-PA-2	1) Onderscheid tussen hydrologisch en systeem en wat maakt dat uit voor gebruikersfuncties 2) Is er voldoende water, watervraag, beschikbaar, tekort? 3) Gebruikerskant: standplaats conditites, indicatie voor natuur. Heeft ook met zout te maken en grondwaterstand uitzakking (ecoloog spreken) 4) Waterkwaliteit, concetratie zout in IJM en regionaal systeem. 5) Grondwaterstand in veengebieden 6) Effect van maatrgelen: peil opzeetten winter en uitzakken zomer, WV uitgedrukt in dijkhoogte en of breete en stabiliteitsmaatrgelene. 7) WV: Opbouwen vanaf lange lijst indicatoren en dit categoriseren en daar een score aan hangen 8) Drinkwatervoorziening, kans op opsluting inname IJM	In de tijd en in bepaalde events, voor het hele gebeid en een niveau lager per delgebeid en hoe verhouden deze tot elkaar Sommige alleen IJM nodig. Voor ZW voorziening kom je snel in landelijk gebied uit, voor die andere dingen echt lokaal kijken.
SI-R-2	Doel is onzekerheden reduceren: hoe je dat het best doet is niet alleen klimaatverandering in beeld brengen maar juist de interactie, onzekerheden in kaart brengen. Hoe adaptiever hoe beter. Besluitvorming scenarios.	Landgebruik maar dan met beslisregels: als dit dan dat, menselijke keuzes, in de ruimtelijke consequencies zetten. Als je doorgaat met landbouw subsidies betekent dat dit het effect is. Interactie tussen gis cellen. Kans op droogte, grondwatervraag, recreatie vraag, heel complex. WBS, wat betekent dat? Variabelen: plaatjes landgebruik type, watervraag, wateraanbod, veiligheid, overlast, ecosysteemdiensten (biodiverciteit), buffering bij overlast. 1bij1 km is al voldoende
SI-PA-3	1) Waterveiligheids doelen: overstromingsfrequentie, normen, dijken en ruimte, en kering of sluizen 2) Verzilting, effecten land inwaards 3) Haven, scheepvaart en buitendijksgebied (politiek gevoelig, maatschappelijk debat) 4) Natura 2000, kaderrichtlijnwater. Kosten en baten haven, investeringkosten, nevenkosten	1) Wel gedailtaleerde sommen nodig. Waterveiligheid moet per dijktraject duideljk zijn wat impact is 2) Tot hoe ver komt het zout 3) Scheepvaaart kan je geen getallen over krijgen. Daar goede getallen bij krijgen is een start 4) Aanpassen natuurdoelen. Ene kant "is het toch niet te handhaven". Tegelijkertijd heb je natuurgegeving wet. Watertekort Beleidsgesprek hoeft niet super gedetaileerd. De hijkele punten moeten er uit moet komen. Als naar de rechter gaat dan veel meer detail nodig.
SI-PA-1	Volkerrak: WV niet heel interessant. ZW bescikbaarheid wel en zoutgehalte, benodigde hoeveelheid water om zoet te houden. Ecologisch in ++ en – denken. Scheepvaart in euros ------------ Landbouw: Landbouwproductie, zw gebruik, zoutgehalte ---------- Measlandkering: WV heel belangrijk nu (slachtoffers schade ect), Zoutindringing, Ecologische indicatoren, Scheepvaart/economie/concurentie positie van de haven	Aantal scenarios argetype, 1/20 event, 1/5 en 1/100 events. Verandering van indicatore per scenario duidelijk maken, dat je wel beeld hebt hoe de indicatoren veranderen .

SI-C-1	1) ZW, waterstanden, dagelijks en extreme condities. Wat is een condictie die te communiseren waard is. 1/10 1/100 dijkmaatregelen. Wat kun je verwachten. Complex wat nog ontwikkeld moet worden wat dagelijks onder water staat. Waterhoogtes extreem vs dagelijks. Weinig ruimte tussen 1/10 of 1/100. 2) Zoutgehalte 3) Buitendijks anders dan binnendijks. Alles kapot is alles kapot. Dan kan je wel iets zeggen of onder L(ocaal risico is)EER. 4) Model alles laten uitspuigen en laten afvangen. Je weet nooit precies de zss, je wilt niet doen alsof je alles exact weet. Mediaan dat soort begrippen zijn lastig. Toename overtromings risico is niet handig om te gebruiken. Mortaliteit is beschikbaarheid van voldoende hoge plekken, zoeken van veilig heenkomen (2e of 3e verdieping van veiligheid). Als de overstroming een extra verdieping vraagt van huizen voor veiligheid, dan is zegt dat meer.	Vanuit de MER wordt het toch nog doorgerekend. Info voor filteren tussen opties moet voldoende zijn, wanr uiteindelijk komt er toch nog een verdipende studie. En binnen de gemeente komen er toch nog andere vragen. Buitendijks moet echt op 10 cm afgerond worden voor inzicht, dus moet wel redelijk specifiek. Als gemeente in dit gebied moet je beslissing nemen hoe buitendijks ontwikkeld. Je weet niet hoe zss zich ontwikkeld en ook niet welke besluiten genomen worden. Hoeveel verschil zit hier in.
SI-R-1	1) Natuur, landbouw, wonen. Wat is effect van de ingrepen daar op. Meer dan alleen schade (kennis van buiten deltares vragen). 2) Iets van robuustheid en veerkracht. Extreme events en onder verschillende scenarios. Hersteltijd, eenmalige maximale schade. Gemiddeld en piek schade zijn beide nodig en de tijd dat het duurt. 3) Zoutgehalte en waterverdeling is wel nodig. Funtioneer je nog als de waterverdeling anders is? Mag het water ook zouter zijn? 4) Landgebruik types per indircator.	1) Kaarten/regios. Voor regios wel meer detail nodig. Maar niet voor landelijk 2) Wateraanvoer wel landelijk model nodig
5. Welke fysieke en sociale processen moet zou het integraal beleidsondersteunend instrument moeten beschrijven om de eerder genoemde output te genereren?		
Interviewee	**Antwoord**	**Opermerkingen detail niveau**
SI-C-2	Wateroverlast en ruimtelijke adaptatie zitten niet zo veel in KP ZSS. Dus kijken hoe je deze een plek kan geven. Samenvallen van extremen bij ingrepen.	
SI-PA-2	-	
SI-R-2		
SI-PA-3	Superpositite kan wel helpen, dat is dus wel een mooi streven. ZSS kan je misschien wel stapelen. Hoeveel cm kunnen ze in combinatie aan en hoeveel kost dat. Dat zou al heel inzichtelijk zijn. Waterveiligheid en watervoorziening: Hoogwater buitendijks vrij simpel wat wel en niet onderwater. Sluitfrequentie scheepvaart. Meest ingewikkeld is laagwater en beschikbaarheid, rivieren+zout met scheepvaart landbouw en natuur. Parameters die we net noemde moeten op modelniveau met elkaar interacteren.	
SI-PA-1	-Waterstanden als gevolg vab zss, zout als gevolg zss en sluis. -Wat doet het fysisch system per scenario en sluizen en Wat betekent dat voor de indicatoren -Morphologie -Weer dezelfde interacties, wat komt er binnen door neerslag en afvoer en waar gaat het heen. -Maatgevende waterstanden moet je wel voor het hele gebied weten en moet je ook de maatregelen voor weten, dan komt het aan op dijken en dan willen we weten hoe duur dat wordt. Buitendijks hetzelfde.	Database of rekenregels werkt wel, 3d is niet nodig, je mist eigeniljk geen effecten. Details naar vereenvoudigen is altijd lastig
SI-C-1	-	
SI-R-1	1) Kaderrichtlijkwater, natuurdoelstellingen, dan gaat het vaak over de fysische randvoorwaarden voor natuur. klassieke indicatoren grondwaterregime, kwel, flux, de afvoeren, min en max, details 2) Gekoppeld grond en oppervlakte water is heel specifiek. Hoe kan je dit gebruiken voor de mataergelen? Wat we willen niet kan met huidige natuur? Dat kun je alleen maar goed laten zien met een locale toepassing. Dit kan soms wel gegeneraliseerd worden per typisch beekdaal voor nederland, dan niet iedere specifiek beekdal nodig. 3) Natuur en landbouw afwegingen. 4) Simplificeren kan als de meganisme er goed in zitten en realistisch zijn. Maar het hoeft dan niet een specifiek systeem te zijn. Rekenregels is wel eerder geprobeerd. Meta modellen maken. Wellicht zelfs AI.	

A.2.2. Use questions responses

1. Hoe zou u zo'n tool willen gebruiken bij het beantwoorden van deze vraag? In wat voor een context wilt u het gebruiken, al overleggend met bestuurders, zelf achter uw bureau? Mogelijk doorvragen om concreter te worden: a. In welke vorm ziet u de uitvoer weergegeven worden zodat u er iets mee kan? kaart/tabel/infographics b. Welke opties moet de uitvoer laten zien? (Maatregelen tov elkaar, 1 maatregel (pakket) vs verschillende scenario's, gemiddelden of juist trend over de jaren?, mate van interactiviteit (interface aan de voorkant van het model)) c. welke rekentijd is acceptabel? (tijd tussen input erin en antwoord eruit) 2. Wie zou de tool (ook) moeten gebruiken? Vereist dat nog weer andere functionele eisen?	
SI-C-2	In eerste instantie goede inbedding, Ruimte voor de Rivier was er eerst als project en daar kwam later de blokkendoos uit als process. Wel belangrijk om beeld te hebben van de context waarin dit gebruikt gaat worden en wat voor tool hoort daar bij. Daarnaast bij RvdR eenvoudige opdracht: hoogwaterafvoer naar beneden zonder de dijken omhoog. Dus de context is heel belangrijk. Als er meerdere doelstellingen zijn wordt dit lastig. Eigenaarschap ook heel belangrijk. Bij KP ZSS zijn bouwstenen ontwikkeld en strategien en de adaptatiepaden. Als het doel van zo'n instrument is om snel en efficient dit in beeld te kunnen brengen dan kan je die bouwstenen gebruiken en breng je dat bij elkaar en dan maak je dat snel inzichtelijk. Dan ben je wel afhankelijk van dingen die al doorgerekend zijn en ga je voorbij aan andere behoeften, dingen die nog niet zijn doorgekerend. Of misschien is het niet optelbaar en moet je dat dus ook niet doen. Misschien moet je wel een meta model doen wat analyses laat zien, effecten inschatten. Ene kant heel goed dat deltares hier mee bezig is, maar is de goede volgorde is belangrijk.
SI-PA-2	-Blijft bij 2 sporen, verkennende tool kan niet foolproof. Wel een grotere groep experts -Een raamwerk en daar modules aan hangen. Modules heb je expters voor nodig (verzilting bijvoobeeld) de vertaalslag daarvan zit in het grotere raamwerk. Bij elke nieuwe vraag moet je weer even langs de experts. 1 tool werkt niet voor een grotere groep. -Vervolgens heb je alalyse gedaan en daar komen dingen uit en daar moet je mee spelen. Een bestuurder of beluistmakers geef je dan vervolgens een aggregatie stap groter dan wat je analyseerd. Die vertaalslag moet er tusen. Dus daarom 2 apparte dingen. -Je hebt een vraag: Welke processen nodig? Welke modullen aan? Eerst verkennen met die module wat de antwooren zijn , dat stop je in de groetere tool en dan kan je verkennen. Dat weer aggregeren en naar bestuurders. Wellicht is het te combineren. -Visueel: Infographic kamer brief, heel statisch dus dat kan fancy. Verschillende knopjes aan en uit. ~Grafiekjes voor experts, plaatsjes voor bestuur~. Voor de tweede doelgroep (bestuurders): Waterbalansgrafiek van Marjolein is een goed voorbeeld om te snappen wat het probleem is. Maar voor oplssoingen heb je meer detail nodig.Voor scenarios iets anders nodig want dan wil je het probleem zien. Het roeptvragen op waardoor je direct dieper wil. Voor poicy mensen wil je weten wat de aannames er achter waren. 1e scherm met plaatjes 2e scherm met meer detail. Probleem analyes en maatregelen hebben iets anders nodig. -Bestuurder geagregeerd duidelik kosten en baten. Dan moet doel en neveneffecten duidelijk zijn. -Voor interfase voor analyse mensen, daar een fuse achtig dingen waar je kan schrollen en dingen kan aanzetten, veel vrijeheid. En de mogelijkheid om zelf dingen toe te voegen. Spelen en vragen kunnen stellenDan heb je niet genoeg aan de voorgeprogrammeerde dingen. Verschillende invalshoeken dan is het een groot denk process.
SI-R-2	-Kaarten, 1980 tot nu -Omgaan met onzekerheden, bewustwording en syteem kennis leren. -2 versies: 1) heel breed publiek, laat iedereen nadenken over wat er kan en niet. Verleden tot nu, grofweg, geloof in kennis en bewustzijn onzekerheid kan ook story lines zijn. 2) daadwerkelijke beleidstafel, complexe vormen governance, het faciliteren van er samen uitkomen. Welke onzekerheden blijven er over. Beslotenheid om concensus te krijgen over inrichten ruimte. Doorgaan met strategie om meegeven of nemen. Dat ondersteunen. Arena van de afhankelijkeheid van besluiten en de gemeenschappelijk probleem analyse te doen. -Heel kort rekentijd. Tijdens facilitatie moet het eigenlijk gewoon een database zijn, of spelletjes spelen moet snel gaan. Gaat niet om details, gaat om inzichten krijgen.
SI-PA-3	-Aantal niveaus: ambtelijk en bestuurlijk, stuk voor stuk mensen die een deel van het probleem overzien. Alleen onderwerp of regio. In die setting wanneer je meerdere mensen met verschillende achtergrond samen hebt. En bestuurlijk. -Een policy analist gaat het niet gebruiken. Voor bestuurlijk contexten moet het gerbuikt worden. Modeleur moet materie overzien, voorbereiden bijeenkomsten, en gesprek kunnen voeren heel belangrijk. -Runtijd, voor de database, vooraf bedenken wat er besproken kan worden. Per direct nieuwe getallen kunnen toveren. Smart table van blokkendoos is voorbeeld. - Hoe visueleren hoe beter, kaarten kleuren, geen getallen -De expert, die de taal van de bestuurders spreekt. Met name voor mensen die niet alles overzien. Deskundige is altijd nodig om uit te leggen wat je er mee kunt. Dit kan niet breed versprijd worden. Beide nodig (expert en model), combinatie is belangrijk

