ENHANCING INNOVATION IN DIKE MONITORING PRACTICE

by Emilie Caroline Buist

A CASE STUDY ON THE IMPLEMENTATION OF NOVEL OPTIC FIBRE PRESSURE SENSORS

"The credit belongs to the man who is actually in the arena."
- Theodore Roosevelt

ENHANCING INNOVATION IN DIKE MONITORING PRACTICE

A CASE STUDY ON THE IMPLEMENTATION OF NOVEL OPTIC FIBRE PRESSURE SENSORS

by Emilie Caroline Buist
14th of February, 2019

in partial fulfilment of the requirements for the degrees of:

MASTER OF SCIENCE
in Civil Engineering (track: Water Management)

and

MASTER OF SCIENCE
in Science Communication

Delft University of Technology

to be defended publicly on February 21st, 2019

Thesis committee
dr. T.A. Bogaard
dr. J.P. Aguilar Lopez
dr. E. Mostert
dr. ir. Steven Flipse
dr. É. Kalmár
prof. dr. M. J. de Vries

Cover image
Taken from the cover of the book 'In de ban van de dijk - de Westfriese Omringdijk' by J.J. Schilstra (1974): "reproductie naar een schilderij van C.Kaay"

An electronic version of this thesis is available at http://repository.tudelft.nl/

PREFACE & ACKNOWLEDGEMENTS

Preface

A little over a year ago I started planning my master thesis: an integrated project for both my masters Water Management and Science Communication. When I spoke to Thom Bogaard about possible topics, he mentioned the DOMINO project, in which novel optic fibre pressure sensors are developed that can be applied to dike monitoring practice. I immediately felt a sense of curiosity and inspiration and chose to write my thesis related to this project.

Eventually, the double degree perspective on the topic steered me towards a research on the implementation on innovation. The extended length of the project provided the opportunity to delve into the subject and make new research choices later in the process. I was able to move beyond the doors of the university and visit many water authorities and other organziations (in both the Netherlands and Italy), attend dike monitoring network meetings and organize brainstorms and a workshop myself. This report is the accumulation of the knowledge I gathered along the way.

Acknowledgements

Doing a combined thesis project resulted in a big team of supervisors. What they had in common was their positive and constructive guidance. I always felt support, as well as trust. Thanks Thom, Steven, Juan, Erik and Eva, I have learned a lot from the discussions we had, and the feedback you gave me.

The combination of practice and analysis was something I really enjoyed. I want to thank everyone that has willingly talked with me and helped me to understand and put into perspective the ins and outs of dike monitoring practice.

The thesis project was much more for me than the research itself. It was a year of personal lessons as well, learning about my personal working style, about time and energy management.

Very important were the contacts with friends and family, fellow students. I was lucky to be surrounded by likeminded and uplifting people. I will always remember things like the jokes and interactions 't Afstudeerhok, the 'summer thesis' refuge together with friends in the airconditioned University Library during the hot summer of 2018, and the not-to-be-skipped after-lunch coffee breaks in Italy.

For sure, a highlight was the month I spent in Padova, Italy, for my research. I want to thank Alessandro Pasuto, Luca Schenato and Luca Palmieri for accommodating me at the university and at CNR, and for helping me with the interviews. Also, I received a very warm welcome by all the master thesis and PhD students there, so that I felt at home even after the first day.

A big thanks to my roommates from my student house in Delft and my new home in the Hague for the warmth and laughs. Next to that, working on the podcast with Emanuele was a nice creative outlet over the whole year. Of course, I want to thank my friends and family for the solid base. A special thanks to my parents for offering me 'the writers retreat' when I needed it, and my grandmother (now 95 years old) for her emails and voicemails. And thanks Thomas, for always cracking me up with your witty being.

With this project, I close off my university education, and as I look back on all opportunities I got and the people that nurtured me in the past years I feel grateful, and I am curious about the next steps and learning paths!

SUMMARY

Flooding currently affects 100 million people on average per year globally, and the number is increasing. The performance of dikes under extreme conditions is crucial to societal flood protection. By deploying measurement instruments in and around the embankment, more accurate insights into the actual status of the dike can be achieved that can be used to prevent the failure of a dike.

Despite growing awareness of the potential of dike monitoring techniques and effort put into the development and testing of instruments, implementation of instrumental dike monitoring into regular practice remains scarce. The objective of this thesis is therefore to shed light on the factors that influence the implementation of innovation in dike monitoring practice by: (1) assessing and analysing the barriers and drivers for implementation of innovation in dike monitoring, by studying a case study of novel optic fibre pressure sensors and trying to influence this practice by (2) designing a communication oriented intervention for the development phase that enhances the implementation process.

Drivers and barriers (Part II of the research)
With the help of a theoretical framework and empirical case study research, the drivers and barriers for implementation of innovation in dike monitoring practice was explored in both the Netherlands and Italy's Po valley. In sum, it is observed that the trend is that the dike monitoring practice does slowly move towards the application of more instrumental dike monitoring techniques, however, there are still hurdles to be overcome.
In both countries, a growing awareness of instrumental dike monitoring is noticed. The urgency to change the existing flood management is slowly increasing and expected to keep increasing, but there is no real push to action yet. In both countries, key individuals act as game changers in the field; with their enthusiasm and persistence, they play an important role in the implementation landscape. A barrier identified in the Netherlands is the conservative and risk-averse nature of the water authorities, which works against innovation. Also, the life cycle management of dikes involves many different parties within and outside of the water authority, which makes the implementation a complex venture, for which a long-term strategy is needed. In Italy, the water authorities are also considered risk-averse and conservative, and a bureaucratic culture hampers initiative. Furthermore, minimal financial resources and capacity limit the options to implement innovative practices.

As for the innovations, the performance is crucial, and not easily trusted by the end-users. The development of ICT can enable to retrieve usable information out of the big amounts of data. Accessible ICT and data management could also help to show the added value for different stakeholders involved throughout the lifecycle of the dike.

The novel optic fibre pressure sensors developed by DOMINO have the potential for use in practice, but there is still a long way of development ahead. Pressure measurements are interesting for the water authorities and they can easily fit into the current system and calculations. There are some requirements to be met, such as performance, as well as a decrease in cost. The implementation of these optic fibres should be seen in the context of other technologies for dike monitoring practice, and the implementation would also benefit from a higher commitment from the practice towards the use of monitoring techniques.

Intervention (Part III of the research)
Many of the challenges in the implementation process link to communication and collaboration. These barriers are encountered across different groups of stakeholders and collaborations, and in different moments in time: from the very first idea until the adoption and implementation stages. In this part of the research, the aim was to design an intervention that can overcome these kinds of challenges. Following the guidelines of the Design Council (2015), the design process followed a divergent and convergent pattern.

To ensure a feasible design that could be made within the scope of this research, a focus was chosen. The design goal was to come up with something that allows both end-users and developers to oversee the bigger picture of the implementation process while enabling them to reflect and act upon their commitment to collaborate.

Based on both practical criteria and criteria related to relevance and preferences indicated by the stakeholders, a workshop with brainstorm elements was chosen as the appropriate form. Insights from literature and practice were sought to fill in the elements that the workshop needed to contain, with relation to its aim, content, workshop exercises, and form. These insights also helped to secure the relevance of the workshop.

The final design is a set of two workshops. The first workshop is meant to be strategic/visionary, while the second workshop works towards a plan of action, based on the results of the first workshop.

The workshops are guided by the 'Implementation Donut'. The circular shape represents both the iterative process, as well as the boundary conditions that are faced. The iterative implementation process is brought into the workshops through crosschecks of the previous results. The implementation donut also provides visual guidance for the workshop, as well as the opportunity to map all progress and results. In this way, the Donut is used as a reference throughout the two workshops.

The first evaluations of the design are promising, and the next step after fine-tuning of the design would be an opportunity to try and evaluate the workshops with practitioners. Once further developed, the workshop could be used as a kick-off for innovation projects, preferably linked to existing procedures.

GLOSSARY

Definitions

Related to dike monitoring

dike failure: when a dike is damaged or breeched and cannot retain the water anymore, causing the land behind it to flood

dike failure mechanism: the mechanism that causes the dike to fail, for example overtopping, piping or damage to the dike outer layer

life cycle monitoring: the optimization of a monitoring plan with regard to the whole life cycle of a dike

monitoring strategy: strategy that encompasses at least the measuring location of the sensors and frequency of the data based on the later use of the data

instrumental dike monitoring: dike monitoring done with measuring instruments and technologies, either within the dike (in situ), or from a distance (remote sensing)

risk: a function of hazard potential (likelihood of a hazard and its intensity) and vulnerability (number of exposed elements)

sensor: a device which detects or measures a physical property and responds to it

visual inspection: check for irregularities in the dike by inspectors through observation of the inspector

Related to implementation of innovation

adoption of innovation: the decision to implement an innovation

barrier: in this thesis, a restraining force for the implementation of innovation

diffusion of innovation: the spreading of a new technology over a network of end-users

driver: in this thesis, a driving force for the implementation of innovation

implementation of innovation: the decision to work with an innovation, its fit into the current working processes and the consistent use of an innovation after the adoption of the innovation

innovation: "an idea, practice, or object that is perceived as new by an individual or other unit of adoption".

slack resources: excess resources that can be spent on for example organizational growth or innovation

Related to communication

double diamond: research approach for design process

intervention: action designed to improve a situation

List of acronyms

BZ I&M	BZ Ingenieurs & Managers
CNR	National Research Council (in Italy)
DOMINO	Dikes and debris flows monitoring by novel optical fiber sensors
DDSC	Dijk Data Service Center
EU	European Union
FOS	Fiber Optic Sensors
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NWO	Nederlandse Organisatie voor Wetenschappellijk Onderzoek
OECD	Organisation for EconomicCo-operation and Development
PIW3.0	Professionaliseren Inspectie Waterkeringen 3.0
RRI	Responsible Research and Innovation
SRL	Stakeholder Readiness Level
STOWA	Stichting Toegepast Onderzoek Waterbeheer
TRL	Technology Readiness Level
WBI 2017	Wettelijk Beoordelingsinstrumentarium 2017

CONTENT

LIST OF FIGURES, BOXES & LIST OF TABLES

List of figures

List of Boxes

List of tables

PART I

INTRODUCTION TO THE RESEARCH

In Part I the foundation for this research is laid out. It introduces the research and its context, and gives a glimpse of what will follow in the rest of this report.

CONTENT

1.1 INTRODUCTION

Instrumental dike monitoring has the potential to give a more accurate insight into the stability of a dike and can therefore contribute to flood protection. This thesis will have a closer look at the implementation of innovation into dike monitoring pratice. In this section, the research and research context are introduced.

1.1.1 Introduction research

The performance of dikes under extreme conditions is crucial to societal flood protection. By deploying measurement instruments in and around the embankment, more accurate insights into the actual status of the dike can be achieved. A monitoring strategy can allow for an early warning to prevent the failure of a dike. Furthermore, it can give more specific indications of the actions required for maintenance during the life cycle of the dike.

According to IPCC's (2014) most recent reports, a higher risk of flooding is expected due to increased sea levels and wind speed. In addition, higher precipitation rates will increase the risk of disasters such as flash floods. On the other hand, more extreme droughts are expected, which can also be a threat to the stability of dikes (Deltaproof, 2018), with the Dutch summer of 2018 as a clear example. These expected extreme conditions increase the need for new and creative ways to deal with flood protection.

Much effort is put into the research and development of innovations that can deal with the increased risk of climate change related hazards. Within the context of dike monitoring, there is an increased awareness of the potential of new technologies, however these new technologies still struggle to find their way into practice.

The objective of this thesis is to shed light on the factors that influence the implementation of innovation in dike monitoring practice by:

(1) assessing and analysing the barriers and drivers for implementation of innovation in dike monitoring, by studying a case study of novel optic fibre pressure sensors

and trying to influence this practice by:

(2) designing a communication oriented intervention for the development phase that enhances the implementation process.

Scope

The innovation studied in detail within this thesis research is a product of the so-called DOMINO project (WaterWorks2014-DOMINO). Within the DOMINO project with a budget of 11 million euro, novel fiber optic sensors (FOS) are developed to monitor dike stability and debris flows. The project partners are spread across Europe, in the Netherlands, Italy and Spain.

The research of this thesis is conducted in two areas: the Netherlands and the Po valley in Northeast Italy, where the potential end-users for DOMINO are found. Geo-phyiscally these areas show similar traits: both areas are relatively flat and have been dealing with problems of 'too much water'. Furthermore, both regions have a similar chronology of land reclamation starting in medieval times. The organization of flood protection and the management of the dike differ largely between the two countries (Curtis & Compopiano, 2014). By contrasting these two regions, insights are gained into the relative importance of factors that influence implementation in different cultural and organizational settings.

1.1.2 Context: Dike monitoring

This section gives an overview of several aspects regarding monitoring in flood risk management. It addresses why monitoring is important, which actors are involved in monitoring, as well as how and where it can be done.

Why dike monitoring?

Flooding is affecting 100 million people on average per year globally. The risk of flooding is increasing due to global climate change, land subsidence and accelerating urbanization of flood-prone delta regions (Sips, van der Vlis, Nagel, & Havers, 2013). Flood risk management is performed through the 'Multilayer safety concept', through flood alerts and evacuation, spatial planning and flood protection through flood defenses (Slomp, 2012).

Even in a country like the Netherlands, where much attention is given to flood prevention, there is still a great uncertainty about the actual conditions of the dike system. Apart from the option of building a more robust system to reduce uncertainty about the system, monitoring of dikes with sensors can provide insights into whether the dike can withstand the water. Indeed, *"the more that is known about the condition of the dikes, the more likely possible failures can be anticipated. (…). How strong is the dike in relation to the forces it has to face? Where are the weak spots? Is extra monitoring required?"* (Consortium Flood Control 2015, 2015, p.48). This can help to influence dike and levee management on the long term as well as decisions in crisis-situations.

Traditionally, in both the Netherlands and Italy, monitoring is done by visual inspection. In the Netherlands, stability evaluation is performed every six to twelve years. Recently, monitoring has been extended by performing innovative physical measurements inside and on levees, mainly using standpipes for water level measurements (Hopman, Kruiver, Koelewijn, & Peters, 2010). Technology can help to assess and therefore influence an adequate response to risky situations (Consortium Flood Control 2015, 2015). And, *"the instrumentation of levees should focus on reducing the uncertainties regarding the potential failure mechanisms threatening a specific levee. Risk reduction should be the prime goal when drawing up the instrumentation plan."* (Hopman et al., 2010, p. 3).

Water governance in the Netherlands is inclined to stick to tradition (Jong & Brink, 2017). On the 1st of January of 2017, the new Water Law was presented, which contains new directives for the norms for flood safety. Because of the new norms and new assessments, many dikes have been evaluated below the safety norms. Huge investments have to be made to reinforce these dike stretches. Consequentially, dike monitoring is on the agenda, since it can be an interesting extension in these reinforcement strategies. Part of the new programme are 'project over-arching' research teams, of which 'Life Cycle Monitoring' is one theme (Koelewijn & van der Meer, 2018).

Who is responsible for dike monitoring?
Responsibilities regarding flood prevention are spread among several governmental levels. In the Netherlands, in terms of flood safety, the dikes or managed by the Regional Water Authorities. Rijkswaterstaat, on the national level, manages a few of the primary dikes. The legal safety norms and policy frameworks are decided on the national level (Slomp, 2012). The authorities collaborate with universities, knowledge centres and consultancy firms. Together with the water authorities they all play a part in the realization of innovation in flood risk (Consortium Flood Control 2015, 2015).

In Italy, many layers of authority are involved in securing flood safety and dike operation. The different rivers are grouped into 8 river basin areas over Italy. The institutional layers are on national, river basin, regional and sub-regional level. The river basin authority makes the policies for the river basin, such as the planning in terms of risks, or how to use the water resources (IT1). The maintenance and operational work is done on a regional level.

How is dike monitoring organized?
Monitoring is done with the help of instruments that can measure certain physical parameters. When setting up a monitoring plan, the parameter of interest has to be defined, as well as the location and time steps in which data is recorded. *"Knowledge about the body (the levee) and its environmental exposure is essential for the right application and placement (where to look at), correct interpretation and decisions based on this information"* (Hopman et al., 2010, p.2).
To make information out of the data, ICT is needed to translate the data to interpretable knowledge. The next step is the active use of this information (Figure 1). To obtain maximum value from the monitoring, all these steps should be thought through. Similar layers are proposed by Herle, Becker, & Blankenbach (2016): a sensor layer, integration layer and a presentation layer.

Types of instruments
For dike monitoring, the data can be retrieved within and around the dike *(in situ)*, and from a distance *(remote)*. In situ techniques are used on and within the dike to measure physical parameters, such as temperature differences, water pressure and inclination. With remote sensing, for example, temperature changes could be detected with infrared (Hopman et al, 2010).

Information systems
The raw data that sensors provide should be presented in information systems. By coupling the data to models, insights into the state of the dike related to failure mechanisms can be shown. This could be arranged centrally, and an example of an effort is the Dijk Data Service Center (DDSC), a portal to collect and process Big Data, developed by Nelen & Schuurmans and Fugro. However, further development of this or similar platforms is needed to make it fit for operational use (Stoorvogel-van der Horst, 2016).

Current use of dike monitoring
So far, in the Netherlands, some full-scale field experiments have been conducted on levees. The most known example is the 'IJkdijk', translated to 'Calibration levee' (Figures 2 and 3). Operational use of new sensor techniques remain scarce (Hopman et al., 2010). In Italy, a pilot application of distributed temperature sensing with optic fibres in dikes have taken place, in the province of Bolzano (IT2).

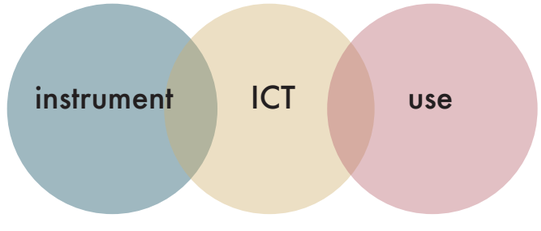


Figure 1 - Monitoring system

Figures 2 & 3 - Preparing the IJkdijk, Source: Stoorvogel-van der Horst, 2016

Where can dike monitoring be done?
In the Netherlands, 3200 km of primary levees and 14,000 km of secondary levees protect the land from flooding (Hopman et al, 2010).
In the Po valley, the total numbers were not found, but an in impression with some numbers can be given: the river Po has a flood canal along the final 420 km of the Po River watercourse; with levees on both sides (Manieri, 2016). On the regional level, as for one of the ten regional water authorities in Veneto has 300 km of secondary levees to maintain (Consorzio di Bonifica Adige Euganeo, 2013).

Installing sensors over the entire levee length is not feasible. When writing on Smart levees, Deltares (Hopman et al., 2013) considers three types of levees that are interesting for intense monitoring. These locations are most interesting for gaining insights in uncertainties, and therefore increased knowledge can result in a tailor-made action plan.

"Three categories of levees that could benefit from the application of sensors:
1. Levees to be used as reference location for specific frequently encountered types of levees, this may cover up to 80% of all levees by instrumenting only a limited number of sections;
2. Problematic levees or weak levees according to calculations, these levees might already be included in a reconstruction plan (spanning several years, sometimes more than a decade);
3. New levees and large scale improvement works on existing levees".
(Hopman et al., 2010, p. 3).

1.1.3 Context: DOMINO project and fibre optic sensors

The innovation that is used as starting point within this thesis are the novel optic fibre pressure sensors developed by the DOMINO project. The DOMINO project is a European research project with four partners from three countries: the University of Padova and the National Research Council – Research Institute for Geo-Hydrological Protection in Italy, the University of Alcala in Spain and Delft University of Technology in the Netherlands, all adding their unique knowledge to this project.

Aim of DOMINO

The aim of DOMINO is to develop two kinds of novel optical fibre sensors; one based on acoustic sensing and one based on pressure sensing. They are used for two applications; the detection of debris flows and dike stability. Although the original aim was to use only the pressure sensors for dikes, there is also a cross over, with acoustic sensing being applied to dikes (DOMINO, 2014).

Funding of DOMINO

DOMINO is funded by the European Commission under a cofunding construction. It is funded both by the European Commission and a national fund of each respective country. The money was awarded through the ERA-NET Cofund WaterWorks2014 Call 'Changing World Joint Porgramme Initiative (DOMINO, n.d.).

Optic fibres

Optic fibres are used all around us, with the main application for communication purposes, such as the provision of our Internet. However, they can also be used as sensor for different physical parameters, such as mechanical deformation and temperature. Advantages of the optical fibres are their intrinsic robustness and the possibility to operate remotely with the cable acting as the communication channel. Since the optic fibre itself is cheap, you can easily add more length to the system and operate the interrogator (which is used to 'read' the data) on a desired location. Also they are capable of 'quasi-distributed sensing' (Figure 4) and 'distributed sensing' (Figure 5), by having measuring points all along the cable. Therefore, for large sites optic fibre sensors are an attractive choice.

