The introduction of interactive modelling by 3Di in flood resilient urban spatial planning

Frank Tibben Bsc.

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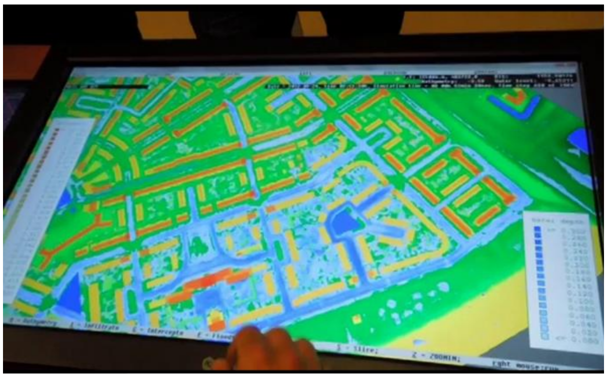

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The introduction of interactive modelling by 3Di in flood resilient urban spatial planning

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Cover photo: screenshot from a 3D flight above the Watergraafsmeer district in Amsterdam (24-03-2014) and the 3Di touch table during a workshop about climate adaptation in Betondorp, a district in Amsterdam (22-05-2013)

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SUMMARY

Due to changing climate change predictions resulting in more intense rain in combination with larger urban areas, municipalities, water boards and provinces are not only focusing on their sewage systems but also on flood measures in spatial planning to prevent urban flooding. This has resulted in a flood resilient urban spatial planning sector, which cares about minimizing the consequences of floods, but at the same time allowing some flooding. By allowing some flooding, smaller changes are needed to minimize flooding in the, often space-limited, urban environment.

In order to support the decision making process in flood resilient urban spatial planning, computer simulation models are available which could assess the effectiveness of spatial measures. These models could be used in an interactive manner which makes it possible to pause a flood calculation in order to make adjustments (for example raising or lowering a specific piece of land). This gives users direct feedback during a calculation, e.g. when used during meetings. An example of such a model is 3Di. However, in current work processes such interactive models are hard to implement. Therefore the goal of this research is to find out what aspects of current decision making process could be changed in order to evaluate how this process could be shaped to be more suitable for the use of an interactive water management model.

A first step towards this research goal was to identify the current decision making process in flood resilient urban spatial planning. After a literature study a questionnaire is developed and distributed among a broad field of stakeholders in flood resilient urban spatial planning. The results of the questionnaires are used to define which aspects of the decision making process could be changed. The second step was to investigate the possibilities of implementation of 3Di in flood resilient urban spatial planning. Workshops in which 3Di is used at municipalities, water boards and related organizations are visited and interviews are conducted. Also model purposes are reviewed. A case study of the formation process of a Basis Sewage Plan (Dutch; 'Basisrioleringsplan' [BRP]) is conducted. The results of the case study are, together with the results of step one and two used to evaluate how a decision making process could be shaped to implement 3Di.

The results of the literature review and questionnaires generate an overview of the possibility of change of nine aspects of the decision making process:

- Experience and knowledge levels of actors
- Roles of actors
- Willingness to innovate
- Initiators for innovation implementation
- Kind of information received from each actor
- Knowledge sharing
- Trust in model results
- Structure of the decision making network
- Extent of shared goals and beliefs

The workshops and interviews showed that especially the interactive character, realistic and detailed visualizations and cloud-based operating of 3Di are of importance in the decision making process in flood resilient urban spatial planning. The realistic and detailed visualizations (e.g. representing the flooded area from a plane view in 3D) make it possible to involve non-technical stakeholders in the model process. Working of 3Di 'in the cloud' (3Di calculations are performed by a powerful computer in a data center which could be operated by every device with an internet connection) removes the

limitation of the processing power of a normal computer and makes the model approachable from every device with an internet connection.

A Basis Sewage Plan contains information about the existing facilities of a municipal sewage system and its hydraulic and environmental performance. In the new guidelines for composing a BRP not only subsurface measures are important but also flood measures in spatial planning (above surface level) need to be considered due to changing climate change predictions. The BRP case study teaches that in the current process models are only used in a predictive model purpose during one step in the process. Potential added value of 3Di implementation is assessed in:

- Making the BRP process more accessible for non-technical stakeholders (like policy-makers, decision makers and citizens).
- Using 3Di in the whole BRP process and in predictive, exploratory and communication model purposes. For example using the model in an exploratory analysis purpose makes it possible to perform simulations of a range climate change scenarios for the new (broadened) BRP
- Organizing interactive meetings in which 3Di is used to communicate a case to non-technical stakeholders and offer them the possibility to work with the model during a meeting.

A new process design of implementation of 3Di is suggested by defining a number of claims divided in opportunities and barriers. Two opportunities could be seen as especially important for the implementation of 3Di; the use of the 3Di during meetings in the decision making process and the introduction of 3Di at the start of a decision making process. Important barriers to overcome are the change in the 'classic' roles of stakeholders in the decision making process and a shift in model purpose(s) in relation to current model purpose(s) used in the decision making process. A transition process from the current situation to the new situation is needed in order to support a successful implementation of 3Di.

In conclusion could be said that the implementation of 3Di in the decision making process has good potential to improve the process and its outcomes and in making the process more accessible for its stakeholders. In order to implement and get advantage of 3Di some important changes in the traditional way of decision making need to be taken (like the use of an interactive model during meetings) and a 3Di model should be operational at the start of a decision making process. These changes need good support to encourage a successful implementation of 3Di in a decision making process in flood resilient urban spatial planning

PREFACE

This report is the result of my graduation research in order to conclude my master in Civil Engineering & Management. My master was focused on the track 'Water Engineering and Management' (WEM). During my master courses I started to look for a topic for my graduation, when I heard about Nelen & Schuurmans from fellow students, a consulting company which provides solutions for solving water management problems. I came in contact with Anne Leskens, who worked on his PhD research (*Flood models in context. Bridging the gap between model experts and decision makers*) at the WEM department of the University of Twente in cooperation with Nelen & Schuurmans. This first contact leads to a graduation research as part of the PhD research, of which this report presents the design, results and conclusions.

After finishing my research proposal I started to work on my research at Nelen & Schuurmans in Utrecht. During the 5 months that I was part of the 3Di Academy I could make use of the valuable resources and knowledge, which has led to good input for my research.

I would like to thank all respondents of my survey for offering their time to complete the questionnaires. Without these results this research was not possible. Furthermore I would like to thank the staff of Nelen and Schuurmans for their support and providing a pleasant work environment. Especially I would thank my supervisors, Maarten Krol, Marcela Brugnach and Anne Leskens for their critical eye and valuable advice.

Amsterdam, November 2014

Frank Tibben

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1. INTRODUCTION

In the last decennia more and more people are moving to the cities, resulting in larger urban areas. At the same time, climate change predictions expect more intense rain during winters, major flooding and a rising sea level (European Environmental Agency, 2004), which are major threats to main urban areas (Woltjer & Al, 2007). However in these growing urban areas less and less surface area is available for storing water in case of abundant water flows. Moreover additional storage is needed due to large areas of pavement in the urban environment, which restricts the infiltration of water and accelerates the discharge. Therefore the adjustment of (existing) urban area by spatial planning is important in order to facilitate abundant water flows, but urban area is scarce and has many spatial functions. In that case flood resilient spatial planning comes into play. Flood resilient planning can be defined as minimizing the consequences of floods, but at the same time allowing some flooding (Vis, Klijn, De Bruijn, & Van Buuren, 2003). By doing so, smaller changes in the often space-limited urban environment are needed in order to minimize flooding.

As Gersonius, Zevenbergen, & Van Herk (2008) stated, the implementation of flood resilient urban measures need the provision of good quality information and planning tools in the participatory process. Access to information for stakeholders and offering them planning tools are important aspects of facilitating participation (for example offering stakeholders access to information about the consequences of different flood prevention measures) (Bruns (2003); Cornwall (2008)). To manage all different spatial functions and to evaluate the effectiveness of possible measures (think about adapted pavement types, green roofs, water squares, etc.) an interactive model interface would be valuable to support the decision making process in flood resilient spatial planning. An interactive model is capable to pause a calculation, make adjustments in the model configuration (e.g. change or add green roofs or water squares), and continue the calculation. This has the advantage of getting a direct assessment of the effectiveness of proposed measures, e.g. during a stakeholder meeting. Such an interactive, model toolbox is in development by the 3Di Water Management Consortium (3Di Consortium, 2014), see the text box below. However how do spatial planners react on this new type of instrument, and how could this instrument be of additional value in these decision making processes? Would they actually use the interactive possibilities of 3Di, or would they prefer their current way of working? These are questions to be assessed in this research. In the remaining of this thesis '3Di' refers to the whole 3Di model toolbox (see also Text box 1).

TEXT BOX 1: THE 3DI WATER MANAGEMENT RESEARCH PROGRAM

The 3Di Water Management research program

The 3Di Water Management research program tries to deal with the limitations of earlier flood models and longer known issues in the field of communication and organization. They focus at developing a modelling tool which is also especially suitable for non-technical users (for example spatial planners who want to assess the suitability of spatial planning measures in relation to water management) and is widely available and easy to use for municipalities, water boards, provinces, etc. (3Di Consortium, 2014). The 3Di water management consortium is a four-year research program, which develops a whole new calculation toolbox in order to set up an integrated flood model interface (3Di Consortium, 2014). 3Di consists of the 3Di model toolbox, which combines different ICT products, like the Flood Early Warning System (FEWS) and the Lizard

Flooding software for generating flood calculations, and different databases, like for land use, land elevation and locations of waterways and constructions. This makes the 3Di toolbox suitable for analysing problems in the field of multi-level safety, flood risks and regional and urban flooding. Hydrodynamic calculations are carried out at a high level of detail at a large scale and could be realistic visualized in (3D) stereo, which could be especially helpful for representing outcomes to people not familiar with 3Di, like spatial planners and decision makers. Important innovations of the 3Di model toolbox are fast calculations, high resolution representations and its interactive character (3Di Consortium, 2014). The interactive character makes it possible to pause a flood model calculation in order to make adjustments to the model. For example it allows users to simulate a sequence of dike breaches or to incrementally extend a measure until the desired effect is reached during an analysis. This could make the 3Di toolbox a helpful tool during work sessions with (non-)specialist in order to assess the feasibility of measures and to improve the water awareness of decision makers and the public. Many public authorities are facing the challenge of how to manage the risks of urban floods in their redevelopment projects and expansions in at risk areas (Gersonius, Zevenbergen, & Van Herk, 2008). This is a new field of research in which the 3Di model toolbox can be of valuable use.

1.1. PROBLEM DEFINITION

In water management the use of flood models have always been of significant value. Models are able to calculate and simulate extensive water movements in all kinds of spatial areas and scales. Nowadays flood models keep getting more accurate, spatially more detailed and faster, and on the other hand computational power is increasing. Although these flood models are very advanced in terms of integration of physical processes, detail of outcomes and visualization techniques, the flood models are used in a limited scope of decision making processes and by a limited number of people (Borowski & Hare (2007); Brugnach, Tagg, Keil, & De Lange (2007)). This is due to a misunderstanding between model developers and decision makers about the use of models in decision making (Borowski & Hare (2007); Janssen, Hoekstra, De Kok, & Schielen (2009); Timmerman, Beinat, Termeer, & Cofino (2010)). This misunderstanding is stated by Downton, Morss, Wilhelmi, Gruntfest, & Higgins (2005) and Morss, Wilhelmi, Downton, &Gruntfest (2005) as the result of a poor understanding of computer models, on the side of policy makers, and a lack of understanding of the use of models in the decision making process, on the side of model developers. This misunderstanding can limit the adoption of these models by stakeholders and is called the 'water information gap' (Borowski & Hare, 2007). This results in the problem that modelling tools are developed from the point of view of technical possibilities, instead of from the perspective and requirements of decision makers (Leskens J. , 2011) (see Figure 1). The result of this discrepancy between modellers and decision makers is the lack of use of available models, as explained in literature (Leskens, Brugnach, Hoekstra, & Schuurmans (2013); Borowski & Hare (2007); Janssen, Hoekstra, De Kok, & Schielen (2009); Timmerman, Beinat, Termeer, & Cofino (2010)).

However, important to acknowledge is that model developments continue on further technological improvement, despite this misunderstanding between model developers and decision makers (Leskens J. , 2013). Moreover, while technical possibilities of computer modelling are increasing, other complexities may become more important, like organizational and political complexities (Leskens, Brugnach, Hoekstra, & Schuurmans, 2013). It is important that current technological developments take into account the dynamics in the decision making context. Therefore bringing together the modellers domain and the flood decision making domain could be helpful.

One side of this problem is to look at the decision making process in which the models are being used. With this separation of both domains in mind the introduction of interactive model usage in decision making processes will be assessed in this research. This could be seen as a first evaluation of the possibility of connecting the modellers domain and decision making domain, however connecting these domain is not part of this research. The question is posed how the decision making process could be shaped in order to encourage the use of an interactive model. In this research the focus is on decision making processes in flood resilient urban spatial planning.

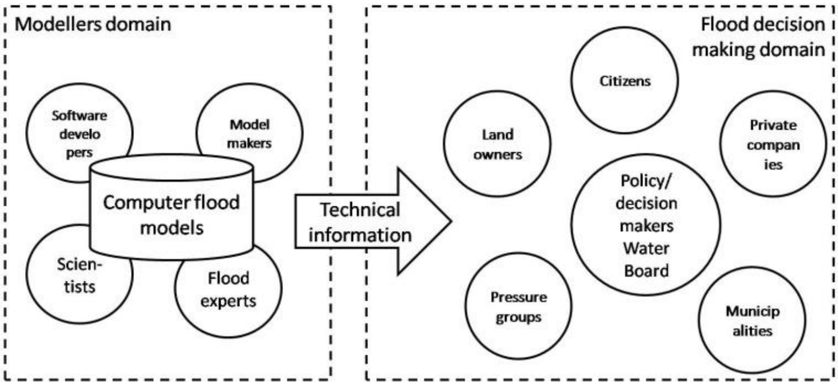


FIGURE 1: THE CURRENT SEPARATION OF MODELLERS DOMAIN AND FLOOD DECISION MAKING DOMAIN (LESKENS J. , 2011)

1.2. RESEARCH OBJECTIVE AND RESEARCH QUESTIONS

This research will focus on assessing the use of 3Di as an interactive model in decision making processes in the flood resilient urban spatial planning sector. Flood resilient spatial planning is one of the three components of the current multi-level safety approach in the Netherlands (Ministry of Infrastructure and the Environment, 2009) (Kolen, Maaskant, & Hoss, 2010). An interactive model is especially suitable for non-technical users, and for cooperation between experts and non-technical users (3Di Consortium, 2014). For this reason assessing the use of such an interactive model in decision making processes could have potential. In these processes in the field of water management many stakeholders are involved. An easy accessible model, both for experts and non-experts, could help in serving all interests of the stakeholders. The application of 3Di in flood calamity management, the third component of the multi-level safety approach, was assessed by the research of Hoff (2013). Differently this research will focus on assessing the use of 3Di in the second component of the multi-level safety approach; flood resilient spatial planning. This is not researched before.

A tool which support interactive modelling and is suitable for analysing problems in the field of multi-level safety is *3Di Water Management* (see Text box 1). The current 3Di model toolbox as available in the project 3Di Water Management is considered as given. It must be taken into consideration that the 3Di model toolbox is developed for, for example, application in the multi-level safety approach in the Netherlands. Therefore this research will focus on how the process of flood resilient urban spatial planning could connect with the 3Di Water Management model to let 3Di be of additional value in this process.

To differentiate between what aspects are changeable and which are not in the decision making process of flood resilient urban spatial planning, two definitions are used in this research. The first definition is the '*fixed context*' which is defined as the characteristics in the decision making environment which are not likely to change, or not able to change, within the time scale of several years, like the background of an actor. The second definition is the '*changeable condition*', which is a characteristics of the decision making process which has the possibility to change in order to comply with the conditions following from the (new) model toolbox. Following these definitions, the goal of this research is formulated as; '*to define the changeable conditions in the decision making process of flood resilient urban spatial planning and to evaluate how this decision making process could be designed to use an interactive water management model'*. An investigation of the changeable conditions of the decision making process of flood resilient urban spatial planning is needed in order to assess which conditions could, or have to, be changed in the process if appears that the use of 3Di is of additional value for the process.

According to the problem definition and the context of the problem the following research questions are defined to fulfil the goal of this research.

I. What are the changeable characteristics in the decision making process of flood resilient urban spatial planning?

II. What are the possibilities of 3Di of importance in flood resilient urban spatial planning?

III. How could the decision making process of flood resilient urban spatial planning be shaped to use 3Di?

1.3. RESEARCH DESIGN

In this research the dynamic decision making process in relation to actual model development will be considered in assessing the suitability of the adoption of a new process design of the decision making process in flood resilient urban spatial planning. To be able to get a clear understanding of which factors of the decision making environment are changeable and which factors are fixed, an assessment of what is 'fixed context' and what are 'changeable conditions' will be carried out for this process. The sources of information to make this distinction will consist of literature review, questionnaires, interviews and visited workshops. These sources will also be used to assess the possibilities of 3Di in the flood resilient urban spatial planning sector. The methodology of this research consists of three phases following from the three research questions. Figure 2 presents the applied steps in the methodology, these steps are elaborated below.

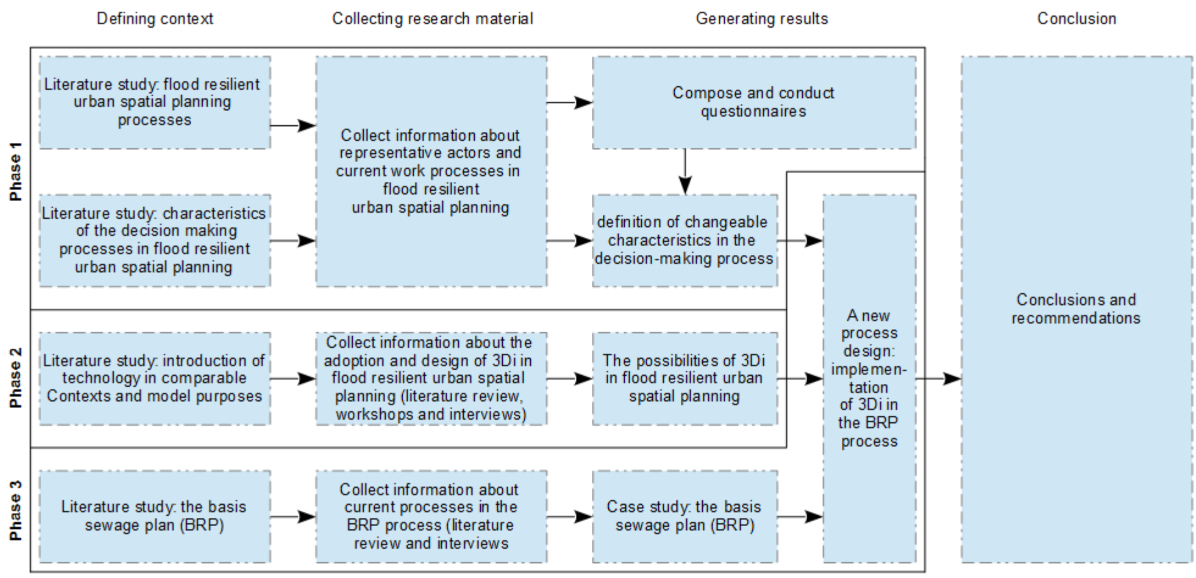


FIGURE 2: APPLIED STEPS IN THE RESEARCH DESIGN

The first phase focuses at the first research question: 'What are the changeable characteristics in the decision making process of flood resilient urban spatial planning'. The method of research could be differentiated in three steps:

- A literature review. The literature review focuses at investigating the decision making environment and work processes in flood resilient urban spatial planning. With this information a list of characteristics defining this decision making process will be composed. The literature review is elaborated from decision making processes in general, to decision making processes in flood resilient urban spatial planning, to a specific example of a decision making process in flood resilient urban spatial planning (the Basis Sewage Plan).
- Attending workshops. These workshops are interactive sessions (at water boards, municipalities, conferences, companies, etc.) in which the current situation in flood resilient urban spatial planning is assessed and the role of models is discussed. The workshops lead to information about current work processes and decision making processes and factors of importance for assessing model use. For example information about how models and other information resources are used and where decisions are based on. During the workshops potential respondents for the questionnaire (see next step) are be selected.
- Questionnaires. These questionnaires focus at defining and understanding the flood resilient urban spatial planning process, current work processes and to assess to what extent the process characteristics are changeable. The process characteristics from the literature study in phase one will be made measureable by defining survey questions. The target group of these questionnaires consist of a list of selected actors in the field of flood resilient urban spatial planning, selected from the visited workshops, training sessions and model presentations of 3Di. The results of the questionnaires will lead to an overview of changeable conditions in a decision making process and process requirements for model implementation.

The second phase gives answer to the research question: 'What are the possibilities of 3Di of importance in flood resilient urban spatial planning'. Two steps will be done to come to an answer:

- Possibilities of 3Di. Which possibilities of 3Di could be important for decision making in flood resilient urban spatial planning? Based on the visited workshops at municipalities, water boards and organizations the suitability of the possibilities of 3Di could be elaborated and information/observations from how actors will use 3Di could be gained. This information could be supplemented with one-to-one interviews. Stakeholders who could 'test' 3Di in the workshops could indicate which possibilities of 3Di they see as additional value in their job function. Also in order to implement 3Di in this research and draw conclusions based on it, the technical possibilities and limitations of this model toolbox need to be clear. This will be done by literature review and information gained from workshops and advisors at Nelen & Schuurmans. Next to this a literature study about the introduction of technology in comparable contexts is conducted, which complements the earlier literature study.
- Purposes of 3Di. What is/are the purpose(s) of 3Di in urban spatial planning? In literature (Brugnach & Pahl-Wostl, 2008) four different model purposes are discussed: a prediction purpose, an exploratory analysis purpose, a communicative purpose and a learning purpose. Goal is to investigate these different modelling purposes and assess which purposes 3Di could serve and which purposes connect with application of an interactive model in the decision making process.

The third phase focuses at the question: How can the decision making process of flood resilient urban spatial planning be shaped to use 3Di? A case study (Basis Sewage Plan [Dutch: Basisrioleringsplan, BRP]) is chosen to answer this question. First the current process of a BRP is analysed by doing literature review and conducting interviews with involved persons. This will give an overview of how the current process is organized, which stakeholders are involved and how models are used to support this process. When this is clear the results of research question 1 (what are the changeable characteristics) and the results of research question 2 (what are the possibilities of 3Di) will be used to investigate how the decision making process could be shaped to use 3Di.

1.4. Thesis outline

In chapter two the results of the literature review are described. The current decision making process in flood resilient urban spatial planning is elaborated and a list of characteristics of this process is composed. Also four model purposes are discussed from literature and their relation to 3Di.

Chapter three discussed the formulation and results of the survey, which is conducted by distributing the composed questionnaires among respondents in flood resilient urban spatial planning. Subsequently in chapter four the results of the literature review and the results of the survey are used to define the changeable characteristics of the decision making process in flood resilient urban spatial planning. This gives an answer to the first research question.

In chapter 5 the second research question - what are the 3Di possibilities in flood resilient urban spatial planning -will be answered by comparing 3Di with current used model toolboxes and by using the results of the visited workshops to get an overview of the use of 3Di in practise.

Chapter 6 introduces the case study about the Basis Sewage Plan (BRP), which will be used to answer the third research question. In chapter 7 the results of research question 1 and 2 and the case study will be used to compose a process design for 3Di implementation.

In chapter 8 a discussion of the results of this thesis is presented, and in chapter 9 the conclusions and recommendations are given.

2. Flood resilient urban spatial planning

As Gersonius, Zevenbergen, & Van Herk (2008) stated: 'In order to comply with policies on climate-proofing urban areas in relation to flooding, actors in the design/decision making process will need to adopt a more integrated approach to spatial planning, flood risk and its various consequences'. This indicates the (need for a) changing decision making process in flood resilient spatial planning. The introduction of a whole new modelling approach in water management, called interactive modelling, may fit in this changing environment. To be able to research the implementation of this new approach (by using the 3Di model toolbox) the organization of the current decision making process is elaborated by a literature review.

In this chapter first the decision making process in flood resilient urban spatial planning will be discussed and secondly characteristics of this process will be defined. In the last section model purposes from literature are discussed, and their applicability focussed on using 3Di in flood resilient urban spatial planning. This is done in order to explore the possibilities of 3Di in the flood resilient urban spatial planning sector.

2.1. Introduction

Flood resilient spatial planning concerns two sectors, namely spatial planning and water management. The first sector, spatial planning, can be defined as methods mainly used by the public sector in order to influence the future distribution of activities in the environment (European Commision, 1997). In other words, this is done by the structural planning of spatial developments in space. In the Netherlands, spatial planning includes the whole sector of spatial development in the field of area, living, infrastructure, nature, space and the environment (Ministry of Infrastructure and the Environment, 2013). Spatial developments are taken on national, regional and local level by, dependent on the spatial scale, the ministry, provinces and municipalities. These authorities define in 'structural concepts' [Dutch: structuurvisies] what spatial developments are expected and how to implement or regulate them. These structural concepts replace the former 'key planning decisions' [Dutch: planologische kernbeslissingen] of the government, 'regional plans' [Dutch: streekplannen] of the provinces and 'structural plans' [Dutch: structuurplannen] of the municipalities. More specific, spatial planning is regulated by the government, of which the ministry of infrastructure and environment is the responsible authority. However the design and implementation of spatial planning is mainly done by municipalities. They have specified information about the local situation. Spatial plans on a larger scale are still implemented by the government or the province. The 'structural concept infrastructure and environment' [Dutch: Structuurvisie Infrastructuur en Ruimte] defines the national interest of the government, like accessibility. Provincial and municipal 'structural concepts' define regional/local interest, like the management of landscapes, urbanization and preserving green areas (Ministry of Infrastructure and the Environment, 2013).

The second sector, water management, is also regulated by the ministry, provinces and municipalities, but on the regional/ local scale there are special institutions called water boards. Water boards are decentralized functional governments responsible for protection against flooding, water quantity, water quality and maintenance of regional waterways (De Vries & Wolsink, 2009). Water boards have their own democratically elected council which is elected by people directly interested in the activities of the water board (e.g. inhabitants, land owners and property owners) (De Vries & Wolsink, 2009). This separation of these two sectors, as displayed in Figure 3, indicates that these two sectors are not completely disconnected, but policy connections between them are often weak or indirect (Woltjer & Al, 2007). Due to earlier discussed results of climate change predictions, leading to direct treats of major urban areas, The Netherlands is in search for urban and regional spatial planning that takes water management more into account (Kabat, Van Vierssen, Veraart, Vellinga, & Aerts, 2005)). In the current situation (2014) the Ministry of Transport, Public Works and Water Management and the Ministry of Housing, Spatial Planning and Environment are already combined into the Ministry of Infrastructure and the Environment, but the separation of the two sectors on provincial and local/regional level is still organized like showed in Figure 3.