SI-PA-1	-Hoopt op een model waarbij niet persee de experts er moeten zijn, is wel lastig. Kan voorstellen waarbij eeerdere versies zijn waarbij wel expert nodig is. Onvermijdeljk. -Paar minuutjes max, koffie halen en klaar zijn meerdere scenarios tegelijker tijd mag iets langer duren. -Expert individueel die analyses doet, expert+beleidspersoon die samen toewerken naar iets wat voor iedereen te gerbuiken. Later zou het niet experts kunnen zijn die samen discussieren over strategien. -Idealiter verschillende zaken visueel, kaart belangrijk, sliding screen voor verschillende opties met elkaar vergelijken. Simpele tabellen en taart diagrammen. Vooral vergelijken opties uitgedrukt in kernindicatoren. Voor de liefhebber wat gedetaileerde grafieken. Zo veel mogelijk aanbieden, maar wel op een manier dat mensen niet verdrinken. Uuitvoer scherm voor een bredere groep met versimpeling en een optie achter de schermen voor de experts. Voor verschillende gebruikers verschillende functionele eisen, vrijheid voor expert en zodra er een user interface komt raak je daarvan wat kwijt.
SI-C-1	-Vizueel en gevoelsmatig. Behulpzaam als mensen op verschillende manier mee genomen worden. -Bedenk wat mensen beweegt. Met WBS laatste tijd de dingen naar onze hand gezet. Daar waar het syteem een duidelijke grens heeft kan je mensen mee nemen in zo'n principe. Maar de wereld van de keuzes zijn niet zwart wit. De gevolgen van de kuezes zijn zo'n groot. Je zou naar de effecten moeten kijken maar ook de opties die er tegenaan plakken. De voorkant van het probleem is wellicht te klein om bestuurders te bedienden. Tool voor deltares is een andere tool. Profs vind het fijn om infomatie boven tafel te hebben, minder beeldend nodig en incoontjes. Voor besluiten moet je de bestuurders mee nemen. Die hebben gewoon minder verstand. DP is allebei, je hebt teams die er dagelijk aan werken. Maar zodra die een presentatie geven moet het op het andere niveau. Porberen begrijpelijk zijn is belangrijk. Ziet voor zich dat het niet een bestuurder is die achter een laptop zit. Interface is belangrijk. Kaartlagen die je kan aanklikken, maar dan moet je wel gis kennen. Zo'n scherm is hocus pocus. Dat moet zo min mogelijk zijn. Breden gezelschap, expert+tool is de juiste combi. Ophalen uit database mag alleen maar 5 sec zijn. Bestuurder is prima als het alleen ophalen is. Dan is het raar als je echt berekeningen gaat doen. Je kan niet in alles voorzien dus groffe maatregelen is genoegn. Waar de sluis komt is dus niet aan te passen maar wel of niet sluis.
SI-R-1	-Landelijk iets met kaarten. Landgebruik, gis, metamodellen voor regionale afwegingen. Events en droogte enzo voor een hydrologish kleiner model. Op hoofdniveau economisch, regionaal impacts. - Gebruik met name onderzoek met stakeholders erbij maar waar het niet gaat over een beleidskeuze voor morgen maken. Voor lange termijn. -Setting: eerst met een aantal experts, ook van beleid, uitdicuseren. Leren en kijken met regionale. Studies van PBL zouden gebruikt kunnen worden. Doorvertalen naar spelvorm kom je bij bewustwoorden en leren. Generieke instrument opvolgen met detail analyse. Moet hetzelfde soort raamwerk zijn maar met meer detail. - Moet iets zijn wat snel dingen kan laten zien. On the spot. Maar is ook niet erg dat wat je van te voren alles hebt voorbereid. - Een nieuwe maatregelen toevoegen moet binnen een dag te rekenen. Hoe flexibeler hoe beter. -Aan de voorkant ook versimpelen: normatieve scenarios. Heldere categorien die een algemenere insteek hebben. Een pakket aan maatregelen dus. Regionaal wellicht wel verschillende opties. -Alleen geschikt voor landelijk. Specifiek voor die ene beek kan niet. Dus daar niet voor geschikt
3. Wilt u verder nog iets kwijt?	
SI-C-2	Belangrijkste dingen gezegd. Kijk naar variatie in instrument en naar het probleem. Zit zelf niet naar achregatie tool te kijken, want dat heeft altijd beperkingen want dan kijk je naar dingen die je al weet. En wie moet dat dan maken. Moet de markt dat doen of Deltares? Als je dan scherp hebt wat je probleem is waar je een instrument voor nodig hebt? Wie gaat je dat dan bieden?
SI-PA-2	-
SI-R-2	-
SI-PA-3	Een ding: Ruimtelijke kwaliteit. Dat is ook heel belangrijk, iets "moois" maken, wenkend perspectief. Onder de streep een plus voor het gebied. Kwalitatief met mooie plaatjes. Dus het verhaal moet er ook bij.
SI-PA-1	-
SI-C-1	-Voor verschillende type beslissingen heb je verschillende tijdschalen aan of die vragen er nu al liggen. Inzet van zo'n tool binnen het process is belangrijk. Je wilt niet dat er aan allerlei tafels al keuzes gemaakt wroden. Dus het process is heel belangrijk. -Complexiteit van data is heeeeel groot, maar in weze is het hetzelfe vraag stuk: wat betekent deze keuze?
SI-R-1	-

B

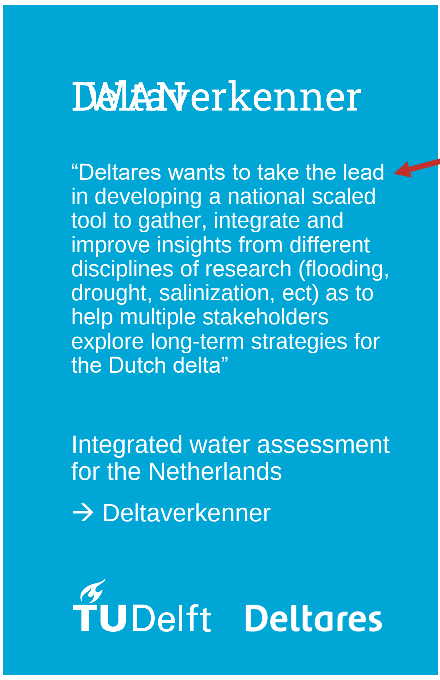
Appendix B Design workshop

This Appendix provides details on the materials used and the results of the design workshop. First, the PowerPoint used to inform the participants is displayed. Additionally, the functional requirements table, derived from the stakeholder interviews, used to provide background for the participants is displayed. Next, pictures and scans of the drawings of the concepts and properties tables resulting from challenge 2 are displayed. Lastly, the overview of the votes and the reasoning of the participants for challenge 3 are presented.