With the help of an interrogator, the backscattering of light in the optic fibre can be measured. The backscattering is influenced by parameters in the environment of the cable as pictured in Figure 6. Making use of this effect, you can send a laser beam into the fibre optics, and some of this light is backscattered. By analysing the characteristics of the backscattered light, it is possible to measure the properties of the local environment. With the time measured for a pulse to come back, the position along the cable can be determined (DOMINO, 2014).

Current use of optic fibres as sensors

The use of optic fibers in dike monitoring concern temperature measurements that are used to detect seepage, and they are also used for deformation measurements of large structures like dams. Despite it being a proven technology in other applications, there is not much practical experience with the use of optic fibres for dike monitoring yet (Koelewijn & van der Meer, 2018).

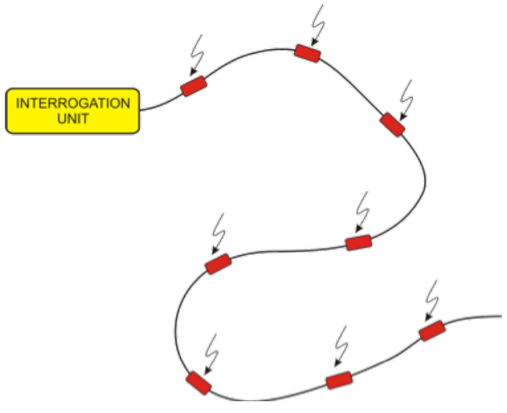


Figure 4 - Quasi distributed sensing
Source: DOMINO, n.d.

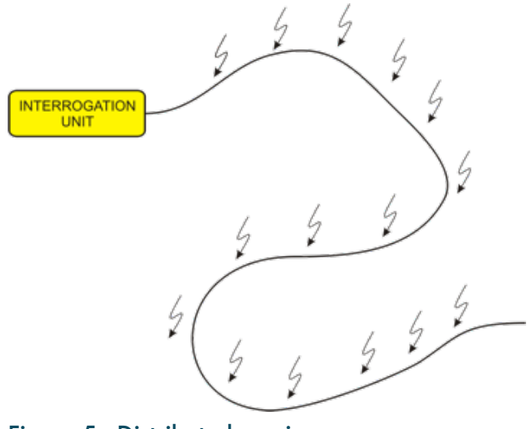


Figure 5 - Distributed sensing
Source: DOMINO, n.d.

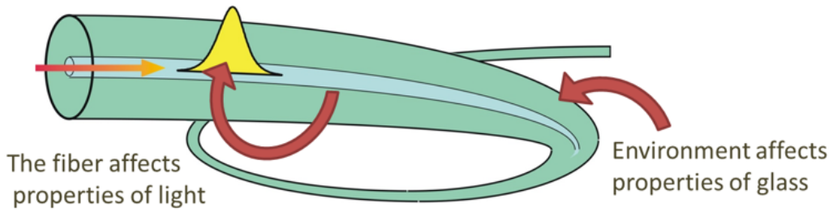


Figure 6 - Optical fibers
Source: DOMINO, n.d.

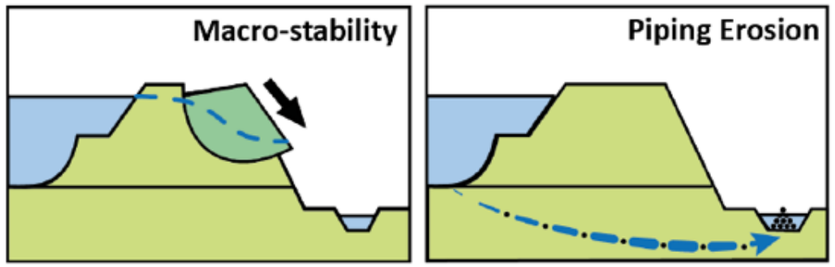


Figure 7: Dike failure mechanisms macro-stability & piping erosion
Source: Aguilar-López & Bogaard, 2016

Pressure measurements and failure mechanisms

Hydrostatic pressures are at the base of several dike weakening or failure mechanism like backward-erosion piping, slope failure and dike uplift mechanisms (DOMINO, 2014). For the different failure mechanisms, the monitoring strategy will be different; concerning the measuring location of the cables and frequency of the data. Through interviews with four dike experts, it was found that macro-stability and piping erosion should be prioritised (Figure 7), given their associated level of risk and uncertainty (Aguilar-López & Bogaard, 2016).

Design

In order to measure pressure with fiber optics, certain adjustments have to be made to the cable. In the current design, this is a small box around the cable. Water can flow inside the box and will then perform a pressure (the water pressure in that point) on a membrane. The fibre optic cable is connected to this membrane, and with the help of calibration, one can link the deformation that was measured to the water pressure. With this design, quasi-distributed pressure measurements can be made (Zhihua, n.d.).

Current stage of development sensors DOMINO

As of Feburary 2019, the novel optic fibre pressure sensors have been designed and produced on a small scale with a casing printed with a 3D printer. These have been tested in the lab as well as in a validation dike of Flood Proof Holland in Delft. As Thom Bogaard states in the NWO article published for this occassion: *"it is exciting that we can measure water pressures with fibre optic cables, because a lot of people said it was not possible. But we will need a few more years to be able to distributedly measure pressures over the length of a cable of for example a few hundred meters."* (NWO, 2018). The Technology Readiness Level (TRL) of the novel optic fibre pressure sensors as defined by NASA (Jenkins, 1995) as of February 2019 would be estimated around 5 on a scale of 10.

1.1.4 Context: Innovation & Implementation

This research deals with the implementation of innovation. In this section, an introduction to the definitions concerning innovation and implementation is given and different perspectives that can be used to approach the research topic are discussed.

Innovation

Many scholars base their definition of innovation on Rogers (2003), who defines innovation as *"an idea, practice, or object that is perceived as new by an individual or other unit of adoption".* Innovation in dike monitoring practice belongs to public sector innovation, in which the unit of adoption is a public organization. The outcome of innovation should be able to improve the functioning and outcomes of the public sector, thereby creating public value (Moore, 2005). Another characteristic of innovation in dike monitoring practice is that it is concerned with the physical world. The benefits of innovation in monitoring are not direct: a long-term perspective is needed to account for the return in profit. Furthermore, there are multiple actors involved in these projects.

The changes of innovation in dike monitoring practice can be seen in the light of a technological transition, as introduced by Geels (2002). He defines technological transitions as major technological transformations in a way societal functions are fulfilled. A technological transition involves changes in user practices, regulation, industrial networks, infrastructure and symbolic meaning, adding to the technological change. As Gieske, van Buuren, & Bekkers (2016) point out: *"Public sector organizations are embedded in policy subsystems or regimes (Geels, 2002; Loorbach, 2010) with a societal function which are often rather stable during longer periods of time and becomes change-resistant due to the development of routines and institutional patterns (Baumgartner and Jones, 1991, Sabatier and Jenkins-Smith, 1993, Rip and Kemp, 1998)." (p.3).*

Implementation of innovation

To make innovation come about, the new technology has to be implemented into practice. There are a few steps needed to make this come about. The first is the decision to use the innovation, which is referred to as adoption (Kim & Chung, 2017). The innovation then has to be implemented into the company's working processes. Then there is the consistent use of the innovation after its adoption. Besides the implementation, there is also the diffusion of innovation. Diffusion is the spreading of a new technology over a network of end-users.

Drivers and barriers

Several factors act as a driver or barrier for the implementation of new technologies. Some of these factors have to do with the innovation characteristics, such as the performance of the technology. There could also be a mismatch between the demand of the potential end-users and the product; though the product performance would be great, it is then simply not complying with the demand of the potential end-user. On the other hand, there might also be a resistance to adopt new practices by institutions and societies.

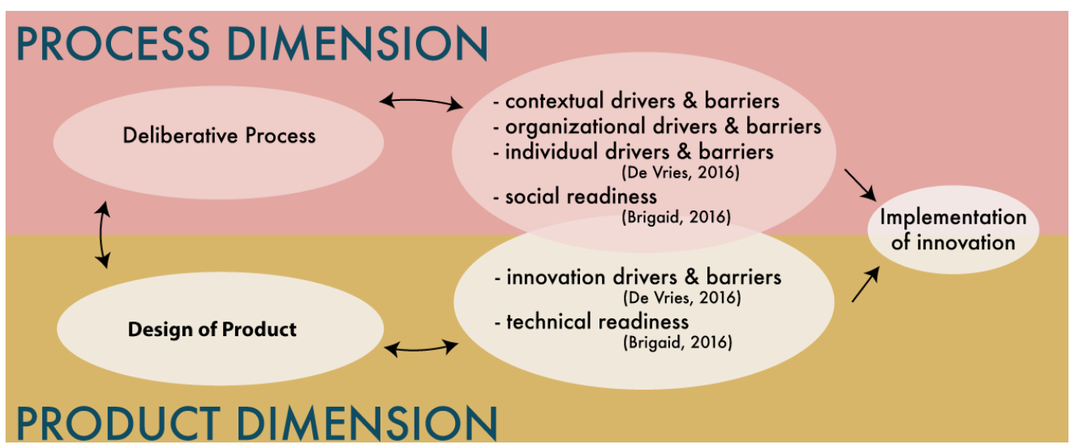


Figure 8 - Preliminary Framework for implementation of innovation

Some existing frameworks shed light onto these types of factors that influence implementation of innovation. For example, the research project BRIGAID has developed a framework focused on the technology developers that defines technological, social and market readiness of an innovation as indicators for the later adoption of the technology (Sebastian et al., 2016). De Vries (2016) proposes a framework with factors that influence public innovation. It categorizes drivers and barriers of innovation into environmental antecedents, organizational antecedents, innovation antecedents and individual antecedents. These frameworks can be helpful to put the dynamics of implementation into perspective.

Role of communication

Communication plays an important role in aligning the different stakeholders and the product. Through early collaboration between developers and potential end-users in and around the process of research and innovation, the implementation process can be influenced. Unforeseen impacts can be minimized and user acceptance increased by bringing together supply and demand (Owen, Macnaghten, & Stilgoe, 2012). Through collaborative approaches technical experts can take societal contexts into account during the development process (Fisher et al., 2015).

The communication of stakeholders throughout the research project fits into the research agenda of Responsible Research and Innovation (RRI). RRI aims to anticipate on the potential societal and environmental impact of an innovation. With regard to RRI, Von Schomberg (2011) identifies two interrelated dimensions: the product dimension and a process dimension. The product dimension tries to capture products in terms of overarching and specific normative anchor points, which he defines as (ethical) acceptability, sustainability and societal desirability. The process dimension envisions a deliberative democratic process; the challenge is to arrive at a more responsive, adaptive and integrated management of the innovation process.

The product and process dimension, combined with different frameworks that look at innovation are captured in the preliminary framework, Figure 8.

1.1.5 Chapter Summary

This chapter has introduced the research context. Dike monitoring is mostly done through visual inspection. Recently, the use of instrumental measuring instruments that can help to give more insights into the actual status of the dike, has gained attention. However, implementation of dike monitoring instruments remains scarce.

The DOMINO project is used as a starting point for this research. Within the DOMINO project, novel optic fibre pressure sensors are developed that have the potential to provide longitudinally distributed pressure measurements from within a dike body.

Studying the implementation of dike monitoring and the case study of DOMINO fall within a certain type of innovation: it belongs to the public sector, and a long-term perspective is needed for the implementation. Already during the development process of a new product, the implementation can be taken into account. In the preliminary framework based (Figure 8), perspectives to analyse the implementaiton process are presented.

In the next chapter, the research of this thesis is further constructed with the presentation of the problem statement and research questions.

1.2 PROBLEM STATEMENT & RESEARCH QUESTIONS

1.2.1 Problem statement

The challenge addressed in this thesis is the implementation of instrumental dike monitoring technologies into dike monitoring practice.

Flooding currently affects 100 million people on average per year globally, and the number is increasing (Sips et al., 2013). Dikes are crucial to flood protection, and instrumental dike monitoring has the potential to give a more accurate insight into the stability of a dike and can therefore contribute to flood protection. Like Consortium Flood Control 2015 has stated: *"the more that is known about the condition of the dikes, the more likely possible failures can be anticipated. (…) How strong is the dike in relation to the forces it has to face? Where are the weak spots? Is extra monitoring required?"* (2015, p.48).

Despite growing awareness of the potential of dike monitoring techniques and new instruments that are being developed and tested, implementation of instrumental dike monitoring into regular practice remains scarce. To know how the implementation can be influenced, the first step is to have more insight into the driving and restricting forces that influence the implementation. The next step would be to find ways to possibly bend the practice. This is where the research questions of this thesis come in.

1.2.2 Research questions

The research questions that are addressed in this thesis are:

1. What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?

2a. How are the dynamics in the field of dike monitoring perceived by the main actors in both the Netherlands and Italy's Po Valley?

2b. Which drivers and barriers are the most relevant for the implementation of innovation in dike monitoring practice?

3. How can the implementation process of innovation process of innovation in dike monitoring be influenced with a communication or collaboration oriented intervention?

A brief description of the scoping and methods used to answer these questions are given in the Methodological Overview in Chapter 1.3. The more elaborate Methodologies are prodivded in before the different parts of the research (Chapter 2.1 & 3.1).

1.2.3 Note on double degree master thesis

This thesis is written as the final product for two master degrees, Water Management (Civil Engineering), and Science Communication. It was set out as an integrated thesis in which both fields of study complement each other in the research. However, after a first integrated stage, for both masters a seperate deepening was made.

Therefore, research question 1 and 2a can be read as the product of the integrated research and are presented in Part II of this report.

Research question 2b represents the deepening step for Water Management. The result is an extra analysis of the dike monitoring practice (results of research question 1 and 2a), and can be found in Chapter 2.7 and Appendix C.

Finally, research question 3 relates to Science Communication and the results of this question are presented in Part II.

1.3 METHODOLOGICAL OVERVIEW

The methods used to address the research questions are briefly described in this section. A more elaborate description of the methods can be found at the start of each of the different parts (Chapter 2.1 and 3.1) of this research.

1.3.1 The research process

This research process was set-up in two phases. The first phase was explorative, while the second phase consisted of two separate deepening steps.

In the first phase, the field of implementation of innovation in dike monitoring practice was explored. A deepening analysis was made of the dike monitoring practice by conceptualising it as a socio-technical system. This helped to identify the key concepts influencing dike monitoring and to building a new framework (Chapter 2.6). Also, a design step was made to serve as an intervention to practice (Part IV).

For the research and design, a so-called double diamond approach was used, following two consecutive diverging and converging stages. The double diamond is a method for design-based research developed by the Design Council (2015). It provides guidelines for a practical and iterative process in order to come to a practical design.

All in all, throughout the different steps, several research methods were used, resulting in a mixed-method approach. By using a mix of methods, the research question can be explored through different angles (Bryman, 2015). The double diamond and different research steps are pictured in Figure 9.

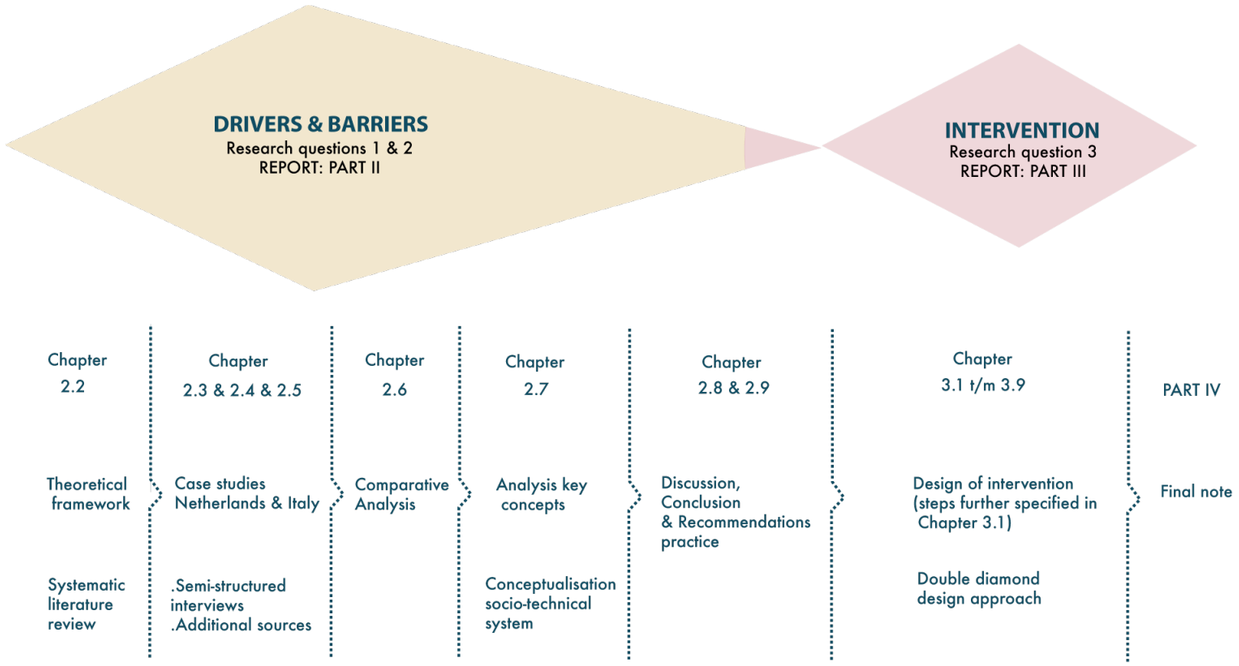


Figure 9 - Research Framework & Structure report

1.3.2 Scoping & methods per research question

1. What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?

Key insights into the drivers and barriers of implementation of innovation were identified through a systematic literature review and were used as input for later empirical research. Given the limited availability of theory on innovation in dike monitoring practice, the scope of the search was set to innovations into public domain, sectors that have a relatively risk-averse environment, or types of innovation that require long-term thinking. The insights were used as a starting point for the empirical step that follows. The results of this research question are presented in Part II.

2a. How are the dynamics in the field of dike monitoring perceived by the main actors in both the Netherlands and Italy's Po Valley?

This research explored two main case studies, focusing on dike monitoring practice in the Netherlands & the Po valley in Northeast Italy. Within the field of dike monitoring, novel optic pressure sensors were used to explore the different drivers and barriers. Semi-structured interviews were held with the potential end-users, in this case water authorities, and the technology developers. Additional sources added to a complete picture. The results of this research question are presented in Part II.

2b. Which drivers and barriers are the most relevant for the implementation of innovation in dike monitoring practice?

To get a deeper understanding of the drivers and barriers in the system and their interactions, two further steps of analysis were made. The first is a comparative analysis of the two countries (Chapter 2.6). By comparing and contrasting them, the aim was to gain a better understanding of the relative importance and generalizability of certain factors.

Also, a conceptualisation of the dike monitoring was made in terms of a socio-technical system. While seeking for an abstraction of the system, the most important actors, concepts and their interactions were identified. In Chapter 2.7 the key concepts are presented in an updated framework. A few steps were made to model the system in an agent-based software as a toy-model, of which the results are mapped in Appendix C.

3. How can the implementation process of innovation in dike monitoring be influenced with a communication or collaboration oriented intervention?

The aim of here was to take a next step and to try to positively influence implementation of innovation through active engagement. First, all communication and collaboration related problems were identified, then filtered into one design goal, and an appropriate form in which to operationalize the design of an empirical intervention was chosen. In part III of this thesis the outcome of this research question can be found.

PART II

DRIVERS & BARRIERS

In this part, both theory and practice are explored to get to know the dynamics of dike monitoring, in both the Netherlands and Italy.

The research questions that are answered are:
1. What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?
2a. How are the dynamics in the field of dike monitoring perceived by the main actors in both the Netherlands and Italy's Po Valley?
2b. Which drivers and barriers are the most relevant for the implementation of innovation in dike monitoring practice?

CONTENT

2.1 METHODOLOGY PART II

This chapter elaborates on the methods used for part II of the research.