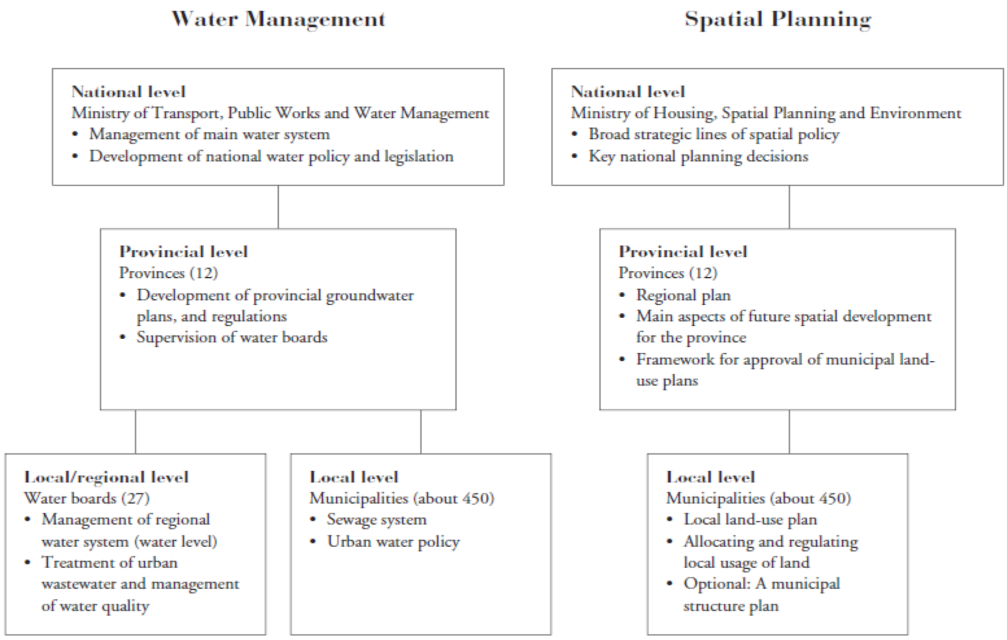


FIGURE 3: THE SEPARATION OF THE DUTCH WATER MANAGEMENT AND SPATIAL PLANNING SYSTEMS AND THEIR RESPONSIBILITIES (WOLTJER & AL, 2007).

Specified to water related spatial planning, the Directorate-General for Spatial Development and Water Affairs (DGRW) and the Directorate-General for Public Works and Water Management [Dutch: Rijkswaterstaat] are the responsible agencies of the ministry, of which the last one is the executive arm of the ministry. At more regional level provinces, water boards and municipalities regulate spatial planning. To guarantee a safe and liveable delta in the Netherlands, the ministry of Infrastructure and Environment defined the National Water Plan 2009-2015 as a ‘structural concept’ based on the ‘Water Act’ [Dutch: Waterwet] and the ‘Spatial Planning Act’ [Dutch: Wet Ruimtelijke Ordening] (Ministry of Infrastructure and the Environment, 2009). This National Water Plan defined a new multi-level safety approach to guarantee future water safety. This multi-level approach works in three layers to protect against water problems, of which the first layer is prevention, the second layer sustainable spatial planning and the third one is focused at flood disaster management (Kolen, Maaskant, & Hoss, 2010). The focus of this research, flood resilient urban spatial planning, is covered by the second layer. Present government is working on a substitution of the Water Act and the Spatial Planning Act in the ‘Environmental Code’ [Dutch: Omgevingswet] (Ministry of Infrastructure and the Environment, 2011).

The second layer of the multi-level safety approach, sustainable spatial planning, is fragmented among different institutions, like municipalities, water boards and provinces and among different sectors, like water management, urban planning, infrastructural planning and the environmental sector (De Kort, 2009). In these institutions and sectors many stakeholders are present, this makes spatial planning a complex process. To realize their spatial goals they have to cooperate, because in general, stakeholders are not able to realize their own spatial goals without interacting with the other stakeholders (De Kort, 2009). To deal with this complexity an integrated approach is valuable and should be used when there is more than a single unambiguous problem or problem owner (Wesselink A. J., 2007). In the context of flood resilient urban spatial planning, focus of this research, this complexity could be observed (fragmentation of the planning process among different institutions and sectors, many involved stakeholders, etc.) and an integrated approach is preferred. In order to deal with the complexity and to realize spatial goals flood models could play an important role. This is, for example, done by modelling and visualizing different scenarios by spatial planners and water managers.

2.2. DECISION MAKING IN FLOOD RESILIENT URBAN SPATIAL PLANNING

Decision making in spatial planning is structured by the Spatial Planning Act, which however has many special provisions and 'back door' measures (Wiering & Immink, 2006). The spatial planning system is defined as hierarchical, but it is not simply the case that non-central bodies have to adjust their plans to meet more abstract plans of higher governmental bodies (Hajer & Zonneveld, 2000). Dutch legislation gives provinces and municipalities main positions in policy making on the regional scale. Water boards are also influential but have strictly functional responsibilities (Woltjer & Al, 2007).

Still the most important instrument in spatial planning is the municipal land use plan. It defines where and what may be built, the dimension of the construction and for which function a specific area may be used (Ministry of Infrastructure and the Environment, 2013). This plan is the only plan which has binding power over both authorities and citizens (Wiering & Immink, 2006). The rules for the content of municipal land use plans and provincial plans are defined in the act 'General spatial planning rules' [Dutch: Besluit algemene regels ruimtelijke ordening]. Moreover the government, provinces and municipalities are obligated to publish all new spatial plans online on the website: www.ruimtelijkeplannen.nl.

Another important instrument specifically addressing water related objectives in spatial planning is the 'Water Test' [Dutch: Watertoets]. Since 2003 this water impact assessment is compulsory in spatial plans such as municipal land use plans. This assessment method is an instrument of the new 21-century water policy to guarantee water related objectives will be taken into account in spatial plans and decisions (RIZA, 2003). With the introduction of this assessment method the water management sector is more incorporated in the process of spatial planning. As stated by the ministry (Ministry of TPW, 2000, p. 45): 'As from this year (2003), the Spatial Planning Act includes the new requirement that water boards must always be involved in consultation about zoning plans' and that 'The 'Water Test' applies to all manner of spatial planning decisions, including amendments to zoning plans, regional plans, new plans for infrastructure, residential construction, business parks and redevelopment plans in urban and rural areas'.

An example of a municipal decision making process in the field of water management and urban spatial planning is the Basis Sewage Plan [Dutch: Basis Riolerings Plan (BRP)]. The BRP includes the municipality's duties of care for both waste- and stormwater, as well as groundwater. A BRP contains the information about the existing facilities of a municipal sewage system and its hydraulic and environmental performance. This process of BRP formulation will be used as a case study in chapter 6 for suggesting opportunities and barriers for 3Di implementation. The process to formulate a new BRP is to a large extent standardized for all municipalities in corporation with the RIONED foundation (Stichting RIONED, 2008). In the RIONED foundation all organizations responsible for the sewage system work together, like the municipalities, water boards, provinces, research institutions and consultancy and engineering companies (Stichting RIONED, 2008).

2.3. CHARACTERISTICS DEFINING THE DECISION MAKING PROCESS

A decision making process is a dynamic process, continuously evolving to meet the needs of stakeholders. Leskens (2011, personal communication) used a social network approach to investigate model requirements from participants in flood decision making. With this approach a decision making process can be seen as a network of participants - the nodes - connected to each other by 'ties', of which each 'tie' can be seen as a relation. Between the nodes an information flow takes place by social interaction, for example by formal reports or informal face to face contacts (Liebowitz, et al. (2000); Liebowitz (2005)). Viewing a decision making network as a social network could be connected with how the decision making network in flood resilient urban spatial planning is organized (see also the explanation of network characteristics below). In order to be able to compare different decision making processes and the development of a decision making process over time in this research, a definition of characteristics of this process is valuable. As a starting point for this overview of process characteristics, an overall categorization of network characteristics in relation to model requirements is selected (2011, personal communication);

- <u>The actors</u>: In flood resilient urban spatial planning many different actors are involved. Think of actors from municipalities, provinces, water boards, governmental parties, citizens and pressure groups. Each actor has different views and knowledge, which influences what kind of information they expect from a flood model.

- <u>Relations</u>: the so called 'ties' in the network. Each relation between two actors can be seen as a flow of information (Hanneman & Riddle, 2005). Based on these flows different roles can be identified (e.g. by creating a knowledge map). Examples are knowledge brokers (people that play a central role in the network in the distribution of information (Hargadon, 2002)) or specialists' roles.

- <u>Context</u>: Organizational properties in flood resilient spatial planning can significantly influence the process and thus the model requirements. For example an organization could standardize a process to a large extent (e.g. the Basis Sewage Plan (Stichting RIONED, 2008)) or define the process as more open to discussion.

Following this threefold classification of the network approach Leskens (2011) defined a list of aspects of social networks from literature. This list of aspects is used a starting point for defining process characteristics of a decision making process in flood resilient urban spatial planning (Table 1). The aspects are divided in three categories; technical, organizational and political properties (MacCrimmon & Taylor, 1976) in order to better understood the decision making environment in flood management. These aspects can be translated in how they influence decision making process requirements. Then for each aspect of the social network, process characteristics are elaborated which can be used as a first step to characterize a decision making process in flood resilient spatial planning. For example the aspect, 'background of actors', can be divided in 'social-cultural, professional or organizational background' and 'trust in new technology' (see Table 1). Note that aspects of social networks are correlated with each other.

Table 1 is further complemented with some aspects following from the literature review on introduction of new technologies, which is performed to collect information about the adoption and implementation of comparable technologies of 3Di. These aspects are shortly described below and processed in Table 1. The introduction of new technology is often defined in literature as the 'implementation' of new technology. The concept 'implementation' can be seen as a process, undertaken to translate a tool, technique, method or other objects into some form of utilization, bounded by the adoption decision and institutionalization (Goodman & Griffith, 1991). The adoption decision is defined as the process by which a new piece of technology is selected for the organization (Dean, 1987). Institutionalization is the process as defined by which a structure persists over time (Goodman & Dean, 1982). The distinction between implementation and institutionalization may be a bit arbitrary, however during a new technology implementation some type of learning curve should be observed, in which equilibrium should be reached when one moves down this curve (Goodman & Griffith, 1991).

Another interesting study (Edmondson, 2003) used the theory of 'framing' to explain the implementation of new technology. This research reveals that a frame, defined as a set of assumptions and beliefs about a particular object or situation, can be of significant influence in implementing a new technology. Following her four elaborated case studies of implementing the new MICS technique (a new technology in heart surgery introduced in the late 1990s aimed at replacing the extremely resistant-to-change routine in open-heart surgery) in a hospital, the difference in successful implementation or abandoning the new technique was not determined by factors like management support, resources, project leader status, expertise or history of innovation, but was determined by how the project was framed by each project leader. This framing gave rise to different attitudes about the new technology and to notable differences in teamwork. Three factors emerged in how the implementation of MICS was framed: *project purpose* (aspirational or defensive), the *leader's role* (interdependent team leader or individual expert) and the *team's role* (empowered team or skilled support staff). So how we think shapes our behaviour, and this influences whether and how effectively desired results are obtained. This is important to acknowledge when implementing a new technology like 3Di.

TABLE 1: PROCESS CHARACTERISTICS OF A DECISION MAKING PROCESS (THE TABLE ORIGINATES FROM THE UNPUBLISHED LITERATURE RESEARCH AS PART OF THE PHD RESEARCH OF LESKENS (2011), ADDITIONS FROM OWN LITERATURE RESEARCH ARE MARKED IN ITALICS

Category	Aspect social network	Influence on process requirements	Process characteristics	Literature
Technical	Content of the problem at hand	The type and structure of the problem for which the project is organized will influence the process requirements	*Size of problem environment* *Predictability of problem aspects* *Control on problem* *Stability of problem environment* *Homogeneous or heterogeneous problem* *Abstract or concrete problem (from perspective of members)* *Isolated or interconnected problem* *Knowledge of causal physical links (by members)* *Need of using loops in defining problem solution*	(Timmerman, Beinat, Termeer, & Cofino, 2010), (MacCrimmon & Taylor, 1976)
	Knowledge of the actors	Actors will have different types of knowledge and therefore require different information to affect this knowledge. *Organizational knowledge distinguished two dimensions of knowledge: degree of articulation and degree of aggregation.* Knowledge types are derived from research on transboundary knowledge transfer	*Degree of articulation (tacit vs. explicit knowledge) and degree of aggregation (individual vs. collective knowledge)* General vs. specific (expert) knowledge Substantive, procedural (process) or political (power) knowledge Level of expertise (no/lay expertise, interactional expertise or contributory expertise)	(Gummesson, 2000), (Jensen & Meckling, 1992), (Leeuwis & Van den Ban, 2004), (Wesselink, De Vriend, Barneveld, Krol, & Bijker, 2009), (Collins & Evans, 2002), (Boh, 2007)
	Background of the actors	Backgrounds of actors include assumptions, rationales and believes which will affect the perspective of actors and subsequently their information needs *and their trust in new technology.*	Social-cultural, professional or organizational *Trust in new technology*	(Stenmark, 2002), (Hommes, Vinke-de Kruijf, Otter, & Bouma, 2009)
Organizational	Tasks and roles of the actors	The tasks and roles of actors (variety of actors) will determine the information needs and subsequently the requirements from the process and the models. Common roles in flood management projects are: experts, policy analysts and decision makers. *Also the 'framing' of a particular object or situation by actors affect how a new technology will be implemented and lead to different attitudes about the technology. Three factors turn out to lead to differences in how implementation is framed.*	Experts, policy analysts and decision-makers *Main tasks of actors* *Framing: project purpose (aspirational or defensive), leader's role (interdependent team leader or individual expert) and team's role (empowered team or skilled support staff)*	(Choo, 2001), (van Gemert-Pijnen, Karreman, Vonderhorst, Verhoeven, & Wentzel, 2011), (Maquire, 2001), (Meadow & Yuan, 1997), (Koskinen, Pihlanto, & Vanharanta, 2003), (MacCrimmon & Taylor, 1976), (Edmondson, 2003)
	Contextual factors *& technology implementation*	Contextual factors: means (paper, direct interaction, etc.), setting (large/small room, distance) and mechanisms. *New technology implementation: specific technology in a specific setting; differences in new technology understanding can affect the implementation process*	Means (paper, direct interaction, etc.), setting (large/ small room, distance) and mechanisms of knowledge-sharing	(Koskinen, Pihlanto, & Vanharanta, 2003), (Krywkow, 2009), (Boh, 2007), (Goodman & Griffith, 1991), (Viswanath, Speier, & Morris, 2002)
	Structure and frequency of exchange of the network	The distribution of roles, knowledge, backgrounds, etc. over the network influence the model requirements. For example, when only 2 experts have to explain the outcomes of models to a broad group of policy analysts, this requires strong communication means understandable for non-experts	Communication of results/outcomes (by experts, advisors, decision-makers, etc.) *Distance between actors in the decision making process.* *Frequency of exchange of knowledge*	(Levin & Cross, 2004), (MacCrimmon & Taylor, 1976)
organizational/political	Quality of relationships	Trust, power and authority between actors in the network and ways how relationships are maintained *will encourage social learning* and affect to whom people will go for new information.	Trust (Level of trust between actors) Power distribution between actors *Traditional authority, charismatic authority or legal authority*	(Granovetter, 1973), (Heimer, 2001), (MacCrimmon & Taylor, 1976), (Weber, 1968)
Political	The 'narrative' of the involved parties/ organizations	This can be explained as the common story, 'believe', goal or 'paradigm' and can be fixed in norms. A process requirement can be to link to these norms.	Common story, 'believe', goal or 'paradigm' of an organization *Differences of rationales of involved organizations* *Drive for innovation*	(Sabatier & Jenkins-Smith, 1993), (MacCrimmon & Taylor, 1976)

2.4. Model purposes

In order to explore the possibilities of 3Di in the flood resilient urban spatial planning sector, the purposes of 3Di will be elaborated. A framework from literature which seemed suitable for this situation is discussed by Brugnach & Pahl-Wostl (2008).These model purposes are discussed in order to assess to what extent 3Di could meet the different purposes. Brugnach & Pahl-Wostl (2008) discussed four different modelling purposes in their paper; (1) *prediction*, (2) *exploratory analysis*, (3) *communication* and (4) *learning*. The common practice in building models is to predict the state of the system to be managed and use this information (based on scientific knowledge) to aid decision making (Brugnach & Pahl-Wostl, 2008). However, due to complex decision making environments and dealing with 'messy problems', this way of modelling to predict the state of the system fails in fully supporting a decision making process (Gunderson, Holling, & Light, 1995). Here, messy problems (Vennix, 1996) are defined by Brugnach & Pahl-Wostl (2008) as controversial situations with conflicting interests in the problem domain, where the different opinions and perspectives have to be integrated in a solution. This applies to the flood resilient urban spatial planning process in which many perspectives and opinions are present in finding a solution. Therefore, in such cases, models to support decision making should focus on the whole process of communication, negotiating and learning (Pahl-Wostl, 2007A). For each model purpose a short explanation and its relation to 3Di is given. These purposes will be used to specify the design of implementation of 3Di in the decision making process of flood resilient urban spatial planning in the next chapter.

The purpose of prediction

3Di is able to predict the (future) system state and supplying this information to support the decision making process. However, next to this 'classic' concept of the prediction purpose, Brugnach & Pahl-Wostl (2008) refer with prediction to understanding the overall properties of the system such as the effect of increasing diversity on the adaptive capacity of the system. In flood resilient urban spatial planning this could be explained by an increasing amount of factors to be taken into account, for example the upcoming focus on climate change. 3Di could help (e.g. with workshops) in assessing the adaptive capacity of the water management system when climate change will be involved. For example in these workshops the ability to adapt to a changing way of decision making could be assessed (Pahl-Wostl, 2007B). A changing way of decision making could be a result of the upcoming focus of climate change.

The purpose of exploratory analysis

An exploratory analysis model purpose is focused on mapping the space of possible development trajectories of a system in order to explore unexpected behaviour or reasons for abrupt change (Brugnach & Pahl-Wostl, 2008). Typical for this model purpose is that exact results of measures could not be given (e.g. probabilities of occurrence or exact amount of flooded area), but the exploratory analysis could give initial insights in problem situations and/or possible solutions. Exploratory analysis could be used as a first step to define potential scenarios with the help of visualizations of flooding area in 3Di (for example in the 3D 'flight simulator' modus). Then the visualization possibilities of 3Di could be an advantage.

The purpose of communication

When focussed on the purpose of communication, the goal of a model is to represent the modelled system clear and easy to understand, especially for non-experts. This is supported by Walker et al. (2006), who defined a communication tool as useful when it reduces the complexity to the few details of the modelled system of importance for the intended stakeholders. It is important to define those variables of the system which are of importance for the intended user, e.g. the decision-makers. It needs to be clear for them which variables of the modelled system they could control to make decisions. Applying the communication model purpose to 3Di means especially non-experts in flood resilient urban spatial planning must be able to understand the modelled situation and draw conclusions based on it. Also in this purpose the visualization possibilities of 3Di could be an advantage.

The purpose of learning

The learning purpose intended goes beyond the individual; namely the model supporting a process of social learning and reflection in stakeholder groups (Brugnach & Pahl-Wostl, 2008). They conclude that the model in this purpose is a tool to engage individuals in a dialogue with the aim of developing a solution. From this point of view 3Di could serve as the instrument to engage stakeholders in the decision making process in order to develop a solution. For example by using a flood scenario in 3Di to involve stakeholders and start up a process of solution development. Pahl-Wostl (2002) suggests the model becomes part of the system it is supposed to represent, which requires a reflexive system (in this research a 'system' is a project in flood resilient urban spatial planning). Then, an important property of a model to use it in a learning purpose is that the model is highly interactive (Brugnach & Pahl-Wostl, 2008). 3Di possess this interactive property, which makes 3Di attractive to use in a learning purpose. With this interactive property of 3Di it is possible to interactively considering problem solutions and also to support 'interactive group model building'. 'Interactive Group model building' in 3Di is explained as interactively working with a group of stakeholders (who could all view the modelled system and performed scenarios on their own device) in the same model as long as there is one 'director' of the model at the moment. Which stakeholder is the 'director' is changeable and other stakeholders could view the actions of the model director.

2.5. Conclusion

This literature review shows that flood resilient urban spatial planning is a relative new field of focus for (especially) municipalities and water boards. It is a fusion of the still relative separated spatial planning and water management sectors. However more and more eyes are heading towards the need of closer cooperation between these two sectors to care for more sustainable solution based on a flood resilient approach. That this need for closer cooperation between these two sectors is upcoming showed the introduction of a new important instrument specifically addressing water related objectives in spatial planning (the 'Water Test'). Also for example the changes in regulation of composing a Basis Sewage Plan (BRP), the so called 'broadened BRP', showed the need for a more sustainable approach of the spatial planning in relation to the water management sector.

The overview of process characteristics (Table 1), which makes the decision making process in flood resilient urban spatial planning more tactile, would be used as a starting point for analysing the current decision making process and for investigating the introduction of a new model tool (3Di) in flood resilient urban spatial planning.

The assessment of model purposes suitable for using 3Di in the decision making environment of flood resilient urban spatial planning shows that especially the *exploratory analysis* and *communicative* model purposes are important for applying 3Di in the flood resilient urban spatial planning sector. The exploratory model purpose is important because 3Di support the interactive way of finding a problem solution, which makes it possible to simulate and judge potential solutions. The communicative model purpose is important because the visualization possibilities (positively assessed by workshop participants) could help in communication of problem situations and potential solutions to especially non-experts.

The literature review started from decision making processes in general and narrowed down to decision making in flood resilient urban spatial planning. In this research the Basis Sewage Plan will be used as a specific example of an instrument in a decision making process in flood resilient urban spatial planning. This plan will be introduced in chapter 6 as a case study. The next chapter will elaborate the survey.

3. The survey: decision making processes in flood resilient urban spatial planning

The results of the survey are, together with the literature review, used to answer the first research question; ‘What are the changeable characteristics in the decision making process of flood resilient urban spatial planning’. In chapter 2 a list of characteristics of the decision making process is composed following from the literature review. In this chapter a survey is carried out by formulating a questionnaire constructed from the results of the literature review. The questionnaires focus at defining and understanding the flood resilient urban spatial planning process, current work processes and to assess to what extent the process characteristics are changeable. The process characteristics in Table 1 are made measureable by defining the survey questions. The target group of these questionnaires consist of a list of selected actors in the field of flood resilient urban spatial planning, selected from the visited workshops, training sessions and model presentations of 3Di (see for example Appendix III – 3Di Workshop Purmerend Climate Proof and Appendix IV – 3Di Workshop Amsterdam Climate Proof Cities).

3.1. Questionnaire formulation

The questionnaire starts with a short introduction of the overall research and is divided in seven sections (each with a short explanation) and covered a total of 47 Dutch questions (see Appendix I – Questionnaire (in Dutch)). The online-based survey tool ‘Google Forms’ is selected as most suitable for conducting this questionnaire. The first half of the questionnaire starts with the chapter, ‘*General’*, which gives information about current job function(s) of respondents, their backgrounds and their work experience. The second chapter, ‘*tasks and roles’* focuses at the roles (expert, decision-maker or policy analyst) respondents address themselves with in projects and the possibility to change from this (combination of) role(s) to another role. The chapter ‘*framing’* assess the personal willingness and the willingness of the organization to innovate in the decision making process of flood resilient urban spatial planning (like the willingness to try new methods or models). Also the possibility to change the ‘willingness to innovate’ is asked, and to what extent four kinds of actors in projects (own staff, process managers, decision-makers and policy analysts) are important as ‘initiators’ for implementation of innovations in an organization.

In the second half of the questionnaire respondents are asked to select a project in the field of urban water management and/or urban planning they work on, or currently have worked on. The ‘*knowledge sharing’* chapter covered questions about the knowledge received in the chosen project from other actors, the knowledge respondents transfer to others in the project, the trust in model results and the levels of knowledge of actors in the project. The ‘*structure’* of the social network in the chosen project is assessed in the next chapter, like the communication distance between experts and decision-makers (direct communication or indirect communication, with one or more intermediary persons). The last two chapters, *‘contextual factors’* and ‘*the narrative of involved organizations and stakeholders’,* focus at, respectively, the physical distance between actors in the project and the extent of shared goals and beliefs between involved actors in the project.

The questionnaire is distributed among a large range of stakeholders in the process of flood resilient urban spatial planning. A total of 166 persons are approached by a personally written e-mail based on their current job functions and an explanation of why their participation is of importance for this research. They are requested to participate in this research by completing the online questionnaire. An indication of 15 minutes is given needed to complete the questionnaire. The respondents are selected from attended workshops, meetings and conferences, from Nelen & Schuurmans, related organizations and from own research. After the distribution (and a reminder after approximately two weeks) a total of 57 persons responded. The respondents covered the organizations mentioned in Table 2.

TABLE 2: ORGANIZATIONS RESPONDENTS ARE CURRENTLY WORKING

	No. of respondents (Total 57)*
Municipalities (Amsterdam, Purmerend, Hoogeveen, Beverwijk, Bergen, Rijswijk, Zutphen, Almere, Alkmaar, Roosendaal, Den Haag, Leidschendam-Voorburg, Tilburg, Utrecht, Landgraaf, Leerdam)	21
Water boards (Hoogheemraadschap Hollands Noorderkwartier, HH Delfland, Waternet, Brabantse Delta, De Dommel, Roer & Overmaas)	14
Research institutes (Deltares, TU Delft, UT, HvA)	4
Consultancy and engineering companies (Nelen & Schuurmans, Grontmij, Arcadis, Copray, Aquademia, Broks-Messelaar Consultancy, Tauw, Oranjewoud, Royal Haskoning)	13
Provinces(Groningen, Overijssel, Zuid-Holland, Zeeland)	5
Governmental organizations (VNG [association of municipalities], IPO [Association of provinces])	7

*due to the overlapping of functions of some respondents the cumulative amount of the different categories exceeds the total of 57 respondents.

In the next section the results of the respondents are processed and visualized. These results will lead to an overview of changeable conditions in the decision making process of flood resilient urban spatial planning (chapter 4) and can be used to discover possible barriers in this process when implementing interactive model tools. Eventually this leads to an overview of opportunities and barriers for the use of interactive modelling in the decision making process in flood resilient urban spatial planning (chapter7).