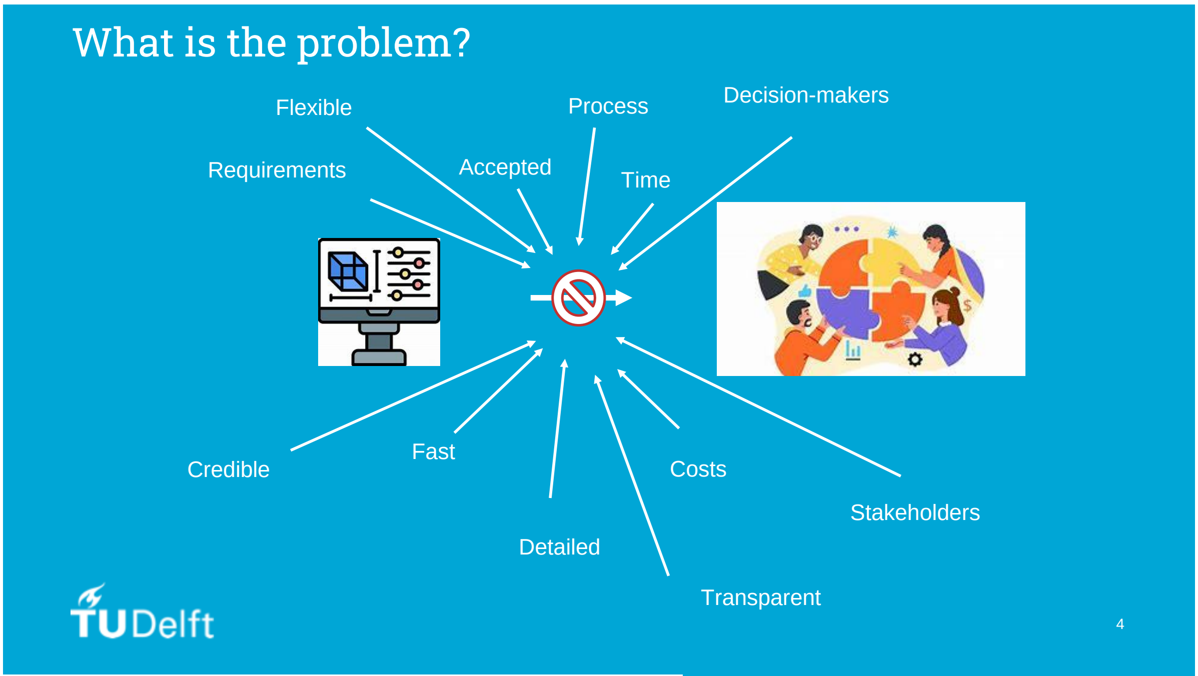
B.1. Materials design workshop

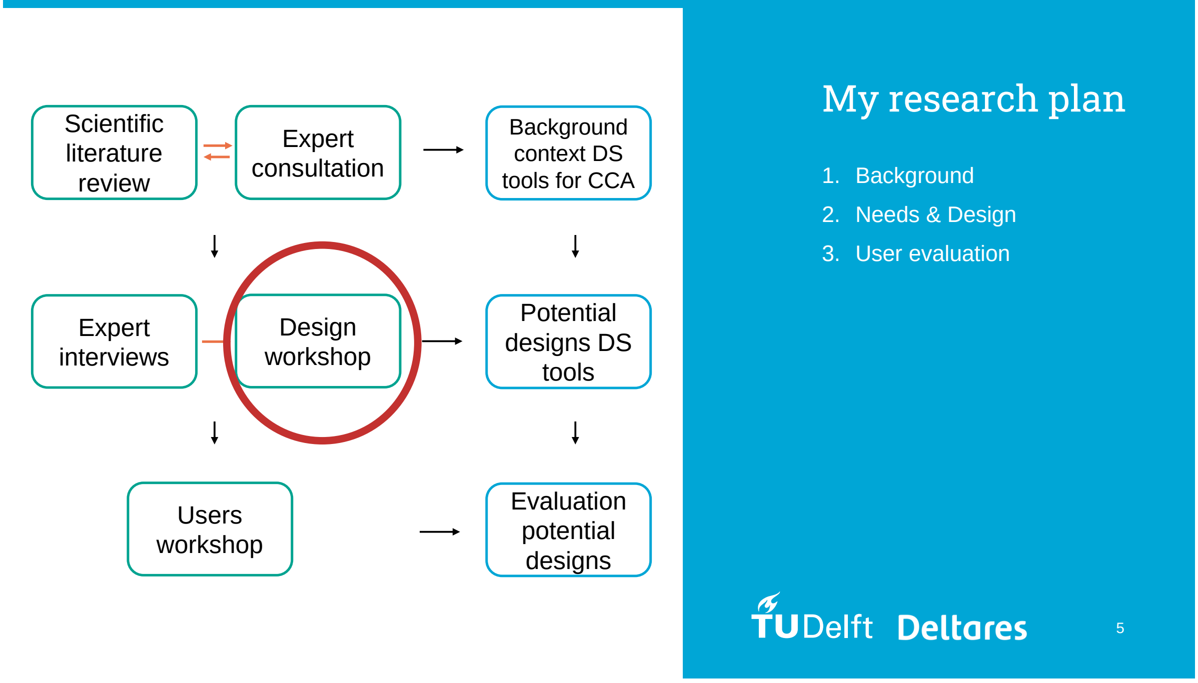
B.1.1. Design workshop PowerPoint


Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat
KNMI'23
climate scenarios
waterveiligheid groter.
Op steeds meer plaatsen
ontstaan knelpunten.
Huidige situatie 2024 + mogelijke waterstanden in 2200
Beschermen
Gesloten en pompen
Beschermen
Gesloten en zoveel mogelijk spuien
Beschermen
Afsluitbaar zeefront met gespreide of geconcentreerde versterkingsopgave
Zeewaarts
Meebewegen van Randstad tot hoog Nederland
TU Delft Deltares


DeltaVerkenner
"Deltares wants to take the lead in developing a national scaled tool to gather, integrate and improve insights from different disciplines of research (flooding, drought, salinization, ect) as to help multiple stakeholders explore long-term strategies for the Dutch delta"
Integrated water assessment for the Netherlands
→ Deltaverkenner
TU Delft Deltares


Deltares
1 Deltas remain habitable, even in the context of two metres of sea level rise, land subsidence and climate change
2 Making the world's population safer from flooding
3 Resilient and healthy water systems for people and nature in 2030
4 In 2030, energy from water and subsurface will account for 75% of the energy required for sustainable collective heating systems
5 By 2040, infrastructure construction, replacement and maintenance will be fully resilient
"Moonshots are inspirational, directive goals to challenge ourselves to go to the limit with major importance for society. This can only be achieved by working together."
3


What is the problem?
Flexible
Process
Decision-makers
Requirements
Accepted
Time
Credible
Fast
Costs
Stakeholders
Detailed
Transparent
TU Delft
4


Scientific literature review
Expert consultation
Background context DS tools for CCA
Expert interviews
Design workshop
Potential designs DS tools
Users workshop
Evaluation potential designs
My research plan
1. Background
2. Needs & Design
3. User evaluation
TU Delft
Deltares
5

What did I find? --> Background

- Level of detail needed for policy decisions is big question
- Process development tool just as tool design itself
- Need relevant outcomes accepted by stakeholders, within acceptable time and cost limits
- Goal DSSs shifted from supporting decision-makers to enhancing stakeholder engagement for better informed decisions
- All the requirements [fast, detailed, flexible] combined impossible, coherent choices tuned to the intended use
- Keep information manageable and process in a transparent way

TUDelft Deltares

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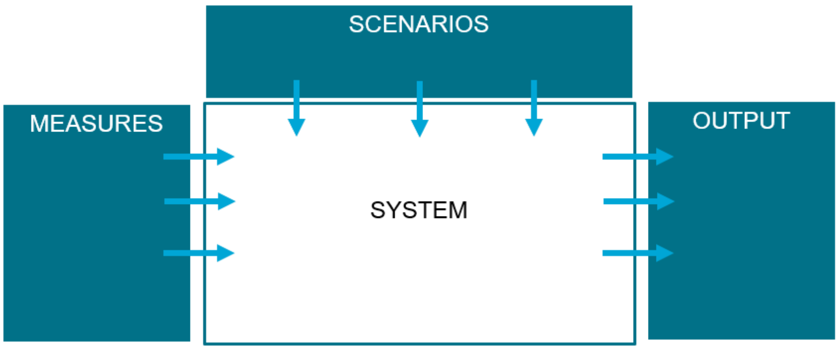
What did I find? --> Needs

- 7 interviews with different types of stakeholders
  - Commissioner, policy analyst, researcher
- Functional requirements
  1. Substantive requirements considering the measures, scenarios and output, level of detail
  2. The need requirements: use, setting, interface
- Extensive list printed
- Not all of them fit!

TUDelft Deltares

7

Functional Requirements



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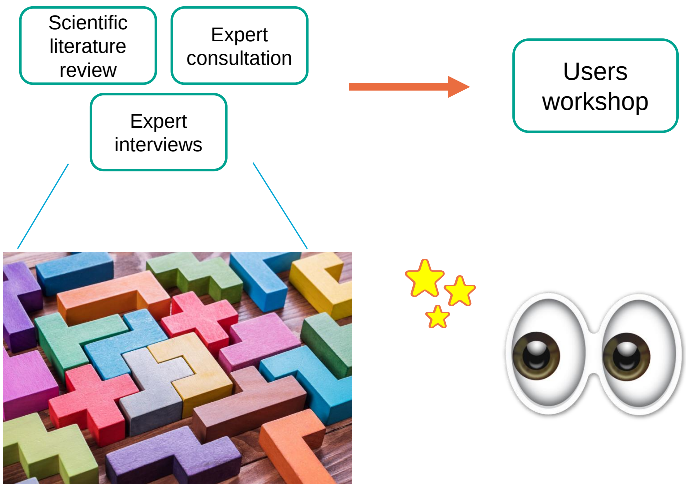
8

Goals for today



Design space

- Explore design space
- (At least) 4 varying designs
- All possible “solutions”
- Not the one/the best solution
- Together make up design space

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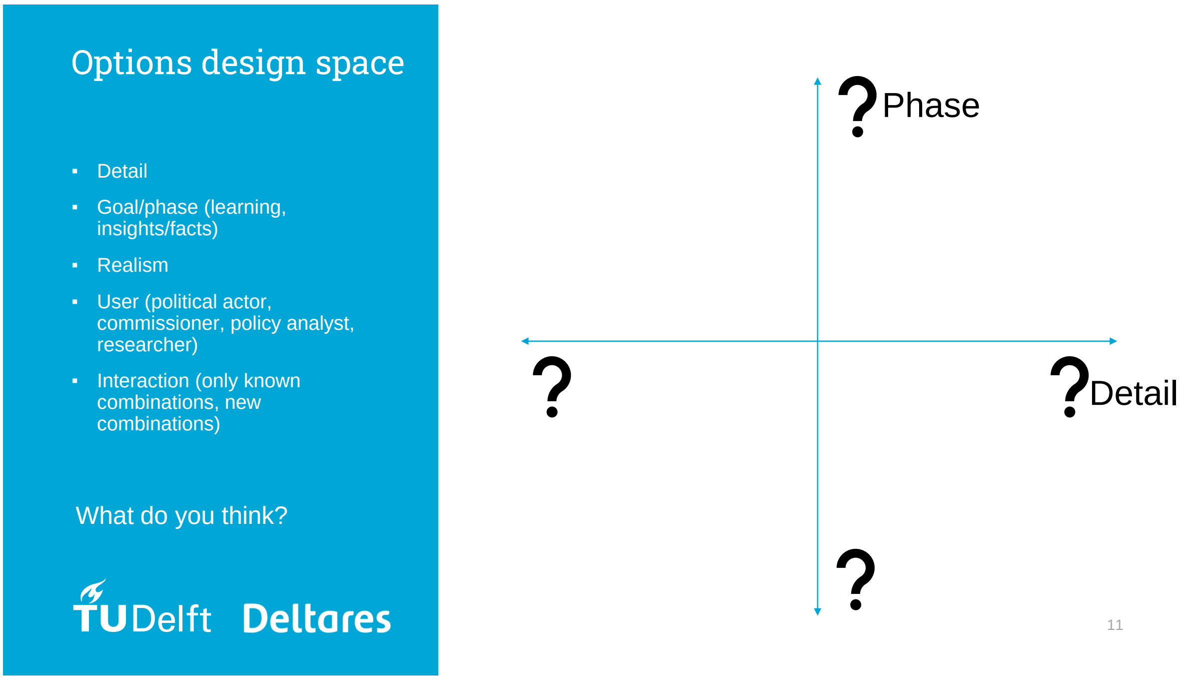
Challenge 1
Deciding on axis
How do we span the designspace
TUDelft Deltares
10


Options design space
Detail
Goal/phase (learning, insights/facts)
Realism
User (political actor, commissioner, policy analyst, researcher)
Interaction (only known combinations, new combinations)
What do you think?
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? Phase
?
? Detail
?
11

Challenge 2

Designing

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Challenge 2: Design

2 groups

- 1 TU Delft, 3 Deltares
- Chose 2 design space combinations to explore

Assignment for each concept

- Make a schematic design concept
- Use table to describe properties
- Think about functional requirements

- 45 min total

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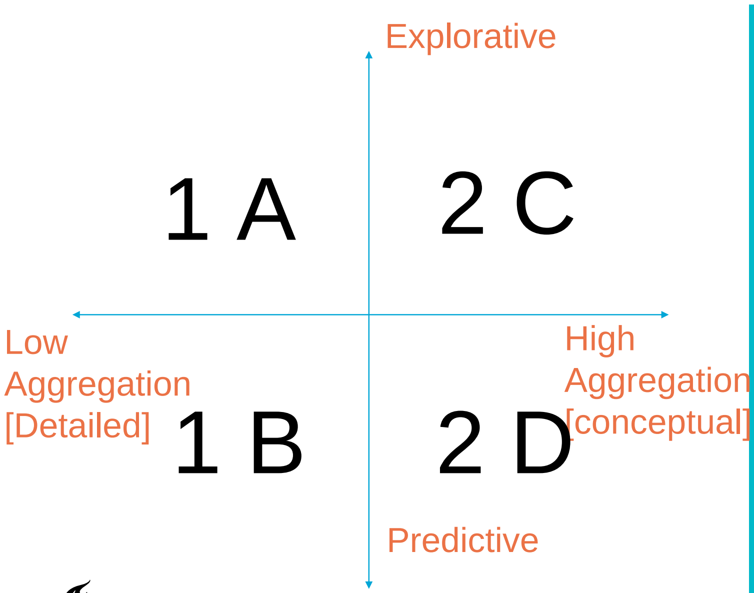
Properties table

	Design 1	Design 2
Level of detail		
Computation time		
Interaction possibility		
Ease of use (knowledge background required)		
Goal/application		
Noteworthy comments?		

14



2 groups

- 1 TU Delft, 3 Deltares
- Chose 2 design space combinations to explore

Challenge for each concept:

- Make a schematic design concept
- Use table to describe properties
- 45 min total

16

Challenge 3

Stars

What is your favorite?