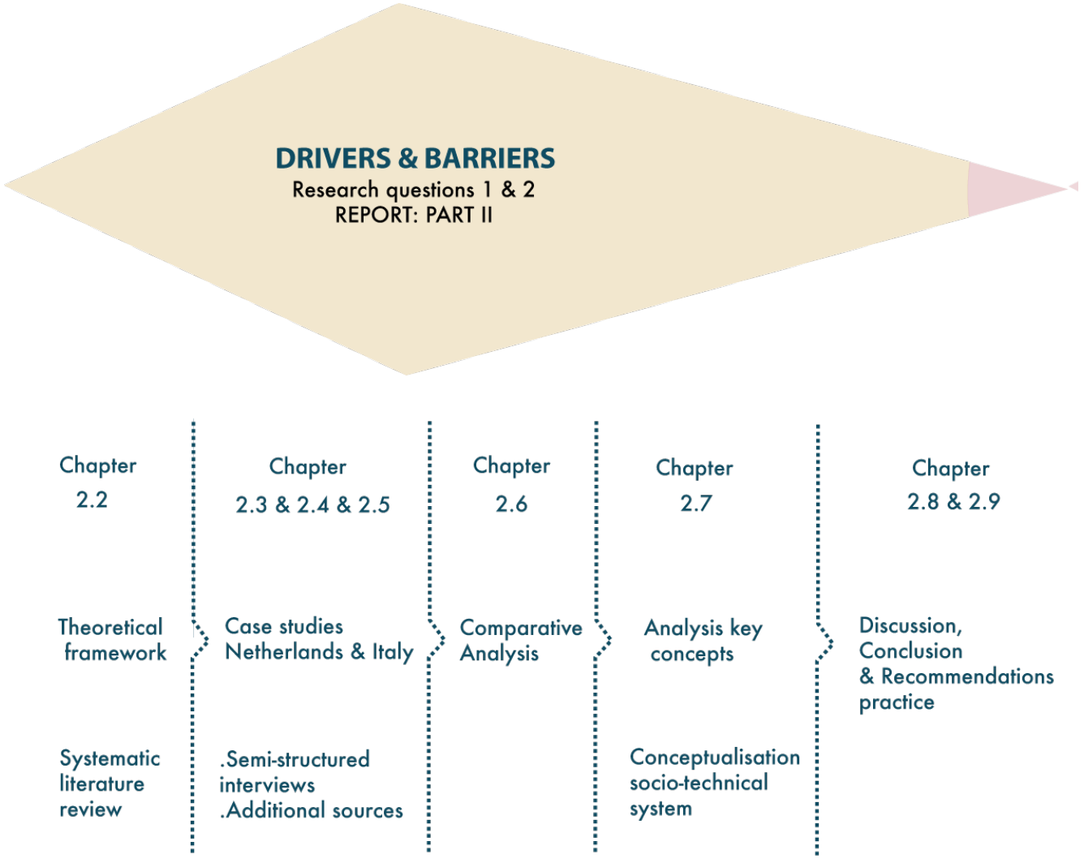


Figure 10 - Research Framework Structure report part II

2.1.1 Introduction

Part II of the research addresses research questions 1 and 2. It consisted of an exploratory part, followed by two analysis steps. Part II of the research ends with a discussion, conclusions and recommendations for practice. In this chapter, the methods used for each of the research steps are explained and justified step-by-step.

2.1.2 Diverge

The divergent phase was meant to get a broad overview of possible drivers and barriers for implementation of innovation in dike monitoring through a systematic literature review. The result was a theoretical framework that could be used as input for the next phases of the research.

Systematic literature review

A systematic literature review is a transparent and replicable way of structuring the literature research. The methods of Bryman (2015) were followed.
In this research, a theoretical framework was set up with the help of a systematic literature study. This framework was used as input for the semi-structured interviews.

Research question

The leading question to conduct the systematic literature review was:

1. What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?

Eligibility criteria

Scopus was used as the database of reference. Review articles that are written between 2009 and 2018 are included in the search. The search was limited to articles published in the last ten years, with the aim to find up-to-date review articles. Only articles published in English language were included. The first selection was done manually, based on the title and abstract of the article.

Only review articles that deal with the implementation of innovation into organizations were selected, excluding those that deal with the adoption by individuals. The reviews needed to focus on an overview of the factors that influence the implementation of innovation. Furthermore, a focus on sectors that have a relatively risk-averse environment, or deal with types of innovation that require a long-term strategy was required.

Articles that were excluded are:
. Articles that deal with implementation into health systems, since the kind of risk in this sector is specifically focused on the wellbeing of specific individuals.
. Articles that are purely about private sector innovation
. Articles that only focus on one aspect or factor that influences implementation

The search terms were defined based on the combination of relevant keywords. A first round that was used for scoping:

> *(systematic AND review AND (implementation OR adoption) AND innovation)*

And a more specific search for frameworks, with updated keywords:

> *innovation AND (implementation OR Adoption) AND (conditions OR factors OR drivers OR barriers OR antecedents OR determinant OR variable) AND framework*

The articles were coded using semi-structured coding in Nvivo 12. The initial coding was based on the categories and factors mentioned by de Vries et al. (2016), but the coding list was open for coding of (sub) factors that were not included in the framework yet.

2.1.3 Scoping: diverge to converge

The theoretical framework that was a deliverable of the systematic literature review, was used for the exploration of dike monitoring practice in the Netherlands & North-east Italy. For the case studies, semi-structured interviews and additional sources were used.

Case studies Netherlands & North-east Italy

This research uses two main case studies, focusing on dike monitoring practice in the Netherlands & Northeast Italy. As a method, case studies are an empirical research step that focuses on a contemporary phenomenon within a real-life

content. (Yin, 1989). They have the advantage to study the unique characteristics of individual cases (Mostert, 2018).

The base case of this research is set in the Netherlands. Northeast Italy was added as a case study. Partly for pragmatic reasons: both countries are involved in the DOMINO project and contacts could be established. The third country in the DOMINO project, Spain, was not chosen because there was no strong link of the research group to the dike practice. As case studies, both Italy and the Netherlands are compatible given that they have similar land reclamation histories and both are actively dealing with flood protection.

The cases were first analysed separately and were then explored for patterns of similarity or difference (method described in 2.1.3).

In the Netherlands data from 3 different water authorities was used. These different authorities are part of the same landscape, but do have organizational differences. Therefore, on the organizational level, they are three small case studies and also give insights into different organizational aspects.

A second dimension in the case studies is the focus on novel optic fibre pressure sensors. Although dike monitoring was explored through the lens of optic fibre pressure sensors to pinpoint the innovation characteristics that matter for the adoption and implementation, several sources on implementation of other types if innovations were also studied.

By using several types of sources, more depth can be reached within the case study (Verschuren, Doorewaard, & Mellion, 2010).

Both case studies are both based on:
. semi-structured interviews with end-users
. semi- structured interviews with researchers/ technology developers
. additional resources such as presentations, documents and additional literature

Semi-structured interviews
Semi-structured interviews were held with the main stakeholders: identified as the end-users and the developers. Although semi-structured interviews should be prepared, there is still a flexible and open element to them (Bryman, 2015).

The interviews with the end-user had different purposes. The main purpose was to get a view of drivers and barriers for the implementation of innovation that applies to this case study. It was also intended to get an overview of the different actors involved in dike monitoring and their collaborations.

Also, the researchers (developers) were interviewed about their motivation and interest to collaborate with end-users. Furthermore, their perspective on the barriers and drivers on later implementation of the product was asked.

The interviews were also meant to scope the communication and collaboration related problems, and ideas for solutions. These were later used as input for Part III of the research.

Interview questions
The questions were prepared based on the prior literature review, as well as a preliminary interview and documents. For each of the factors defined in the theoretical framework related questions were drawn. The questions were used as a checklist throughout the interview, but during the interview follow-up questions were also asked. The list of questions prepared for the interviews, and can be found in Appendix A.

Sample of the semi-structured interviews
The end-users were selected in terms of their connection to innovation in dike monitoring. The first interviewees were found through initial contacts and snowball sampling. Both the dynamics along different levels of the organization in one water authority, as well as a cross-section amongst several water authorities were important for the sample. The vertical sample (different organizational layers) was used to produce cross-organizational insights and gain insights into the internal dynamics of the organization, as well as the different actors within. The 'horizontal sample' was used as complementary data on the implementation climate for innovation across several water authorities.

For the Netherlands, the sample size was based on grounded theory. This means that a study continues until a certain level of information redundancy or saturation occurs, when no new information is emerging in the data. The data collection and analysis occur simultaneously (Bryman, 2015).

As for the researchers, all researchers in Italy and the Netherlands part of the DOMINO project were interviewed.

Analysis of semi-structured interview data
The interviews were recorded, transcribed and coded by hand, as well as in NVivo software, with a semi-structured coding method. The initial codes are based on the theoretical framework that was developed for research question 1.

Note on the interviews in Italy
The research procedure was similar to the semi-structured interviews in the Netherlands, with a few side notes. The questionnaire was translated to English and fine-tuned to match the Italian situation. In some cases there was a translator to conduct the interview in Italian. First, two interviews were performed with experts from academia that have a lot of expertise working with stakeholders. The appointments for the interviews were arranged by the academic supervisors in Italy, with the criteria to interview people from different layers of government.

Additional sources
Throughout the research project, additional sources were found. These were literature sources recommended by interviewees or other contacts, presentations at attended workshops on dike monitoring, and other references. They provided new data and deeper insights into the current dynamics in the field of dike monitoring.

2.1.4 Converge
Twoconverging steps were taken through follow-up analysis of the results of the previous steps. This consisted of a comparative analysis and an analysis of the key concepts in the context of the conceptualisation as a socio-technical system.

Comparative analysis
The aim of using the case studies in this research was to gain in-depth insights into the drivers and barriers that influence implementation. A second aim was to gain a better understanding of the relative importance and generalizability of certain factors through comparing and contrasting them. For qualitative research, this is called 'analytic generalization', *"in which a previously developed theory is used as a template with which to compare the empirical results of the case study. (…) if two or more cases are shown to support the same theory, replication may be claimed"* (Yin, 1989, p. 31)

Through these case studies, the theoretical framework could be both tested and updated for different organizational and cultural settings. Therefore, the multiple case studies offer the opportunity to both understanding the nuances of the case, as well as concluding on general relevance.

Analysis key concepts
A further step of analysis was made through the conceptualisation as a socio-technical system, and the result of this step was the identification of key concepts influencing implementation of innovation in dike monitoring, presented in an updated theoretical framework that is based on the previous theoretical and empirical step. This is presented in Chapter 2.8.

The aim of this part of the research process was to get a deeper understanding of the drivers and barriers acting in our system and their interactions by following the method working towards agent-based modelling of socio-technical systems by Nikolic & Ghorbani (2011).

Within this method, an important step is to make an abstraction of the system, answering questions such as: who are the most important actors, what are the most important concepts, and what is the most important behaviour. The conceptualisation is a creative process, for this *"the art lies in the ability to reconstruct the architecture of a largely unknown system from a few observable signatures that characterise its behaviour."* (Savenije, 2009, p. 160).

Agent-based model
A socio-technical system can be simulated in agent-based modelling software. In the case of this research, a toy-model aiming was made in Netlogo software. Such a model can give the possibility to visualise the system and 'play' with different factors and see the effect of certain changes to the system. Within the timeframe of this research, no significant results were obtained from this step. The work is presented in Appendix C.

2.2 THEORETICAL FRAMEWORK

This section combines four review articles as input for a theoretical framework. These articles were retrieved through a structural literature research approach.

2.2.1 Results literature search

The first set of search terms provided 54 hits, of which 8 articles were selected based on title and abstract. After article screening, 3 of these were selected for the purpose of this research.
The second set search terms provided 63 hits, 9 articles were selected for screening and 1 article selected, but this article was already selected in the first search round. The article search and selection process are represented in Figure 11.

The articles focus on different sectors or types of innovation but were considered to be comparable and valuable for this theoretical framework. Articles that did not fit the eligibility criteria were dismissed for reasons such as: not containing an overview of factors, having a too specific focus, or being focused on purely the private sector.

One article used for the preliminary research framework, recommended by an expert, has been added to the review, this is the article by de Vries, Bekkers, & Tummers (2016).

Thus, in total 4 articles were coded in Nvivo 12 into the drivers and barriers of implementation of innovation. The initial coding was based on the categories and factors mentioned by de Vries et al. (2016), but the coding list was open for bottom-up coding for finds that were not included in the framework yet.

Chosen articles
The four articles all use a systematic literature review as their method. The sum of all articles that are analysed within the four review articles together is 366 articles.

The article that was chosen as the base to further analyse the other articles is the article by de Vries (2016), because it is considered to have a very complete overview of drivers and barriers for implementation of innovation.

A second article is focused on the implementation of innovation into organizations in general. No specification of a type of organization is given (Kim & Chung, 2017). The categorizations and factors overlap with the article by de Vries et al. (2016).

Thenextarticlethatwasselectedisaboutinnovation in construction. As a typology of innovation in the construction sector, it is mentioned that it is a project-based service-enhanced industry and therefore has multiple participants collaborating. The construction sector is stereotyped as a risk-averse industry. It is considered similar to the case study as the implementation of innovation in dike monitoring also involves several parties and has a conservative environment as well (Xue, Zhang, Yang, & Dai, 2014). A differentiating aspect is the prominent role of that the client has in construction innovation.

The fourth article has a focus on eco-innovation (Bonzanini Bossle, Dutra de Barcellos, Marques Vieira, & Sauvée, 2016). It is defined as *"the development of products (goods and services), processes, marketing methods, organizational structure, and new or improved institutional arrangements, which, intentionally or not, contribute to a reduction of environmental impact in comparison with alternative practices"* (OECD, 2009 in Bonzanini Bossle et al. 2016 p. 862). Eco-innovation in itself is focused on a sustainable outcome and requires thinking in long-term benefits, this fits the selection criteria.

Categorisation
Drawing on the frameworks used in the selected articles, two dimensions and four categories were classified. In the process dimension, the drivers and barriers are ordered on a network level, organizational level and individual level. In the product dimension, they are ordered into the innovation characteristics.
Comparable factors were named and grouped differently in the different articles, so logical clusters were made with the help of an overview in Excel.

<table>
<tr><td colspan="2">Research question:
What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?</td></tr>
<tr><td>Keywords 1
(systematic AND review AND (implementation OR adoption) AND innovation)</td><td>Keywords 2
innovation AND (implementation OR Adoption) AND (conditions OR factors OR drivers OR barriers OR antecedents OR determinant OR variable) AND framework</td></tr>
<tr><td>Records from Scopus
n=557</td><td>Records from Scopus
n=2.574</td></tr>
<tr><td colspan="2">Inclusion of review articles and articles published 2009 to 2018
Exclusion of subject area: medicine

n=54 n=63</td></tr>
<tr><td colspan="2">Screening title and abstract

n=8 n=9</td></tr>
<tr><td colspan="2">Evaluation articles

n=3 ~~n=1 (same article)~~</td></tr>
<tr><td>Total:
n=4</td><td>Recommended by expert:
n=1</td></tr>
</table>

Figure 11 - Article search and selection systematic literature review

2.2.2 Drivers and barriers on the societal level

The societal level contains factors that are beyond the scope of the organization, its external context. It contains more abstract pressures from society, as well as pressures retrieved from other organizations and the organization's network.

Societal pressures

In the article by de Vries et al. (2016) these societal pressures are further divided into media attention, public demands and political pressure. To eco-innovation in specific, it is mentioned that governments can play a key role in environmental awareness on the market. The degree of perceived pressure from regulatory stakeholders can boost the implementation of innovation and can influence R&D policies on an organizational level (Bonzanini Bossle et al., 2016). In construction innovation, market demand is mentioned as a key influence on the development of innovation (Xue et al., 2014)

Regulatory pressures

Apart from implicit political pressure, formal regulations are mentioned to have a big role in the implementation of innovation, both as a driver and as a barrier.

According to the review of the Vries et al. (2016), regulation is generally considered to hamper innovation. However, it can also be a driving force in the case of stimulating public policy or public financing, in terms of training or subsidies. It can also be associated with a greater willingness to adopt (eco-) innovation (Bonzanini Bossle et al., 2016).

Competition with other organizations

In order to compete with other organizations, organizations aim to achieve high organizational performance. Innovation is said to improve performance, by boosting product differentiation and reputation, as a starting point for competitive advantage. It can be measured with sales growth, market share and return on investment (Bonzanini Bossle et al., 2016; Xue et al.,2014). This factor could be less essential to public innovation, as well as water authorities in this case study, as they are governmental/public institutions, dealing with public money and are not outcompeted by other companies.

Participation in networks and inter-organizational collaboration

In the article on innovation in the construction sector (Xue et al. 2014), collaborations are mentioned as a separate category, here categorised as a societal influence.

Compatible organizations/agencies adopting the same innovation

Relevant peers and professional organizations can act as a push to adopt certain innovation measures. Also, critical mass is mentioned as a driver, with a definition of *"some threshold of participants or actions has to be crossed before a social movement explodes into being".* (Lou, Luo, & Strong, 2000 in Kim & Chung, 2017, p. 12).

Another factor is network externalities, which means that the innovation becomes more valuable as the number of users increases (Kim & Chung, 2017). In this context, also isomorphism or 'looking alike' is mentioned. This can influence the adoption of other's norms by peer-pressure or mimicking behaviour (de Vries et al., 2016).

Knowledge exchange

Participation in networks also enhances knowledge exchange between different parties. It stimulates the development of new knowledge about innovation. The collaborative relationships can influence implementation of innovation, although it is said not to be sufficient to stimulate innovation (Xue et al., 2014)

Academia-organization collaboration

Academia-organization collaboration is supposed to give a boost to the implementation of innovation. In construction innovation, academia-organization collaboration is regarded as a key factor for the success of an innovation process. Academia and the construction industry are deficient in cooperation, however, the cooperation between them is considered to promote the adoption and access to new technologies (Kim & Chung, 2017).

2.2.3 Drivers and barriers on the organizational level

The organizational level includes the structural and cultural features of an organization (de Vries et al., 2016)

Slack resources

Slack resources such as financial resource availability, talented personnel, ICT facilities and knowledge are said to positively influence the implementation of innovation (De Vries et al., 2016; Kim & Chung, 2017, Xue et al., 2014, Bonzanini Bossle et al. 2016). Firm size is correlated to the amount of slack resources since there are more options to cross-fertilize, and a higher range of skills, as well as more money and talented personnel (de Vries et al., 2016, Bonzanini Bossle et al., 2016).

With the availability of slack resources training and technical assistance, time for experimentation can be made available (Kim & Chung, 2017).

Management/leadership/strategy

Although slack resources can provide the needed room for innovation, it is up to the management to make the decision on what to prioritise. In the context of eco-innovation, the likelihood of a firm to adopt green technologies and an environmental strategy is linked to managerial concern as well as pressure from internal stakeholders (Bonzanini Bossle et al., 2016). Also, management characteristics affect the implementation process, and the more experience they have in addressing important managerial issues, the more effectively they can motivate their employees to participate in implementation. Incentive and rewards are used as a managerial tool to encourage innovation. (Kim & Chung, 2017)

Implementation climate

The organizational culture or climate says much about the freedom employees have to adopt and implement innovations. For example, within a company with a collective learning orientation, employees rarely hesitate to try an innovation because they are not blamed for failure and their psychological safety and trial and reflection is common practice (Kim & Chung, 2017; de Vries et al., 2016). The culture might also reflect the shared perception of importance of innovation (Kim & Chung, 2017). Some organizations have a risk-averse climate or an administrative culture that hampers innovation. Especially in the public sector, there is an important drive to secure trust and legitimacy of the government (de Vries et al., 2016), which may discourage trial and error. Some things can be influenced top-down, but also within the total pool of employees, so-called champions and leaders are important. They can be individual drivers of innovation influencing their environment (Xue et al., 2014).

2.2.4 Drivers and barriers on the individual level

Individual factors give an overview of the key characteristics of an individual's ability and motivation to innovate.

Psychological concepts

Different psychological concepts are mentioned to influence an individual's reception for innovation. A person with high learning and goal orientation is inclined to have a higher efficacy to improve his or her task competence and to have a higher level of self-efficacy and to attempt to improve his/her task competence. Furthermore, he or she is more willing to experiment with new methods (Kim & Chung, 2017). Also, you can think of someone's attitude, emotion and satisfaction with his or her job influencing his or her regard to innovation (de Vries et al., 2016)

Gender and age are said to have an influence on implementation behaviour through someone. A majority of the studies have considered demographics to be a control variable instead of an antecedent of behaviour (Xue et al., 2016).

Experience/tenure

Job-related skills are observed to be highly valued for the implementation of innovation (de Vries et al., 2016; Kim & Chung, 2017).

Personal innovativeness

Creative and autonomous individuals can be key to break through a risk-averse administrative culture. This can also be an effect of right managerial structures that empower individual employees (de Vries et al., 2016; Kim & Chung, 2017).

2.2.5 Drivers and barriers on the innovation level

The innovation characteristics are related to the intrinsic attributes of the innovation, and the perception that is related to these attributes. According to de Vries et al. (2016), the innovation characteristics are less researched; only a few studies mentioned them as being relevant. In the four articles on which this review is based, only de Vries et al. (2016) and Kim & Chung (2017) mention the innovation characteristics as a subgroup, nevertheless they both mention similar antecedents.

Performance oriented evaluation

The comparison of expected or calculated costs against the benefits from using an innovation crucially determines the degree to which individuals participate in or resist implementation, as well as whether the system will enhance the organization's performance. In this regard, it helps if what an innovation can accomplish can be made tangible and visible (Kim & Chung, 2017).

Effort oriented- evaluation

This reflects the ease in use of the innovation as well as the perceived behavioural control. Trialability is the extent to which potential adopters can still experiment or make changes to innovation during the implementation (de Vries et al., 2016; Kim & Chung, 2017).