3.2. QUESTIONNAIRE RESULTS

3.2.1. RESULTS

The results of the survey questions are visualized by graphs (if possible). The most important results are discussed below. The introducing questions in part *A – General* gave an overview of respondents' current activities and work experience. The organizations participants are working at are already listed in Table 2. The respondents are also asked about their current job functions, how long they fulfill this function (Figure 4) and which previous organizations and functions they have worked at. These first questions gave an overview of the characteristics of the respondents.

Respondents are asked which specializations they address themselves with (based on work experience, more answers are possible), see Figure 5. More than half of the respondents (approximately 30 out of 57) mentioned they are currently involved in projects in the field of urban planning and water management. Some mentioned projects; 'development of a flooding model for a city center', 'Water Test [Dutch: Watertoets] process for spatial development plans', 'water discharge in a compact city', 'Amsterdam rainproof', 'municipal sewage plan – the basis sewage plan', 'regional climate adaptation strategy of a neighborhood' and 'anticipating on nuisance as result of extreme precipitation in a city'. These are examples which indicate that respondents are working on the intersection of water management and urban planning. Note that not all respondents are working on intersection of both areas, but all respondents have affinity with one of the two sections and/or both, which make them suitable for this research.

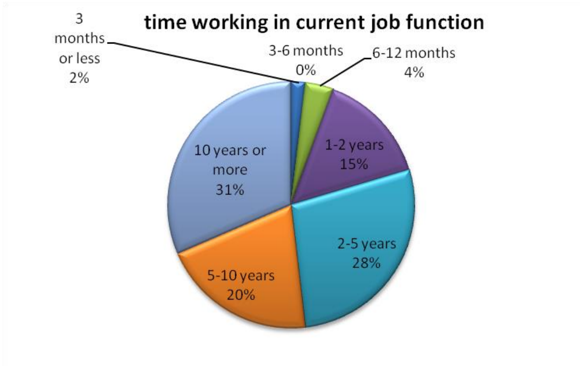


FIGURE 4: RESPONDENTS' TIME WORKING IN CURRENT JOB FUNCTION

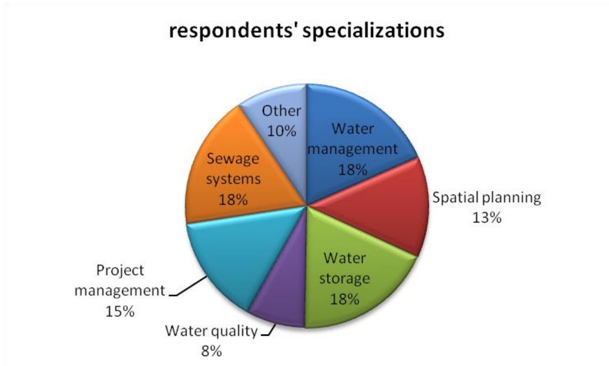
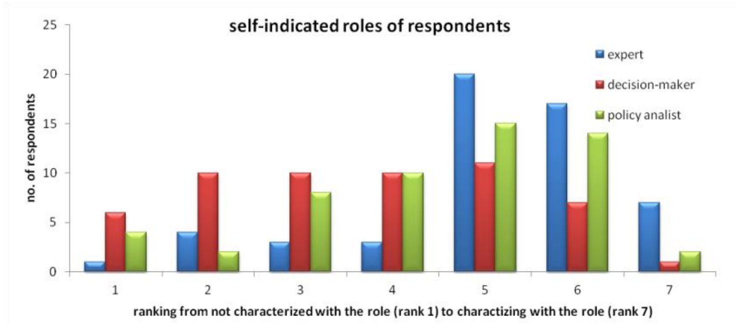


FIGURE 5: RESPONDENTS' SPECIALIZATIONS

Goal of part *B – Tasks and roles* is to assess the changeability of the roles of stakeholders in the decision making process. Respondents are asked to what extent they characterize themselves as expert, decision-maker and policy analyst in projects in the decision making process of flood resilient urban spatial planning. They could give their answers on a scale ranging from 1 to 7, see Figure 6. Thereafter, respondents are asked to give an indication if they think it is possible to change from their self-indicated (combination of) role(s) to be able to work in another (combination of) role(s), see Figure 7.73% of all respondents expect it is possible to change their roles, of which 60% thinks it is possible in about one year or less. In short, three-fourths of the respondents (the percentage answered with 'I don't know' not included) assess the roles as changeable in about one year or less. It must be noted that every respondent assess the changeability of their role based on various arguments. The one respondent will see an aspect as (to some extent) changeable, while another respondent will assess the same aspect as too hard to change within the time scale. However for a first assessment among stakeholders Figure 7 indicates that a change in stakeholder role could be seen as possible.



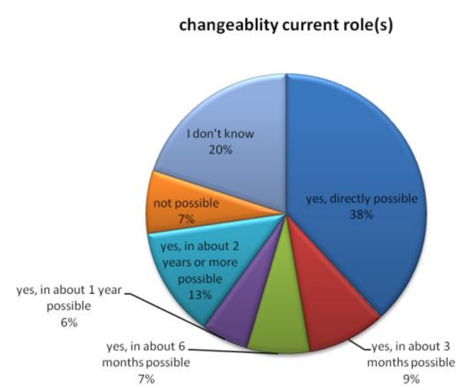
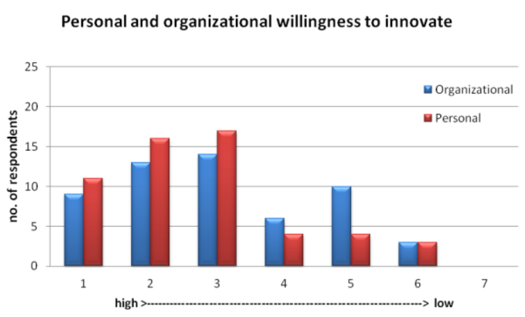


FIGURE 6: SELF-INDICATED ROLES OF RESPONDENTS

FIGURE 7: CHANGEABILITY OF CURRENT ROLE(S)

Part *C – Framing* focused at figuring out how respondents see the implementation of a new technology. Therefore their own 'willingness to innovate' and the willingness of their organization to innovate (Figure 8) is asked. In addition to this is asked if their own willingness to innovate is more or less fixed, or more dependent on other factors (e.g. dependent on the kind of model which is implemented or in which project the new technology is implemented), see Figure 9. In Figure 10 is indicated if the respondent sees it as a possibility to increase the willingness to innovate of their organization and on what time scale. Also here must be noted that a gap might exist between the opinions of respondents and what is really possible. Respondents are in most cases not fully aware of all factors of influence and their changeability when implementing an innovation, but the figures below show a first assessment of the willingness. Also are the aspects 'power' and 'responsibility' of people to change things important. Do the decision-makers who are responsible for the organization of the decision making process (these are not especially the same persons as the 'project' decision-makers) in flood resilient urban spatial planning want to take the responsibility of implementing a new innovation? And do they have the power to implement a new innovation? These are questions which are not questioned in the survey, but important to keep in mind when drawing conclusions about the use of 3Di in decision making.

Another interesting point for the framing of a new technology is the question; who are the 'initiators' for implementing a new technology/ innovation in an organization. In other words, which persons do respondents see as important for putting a new technology on the agenda of an organization? On a scale ranging from 1 to 7 is asked for each of the four roles in projects (own personnel, managers, decision-makers and policy-makers) how important respondents considers each role as an initiator for a new innovation. Figure 11 shows the results for each role. Because these four roles do not cover all possible 'initiators', respondents had the possibility to suggest other stakeholders, which they consider as important. Mentioned initiators are; third parties (e.g. engineering or consultancy companies), implementing bodies, media or citizens.



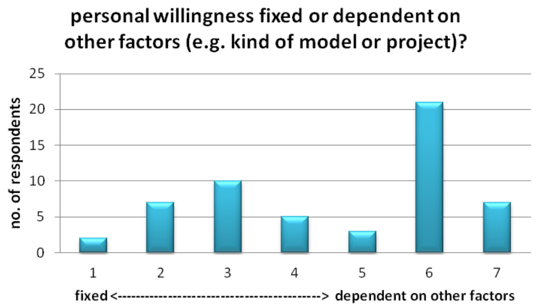


FIGURE 8: PERSONAL AND ORGANIZATIONAL WILLINGNESS TO INNOVATE

FIGURE 9: IS PERSONAL WILLINGNESS TO INNOVATE MORE FIXED OR MORE SITUATION DEPENDENT

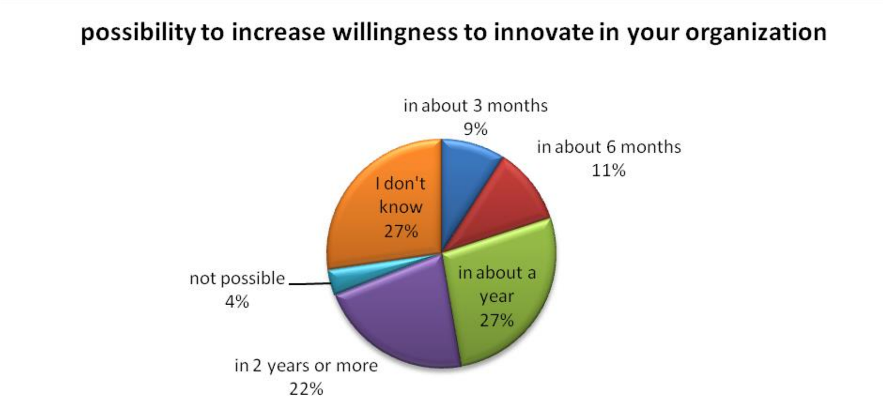


FIGURE 10: POSSIBILITY TO INCREASE WILLINGNESS TO INNOVATE IN RESPONENT'S ORGANIZATION

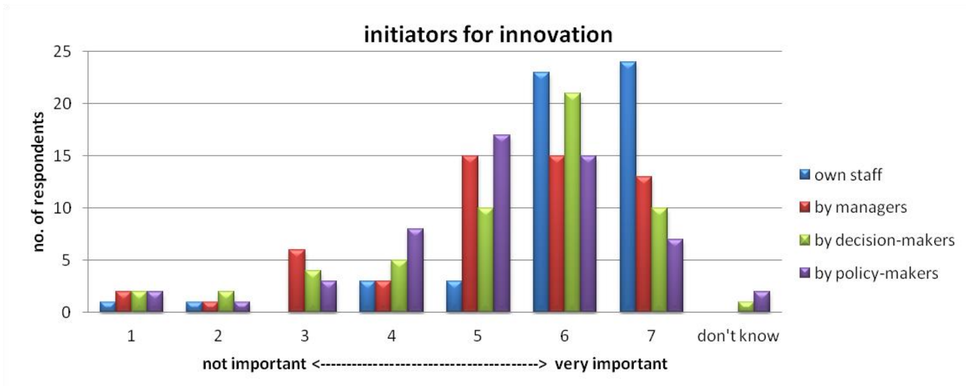


FIGURE 11: INITIATORS WHICH ARE IMPORTANT FOR INCREASING THE CHANCE OF IMPLEMENTATION OF AN INNOVATION BY AN ORGANIZATION

The second half of the questionnaire (part *D – sharing of knowledge*) continues with questions about a chosen project by the respondent. This is a project in the field of water management and urban planning the respondent currently works on, or recently has worked on. Goal of this part is to map the information flows in the decision making network. Respondents are asked to indicate from how many persons they received subsequently; content-related, organizational and political information in the chosen project. When taking the average of all projects, respondents indicate that 57% of the persons deliver content-related information, 25% organizational and 18% political to the respondents in the chosen project.

Also is asked to give frequency of use and quality of received information for a wide range of communication means in the chosen project. A distinction is made between means of communication (and their quality) for receiving information (Figure 12, Figure 13) and means of communication for transferring information (Figure 16). Two respondents mention 'field trips' in addition to the provided means of communication.

Respondents are asked to indicate to what extent they have trust in the results of water management models, by asking them if they would use these model results in their decisions (see Figure 14). Also is asked if this trust is dependent on the kind of (new) model that is used or will be implemented, see Figure 15. Table 1 showed that the 'background of actors' include assumptions, rationales and beliefs which affect the perspective of actors and subsequently their information needs and their trust in new technology. When, in this questionnaire, a respondent indicates they trust model results, this means that they trust the results generated by a model, without knowing the specific processes going on (the 'black box' between input and output of a model) that generates the results. Therefore they have to trust on the 'experts' which developed the model tool.

The last questions in this section focus at the level of knowledge in the decision making process. A difference is made between *the ability to communicate* with experts and understand them at field specific level and *the ability to produce* field specific knowledge (for example specific knowledge about hydrological processes, urban spatial planning, groundwater flows, etc.). The results are showed in Figure 17. Note that this is their own assessed ability; every respondent maintains their own opinion of when they consider themselves as able enough. Figure 17 shows that a majority of the respondents consider themselves as both able to communicate and produce on field specific level in their chosen project.

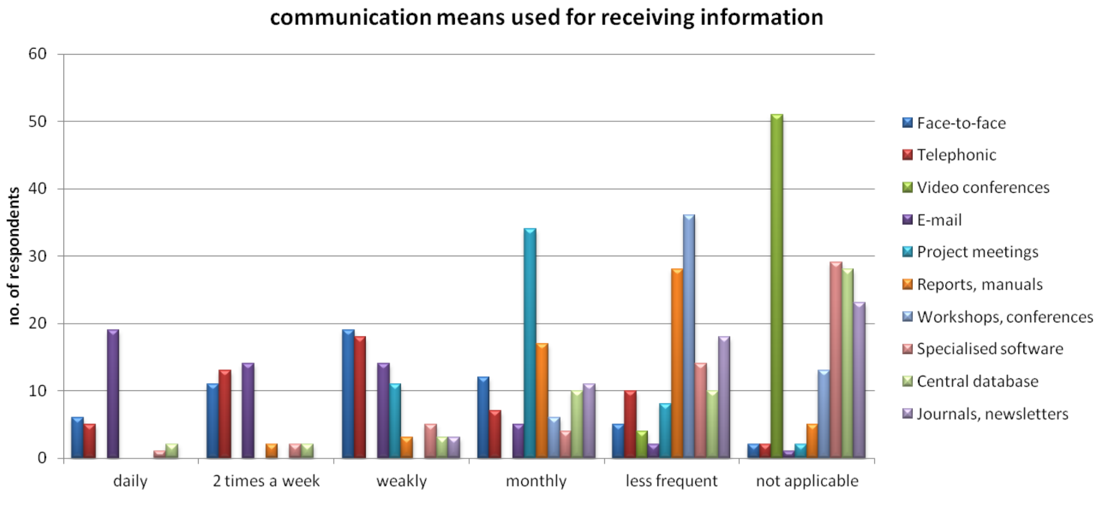


FIGURE 12: MEANS OF COMMUNICATION USED FOR RECEIVING INFORMATION

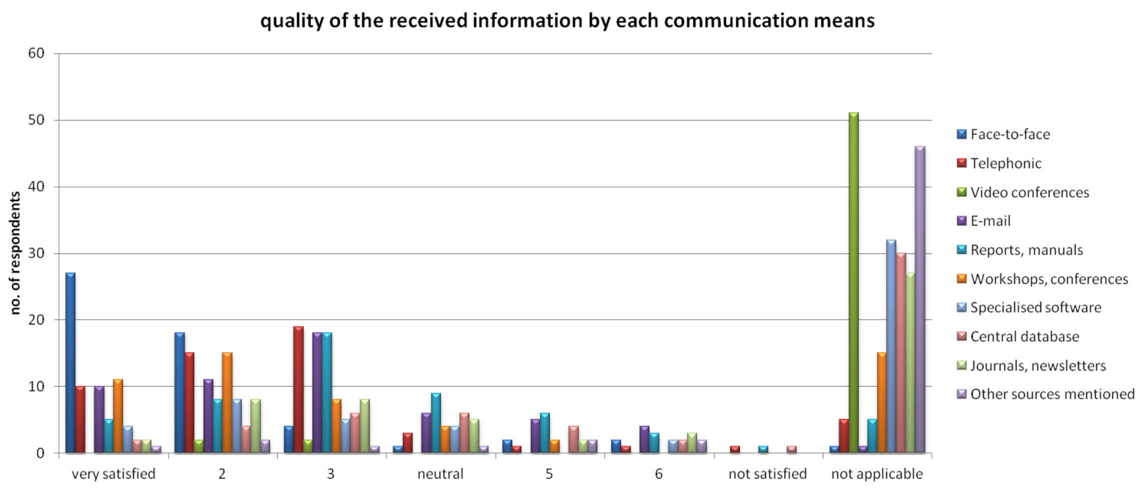


FIGURE 13: QUALITY OF COMMUNICATION MEANS USED FOR RECEIVING INFORMATION

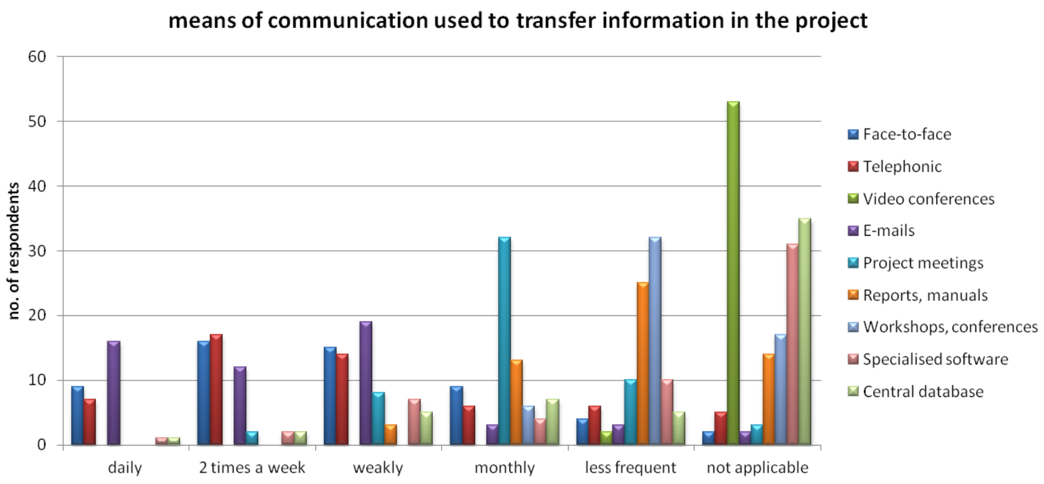
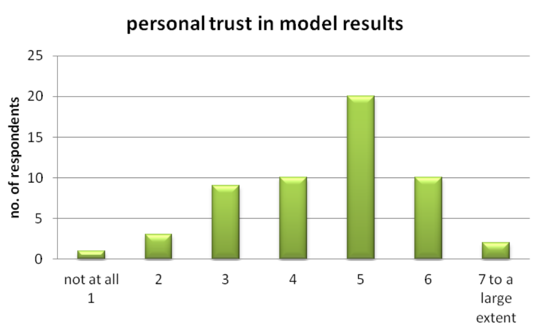


FIGURE 16: MEANS OF COMMUNICATION USED TO TRANSFER INFORMATION IN THE PROJECT



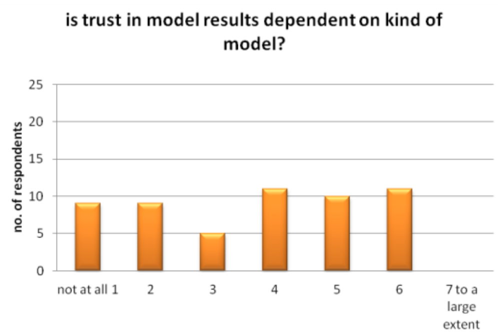


FIGURE 14: PERSONAL TRUST IN MODEL RESULTS

FIGURE 15: IS TRUST DEPENDENT ON KIND OF MODEL

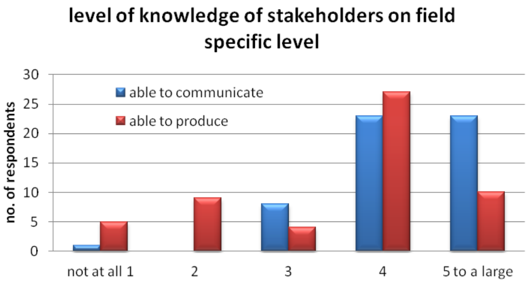


FIGURE 17: LEVEL OF KNOWLEDGE OF STAKEHOLDERS ON FIELD SPECIFIC LEVEL

Part *E – Structure* is aimed at defining the structure of the decision making network between stakeholders in the project chosen by each respondent. First the communication of technical information is assessed by the survey question; 'from whom do you receive the majority of the technical information in the project' (directly from experts, from advisors, from decision-makers, from policy analysts, not applicable, or from others)', see Figure 18. Another important aspect for assessing the structure of the decision making network is the communication distance between experts, decision-makers and policy analysts in projects. This is assessed by asking if there is direct or indirect communication between expert and decision-maker. In the case of indirect communication, respondents are asked how many intermediary persons are present (Figure 19), if it is possible to decrease this communication distance (Figure 20), and if this is possible within the project time scale. 45% of the respondents think it is possible to achieve this within the time scale of the current project. Last, but not least, responds are asked if they think a more direct communication distance is better than the current distance (Figure 21). The opinions are spread, 15 respondents indicate a more direct kind of communication is not directly more positive, 8 respondents are neutral and 22 respondents indicate a more direct kind of communication as (to some extent) more positive.

Figure 18 shows that almost all technical information respondents receive in their chosen project comes directly from experts or from advisors. Moreover Figure 19 indicates that 25% of the respondents said there is a direct communication between expert and decision-maker, and 49% said there is only one intermediary person between expert and decision-maker. These results show that the expert could be an important factor in communicating results of models, and is able to do this in an understandable way to non-experts in projects (e.g. decision-makers). This is important because the way experts communicate results to non-experts could influence the trust people have in the results of the model (see also Figure 14). Moreover it is important experts understand the way of using models in the decision making process (see the 'water information gap', discussed in chapter 1), because experts are responsible for the construction and - often to a large extent - the configuration of these models.

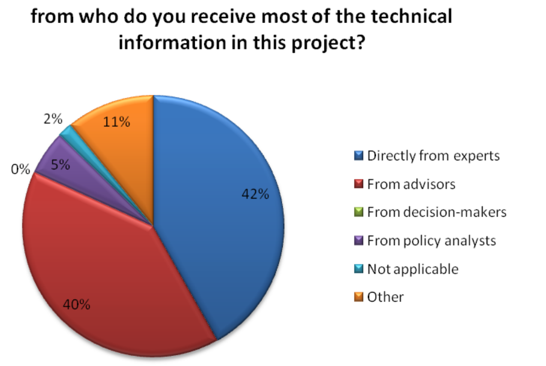


FIGURE 18: FROM WHOM DO RESPONDENTS RECEIVE MOST OF THE TECHNICAL INFORMATION IN THE CHOSEN PROJECT?

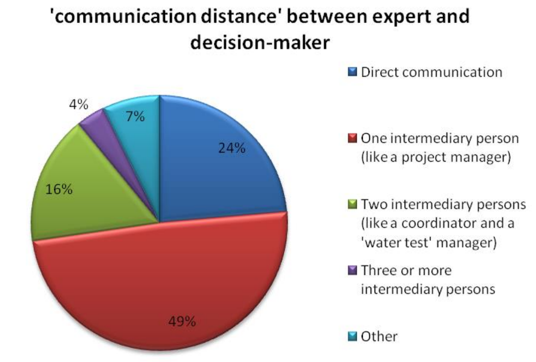


FIGURE 19: HOW RESPONDENTS ASSESS THE COMMUNICATION DISTANCE BETWEEN EXPERT AND DECISION-MAKER

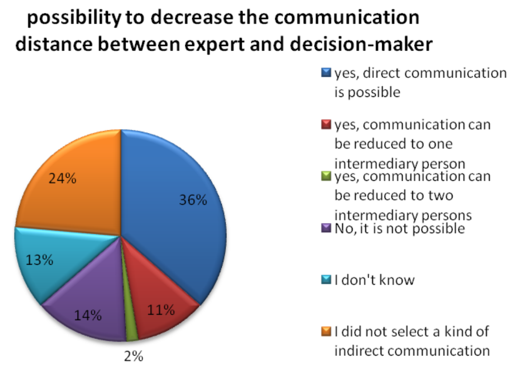


FIGURE 20: POSSIBILITY TO DECREASE THE COMMUNICATION DISTANCE BETWEEN EXPERT AND DECISION-MAKER, ASSESSED BY RESPONDENTS

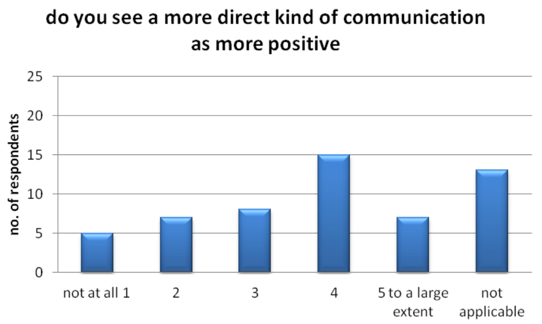


FIGURE 21: IS A MORE DIRECT KIND OF COMMUNICATION ASSESSED AS MORE POSITIVE BY THE RESPONDENTS?

The physical distance between stakeholders in the project is covered as a *contextual factor* in the decision making environment *(Part F* of the questionnaire). Respondents are asked how they assess the physical distance in relation to the majority of the stakeholders in the chosen project, both for stakeholders from within and outside the respondent's own organization (Figure 22). As expected, there is a relative large difference between the physical distance of project members from own organization and project members from other organization(s). The majority of the project members from other organization(s) normally work in another city, while most of the members from own organization work in the same building. The possibility to change the physical distance is assessed by asking if respondents expect that a closer distance is possible, see Figure 23 and Figure 24. Also is asked if a reduction of the physical distance is more positive than the current situation (Figure 25).