17

Challenge 3: Stars

You get
- 10 stars per person: 7 positive + 3 negative
- Post-it notes and pen

Assignment
- Only positive or negative stars to one design
- How many, up to you
- Give reason for rating on post-it


Closing
Thanks so much!
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THANK YOU!
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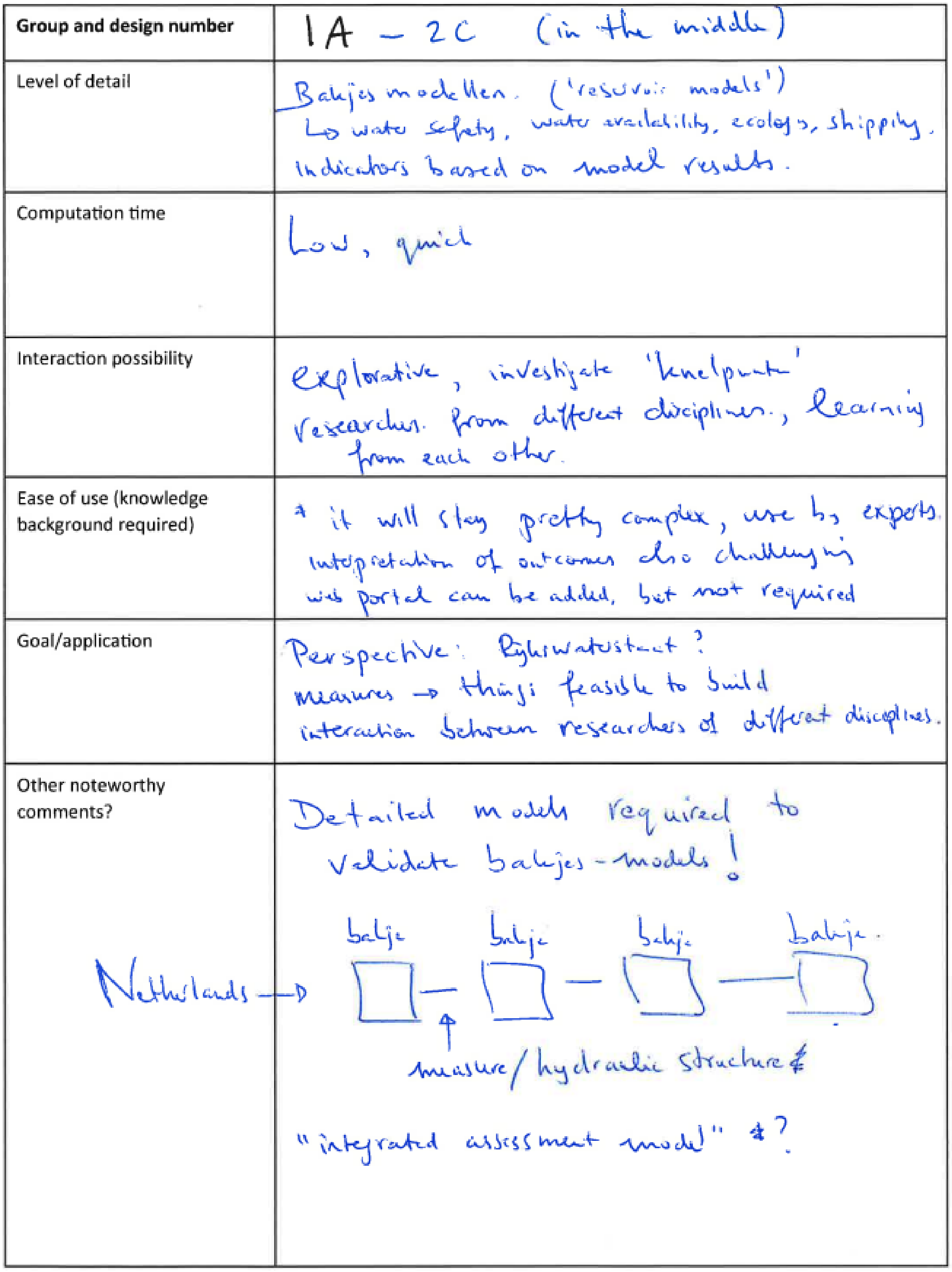
B.1.2. Functional requirements table used in Design workshop

Options / Measures	**Scenarios**	**Outcomes**
Altering …. Water division Buffer capacity Water levels Concentrations (salt and other) Risks acceptance ~ safety laws ~ relocation In general: dikes and locks Specifically: closing or (semi) open zuidwestelijke delta, harbor Rotterdam Land type/use (agriculture, nature, housing, peat), waterbodemsturend Nature/eco goals Water usage Groundwater levels Maintaining current strategy Sand depletion/replenishing	**"Water" scenarios** KNMI '23 scenario's Non-extreme scenario's Deltascenarios Kennisprogramma Zeespiegel (sea level rise) **Other scenario's** Combi-events, cascade events What if scenario's or land use scenarios (PBL, Deltascenarios) (e.g.) Economic scenario's (shipping) Material availability Demographic and migration **Scales**: Series Shocks Event frequency (1/10, 1/100, 1/1000)	Water division, min/max runoff Water availability Buffer Concentrations (salt and other) Safety risks Dikes (safety, space, height, reinforcement) Embankment and locks (safety, space, open frequency) Water safety (fatalities, costs) Land use Nature/eco goals and impacts (e.g. Nature 2000) Water usage Groundwater level "Kwel en flux" Economic opportunity (of land) Costs - investment and impact Resilience (time till repair) Durability of a measure (tipping point) "Kosten en baten" Tidal action Agricultural profit **Scales** Nationally: economics, Regional: impacts Trendline or years (e.g. 2030/2080/2130) Drought: months/years vs Flooding: daily/weekly

B.2. Results design workshop

B.2.1. Challenge 2: scan properties tables



Group and design number	1A – 2C (in the middle)
Level of detail	Bakjes modellen. ('reservoir models') ↳ water safety, water availability, ecology, shipping. Indicators based on model results.
Computation time	Low, quick
Interaction possibility	explorative, investigate 'knelpunten' researchers from different disciplines, learning from each other.
Ease of use (knowledge background required)	* it will stay pretty complex, use by experts. interpretation of outcomes also challenging web portal can be added, but not required
Goal/application	Perspective: Rijkswaterstaat? measures → things feasible to build interaction between researchers of different disciplines.
Other noteworthy comments?	Detailed models required to validate bakjes-models! Netherlands → bakje – bakje – bakje – bakje. measure/hydraulic structure "integrated assessment model" ?

Figure B.1: Properties table concept A.

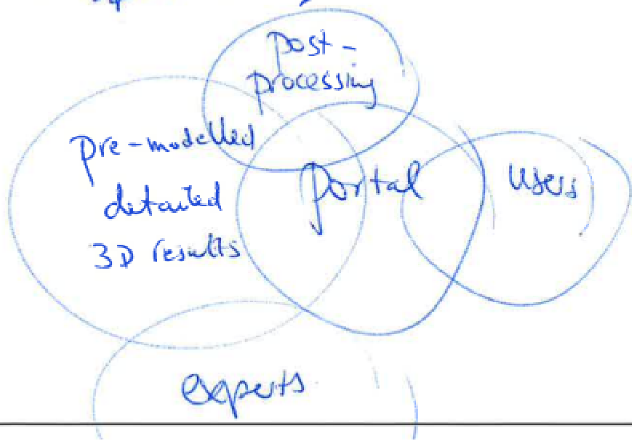
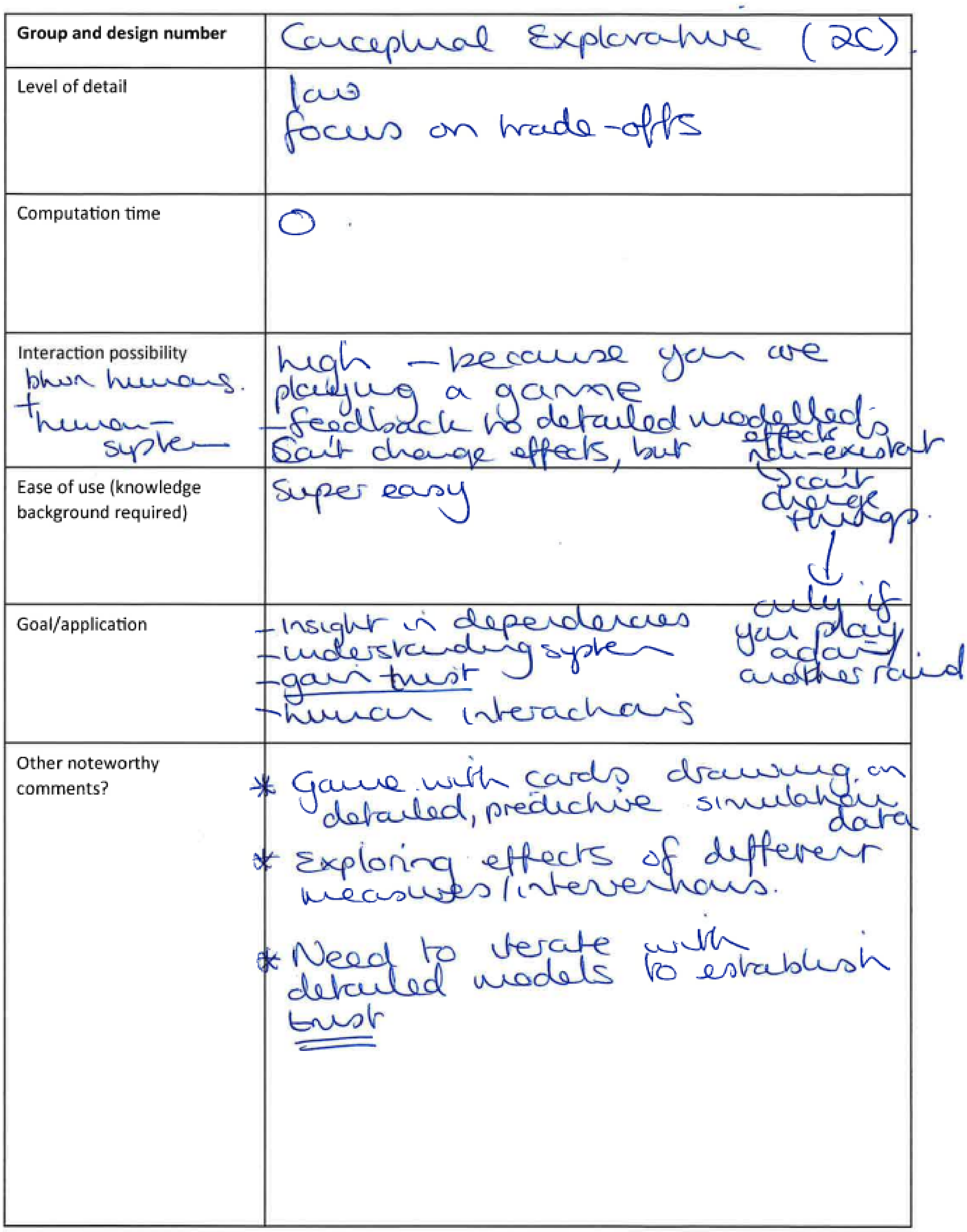
Group and design number	1B
Level of detail	2D and 3D modelling + postprocessing for a certain region (e.g., Rhine-Meuse Delta)
Computation time	Weeks of computation time per day of real time
Interaction possibility	not flexible interaction far away from calculation shell for visualisation for users.
Ease of use (knowledge background required)	only for experts. postprocessing for users. to analyse results.
Goal/application	detailed insights in impact of sea level rise and variations in discharge in a certain region.
Other noteworthy comments?	Suitable for background studies. on ~~flow~~ salinity 

Figure B.2: Properties table concept B.



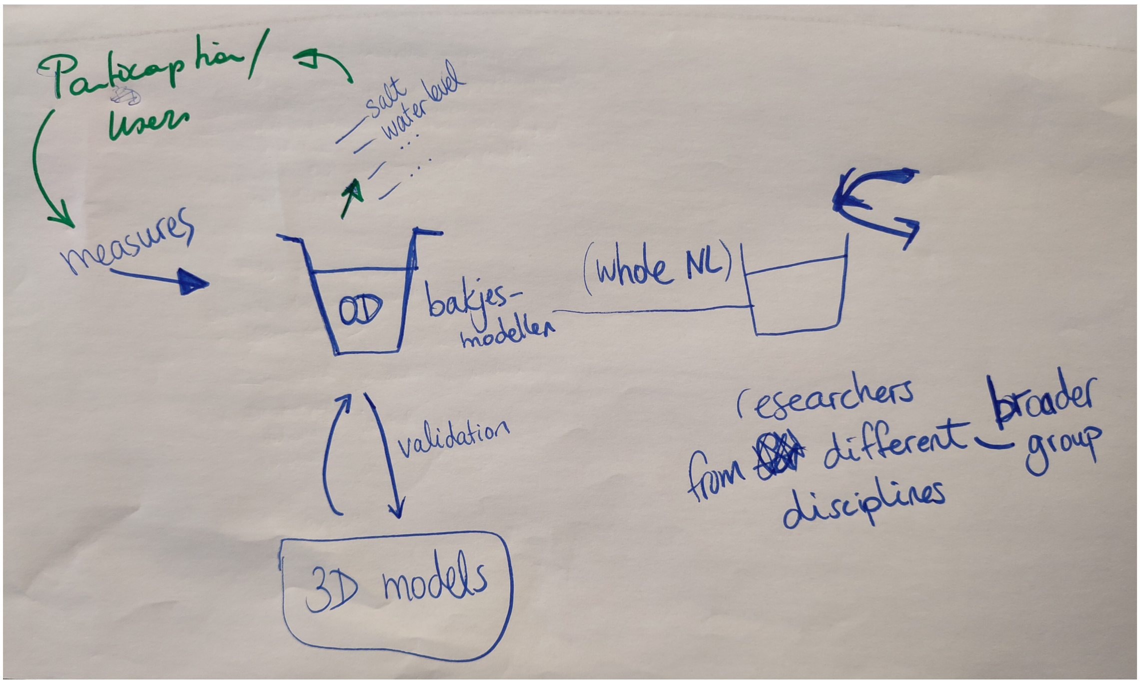
Group and design number	Conceptual Explorative (2C)
Level of detail	low focus on trade-offs
Computation time	0.
Interaction possibility btwn humans. + human-system	high - because you are playing a game - feedback to detailed modelled effects is non-existent Can't change effects, but can't change things. → only if you play again another round
Ease of use (knowledge background required)	Super easy
Goal/application	- insight in dependencies - understanding system - gain trust - human interactions
Other noteworthy comments?	* Game with cards drawing on detailed, predictive simulation data * Exploring effects of different measures/interventions. * Need to iterate with detailed models to establish trust

Figure B.3: Properties table concept C.