Compatibility

This is not the mechanical or instrumental perception of an innovation, but the psychological perceptions stemming from a comparison between the status quo and the innovation. Compatibility is the degree to whether an innovation is consistent with existing beliefs and values and potential needs (Kim & Chung, 2017).

2.2.6 Note on interlinkages and future research

All factors are presented as independent unities; in reality they influence each other. Bonzanini Bossle et al. (2016) propose that external factors can positively induce the improvement of internal skills within the company, developing internal factors to boost the adoption of eco-innovation, since they can increase the organizational capability. Organizational culture and management can influence employees on the individual level and vice-versa. In addition, these factors are not static and change over time. De Vries et al. (2016) also appoint this research gap and advise to look into the process dynamic that occurs between particular antecedents: *"Which ones are first employed, and why?"(p.163)*. Other recommendations for future research are the application in empirical research (Kim & Chung, 2017 & de Vries et al. 2016) and the application of the framework across country boundaries and in different cultural contexts (de Vries et al., 2016).

2.2.7 Theoretical framework

Based on the categories derived from literature, a theoretical framework is presented in Figure 12. This scope of this framework are innovations that require a long-term strategy, and that are implemented to the public domain or to sectors that have a relatively risk-averse environment. In the next part of the research, the theoretical framework is used as a starting point to explore the dynamics within the case studies.

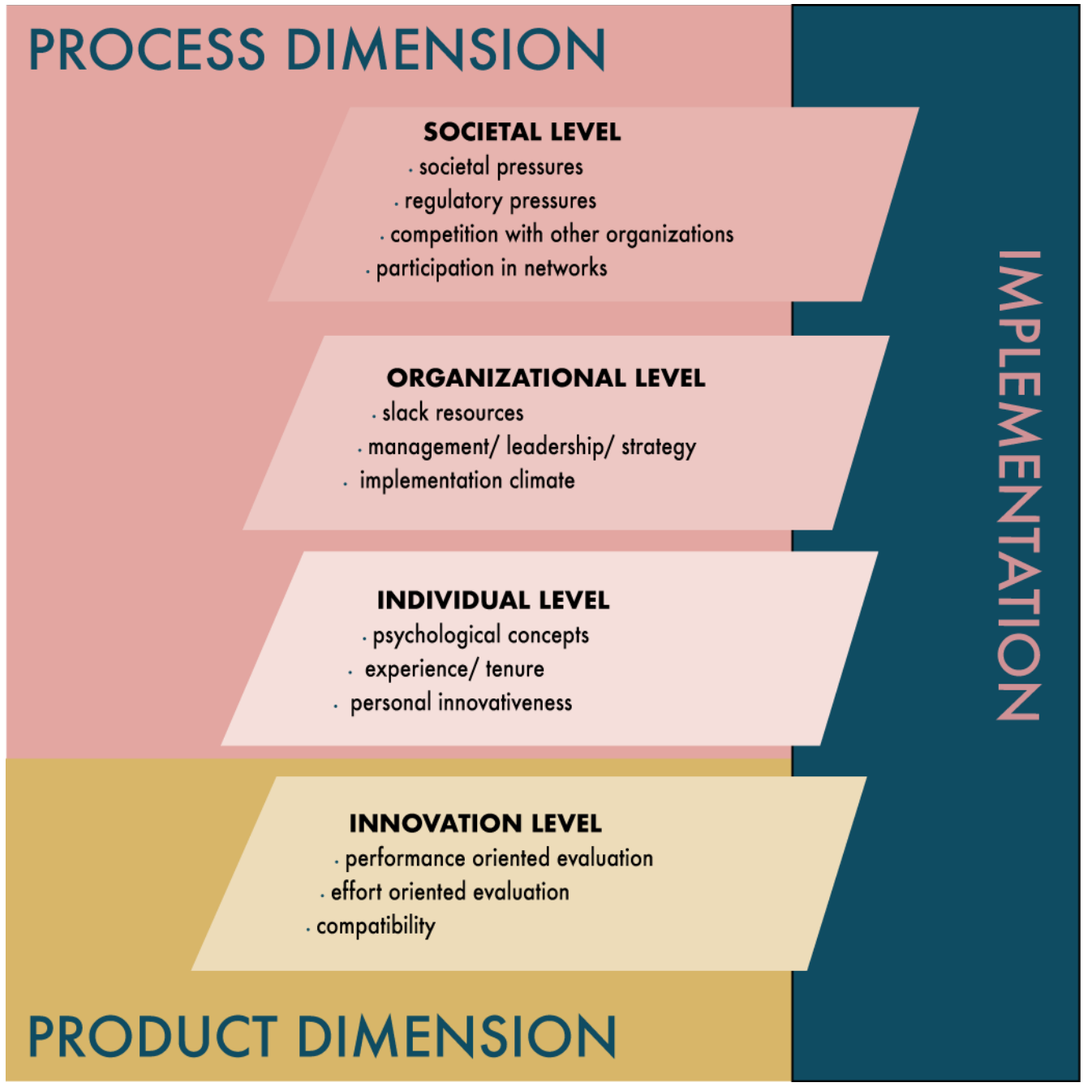


Figure 12 - Theoretical Framework for implementation of innovation in public, risk-averse sectors

2.3 INTRODUCTION CASE STUDIES

This section provides an introduction to the case studies. The context of dike monitoring and the organizational structure in the two countries can be found in Appendix B. The results of the case studies are presented in the next chapters, for the Netherlands (2.4) and Italy (2.5).

2.3.1 Study area case studies

The research is conducted in two research areas: the Netherlands and the Po valley, or Po Plain (*Italian: Pianura Padana*) in Northeast Italy, where the potential end-users for DOMINO could be found. Geo-phyisically these areas show similar traits: both areas are relatively flat and have been dealing with problems of 'too much water'. Furthermore, both regions have a similar chronology of land reclamation starting in medieval times. The organization of flood protection and the management of the dike differ largely between the two countries (Curtis & Compopiano, 2014).

Study area the Netherlands

The study area includes the whole of the Netherlands. However, the interviews were mainly held at the water authorities Hoogheemraadschap van Delfland and Hoogheemraadschap Schieland en Krimpenerwaard. These are both in the Rhine-Meuse estuary. One interview was held at Waternet, which is the overarching organization for water in Amsterdam. These areas are densely populated, and lie underneath the sea level.

Study area Italy

The Po plain, or Pianura Padana is a relatively flat area enclosed by mountain ranges in Northeast Italy. The main river is the Po, but it also encompasses other big rivers in the region such as Adige, Piave and Tagliamento. Part of the study area, close to Venice for example, is below sea level. The River basin authorities in the area are the Po River Basin authority and the special authority Aipo, as well as the River Basin Authority of Alpi Orentiali (IT1, IT2, IT6).

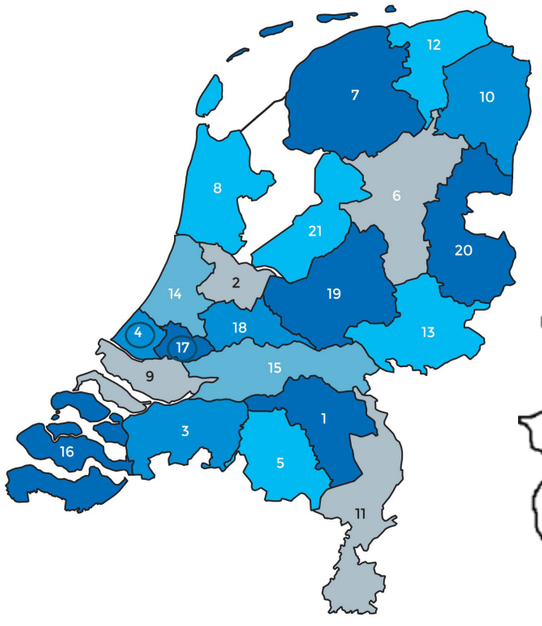


Figure 13 - Water Authorities in the Netherlands with Delfland (4) and Schieland en de Krimpenerwaard (17) Source: Unie van Waterschappen (2018)

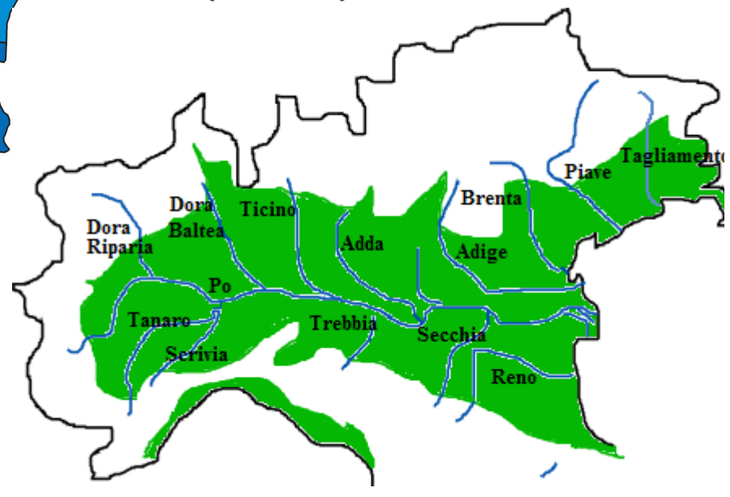


Figure 14 - Northeast Italy: with green the Po plane or Pianura Padana
Source: (Schede di Geografia, n.d.)

2.3.2 Interviews conducted within the case studies

In the case studies, the respondents are quoted anonymously and referenced with a country reference and a number. The list of respondents with information on their general function within the organization is provided below.

The Netherlands

Interviewee	Organization	Department
(NL1)	Hoogheemraadschap Delfland	Policy Embankments
(NL2)	Hoogheemraadschap Delfland	Maintenance Embankments
(NL3)	Hoogheemraadschap Delfland	Strategy
(NL4)	Hoogheemraadschap van Schieland en de Krimpenerwaard	Policy Embankments
(NL5)	Schieland en Krimpenerwaard en de Krimpenerwaard	Maintenance Embankments
(NL6)	Waternet	Engineering Office
(NL7)	TU Delft	Water Management, Civil Engineering
(NL8)	TU Delft	Water Management, Civil Engineering

Apart from the formal interviews, reflections on the topic were made through conversations with employees from Deltares, Fugro, BZ Engineering & Management, Hoogheemraadschap Delfland & Arcadis.

Italy

Interviewee	Organization	Affiliation, Department
(IT1)	University of Padova	Professor Physical Geography, Department of Geoscience
(IT2)	University of Padova	Professor Geotechnical Engineering, Department of Civil Engineering
(IT3)	Aipo	Former technical director
(IT4)	River Basin Authority of Alpi Orientali	Directorate
(IT5)	Consorzio di Bonifica ADIGE EUGANEO	Team dealing with non-ordinary projects
(IT6)	Irpi CNR	Directorate
(IT7)	Irpi CNR	Researcher
(IT8)	Irpi CNR	Reseracher
(IT9)	Irpi CNR	Researcher
(IT10)	University of Padova	Professor, Department of Information Engineering
(IT11)	University of Padova	Professor, Department of Information Engineering

2.4 DRIVERS AND BARRIERS IN THE NETHERLANDS

In this chapter the results of the empirical research are presented. The drivers and barriers are ordered according to the framework into a societal (2.4.1), organizational (2.4.2) and individual level (2.4.3), as well as on the innovation level (2.4.4).

2.4.1 Drivers and barriers on the societal level

Societal pressures

Dike monitoring is a topic that has been on the agenda in the Netherlands for over a decade. Notes from a network meeting on new dike monitoring techniques held in 2004 already stated the potential, although the exact added value and techniques were still perceived uncertain. The then recent dike failures in Wilnis in 2003 and in Stein in 2004 provided the occasion for this particular meeting. The burning question was:
'Could these incidents have been anticipated if the dikes had been more thoroughly monitored?'
The meeting in 2004 concluded that visual dike monitoring techniques would remain the most important inspection method, but that more research should be done to develop and test new techniques ("Visuele technieken blijven belangrijkste vorm van dijkinspectie," 2004).

Since 2004 many efforts have been put into the development of dike monitoring instruments. Most prominently were the live dike experiments by Stichting FloodControl IJkdijk, where experimental dikes filled with multiple different instruments were loaded or forced into failure, to validate the monitoring instruments. The evaluation of these projects has shown that over the last ten years, a more positive attitude towards the use of sensors and novel monitoring techniques has been developed, and slowly the room to experiment enlarges (Stoorvogel-van der Horst, 2016).

The added value for the flood safety and societal benefit is also addressed by the researchers of the DOMINO project, the case study of this research. If a certain technique can offer valuable data about the status of the dike this can be a game changer, not only in the dike monitoring practice, but also for other hydrological applications (NL7).

A professionalization trend is seen in the dike inspection and examination practice. They have undergone a professionalization step in the last ten years. The Professionalisation Inspection of Embankments (Dutch: 'Professionaliseren Inspectie Waterkeringen' (PIW) is currently at its 3.0 phase (Inspectie Waterkeringen, 2018). Former steps have resulted amongst others in a phone application for data processing, 'Digispectie', as well as a cohesive overview for possible dike damages, 'Digigids' (STOWA, 2012). As part of the new high water protection programme, new calculation procedures and methods are provided in the Wettlijke Beoordelings Instrumentarium 2017 (WBI2017).

Twynstra Gudde, a Dutch global organizational consultancy firm has performed a survey with statements that relate to instrumental dike data. Sixty-one respondents from working on jobs related to flood safety at Regional Water Authorities filled in the survey. The survey also confirms the positive perception of the added value of dike monitoring (Figure 15). When asked about the added value of instrumental dike data, the answers are all leaning towards a positive verdict in different types of uses for the data. The highest value of the data is seen for the assessment of the status of a dike as well as for the design of reinforcements. In another statement, the respondents predominantly answer that instrumental dike data can give a more accurate insight into the status of the dike (Twynstra Gudde, 2018).

The interviewees at water authorities mention several factors that add to the urgency to use innovative dike monitoring techniques. The increasing population and climate change put more pressure on the overall management of the embankments (NL3) and given the duty to manage the flood safety of the Netherlands, more data can help the water authorities to lower the uncertainty in their calculation of the strength the dikes they have in their responsibility (NL1).

On the other hand, the urgency, the need to act quickly, is relative. During the economic crisis, the high investment costs of dike maintenance were not always regarded as necessary. Residents would question: *"Why are you working on the dike, we don't see anything, there is no problem.".* This would trickle down into the organization's thinking (NL6). However, the increased pressures from climate change and population growth on the system do also increase the need for smart and innovative solutions (NL3).

The fact that there is already a strong existing practice for flood protection that goes back a long time is said to act as a counteracting force for innovation.

> *"A water authority is very conservative on the one side, because they have been doing their task for 600, 500 years, and it never fails, we barely have any flooding incidents in the Netherlands. (…)."(NL3).*

The Dutch standards are very high; this decreases the urgency for change (NL8). Since most flood risk management is driven by disasters (Slomp, 2012), the high level of protection in the Netherlands does not seem to drive innovative practices.

Regulatory Pressures

Together with the new norms for the level of flood protection that were installed with the Protection Measures against High Water *(Dutch: Hoogwaterberschermingsprogramma)* from the Dutch government, dike monitoring is back on the agenda. Significant investments are needed to have all dikes meet the norms. ("Hoogwaterbeschermingsprogramma," n.d.) Part of the new legislation is the 'zorgplicht', an obligation to care for the system. This is said to be a reason for the use of innovative measure and monitoring techniques. (Stoorvogel-van der Horst, 2016)

Also, financing for research is made available. Part of the new high water protection programme are 'project overarching' research teams, of which 'Life Cycle Monitoring' is one theme (Koelewijn & van der Meer, 2018).

Some legislative forms influence the implementation and installation of dike monitoring on the ground. The 'keur' contains the legislative regulations of the water authorities and defines what you can or cannot do around the embankment. It is possible to apply for a permit to perform activities in or around the dike body. You need to convince the responsible dike operator *(Dutch: 'beheerder'),* but then it would possible to start (NL5, 6). There will most probably be certain demands on the extent of these activities.

> *"In principle, we do not want any cables or pipes inside the dike. But there are some pipes within the dike that lead to the houses. But during dike maintenance activities we try to get these outside of the dike." (NL5).*

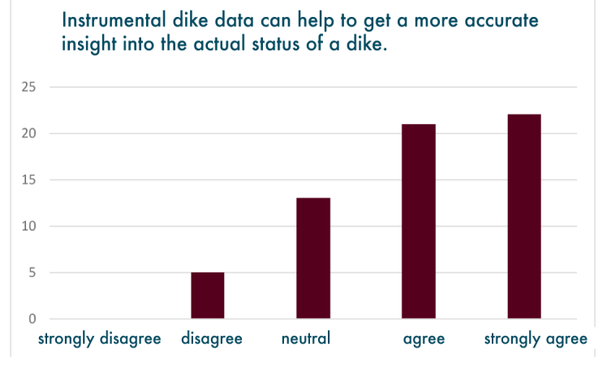


Figure 15 - Survey result by Twynstra Gudde (2018): Insight into actual status dike

One of the operators interviewed admits that when a quick decision is needed, it is easier to choose for certainty and give the proposed monitoring technique a label *'niet beheerbaar'*, meaning that he decides to reject it because he believes that he would not be able to maintain the dike properly within this proposal (NL5).

In the bigger picture, the legislation in favour of flood protection is strong and even actions that are contested by neighbouring residents can be enforced. However, this is not preferred way of working of the water authorities, because it does take up a lot of effort when there are legal procedures (NL2). An illustrative example is given by one of the interviewees:

> *"What played a huge role in that project was that there were trees on the embankment. Monumental trees. And there were some wealthy people living there… So there were also some lawyers amongst them. So this became a huge battle, for every tree that had to be cut down eventually." (NL6).*

It is also kind of a puzzle because when you make some promises to one resident, the other wants this as well (NL3). To work around the legal issues, water authorities prefer to place the monitoring instruments in parts of the dike that are in the ownership of the municipality. This could prevent a potential struggle and ensures access to the monitoring instruments (NL1).

Another legal aspect to take into account is that there are the contracts that water authorities have with engineering companies; they are often the executive party performing the maintenance. One source mentions that at his water authority these contracts are valid for 4 years (NL1).

EXAMPLE: LEARNING NETWORK

An example of an active network collaboration is the project of BZ Ingenieurs & Managers (BZ I&M) with the Water Authority of Schieland and Krimpenerwaard and the Hogeschool of Rotterdam. The aim of this project is to actively get the knowledge into the water authority by means of a work-learning network. This is a network of students that do research for the Water Authority with the help of BZ I&M. The students will familiarize with these technologies and can take this knowledge with them in their later career (4)(Hogeschool Rotterdam, Hoogheemraadschap van Schieland en Krimpenerwaard, & BZ Ingenieurs & Managers, 2018)

Box 1 - Example: Learning Network

Participation in networks

The different water authorities are connected through working groups and network platforms. Many of these are facilitated by STOWA, the knowledge centre of the Regional Water Authorities. Through this network, the word is spread about innovations and new ways of working that can inspire the other authorities.

> *"Often you hear good stories about the results of new techniques, and you think, we should also do something with this." (NL4).*

The knowledge is shared at events or through reports with best practices (NL:1,4,6). Furthermore, the collaboration with neighbouring authorities is tight since some projects are done together (NL1).

Another network is called 'Netwerk Dijkmonitoring', which is set up by Stichting IJkdijk and has an online knowledge platform and organizes several network meetings each year. One of the initiators of this network is also involved in carrying out and advising on innovative dike monitoring projects through his company BZ Ingenieurs & Managers (BZ I&M). This company is born out of the aim to speed up the innovation in dike monitoring (Wouter Zomer, pers. comm).

In Box 1 a particular collaboration a water authority, BZ I&M and Hogeschool Rotterdma is elaborated. Apart from this specific collaboration, not all water authorities have active bonds with universities and colleges (NL:1,4).

> *"In my team it [contact with universities] is limited, but it varies per water authority" (NL4).*

> *"The contact with universities is mostly through STOWA, and that's how they come to us, or they come to us directly. But we do not approach the university directly." (NL1)*

An important link between practice, theory and governance is the consultancy company Deltares. They are strongly involved in the technical aspects of the new norms and the software to assess the dikes (NL6). Other consultancies and engineering companies are hired to prepare designs and plans for maintenance and to carry out the reconstruction work of dikes. These companies are also involved in the network.

Residents living in the areas around the dike

The minimisation of the nuisance caused to residents is considered of high importance. Areas around the dikes are often densely populated. The embankments often interfere with people's backyard. One interviewee who is responsible for maintenance projects of dikes regrettably describes his job as *"destroying gardens"* (NL2), because when a dike needs to be strengthened, the gardens of the residents cannot always be spared. This can also cause undesirable regulatory situations. A precise design made possible by new insights on the dike through monitoring will save nuisance caused to the environment.