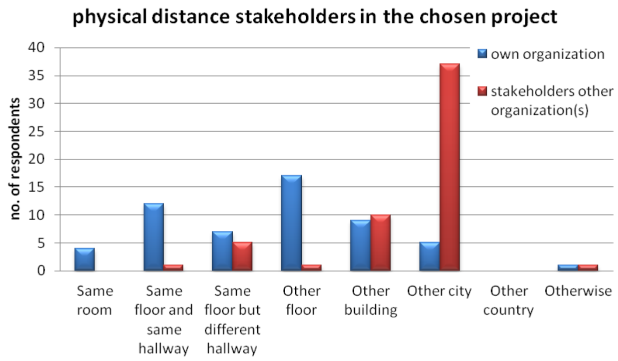


FIGURE 22: PHYSICAL DISTANCE TO OTHER STAKEHOLDERS IN THE CHOSEN PROJECT BY THE RESPONDENT

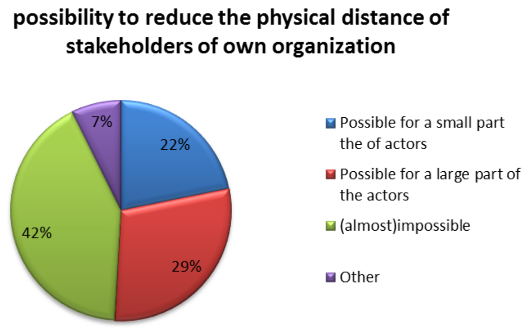


FIGURE 23: POSSIBLITY TO REDUCE THE PHYSICAL DISTANCE TO OTHER STAKEHOLDERS (FROM WITHIN THEIR OWN ORGANIZATION) IN THE CHOSEN PROJECT

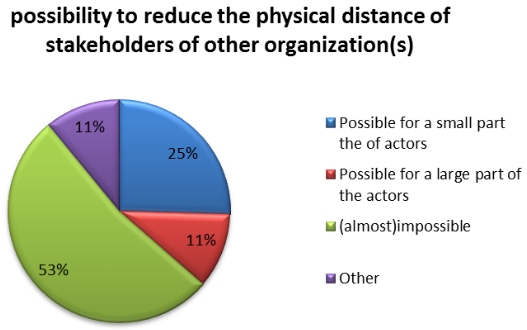


FIGURE 24: POSSIBLITY TO REDUCE THE PHYSICAL DISTANCE TO OTHER STAKEHOLDERS (FROM OTHER ORGANIZATIONS) IN THE CHOSEN PROJECT

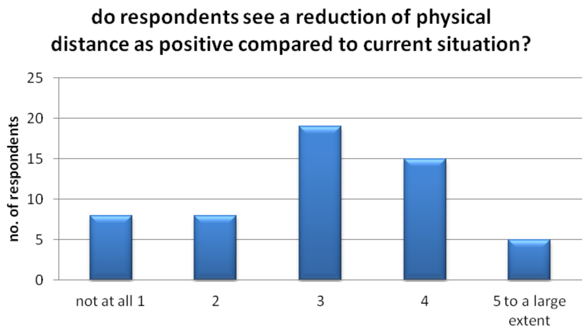


FIGURE 25: EXPECT RESPONDENTS A REDUCTION OF THE PHYSICAL DISTANCE AS POSITIVE COMPARED TO THE CURRENT PHYSICAL DISTANCE IN THE PROJECT

The last part covers the extent of *Shared goals and beliefs.* This part focuses on assessing to what extent respondents have the feeling goals and beliefs in the chosen project are shared (see Figure 26), and if this is subject to change. Also is asked to give an example of a goal and belief in the project of which they think it is shared, or not shared (dependent on their answer of the previous question). Provided examples of (shared or not shared) goals and beliefs are in appendix II. The changeability of this factor is assessed by questioning the respondents if they think it is possible to increase the extent of shared goals and beliefs in the project, for example by using methods like workshops, awareness rising programs, training courses, etc. This, together with a time scale when respondents see it as a possibility is given in Figure 27 and Figure 28.

Comparing the extent of shared goals and beliefs in Figure 26 indicates that respondents have approximately the same feeling about the extent of shared goals and beliefs among project members. The majority of the respondents ranked both, goals and beliefs, as ‘to some extent shared’. However when reading all provided examples of goals and beliefs given by respondents (see Appendix II–Examples of (shared/ not-shared) goals and beliefs given by respondents) it appears that most examples are given of not-shared goals. But when are the examples of not-shared goals in conflict with each other and when they are reconcilable. In other words, when are not-shared goals a barrier for the use of interactive models and when not? This is an important aspect to keep in mind when assessing the use of 3Di in the decision making process.

FIGURE 26: THE EXTENT OF SHARED GOALS AND BELIEFS EXPERIENCED BY RESPONDENTS IN THE CHOSEN PROJECT

FIGURE 27: EXPECTED POSSIBILITY TO INCREASE THE EXTENT OF SHARED GOALS AND BELIEFS BY RESPONDENTS

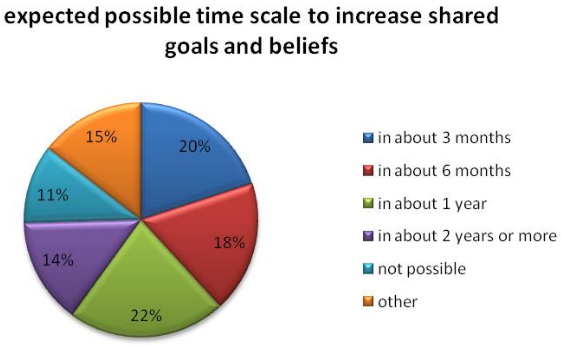


FIGURE 28: RESPONDENTS' EXPECTED POSSIBLE TIME SCALE TO INCREASE SHARED GOALS AND BELIEFS

3.2.2. Discussion of questionnaire results and identification of possible barriers in the current decision making process

The results of the questionnaires are analysed in order to discover possible barriers in the current decision making process which could hinder the implementation of an interactive water management model. This analysis is done by discriminating two variables in the questionnaire results; the *role of respondents* and the *kind of organisation* respondents are working. These two variables are compared with a number of process characteristics addressed in the questionnaire (for all process characteristics see Table 1). The roles of respondents (the actors) are measured by asking to what extent they identify themselves with each role in projects (expert, decision-maker and policy analyst). They have the possibility to rank their association for each role separately on a scale of 1 to 7. Also is asked at which organization the respondent works. The organizations are grouped in the same way as Table 2.

Willingness to innovate versus role of actors

Willingness could be divided into *personal willingness* and *organizational willingness*. When comparing personal willingness to innovate with the role respondents address themselves with (Figure 29), the difference between roles is small, but a clear peak could be observed in the decision-maker role. A respondent is assigned to a role when he or she selects one of the rankings 5, 6 or 7 in the questionnaire. When only using the upper two rankings (6+7, Figure 30) for defining each actor role differences are small. Based on these two graphs the decision-makers could be seen as most willing to innovate.

When comparing the role of respondents with the question if their willingness is more fixed or more situation dependent, it appears that the largest differences in roles could be observed when comparing the roles based on the upper two rankings (6+7, Figure 32). The decision-makers indicate that they see personal willingness more as fixed than the other two roles do.

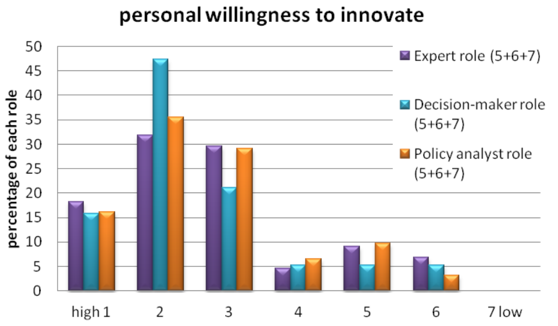


FIGURE 29: THE PERSONAL WILLINGNESS TO INNOVATE SPLIT BY STAKEHOLDER ROLE BASED ON RANKINGS 5, 6 AND 7 IN THE QUESTIONNAIRE)

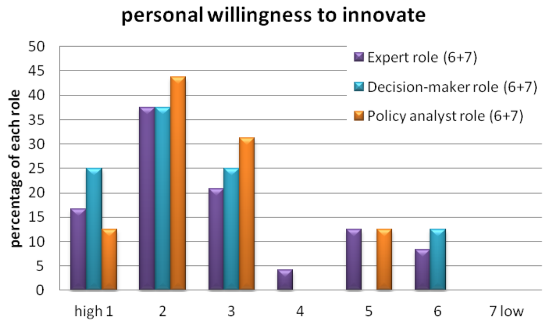


FIGURE 30: THE PERSONAL WILLINGNESS TO INNOVATE SPLIT BY STAKEHOLDER ROLE (BASED ON RANKINGS 6 AND 7 IN THE QUESTIONNAIRE)

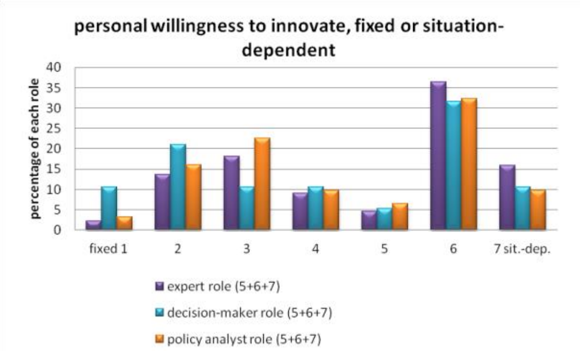


FIGURE 31: IS THE PERSONAL WILLINGNESS TO INNOVATE MORE FIXED OR MORE SITUATION-DEPENDENT BASED ON RANKINGS 5, 6 AND 7 IN THE QUESTIONNAIRE

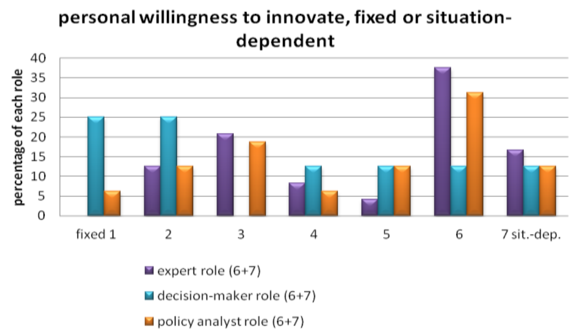


FIGURE 32: IS THE PERSONAL WILLINGNESS TO INNOVATE MORE FIXED OR MORE SITUATION-DEPENDENT BASED ON RANKINGS 6 AND 7 IN THE QUESTIONNAIRE

The organizations of the respondents are grouped by type (Figure 33) and these groups are used to compare organizations based on their willingness to innovate (Figure 34). When looking at the shape of the bars of each kind of organization it could be suggested that respondents of consultancy & engineering companies indicate their organization as most willing to innovate compared to the other organization types. The water boards, and thereafter the municipalities, are more sceptical in the willingness to innovate, based on the answers of respondents. The organization types province, coordinating governmental organizations and research institutes could not be assessed due to their minor amounts of respondents, respectively 3, 1 and 4 respondents.

Another interesting point is that personal willingness to innovate is slightly higher than respondents expect their organization is willing to innovate (Figure 8). This could indicate that sometimes personal willingness is present but the organization is a restraining factor. However, almost 75% of the respondents indicate that they think it is possible to increase their organizational willingness (together with the (eventually) necessary changes in organizational culture).

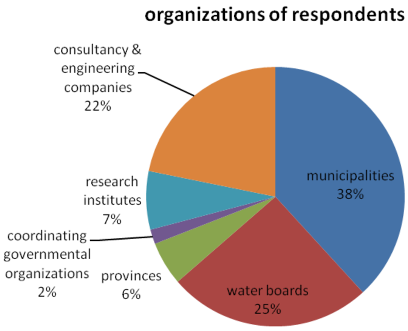


FIGURE 33: THE ORGANIZATIONS RESPONDENTS ARE WORKING, GROUPED BY TYPE OF ORGANIZATION

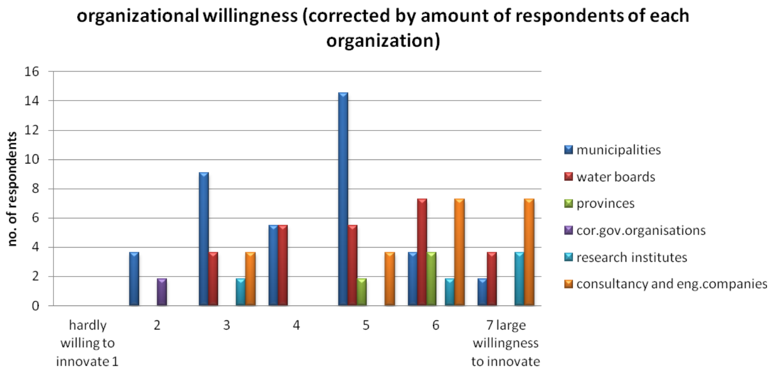
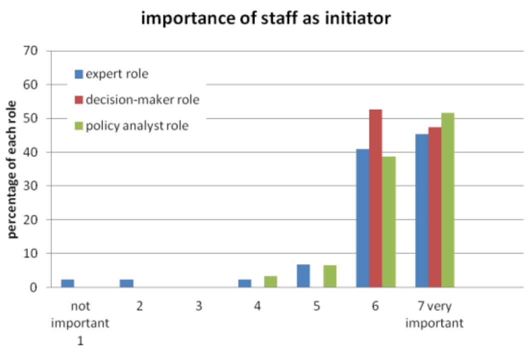
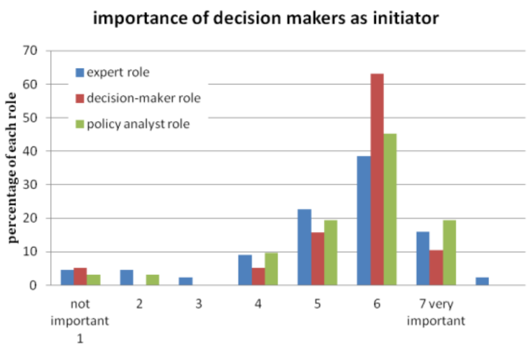


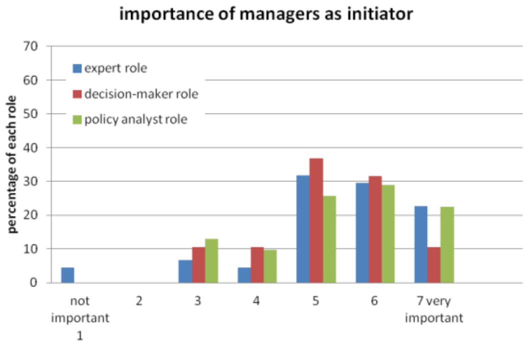
FIGURE 34: THE ORGANIZATIONAL WILLINGNESS, SPLIT BY THE TYPE OF ORGANIZATION

Initiators for a new technology versus role of actors

As stated in the previous paragraph, initiators are the persons which put a new technology on the agenda of an organization. It will be interesting to comparethe role(s) of each respondent with the initiator chosen by each respondent. The initiators covered in the questionnaire are; staff, managers, decision-makers and policy makers. Figure 35 shows that especially the initiator 'staff' is deemed by all roles as important for implementing an innovation. The importance of decision-makers as initiator is also assessed as relatively high by all roles (especially by the decision-makers themselves). This could be connected with the relative highest 'willingness to innovate' of the decision-makers as assessed by respondents in Figure 29 and Figure 30. Thus especially the decision-maker role could be seen as important for implementing an innovation. The importance of the manager and the policy analyst as initiator is somewhat more spread, but the majority of responses are located on the right side of the 'neutral' (rank 4) line. Respondents had also the possibility to suggest other initiators they regard as important. Suggested actors are: citizens, project leader(s), (independent) third parties (advisors/engineers from engineering and consultancy companies, research institutes, etc.) and media (newspapers, journals, etc.).







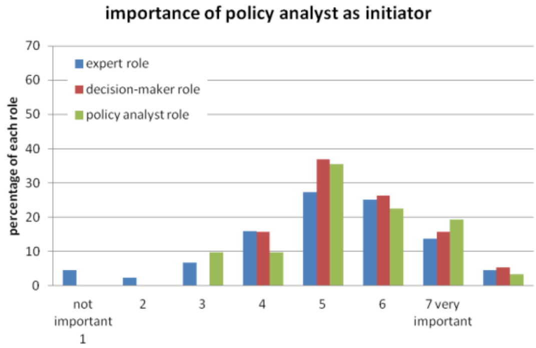


FIGURE 35: IMPORTANCE OF EACH INITIATOR FOR IMPLEMENTING AN INNOVATION IN AN ORGANIZATION. THE ROLES ARE BASED ON RESPONDENTS WHICH CHOOSE THE HIGHEST THREE RANKS OUT OF 7.

Trust in model results versus the role of respondents and the kind of organization

In general respondents indicate in the questionnaire that they do have to some extent trust in using model results in their decisions (Figure 14), which shows they are also sceptical. When the trust in model results is split by actor roles (Figure 36) differences are minor. A slightly higher trust could be noted with the decision-maker role.

This (sensitive) view of actors about trust in model results could depend on external factors (like the model itself, its user friendly character, its understandability, etc.) and on personal thoughts (for example based on previous experiences with models). Figure 37 shows that the extent of respondents’ trust in model results varies widely. About half of the respondents indicate their trust to a relative large extent dependent on external factors, but the other half indicates that external factors are not the main reason for determining their trust in model results. So both ‘external factors’ as ‘personal thoughts’ are important to keep in mind when implementing a new innovation like 3Di.

This relative careful trust in model results could indicate that respondents are reserved in trying out new models, because they do not know if they could trust the results. Also do the users of the model in general not know what is going on in the ‘black box’ of the model, so they have to trust the experts who developed the model. When this is the case, it is important to give potential users of a new model the reasons why the results are reliable. Therefore it is assumed that it is important model users have the possibility to ask experts about the reliability and the uncertainty of their model results. When looking at the potential use of 3Di in the decision making network it could be important to offer model users the support of model experts to secure their trust.

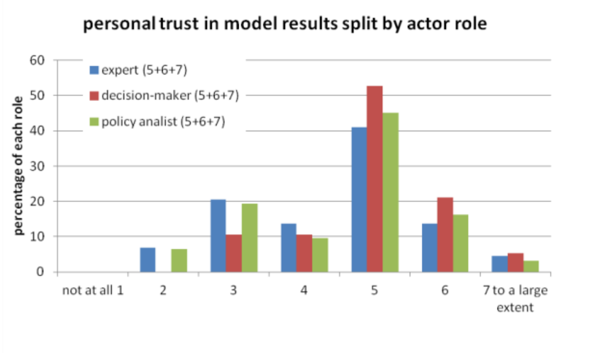


FIGURE 36: PERSONAL TRUST IN MODEL RESULTS SPLIT BY ACTOR ROLE

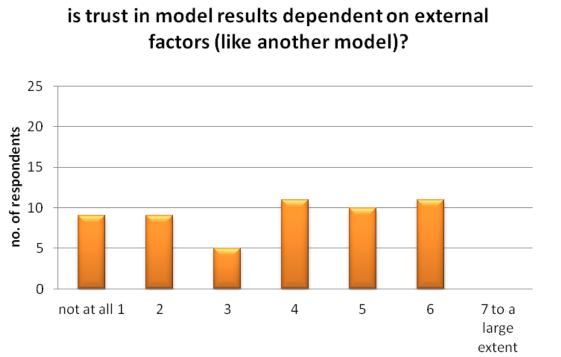


FIGURE 37: IS TRUST DEPENDENT ON EXTERNAL FACTORS

Level of knowledge of stakeholders on field specific level

In the questionnaire a difference is made in the level of knowledge of stakeholders in the decision making process. Respondents could indicate to what extent they expect to have *the ability to communicate* with experts and understand them at field specific level and *the ability to produce* field specific knowledge. Figure 38 and Figure 39 showed that almost all respondents assess themselves as able to communicate on field specific level (rank 4 and 5, Figure 38). However the ability to produce field specific knowledge is more spread among the respondents, indicating that there is a small group of respondents which assess themselves as having more expert knowledge than the majority. Translating the results of the questionnaire to the decision making process in which the implementation of 3Di is researched, these results could indicate that there is a small group of stakeholders which have more expert knowledge than the majority of the stakeholders in the process. When implementing an interactive model like 3Di, which is aimed at involving a more various group of stakeholders in the interactive model phase of a project (see Text box 1), it is important that this larger group of stakeholders is able to understand and operate the interactive model.

These results are also split by the roles respondents identify themselves with, see Figure 38 and Figure 39. The differences between roles are small, which indicate that respondents regard themselves as equally able to communicate and produce on field specific level. However it is hard to measure this aspect in a questionnaire. For example might be expected that experts are more able to produce field specific knowledge, which decision-makers and policy analysts then could use to base their decisions on, but this is not possible to conclude based on these results.

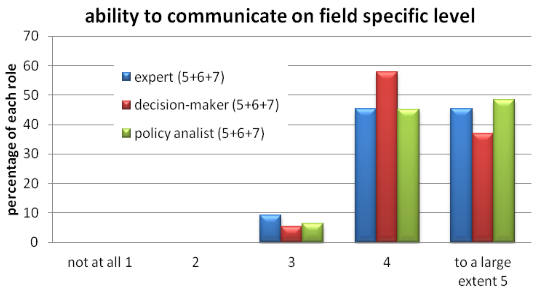


FIGURE 38: THE ABILITY TO COMMUNICATE ON FIELD SPECIFIC LEVEL INDICATED BY RESPONDENTS

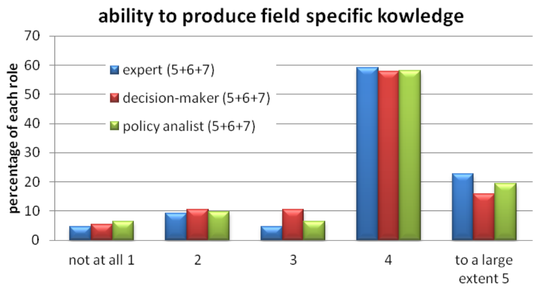


FIGURE 39: THE ABILITY TO PRODUCE FIELD SPECIFIC KNOWLEDGE AS INDICATED BY RESPONDENTS

3.3. CONCLUSION

The outcomes of the questionnaire show a broad field of respondents (57 persons), especially from municipalities, water boards and consultancy/engineering companies. They cover, in relatively equal parts, the different specializations of importance in flood resilient urban spatial planning (like water management, spatial planning, sewage systems, project management, etc.). More than half of the respondents are working more than 5 years in their current job function (31% of total respondents even more than 10 years). This leads to a diverse group of respondents which covers a large part of the flood resilient urban spatial planning sector. However must kept in mind that using a questionnaire with a relative small group of respondents for representing the whole flood resilient urban spatial planning has its limitations. The outcomes could be used for first indications of asked topics, but hard conclusions could not be drawn. Then a much larger group is needed. Another limitation is that there is a gap between the opinions of the respondent and what is really possible. The aspects ‘power’ and ‘responsibility’ of people to change things are important. If respondents indicate something as possible, it must be wondered if the decision-makers who are responsible for the organization of the decision making process want to take the responsibility of implementing a new innovation. And if they do have the power to implement a new innovation. These considerations are not assessed in the questionnaire but are important to keep in mind when drawing conclusions about the potential use of 3Di in this research.

The questionnaire results showed that several factors could be important to assess the suitability of using interactive models like 3Di in the decision making process. On the one hand model-related factors, like the possibility of interactive use of the model and if the model could avoid the need for a physical get together (e.g. cloud-based models like 3Di). On the other hand, factors like the way of knowledge-sharing, physical distance and structure and frequency of interaction in the decision making process could be of influence. The influence of the latter factors is especially important for assessing the opportunities and barriers of implementing 3Di. These factors show some interesting aspects of the current decision making process to focus on when introducing 3Di in this process.

A first aspect is to approach the stakeholders of which is expected that they have more potential to innovate than other stakeholders in the decision making process when implementing a new technology. This is important to let succeed the adoption decision (Goodman & Griffith, 1991) (Dean, 1987) as the first part of a new technology implementation (see also chapter 2.3). Rogers (1962) (2003) defined five stages of innovation adoption and implementation. The selection of high potential stakeholders is especially important to let success the first three stages of Rogers (1: generating awareness of existence of an innovation, 2: persuasion and the forming of an attitude towards the innovation and 3: an adoption decision).

The results of the questionnaire suggest that the decision-makers who are slightly more willing to innovate, are seen as best initiators for a new innovation and assessed as having the highest trust in model results (compared to the policy analysts and the experts). Respondents of consultancy & engineering companies indicate their organization as most willing to innovate. However it is hard to draw conclusions based on these - relative small - group of respondents, these results showed that specific groups of stakeholders are more sensitive (or more in power) of implementing a new technology. Also differences between personal willingness to innovate and organisational willingness to innovate show that for example employees of an organization like to implement a new technology, but the organization is more reserved to implement it. A note could be placed by the question if asking the respondents about their own and organizational willingness is a suitable and reliable way of measuring willingness for a new innovation. Respondents could understand 'willingness' in different ways and have different thoughts about the dependency of 'willingness' on other aspects (e.g. willingness in relation to power to change things).

When looking at the second part of introducing a new technology, the actual implementation (Rogers, Diffusion of Innovations 1st edition, 1962) (Rogers, Diffusion of Innovations, 2003) a second aspect following from the questionnaire results could be important: the trust people (and organizations) have in using the results of models in their decisions. Different actors and organizations showed different levels of trust on model results and the extent of using models in their decisions. The results showed that the underlying reasons for whether or not using results of models in their decisions are diverse; ranging from earlier personal experiences with models, to which specific model produces the results. For a successful implementation of 3Di the results of the questionnaires suggest that it is important to give potential users of 3Di (and especially the non-technical stakeholders, who appear to have less trust in model results than the experts) the reasons of why they could trust the results. This is important for accepting the model in their work processes and to increase the willingness to try out 3Di. When stakeholders do not have (enough) trust in the results of 3Di to use it in their decisions it is important that these stakeholders have the possibility to ask experts to what extent they could trust the results. This will improve both the adoption decision as well as the implementation of 3Di.

The questionnaire results showed differences in the level of knowledge of stakeholders in flood resilient urban spatial planning processes. For a successful implementation of an interactive model like 3Di it is important that all types of stakeholders in the process are able to understand and to operate it. A last aspect is the amount of shared goals and beliefs in project in flood resilient urban spatial planning. The results indicate that, however overall beliefs of stakeholders in project are quite in accordance, the amount of shared goals in projects is less conform. For implementing 3Di it is important to assess when the not-shared goals are a barrier for the use of interactive models and when not.

4. What are the changeable characteristics in the decision making process of flood resilient urban spatial planning?

In this chapter the possibility to change the characteristics of the decision making process in flood resilient urban spatial planning is assessed based on the results of the survey and the literature review (see also Table 1). In this research a 'changeable characteristic', is defined as an aspect of the decision making process which is able to change within a time scale of a few years (contrary to a 'fixed characteristic' which is not able to change within a few years, see chapter 1.2). An exact time scale in which the 'changeable characteristics' are able to change is not defined because each characteristic differs in how changeable it is and on what time scale. These characteristics will be used to define the 'keys' to control the decision making process and adjust them to the new, interactive, model toolbox. Preferable the characteristics are able to change from the start of a new project.

The changeable characteristics will be used in answering the second and third research question in the next chapters to explore the possibilities of 3Di in flood resilient urban spatial planning and to assess how the decision making network of flood resilient urban spatial planning could be shaped to use 3Di.