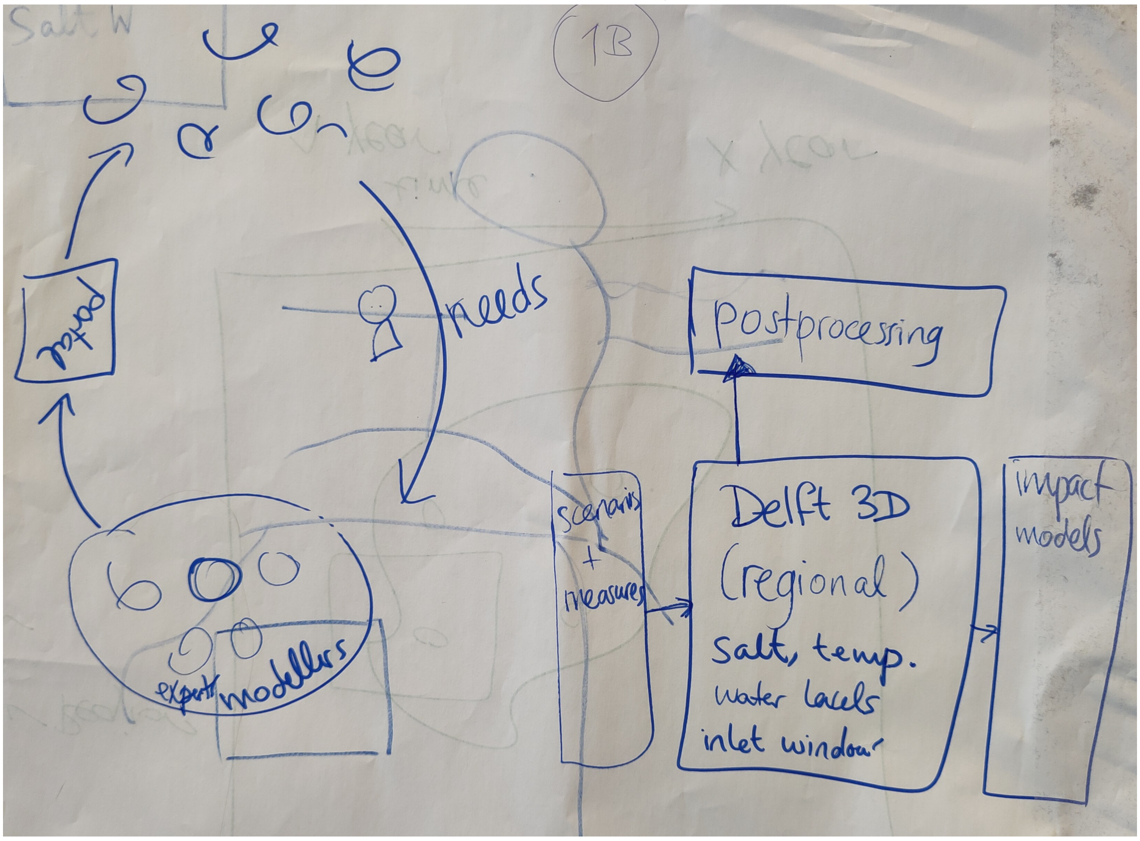
Group and design number	Conceptual, Predictive (2D).
Level of detail	balges + flows / CLD + stock-flow system dynamics
Computation time	low
Interaction possibility	- more limited than 2C - Can change measures + scenario variables & re-simulate. - easily build user interface
Ease of use (knowledge background required)	- can do technical exploration. - What if? (It rains 2x as much)
Goal/application	Exploring consequences of measures & scenarios over time Patterns of behaviour
Other noteworthy comments?	see physical system, but @ aggregated level. heuristic physical processes + human decision making. Simulation model. * need to validate against more detailed models * can include navigation economics ---> Trade-offs. Where does FloodAdapt fit?

Figure B.4: Properties table concept D.

B.2.2. Challenge 2: photo's of concept drawings



(a) Group 1 concept drawing 1A.



(b) Group 1 concept drawing 1B.

Figure B.5: Zoom in on concept drawings for quadrant A and B from group 1.

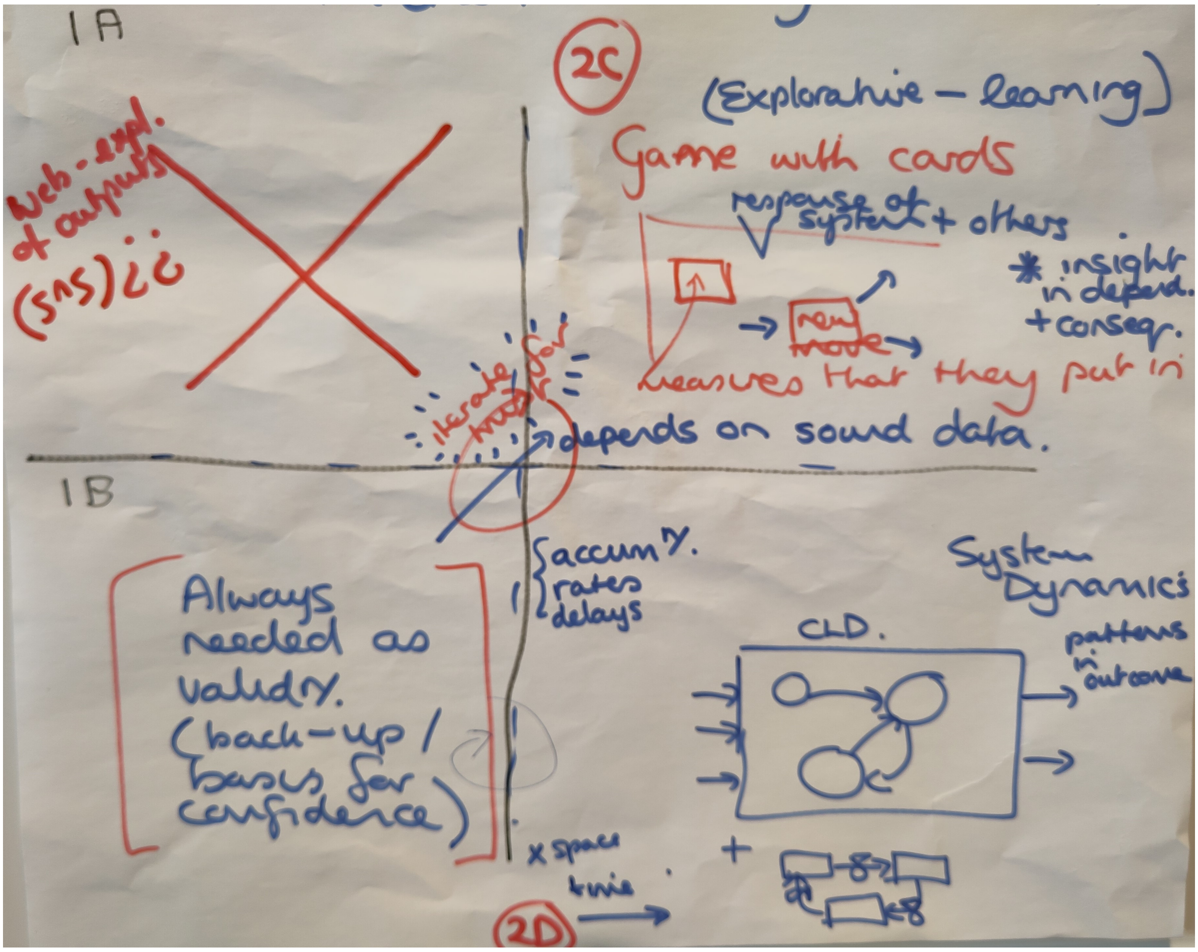
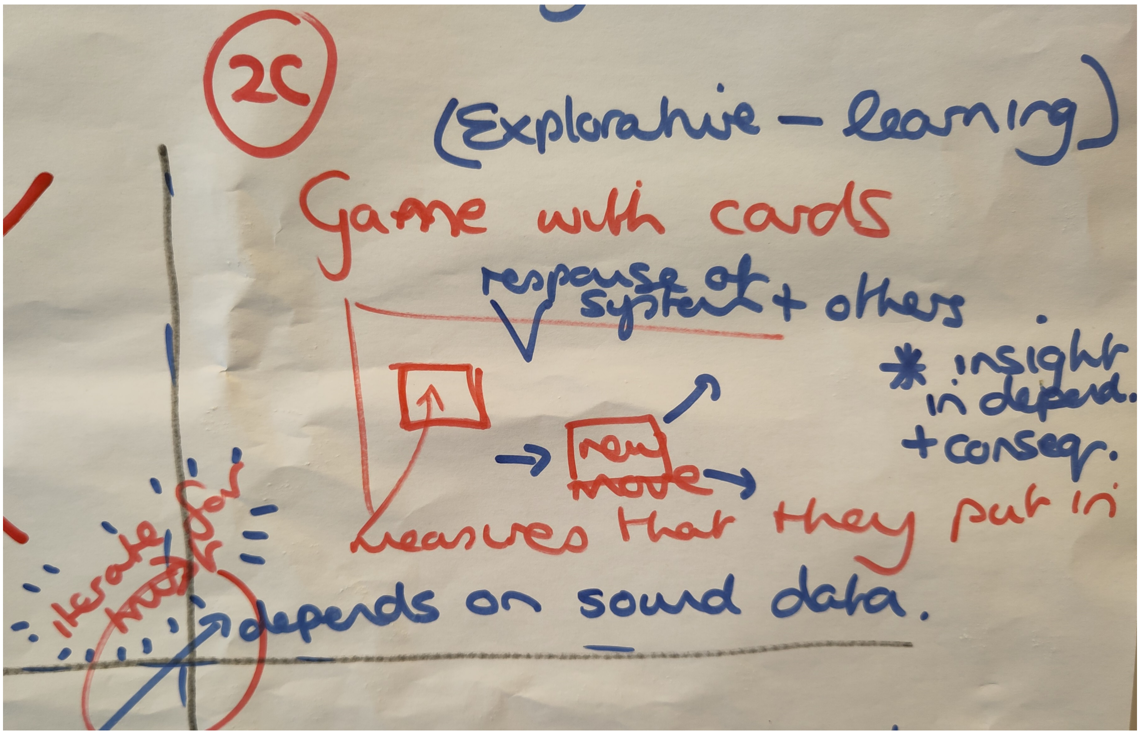
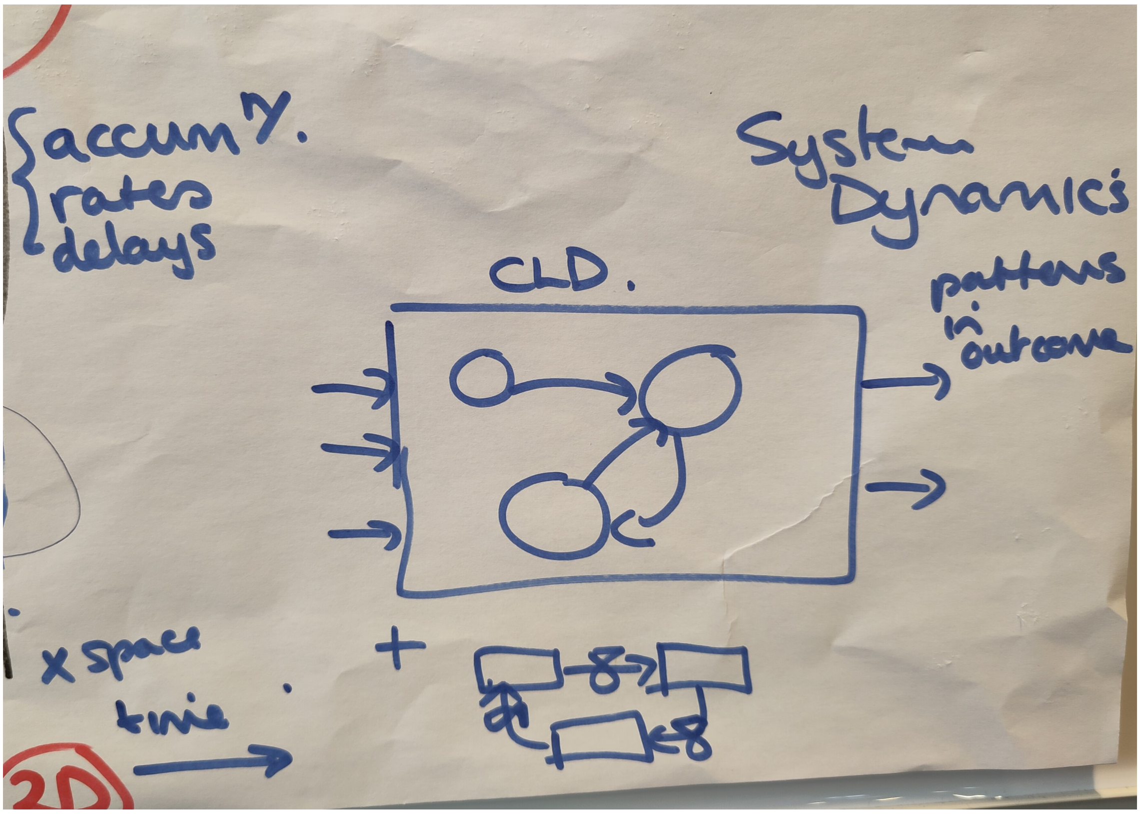