The desires of the residents tend to be ambiguous. On the one hand, they want to be safe and not be harmed by the water, but they also do not want to be disturbed by any kind of maintenance work. The water authorities take care not to bother them. Any additional work on the dike, will receive resistance from these residents, so you need to have a good story for the reason why this work is carried out. Monitoring can cause uncertain situations for the residents: why wouldn't the dike just be strengthened? What will happen afterwards? The procedure and benefits have to be communicated clearly (Neijenhuis, 2018).

There are plenty of stakeholder-managers (Dutch: omgevings managers) employed to smoothen this process. If monitoring is less intrusive to the residents, this is a driving force to apply more monitoring (NL1; Stoorvogel-van der Horst, 2016)

Competition with other organizations

The interviewees do not regard the competition with other organizations as something that influences the implementation process. All the water authorities are public organizations dealing with public money. Therefore there is a strong sense of responsibility to share knowledge and no sense of competition. This does not mean that the authorities are always on the same page; they have different challenges and different leaders with certain interests (NL:1,3).

Summary societal level

A summary of the drivers and barriers for implementation of innovation in dike monitoring practice on the societal level in the Netherlands can be found in Table 1.

SUMMARY FACTORS SOCIETAL LEVEL THE NETHERLANDS	
BARRIERS	**DRIVERS**
. During the economic crisis the attitude was more conservative: resources are important.	. Over the last 10 years, there is a more positive attitude towards new dike monitoring techniques
. Conservative attitude, due to long history, as well as high protection levels	. Incidents with dike breeches (have) put dike monitoring techniques on the agenda
. Due to the high protection levels monitoring may not be needed or have priority	. Increasing population and climate change put more pressure on the management of the dike system, innovative solutions are needed
. Permits are required to be able to place monitoring equipment and the permits can be hard to obtain	. New norm and 'care duty' give incentive for dike monitoring practice. the law favouring flood protection is strong
. Neighbouring residents are considered important, and not to be bothered. This also adds extra efforts to get them on board.	. When positive stories and knowledge spread through the network, this creates willingness at other parties
	. If less reconstruction is needed due to the monitoring, this results in less nuisance to the neighbouring residents.

Table 1 - Summary drivers and barriers on the societal level in the Netherlands

2.4.2 Drivers and barriers on the organizational level

Slack resources

Financial resources

Financial resources may not always be directly available to employees, but overall, the Dutch water authorities do have money available for monitoring.

Given the results of the survey by Twynstra Gudde (2018) in Figure 16 it seems that the majority of the employees have the perception that their organization is willing to invest into instrumental dike data [dike monitoring].

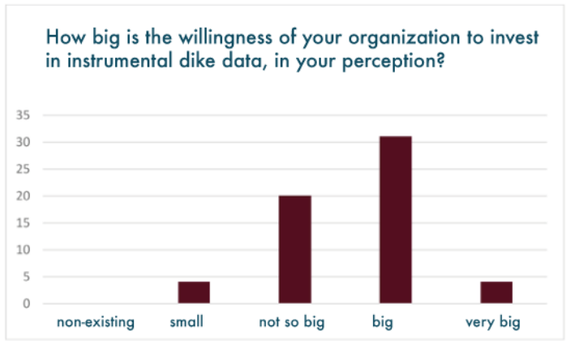


Figure 16 - Survey result by Twynstra Gudde (2018): Willingness to invest

Within the different water authorities, there are different constructions. To a certain extent, an employee has the freedom to decide to spend money on a certain innovation. However, there is a limit. As one employee puts it:

> *"When it comes above 10.000 euros I will have to ask people whether they think it is a good idea". The project then has to be approved by the team leader, and even the executive board. One of the regulatory aspects starts to act if a project budget becomes higher than a certain amount: it is not allowed to spend more than 50.000 euros without having a public call. In that case, you need to show at least three offers of different companies. If there is only one company that can provide the services, you need to start an alternative procedure. Then you have to start a procedure of which you don't want too many in one year. It takes a lot of energy."(NL5).*

At one of the regional water authorities, there is an innovation fund. Yearly, a million euros is dedicated to innovation. Ideas can be funded as long as they comply with the mission and vision of the water authority. It provides a direct link for employees to receive funding for their bottom-up ideas (NL3).

Human resources

The transition to the use of more data from embankments also requires a certain set of skills that traditionally is not part of the practice. For example, people who have knowledge of programming or artificial intelligence (machine learning) (NL:4, 6). This is something that can be managed through human resources.

> *"I immediately thought of two things. Who is going to deal with that huge amount of data and how? I am immediately thinking, do we have someone who can do this? (…) It would be quite a thing for our organization to deal with such a huge amount of data. Then there will always be people that say: we do not even have a solid base for the normal activities, so let's wait before we engage with all this new data." (NL4)*

A project can also be rejected because there simply is no project manager available who can dedicate time to it (innovation manager Delfland, pers.comm.) In this regard, it is mentioned that it is mostly the mid-management level that is very occupied, and cannot take on extra responsibilities (project manager Arcadis, pers.comm.)

ICT

Apart from the human resources, the ICT infrastructure needed is brought up in nearly all interviews (NL:1,4,5,6). You will have an enormous amount of data, but "how to make information from this data"(NL4). According to one interviewee, there would ideally be a central system. Currently, there are different types of software available, but there is no national standard (NL6).

The Dike Data Service Center (Dutch: 'Dijk Data Service Center') is a portal developed to save and make sense of the monitoring data. It is a platform for saving real-time and historical data, and can be coupled with the data of other water authorities. It is all about enabling to use the data throughout the different work processes. However, the system needs to be further developed, especially for anomaly detection and validation of data (Stoorvogel-van der Horst, 2016).

Management/leadership style

From both a network and an organizational perspective, a long-term integrative vision with regard to monitoring.

> *"It [the strategy] could also say, we need this kind of people that we need to attract and employ. (…) We need that extra gear to step up our efforts." (NL6).*

Other ways to stimulate innovation through management are also mentioned. For example, at one of the regional authorities, there is a unit of innovation that controls an innovation fund. Ideas can be funded as long as they comply with the mission and vision of the water authority. It provides a direct link for employees to receive funding for their bottom-up ideas. According to the interviewee, it is a way in which employees feel responsible for their project through ownership. In so-called 'innovation lunches', new technologies can be pitched. During these lunch discussions, you can only provide positive feedback. *"In the beginning, there was a bit of scepticism, but now we have it for the second year in a row and the fund is already nearly fully used for this year [in July]. People know where to find us and that there is room for innovation."* (NL3). Besides, there is a budget for research at this water authority (NL1).

Within water authorities, there is always a certain political aspect present. The managing board wants to be re-elected at the next elections, so they need to fulfil some promises, which may take up their attention. This is a dynamic that you also need to deal with as an employee (NL3,6).

Some managers have a technical background or have experience working with innovations. When they grow into management positions, this change is also noticed. "*Then you suddenly see that things start to move".* These leaders are skilled in the technical, but also in the political field (NL6).

Project management

Challenges with project management are also encountered. There is a need for organizational examples of the implementation of innovations into the organization and regular work processes are needed (NL1,4,; Stoorvogel-van der Horst, 2016). This could answer questions such as: *"Where do you find the money, where do you find the time and people? Which parties have been used for that." (NL4)*

For a successful implementation of an innovation, it has to be embedded within the work processes of the organization. It is also a way to ensure the follow-up of the implementation process. Even after the decision for implementation is taken, there are many challenges ahead for a successful continuation of the project. One of the water authorities ran a pilot with optic fibres that measure strain. However, after the project leader had to leave due to sickness, the project was not looked after anymore. Up until now, the data has not been studied (Netwerk Dijkmonitoring, 2018).

Life cycle monitoring

In this regard, it was repeatedly mentioned that the monitoring is not just about the specific project, but it belongs to the whole organization (Rinsema, Stokkum, Zomer, Koelewijn, & Veendorp, 2017).

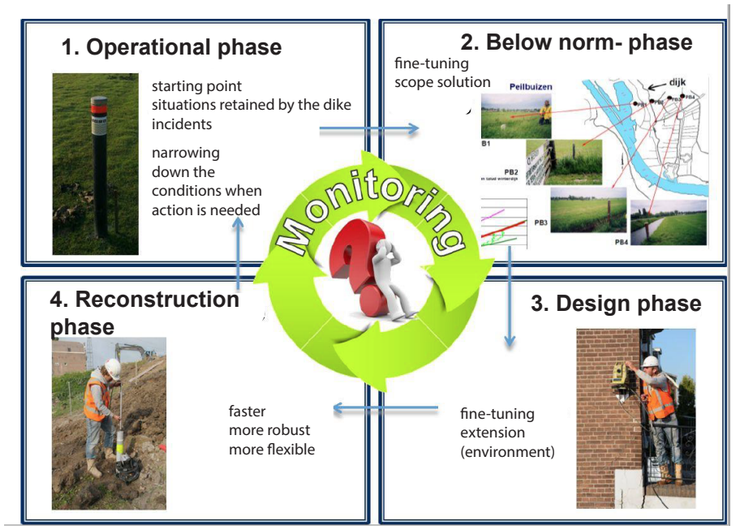


Figure 17 - Life Cycle monitoring of Dike. Source: Koelewijn & van der Meer, 2018

This stems from the perspective of Life Cycle Monitoring (Figure 17), a form of asset management, in which all data and information are stored and used for the whole life cycle of a structure.

The idea is that knowledge about a dike stretch is continuously updated and refined, which increases the knowledge of the dike. In this regard, dikes are considered as dynamic entities. Data that is missing could be spotted, and a more realistic estimation of the dike strength can be possible. In the organization, data and information are mostly lost when the management moves into the next phase, which is coordinated by a different group of people (van der Meer, Koelewijn, Weijenborg, & Konstantinou, 2016).

Implementation climate

The implementation climate is very much linked to the fact that a water authority is a public institution.

> *"We are a public institution, we file taxes. We also have to deal with a board that looks at the way the money is spent. They are sober and goal oriented, so we have a responsibility to do our work properly. An innovation has to show in an early stage that it can add to the public goals, will it contribute something for the citizens." (NL4).*

> *"A research causes less resistance than a change in the way of work or culture (NL1)."*

On the other hand, it is not just another public institution, since a water authority has a very executive task, working in the field performing physical interventions. It is a technical organization.

> *"I think that there is an innovative capacity that is much more at the surface, due to the technical orientation. There are also many connections with the technical universities where there are many ingenious ideas." (NL3)*

The water authority is the commissioning organization; it has the power to define the assignments (NL1).

Commenting on the organizational culture, one of the interviewees mentions a changing environment. Slowly, it is getting less hierarchical. Young people that come in are a lot more outspoken than before.

> *"Nowadays you can also talk to the chairman of the water authority (Dutch: dijkgraaf), there is less hierarchy I also notice this within other water authorities" (NL6).*

Another factor that hinders implementation is the organizational structure. One of the interviewees notes that the policy makers and operators work in two worlds apart, making the collaboration for the implementation into dike monitoring a tough job (NL2). The fact that many things are outsourced to engineering and consultancy firms also resulted in the technical knowledge moving away from the water authorities, and even more parties needed and involved in the life cycle management of dikes (NL2).

Comparison authorities

Between authorities, there is a difference in organisational structure, as well as their focus on innovation. Some of them are smaller, and it is mentioned that here, people are working very closely together, with small ties between most of their colleagues and less hierarchy (NL4,5). Others are bigger but do have more budget and organizational focus on innovation and research (NL3,6). It is also mentioned that some water authorities are more innovative than others, acting as pioneers (NL6). Short ties between the operators in the field and the specialists that perform calculations on the strength of the dike can ensure cross-fertilization of ideas and needs (NL:1,4,5).

Summary organizational level

A summary of the drivers and barriers for implementation of innovation in dike monitoring practice on the organizational level in the Netherlands can be found in Table 2.

SUMMARY FACTORS ORGANIZATIONAL LEVEL THE NETHERLANDS	
BARRIERS	**DRIVERS**
. The effort needed to convince managers etc. to have access to funds	. Slack financial resources generally are available at the water authorities; it helps if there is a short way to get access to finances.
. Lack of capacity: when the employees cannot get or have not time to spend on innovation; especially hard at mid-management level	. The water authorities are a technical environment; and people are efficiency minded.
. Dike monitoring requires employees skilled to deal with the data.	.The hierarchy is slowly disappearing which brings more room for bottom-up ideas
. To make information out of the data, new ICT infrastructures and support are needed.	
. There is a lack of long term vision and strategy	. *A long term vision and policy dedicated to innovation help; such as an innovation fund*
. Projects that stifle due to lack of project management; no follow-up	
. Asset management of a dike requires many different parties within the organization, these all need to be involved	
. Implementation climate is conservative; public organization	

Table 2 - Summary drivers and barriers on the organizational level in the Netherlands

2.4.3 Drivers and barriers on the individual level

Experience/tenure
The importance of first-hand experience with the implementation of innovation is stressed. Not only to become acquainted with the technology but also to become familiar with the organizational process (NL:1,4,5).

> *"Sometimes I feel that we should just try it sometimes, to get more involved in what is out there." (NL4).*

> *"I like to give technologies a chance but I need to get a realistic feeling of whether it has potential. The first logical step is to do a pilot or something like that. That way it is much easier to really see the potential." (NL5).*

Sometimes a window of opportunities appears. However, in that particular moment it is hard to decide whether or not to apply a particular new technology, because there are unknowns and uncertainties about the performance, maintenance and use of the application. The moment then passes without implementation (NL4).

One interviewee mentions a lack of knowledge of the range of technologies.

> *"I don't think that we have a complete view of what is possible. You would also like to know this from all water authorities, to know what all the possibilities are. You have to explore the market by yourself, and I am convinced that you also miss things."(NL1).*

From both the organization and individual's perspective, knowledge sharing is seen as an important way to stimulate the implementation of novel monitoring techniques. Wouter Zomer, himself an important player with regard to innovation in dike monitoring, has made it his personal mission to stimulate the implementation of monitoring technologies, for the sake of the flood safety of the Netherlands. Knowledge sharing is the way he is trying to stimulate this, for example with the Network Dijkmonitoring. He is setting up cross connections between universities, with trainee programs, workshops, courses etc. He also sees the opportunity to share the knowledge with young engineers who will form the next generation of employees of water authorities. When they already bring this knowledge from their education, they might be more at ease to take on novel ways of monitoring (Zomer, pers.comm).

Also, managers that have worked at innovative companies seem to take this knowledge with them into their new positions (NL6). For data generating, a certain set of skills is needed to deal with big data.

> *"I know that at another water authority, there is someone who knows a lot about geo-technology and programming. He is able to retrieve a lot of knowledge out of these sensor measurements." (NL4)*

Communication skills are also considered important. On the one hand, the ability to speak in the different 'languages' required dealing with different levels within the organization, and people from different backgrounds. (NL:3,6) On the other hand, communication skills can help to get people on the same page. When this lacks, it can hinder the implementation. *"You need someone who can sell it. (…) It does matter. " (NL6).*

Psychological concepts
A fear for lost jobs can hinder implementation.

> *"Changing this the practice would definitely be resisted by people that fear to lose their jobs." (NL2)*

> *"When you say, let's innovate, people will say, why should we do that? They do not see the necessity, they are afraid to lose their job, or that other jobs will be lost." (NL3)*

This is mostly linked to people working with regard to inspection and maintenance, the 'operators'. A worry is that their work will be unnecessary. However, it is also said to be an unnecessary worry, since the human inspection will always be needed in this kind of practice (NL:1,2,3,6).

Another fear is the fear of artificial intelligence, which can be applied on the data gathered through monitoring. Artificial intelligence is seen as a black box, but people are slowly getting used to it (NL6).

Personal innovativeness/ Individual leadership
In general, we see that certain individuals act as pioneers: they are a pulling force for innovation. When they leave the scene, the innovative project often stagnates.

> *"They have huge perseverance, it takes a lot of time to get people to tag along… It's definitely something for the long haul." (NL5)*

And as one of the interviewees states from personal experience:

> *"Now, six years later, you notice that people are more open to the changes. That there is a culture change. But that is also a bit of the story of my life, I am always ahead of the crowd." (NL6).*

A personal interest or fascination for a certain technique certainly can push the implementation process.

> *"Often it has to do with personal interest. I cannot make any time for something because there is no relation to my daily work. Then it really has to come out of my own, I have to think, and I find this so important that I want to put my energy into this." (NL4)*

Also for the innovation lunches, often it is the same core group of people that show up (NL3). Apart from these real pioneers, according to one interviewee (NL6), all employees could use a bit of bravery to fight for something: leadership on the employee level.

Summary individual level
A summary of the drivers and barriers for implementation of innovation in dike monitoring practice on the individual level in the Netherlands can be found in Table 3.

SUMMARY FACTORS INDIVIDUAL LEVEL THE NETHERLANDS

BARRIERS	DRIVERS
. Little first hand experience with new monitoring techniques . Lack of knowledge and overview of all technologies . You need to be able to sell the technology with communication skills, courage and perseverance is needed . There is a fear that jobs will be obsolete, especially for dike operators . There is a fear of new technologies and artificial intelligence (slowly changing)	. Individuals that have experience with dike management, can be managers of the future . 'Pioneers' that have an interest in dike monitoring and have the perseverance to materialise their ideas (leadership)

Table 3 - Summary drivers and barriers on the individual level in the Netherlands

2.4.4 Drivers and barriers on the innovation level

Performance
The performance of the innovation is crucial to its adoption. This underlines the importance of field tests, like IJkdijk in which the performance of dike monitoring technologies is validated.

> *"When a technology proves itself, this is a very important factor in the water authority world (NL5)".*

The IJkdijk experiments have indeed given new knowledge on the performance of the technologies.

Furthermore, it depends on the kind of monitoring that is envisioned. If it is active real-time early warning monitoring, there are different aspects to the performance than if the data is used to assess the dike strength. Real-time monitoring also brings up organizational questions, such as: will it be regulated internally or externally, who carries the responsibility? Which values do you agree to be normal or abnormal?

> *"Will you trust that the signal is given in time when something strange is going on? What if there is a sudden failure of the system? And what if there's a storm and we are all out having weekend, but there is no signal… then we have no idea what is going on." (NL5)*

Trust in the performance of the system is, therefore, a very important factor for implementation.

In this regard, the remark: *"One sensor is no sensor"* (Wouter Zomer, pers.comm.), is important. Even if the innovation is working well, there will always be a need for other data to validate the data.

The confidence in the performance depends on the person and perspective.

An interesting outcome of the survey by Twynsta Gudde (2018) is the set of answers to the question whether 'Instrumental dike data is sufficiently developed to bring into practice on a big scale'. The majority of the respondents are neutral, and there are a bit more people negative than positive: so the dike monitoring techniques are predominantly seen as in development.

However, as a true believer in the added value of dike monitoring says:

> *"I stopped calling it innovation, but I now call it state-of-the art. The technologies have been proven already." (Zomer, pers. comm.)*

When is technology is developed and is the performance proven for the water authorities to adopt them into their practice? This is an important question and there clearly is a gap in the perception.

> *"In my view, it is a question of, will you first do a pilot, or will you immediately scale-up. If it works in one place that does not mean that it will work in another place. How do you translate this to the general situation? If that is proven, if it is applied, then you need to find a way to implement it into your organization (NL1)."*

It is not just about the performance of the technology itself, but also here, the performance of the related software, is essential for the performance of these technologies.

Case study: novel optic fibre pressure sensors
The prior is also applicable to the case study of novel optic fibre pressure sensors that are developed in the DOMINO project. The Dutch researchers also see the importance of the proof of concept of a new product. As such, the availability of a field test facility ivnks very convenient: "the importance of Flood Proof Holland [where the sensor is tested] is very big. Where else can you make holes in the dike and raise the water level to your wishes?" (NL1)

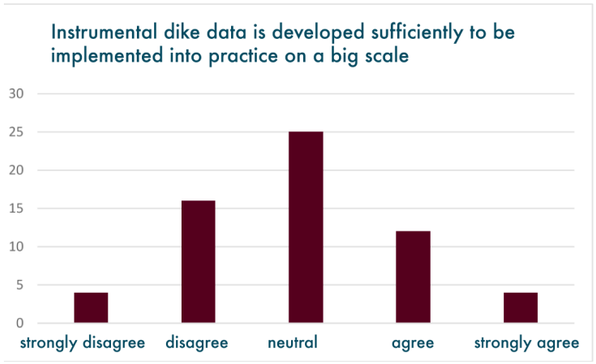


Figure 18 - Survey result by Twynstra Gudde (2018): Perceived development status technology

With regard to this particular innovation, the interviewees at water authorities made some specific remarks.

One thing that popped up is the trust in the reliability of the pressure measurements. One interviewee mentioned that the water pressure meters currently used offer really strange data so that they are now considering not using water pressure meters anymore. This negative association could be made when hearing about the new technology (NL4).