4.1. Changeability of process characteristics

The first research question was defined as: 'What are the changeable characteristics in the decision making process of flood resilient urban spatial planning?' The results of the literature study (Table 1) were used to compose a questionnaire which is divided in a number of topics (aspects of the decision making network in flood resilient urban spatial planning). Based on the topics in the questionnaire 9 process characteristics are assessed on their changeability:

- **Experience and knowledge levels of actors**
  Experience of actors in the process could basically be divided in content-related (from general to specific) and process-related experience. Knowledge levels could be divided in lay, interactional and contributory levels of knowledge. Previously acquired experience and accumulated knowledge is not changeable, however new experiences could be built up. Acquired experiences (e.g. with conventional models) could affect application of new models. The survey shows the different knowledge levels (Figure 17), but based on these results the changeability of this characteristic could not be assessed.
- **Roles of actors**
  Roles of actors in this research are divided in; expert, decision-maker and policy analyst. Results of the survey indicate that one-third of the respondents expect it as directly possible to function in another role. Another third of the respondents expect it is possible on a larger time scale, and the remaining respondents expect it as not possible or don't know (Figure 7).
- **Willingness to innovate**
  Personal willingness to innovate of actors is an important aspect that has the possibility to change. Opinions are roughly equally split between the question if personal willingness is

more fixed or dependent on other factors (e.g. dependent on the kind of model which is implemented or in which project the new technology is implemented) (Figure 9). Also organizational willingness is an important aspect that has the possibility to change. 69% of the respondents expect it as possible to change (27% don't know, 4%: not possible) on a time scale ranging from 3 months to 2 years or more (Figure 10).

- **Initiators for innovation implementation**
  Own staff, decision-makers, managers and policy makers are seen as important stakeholders for putting a new innovation on the agenda of an organization (Figure 35). Which initiators are important for encouraging the implementation of an innovation has the possibility to change, but based on the results of the survey it is hard to say on which time scale this is possible. It would be suggested to find the best (combination of) initiators to focus on when trying to implement a new innovation. Which initiators will introduce a new technology could influence how it will be framed (Edmondson, 2003), see also chapter 2.3.
- **Kind of information received from each actor**
  Difference is made between content-related, organizational and political information. The average of all respondents indicates that 57% of the persons deliver content-related, 25% organizational and 18% political information to the respondents in the chosen project. This characteristic is changeable to some extent. From which actor (and from how many actors, see chapter 3.2.1 part D) information is received in a project is subject to change. See also the 'communication of technical information' below.
- **Knowledge sharing**
  This process characteristic could be divided in; *resources used for receiving information in a project*, *quality of the received information by each resource* and *resources used for transferring information in a project*. The resources used for knowledge sharing (Figure 12 and Figure 16) have the possibility to change to a certain extent. For example when implementing another way of modelling (like interactive modelling) a shift in which resources are used could appear.
- **Trust in model results**
  To assess this process characteristic, respondents are asked to what extent they trust model results in their decisions and if this trust is fixed or dependent on external factors. Half of the respondents indicate their trust is to some extent dependent on external factors (like another model), see Figure 15. This suggests the 'trust' is to some extent changeable if external conditions are favourable.
- **Structure of the decision making network**
  This characteristic is divided in three components;
    - Communication of technical information (by expert, decision-maker, policy analyst or other) is assessed as to some extent changeable. For example the communication of technical information by experts (Figure 18) could shift to communication by another role if the technical information is easier to interpret. E.g. when the used model supply technical information which is easier to interpret and offers non-experts the possibility to transfer this information to other stakeholders.
    - Communication distance between expert and decision-maker. Approximately two-third of the respondents indicates it is possible to change (reduce) the

communication distance (Figure 20). Half of these actors expect it is possible within current project time scale.

- Physical distance between actors (within an organization and between organizations). This is assessed as hard to change. Only 29% and 11% of respondents indicate it is possible to reduce the physical distance between actors from respectively their own and other organizations within the project time scale (Figure 23, Figure 24).

- **Extent of shared goals and beliefs**

  To what extent do actors feel that goals and beliefs are shared between involved project members? Approximately 75% of respondents indicate the extent of shared goals and beliefs could be changed (increased) within a time scale of 2 years (Figure 27).

Appendix 5 Table 6 shows an overview of the above described process characteristics and their changeability.

4.2. CONCLUSION

This chapter gives an overview of the changeability of the process characteristics in the decision making network of flood resilient urban spatial planning, which gives an answer to the first research question; what are the changeable characteristics in the decision making process of flood resilient urban spatial planning? The changeability of the characteristic '*experience and knowledge levels of actors*' could not be assessed based on the results of this research and is not marked as changeable. The aspect '*physical distance between actors'* is marked as not changeable in this research. The other process characteristics are (to some extent) changeable.

An interesting result of comparing the answers of the aspects '*personal willingness*' and '*organizational willingness*' (Figure 8) is that first aspect is assessed as slightly higher than the second. This could indicate that the organization is the restraining factor. This will be taken into account when investigating the possibilities to use 3Di in the case study in chapter 6 and 7.

Assessing the changeability of process characteristics with a questionnaire gives not the entire answer to the question if a characteristic is changeable of not, since mostly opinions of respondents are asked. Each respondent has their own field of view - for example shaped by their current job function – in which they answer the questions. Also by assessing changeability, respondents differ in when they see something as changeable or not. This differs from an objective measurement of the changeability of characteristics. However by comparing these observations (opinions of respondents and observations done in e.g. workshops in the next chapter) with real facts about the changeability of characteristics, indications could be given of where opportunities and barriers arise in implementing 3Di. The case study in chapter 6 is more focussed on the real situation, which could be compared with the outcomes of this chapter.

5. What are the 3Di possibilities in flood resilient urban spatial planning?

3Di Water Management is an environmental model tool which offers the possibility to perform interactive calculations in order to support participatory decision making. A water management model with an interactive nature was not available before. However, could this interactive nature, together with the other properties of 3Di lead to new possibilities in the process of decision making? Moreover, to let 3Di be of additional value it is important that the decision making process connects with the way of modelling in 3Di, and even more important, 3Di needs to be accepted by the involved actors in the process.

The previous chapter gave an overview of the changeable characteristics in the decision making process of flood resilient urban spatial planning, which answered the first research question. This chapter focuses at the second research question; 'what are the possibilities of 3Di of importance in flood resilient urban spatial planning'. Which possibilities of 3Di could be distinguished (and are distinctive compared to conventional model tools), and which of them are important to consider with respect to decision making in flood resilient urban spatial planning. Therefore, first the model properties and possibilities of 3Di are given and compared to other models. In the next section user's expectations and experiences of 3Di following from the workshops, conferences and presentations where the 3Di model was presented to stakeholders are discussed. This chapter concludes with a specification of which model properties and visualizations methods of 3Di are of importance in the flood resilient urban spatial planning sector.

5.1. 3Di and its differences compared to other model tools

3Di is an environmental model toolbox with an interactive nature which could be used to support participative decision making (3Di Consortium, 2014). The calculation core consists of a two-dimensional flow model with 3D visualization possibilities. The 3Di calculation toolbox integrates the discharge of water in the surface and subsurface area and in the sewage system. The 3Di model gives a representation of the water flows on a grid level of 0.5 x 0.5 meter (Stichting RIONED, 2014). This resolution is based on the resolution of the AHN2 elevation dataset (the elevation map of the Netherlands), which serves as the basic layer for the 3Di data model.

3Di Water Management is a cloud-based model toolbox. This means there is one central server which carries out all calculations and contains all data. The input and output of 3Di calculations is approachable in a web browser, which need to be connected to the internet. Therefore the calculation core is approachable by every device with an internet connection (computer, tablet, mobile phone, etc.) and from every location. When someone wants to use the 3Di model for a calculation he or she must be the 'director' of the model and other stakeholders could watch his actions from their own device. This eliminates the need for physical proximity within the stakeholders and the operator of the model.

When taking SOBEK (a modelling suite for integrated water solution, developed by Deltares (2012)) as an example for comparing it with 3Di the differences are described in Table 3. The main difference is that SOBEK is more a static model on a specific computer; the user defines the model input and start the calculation which - when finished - shows the results. With 3Di the user opens the desired model in their browser and makes adjustments in the model when it is running.

An example of an application of 3Di in flood resilient urban spatial planning is to carry out a 'waterscan' as part of an urban spatial plan (3Di Consortium, 2014). In the new 'Environmental Code' [Dutch: Omgevingswet] of the government (a substitution of the Water Act and the Spatial Planning Act, see also chapter 2.1) an integrated spatial analysis of water behaviour is required. By using an environmental model, 3Di could perform a 'waterscan' on tile-level (in the case of excessive precipitation in order to indicate sensitive areas of a city.

TABLE 3: COMPARISON OF SOBEK WITH 3DI WATER MANAGEMENT (3DI CONSORTIUM, 2014) (DELTARES, 2012)

	SOBEK	3Di Water management
Calculation time	Limited to the size of the internal memory of the computer	Direct results by super computer through the cloud. Dependent on the speed of the internet
1D/ 2D / 3D possibilities	Hydrodynamic 1D/2D simulation engine	1D/2D water flow model with 3D simulation possibilities
Interactive calculations	Not possible	Possible. During a calculation adaptations could be made in the bathymetry of the model
Visualization possibilities	1D (e.g. cross-sections) and 2D visualization of the modelled area	2D model rendering in browser, 2D/3D visualization by using a 'point cloud' during model progress, in which the position of the viewer could be chosen freely and as it were from a plane view.
Integrated approach	One software toolbox for the simulation of water management in the areas of river and estuarine systems, drainage and irrigation systems and waste- and stormwater systems	The model is suitable for the simulation of problems in the field of multi-level safety, flooding risks and analysis of regional and urban flooding
Devices	Computer with the SOBEK model installed and activated	Through a browser accessible from a device with an internet connection (computer, mobile, tablet)

5.2. 3Di USE IN PRACTICE

After the more literature-based paragraphs about 3Di possibilities and model purposes, this paragraph discuss the experiences of applying 3Di in practice. The prototype of the 3Di model toolbox is presented and used in several settings (workshops, conferences, interviews, etc.) and with different visualization methods (e.g. a touch table, with 3D glasses, on a tablet and a computer). In these workshops stakeholders from municipalities, water boards and organizations were able to use the 3Di model tool for decision making in a case study. Observations are made and analysed to assess how stakeholders 'judge' the use of 3Di; what are additional functions/ possibilities and what are points of discussion, opportunities or barriers?

5.2.1. ORGANIZATION AND RESULTS OF THE TEST ENVIRONMENTS

The general organization of a workshop consists of a regional model representation in 3Di of their municipality or neighbourhood (see appendix III and IV). This makes it easier for participants to understand the situation, and to identify with their neighbourhood. One of the most interesting observations of the workshops is that participants know very specific details of the local situation, and sometimes not documented problems, barriers, restrictions or improvements. Another part of the workshops is the interactive part, were participant are divided in two groups; one group is provided with the model and the other group only uses static, hardcopy, maps. Both groups are asked to create potential scenarios and assess the effectiveness of the scenarios in the given case (for example an extreme rainfall event or a secondary dike breach). The results of these experiences are collected in Table 4.

Next to the participatory workshops, short individual interviews are conducted with non-experts without experience in operating the 3Di system (7 interview participants, both male and female). In these interviews questions are asked based on provided static maps with maximum water depths (Figure 40) and a 3D animation of a virtual plane flight (Figure 41). Both representations are taken during a flooding scenario in the Watergraafsmeer district in Amsterdam. Participants are asked which of the two representations is more suitable for estimating damage to buildings, amount of victims and the need for (horizontal) evacuation (Table 5). Also is asked if the 3Di animation has additional value compared to the static 2D representation. In the second part participants are asked to perform an analysis by themselves. After a short introduction of the 3Di live site (the 3Di model toolbox is approachable and interactive usable in a browser) the question asked was to find out which ways stay passable for traffic when a rainfall event occurs with an amount of 100 mm in an hour. The time is measured until participants give an answer. Four participants perform this second part of the interview and needed respectively; 4, 6, 7 and 4 minutes to determine which streets where inaccessible by car.

TABLE 4: EXPERIENCES OF PARTICIPANTS DURING PRESENTATIONS OF 3DI IN WORKSHOPS. THE TABLE CONSISTS OF DIRECT CITATIONS (IN QUATATION MARKS, FOR MORE SEE APPENDIX III AND IV) AND SUMMARIZED EXPERIENCES FROM RESPONDENTS

	Representa-tion of 3Di	**Additional value of 3Di assessed by participants**	**Interactive nature**	**Integral nature**	**Level of understanding**
Workshop Waternet 'Climate Proof Cities' 22-05-2013 Participants: water board and municipality	3Di on touch table	'3Di could help with visualizations.' 3Di works much faster and more detailed. The model is easy to interpret	'The more interactive, faster and detailed the model, the more people can and want add.' 'The interactive representation in 3Di leads to much, otherwise not, reviewed ideas.'	'The integrality in 3Di makes it very complex, however this integrality is what we want in the end.'	The participants were able to understand the modelled problem and scenarios in a few minutes. However; 'apparent reality in a model, it looks realistic but it is not always as realistic as it appears.'
Workshop Purmerend 'Climate Proof Cities' 04-09-2013 Participants from municipality and water boards	3Di on touch table and 3D visualization on screen with 3D glasses	Participants mention that 3Di makes it possible to calculate potential solutions in a fast and efficient manner. 'The model gave me new understanding of the physical behaviour of inundations and triggered me to learn more.' 'The model should be applied in the water test [Dutch: watertoets].'	Participants indicate that they could directly use the results of their proposed measures in 3Di as input for further measures. 'This makes clear which options we have to choose from.' 'We require a structural vision on measures instead of 'trial and error' with the model. Therefore a process design is required to use the model.'	Working with 3Di in the workshops triggers the need for a more integral focus in spatial planning in which 'space for water' get more attention. 'This connects different people and disciplines.' 'I triggered my need for more technical insight.'	Participants were able to implement their proposed measures at the 3Di touch table during the workshop
Workshop 'HogeschoolAmsterdam' 11-09-2013 Participants: municipalities, water boards, research institutes and consultancy companies	3Di on touch table	Participants mention that 3Di could assist in shifting to a more integral approach of water management in spatial planning	Not assessed in this workshop	The presentation of 3Di triggers the need for a more integral approach of (especially) water management in spatial planning	Participants were able to understand and suggest possible solutions in response of the 3Di scenario showed on the touch table
National Congress Public Space, Alphen aan den Rijn 30-10-2013 Participants: municipalities, water boards, provinces and consultancy companies	3Di on touch table	In the changing environment in relation to climate change increasing 'water at street level' got more attention. This is where participants mention 3Di as valuable	-	Discharge of groundwater and precipitation got more and more intertwined with other disciplines which need an integral nature. 3Di is seen as a positive step towards that integral nature by participants	3Di is perceived as easy to understand
Water Info Dag Nieuwegein 13-02-2014 participants from a broad range of water-related disciplines	3Di on touch table and tablet.	Participants mention that 3Di is faster than current flow models and is easily accessible (everywhere with internet connection). Data storage is mentioned as safe (model data is not on a specific device but 'in the cloud').	Participants note that results are 'live' calculated, e.g. fast forward is not possible. Participants mention it as an advantage that it is possible to watch someone's actions in 3Di from other browsers, this eliminate the need for a physical meeting	Participants mention 'classic' flow models as sufficient for e.g. calculations within the river bed, but when water overflows the river bed 3Di has additional value. Tidal flows are not possible yet in 3Di, but intended for near future	After a short introduction of the 3Di touch table and tablet, participants were able to understand how to operate a scenario in 3Di

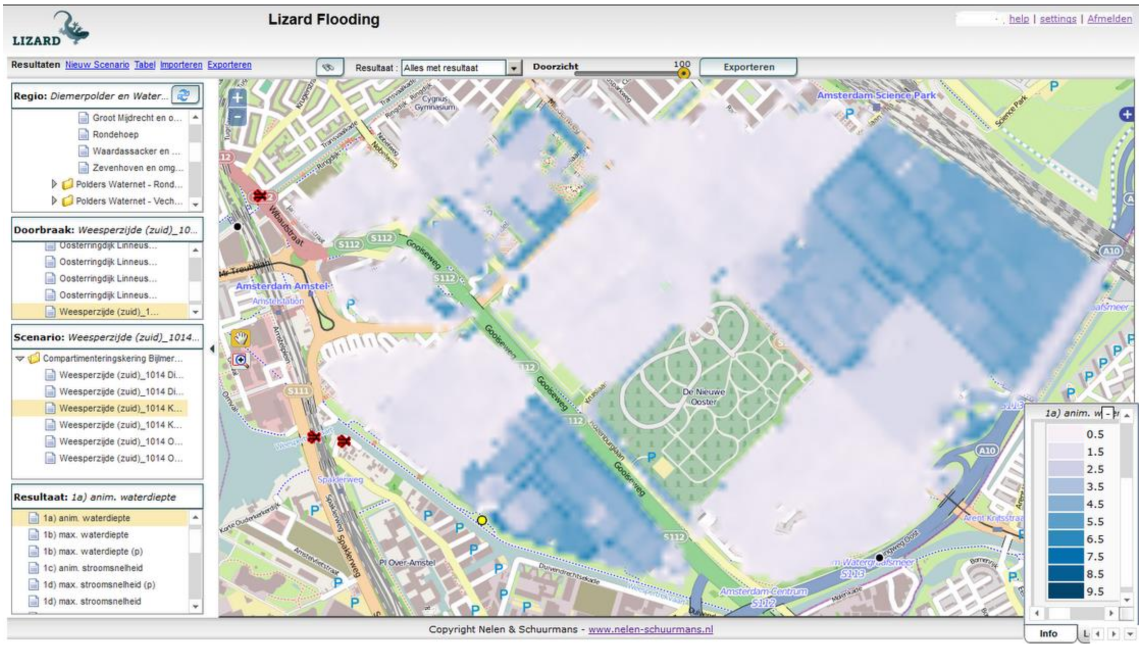


FIGURE 40: STATIC MAP OF THE WATERGRAAFSMEER DISTRICT IN AMSTERDAM, WITH MAXIMUM WATER DEPTHS INDICATED BY DARKNESS OF COLOURS

FIGURE 41: SCREENSHOT FROM THE 3DI FLIGHT SIMULATOR MOVING OVER THE FLOODED AREA IN THE WATERGRAAFSMEER DISTRICT IN AMSTERDAM

TABLE 5: THE RESULTS OF 7 SHORT INDIVIDUAL INTERVIEWS TO ASSESS THE USEFULLNESS OF THE 3DI SYSTEM FOR NON-EXPERTS

<table>
<tr><th colspan="2"></th><th colspan="2">A) 3D animation (no. participants)</th><th colspan="2">B) 2D map (no. participants)</th><th>C) No difference (no. participants)</th></tr>
<tr><td colspan="2">Which image is best suitable for estimation of damages to houses?</td><td colspan="2">5</td><td colspan="2">2</td><td>0</td></tr>
<tr><td colspan="2">Which image is best suitable for estimation of the amount of casualties?</td><td colspan="2">5</td><td colspan="2">2</td><td>0</td></tr>
<tr><td colspan="2">Which image is best suitable for estimation of necessity (horizontal) evacuation?</td><td colspan="2">3</td><td colspan="2">3</td><td>1</td></tr>
<tr><td colspan="7">Does the 3D animation have added value compared to the static 2D image and, and if yes, what is this added value?</td></tr>
<tr><td>‘3D zorgt voor inleving. De dreiging is meer reëel. Je ziet ontwikkeling van de problematiek. Het worst case beeld wordt duidelijk.’</td><td>‘The 3D beeld is herkenbaar. Het levert meer gevoel op bij de situatie.’</td><td>‘Het 3D beeld is realistischer. Het oogt gedetailleerder. Er is minder interpretatie van de resultaten nodig. De beleving is directer.’</td><td>‘Het spreekt meer aan. Het beeld is levender. Het verloop in de tijd is duidelijker.’</td><td>‘De 3D animatie behoefd minder interpretatie wat betreft schade en slachtoffers.’</td><td>‘De 3D beelden geven meer gevoel van de situatie. Het is makkelijker te zien wat eraan de hand is.’</td><td>‘Het 3D beeld geeft het effect op de omgeving goed weer.’</td></tr>
</table>

5.3. CONCLUSION

The comparison of 3Di with SOBEK Suite (modelling suite for integrated water solution) leads to three major differences;

- 3Di is interactive; during calculations adaptation could be done, SOBEK does not support this.
- The SOBEK model is installed on a computer, 3Di works in the cloud, which makes 3Di assessable for every device regardless its location.
- Both models could perform 1D and 2D water flow calculations, 3Di could visualize the results in 3D, leading to easier interpretation by non-experts.

Information from participants of the workshops and interviews learned that they positively assess the visualization properties of 3Di and the interactive and integral nature of 3Di. On the other hand is mentioned that the more accessible 3Di is for a broad group of stakeholders (not only the model experts) the more people want to add to the model process, which could lead to an overflow of information. Also is remarked by participants that the integral approach of spatial planning and water management in 3Di leads to a complex situation. They mention that this integrality is what they prefer in flood resilient urban spatial planning, however the outcomes has to be carefully checked on consistency with the real situation.

Knowing the possibilities of 3Di and having a first insight in how stakeholders in such a decision making process react on a new way of modeling, the interactive way of modeling, integral nature and visualization possibilities of 3Di could be seen as important aspects to focus on when introducing 3Di in this process. The decision making process in flood resilient urban spatial planning need to be accommodated with this revised way of modeling to gain its full profit.

6. Case study: The basis sewage plan

The third research question is: ‘How can the decision making process of flood resilient urban spatial planning be shaped to use 3Di?’ In this chapter, the results of the first research question (which aspects are changeable in the decision making process), together with the results of the second research question (what are the possibilities of 3Di) are used to investigate the opportunities and barriers of using 3Di in order to answer research question three. In order to do so, a case study is selected; the decision making process of constructing a Basis Sewage Plan [Dutch: Basisrioleringsplan (BRP)]. First the case study will be introduced and the Basis Sewage Plan explained, and secondly opportunities and barriers will be formulated for this case study. Possibilities for 3Di use within the BRP process are discussed. It is indicated when changes are needed in the BRP process in order to use 3Di.

6.1. Introduction of the basis sewage plan

A Basis Sewage Plan [Basisrioleringsplan (BRP)] contains information about the existing facilities of a municipal sewage system and its hydraulic and environmental performance. The BRP includes the municipality’s duties of care for both waste- and stormwater, as well as groundwater. A BRP provides the information for a municipal sewage plan [Dutch: Gemeentelijk rioleringsplan (GRP)]. A GRP is a compulsory task leading from the ‘Environmental Protection Act’ [Dutch: Wet Milieubeheer] in which the municipality presents its policy for their sewage management. The BRP itself does not contain policy related choices. Next to the GRP, a BRP serves also as a support document for measures in the field of surface water pollution and abundant urban surface water.

In defining a BRP, the water-, environment- and spatial planning sector are involved. This means there is interaction between the several planning processes of these sectors. A flow of information from the different sectors (both internal as external of the municipality departments) will arise in order to gather all needed information to compose a BRP. The current manual for constructing a BRP (Stichting RIONED, 2008) contains three additional fields of interest compared to a classic BRP; anticipation of climate adaptation, collection and processing of excess rainwater and collection and processing of excess groundwater. This is called the ‘broadened BRP’ and is described in the ‘Leidraad Riolering Module C1000 (Stichting RIONED, 2008). These (new) additional fields will require new and/or updated information about the municipal water management system and its relation to the municipal spatial planning.

How the current process of constructing a basis sewage plan is organized, which stakeholders are involved, and how models are used in the current situation is analysed by literature review and interviews and elaborated below.

6.2. The current process

The initiative party of a new BRP is a municipality. In most cases there is a client versus contractor relation. A municipality contracts a consultancy or engineering company (the experts) to compose the calculation models for the BRP. Large municipalities (e.g. Rotterdam or Almere) have their own knowledge and experts for composing calculation models in order to perform a BRP. The municipality adopt to the role as policy-maker in this process of composing a BRP. Important to acknowledge is that these policy-makers are often also responsible for composing the GRP, which defines the requirements of the BRP. Result of a BRP is to determine improvement measures where the sewage system does not meet the requirements. This generates (financial) input for the GRP. Because the BRP and GRP are in most cases conducted by the same people, the policy-makers are often also the decision-makers. The eventual consideration of which proposed measures will be carried out and which not is decided by the decision-makers based on the BRP and GRP. (Deckers, 2014)

The need for a new BRP follows from current state of affairs within a municipality, which could be summarized in the considerations according to ‘Module C1000 – Opstellen Basisrioleringsplan’ (Stichting RIONED, 2008) in Text box 2. When the need for a new BRP is determined, the process of formulation a new BRP is given in Figure 42. The goal of a new BRP is to get insight in the hydraulic and environmental functioning of the sewage system in the current situation and in the close and distant future. For example in the BRP of the municipality of Assen (Nelen & Schuurmans, 2008) three scenarios are defined; for the current situation, the 2015 situation and the 2050 situation. Within a municipality the strategic advisor gives the sewage manager the order to define a new BRP. Dependent on the size of a municipality the sewage manager conducts a BRP or outsources this to a consultancy or engineering company. The average processing time of composing a BRP is 3-12 months and will in most cases be conducted before the start of the GRP set-up. However in some cases it could be beneficial to conduct a BRP and GRP parallel to each other (e.g. in the case of important policy adjustments).

In the process of BRP formation, alignment with other (external) parties and other planning forms is important for up-to-date information exchange and using technical models. In Figure 42 is indicated which intern and extern parties are involved for information exchange and in which process step(s) they are involved. In step 2 (Text box 2) of the process is considered which other plan forms (next to the GRP) need to be taken into account in the formulation of a BRP, and which external parties need to be contacted to gain this information. In step 3 the assumptions of the BRP are formulated in accordance with other plans of influence on a BRP (Text box 2). Think about plans like the land use plan, a (municipal)water plan, an integral area-analysis [Dutch: integrale gebiedsanalyse (IGA)] or a wastewater optimization study [Dutch: optimalisatie afvalwaterstudie (OAS)].

In the current process of BRP formulation hydraulic models are used, together with measured situations and reports (e.g. complaints from citizens) to calculate the hydraulic functioning of the sewage system (both in normal and extreme circumstances) and to calculate effects of (possible) measures. For example in the BRP of the municipality of Assen, The Netherlands, a precipitation-discharge model and an integrated hydraulic model is used (modelled in SOBEK) to calculate the hydraulic functioning of the sewage system (Nelen & Schuurmans, 2008). The BRP consists largely of results of calculations together with graphical representations of relevant situations.