Figure B.6: Concept drawing group 2.



(a) Group 2 zoom 2C.



(b) Group 2 zoom 2D.

Figure B.7: Zoom in on concept drawings for quadrant C and D from group 2.

B.2.3. Challenge 3: votes overview

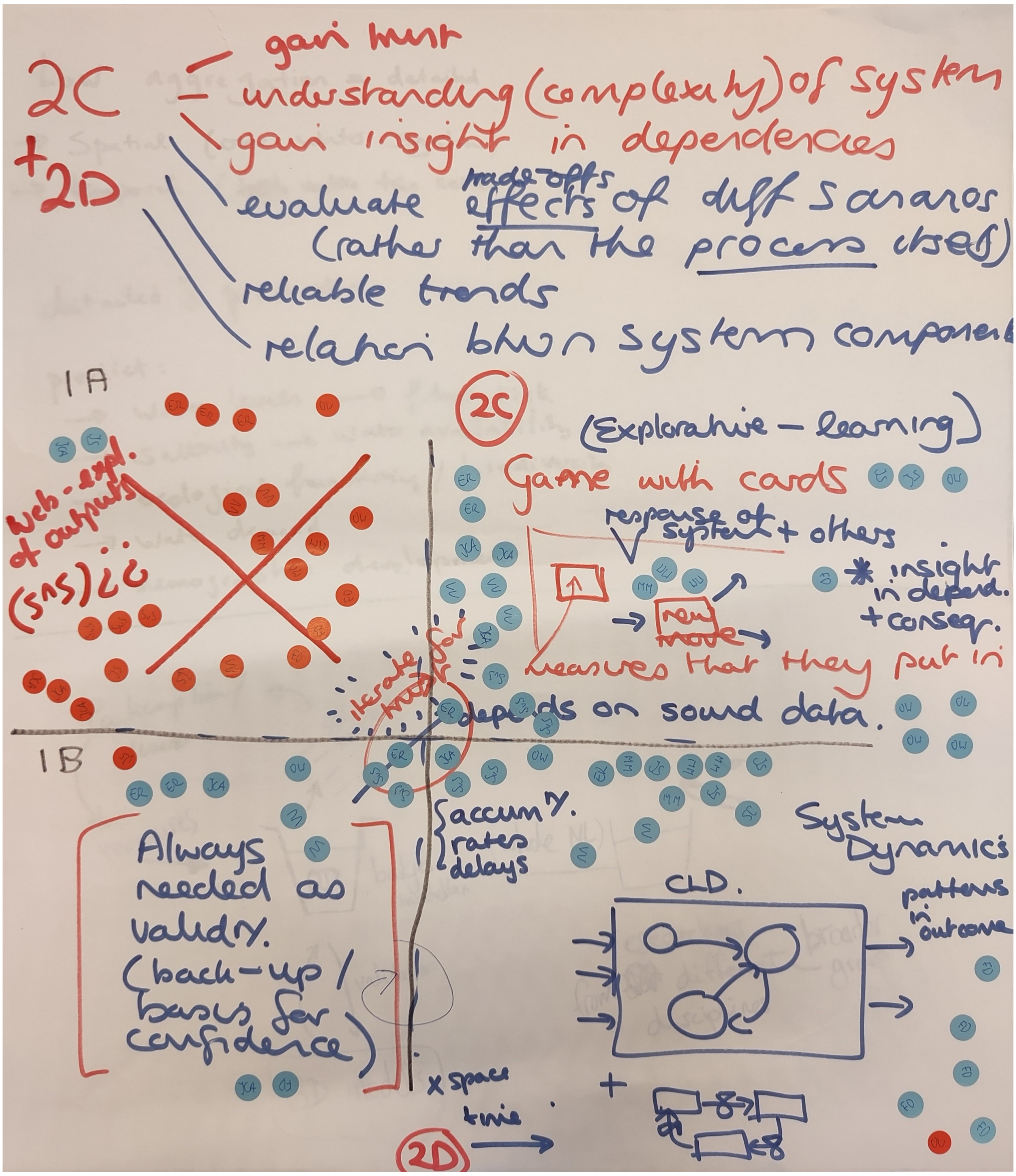


Figure B.8: Picture of votes of favorite concepts design workshop. Blue stickers are positive, red are negative.

Votes			
Conce	**Posit**	**Negat**	**Reason**
A	1 (A1)	2 (A2)	A1: I think a web-based tool that people can use to explore detailed GIS-specific data is useful e.g. SIGMS-PLAN in belgium, A2: negative votes
B	0	1	B: Don't focus too much on detailed modelling in the tool. It's a "basis behoefte"
C	2	0	C: Explorative card-based game is likely to teach people about the trade-offs in the system
D	4	0	D: because we can predict+explore consequences of actions+external variables. Also with stakeholders
A	1 (A1)	3 (A2)	(it's difficult to not, it's abstract)
B	2	0	Model of the processes and indicatiors is necessary at the level of detail that might be useful to explore consequences (experts)
C	3	0	"tool" to learn about the relationships between processes and consequences accross various goals
D	1	0	
A	0	3	Iets over schaalniveaus
B	3	0	
C	3	0	
D	1	0	
A	0	3	ik denk dat je altijd 1B nodig hebt, omdat je het systeem moet begrijpen voordat je kunt aggregeren. In de workshop concludeerden we ook dat 2D voor sommige onderdelen
B	2	0	van de problematiek aanvullende concepten levert om het systeem te begrijpen. Als je beide in de vingers hebt, kun je naar een hoger aggregatie-niveau om te exploreren,
C	3	0	zoals in 1B. Als je deze gedachtengang volgt, sla je 1A over. En ik denk dat dat niet erg is.
D	2	0	
A	0	3	A: Het lijkt erg lastig om een combinatie te maken van gedetailleerde modellen (links) met vaak disciplinaire kennis (hydrodynamics) en dat dan in een vorm te gieten waarbij
B	0	0	veel interactie mogelijk is om met allerlei stakeholders te gaan verkennen wat allerlei maatregelen voor effect zouden kunnen hebben.
C	3	0	C+D: Rechts, omdat je voor integraliteit niets anders kan dan informatie aggregeren, anders krijg je een monstermodel. Niet voor niets is er een heel vakgebied rondom
D	4	0	integrated assesssment models. De verticale as vind ik lastiger, omdat ik in gedachten heen en weer schiet tussen 1) het onderliggende model waarmee berekeningen gedaan kunnen worden en 2) het ‘window’ of ‘portaal’ waarmee de resultaten toegankelijk worden voor grote groep stakeholders. oNr1 zit meer onderin, maar niet helemaal. Extreme variant is dat maar 1 expert snapt hoe het model aangestuurd kan worden. In dit geval moeten expertises geïntegreerd worden en wil je een model dat door meerdere experts (inhoudelijke mensen maar vanuit andere achtergrond) aangestuurd kan worden. Zodat bv waterveiligheidsexperts zelf kunnen uitrekenen wat er gebeurt met verzilting, of andersom. oNr2 zit meer naar boven. Ik twijfel of dit dan echt interactief moet worden, dus dat iedereen zijn eigen maatregeltje moet kunnen doorrekenen. Of (net als blokkendoos) dat de iteratie minder direct is. De gebruiker kan wel eigen maatregel aandragen, maar die moet dan eerst even doorgerekend worden en daarna in de ‘blokkendoos’ gehangen. In de blokkendoos kon je wel pakketten samenstellen. Dat zou wel echt heel leuk zijn als dat kon. Dus met beschikbare maatregelen die al doorgerekend zijn. Hier is de aanname van stapelbaarheid erg belangrijk.
A	0	3	Mijn grote voorkeur gaat uit naar 2D. Voor mij is belangrijk dat we een tool hebben die het maken van adaptatiepaden kan ondersteunen. Kortgezegd: dat we niet alleen
B	1	0	tekenen maar ook rekenen. Tegelijkertijd ben ik er voorstander van dat een brede groep kan rekenen, niet alleen modelexperts. En dat toekomstverkenningen relatief snel
C	1	0	uitgevoerd kunnen worden. Dat kan m.i. alleen in optie 2D
D	5	0	
A	0	2	De primaire cyclus die het tool moet ondersteunen is daarom m.i. het kunnen inbrengen van die systeem-ingrepen, het doorrekenen ervan en het presenteren van de
B	1	0	consequenties. Een grote uitdaging zal nog zijn het wegen van de zeer verschillende aspecten: bv: de belangen van de natuur (met een zoetwatervraag) en die van de
C	4 +1	0	landbouw. Dat zal uiteindelijk de kern vormen van de discussies die o.b.v. de uitkomsten gevoerd moeten worden: het gaat om deze discussies, gevoed met de resultaten
D	1	1	van de tool. Voor een korte feedback-tijd is een bakjesmodel dan het meest geschikt
A	0	3	
B	2	0	B: Need detailed moddels to build trust
C	3	0	C+D: global what/if analyses where you can very with measures and investigate impact
D	2	0	

Figure B.9: Overview reasoning of participants for voting favourite concepts during design workshop.

C

Appendix C User workshop

This Appendix shows the materials used and results from the User workshop. First, the from and hand-out that were handed out to the participants are displayed. Next, the results accumulated from these forms are presented.

C.1. Materials User workshop

C.1.1. Form

De Deltaverkenner - MSc Thesis Inge Faber - Vragenlijst

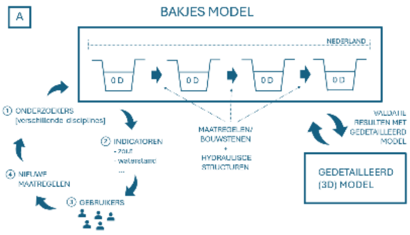
Deel 1: Akkoord data gebruik

Deze vragenlijst in onderdeel van het MSc thesis onderzoek van Inge Faber. De antwoorden die met deze vragenlijst verzameld zijn, zullen opgeslagen en gepubliceerd worden in het thesis rapport. Deze zal te vinden zijn op de TU Delft thesis repository na afronding van het onderzoek rond eind oktober. Het invullen van de vragenlijst is vrijwillig. Door het invullen van deze vragenlijst geef je toestemming voor het gebruik van deze (anonieme) data voor het onderzoek.