The performance on long term is questioned:

> *"How sensitive is it? How do you know at what depth it is positioned? If this location changes due to settlements, can you track this change? How sensitive is it to the mowing of the grass on the dike? Is that a problem?"(NL:1,5) Will it break easily? (NL:5,6) How do you control its performance? "We need to heighten the embankment every 10 years. This means that it is constantly settling. How do you deal with this? Every time it will be positioned a bit deeper inside the dike, how do you deal with that? "(NL5).*

The importance of the performance is regarded as an asset by the researchers. According to one of the researchers: *"If a distributed pressure sensor really works, I am convinced that it will find its way into implementation."(NL8)*

Effort:
Things related to effort are mentioned with regard to the whole lifespan of a monitoring system: they are related to the implementation into the regular work processes, the installation, but also the maintenance of the system.

Monitoring can never be one single instrument; it should always be a combination of instruments to increase the reliability and validity. Also, data management is very important, because it is a boundary condition for the data to be used (Netwerk Dijkmonitoring, 2018). The analysis and interpretation is an integral part of the monitoring strategy of a monitoring strategy set up for the Lekdijk (Rinsema et al., 2018). This also involves that model that facilitates conclusions from the measured data, to decrease the effort of use.

Case study: Installation
With regard to the fibre optic pressure sensor of DOMINO, the installation within the dike is seen as an obstacle to implementation, but in different degrees. *"It seems very complicated to open up a dike, or dig a small trench to put a cable inside."* Also horizontal drilling has the potential to be a complicated operation. "*The dikes have been there for hundreds of years, and with periods of 30 to 50 years, they have been strengthened. They are not homogeneous. This will not be a problem with new dikes." (NL5)* Also, bridges, or sluices can be a problem (NL6). *"I find that very interesting to hear, because, if you can drill the cable in it is a lot more appealing than if you have to dig a trench to put it in. Because if you dig it, it is only a local disturbance (…) Maybe it is even a precondition for the implementation".* However, someone who works in practice does not see that big of a deal in digging a trench. This can be done with little stretches at a time: *"It is not a very big operation.". (NL2)*

The intrusiveness of the sensor to the dike is also seen as a big disadvantage by the developers of the sensor. This is not only about the effort to install it, but also about safety. The installation of a cable within the dike increases a risk of creating seepage paths. (NL2)

Case study: Maintenance over lifetime
In response to the innovation, many questions pop up regarding the lifespan of the optic fiber cables.

> *"What if we have maintenance works on the dike, do we have to put a new cable in each time? Do we need to remove it? If we leave it in, will our dike become full of cables?" (NL1)*
> *"How can we maintain the cable? (..) Often many things happen, people even build staircases on the dike. What happens if pipe companies are also drilling in the dike, can they still do this?" (NL5).*

One of the disadvantages of temperature measuring fiber optics that arose is the vulnerability of the system. Around the area where the fiber optic is applied, nothing can be built etc. It is now kind of a protected area that cannot be touched (Netwerk Dijkmonitoring, 2018).

Compatibility
Does the innovation comply with the needs of the water authority? Then what are those needs?

> *"It should be appealing, or according to legislation or consistent with our core tasks (…) We want to measure from our demand. During the test calculations, we come across questions about the behaviour of a dike or piping… Then you might need more information about the dike material. Or you make assumptions, or ask an expert. (…) It would be interesting for our cluster, it is not just about costs, but it is the information that we are interested in. If we can get useful information that can help us to understand the dynamics of the dike, then it doesn't matter if it costs us a few thousand euros or even a few hundred thousand. " (NL4).*

It helps if it is an appealing innovation, with a good story to sell (NL:1,5,6)

Case study: compatibility
In this regard, it is confirmed that more water pressure measurements are always relevant (NL:1,6). Pressure measurements are now point-measurements, and continuous data would be very appealing, already if this is one data point every 10 meters. (NL1)

What makes optic fibre cables interesting are the longitudinal distributed measurements that are spatially dense. Nowadays, there may only a few data points. If the cable could perform with one data point per 10 meters that would already be a huge improvement (NL1). More data can also be used for research purposes and to find unknown relationships (NL:1,6), like the influence of roads on the phreatic line (NL6).

> *"What we see is that we cannot explain certain variations in the phreatic line between embankments that seem very similar from the outside". (NL1).*

The most extreme data points are the most interesting: the highest and the lowest measurements of the phreatic line. You need to take a long time series of measurements because in a short time period, these extremes might not occur (NL1).

In terms of real-time monitoring:

> *"I think it would be fantastic if there is a dashboard and there is a little light that will turn on when the situation is critical somewhere. A control room, just like in the wastewater part." (NL5)*

If the performance is good, and you trust your data, this implies that also in the life cycle of a dike, less strengthening activities are needed. These activities are expensive and also a great nuisance to those living around the dikes or using the roads. A technology is not yet usable if it's only the sensor.

> *"You also need to know where to put them and how often you have to measure." (NL8)*

Cost-benefit
The costs are also an important factor with respect to the performance. It is dependent on the size of the project. A dike-reinforcing project is a project of a few million per km. Especially when the dike is already opened for construction work, for relatively little money they can add sensors, creating a win-win situation (NL:5,6).
In Box 2, the cost-benefit analysis as performed for monitoring strategies for the Lekdijk is explained, as commisioned by Hoogheemraadschap Stichtse Rijnlanden. Another example from the Live Dike experiments shows that an investment of 1,5 million for monitoring, has contributed to a cost reduction of 20 million euro, because of new insights into the conditions of the dike (Stoorvogel-van der Horst, 2016). The practice also acknowledges the potential cost reduction in the management of embankments (Figure 19).
Also in the case of the DOMINO project, the cost benefit analysis is regarded as an important step to make (NL9).

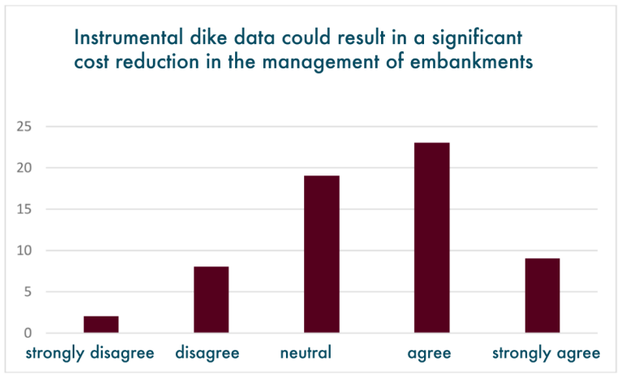


Figure 19: Survey result by Twynstra Gudde (2018) Potential cost reduction

EXAMPLE: MONITORING STRATEGY & COST BENEFIT ANALYSIS STERKE LEKDIJK
The Water Authority of Stichtse Rijnlanden had the ambition to use monitoring for certain dike stretches as a way of gaining more insights into the status of the dike, and the strengthening activities that were needed. In a consultancy project performed by three Dutch companies, three monitoring strategies were developed that tackled the identified information need. With a Cost Benefit Analysis (CBA) the potential advantage of monitoring was estimated. This is an innovative project with regard to the technologies, but also on an organizational level, since an integrated and large scale application of monitoring systems has not been applied often within a water authority.

Their CBA set the cost of all the monitoring activities against the estimated gains. The gains are mostly derived from dike stretches that need fewer actions. With monitoring the weak spots in the dike can be identified more closely so that the maintenance activities can be directed to these areas. The outcome of this research shows a positive CBA towards monitoring activities. The dike strengthening cost would normally be 7 million € per km, coming to a total of 67,5 million €. Although the cost of monitoring would need an investment of around 234 -268 thousand €, it could easily save millions of money needed for reconstruction that was not apparently not needed given the new insights. (Rinsema, Stokkum, Zomer, Koelewijn, & Veendorp, 2017).

Box 2 - Example: Monitoring Strategy & Cost Benefit Analysis Sterke Lekdijk

SUMMARY FACTORS INNOVATION LEVEL THE NETHERLANDS	
BARRIERS	**DRIVERS**
. Perceived uncertainty in performance: performance is not completely trusted by end-user . Lack of proper tools for data management . Safety of installation is a prerequisite . Long measuring time is needed to obtain interesting data of extreme events . Development of technology is perceived to be not far enough to use on a big scale. *Case study:* *. Installation of optic fibre takes a lot of effort* *. High cost*	. Reliable performance . The insights gained through dike monitoring have the potential to save millions in reconstruction works of dikes *Case study:* *. Pressure measurements are always relevant* *. Optic fibre gives the possibility for longitudinal measurements*

Table 4 - Summary drivers and barriers on the innovation level in the Netherlands

2.5 DRIVERS AND BARRIERS IN ITALY

Just like the prior case study of the Netherlands the results of the empirical research are presented for the societal, organizational, individual and innovation level.

2.5.1 Drivers and barriers on the societal level

Environmental pressures

There is a pattern that the urgency to deal with a disaster is always high right after the disaster, when there is a lot of media attention and a push to make more money available.

> *"In my opinion it is a system that goes up and down. All the ups are following a disaster." (IT9).*

> *"(...) But in the reality nothing really happens" (IT8).*

These are not only disasters that have to deal with dikes, but also debris flows that have killed people in several events in mountainous areas, which are densely populated (IT2).

Since Italy deals with several types of (natural) hazards apart from flooding, one can wonder how these hazards compare to one another. Is flooding less a priority given for example the risk to landslides and debris flows? Flooding is a periodical hazard *"only in some periods there is a high risk to be affected by the dikes" (IT1)*.
However, *"a flood that happens in the Po River is a national catastrophe." (IT3).* Also in a more regional setting a dike breach would have great consequences *"when the dike collapse this is a catastrophic event". (IT5)*

North Eastern Italy is home to one third of the population and responsible for half of the national income (IT6).

> *"The largest cities are in the alluvial plain, so I agree that for you (in the Netherlands) it is an everyday problem, here, floods are a big issue, and when there is a flood it can causes big loss of money. Dikes are still very important, even if you cannot manage the river only with dikes." (IT1).*

Other ways of dealing with flood management are for example flood propagation modelling, building retention basins, or non-structural measures (IT1,3). In this spectre of measures, monitoring techniques are one of the options.

The director of one the River Basin Authorities states: *"I prefer to spend money on monitoring, not to spend 400 million on repairs; also this ensures the security for the people, the industry and the territory." (IT4)*

And about the importance of more data to know the current status of the dikes, one interviewe mentions how important it is to know more about the structural situation of the embankment; *"at the moment we do not know so much."(IT4)*

The prevention of floods causes a self-reinforcement of the challenge, mentioned by one of the interviewees:

> *"When you start doing an embankment it is it not only changing the river acivity, but also the human and social activity that is around." (IT3)*

Since the activity grows with the first embankment, higher safety standards will be needed; then it attracts even more economic activity and the embankments need to be updated. It is a self-positive loop (IT3).

The pressure also rises due to climate change and the increasing sea level. More intense rainfall will increase the probability of flooding. The results of the interviews confirm the importance of flood protection and the urgency to continue to improve the flood management and monitoring (IT4).

The European Flood directive influences the flood management of the EU member countries. Not only the way authorities are organized, but also for the actions that are required: such as flood risk assessment, flood risk maps, and flood risk management plans. This steers the methods used, and also enlarges the need for data related to the water basin and flood protection. From the European Union there are also some resources available (IT:1,4).

Regulatory pressures

Concerning the Po River, there are very strict regulations that prohibit any building activities along the dikes. This makes it very hard to implement fibre optics within the dike. A flooding of the Po is a 'second class' catastrophe according to Italian legislation, which refers to a catastrophe on national level.

The legislation is quite strict and guiding.

> *"In practice in the embankment you can do almost nothing. No trenches, no trees, you cannot damage the crest; you cannot leave the animal there. You shouldn't go and drive with cars, with horses, and if you do something against the embankment there is a panel with a charge between two and four years. It is a national importance level. If you want to do something you have to get the authorisation of Aipo. This is the hydraulic authority. For fifty meters you cannot use it for houses, this is forbidden (…) Also everything is a temporary permit and Aipo at some point can say, you are not anymore allowed to have these kind of things." (IT3)*

Participation in networks

The network formed by reseseachers and practicioners in the water sector seems to be quite tight, linking informal and formal connections
There are often links between people working in different organizations, for example former graduation students (IT1, IT6).

The network is useful for research purposes, for example to find and setup test sites for the monitoring techniques.

> *"He is the director of the part of dikes, river protection in Bolzano. He is a friend of mine and he involved us in monitoring this of river along the Adige River, and we installed overall two km fibres into the soil." (IT2).*

Some have worked in practice and take their contacts along to a new context: *"I have worked for a couple of years at the basin authority, then I maintained some relationship with them."(IT1)*

Authorities sometimes ask universities for consultancies, for example to make a design of a new dike (IT2). Also, CNR is linked to the Civil Protection and can be asked to help in case of emergency. These efforts are not always paid for (IT7).

As an organization CNR links theory and practice, university and stakeholders, since it is dedicated to research application (IT6). If there is an emergency, CNR is asked for advice, and they are continuously in touch with the university of Padova.

Competition with other organizations

The responsibility for the flood protection is shared amongst the different layers authorities. They have different, but sometimes overlapping

tasks. Often, the organizations in lower hierarchy have to ask permission to the overlaying authorities (IT5). This also raises the level of bureaucracy. The shared responsibility also gives confusion and frustration, as stated:

> *"There is a big problem that there are a lot of governments, on the same area you have a competition with different public authorities. Consorzia di bonificia, the region, water basin management authority and so on. That's a big problem in Italy, they are one over the other with no clear distinction of competency between the different authorities. Irrigation, drainage, on different levels, is not clearly defined. This is mine, this is yours. It's not clear as they overtop one another" (IT9).*

Summary
A summary of the drivers and barriers on the societal level is provided in Table 5.

2.5.2 Drivers and barriers on the organizational level

Slack resources
The available resources are limited, and this is the number one issue brought up in conversation. This concerns money, but also the human resources.

> *"The main issue is the money to install and manage it. You need someone to install it and you need someone to provide the output of the data. There is a lack of money and a lack of people." (IT6).*

> *"A main issue is funding; this is very, very limited. (...) Even the salary of the employees is at low level." (IT3)*

The researchers also confirm the limited resources. According to them this is the biggest barrier (IT:7,8,9).

> *"The real problem starts when they ask: "How much does it cost?""(IT7)*

The water authorities do not have funds to do regular inspections. This also affects the amount of collaborations. When there was more money available in the past, the involvement of stakeholders was bigger (IT8).

The lack of resources can also imbalance the relations between different stakeholders.

> *"One of the consequences of lack of resources is also that authorities ask for 'free' favours, from universities/water authorities etc... And do not pay for this. Just like the Liguria region wants help from Aipo, even though they are only slightly in the basin, and do not pay." (IT3).*

Often in emergency situations extra funds are made available from the national or regional governance levels and this is sometimes spent on monitoring, but this is only in exceptional situations. Even though there is awareness that an investment in dike monitoring could save a lot of money by preventing these emergencies (IT4).

Management/ leadership style
A specific example of leadership style was found at the basin authority, where due to the reorganization new people were hired. He chose to hire only young people, because of their new ideas and work attitude (IT4).

Implementation climate
Traditionally, the culture at the different level of water authorities is quite hierarchical and conservative. It is quite a bureaucratic and administrative culture, which tends to slow down the innovation processes (IT9). The researchers also confirm a conservative climate: they tend to stick to the way of working that they are used to (IT8).
It seems like this culture is slightly changing and becomes less top-down, and steering towards more involvement of society (IT1).

Authorities have to deal with pungent problems, such as corruption (IT9). The fact that innovation is not implemented is a *"failure in the political level, not an academic failure". (IT8)*

The employees of the authorities dealing with water are mostly politicians, with little technical sensibility (IT8), which makes it harder to convey the innovation or to work with the data (IT6).

Summary
A summary of the drivers and barriers on the organizational level is provided in Table 6.

2.5.3 Drivers and barriers on the individual level

The importance of individuals was not directly discussed, and so the insights were to be read between the lines. Some individuals are specifically innovation minded. For example, the director in Bolzano, who decides to experiment with fibre optics to learn more about seepage. Or the basin director who is *"always supporting our new ideas"*, open minded towards innovations (IT6). These individuals take the extra effort to sure that innovations are tested within their environment. Within the group of researchers, there is one person identified as an important bridge person between different disciplines. Having experience working in academics and the research institute CNR, he can understand the needs of the different parties, and also translate the needs of the stakeholders into a feasible project (IT6).

Altough most interviewees were enthousiastic about the innovative projects, a certain level of scepticism was also encountered. It was questioned whether it would be possible to successfully changethe current regime (IT8).

Summary
A summary of the drivers and barriers on the individual level is provided in Table 7.

SUMMARY FACTORS SOCIETAL LEVEL ITALY	
BARRIERS	**DRIVERS**
. Attention is shared with many different natural hazards; not solely flood safety . Strict regulations on the integrity of a dike body . Many layers of government with shared and unclear responsibilities . Bureaucracy	. Higher urgency after a recent disaster/incident . The flood plains are densely populated and have high economic value . Added value of monitoring is acknowledged . Climate change and increased flooding risk increases pressure on the system . Regulatory pressures from EU . Network relations are tight

Table 5 - Summary drivers and barriers on the societal level in Italy

SUMMARY FACTORS ORGANIZATIONAL LEVEL ITALY	
BARRIERS	**DRIVERS**
. Limited financial resources . Limited capacity . Bureaucratic, hierarchical and conservative organizational culture . Limited technical sensibility within the employees of the responsible authorities	. Leadership with a view to new ideas . Organizational culture slowly becoming less hierarchical

Table 6 - Summary drivers and barriers on the organizational level in Italy

SUMMARY FACTORS INDIVIDUAL LEVEL ITALY	
BARRIERS	**DRIVERS**
. Slightly negative perception of the agency that an individual has within the system	. Individuals that are innovation minded . Innovations with strong persistence to implement an innovation . Individuals that can bridge different disciplines and working environments

Table 7 - Summary drivers and barriers on the individual level in Italy

2.5.4 Drivers and barriers on the Innovation level

Performance

The importance of the performance of the system is very important. In case of an early-warning system, too many false positives will undermine the working of the system: *"people will say, we don't care… there is the 20th time that there…" (IT9).* It is not easy to make people aware of the danger.

Related to the performance of an innovation is the proof of concept; whether the performance is shown and trusted. Often, this is shown through pilot projects. These need test sites. For example, in the province of Bolzano (Box 3), thermal sensing optic fibres were installed to gain influence in seepage flows. However, since the instalment three years ago there has been no flood event, so there is no interesting data yet. This is tricky, since a lot of money is invested and it takes a lot of waiting time. In a field test in an artificial setting it is possible to have more control of the boundary conditions (IT2).

Case study

The performance of the novel optic fibre pressure sensors is tested in the lab as well as in the field. From the lab tests, the performance of the pressure sensor showed to be very promising. The researchers mention to be pleasantly surprised by the sensitivity shown by the sensors. This sensitivity is actually too high for the application in dikes, but it also opens up new opportunities of applications in other sectors (IT:7,11).

The field test is regarded very important with regard to the performance. In the field, unexpected things can pop up. One important factor is the packaging of the sensor. Will the packaging hold under the conditions in the field, or when other people handle them? This is important for the durability of the sensor lifetime (IT11). Instruments in the field need constant attention:

> *"There are problems to solve every day… There are rodents that chew cables, they eat something… the plastic… small rodents and squirrels and so on. So they are a problem to solve anyway." (IT9)*

These are all things that the developers need to take into account in their design.
With regard to the field test, it is mentioned:

> *"The worst thing that can happen with the test is that you do not know what went wrong." (IT6)*

Effort

Case study

The optic fibres have to be placed within the dike. This is an intrusive operation that is regarded quite cumbersome, not just the operation, (IT:3,4,5) but also because extra effort is needed to achieve the right permits to be able to enter the dike and to convince all stakeholders.

> *"It's impossible to monitor everything, but the critical points this may be interesting." (IT5).*

Compatibility

The need for and the importance of more monitoring are endorsed.

> *"The point is that we must know the situation in the embankment before the situation of the flooding. This is very important."(IT4).*

Currently, there is not much insight into the actual status of the dike, and more data could help to gain these insights.

> *"We are in a very, very, early stage into innovation with sensors." (IT3)*

The data can be used to update the risk models, and the accompanying policies. However, *"regional authorities often don't see the point why they must spend the money for this monitoring."(IT4)*

Originally, according to legislation, all dikes are supposed to have a dense network of visual inspections, however, due to cuts in budget this is done less and less.

> *"So from that point of view any kind of technology that somehow replaces the traditional inspections, any kind of visual aid… is needed" (IT3).*

On the other hand, *"monitoring is done, but in exceptional cases. Having a continuous monitoring is not possible at the moment, it is not sustainable [financially]." (IT3).*

Also, the importance to combine several sensors is stressed, *"I used to say the best approach is to integrate different kinds of sensors. Because if one sensor fails, I have another". (IT4).*

The costs of the product are very important, even if something performs very well. The authorities are looking for the cheap approach.