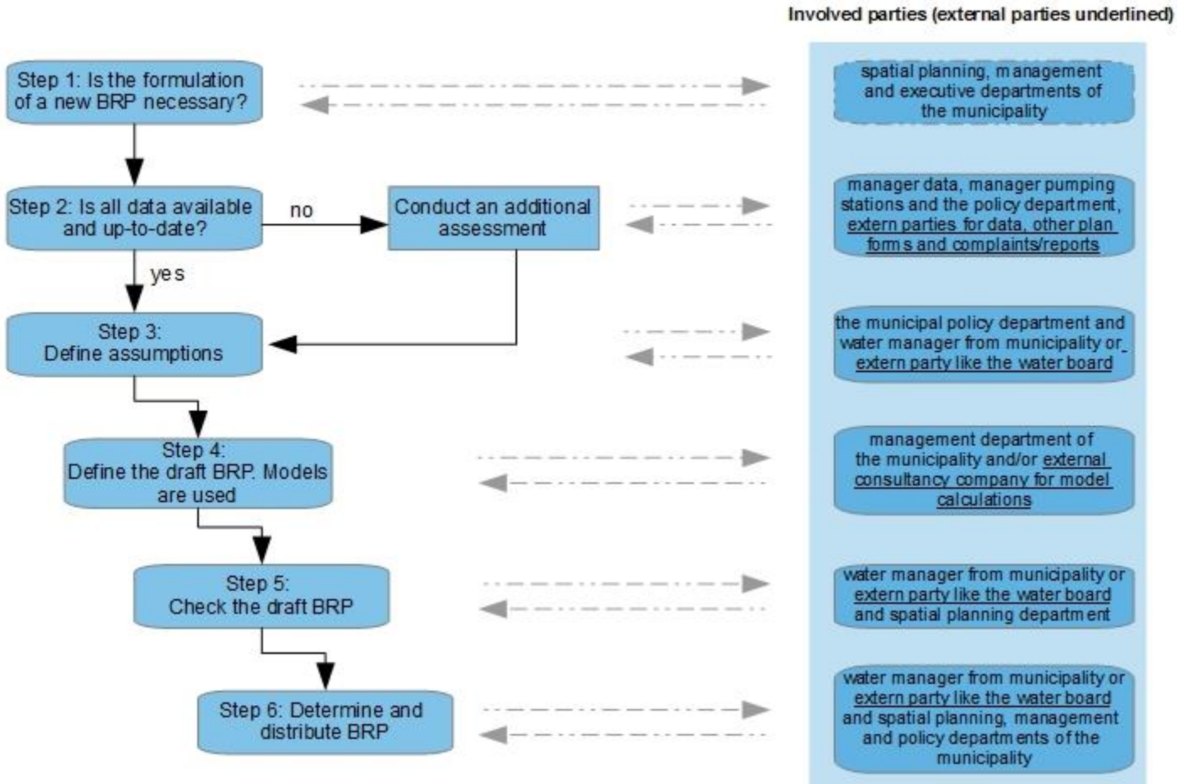


FIGURE 42: THE PHASED PROCESS OF BRP FORMATION, INVOLVED PARTIES AND MODEL USE (ADAPTED FROM FIGURE 3.1 IN LEIDRAAD RIOLERING - MODULE C1000 OPSTELLEN BRP (STICHTING RIONED, 2008)).

TEXT BOX 2: EXPLANATION OF PROCESS STEPS FOR COMPOSING A BRP, ACCORDING TO LEIDRAAD RIOLERING – MODULE C1000 OPSTELLEN BASISRIOLERINGSPLAN (BRP) (STICHTING RIONED, 2008)

Step 1: Is the formulation of a new BRP necessary?

The following considerations apply:

- Could important changes in size or structure of (sewage) systems be observed compared to the previous BRP?
- Are there indications of dysfunction (like (ground) water nuisance, odour nuisance, etc.)?
- Have there been changes in the requirements of functioning of the sewage system (leading from GRP, permit requirements or legislation)?
- Are important changes expected in spatial planning, for example indicated in the land use plan?
- Are areas without a BRP present, or areas which are not included in the current BRP?

Step 2: Is all data available and up-to-date?

- Check the data on quality: accuracy, reliability, completeness, timeliness, and consistency
- Are policy principles clearly quantified in the GRP?
- Is data about systems from third parties available (like surface water levels and pump capacities)
- Measurement data if any
- Register of complaints/reports
- Which other plan forms need to be taken into consideration or need to be connected (other than GRP) when formulation a BRP. Think about a land use plan, (municipal) water plan, integral area-analysis or wastewater optimization study

Step 3: Define assumptions

- Which works are under construction or will be implemented within the GRP period?
- Define the time-horizon of the BRP in conjunction with the GRP

- Collect all relevant plans which are of influence of the BRP. Think about a water plan, land use plan, wastewater optimization study, integral area-analysis, water quality norms and measurement plans

Step 4: Define the draft-BRP

- Where necessary: conduct a (re)assessment of the data and assumptions for the BRP
- Describe the current situation: which systems are present and on which place
- Describe the current functioning of these systems based on reports, measurements and model calculations
- Determine, if yes, where, how, and to which extent these systems do not meet the requirements as defined in the GRP
- Compose a list of possible measures to fulfil the functional requirements

Step 5: Check the draft-BRP

- Test the draft-BRP with the requirements of the GRP
- Test the draft-BRP with the water plan
- Test the draft-BRP with the land use plan
- Test the draft-BRP with the wastewater optimization study, if present

Step 6: Determine and distribute the BRP

- Make the BRP final
- Distribute the BRP intern and extern. Intern: department of spatial planning, department of management and executive department. Extern: water manager(s)

6.3. Opportunities and barriers for using 3Di in composing an urban sewage plan (BRP)

The current process of BRP formation is defined in the previous paragraph. In the previous chapters a process analysis is carried out which resulted in a list of (possible) changeable characteristics of a decision making process. Next to this the possibilities of 3Di are researched and user experiences are gained, which led to an overview of the different model uses and purposes of 3Di. This information will be processed in this case study to investigate opportunities and barriers for the use of 3Di in the formation process of a BRP. First, for each process step (see Figure 42) the potential added value of 3Di is evaluated. Subsequently, associated changes in the process of BRP formation in order to use 3Di are proposed.

Potential added value of 3Di implementation in each process step

With respect to the current process of BRP formulation improvement could be gained when the decision-makers will be included in the consideration process when composing a new BRP (Deckers, 2014). In the current process they are only involved when the BRP is already finished, which, more or less, force them to choose from proposed improvement measures (e.g. where the sewage system does not meet the requirements). An earlier introduction of an interactive environmental model of the area of interest (in this case a municipality) gives non-experts (like policy-makers, decision-makers) the possibility to understand and 'play' with the (sewage)system. This gives the decision-makers the possibility to express the, for them, important considerations in an early stage of BRP formation (like the risk of water nuisance they want to cover, and at what costs, e.g. never allowing water in the streets). Also is suggested in one of the workshops in which 3Di is used that; 'Policy makers need to take this instrument (3Di) into account' (see appendix III). However must also be kept in mind when involving more stakeholders that; 'the more interactive, faster and detailed the model, the more people can and want to add' (appendix IV) and that 'we require a structural vision on measures instead of 'trial and error' with the model. Therefore a process design is required to use the model' (Appendix III – 3Di Workshop Purmerend Climate Proof). These are important considerations to avoid a not-structured process which distract from the BRP process itself and an information overflow as result of taking into consideration all suggested measures from all stakeholders.

In the current manual for constructing a BRP (Stichting RIONED, 2008) three additional fields of interest are added compared to a classic BRP; anticipation of climate adaptation, collection and processing of excess rainwater and collection and processing of excess groundwater. This means a municipality is next to their duty of care for waste/ and storm water also responsible for its groundwater task. This is called the 'broadened BRP'. Most municipalities currently compose a broadened BRP for the first time which has as result that available information in a municipality with respect to drainage systems is (very) limited. Incorporation of groundwater/drainage aspects in current model software (e.g. SOBEK) requires extensive (expert) knowledge. Advantage of an environmental 3Di model of a municipality is that all these (new) aspects of a 'broadened BRP' could be covered in one model. This makes 3Di accessible for non-experts. The interactive possibility of 3Di makes the model continuous adaptable during model calculation, which makes it suitable for exploratory analysis (Brugnach & Pahl-Wostl, 2008). Especially in including these new aspects in a 'broadened BRP' municipalities do not yet have much experiences of the consequences of climate adaptation or groundwater aspects on the current sewage system. When using their environmental model in 3Di with an exploratory analysis purpose they could map the space of possible development trajectories in their sewage system in order to explore unexpected behaviour or reasons for abrupt change.

The **first process step** is focussed on assessing if a new BRP is necessary. The conditions needed to formulate a new BRP are mentioned in the previous paragraph (Text box 2). The involved parties are the spatial planning, management and executive departments of the municipality. There are no extern parties in this step. In order to assess if a new BRP is needed, the functioning of current sewage systems need to be evaluated. In the current process the need for a new BRP follows from concerns or considerations without the use of model results. Think about complaints about the sewage system, groundwater nuisance, expected changes in spatial planning or other systems which are of influence of the BRP.

To prevent complaints (which trigger the need for a new BRP), an up-to-date integral (sewage) water management model could give indications upfront which lead to the conclusion to define a new BRP. Unlike current water management models (like SOBEK) small changes in municipal (sewage) systems or interrelated system could be entered directly into an environmental model of the municipality in 3Di. The advantage is that these changes in the 3Di model are easy to interpret by non-expert. They could directly use the outcomes of 3Di. For example with a SOBEK model, intervention of an expert is needed to 'translate' model results so they could be interpreted by the non-experts (e.g. the decision-makers or the policy makers). When (small) changes directly could be implemented in an environmental model of the municipal sewage system, the consequences of these changes will be visible and it could be assessed if composing a new BRP is needed.

Step 2 embraces the check if all data is up-to-date and available. A number of aspects in this step could be checked without interference of model information, for example the check if policy assumptions in the GRP are quantified in a clear way to be able to formulate a new BRP (Stichting RIONED, 2008). However when using an integral environmental 3Di model of the municipality most aspects of this step could be simplified due to the availability of most of the data in one model. Also when taking into consideration that the broadened-BRP require a more extensive data check by incorporation of groundwater/drainage aspects. Non-experts could operate this model and perform this check by themselves. The check on availability and actuality of measurement data, information from other systems from third parties, registers of complaints and information from other plan forms (see Text box 2) could be simplified when these data sources are already incorporated in the model.

Step 3 contains the formulation of the assumptions of the BRP in accordance with other plans of influence on a BRP (Text box 2). All relevant plans of influence on a BRP will be collected, like a (municipal) water plan, land use plan, wastewater optimization study, etc. Model results are not used in this step in the current process. However most actions in this step don't require model input, upfront model results could be helpful. Measures of influence on a BRP, as proposed in other plans, could be processed in an environmental model of the municipality to receive a first impression of the consequences these measures could have on the current situation. In other words the model could serve an exploratory analysis purpose (Brugnach & Pahl-Wostl, 2008) in which not-suitable options could be filtered out in an early stage, narrowing down the potential measures to be considered when composing the final BRP.

Step 4 is the traditional model phase of the BRP process. In this step a draft-BRP is composed by using model calculations to predict the sewage system capacity (a predictive model purpose), together with reports and measurements from the field (see also Text box 2). For example in the BRP of the municipality of Assen (Nelen & Schuurmans, 2008), two hydraulic calculation models in SOBEK are used; a precipitation-discharge model and an integral hydraulic calculation model. An inventory of current (sewage)systems is processed in the models and current functioning is calculated. If these systems do not meet the requirements as stated in the GRP a list of possible measures is composed.

Current model software (e.g. SOBEK) does meet the requirements to compose a draft-BRP. However as is mentioned in the BRP of Assen (2008) the integrated hydraulic SOBEK model is very suitable to assess the functioning of the sewage system, but calculation times are very long. These long calculation times could be a limiting factor for the assessment of a larger number of potential solutions or the effect of small adaptations to the modeled situation.

Implementing an interactive integral environment model could offer benefits with respect to current software. Functioning and defects in current (sewage)systems could be assessed by non-experts in 3Di. In defining measures to meet the requirements as stated in the GRP the interactive character of 3Di is helpful in order to define suitable measures step-by-step. During a model calculation the model could be paused in order to adjust proposed measures to fit the requirements. As results of the policy changes of the last version of the guidelines for composing a BRP (Stichting RIONED, 2008), municipalities are required to compose a 'broadened BRP', which includes incorporating the effects of climate change on the sewage system. When incorporating climate change the purpose of using a (sewage)model in a BRP will shift more towards simulation of possible (climate) scenarios, rather than solely a prediction model purpose. The effects of climate change could only be simulated based on possible scenarios instead of an exact prediction. This requires a model toolbox which is able to simulate a range of potential scenarios and assess the sensibility of specific parameters. These requirements could be categorized as an exploratory analysis model purpose, instead of solely a prediction model purpose. Typical for an exploratory analysis model purpose is that exact results of measures could not be given (e.g. the exact amount of flooded area), but this purpose could give initial insight in problem situations and/or possible solutions (by performing simulations) (Brugnach & Pahl-Wostl, 2008). Due to the visualization properties of 3Di, which makes it easy to understand the (sewage)system for non-experts and its interactive character, this model step in composing a BRP could benefit of using 3Di.

In **Step 5** the draft-BRP will be checked with the requirements following from GRP, water plan, waste water optimization study (if any) and land use plan. In this step (in addition to current process) the proposed measures in the draft-BRP could be re-calculated with the requirements following from the other plans in order to make sure there are no barriers.

Step 6 is an important step with respect to clear communication of the new BRP, especially to non-experts. The results of the BRP need to be formulated and visualized in such a way that they are easy to understand for the decision-makers and policy-makers. They are responsible for making decisions and new policies based on the BRP. Especially a communication model purpose is desired in this step (Brugnach & Pahl-Wostl, 2008). Next to the written report in which the new BRP is presented, improvements could be made by providing a - via browser - approachable interactive environmental model of the municipality. In this model the hydraulic and environmental functioning of current and proposed future state of the (sewage)system could be provided. Especially the visualization possibilities of this model could improve the decision making process based on the BRP. Questions with respect to the model could directly be checked and visualized by using the interactive model in its desired scenario.

6.4. CONCLUSION

In the case study the potential added value of using the 3Di model toolbox in composing a (broadened) BRP is assessed. In the current way of composing a BRP municipalities use a water management model (like SOBEK) to perform the calculation of the hydraulic functioning of the sewage system (step 4 in the current BRP process). This could be seen as using the model in a prediction purpose. In the other process steps of composing a BRP model software is not, of hardly, used.

In summarizing the analysis of the potential added value of using the 3Di model toolbox in this case, the following three aspects could be distinguished;

- In the current process models are only used in step 4 in a predictive model purpose. Much advantage could be gained by using 3Di in the whole BRP process and in predictive, exploratory and communication model purposes. Therefore it is important to organize interactive meetings in which 3Di is used to communicate the case to non-experts and offer them the possibility to work with the model during a meeting. Using the model during these meetings is important to receive direct feedback from the model, instead of presenting the results of the model in a next meeting.

- In making the BRP process more accessible for non-experts. The clear (3D) visualization properties of 3Di makes the (sewage)system easy to understand for all stakeholders. The possibility of approaching the 3Di model 'in the cloud' (by using a browser) makes the model accessible for all stakeholders in a BRP process, regardless their physical proximity.

- In working with the new guidelines for composing a BRP, called the 'broadened BRP, which includes anticipation of climate adaptation, collection and processing of excess rainwater and collection and processing of excess groundwater. The 3Di model could serve an exploratory analysis purpose, which makes is possible to perform simulations of a range climate change scenarios and interactively assessing the sensibility of model parameters without the need to recalculate the whole scenario each time. This saves processing time of models, and results could directly be gathered during a stakeholder meeting, instead of presenting the results of proposed measures at the next meeting.

7. OPPORTUNITIES AND BARRIERS FOR THE IMPLEMENTATION OF 3DI

The previous chapters discussed the first two research questions. This chapter combines these results and focuses on the last research question: How could the decision making process of flood resilient urban spatial planning be shaped to use 3Di? In order to answer this question a number of claims, divided in opportunities and barriers for 3Di use are stated and substantiated with the results of this research.

Each claim originates from an aspect of the analysis of the BRP case study (chapter 6). Each aspect is worked out as an opportunity or a barrier for 3Di implementation. This opportunity or barrier is evaluated against the changeable characteristics (chapter 4) to assess if it has the possibility to change in the decision making process of flood resilient urban spatial planning. Next to this the literature review (chapter 2) is used to check if it is an opportunity or barrier. A fourth aspect is to assess the claim according to the possibilities of 3Di in practice (chapter 3 & 5).

7.1. OPPORTUNITIES

Based on this research, the involvement of the 3Di Water Management toolbox in decision making processes in flood resilient urban spatial planning results in a number of opportunities. For each opportunity underlying reasons and links to previous chapters are given (changeable characteristics are marked Italic and could be looked up in Table 6. In the next section possible barriers in relation to these opportunities are discussed.

(**Earlier) involvement and input of citizens and local organizations in the decision making process.**

The BRP case study as an example showed that projects in flood resilient urban spatial planning require a lot of specific knowledge of the local situation. Next to calculations to assess the hydraulic functioning of the sewage system, stakeholders in the decision making process (e.g. municipalities and engineering companies) indicate that experiences from citizens, (housing)organizations, public space managers, etc. are especially important to provide information about the current local situation. The visited workshops and the case study (chapter 5 and 6) showed that local people often have specific knowledge of previous flood events or could suggest improvements in the current situation. In order to benefit from this knowledge it is important that they could deliver this input in the decision making process (see for example citations 56, 64, 68, 72 and 73 in appendix II, Table 4 and Table 5 for support of the importance of early involvement and input from citizens and local organizations). Including this 'local' information could accelerate and improve the process; it could prevent miscalculations upfront where the model does not exactly meet the local situation and improve proposed measures by taking into consideration specific local information which is only known by local parties.

The visualization possibilities of 3Di make it possible to show and understand the model situation to local people (see Text box 1 and Table 4). Subsequently they could supplement the modeled situation and check if it matches the real situation. For example a scenario of extreme rainfall could be generated for a specific neighborhood. Visualization of this scenario in 3D could trigger a discussion about improvement measures. Meetings should be organized in which these local parties could deliver their input with the help of 3Di.

The involvement of local parties (citizens, local organizations) will have consequences for the structure of the decision making network and the way of information sharing (see literature review in chapter 2 and results of the survey in chapter 3). The local parties could be seen as an extra stakeholder in the process, which could differ in *experience and knowledge levels* compared to other stakeholders in the process. Also the *kind of information received* from these local parties, the *way of knowledge sharing* and the *communication of technical information* by these parties could lead to changes in the current decision making network. According to Table 6 all these aspects are (to some extent) changeable, however a change in these aspects needs good support (see also chapter 8 – Discussion).

The use of the interactive water management model <u>during</u> meetings in the decision making process.

Proposed measures could directly be checked on feasibility during a meeting. With current models (e.g. SOBEK) suggested measures are processed in SOBEK after the meeting and discussion of results of this analysis need to be done in the next meeting. With an interactive model this is not needed any more, which could accelerate the process (Table 4, Table 5, Appendix II). Unfeasible options could be rejected in an earlier stage.

With this opportunity model results gain a more central role in stakeholder meetings. An important point of focus is to secure the *trust in model results* (Table 6) of stakeholders when using these interactive models during meetings. In Table 6 this aspect is defined as to some extent changeable, and depending on the way of introducing these models. To improve the trust in model results good support is needed (see the barrier about the transition process, discussed below).

Another advantage of the use of 3Di as an interactive water management model is that if some stakeholders could not attend a meeting, they could follow the modeled actions during the meeting in 3Di by using their browser. As is said in a workshop; 'Participants mention it as an advantage that it is possible to watch someone's actions in 3Di from another browser, this eliminates the need for a physical meeting.' As Table 6 showed the characteristic '*physical distance between actors*' is hard to change. Reducing the physical distance between actors to promote a better corporation between the, still relatively separated (see chapter 2.1), spatial planning and water management department is hard. However by using 3Di, actors of other departments could follow the modelled actions without the need for reducing the physical distance.

An example of the benefits of an interactive water management model could be given in relation to the 'Water Test' (see chapter 2.2, p. 17). This water impact assessment is compulsory in spatial plans since 2003 and requires that 'water boards must always be involved in consultation about zoning plans' and that 'The 'Water Test' applies to all manner of spatial planning decisions, including amendments to zoning plans, regional plans, new plans for infrastructure, residential construction, business parks and redevelopment plans in urban and rural areas' (Ministry of TPW, 2000, p. 45). During the development of spatial plans, a water impact assessment could be directly performed in an interactive environmental model. When a physical meeting with all the stakeholders is not possible, the stakeholders who are not present could follow taken actions in the model in their own browser.

Introduction of an environmental water management model at the start of a decision making process.

The BRP case study shows that advantage could be gathered when using an interactive environmental water management model in each step of composing a BRP instead of only in the model phase (chapter 6.3). When introducing such a model tool (like 3Di) at the start of a decision making process this advantage could be used. Next to the conventional model purpose of prediction, 3Di could then be used to support the decision making process and its stakeholders to better understand the situation and communicate on the same level (a communication model purpose). Not only the experts ‘play’ with the model, also the decision-makers and policy analysts are able to do this and come up with suggestions and support for their ideas during the process (an exploratory analysis model purpose).

The introduction of 3Di at the start of a decision making process has effect on the *role of actors* (Table 6) since the model is also accessible for decision-makers and policy analysts, the experts are no longer the only persons who could access and control the model toolbox. However the role of actors is assessed as changeable to some extent (Table 6, Figure 7). This change in roles could lead to a barrier for 3Di implementation (see next paragraph). Also the *willingness to innovate (both personal and organizational,* Table 6) is important for accepting 3Di. Not only a new innovation will be introduced, also a new process design is required to let it work; ‘We require a structural vision on measures instead of 'trial and error' with the model, therefore a process design is required to use the model.’ (workshop Purmerend Climate Proof, appendix III). Willingness to innovate is assessed as a changeable characteristic according to the survey.

7.2. BARRIERS

A change in the ‘classic’ roles in the decision making process.

As discussed in the case study a change in roles will appear when implementing a new interactive model. Especially the role of expert will change. However, how changeable is the role of expert, and are the ‘experts’ willing to accept a change in their role? Not only the experts but also the other stakeholders will be able to access the model. The role of the expert will change from ‘communicator’ of model results and ‘model operator’ to a more supporting role as ‘facilitator’ in assessing the suitability and feasibility of proposed measures in a BRP process. Will the expert accept the involvement of the ‘non-experts’ in his field? On the other side, the expert will be more involved in the decision making process. Policymaking is not or no longer characterized only by ‘the choice of the policymaker’ (Van de Riet, 2003). By spreading of resources and decision making, the actors become independent of each other, and policy can only be realized on the basis of corporation (or at least collaboration) in which the actors involved contribute to the resources needed (Van de Riet, 2003). Therefore it is important that this contribution is supported by an interactive model and that all actors have access to, and could understand, the model toolbox.

When reviewing the results of the survey, most respondents (73%, 20% don't know) indicate that they are able to change from their current role(s) to function in another role (Figure 7, Table 6). Next to the ability to function in another role it is thus important to collaborate with the other roles to gain policy relevant outcomes.

A shift in model purpose(s) in relation to current model purpose(s) used in the decision making process.

Of the four model purposes discussed by Brugnach & Pahl-Wostl (2008), the BRP case study shows that the models used in current BRP process serve (almost) only the prediction model purpose. The model software has not the possibilities to serve the other model purposes (exploratory analysis, learning and communication) and models are almost entirely operated by experts (e.g. in a BRP formation process most municipalities outsource the modelling part to a consultancy or engineering company). When implementing 3Di a change in using the model toolbox beyond the purpose of prediction is necessary to exploit 3Di's full benefits in contrast to conventional models (like the interactive character of 3Di).

An important aspect to overcome is that stakeholders in the decision making process have to accept the use of an interactive water management model beyond the purpose of prediction. *Willingness to innovate, trust in model results* and *kind of information received from each actor* (Table 6) are important characteristics of the decision making process in flood resilient urban spatial planning. The characteristics trust and willingness are both assessed as possible to change (chapter 4) but are dependent of each other. Respondents of the survey indicate that both willingness and trust are to some extent dependent on the kind of model which will be implemented (Figure 9, Figure 15). Which model and how it will be introduced is important for increasing stakeholder's willingness and trust, and thus the chance of accepting the innovation. Since the implementation of 3Di involves not only a new model toolbox but also a change in model purposes, the kind of information received from each actor (see also the previous barrier about changing actor roles) will also change. This leads to an extra barrier to overcome.

A transition process from the current situation to the new situation is needed in order to support a successful implementation of 3Di.

Introducing and implementing the 3Di model toolbox requires not only the toolbox itself, but also a process design in which the process could benefit from the possibilities 3Di offers (see chapter 5 for the possibilities of 3Di). In order to lower the threshold for organizations for using 3Di a transition process from their current situation to the new situation may be an advantage. The case study in the previous chapter showed that next to the traditional model phase of a BRP 3Di may be of additional value in the other steps of composing a BRP (and in other model purposes). Organization of interactive meetings is required to let 3Di work as interactive model.

Therefore a first step in a transition process could be to use the 3Di toolbox as a decision-support tool, in which it supports the decision making process with visualizations of possible measures proposed in the BRP (like the 3D visualization). Then stakeholders could learn to use the additional possibilities of 3Di (in an exploratory and communicative model purpose) next to using a model only in the traditional model phase (see chapter 2.4). Later on, the current model tools used in a BRP process could gradually be replaced by the 3Di model toolbox. Eventually 3Di could support the whole process of problem diagnosis, scenario analysis and choice of measures (workshops and case studies with potential stakeholders showed that 3Di has the potential to support the whole process, for example the workshop 'Purmerend Climate Proof', see also Table 4). This transition process gives potential users time to get used to the 3Di toolbox and gives time to build a municipal 3Di model.

Important changeable characteristics for this barrier are the *trust in model results* and the *initiators for innovation implementation* (Table 6). Focus on securing and increasing trust of possible organizations/individuals is important because of the background of actors which include assumptions, rationales and beliefs which affect the perspective of these actors and subsequently their information needs and their trust in new technology (see the 'background of actors' aspect, Table 1). This indicates that there are varying levels of trust of actors, and the survey results show a significant amount of people which are skeptical with respect to trust in model results (Figure 14). Since the potential implementation of 3Di incorporates a (interactive)model in all aspects of the process, it is important that people trust the results of these models. During the transition process the trust of stakeholders in the model results should be assured by offering the possibility to ask (model)experts to explain how model results are gathered and to explain the (un)certainty in these model results. This is an important aspect since approximately half of the respondents indicate their trust in model results is dependent on which model is used (Figure 15). Next to trust, selecting the suitable initiators for innovation implementation to focus on is important (Table 6). Especially 'own staff' is assessed as important by respondents of the questionnaire (Figure 11). In the BRP case 'own staff' are for example the stakeholders working at the municipal departments involved in composing the BRP (see also Figure 42). These initiators are important to put the innovation on the agenda of the other stakeholders in the decision making process (like the decision-makers, policy-analysts and managers).