1. Met welke discipline heb je de meeste affiniteit (meerdere antwoorden mogelijk)?
   □ Zoetwater □ Water veiligheid □ Ecologie en Waterkwaliteit
   □ Ruimtelijke adaptatie □ Anders, namelijk: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Deel 2: Vijf verschillende concepten

A. 'Het bakjes model'



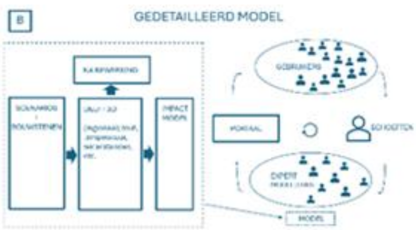
In hoeverre kan concept A een verrijking zijn van jou werkveld?
Geef een cijfer van 1 (geen verrijking) tot 5 (veel verrijking).

1 □ 2 □ 3 □ 4 □ 5 □

Is er een of meer eigenschap(pen) die je het meest aanspreekt en of afschrikt?

	Aansprekend	Afschrikkend
Detailniveau	□	□
Rekentijd	□	□
Interactie mogelijkheden	□	□
Toepassing/doel	□	□
Niet van toepassing	□	□
Anders, namelijk: _	□	□

B. 'Gedetailleerd model'



In hoeverre kan concept B een verrijking zijn van jou werkveld?
Geef een cijfer van 1 (geen verrijking) tot 5 (veel verrijking).

1 □ 2 □ 3 □ 4 □ 5 □

Is er een of meer eigenschap(pen) die je het meest aanspreekt en of afschrikt?

	Aansprekend	Afschrikkend
Detailniveau	☐	☐
Rekentijd	☐	☐
Interactie mogelijkheden	☐	☐
Toepassing/doel	☐	☐
Niet van toepassing	☐	☐

Anders, namelijk: ____________________

C. 'Spel met kaarten'

In hoeverre kan concept C een verrijking zijn van jou werkveld?

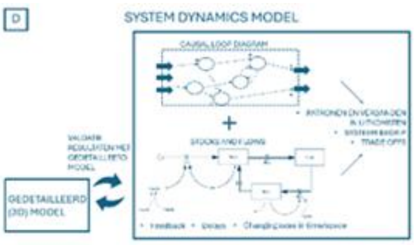
Geef een cijfer van 1 (geen verrijking) tot 5 (veel verrijking).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Is er een of meer eigenschap(pen) die je het meest aanspreekt en of afschrikt?

	Aansprekend	Afschrikkend
Detailniveau	☐	☐
Rekentijd	☐	☐
Interactie mogelijkheden	☐	☐
Toepassing/doel	☐	☐
Niet van toepassing	☐	☐
Anders, namelijk: ____________________	☐	☐

D. 'System dynamics'



In hoeverre kan concept D een verrijking zijn van jou werkveld?

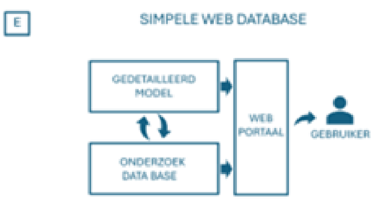
Geef een cijfer van 1 (geen verrijking) tot 5 (veel verrijking).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Is er een of meer eigenschap(pen) die je het meest aanspreekt en of afschrikt?

	Aansprekend	Afschrikkend
Detailniveau	☐	☐
Rekentijd	☐	☐
Interactie mogelijkheden	☐	☐
Toepassing/doel	☐	☐
Niet van toepassing	☐	☐
Anders, namelijk: ____________________	☐	☐

E. ‘Web database’



In hoeverre kan concept B een verrijking zijn van jou werkveld?
Geef een cijfer van 1 (geen verrijking) tot 5 (veel verrijking).

1 □ 2 □ 3 □ 4 □ 5 □

Is er een of meer eigenschap(pen) die je het meest aanspreekt en of afschrikt?

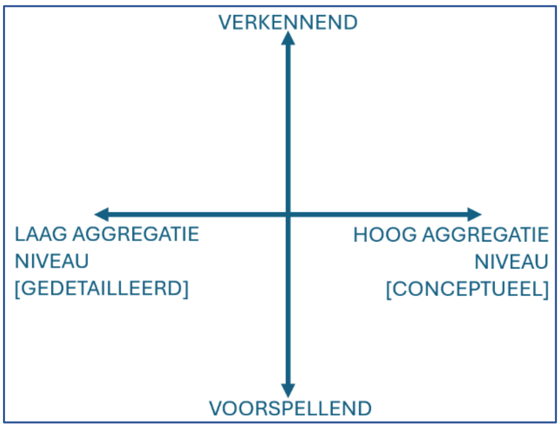
	Aansprekend	Afschrikkend
Detailniveau	□	□
Rekentijd	□	□
Interactie mogelijkheden	□	□
Toepassing/doel	□	□
Niet van toepassing	□	□
Anders, namelijk: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _	□	□

F. Welk concept spreekt je het meeste aan?
Rankschik ze van nummer 1 (meest aansprekend) tot nummer 5 (minst aansprekend).

Concept	*nummer*
A	
B	
C	
D	
E	

Deel 3: Algemene vragen

1. Zet een kruis in dit assenstelsel waar jij de meeste potentie vind zitten voor een uitwerking van een Deltaverkenner tool.



2. Welk aspect vind jij het meest belangrijk als eis voor een Deltaverkenner tool?
Rankschik ze van nummer 1 (meest belangrijk) tot nummer 3 (minst belangrijk).

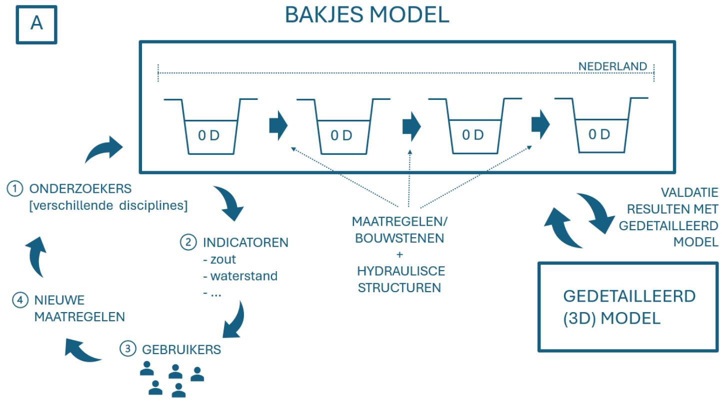
Aspect	*nummer*
Korte rekentijd	
Hoge nauwkeurigheid resultaat (op de meter/minuut/ liter/etc. nauwkeurig)	
Gebruikersgemak (gemak van het begrijpen van de resultaten)	

3. Wat vind jij het belangrijkste doel om te bereiken met een Deltaverkenner tool?
Rankschik ze van nummer tot nummer 1 (meest belangrijk) tot nummer 4 (minst belangrijk).

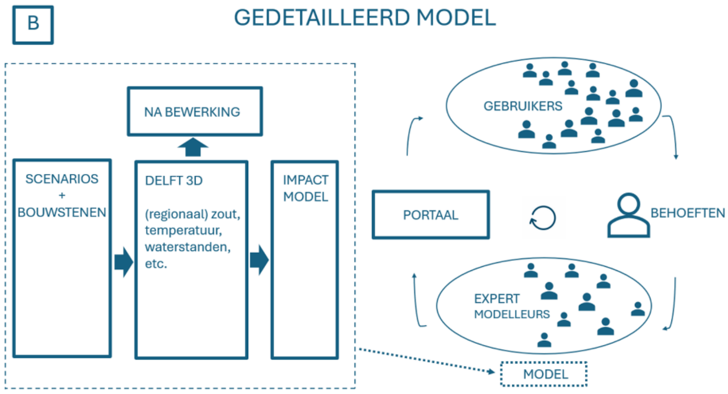
Doel	*nummer*
Systeemkennis verkrijgen (meer inzicht in processen)	
Leren als gebruiker door het gebruik van de tool	
Exacte data genereren voor nieuwe scenario's en bouwstenen	
Gemeenschappelijke tafel/dialoog ruimte creëren voor verschillende gebruikers	

4. Is er verder nog iets wat je kwijt wilt?

C.1.2. Hand out

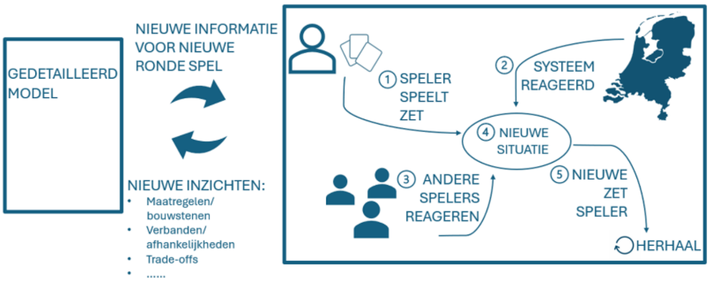


Eigenschap	Concept A: het bakjes model
Detailniveau	Geaggregeerd bakjes model
Rekentijd	Koffie pauze
Interactie mogelijkheid	Gemiddeld, veel interactie tussen onderzoekers en tussen gebruikers
Gebruikersgemak	Gemiddeld, interactie expert en gebruiker
Toepassing/doel	Interactie onderzoekers, verkennen bouwstenen en knelpunten



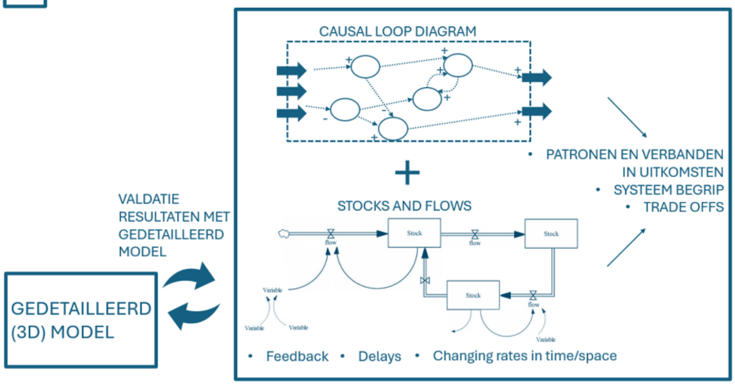
Eigenschap	Concept B: Gedetailleerd model
Detailniveau	Hoog, combinatie 2D&3D
Rekentijd	Weken
Interactie mogelijkheid	Nauwelijks
Gebruikersgemak	Alleen experts, na bewerking nodig voor gebruikers
Toepassing/doel	Detail studie

C SPEL MET KAARTEN



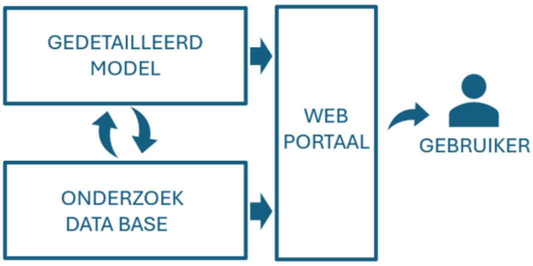
Eigenschap	Concept C: Spel met kaarten
Detailniveau	Laag
Rekentijd	0
Interactie mogelijkheid	Veel, directe interactie met systeem en mens
Gebruikersgemak	Makkelijk
Toepassing/doel	Leren van systeem, verkennen systeem en menselijke keuzes

D SYSTEM DYNAMICS MODEL



Eigenschap	Concept D: System dynamics
Detail niveau	Dynamisch geaggregeerd
Rekentijd	Koffie pauze
Interactie mogelijkheid	Redelijk veel, makkelijk aanpassingen doorvoeren
Gebruikersgemak	Gemiddeld, interactie expert en gebruiker
Toepassing/doel	Systeem kennis, verbanden processen en mensen verkennen

E SIMPELE WEB DATABASE



Eigenschap	Concept E: Web database
Detail niveau	Hoog en uitgebreid
Rekentijd	0
Interactie mogelijkheid	Nauwelijks
Gebruikersgemak	Afhankelijk van materiaal, maar vaak achtergrond kennis expert nodig
Toepassing/doel	Verzamelen, overzichtelijk en toegankelijk maken van kennis

C.2. Results user workshop

C.2.1. Part 1 of form: associated fields of expertise

Table C.1: Overview of associated fields of expertise of participants user workshop. Reaction on questions ”deel 1” user workshop form, see C.1.2.