Case study

> *"The approach of optical fibre is very interesting. But we must have the cheap option." (IT4)*

Though optic fibres are an attractive choice because they can offer an enormous amount of data points, the investment costs are too high at the moment. This is mainly due to the costs of the interrogator, so a solution should be found to make it attractive to stakeholders (IT7).

Summary

A summary of the drivers and barriers on the innovation level in Italy is provided in Table 8.

BOLZANO

The province of Bolzano was mentioned as an exceptional example, where a pilot with thermal sensing optic fibres is run for the detection of seepage in a dike. Bolzano is a more autonomous and also more rich province within Italy. The province is densely populated and the risk from natural hazards is an issue. "If you have a chance it would be very useful to talk with people in Bolzano. This is a special place; it's a small province where they speak German. They became part of Italy only one hundred years ago, and so they have more money. So let's say, in terms of rivers and management they use the money very well. They are very open also; they put a lot of care and tension about the risk (…) Over the last year they are also very much concerned about the environmental issues. They are one step ahead compared to the other parts."(IT1)

Box 3 - Example: implementation of a pilot in the province of Bolzano

SUMMARY FACTORS INNOVATION LEVEL ITALY	
BARRIERS	**DRIVERS**
. Performance is crucuial to continous application, can be proven with field test Demand for maintenance over sensor lifetime *Case study* *. Intrusiveness of the optic fibre cable* *. High cost of the system (interrogator)*	. Demand for more data *Case study* *. high sensitivity of the pressure instrument* *. optic fibre will give many data points*

Table 8 - Summary drivers and barriers on the innovation level in Italy

2.6 COMPARATIVE ANALYSIS

In this chapter, the results of the two case study regions are contrasted and the similarities and differences in both case studies are identified.

.

2.6.1 Introduction

In the previous two chapters, the drivers and barriers for implementation of new practices in dike monitoring in the Netherlands and Italy were identified through case study research.

In this chapter, the results of the two regions are contrasted and the similarities and differences in both case studies are identified. The aim is to to gain insights into the relative importance and effect of factors that influence implementation in different cultural and organizational settings. This comparative analysis is a step towards empiracally built theory through analytic generalization (Yin, 1989), where in the next chapter the most relevant concepts (2.7) are identified.

2.6.2 Societal level

Flood safety system

The way in which the life cycle of a dike is managed, as described in Appendix B, is different for the two countries. In the Netherlands the law prescribes that the safety of all dikes is 'tested' to the norm every six years. For these tests there are standards with calculation rules that have to be filled with data ("Hoogwaterbeschermingsprogramma," n.d.). More data can reduce the uncertainty of these calculations. However, visual inspection remains the main monitoring technique.

In Italy, dikes are designed based on design rules that are also accounted for in legislation (IT3). The monitoring is purely based on visual inspection. In some exceptional cases instrumental measurements will be done (IT:1,3,6). There is not a standardised way to test and calculate the dike safety, calculations on the strength are exceptions (IT3). The main failure mechanism taken into account is overtopping (IT:2,6). There is not a direct system to which the data can feed.

Influence of EU

In both countries you can see an influence of the European policy trickling down to the national and regional level. In Italy, this has caused reorganizations of the water basin authorities. This was mentioned during several interviews and conversations (e.g. IT1,4). In the Netherlands, the influence was less visible, although the Directives such as the Flood Directive and the Water Framework Directive also have increasing influence on the way which regional water authorities perform their tasks in the Netherlands. The directives have to be transposed into the national law; therefore, there is a great legal influence in all member states (Havekes et al., 2015).

Different hazards risks

Both the regions have a history of dealing with flood risk and both have a system of dikes to protect the surroundings from flooding. However, a main distinction is the other types of risks that Italy faces besides flooding. In Italy, as well as in specific area studied, there are many more hazards that cause a societal risk, such as landslides, earthquakes and debris flows (IT: 1,3,5). This is reflected also in the profile of academic professors. They are geotechnical engineers, and part of their expertise is dikes. In the Netherlands, this is one specialisation.

The interviewees in Italy emphasise that this does not mean that flooding is less of a priority or threat (IT: 1,3,5,6). Still, the attention has to be spread amongst different risks and the money has to be allocated. This is something that does influence the risk perception in the different countries, and is important to keep in mind when thinking about risk reduction in the both countries.

Legislation

For the primary levees of the Po river, the legislation is very tight, and the integrity of the dike has to remain intact (IT3). For the regional levees this is not mentioned as a problem. For the Netherlands only regional levels were reflected although it is not directly allowed, permission can be given by the 'beheerders' to install cables into the dike body (Dutch: *'ontheffing'*) (NL: 5,6). The legislation that prohibits to interfere into the dike seems more tight in Italy.

Network

In both countries, the network is a building block for many initiatives (NL: 1,4,6; IT: 1,2,6). In Italy the formal and informal network seem to be overlap, where colleagues are often called friends (e.g. IT2, IT6). However, as we quote Hofstede (2010): *"the word "friend" should not be misinterpreted because in business it has a slightly different meaning: someone that you know and can be useful for introducing you to the important or powerful people."*

2.6.3 Organizational level

Resources

A critical difference is the amount of available resources within the organization. In Italy, this is brought up as the number one barrier to implementation of innovation in nearly every interview (IT: 3,7,8,9). First of all, the amount of resources available in public institutions is limited. Also the capacity of employees is less; there is *"a lack of people" (IT3).*

In contrast, in the Netherlands, although the money is not always freely available, there are financial sources to draw from, and in some cases innovation funds (NL3) within the organization that offer the financial slack to easily take off with an innovative project.

Implementation climate

Political organization/ bureaucracy

Although the bureaucratic practices are surrounding the implementation into dike monitoring in both countries, from the research the Italian practice seems more bureaucratic. The political organization is set up in several layers with overlapping responsibilities, which can cause ambiguity in the responsibilities. The interviewees themselves mention that this hampers the innovation process: to start something, many actions need to be taken and many people need to be contacted (IT: 5,9).
The same mechanisms also play in the Netherlands within the organization; when a project costs more than a certain threshold, several permissions are needed to take off (NL5).

In contrast to the lower layers of water governance in Italy, the water authorities in the Netherlands have the full legal decision power over the dikes and embankments (Slomp, 2012) and they do not have to gain permission from a higher layer of authority.

A similarity of the two countries is that the organizational culture is said to become less hierarchical in both countries, which creates space for innovation from bottom-up (NL6, IT1).

2.6.4 Individual level

In both countries an important role is given to individuals that have the perseverance and capabilities to push through (NL:3,4,5,6; IT:6,8). There seems to be a difference in the perception of individuals of the change they can make. In Italy a slightly more pessimistic attitude is noted with regard to the belief whether the situation can be changed by individual effort (IT8). Given that there are more barriers for implementation of innvation observed in Italy in the research, this might be reflected in the personal attitude: there is less impact to be made, so the perception of your individual power for change is naturally lower.

2.6.5 Innovation level

On the innovation level, the performance is crucia (NL5, IT9), and with respect to instruments, similar requirements are stated. In both countries the importance of field tests is stressed. With regard to the case study of optic fibers, similar questions are asked, such as, will the cable hold, how much maintenance do they need?

In both countries, the same words: *"one sensor is no sensor"* were used to express the need for several instruments to back up each other (Wouter Zomer, pers. comm. IT4). The intrusiveness into the dike is seen as a barrier and given the constraints, in some cases in Italy even impossible to apply optic fibers (IT3).

In Italy, the cost of the system was more important, cheap options are preferred (IT4).

In both countries the need for more measurements is acknowledged (NL: 1,6; IT4). Pressure measurements are easy to interpret and fit into the system. Since the Netherlands already performs strength assessments for dikes, it might be easier to apply it there. In Italy, the data can also fit into risk models.

2.6.6 Chapter Summary

The main differences and similarities are summarised in Table 9.

SUMMARY COMPARATIVE ANALYSIS	
MAIN DIFFERENCES	**MAIN SIMILARITIES**
. System in the Netherlands; standard system for calculations about flood safety regulated by law . Amount of resources available: fewer resources in Italy . Amount of hazards to deal with . Style of organization; in Italy more levels of authority dealing with water and a higher level of bureaucracy . Perception of an individual's agency	. Network ties . Individuals play an important role . Both countries are influenced by European level . In a way; public innovation; hierarchy and effort is both countries; slightly less in the Netherlands. . Visual inspection is the most important inspection method in both countries . In both countries there is a positive attitude towards dike monitoring, but not a lot of implementation

Table 9 - Summary comparative analysis: main differences and main similarities with regard to the implementation of innovation in dike monitoring in Italy & the Netherlands

2.7 ANALYSIS KEY CONCEPTS

In this chapter, a futher analysis step is taken, and the drivers and barriers are categorised into key concepts.

2.7.1 Introduction

As we observe in the results of the case studies in Part II of this research, the social and technical dimensions influence each other in the implementation process of innovation in dike monitoring. For example, the implementation of new technologies requires new ways of working, and a change in the current regime (e.g. with regard to life cycle monitoring as mentioned in 4.3.2). And the other way around, the social factors influence the use of the technologies.

By conceptualising and modelling dike monitoring practice as a socio-technical system, the aim is to get a deeper understanding of the drivers and barriers acting in our system and their interactions. The main lack of insight addressed is the question what are the critical factors affecting implementation of innovations into dike monitoring practice and how these can be overcome. The observed emergent pattern is technologies in the field of dike monitoring which are not implemented into regular use, despite a general awareness and increasing interest of the potential of these technologies.

An important step is to make an abstraction of the system, answering questions such as: who are the most important actors, what are the most important concepts, and what is the most important behaviour. In this chapter, the conceptualisation focuses on the key concepts. In Appendix C, the further conceptualisation can be found, as well as the toy model that was based on this conceptualisation.
.

2.7.2 System identification

The key concepts were identified with a causal diagram that is presented in Table 10. This section explains the underlying relations presented in the causal diagram, based on the prior empirical research.

What these key concepts have in common, is that the research indicates they all have a direct effect on the decision to implement novel dike monitoring techniques or not.

These concepts are:
. Urgency
. Slack resources
. Innovativeness
. Decision making power
. Awareness/knowledge/experience level
. Added value innovation

Concept	Definition	Feedbacks:
Urgency	The societal pressures that influence the importance of immediate change	Implementation: : the scoietal pressures increase the need for smart working ways and innovative solutions to work more efficiently, thus enhance implementation Innovativeness: may urge organizations to change policy with regard to innovation Resources: higher urgency can influence the amount of resources available Added value innovation: a higher urgency may influence amount of funds available for development of innovation Awareness: urgency puts the topic on the agenda
Slack resources	Availability of monetary resources, ICT and human resources that can be dedicated to innovation	Implementation: resources can be a direct to implementation: no resources, no innovation. Innovativeness: employees that are innovation minded can strongly influence the innovativeness of the organization
Innovativeness - organization - regime	Innovativeness describes the attitude towards innovation, as well as the fit into a certain regime.	Implementation: the attitude influeces the decision on whether to adopt or reject the innovation Resources: a positive attitude towards innovation may increase the amount of resources available
Decision making power	The power an organization has to make the final decision on implementation of innovation	Implementation: if there is a low decision making power, the innovation cannot be implemented directly, and is dependent on a different layer of organization, this can discourage, slow down or stifle the implementation
Awareness/knowledge/ experience level	Different types of knowledge; from awareness to technical knowledge to tacit knowledge from experience	Implementation: the knowledge is said to influence implementation directly, with limted knowledge or experience it is hard to trust the technology Innovativeness: managers with knowledge of or experience with the innovation tend to implement it more easily
Added value innovation	The perception of the sum of all the value an innovation can offer minus the disadvantages.	Implementation: the more value an innovation can offer, the more eager the potential users are to implement it.

Table 10 - Key concepts influencing implementation defined

Urgency

Society and the environment can enforce different kinds of pressures on the development and implementation of innovations. In the causal diagram, they all come together in one term: urgency.

In both the Netherlands and Italy pressures from climate change and increased density of population are mentioned (NL1, NL3, IT4). These urge for new and smart solutions when current practices do adapt to changes and therefore increase the need for innovation (NL3). Also new policies or safety norms are mentioned. In the Netherlands, the recently updated safety norms for dikes create a momentum for changing the practice, since the maintenance activities need a huge direct investment, and suddenly smart solutions or monitoring practices are on the agenda ("Hoogwaterbeschermingsprogramma," n.d., Koelewijn & Meer, 2018).
In Italy, the EU policy has resulted in several re-organizations (IT1).

In both countries, in case of a recent event, in both countries it is said that the urgency immediately rises and new plans are made (e.g. Slomp, 2012, IT8, IT9) On the other hand, it can also fade away quickly, when the impact is forgotten (IT9). In Italy, the presence of other hazard related risks also plays a role (IT1, IT3, IT5). This points towards the fact that the urgency is related to the relative perceived risk.

The urgency may influence the way the organization deals with innovation; it might adopt its strategy towards a certain field. It may also influence the amount of money made available for the development of a technology. On the other hand; urgency may also directly influence the decision to implement. It can be seen as an overall pressure on the system.

Available Resources

The resources depend on several things: they are the monetary resources, ICT and human resources. They are grouped into the term resources, similarly as in the theoretical framework Chapter 2.2.

Even when there are enough resources within an organization, they are not always allocated to innovation projects. Therefore, a positive policy regarding innovation can make resources available to innovation, in hours of works being assigned to a project, or the example of an innovation fund has money allocated to innovation (NL3, NL5).

The amount of resources has a direct effect on the decision to implement an innovation. With no resources, innovation is very hard. This was seen through the Italian interviews, where the resources (both financial and available employees) where always a limiting factor (IT3,7,8,9). The fewer the resources, the harder it is to implement innovation. However, the Twynstra Gudde survey (2018), shows that in the Netherlands there is quite a willingness to invest by the water organizations, but still, there is limited implementation, so also resources alone do not do the trick.

Innovativeness

Can the innovativeness of the organization be captured in one term? It is by definition a big abstraction of a lot of different factors. However, some organizations do and some do not implement. There is a clearly a difference in innovativeness between the different water authorities, as seen from the comparison in section 2.4.2.

In an example of a conceptualization of adoption of innovation from literature, the innovativeness of individuals was captured as one concept *"individual differences in adopting or rejecting innovations due to personality as well as communication habits and socio-demographic characteristics"* (Schwarz & Ernst, 2009). If we translate this concept to an organizational level, what is it influenced by?

It is partly the organizational climate that can enables individuals to implement an innovation, which can be stimulated through policy and leadership (section 2.4.2: Management/Leadersip style). Furthermore, the capability to organize a project and its follow-up, also defines whether an organization can enable and stimulate innovation (Netwerk Dijkmonitoring, 2018)

Within the organization, the actions of individuals and the organizational culture and policies influence each other. From the interviews, it was very clear that certain individuals could make the difference within the organization. If they are passionate and have the perseverance to continue to 'push', they can make the difference whether a project is implemented or not. So, the presence of such an individual would increase the innovativeness. This was found both in the Netherlands and Italy (NL:3,4,5,6; IT:6,8). This provides a feedback from the resources (human resources) to innovativeness.

Also, the innovation should be fitted it in the current regime. The system can be very stuck into certain ways of working, which could make it hard to implement the innovation despite good intentions.

The innovativeness also has a feedback from the available knowledge of the organization. This is an insight from both literature and the interviews. If knowledge is present in an organization, this can influence the innovative capacity; for example, the new managers that came from Deltares to a certain water authority, who have a lot of experience with state-of-the-art technology (NL6; Gieske et al., 2016). There is also a need for organizational examples on how others have dealt with this aspect (NL1,4 Stoorvogel-van der Horst, 2016).

Decision power

Does the organization have the power to make the decision to implement? Are there other layers of governance that need to give permission? If not, can the organization be innovative? In this causal diagram it is reflected as 'the decision making power'.

This insight was gained through the comparative analysis (Chapter 2.6, section 2.6.3). The presence of several layers of government in Italy shows that the power of an organization to make the decision to implement is not always evident.

Awareness/Knowledge/Experience

Knowledge and experience were mentioned to influence the decision to adopt an innovation directly (NL:1,4,5). If you have experience, this takes away many unknowns and smoothens the process and naturally, awareness is needed to even consider an innovation Therefore, knowledge is also one of the core concepts by itself.

Gieske et al. (2013) who have researched the innovative capacity of water authorities in the Netherlands, defines the capability to learn as one of three important pillars.

The connections in the network influence this knowledge. The capacity is also influenced by trainings followed, or if people are allowed, have time, decide to join in network events. This is partly due to organizational and individual characteristics gathered in the concepts 'resources' and 'innovativeness'.

Added value innovation

The innovation characteristics are an important factor for the adoption and implementation. The innovation characteristics are grouped in the term 'added value' as the most important decision criteria for a water authority to adopt an innovation.

The added value depends on the performance (NL5, IT9), which is also affected by stage of development. Also, the associated risks are important. The TRL levels could express these aforementioned factors.
Then there are several factors that influence whether an innovation can fit into society. Sometimes it is not possible to implement an innovation that works due to legislative reasons. It might also not fit the internal working processes of the organization. In this case study, the intrusiveness of the innovation into the dike is an important barrier (NL: 1,5,6 & IT: 3,4,5). This has to do with the ease of use and ease of implementation. Other factors are the compatibility; does it comply with the needs of the water authority? These factors can be grouped into social readiness. Lastly, there is the cost of the innovation that matters (IT4).

2.7.3 Framework

On the next pages, the proposed updated framework, based on this analysis is drawn (Figure 20).

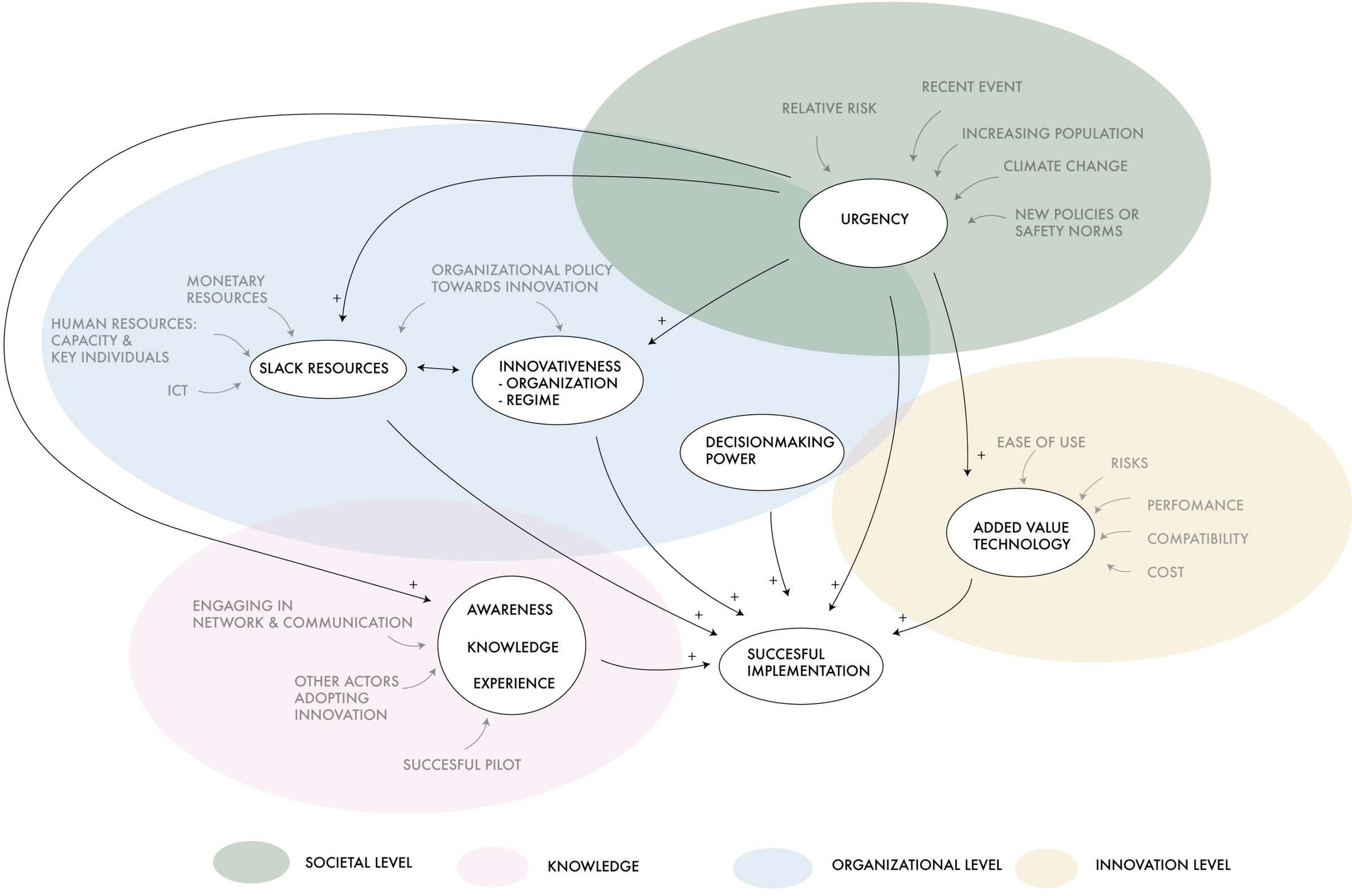


Figure 20 - Framework connecting key concepts for succesful implementation

2.8 DISCUSSION PART II

Below, a critical look at the results of part II is given In section 2.8.1 the results from the case studies are interpreted. Then, section 2.8.2 the theoretical framework is evaluated. Lastly, in 2.8.3 the validity and reliability of the research methods the limitations of the research are discussed. A discussion of the results in the light of other research can be found in Chapter 5.1.