7.3. CONCLUSION

The chosen case study generates important suggestions and recommendations for changes in the process of BRP formulation. The generalization of the results of the case study to the flood resilient urban spatial planning sector showed that especially the aspects of trust in model results, changing stakeholder roles and a shift in model purpose are important to focus on when implementing an interactive water management model like 3Di.

Important opportunities were suggested by introducing 3Di at the start of a project and during each meeting in order to benefit from the possibilities of 3Di. For example the involvement of non-experts, like decision-makers, policy analysts, local organizations and citizens from the start of a project. These stakeholders could offer a lot of specific local knowledge, which could be incorporated directly when exploring the possibilities of a case in 3Di. With the current model use in the flood resilient urban spatial planning process this involvement is often not possible due to a 'closed' model phase, only operated by the experts.

A transition process is important to support a successful implementation of 3Di in the decision making process. For example one aspect is that in order to let 3Di work in this decision making process interactive meetings should be organized. In these meeting 3Di should be available for direct assessment of discussed topics. On the one hand this transition process is important to give organizations time to let build and fund suitable models for their area of interest. On the other hand a transition process is important to deal with the changes in their (decision making) process and to prepare their employees and third parties to use the different way of working with an interactive model. Without a suitable transition process consequences could be that users (and the decision making process) get lost in the possibility for everyone to bring in their ideas.

8. Discussion

In this chapter the framework, scope and results of this research are discussed. Each subject will be elaborated below.

8.1. Research context and scope

Research scope

The research scope is narrowed down to flood resilient spatial planning on urban level. Mainly municipalities, and to a lesser extend water boards are involved on this level. Extending the scope to beyond urban area changes the involved stakeholders (e.g. municipalities become less important and water boards and provinces more) and the kind and scale of flood measures. The choice for an urban level has to do with the developments of the 3Di Water Management program and given workshops. During the time of this research they mainly focus at the urban scale, which delivered useful input for this research.

Another point of discussion is that water management on urban scale is not always that important on the agenda of municipalities. The spatial planning sector and water management sector were relatively separated in the past, especially at municipalities. However municipalities more and more realize that combining these fields is needed to deal with (excessive) water discharge at urban scale, they mention that water management is 'just one of the many' topics they have to deal with (next to topics like housing, security, education, labour, health care, etc.). It should be noted that this could be a first barrier to handle before focussing on implementing a new model. On the other hand 3Di has appeared to be able to move the focus to water management, for example by showing the consequences and probability of large flood events in a municipality.

Research objective

In the introduction the separation of modellers domain and flood decision making domain was discussed as important to keep in mind in this research. While bringing together both domains was not goal of this research, it could be said that an interactive model like 3Di has showed to be very helpful in narrowing down the distance between both domains. For example in the proposed interactive meetings in which 3Di will be used as part of the decision making process (see chapter 7.1), model experts could become more easily in touch with the decision makers by working together in the same meeting. In the 'classic' way of using models in the decision making process model experts/developers do not participate in meetings with decision-makers.

This research focused at the process-based side of 3Di implementation, in other words, how the decision making context could be shaped in order to implement 3Di. The 3Di model is used as currently available. However next to suggesting how the decision making context could be shaped, adaptation of the 3Di model toolbox itself to fit in the flood resilient urban spatial planning sector may be of importance. The latter aspect is not covered in this research, due to narrowing down the research objective to fit the time frame of this research.

In the introduction of this research (chapter 1.2) is mentioned 'it must be taken into consideration that the 3Di model toolbox is developed for, for example, application in the multi-level safety approach in the Netherlands'. This research is carried out in the Netherlands and results are based on the Dutch way of decision making. However are results of this research applicable when looking at 3Di implementation in other decision making environments, like in other countries? Probably the major difference is to what extent the process characteristics (see Table 6) of another decision making environment appear to be changeable. For example is expected that the willingness to innovate is an important characteristic that varies in other countries. Also the number of involved stakeholders and the distribution of power between stakeholders will varies in other countries, with as result another kind of process design for the use of interactive modelling in decision making. However, the research design of this research (by defining the changeability of process characteristics) was considered as a suitable way to assess how a decision making process could be shaped to support the use of interactive modelling (like with 3Di). The same research design would be proposed for an analysis of the potential use of an interactive model in another decision making environment.

8.2. Research method and results

Research question 1 – What are the changeable characteristics in the decision making process of flood resilient urban spatial planning?

This question is answered by conducting a literature review, a survey and attending workshops in which 3Di is used. The framework of the social network (see chapter 2.3) was selected to compose the list of characteristics defining the decision making process. There are also other frameworks available in literature which could be applied to characterize a decision making process. Using another framework may have led to another structuring of this research, yet the used framework (see Table 1) seemed to be suitable for answering the first research question.

The respondents of the questionnaire are not equal distributed among the organizations of which they originate. This is taken into account when analyzing the survey results, however respondents of some groups of organizations (like provinces or research institutes) are minor which makes it hard to draw conclusions specified to these groups. This is noted in the research and the conclusions are based on the respondents from the municipalities, the water boards and the consultancy & engineering companies. These groups appeared to be most important for performing this research.

The literature framework, together with the results of the survey, led to an overview of changeable characteristics in the decision making process of urban spatial planning. However with respect to a changeable characteristic, it is not simply the case that this aspect is fully 'changeable' or changeable from one moment to another. The one aspect is more changeable than another aspect, which makes it hard to assess the feasibility of opportunities and barriers (which are sometimes based on the changeability of more than one aspect in the decision making process) for implementing 3Di. This is an aspect that needs further research and testing in a case study to assess the feasibility. To guide a change of a characteristic in the decision making process and increase the chance of being successful, this change needs good support and must be part of a transition process.

Research question 2 – What are the possibilities of 3Di of importance in flood resilient urban spatial planning?

Visiting the workshops at different municipalities, water boards and organizations yield useful suggestions and observations to take into consideration when assessing the use of 3Di. However due to the small number of visited workshops (5 in total) and the differences in set-up of each workshop it was not possible to draw significant conclusions or compare results between workshops. Therefore mainly individual comments or consistent opinions of groups of participants are used in this research.

To classify the possibilities of 3Di, the framework about modelling purposes of Brugnach & Pahl-Wostl (2008) was selected. This may lead to biased results since also other frameworks to classify model possibilities are available. Also the classification of the possibilities of 3Di into four model purposes may led to biased results if these purposes do not cover all possibilities. However this way of classifying, to explore the possibilities and to use it to suggest opportunities and barriers for the process design of 3Di was considered as suitable for this research.

Research question 3 – How can the decision making process of flood resilient urban spatial planning be shaped to implement 3Di?

Due to the time scale of this research only one case study is selected and worked out in order to assess potential opportunities and barriers in using 3Di. This has the danger of biased results towards the selected case. The chosen case study is selected because of the recent changes in the guidelines to compose a municipal BRP which places the BRP on the intersection of spatial planning and water management on an urban scale. Normally, composing a BRP is largely based on technical non-complex issues except when urban spatial planning gets in. This is the case when introducing the new guidelines of the 'broadened-BRP', which have to be followed when a municipality compose a new BRP. Therefore this case study was interesting, a new way of working with a model (interactive modelling) could be assessed in a recently changed decision making process.

A last remark could be placed at the actual introduction and implementation of 3Di in the work processes of the organizations. Yet 3Di has lots of potential to improve the decision making process in flood resilient urban spatial planning, at first an operational process design needs to be composed to benefit from the suggested opportunities and to overcome the discussed barriers. When such an operational process design is defined, detailed environmental models need to be build and funded by municipalities and other stakeholders. This is an important consideration for stakeholders when considering implementing 3Di in their organization.

9. Conclusions and recommendations

9.1. Conclusions

9.1.1. What are the changeable characteristics of the decision making process in flood resilient urban spatial planning?

Most of the characteristics of the decision making process in Table 6 are marked as changeable, which means they are changeable within a time scale of a few years. The extent and easiness to change these characteristics varies between the characteristics and characteristics are dependent on each other. These characteristics are used as the 'keys' to control the decision making process and are adjusted to fit with the new interactive model environment of 3Di.

The characteristics '*willingness to innovate*', '*roles of actors'* and '*trust in model results'* could be seen as most important for the success of 3D implementation. These three factors played a key role in suggesting opportunities and barriers of the introduction, implementation and use of 3Di. The changeable characteristic '*initiators for innovation implementation*' is important for encouraging the use of an innovation among stakeholders. Own staff, decision-makers, managers and policy makers are seen as most important initiators for putting a new innovation on the agenda of an organization. '*Physical distance between stakeholders*' is not marked as changeable.

9.1.2. What are the possibilities of 3Di of importance in flood resilient urban spatial planning?

The comparison of 3Di with other model toolboxes, information from participants of workshops and interviews showed that especially the interactive character, the cloud based model and the visualization properties of 3Di are indicated as positive and distinctive. However participants mention also that the more accessible the 3Di model is for a broad group of stakeholder, the more people want to add their opinion to the process. This could result in an information overflow.

3Di with its interactive model environment could be used during meetings in the decision making process instead of after or before meetings. Using this interactive model environment has the advantage of getting a direct assessment of the effectiveness of proposed measures during a stakeholder meeting. This factor significantly increases the effectiveness of proposed measures and reduces the time needed for modelling. As a result, the involvement of more stakeholders (both from intern and extern) is realistic. Think about the early involvement of citizens and local organizations. The visited workshops and the BRP case study showed also that a closer cooperation between intern and extern stakeholders may be possible, like in defining the draft-BRP (step 4 of BRP process, Figure 42). In the current process only the intern management department of a municipality is involved in the alignment of proposed measures in the draft-BRP.

The case study of the ‘broadened-BRP’ showed that 3Di is suitable for working with the sustainable solutions requested in the guidelines for a broadened-BRP, like anticipation of climate adaptation, collection and processing of excess rainwater, and collection and processing of excess groundwater. 3Di makes it possible to perform simulations of a range of climate change scenarios and for interactive assessment of the sensibility of model parameters without the need to recalculate the whole scenario each time (an exploratory analysis model purpose). This saves processing time of models, and results could directly be gathered during a stakeholder meeting, instead of presenting the results of proposed measures at the next meeting.

The clear (3D) visualization properties of 3Di make the water management and spatial planning sectors better accessible for non-experts and easier to understand for all stakeholders. Working ‘in the cloud’ of 3Di (by using a browser) makes the model approachable for all stakeholders in a decision making process, regardless their physical proximity.

9.1.3. How can the decision making process of flood resilient urban spatial planning be shaped to use 3Di?

Two opportunities that arose in the decision making process by introducing 3Di could also be seen as important for the implementation of 3Di; the use of the 3Di <u>during</u> meetings in the decision making process and the introduction of 3Di at the start of a decision making process.

To get advantage of the use of 3Di this model should be used during stakeholder meetings. In models which are not interactive, suggested measures in a meeting need to be processed after the meeting and results could be discussed in the next meeting. By using 3Di during these meetings, proposed measures could directly be checked on feasibility during a meeting, and unfeasible solutions could be rejected in an early stage. This could accelerate the process, compared to models which are not interactive.

The other important opportunity for using 3Di in the decision making process is to introduce 3Di at the start of the decision making process. The BRP case study showed that by introducing an environmental water management model in 3Di at the start of the decision making process and in each step of the process, the model could not only be used in a predictive model purpose but also to support the decision making process and its stakeholders to better understand the situation and to communicate at the same level. Not only the experts ‘play’ with the model, also the decision-makers and policy-analysts are able to do this and come up with suggestions and support for their ideas during the process. Moreover by introducing 3Di at the start of a decision making process the early involvement and input of citizens and local organizations is possible. By using the visualization properties of 3Di to explain the situation, local stakeholders can provide important information about the current situation and could suggest improvements in the current situation, e.g. based on their knowledge of previous (local) flood events. A 3Di environmental model should be ready at the start of the decision making process.

When implementing 3Di, the most important aspects to overcome are the change in the ‘classic’ roles in the decision making process and a shift in model purpose(s) in relation to current model purpose(s) used in the decision making process. A transition process from the current situation to the new situation is needed in order to support a successful implementation of 3Di (as discussed in chapter 7.2).

In conclusion could be said that the implementation of 3Di in the decision making process has good potential to improve the process and its outcomes and in making the process more accessible for its stakeholders. In order to implement and get advantage of 3Di some significant changes in the traditional way of decision making need to be taken and a 3Di model should be operational at the start of a decision making process. These changes need good support to encourage a successful implementation of 3Di in a decision making process in flood resilient urban spatial planning.

9.2. RECOMMENDATIONS

The implementation of interactive modelling by 3Di requires a new way of working, e.g. in the process of BRP formation. In order to encourage the use of interactive modelling in flood resilient urban spatial planning, a number of recommendations are given;

- Aim at specific target groups for both the promotion and actual implementation of interactive modeling. Results of the survey show that especially own staff of organizations is willing to innovate and that they often are the initiators for a new innovation (Figure 11). However these initiator are not necessary the same stakeholders which implement the innovation, creating broader support for this innovation in the decision making process becomes easier and willingness to innovate of stakeholders and organizations will increase when these initiator are enthusiast about an innovation.

- Looking for opportunities and barriers for using interactive modelling by 3Di in more case studies (instead of only a BRP process in this research). When other case studies will be performed new or different opportunities and barriers for 3Di implementation may arise.

- Testing the feasibility of the results of this research by performing a test case in which 3Di will be used in a decision making process. As is mentioned in the discussion (chapter 8.2), one characteristic of the decision making process is more changeable than an other characteristic which makes hard to assess the feasibility of the opportunities and barriers without a real implementation of 3Di in a decision making process. Therefore a test case will be recommended.

- Further research on the introduction and implementation of 3Di in other fields next to flood resilient urban spatial planning is important. For example to review the use of 3Di in non-urban environments, in which other organizations are involved or play an important role.

- Further research about the difference between opinions and real facts. By conducting a survey with questionnaires and visiting workshops in this research observations are done about the changeability of process characteristics and the possibilities for 3Di implementation. Comparing the differences between observations and real facts (e.g. by a real test case in which 3Di is implemented) leads to indications of where possibilities or limitations are. The real facts with respect to changeability of characteristics and implementation of 3Di in the decision making process are only to a small extent assessed in this research. By assessing these real facts useful indications could be given about the difference between the observation in this research and the real facts.

- Further research with a larger group of respondents. In this research a questionnaire is used to collect a part of the data (next to a literature study and visiting workshops). The group of respondents is considered as representative for the flood resilient urban spatial planning sector, however the amount of respondents (57 respondents) has its limitations. The outcomes could be used for first indications of asked topics, but the group is not large enough to base hard conclusions on.

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APPENDICES

APPENDIX I – QUESTIONNAIRE (IN DUTCH)

BESLUITVORMINGSPROCESSEN RONDOM STEDELIJKE WATEROVERLAST EN RUIMTELIJKE ORDENING

Naam: ....

Datum:..

Leeftijd: ....

Om voorbereid te zijn op hevigere neerslag als gevolg van klimaatverandering richten o.a. gemeenten, provincies en waterschappen zich tegenwoordig niet alleen op maatregelen in de riolering, maar ook op maatregelen in de ruimtelijke ordening.

Om dit besluitvormingsproces te ondersteunen zijn tegenwoordig computer simulatie modellen beschikbaar waarmee de effectiviteit van ruimtelijke maatregelen getest kan worden. Deze modellen kunnen direct tijdens vergaderingen worden gebruikt en geven een realistische en gedetailleerde output. Een voorbeeld van een dergelijke interactief model is het 3Di-model (www.3di.nu). Echter, in huidige werkprocessen zijn deze interactieve modellen vaak nog moeilijk inpasbaar.

Het doel van dit onderzoek is om een nieuw werkproces te ontwerpen waarin deze interactieve modellen wel inpasbaar zijn. Met deze vragenlijst willen we een beeld krijgen welke factoren van het besluitvormingsproces veranderbaar zijn, om hiermee een nieuw procesontwerp te maken.

Deze vragenlijst maakt onderdeel uit van mijn afstudeeronderzoek genaamd; 'Een procesontwerp voor interactief modelleren in werkprocessen rondom stedelijke wateroverlast en ruimtelijke ordening'.

Dit onderzoek wordt uitgevoerd voor het 3Di Consortium, bestaande uit Deltares, TU Delft en Nelen & Schuurmans, en dient als afsluiting van mijn master Water Engineering and Management aan de Universiteit Twente.

Uw bijdrage aan dit onderzoek is erg waardevol. Het invullen van deze vragenlijst neemt ongeveer 15 minuten in beslag. Uw resultaten worden anoniem verwerkt en niet verstrekt aan derden.

A. Algemeen

1. Bij welke organisatie(s) werkt u momenteel?
   ....

2. Wat is uw huidige functie?
   ....

3. Hoe lang werkt u in deze functie?
   - 3 maanden of minder
   - 3-6 maanden
   - 6-12 maanden
   - 1-2 jaren
   - 2-5 jaren
   - 5 jaren of meer, namelijk.......

4. Bij welke organisatie(s) en in welke functie(s) heeft u eerder gewerkt?

Organisatie:............	Functie..............
Organisatie:............	Functie..............
Organisatie:............	Functie..............
Organisatie:............	Functie..............

5. Gebaseerd op uw ervaring, waar plaatst u uzelf op een schaal van 'niet specifiek inhoudelijk gerichte ervaring' tot 'specialistische ervaring'? Denk aan bijvoorbeeld specialistische kennis op het gebied van waterstromingen, riolering, beleidsvorming, etc.
   Niet specifiek inhoudelijk gerichte ervaring 1 2 3 4 5 6 7 specialistische ervaring

6. Gebaseerd op uw ervaring, waar plaatst u uzelf op een schaal van geen (besluitvormings)proces gerelateerde ervaring tot uitgebreide (besluitvormings)proces gerelateerde ervaring?
   Geen proces gerelateerde ervaring 1 2 3 4 5 6 7 uitgebreide proces gerelateerde ervaring

7. Wat is/zijn uw specialisatie(s) (ook gebaseerd op eerdere werkervaring)? Er zijn meerdere antwoorden mogelijk.
   - Watermanagement
   - Water berging
   - Project management
   - Anders............
   - Ruimtelijke ordening
   - Water kwaliteit
   - Riolering

8. Bent u momenteel betrokken in een project/projecten rondom stedelijke planning en watermanagement? Zo ja, welke?

   ………………………………………..

B. Taken en rollen

9. In hoeverre karakteriseert u uw rol als de rol van expert in het besluitvormingsproces rondom stedelijk planning en watermanagement?
   Ik karakteriseer mijzelf niet als expert 1 2 3 4 5 6 7 ik karakteriseer mijzelf als expert

10. In hoeverre karakteriseert u uw rol als de rol van besluitvormer in het besluitvormingsproces rondom stedelijke planning en watermanagement?
    Ik karakteriseer mijzelf niet als besluitvormer 1 2 3 4 5 6 7 ik karakteriseer mijzelf als besluitvormer

11. In hoeverre karakteriseert u uw rol als de rol van beleidsanalist in het besluitvormingsproces rondom stedelijke planning en watermanagement?
    Ik karakteriseer mijzelf niet als beleidsanalist 1 2 3 4 5 6 7 ik karakteriseer mijzelf als beleidsanalist

12. Ziet u het als een mogelijkheid te veranderen van uw huidige (combinatie van) rol(len), zoals is gebleken uit de voorgaande vragen, om te kunnen functioneren in een van de andere rollen in het proces rondom stedelijk planning en watermanagement (expert, besluitvormer of beleidsanalist)? En zo ja, op welke tijdschaal?
    - Ja, direct mogelijk
    - Ja, over ongeveer 3 maanden mogelijk
    - Ja, over ongeveer 6 maanden mogelijk
    - Ja, over ongeveer een jaar mogelijk
    - Ja, over 2 jaren of meer mogelijk
    - Niet mogelijk
    - Weet ik niet

C. Framing

De volgende vragen zijn gericht op de kijk van actoren op de implementatie van een nieuwe technologie. Om deze 'framing' van een nieuwe technologie te beoordelen kijken we naar de 'wil' om te innoveren van actoren, en in hoeverre die wil afhankelijk is van externe factoren.

13. Welke wil heeft u om te innoveren d.m.v. het toepassen van nieuwe technologieën in het besluitvormingsproces rondom stedelijke planning en watermanagement? Een vooruitstrevende benadering wordt gekenmerkt door op de hoogte te zijn van de nieuwste 'snufjes' en deze innovaties direct te willen uittesten en toepassen in je functie. Een terughoudende benadering wordt gekenmerkt door een tevredenheid met de huidige technologieën, niet steeds te willen innoveren omdat het (leren) gebruiken van innovaties niet altijd opweegt tegen het gemak en de kennis van huidige technologieën.
    Vooruitstrevende benadering 1 2 3 4 5 6 7 terughoudende benadering

14. Is uw wil om te innoveren min of meer een vaststaand gegeven, of is het meer situatie afhankelijk, bijvoorbeeld afhankelijk van binnen welk project u werkt en met welke mensen u een nieuwe technologie implementeert?

    Meer vaststaand 1 2 3 4 5 6 7 meer situatie afhankelijk

15. Hoe karakteriseert u de wil om te innoveren (bijv. door state of the art modellen te gebruiken, de bereidheid om nieuwe methoden/software uit te proberen, etc.) van uw <u>organisatie</u> binnen het proces van besluitvorming rondom stedelijke planning en watermanagement?
    Nauwelijks wil om te innoveren 1 2 3 4 5 6 7 grote wil om te innoveren

16. Of, en op welke tijdschaal ziet u het als een mogelijkheid om de wil om te innoveren door uw <u>organisatie</u> te vergroten (bijv. door meer informatie over nieuwe technologieën)? Denk hierbij ook aan de (eventueel) noodzakelijke cultuurveranderingen in uw organisatie benodigd voor het vergroten van de wil om te innoveren.
    - In ongeveer 3 maanden
    - In ongeveer 6 maanden
    - In ongeveer een jaar
    - In 2 jaar of meer
    - Niet mogelijk
    - Weet ik niet

17. Een nieuwe technologie/innovatie kan op verschillende manieren op de agenda komen bij een organisatie. Wie ziet u als belangrijke 'trekkers' voor implementatie van een nieuwe innovatie door een organisatie? Geef voor onderstaande actoren aan hoe belangrijk u deze acht voor het 'trekken' van nieuwe innovaties.
    - Eigen personeel (bijvoorbeeld een werknemer die betrokken is bij het opzetten van een nieuwe technologie/innovatie)
      Niet belangrijk 1 2 3 4 5 6 7 zeer belangrijk, o weet ik niet
    - Bestuurders (bijvoorbeeld bestuurders die graag zien dat een nieuwe technologie/innovatie wordt gebruikt door de uitvoerende organisatie)
      Niet belangrijk 1 2 3 4 5 6 7 zeer belangrijk, o weet ik niet
    - Besluitvormers (vanuit het besluitvormingsproces wordt graag gezien dat een organisatie een nieuwe technologie/ innovatie toepast)
      Niet belangrijk 1 2 3 4 5 6 7 zeer belangrijk, o weet ik niet
    - Beleidsmakers (vanuit het (op te stellen) beleid wordt (graag) gezien dat een organisatie een nieuwe technologie/innovatie toepast)
      Niet belangrijk 1 2 3 4 5 6 7 zeer belangrijk, o weet ik niet

18. Zijn er nog andere actoren die u belangrijk acht voor het 'trekken' van nieuwe technologieën voor implementatie door organisaties?
    ……..

D. Het delen van kennis

De volgende vragen gaan over de kennis die u ontvangt van andere actoren in het netwerk rondom stedelijke planning en watermanagement. Hiervoor vraag ik u een project te selecteren waar u momenteel aan werkt of onlangs heeft gewerkt. De vragen gaan over dit project.

19. Wat is een project waar u momenteel aan werkt of onlangs aan heeft gewerkt rondom stedelijke planning en watermanagement? Het is belangrijk een geschikt project te selecteren, dit zal gebruikt worden voor een groot gedeelte van de vragen Geef de naam, korte omschrijving, (verwachte) duur van het project en de betrokken organisaties/ instanties in het project.
………

20. Van hoeveel personen in het project heeft u inhoudelijke informatie ontvangen?
………

21. Van hoeveel personen in het project heeft u organisatorische informatie ontvangen (denk hierbij aan bijvoorbeeld planning van projecten en organisatie van het project)?
………

22. Van hoeveel personen in het project heeft u informatie met betrekking tot politieke processen ontvangen (denk hierbij aan bijvoorbeeld relaties tussen actoren in het project en besluitvorming in het project)?
………

23. Kunt u voor onderstaande communicatiemiddelen aangeven hoe vaak u via elk middel informatie in dit project ontvangt (zowel via anderen als zelf opgezocht)?

	dagelijks	2x per week	wekelijks	maandelijks	minder frequent	n.v.t.
Face-to-face communicatie						
Telefonische communicatie						
Video conferenties						
E-mail						
Project vergaderingen						
Rapporten, handleidingen						
Workshops, conferenties						
Specialistische software						
Centrale database gebruikt in het project						
Vakbladen, nieuwsbrieven						

24. Zijn er andere communicatiemiddelen die gebruikt worden om informatie naar u over te brengen binnen dit project die hierboven niet genoemd zijn?

....

25. Kunt u voor onderstaande communicatiemiddelen aangeven hoe tevreden u bent over de kwaliteit van de <u>ontvangen</u> informatie die door elk middel wordt overgebracht in het door u gekozen project?
    - Face-to-face communicatie erg tevreden 1 2 3 4 5 6 7 ontevreden, (n.v.t.)
    - Telefonische communicatie erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Video conferenties erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - E-mail erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Rapporten, handleidingen erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Workshops, cursussen, conferenties erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Specialistische software erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Centrale database gebruikt in het project erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Vakbladen, nieuwsbrieven erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)
    - Evt. andere communicatie-Middelen door u genoemd in Vorige vraag erg tevreden 1 2 3 4 5 67 ontevreden, (n.v.t.)

De volgende vragen gaan over de kennis die u <u>overbrengt</u> naar andere actoren in het netwerk rondom stedelijke planning en watermanagement. De vragen hierbij gaan wederom om hetzelfde, door u gekozen project.