Deelnemer	zoetwater	watervei-ligheid	ecologie en waterk-waliteit	ruimtelijke adaptatie	anders, namelijk:
1	x	x			
2					model-based decision-support
3		x	x		
4			x		
5	x	x	x		
6	x	x	x		
7	x				
8	x	x		x	economie
9		x			
10					integraal water beheer (incl. scheepvaart)
11	x				
12					niets ingevuld
13			x		
14	x				
15	x				
16	x	x			
17	x		x	x	
18	x	x		x	Ruimtelijk ordening, wateroverlast
19	x				
20		x			
totaal	12	9	6	3	

C.2.2. Part 2 of form: concepts

Concept A								
UW-...	**cijfer**	**detail**	**rekentijd**	**interactie**	**doel**	**nvt**	**anders**	**opmerking**
1	3							Erg technocratisch, weinig focus op maatsschappelijke impact ruimtelijk betekenis
2	4	p	p	p	p			
3	4	n	p	n	p			
4	2	p	p	p	p			
5	4		p	p				
6	5		p	p				
7	3	p	p					Al veel beschikbaar/ontwikkeld
8	-	n	p	n	n			Een bakjes model kan wel degelijk geavanceerd -> dezy als je onzekerhede niet meeneemt heb je er niets aan, nu is het als een simpel model beschouwd obv causale relaties, een dezy model zit onder system dynamics
9	3		p	p				
10	5		p	p	p			
11	-			p		n		
12	5		p	p				
13	4							Voor brede groep bruikbaar
14	4	p	p	p	p		n: integraliteit van opgaven vangen in 1 simpel model	
15	-							
16	4	p	p	p	p			
17	5	p	p	p	n			Ik werk al met bakjesmodellen voor een specifiek toepassings gebied. Dat schiet echt tekort om uit te breiden naar ruimte, ecologie, economie
18	4	p	p	p				
19	5		p	p				
20	5	p	p	p				
Concept B								
UW-...	**cijfer**	**detail**	**rekentijd**	**interactie**	**doel**	**nvt**	**anders**	**opmerking**
1	3							Wel van belang maar behoefte ligt meer in integrale snelle impact assessment tools
2	2	n	n	n	p			Alleen samen met grof model
3	2	p						
4	2	p	n	n	n			
5	5	p	n	n				Goede basis voor veel toepassingen
6	5	p						
7	2		n					Al veel beschikbaar/ontwikkeld
8	1	n	n	n	n			Deze modellen bestaan al
9	2		n	n				
10	1		n	n				
11	3				p	n		
12	5	p						
13	-	p		n				Alleen voor specialisten bruikbaar en je moet vooraf heel precies weten wat je wilt
14	1	p	n	n	p		n: hier hebben we al veel apparte sectorale modellen van	
15	-							
16	3	p	n	n	p			
17	5	p	n	n	p			Ik werk met detailmodellen, maar op schaal van afgebakende systeemwerking, maatregel in detail doorrekenen. Soms zijn ze te detetailleerd
18	2		n	n				
19	2	p			p			Voor specifieke vragen buiten huidige modeldomein
20	4	p	n	n				

Figure C.1: Responses concept A&B on questions "deel 2" user workshop form, see C.1.2.

Concept C								
UW-...	**cijfer**	**detail**	**rekentijd**	**interactie**	**doel**	**nvt**	**anders**	**opmerking**
1	1							Hiervoor is eerst een basis nodig met duidelijke wens
2	1	p	p	n	n			Alleen als presentatie mogelijkheid
3	2	n		p				
4	4	p	p	p	p		p: breed toe te passen	
5	2			p				Leuk maar is meer eenmalig
6	4			p				
7	-							
8	1	n	n	n	n			Gaming is geen oplossing want hiervoor heb je eerst de andere modellen nodig
9	3	n		p				
10	4			p	p			
11	1						n: spreekt niet aan	
12	2			p				
13	-							Is er wel de juiste input uit de gedetailleerde modellen?
14	3	n	p	p	p		n: Dit gesprek voeren we al heel veel (zonder kaartjes) bijvoorbeeld in de context van het Deltaprogramma	
15	-							
16	1					np		
17	5	p	p	p	p			Ik werk met serious games. Super nuttig voor het inzicht in de kwalitatieve kant van het beslisprobleem
18	3				p			
19	4			p				
20	3			p				

Concept D								
UW-...	**cijfer**	**detail**	**rekentijd**	**interactie**	**doel**	**nvt**	**anders**	**opmerking**
1	4							detail model lijkt nodig voor basis, maar denk ook aan hybride model concepten waarin koppeling met vuistregels plaats vindt
2	5	p	p	p	p			
3	4	p	p					
4	-	p	p	n	p			
5	5	p	p	p	p			Dit is waar we in NL wel behoefte aan hebben
6	4						p: verbanden en oorzaak gevolgen inzichtelijk maken	
7	-							
8	5	p	p	p	p			Dit zit al in een correct bakjes model of bedoel je dan een Dezy toepassing. Dezy gebruikt vooraf opgestelde databases met allerlei scenario's+kansen
9	4	p			p			
10	5		p	p	p			
11	2							
12	5						p: focus op werking systeem & relaties	
13	-		p	p				Lijkt te passen bij doel
14	4	p	p	p	p		p: klinkt als een verbeterde versie van A, integraliteit ook beter te vangen	
15	-							
16	4	p	p	p	p			
17	5							Verrijking van A
18	3				p			
19	4				p			Vanwege de feedbacks tussen watersysteem en de mens
20	3			p				

Figure C.2: Responses concept C&D on questions "deel 2" user workshop form, see C.1.2.

Concept E								
UW-...	cijfer	detail	rekentijd	interactie	doel	nvt	anders	opmerking
1	-							Wat komt hier uiteindelijk uit? Behoefte aan duiding betekenis voor gebieden/regio's en maatschappelijke doorwerking
2	1	n	n	n	n			
3	2							Als educatie mogelijkheid
4	-	n	p	n	n			
5	3	p	p	p	p			
6	3			p			n: gebrek aan uitleg bij de gebruiker: de uitkomsten zijn gegenereerd onder bepaalde aannames. Gaat bij gebruiker eraan voorbij of niet?	
7	-							
8	1							Web based is de vorm van het model, dit kun toepassen op alle modellen
9	3			n	p			
10	3	n		n	p			
11	4				p			
12	2			p				
13	-							
14	2	n	p	n	p		p: altijd en overal toegankelijk nodigt uit tot zelfstudie	
15	-							
16	3	p	p	n	p			
17	-							Ik zou hier generatieve AI aan toevoegen, probeer de huidige kennis ander te aansluiten over domeingrenzen heen
18	1							
19	1							
20	3			p				

Figure C.3: Responses concept E on questions "deel 2" user workshop form, see C.1.2.

Vraag 2.F	Welk concept spreekt je het meeste aan? Rankschik ze van nummer 1 (meest aansprekend) tot nummer 5 (minst aansprekend).																			totaal
UW-...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
A	3	2	2	4	3	1	-	4	3	2	4	1	-	2	-	2	-	1	1	1	2,133333
B	4	4	4	1	2	2	-	5	5	5	3	3	-	5	-	3	-	4	4	2	3,4
C	5	3	5	2	5	4	-	1	4	3	5	5	-	3	-	5	-	3	3	5	4
D	2	1	1	3	1	3	-	5	1	1	2	2	-	1	-	1	-	2	2	3	1,733333
E	1	5	3	5	4	5	-	5	2	4	1	4	-	4	-	4	-	5	5	4	3,733333

Figure C.4: Responses question 2F of "deel 2" user workshop form, see C.1.2. Incomplete answers are not taken into account for the averages.

C.2.3. Part 3 of form: general questions design space

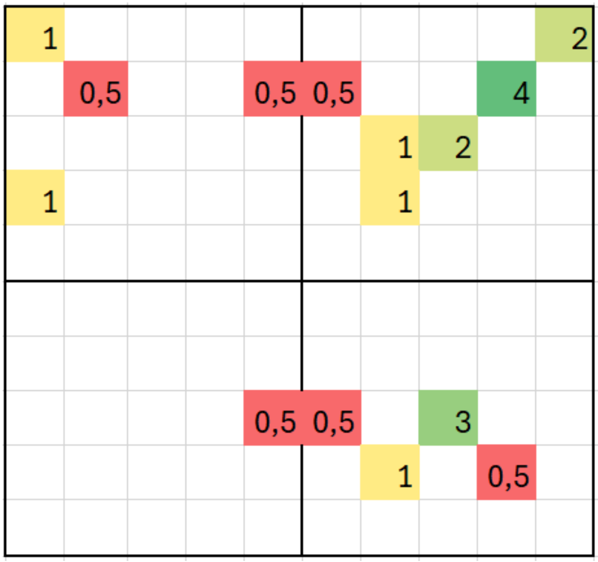


Figure C.5: Larger grid size of heat map question 1 of "deel 3" user workshop form, see C.1.2.

UW-...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Vraag 2	***Welk aspect vind jij het meest belangrijk als eis voor een Deltaverkenner tool?***																				
	Rankschik ze van nummer 1 (meest belangrijk) tot nummer 3 (minst belangrijk).																				**totaal**
Korte rekentijd	1	1	2	2	3	2	2	1	2	2	3	1	-	2	-	3	-	2	2	1	1,875
Hoge nauwkeurigheid	3	3	3	3	2	-	3	3	3	3	1	3	-	3	-	1	-	3	3	3	2,6875
Gebruikersgemak	2	2	1	1	1	1	1	2	1	1	2	2	-	1	-	2	1	1	1	2	1,4375
Vraag 3	***Wat vind jij het belangrijkste doel om te bereiken met een Deltaverkenner tool?***																				
	Rankschik ze van nummer 1 (meest belangrijk) tot nummer 4 (minst belangrijk).																				**totaal**
Systeem kennis	1	1	1	1	2	3	1	2	1	2	3	2	1	2	2	1	-	1	3	1	1,5625
Leren	3	2	3	4	3	-	4	4	4	4	4	3	4	3	3	3	-	3	2	2	3,1875
Exacte data genereren	4	4	4	3	4	-	2	3	3	3	1	4	2	4	4	2	-	4	4	4	3,3125
Dialoog	2	3	2	2	1	1	3	1	2	1	2	1	3	1	1	4	1	2	1	3	1,9375

Figure C.6: Responses question 2&3 of "deel 3" user workshop form, see C.1.2. Incomplete answers are not taken into account for the averages.

UW-...	Is er verder nog iets wat je kwijt wilt?
1	Zie werksessie en flaps!
2	Meerdere schaalniveau's betekent meerdere modellen
3	Succes
4	Graag wel dynamisch in de tijd aspecten van veranderend totaal meenemen
5	Er zijn al veel modellen, ontwikkelen is niet het doel, maar het goed bereiken van (nieuwe) doelgroepen
6	Een model/instrument is maar een middel. Alles hangt af van wat je daarmee moet/wil doen cq bereiken
7	Maak gebruik van wat er al beschikbaar is en ontwikkel dit door obv de behoeften/vragen van de gebruikers. Geen grote nieuwe ontwikkelingen starten. Probleem nu is lange rekentijd bij veel detail. Je wil naar kortere rekentijden maar wel detail behoude. Veel van de huidige quick scan tools verliezn veel detail informatie/gro agregatie niveau
8	De indeling in modellen kan ik niet volgen. Het bakjesmodel zie ik als model waar een regio een eenheid is en gebruik maakt van rekenregels. Dat kan ook een database zijn waarin onzekerheden zitten. Dit type modellen (Dezy) heb ik onder 'system dynamics' geschaard
9	-
10	Uiteindelijk gaat het niet om de keuze voor 1 concept, maar om het combineren van verschillende concepten
11	-
12	Goed helder hebben voor welk probleem dit een oplossing is. Van black box modellen naar communiceren "knoppen/systeemkennis en snel inzichtelijk maken varianten voor bredere doelgroep (RO, bestuurders)
13	-
14	-
15	Crux is inzicht opleveren
16	-
17	Uitdagende klus! Dit (vraag 1.F) hangt van toepassing&doelgroep af. Volgens mij heb jee een bouwwerk over schalen heen nodig .Voor de deltaverkenner zou ik aan de bovenkant beginnen, een mix van E met C en D
18	Volgens mij moet je eerst doel, gebruikersgroep en toepassing (specifiek traject?) bepalen en daar een geschikt model óf geschikt werkwijze/werkvorm bij bedenken
19	Succes :)
20	Combinatie van A en B. Maar deltaverkenner moet A zijn en gevoed worden door B

Figure C.7: Responses question 4 of ”deel 3” user workshop form, see C.1.2.