26. Welke communicatiemiddelen gebruikt u voor het overbrengen van informatie binnen het project? Geef voor elk van onderstaande middelen aan hoe vaak u er gebruik van maakt.

	dagelijks	2x per week	wekelijks	maandelijks	minder frequent	n.v.t.
Face-to-face communicatie						
Telefonische communicatie						
Video conferenties						
E-mail						
Project vergaderingen						
Rapporten, handleidingen						
Workshops, conferenties						
Specialistische software						
Centrale database gebruikt in het project						

27. Zijn er andere communicatiemiddelen die u gebruikt voor communicatie met actoren binnen het project die hierboven niet genoemd zijn?

   ....

28. In hoeverre vertrouwt u op de resultaten van modellen in uw beslissingen?
   Helemaal niet 1 2 3 4 5 6 7 in grote mate

29. Is de mate waarin u vertrouwt op de resultaten van modellen in uw beslissingen afhankelijk van externe factoren, bijvoorbeeld door het gebruik van een ander (nieuw) model?
   Helemaal niet 1 2 3 4 5 6 7 in grote mate

De volgende vragen gaan over de verschillende kennisniveaus in het besluitvormingsproces; in staat zijn om te communiceren op vakgebied technisch niveau en/of in staat zijn om ook bij te dragen aan de vakgebied technische kennis.

30. Bent u, met uw huidige kennis, in staat om op vakgebied technisch niveau <u>interactief tecommuniceren</u> met experts en deze te begrijpen, zonder zelf persé in staat te zijn om deze kennis te produceren?

   Helemaal niet 1 2 3 4 5 in grote mate
31. Ben u in staat om zelf vakgebied technische kennis te produceren (bijv. specifieke kennis over hydrologische processen of stedelijke inrichting of grondwater stromingen, etc.) in het door u gekozen project?
   Helemaal niet 1 2 3 4 5 in grote mate

E. Structuur en frequentie

De volgende vraag gaat over het communiceren van technische informatie van actoren in dit project.

32. Van wie ontvangt u het merendeel van de technische informatie in dit project?
    - Direct van experts
    - Van besluitvormers
    - N.v.t.
    - Van adviseurs
    - Van beleidsanalisten
    - Anders...........

De volgende vragen gaan over de 'communicatieafstand' tussen experts, besluitvormers en beleidsanalisten in dit project.

33. Gebaseerd op uw eigen functie, wat is de karakteristieke 'communicatieafstand' tussen **experts** (verantwoordelijk voor het produceren van bijvoorbeeld technische informatie) en **besluitvormers** in het besluitvormingsproces rondom stedelijke planning en watermanagement? Geef de afstand weer in de relatie tussen expert en besluitvormer, waarbinnen uzelf expert, besluitvormer of tussenpersoon bent.
    - Directe communicatie tussen expert en besluitvormer (bijvoorbeeld tussen een expert van een adviesbureau en een peilbeheerder)
    - Indirecte communicatie tussen expert en besluitvormer door middel van een tussenpersoon (bijvoorbeeld de projectleider als tussenpersoon)
    - Indirecte communicatie tussen expert en besluitvormer door middel van twee tussenpersonen (bijvoorbeeld communicatie van expert naar besluitvormer door tussenkomst van een watertoetser en een coördinator
    - Indirecte communicatie tussen expert en besluitvormer door middel van drie of meer tussenpersonen
    - Anders..................................

34. Als u een indirecte vorm van communicatie hebt geselecteerd in de vorige vraag, denkt u dat het mogelijk is om de afstand tussen de expert en de besluitvormer te verkleinen?
    - Ja, directe communicatie is mogelijk
    - Ja, communicatie kan worden gereduceerd tot een tussenpersoon
    - Ja, communicatie kan worden gereduceerd tot twee tussenpersonen
    - Nee, het is niet mogelijk om de afstand tussen expert en besluitvormer te verkleinen
    - Weet ik niet
    - Ik had geen indirecte vorm van communicatie geselecteerd in de vorige vraag

35. Als u heeft geselecteerd dat het mogelijk is om de afstand tussen expert en besluitvormer te verkleinen, verwacht u dat dit mogelijk is binnen de tijdschaal van dit project?
    - Ja
    - Nee

36. Ziet u een directere vorm van communicatie (dus met minder tussenpersonen) als meer positief t.o.v. de huidige situatie?
    Helemaal niet 1 2 3 4 5 in grote mate

F. Contextuele factoren

De volgende vragen gaan over de fysieke afstand van de actoren in het door u geselecteerde project.

37. Wat is, in dit project, de **fysieke afstand** ten opzichte van de meerderheid van de actoren (van <u>binnen</u> je eigen organisatie)?
    - Zelfde kamer
    - Zelfde verdieping en zelfde gang
    - Zelfde verdieping maar andere gang
    - Andere verdieping
    - Ander gebouw
    - Andere stad
    - Ander land
    - Anders…………..

38. In hoeverre denkt u dat het mogelijk is om de fysieke afstand tot het merendeel van de andere actoren van binnen uw organisatie een niveau dichter bij elkaar te brengen (vergeleken met uw antwoord op de vorige vraag) binnen de looptijd van dit project?
    - Voor een klein gedeelte van de actoren mogelijk
    - Voor een groot gedeelte van de actoren mogelijk
    - (bijna) onmogelijk
    - Anders...................................

39. Wat is, in dit project, de **fysieke afstand** ten opzichte van de meerderheid van de actoren (van <u>buiten</u> je eigen organisatie)?
    - Zelfde kamer
    - Zelfde verdieping en zelfde gang
    - Zelfde verdieping maar andere gang
    - Andere verdieping
    - Ander gebouw
    - Andere stad
    - Ander land
    - Anders, namelijk…..

40. In hoeverre denkt u dat het mogelijk is om de fysieke afstand tot het merendeel van de andere actoren van buiten uw organisatie een niveau dichter bij elkaar te brengen (vergeleken met uw antwoord op de vorige vraag) binnen de looptijd van dit project?
    - Voor een klein gedeelte van de actoren mogelijk
    - Voor een groot gedeelte van de actoren mogelijk
    - (bijna) onmogelijk
    - Anders...................................

41. Ziet u een verkleining van de fysieke afstand tot andere actoren in het project als meer positief t.o.v. de huidige situatie?
    Helemaal niet 1 2 3 4 5 in grote mate

G. De 'overtuiging' van betrokken organisaties en actoren

De volgende vragen gaan over de 'overtuiging', doelen en paradigma's van betrokken actoren in het besluitvormingsproces. De vragen gaan over het door u geselecteerde project.

42. In hoeverre heeft u het gevoel dat dezelfde doelstellingen worden nagestreefd tussen de actoren in het door u gekozen project?
    Nauwelijks dezelfde doelstellingen 1 2 3 4 5 6 7 volledig gedeelde doelstelling

43. Geef een voorbeeld van een doelstelling tussen actoren in het project, en geef aan of deze juist niet of juist wel wordt gedeeld door alle actoren in het project.
    ……………………………………………………………………………………

44. In hoeverre heeft u het gevoel dat er een collectief gedeelde overtuiging is tussen alle betrokken actoren (in het door u geselecteerde project) over hoe het besluitvormingsproces er uit moet zien om succesvol te kunnen zijn?
    Nauwelijks collectief gedeelde overtuiging 1 2 3 4 5 6 7 volledig collectief gedeelde overtuiging

45. Wat is deze (al dan niet gedeelde) overtuiging volgens u?
    ……………………………………………………………………………..

46. Denkt u dat de mate van gedeelde doelstellingen en overtuigingen tussen actoren in het project verhoogd kan worden, door gebruik te maken van voorlichting, workshops, een cursus, e.d.?
    Kan niet worden verhoogd 1 2 3 4 5 6 7 kan in grote mate worden verhoogd

47. Op welke tijdschaal denkt u dat dit mogelijk is?
    - In ongeveer 3 maanden
    - In ongeveer 6 maanden
    - In ongeveer een jaar
    - in ongeveer 2 jaar of meer
    - Niet mogelijk

- *Bedankt voor uw deelname aan dit onderzoek* -

Appendix II–Examples of (shared/ not-shared) goals and beliefs given by respondents

Goals:

1	provincie: waterveiligheid verbeteren, gemeente: ruimtelijk ontwikkelingspotentieel verbeteren, waterschap: peilbeheer beheersgebied handhaven, studenten: halen voldoende voor vak, mezelf: leerproces studenten
2	Ontwikkelaar wil winst maximalisatie, wij als overheid dienen algemene belangen zoals, gebouw en woonkwaliteit, stedelijke hoogwaardige uitstraling, goede verblijfskwaliteit e.d.
3	Vaak planning en standaard-ontwerpen versus wat meest optimale en integrale lange termijn oplossing is.
4	gezamenlijk doel is de aannemer snel en eenduidig te bedienen
5	Verbetering van de waterkwaliteit (met name zuurstofgehalte) kent binnen de gemeente Purmerend een hoog ambitieniveau. De experts van het hoogheemraadschap zijn daar genuanceerder (realistischer) in.
6	Kustveiligheidsoplossing combineren met parkeergarage
7	Doelstelling dat er 209 ruimte voor ruimte kavels met ruime mogelijkheden voor vrijheid wordt gedeeld. Waar de waterberging het beste kan worden gerealiseerd en relatie tussen straatprofiel en afstromend hemelwater verschilt.
8	realiseren waterbergingsopgave realiseren van een project waar de burger blij van wordt en de omgeving verbetert
9	waterbergingsopgave is voor een waterschap heel erg belangrijk. Voor een gemeente is het hele wateraspect maar een klein onderdeel van alle aspecten die rondom planvorming spelen. Aspecten als grondexploitatie, economische ontwikkeling, sociale veiligheid, voorzieningen, stedenbouwkundige en landschappelijke aspecten wegen vaak voor een gemeente heel zwaar en zijn voor een waterschap niet interessant.
10	Realiseren voldoende ruimte voor water. Wordt niet per definitie/per definitie niet gedeeld door alle actoren. Ontwikkelaar moet z'n investering eruit halen en daarvoor zal vaak bebouwbare oppervlakte nodig zijn.
11	Inzet van alternatieve vormen van piekberging in dichte stad ten gunste van uitgeefbaar oppervlak. waterschap: ja, stedenbouwkundige: ja, pr. ontwikkelaar: ja, mits, gemeente: onbepaald, planvoorbereiding/deskundigen: ja, mits
12	Het doel van de opdrachtnemer (Nelen & Schuurmans) is anders dan het doel van de opdrachtgever (Gemeente). De opdrachtgever heeft een probleem en zoekt daarvoor een oplossing. De opdrachtnemer heeft als doel het project succesvol uit te voeren en een goede klantrelatie op te bouwen.
13	Deel wil alleen de analyse en een deel wil ook oplossingen
14	Het realiseren van een schone en veilige stad, wordt gedeeld door alle actoren
15	Adviseur: goede oplossing, geen onnodige varianten doorrekenen. Een van de opdrachtgevers: wil vasthouden aan strak schema van varianten
16	Waterkwaliteit zou verbeteren door het water door de stad te leiden, dit was een oude doelstelling, deze was inmiddels achterhaald doordat de waterkwaliteit in de stad door andere maatregelen reeds sterk verbeterd was.
17	water bergen / vertragen via groen is doelstelling van waternet. Waar mogelijk deel ik deze doelstelling. Alleen wil ik groen van waarde behouden en risico's correct inschatten. De effecten van het onder water staan bij actieve beworteling wordt onvoldoende onderkend. Ook niet door de overage actoren.
18	Hoge kwaliteit watersysteem: niet door iedereen gedeeld. Projectplanning halen: bijna iedereen
19	Vermindering wateroverlast alle actoren
20	Door de vervanging en afkoppeling van de riolering en herbestrating is de buurt voor de komende 30 jaar klaar. Niet gedeeld. De doelstelling is vanuit geld geredeneerd en niet vanuit de behoefte. Een buurt blijft door wensen van bewoners en veranderingen in gebruik (bijv. vuil anders inzamelen, maatvoering parkeervakken, etc.) onderhevig aan veranderingen.
21	Onderzoek naar nut en noodzaak van compartimenteringskeringen wordt in zijn algemeenheid door alle actoren gedeeld. De uitkomsten en oplossingsrichtingen c/q wie doet vervolgens wat, wie betaalt wat, etc. kunnen uiteenlopen.
22	Inhoudelijke interactie tussen riolering en watersysteem zonder elke keer de verantwoordelijkheid te benadrukken van of gemeente of waterschap

23	hoogwaterveiligheid, wordt gedeeld.
24	realiseren waterberging. Wordt gedeeld door Waternet en partijen bij stadsdeel.
25	Wel: Voorkomen wateroverlast. Niet: Voorkomen van het lozen van verontreinigd regenwater (vanwege foutaansluitingen).
26	Voorkomen groundwater overlast -->wordt gedeeld
27	Dijkversterking vs. natuur vriendelijke oever
28	De collectieve inzet van dit project is het voorkomen van wateroverlast door ingrepen in het maaiveldprofiel te projecteren
29	Voldoende waterberging liefst bovengronds conflicteert soms met wensen stedenbouwkundige, projectleider of andere actoren.
30	we meten en monitoren gezamenlijk oppervlakte- en afvalwater
31	Adviesbureau wil methodiek uittesten met project als case. Gemeente wil resultaten voor concreet gebied beide doelstellingen kunnen goed samengaan
32	ruimte voor water in stedelijk gebied. ruimte voor economische ontwikkeling
33	het voorkomen van wateroverlast bij de maatgevende bui
34	Het eindresultaat moet de waterproblemen oplossen en een aantrekkelijk beeld opleveren wat qua dimensionering en materiaal gebruik past in de omgeving van het project- het dorp Wijk aan Zee. Het oplossen van de problemen wordt gedeeld de manier waarop verschillen we soms over van mening.
35	Integraliteit van ruimtelijke ontwikkelingen - verschillende perspectieven op ad-hoc besluiten of definitie integraal
36	Alle kabel en leidingbedrijven willen goede tracés om alle percelen goed te kunnen aansluiten. Belang wordt niet gedeeld door dienst ruimtelijke ordening en projectontwikkelaars
37	Alle actoren willen klimaatbestendige stad bereiken, maar hebben daar elk nog een eigen beeld bij en een ander idee over de weg daar naar toe.
38	doel om (mogelijke water)overlast bij extreme neerslag te verminderen. Maar hiervoor zijn maatregelen noodzakelijk, welke geld kosten en soms impact hebben voor de openbare ruimte. Vragen die spelen: "wat zij de kosten, hoe groot is kans van overlast en waarom niet accepteren en schades vergoeden" en daarnaast "andere indeling van openbare ruimte botst met de bestaande ideeën"
39	Tegenstrijdig belang: propageren integratie waterbeheer en RO door adviseur vs. robuuste oplossing met rioleringsbuizen door gemeente
40	beheersmaatregelen grondwater in urbaan gebied afstemmen op specifieke functie van het gebied: daar zijn de actoren IN het project het over eens

Beliefs:

41	Integrale project biedt aankoppelkansen / opties voor synergie
42	Het welslagen van het project.
43	de wijze van samenwerken tussen de provincie en HHNK moet nog verder gedeeld en vastgesteld worden
44	De stuurgroep neemt de besluiten en legt deze voor aan de individuele colleges.
45	Het moet mogelijk zijn kustveiligheidsoplossingen te combineren met andere ruimtelijk noodzakelijk verbeteringen
46	Bestemmingsplanprocedure is bepalend en over het algemeen is hier wel consensus over. Alleen planning is niet altijd duidelijk, het is een project van hollen en stilstaan, waarbij alleen de projectleider het totaaloverzicht houdt.
47	Proberen tegen laagste maatschappelijke kosten iets moois neer te zetten.
48	Geen natte voeten
49	Alternatieve vormen van piekberging leveren voordelen bij ontwikkeling van een compacte stad/woonwijk
50	Alle actoren willen het probleem oplossen.
51	Politiek moet keuzes kunnen maken uit verschillende varianten

52	Het instellen van een meer natuurlijk watersysteem, dat robuuster is dan het kunstmatige huidige systeem.
53	Noodzaak tot het realiseren van een watermanagement opzet dat ingericht is op de 'aankomende' klimaatveranderingen.
54	Ambtelijk: Het moet formeel en goed. Ontwikkelaar: Het moet praktisch en snel
55	De graad van succes, voor het project niet de besluitvorming, kan worden gemeten door de voortgang te monitoren. Als de monitor goed is heeft het project kans van slagen.
56	De bewoners van de wijk vanaf het begin van het project bij de plannen betrekken en goed op de hoogte te houden van alle stappen. Transparant te werken en de plannen bestuurlijk vast te laten stellen in de verschillende fases van het project.
57	Nut en noodzaak van compartimenteringskeringen wordt in zijn algemeenheid door alle actoren gedeeld.
58	Op de eerste plaats gezamenlijk zoeken naar de technisch optimale oplossing. Daarna pas kijken wat daarvan de financiële en bestuurlijke gevolgen zijn voor de verschillende partijen.
59	Door RWS voorgeschreven SNIP-fasering
60	Behalen planning en gecombineerd bestek straatwerk (Stadsdeel) en Riolering + Drinkwater (Waternet Afvalwater en Drinkwater)
61	Overlast voorkomen en niet te dure investeringen
62	Bij stedelijke ontwerpen moet rekening worden gehouden met extreme neerslag.
63	Met een goed duurzaam plan komen
64	Dat RO maatregelen oplossing kunnen bieden om wateroverlast tegen te gaan: RO-ers en waterbeheerders moeten samen optrekken bij (her)inrichting van stedelijke gebieden
65	Besluitvorming was niet het doel van dit project
66	Ruimte voor water is noodzakelijk voor droge voeten
67	Dat de maatgevende bui een afdoende uitgangspunt
68	Dat de inrichting van de straat moet worden afgestemd op de wensen van bewoners, of in ieder geval dat ze in het proces worden meegenomen.
69	Versnipperde verantwoordelijkheden / beperkte integratie en gedeeld perspectief
70	Om tegen de laagst maatschappelijk kosten het project te realiseren
71	De weg naar besluitvorming is er een die verkennend en 'al doende' wordt bewandeld.
72	Door middel van workshops waarbij aanwezig de verschillende actoren en door middel van simulatie modellen aantonen wat er kan gebeuren, waar kritische situaties zijn en mogelijke gevolgen laten zien, bespreken en toetsen met praktijk voorbeelden. Proces om zaken net iets anders te benaderen kan niet van de ene op de andere dag, maar heeft enige tijd nodig.
73	Proberen zoveel mogelijk verschillende vakdisciplines bij proces te betrekken. Dit gaat prima. Betrekken van bestuurders is lastiger t.g.v. drukke agenda's en andere prioriteiten.
74	De overtuiging is dat er veel meer mogelijk is dan de meeste beleidsmakers denken. Men durft de beleidsruimte niet volledig te benutten. Hierover zijn we het redelijk eens.

Appendix III – 3Di Workshop Purmerend Climate Proof

4 September 2013.

Location: Municipal Purmerend, The Netherlands

Participants: approximately 25 attendees

Scheme:

12.00-12.30 Lunch

12.30-12.40 Opening by city counsellor of Purmerend

12.40-12.45 Workshop outline (Cees-Anton van den Dool)

12.45-13.15 Explanation concept 'Water in de stad, bergen in de ruimte' and an interactive session with 6 statements and discussion (Anne Leskens);

- The sewage system is OK
- Rainfall becomes more and more intensive
- When the boezemkade (secondary dike) is about to break, the whole municipality of Purmerend needs to be evacuated
- Water storage in the sewage system is too expensive, we have to create storage at the surface level
- Constructing green roofs is the solution to water problems in the urban area
- Purmerend needs to be a (international) example of a climate proof city

13.15-14.00 What if it goes wrong? (Bram de Vries / Frank Tibben)

- Explanation situation district 'Gors-zuid'
- Gors: simulation 0-scenario in prototype of water hindrance in the case of a 100mm rainfall event in 1 hour and illustrate 3 potential solutions (green roofs, water squares and permeable pavements)
- 'De Purmer': simulation 0-scenario in prototype of a dike break in the Purmer polder
- Presentation of the dike breach scenario in 3D
- Adaption of some measures in Lizard and show the results

13.50-14.20 Break

14.20-15.30 Hands-on session

- Explanation hands-on session and division in two groups
- Group 1 starts with the maps: potential scenarios will be devised based on the given potential solutions

- Group 2 starts with the touch table: test potential scenarios
- Change (after half an hour)

15.30-15.45 Evaluation of the results of the two groups and summary of interactive version

15.45-16.00 How to proceed now: tools (3Di, Lizard, rain-app) very usable for further elaboration. The workshop is concluded by asking the attendees about the experiences/ points of discussion they have, some quotes;

- This connects different people and disciplines
- The model gave me new understanding of the physical behaviour of inundations and triggered me to learn more
- This makes clear which options we have to choose from
- We will definitely use this in our following masterplan for water management in the city
- My team has to use this
- I triggered my need for more technical insight
- Policy makers need to take this instrument into account
- We require a structural vision on measures instead of 'trial and error' with the model. Therefore a process design is required to use the model
- It gave me much inspiration
- Integrated water management is hard to implement as a consequence of different 'departments' and budgets. Therefore it should be a political choice, based on a long term vision to involve spatial planning in water management
- The model should be used for new project development
- The model should be used in the critical last phase disaster management
- The model should be applied in the ‘watertoets’ [water test]

APPENDIX IV – 3DI WORKSHOP AMSTERDAM CLIMATE PROOF CITIES

22 may 2013 - sketch session neighborhood 'Betondorp'

Participants: approximately 20 attendees

Location: Waternet, Amsterdam

Scheme:

- Opening of the workshop (Eljakim Koopman)
- Goal and scheme of the day (Elgard van Leeuwen)
- Neighborhood 'Betondorp' (What preceded this session)
- Design session 3Di Waterbeheer (Anne Leskens)
- Possible solutions for Betondorp (Floris Boogaard)
- Calculation of four scenarios with 3Di (Anne Leskens)
- Interactive session of the 3Di toolbox (everyone)
- Feedback, discussion en conclusions (Elgard van Leeuwen)

During the workshop the following quotes are mentioned by participants;

- 3Di could help with visualizations
- How are costs incorporated in 3Di? Does 3Di provide an overview of the costs for a specific scenario?
- The integrality in 3Di makes it very complex, however this integrality is what we want in the end
- Apparent reality in a model, it looks realistic but it is not always as realistic as it appears
- The more interactive, faster and detailed the model, the more people can and want add
- The interactive representation in 3Di leads to much, otherwise not, reviewed ideas

APPENDIX V – CHANGEABILITY PROCESS CHARACTERISTICS

The process characteristics of which the explanation is marked in green letters are (to some extent) changeable. The changeability of the characteristic 'experience and knowledge levels of actors'could not be assessed based on the results of this research and is not marked as changeable. The aspect 'physical distance between actors' is marked as not changeable in this research.

TABLE 6: CHANGEABILITY OF THE DECISION MAKING PROCESS CHARACTERISTICS IN FLOOD RESILIENT URBAN SPATIAL PLANNING. GREEN MARKED MEANS CHANGEABLE, YELLOW COULD NOT BE ASSESSED AND RED IS NON-CHANGEABLE

Process characteristics	Explanation	Changeability
Experience and knowledge levels of actors	Experience of actors in the process could basically be divided in content-related (from general to specific) and process-related experience.	Previously acquired experience and accumulated knowledge is not changeable, however new experiences could be build up. Acquired experience (e.g. with conventional models) could affect application of new models. The survey shows the different knowledge levels (Figure 17), but based on these results the changeability of this characteristic could not be assessed.
	Lay, interactional and contributory levels of knowledge	
Roles of actors	Roles of actors in this research are divided in; expert, decision-maker and policy analyst.	Results of the survey indicate that one-third of the respondents expect it as directly possible to function in another role. Another third of the respondents expect it is possible on a larger time scale, and the remaining respondents expect it as not possible or don't know (Figure 7)
Willingness to innovate	Personal willingness	This is an important aspect that has the possibility to change. Opinions are roughly equally split between the question if personal willingness is more fixed or dependent on other factors (e.g. dependent on the kind of model which is implemented or in which project the new technology is implemented) (Figure 9).
	Organizational willingness	This is an important aspect that has the possibility to change. 69% of the respondents expect it as possible to change (27% don't know,4%: not possible) on a time scale ranging from 3 months to 2 years or more (Figure 10).
initiators for innovation implementation	Own staff, decision-makers, managers and policy-makers are seen as important stakeholders for putting a new innovation on the agenda of an organization (Figure 35)	Which initiators are important for encouraging the implementation of an innovation has the possibility to change, but based on the results of the survey it is hard to say on which time scale this is possible. It would be suggested to find the best (combination of) initiators to focus on when trying to implement a new innovation. Which initiators will introduce a new technology could influence how it will be framed (Edmondson, 2003), see also chapter 2.4.
Kind of information received from each actor	Difference is made between content-related, organizational and political information. Average of all respondents indicates that 57% of the persons deliver content-related, 25% organizational and 18% political information to the respondents in the chosen project.	To some extent changeable. From which actor (and from how many actors, see chapter 3.2.1 part D) information is received in a project is subject to change. See also the 'communication of technical information' below in this table.

Knowledge sharing	Resources used for receiving information in a project Quality of received information by each resource Resources used for transferring information in a project	The resources used for knowledge sharing (Figure 12 and Figure 16) have the possibility to change to a certain extent. For example when implementing another way of modelling (like interactive modelling) a shift in which resources are used could appear.
Trust in model results	Respondents are asked to what extent they trust model results in their decisions and if this trust is fixed or dependent on external factors	Half of the respondents indicate their trust is to some extent dependent on external factors (like another model), seeFigure 15. This suggests the 'trust' is to some extent changeable if external conditions are favourable.
Structure of the network	Communication of technical information (by expert, decision-maker, policy analyst or other).	To some extent changeable. For example the communication of technical information by experts (Figure 18) could shift to communication by another role if the technical information is easier to interpret. E.g. when the used model supply technical information which is easier to interpret and offers non-experts the possibility to transfer this information to other stakeholders.
	Communication distance between expert and decision-maker.	Changeable. Approximately two-third of the respondents indicates it is possible to change (reduce) the communication distance (Figure 20). Half of these actors expect it is possible within current project time scale.
	Physical distance between actors (within an organization and between organizations)	Hard to change. Only 29% and 11% of respondents indicate it is possible to reduce the physical distance between actors from respectively their own and other organizations within the project time scale (Figure 23, Figure 24).
Extent of shared goals and beliefs	To what extent do actors feel that goals and beliefs are shared between involved project members.	Approximately 75% of respondents indicate the extent of shared goals and beliefs could be changed (increased) within 2 years (Figure 27).