2.8.1 Interpretation results

This chapter starts with the interpretation of the results. A reminder of the research questions of part II is given in Box 4. Each part starts with a question, the Discussion Points (DP) followed by a discussion, and ends with a conclusive statement, a proposition.

Drivers and barriers

The theoretic framework provided the different factors that could act as drivers or barriers for innovation. An important observation to make is that whether something is a driver or barrier is a fluid scale, they are forces that can be big or small and can act in both ways. In this discussion, some points are discussed in drivers, but could also be categorised as a slowly diminishing barrier.

To consider where the field of dike monitoring is moving towards based on the drivers and barriers, a first discussion point is whether the dike monitoring practice is changing, and into which direction.

RESEARCH QUESTIONS

The research questions that were addressed in this part 2 of the thesis are:

1. What could be drivers or barriers for implementation of innovation in dike monitoring practice according to literature?
2a. How are the dynamics in the field of dike monitoring perceived by the main actors in both the Netherlands and Italy's Po Valley?
2b. Which drivers and barriers are the most relevant for the implementation of innovation in dike monitoring practice?

Box 4 - Research questions Part II

DP: Is the system of dike monitoring practice slowly changing towards more instrumental dike monitoring?

Does the sum of all drivers, barriers and within the boundary conditions of the system of dike monitoring practice, enable innovation to be implemented? To anticipate on to the main observation, in both the Netherlands and Italy the following proposition is presented:

> *(1)…. The logical trend is that the dike monitoring practice is slowly going towards application of more instrumental dike monitoring techniques.*
> *(2) …. However we are not there yet: there are many barriers to overcome.*

To work towards this observation, the main drivers and barriers that can be filtered from the research will be highlighted below.

DP: To what extent is there a driving force to change the system? What are the main drivers?

The main forces that can be categorised as driving forces are a growing awareness of dike monitoring, a slowly increasing sense of urgency as well as an added value that instrumental dike monitoring can offer. Key individuals play an important role to trigger change. However, the dynamics only change slowly.

DP: Is dike monitoring on the agenda?

The Netherlands

By counting the number of application of novel dike monitoring techniques, you could have the impression that there is still little going on in the field of dike monitoring. However, under the surface, the dynamics seem to be slowly moving towards implementation of instrumental dike data on a bigger scale.

In the Netherlands, the meeting held in 2004 after the then recent dike breeches in Wilnis and Stein, concluded that visual inspection would remain the main monitoring technique and that instrumental dike monitoring should be further developed ("Visuele technieken blijven belangrijkste vorm van dijkinspectie," 2004). Fourteen years later, there are still network meetings (e.g. Netwerk Dijkmonitoring, 2018) that discuss the potential of the techniques, but little action on the implementation into dikes is seen.

Yet, many efforts have been undertaken on the development and validation of the techniques through the IJkdijk experiments (Stoorvogel-van der Horst, 2016), as well as the spreading of knowledge through the network. These efforts have had an effect on the awareness. There is a growing awareness in the dike sector about dike monitoring, as can be seen from a recent survey (Twynstra Gudde, 2018), the IJkdijk evaluation (Stoorvogel-van der Horst, 2016), and the interviews in this research (NL: 1,4,6).

In the literature it is stressed that relevant peers adopting innovation can act as a push for innovation (Kim & Chung, 2017). In the Netherlands, this dynamic also seems to be in place. In the interviews this effect was mentioned: once another organizations had tried something new, the innovation becomes interesting and the employees would ask around (e.g. NL4). However, given the limited implementation, this reinforcement would still be little.

The wait-and-see attitude could also be due to the risk and trust in the innovation; when others have adopted successfully, it is easier to trust the performance of the innovation. This is related to concepts from literature such as critical mass and network externalities (Kim & Chung, 2017). Therefore, you could argue that it is important that some organizations take the lead and break through the barrier to be the first one.

The literature framework mentioned the role of governments that can play a key role in environmental awareness on the market. The perceived pressure from regulatory stakeholders could boost the implementation of innovation (Bonzanini Bossle et al., 2016). In the new "Hoogwaterbeschermingsprogramma," (n.d.) there is money available for research on dike monitoring (Koelewijn & van der Meer, 2018), although it seems like the pressure comes more from actors within the network. This national government is then not so much a driver in the current practice yet.

All in all, dike monitoring is a topic that with increasing presence on the agenda of the dike sector, but with the potential to keep growing.

Italy

Also in Italy, the awareness of instrumental dike monitoring was noticed in the interviews (IT: 1-5). The main activities with regard to the monitoring of dikes are through research applications; application is in a very early stage (IT3). Monitoring is common practice for other hazards such as landslides (IT8).

.
The proposition for both countries is:

> *(3)… There is a growing awareness of and attention to instrumental dike monitoring*

DP: Is there a sense of urgency to implement dike monitoring?
In both Italy and the Netherlands, climate change and population growth were mentioned to be increasing the need for innovative solutions, since both the probability of the hazard and the impact would increase (NL1, NL3, IT4). Dike monitoring could play a role in this increased need of flood protection.

As undesirable as it may be, an incident or dike breech would increase the urgency enormously This was mentioned in both countries as a push for change (Slomp, 2012, IT8, IT9).

In the sense of urgency to change, the high flood protection norms in the Netherlands do not leave a lot of room for incidents (NL3, NL8), so as long as nothing happens, the urgency does not come from this side.

In Italy, the dikes have lower design standards than in the Netherlands (IT3), so chances of dike failure would also be bigger. In Italy, there are also the risks from natural other hazards that have to be taken into account (IT: 1,2). Would this mean that flood protection is less a priority? According to the interviewees, it is not less a priority, because the study area is of great economic value, and a dike breach would be a catastrophe for the region (IT: 1,2,3,6). On the other hand, the budget and attention has to be allocated to these different hazards, so in way it has to compete, and this might lower the urgency.

For both countries we may say, that urgency is a potential driver, although the urgency is still relatively low:

> *(4) … the urgency and need are slowly growing, however a real push to action is missing*

DP: Who are the drivers of change?
As the theoretical framework already described: creative and autonomous individuals are important to break through a risk-averse administrative culture (De Vries et al., 2016; Kim & Chung, 2017). These key-individuals were also encountered in our case studies. Pioneers, with a lot of perseverance and intrinsic motivation to change the practice. This was seen in both the Netherlands and Italy (NL: 3,4,5,6: IT 5,6).

Rogers' (1962) theory of innovation diffusion relates to this. His theory of innovation diffusion classifies members of a social system into innovativeness; the degree to which he she is early in adopting new ideas. Only a small percentage of the people are innovators (pioneers).

According to the theoretic framework, right managerial structures can empower individual employees (De Vries et al., 2016; Kim & Chung, 2017). One of these innovators was demotivated by all the years of effort, but big resistance that he kept receiving (NL6). In that case, support from management could help to nurture the pioneers.

The efforts that individuals play in the system are described in proposition 5:

> *(5)… key individuals play an important role in the system*

DP: Does dike monitoring have an added value?
The added value of dike monitoring could be expressed in a Cost Benefit Analysis (CBA). In the end, it is about the flood safety, and if reconstruction of the dikes is cheaper and feasible, dike monitoring may never be feasible.

However, some initial CBAs show that dike monitoring has the potential to save many millions of euros (Rinsema et al., 2017; Stoorvogel-van der Horst, 2016). The water authorities can invest in the reconstruction of the more specifically identified weak parts of the dike, instead of whole dike stretches.

Nevertheless, this is on the long term, and the investment into the monitoring techniques has to be made at the start. Furthermore, there is a lot of uncertainty in the expected savings. However, with the help of instrumental dike monitoring unanticipated weaknesses in the dike could be found, that would have had the potential of causing a dike breach with enormous consequences (van der Meer, pers. comm.).

The added value of dike monitoring is found through the whole Life cycle of asset management of the dike. Within the normal lifecycle, for the evaluation, redesign and during the reconstruction, instrumental monitoring can have value. Different groups that work with the dike throughout its lifecycle can benefit from these instruments, but the value for other groups are not always taken into account when considering the implementation. By aligning all the different types of added value and the goals that the data can serve, the value of the monitoring can be increased (Koelewijn & van der Meer, 2018). It also means that the adoption of the monitoring can take place at the different stages, but can still serve different aims.

A strange effect of the monitoring is that the knowledge also brings along new responsibilities; if the data shows that something is wrong or strange, there should also be action taken (van der Meer, pers. comm.). These new responsibilities could also be holding the implementation back.

The investment is not only needed for the implementation, there are also resources needed for the further validation and development of the techniques. The first operational use will have higher costs than if the product is used by more end-users. Although initial investment is needed, the techniques could become less expensive in the future. Still, dikes are very heterogeneous, and each dike would need a different plan of action (e.g. NL4).

Italy
This research does not have detailed insights into the Cost Benefit Analysis for Italy. In the interviews, the preventive value that instrumental dike monitoring can offer was acknowledged (IT4). There is a lot of experience with monitoring for other hazards, such as landslides and debris flows (IT: 1,6,8). It was emphasised that the solutions should be sought in cheap measuring instruments (IT4). Given that data is mostly gathered in exceptional circumstances (IT: 1,3,6), Italy could benefit from a bit more structural measurements.

Still, for both countries the proposition is:

> *(6) …. Dike monitoring could have an added value; but it needs to be tailor made to the situation (different applications; goals; techniques)*

DP: What is making it so hard for these organizations to implement something new into (regular) dike monitoring practice?

Implementing innovation into dike monitoring practice seems hard due to organizational barriers. Here, I argue that this is because of the nature of the public organization and due to the nature of the current regime: the system of management of the life cycle of dikes is complex and with many actors involved.

Nature of organization
An administrative culture hampers innovation (de Vries et al., 2016). In both countries bureaucracy was mentioned to be an issue, especially when several permissions from different layers of management or government are needed to start a project. In Italy, this was explicitly mentioned to hinder innovation.

Another boundary condition is the political and public dimension of the organization: public authorities. This is very present in the way that is dealt with innovation (NL1, Nl4). Just like the literature states: some organizations have a risk-averse climate, or an administrative culture hampers innovation. Especially in the public sector there is an important drive to secure trust and legitimacy of the government, which may discourage trial and error (de Vries, 2016).

In this case, the water authorities are dealing with public safety, which gives them an enormous responsibility. They have to justify whether all their choices are in line with these goals. Continuing in the same way: reconstructing and heightening the dikes is the safe option, even if this will cost much more in the end. The risk-averse nature is something you also see at the level of the innovation characteristics: the water authorities do not easily accept the performance of an innovation (NL1, NL4).

Italy
In Italy the same dynamics are at play the different layers of government also make the responsibilities less transparent. Transparency of responsibility can improve accountability and legitimacy (Hill, 2013; Stoker, 1998 in Mostert, 2014). When one layer of governance fails, others may take over its function (Mostert, 2014).

This transparency of responsibility could work out two ways. Maybe because no one really has responsibility, and in case the situation turns out wrong, there is no one to blame. In that case it is easier to take the risk. On the other hand, the responsibility is shared and no one feels the responsibility to act. Also, the shared responsibility also enhances the bureaucratic culture, which is really in the way of the implementation of innovation.

In this regard the term ambidextrous capacity is interesting. *"Ambidextrous capacity is the ability of an organization to combine both exploitation and exploration, improvement of existing routines or services based on existing knowledge and innovation (March, 1991; Jansen et al, 2005)"* (Gieske et al. , 2016, p. 5).

The organization would have to balance the practices it is performing with exploration to new practices. The regular practice does not have to be replaced, but a healthy exploration into new ways of workings will improve the innovative capacity of the water authorities.

> *(7)...the innovativeness of the water authorities is low due to the nature of the organization and flood protection*

Nature of regime

Netherlands

The structure of organization for flood safety is organised and the dikes are managed is quite complex with many different parties involved within and outside the organization. Considering the Netherlands, each part of the life cycle of the dike, different groups are responsible. Starting a dike-monitoring project also involves laying the infrastructure for dike monitoring and the data, through all of these different parties. To do so, you need a long-term vision and plan, otherwise, it will get stuck somewhere in between (e.g. NL6). You need to make a long plan, think about everyone that is involved, and get them on board. To initiate such an endeavour takes a lot of effort, especially if you do it alongside your normal task set. However, if the long term is not secured, projects could fall into a silent death without follow-up.

This complex project management was not identified as a barrier in the theoretic framework, but definitely is a complicating factor for (successful) implementation of innovation. A pilot is easier; it is only a one-time thing and not everyone is involved. The regular practice does not have to change directly when performing a pilot (innovation manager Hoogheemraadschap Delfland, pers.comm.)

Within the water authorities, a special role is dedicated to the dike operators. They have a lot of power since they are the ones that should give permits (NL5, NL6). They have responsibility of the dike in the field. It is important to take them along in these processes of change.

In the Netherlands, other stakeholders to take into account are the residents that live around the dike. A high importance was given to comfort the residents that live around the dike body (e.g. NL6). Much effort is put to accommodate the residents.

All in all, the complex nature of the management of the life cycle of the dike and the collaborations and long-term strategy needed to change this is a complicating factor for implementation of innovation into dike monitoring practice. The proposition made here is:

> *(8)... the innovativeness of the water authorities is low due to the complex nature of the regime in which dikes are managed*

Italy

For Italy, the research has detailed insight into the exact asset management of dikes and the specific collaborations needed. Therefore, proposition 8 cannot be supported for Italy, and this could be recommended for further research. However, another factor had a more immediate presence: the limited amount of resources available (IT: 3,7,8,9).

> *(9)…. In Italy the most immediate constraint for the implementation of innovation are the limited availability of resources (both financial and capacity of employees).*

DP: When is the technology developed far enough for implementation?

Different stakeholders perceive the performance as well as the development stage of the technology differently. The general perception of the employees of water authorities is that the technologies are not yet in a stage of application on the big scale (Twynstra Gudde, 2018). However, other parties say that some technologies are not innovation but state-of the art (Zomer, pers. comm).

Maybe the truth is somewhere in between, but there is definitely a difference in perception. The trust in the technology could be due to a knowledge gap or lack of experience, it should be tried to know what it can offer (NL: 4,5).

It points towards an interesting spectrum: when is technology developed and proven enough for the water authorities to take them into their practice? Most technologies have been validated in LiveDike experiments like IJKDIJK, so when the added value is clearly seen, and there is money, what is still holding the stakeholders back to apply it? Of course, the decision makers that carry the final responsibility have a different perspective of the risk. It is important to have them involved in the experiments and performance tests.

On the other hand, the development does not only have to deal with technical performance. The way it can be used is also important, like the accompanying ICT, knowledge on how to put it in the field, the maintenance, etc…. These types of knowledge are also very important and are not captured through operational testing only.
To summarize, there is limited trust, and increasing the certainty of performance through operational testing could help. Also, to increase the trust in the performance, there are knowledge steps to be made to make the end-users aware of the status quo. In this regard, first-hand experience is mentioned to be the most desirable (NL: 1,4,5).

> *(10)… The performance of innovations in dike monitoring are not easily trusted by the end-user*
> *(11) knowledge from first-hand experience could is desired*

DP: How is the DOMINO project positioned within the field of dike monitoring? Does it have added value?

In this research, the starting point to explore the field of dike monitoring was the DOMINO project, in which novel optic fibre pressure sensors are developed. The first reaction to the novel optic fibre pressure sensors by those interviewed at water authorities was positive mostly due to the fact that pressure measurements are always useful with respect to the asset management of the dike. And even as quasi-distributed pressure sensor it could give many more data points than are assembled now. They can directly feed into the management phase, the evaluation phase and the redesign. Pressure measurements could feed directly into the calculations already used. The longitudinally distributed data points could be used for a better insight into the conditions of the dike, and also for research purposes (NL: 1,6).

Another application would be to use the optic fibres as the detection of failure as a real-time early-warning system of for example piping or macro-stability. In this case, accompanying software is crucial for the interpretation of the data, and tipping points for alarm would have to be derived. There would have to be regulations on what to do with the different alarms.

In both cases, the positioning of the cables is very important, and monitoring strategies have to be laid out (NL8). This is something that should be done on a case-to-case basis.

For the water authorities, it is most interesting is to use optic fibres in combination with other instruments. It is the combination of the different sources of data, with different time and spatial scales that helps to understand the conditions of the dike: "one sensor is no sensor" (e.g. Wouter Zomer, pers. comm.). The water authorities would have to decide for each dike stretch what would be the most interesting combination of monitoring equipment, and work from there. The demand for DOMINOs optic fibres is thus always to be considered in the light of other techniques, and does not stand by itself.

Considering that them implementation of optic fibres does not stand by itself, a shift in mind-set towards dike monitoring within the water authorities would also benefit the implementation of the optic fibres. This can be seen in the light of network externalities: the innovation becoming more valuable as the number of users increases (Kim & Chung, 2017), an increase in dike monitoring may also develop the needed infrastructures, for example for data management, or expertise within the field with

regard to monitoring. The way of working within the authorities might also change to a more receptive attitude towards monitoring techniques.

As for the innovation characteristics, a main barrier is the installation of the optic fibres within the dike. There were variable perceptions at the stakeholders interviewed about this (NL: 1,5,6 &IT: 3,4,5), mostly considering it to be very risky, since it intrudes into the dike body, as well as expensive/labour intensive to install it. However, one of the operators did not see that many problems with this; the dike is opened from time to time for either reconstruction activities or other cables and pipes that have to be installed (NL2).

Another barrier is the cost of the optic fibre system. In this case, it is the interrogator that has high costs, but this could change over time (IT7).

All in all, the novel optic fibre pressure sensors of the DOMINO project still have a long way of development to go, with regard to their performance, the business plan, as well the fit into the current regime, proposition 12:

> *(12)…The novel optic fibre pressure sensors of DOMINO still have a long way of development to go before implementation into regular practice, from operational testing, to a good fit into the work processes*

2.8.2 Discussion Theoretical Framework & Conceptualisation

.In Chapter 2.2 the theoretical framework was presented that was the basis for the empirical research. In this part of the discussion the theoretical framework is evaluated. Did it hold? Were there any unexpected factors?

There were a few things found in the empirical research that were not so explicit in the theoretical framework. On the organizational level this was the project organization that missed: the way to make the innovation fit within the working processes. This was not explicitly mentioned in the framework, but it was found one of the main barriers from practice. The organization has a certain innovativeness, which is partly due to the organizational culture and attitude towards innovation, and partly the structure of the organization and regime that simply can take up innovation easily or not.

On the individual level within the section psychological factors, the main barrier found in the empirical research was fear. This was not named in the theoretical framework yet.
Also, on the individual level, there was a factor personal innovativeness, in the framework it said: “creative and autonomous individuals can be key to break through a risk-avers administrative culture” (de Vries et al., 2016 & Kim & Chung, 2017). In practice it was found that certain key individuals could be appointed, that indeed bring about change. This could be more clearly part of the theoretical framework.

On the individual level, compatibility turned out to be a broad concept. Not only is it the fit to the beliefs and values of the organization (Kim & Chung, 2017), in practice it was also a fit to the current system. Part of compatibility was the cost of the innovation and the benefit analysis. The cost of the innovation could be more notably part of the framework, given that in certain contexts, the cost can be a limiting factor for implementation.

On a more general level, the framework helped to guide the semi-structured interviews, and did allow for a broad range of factors to be identified. In later conversations, workshops attended, and for example the sessions held for part III of this research (Chapter 3.4) there did not seem to come up any new factors that were not covered by the framework yet.

Later, in Chapter 2.7, after further analysis of the key concepts a new framework was presented. The conceptualisation made here helped to capture the essential process and feedbacks, and forced the researcher to make assumptions and choices between the different concepts. The drivers and barriers from theoretical framework, combined with the empirical findings were now regrouped into certain concepts. The added value here is that there were also some links identified between the concepts. For future research it would be interesting to build on this framework and evaluate its value for different cases.

2.8.3 Discussion research methods & Limitations

The main purpose of Part II of the research was to get a view of drivers and barriers for the implementation of innovation that applies to this case study. The research methods should be able to answer these questions.

Systematic literature review
The theoretical framework was composed with the help of a systematic literature review. Only review articles were selected, those that gave on overview of the different factors influencing implementation of innovation. This helped to get a holistic, broad overview of all the drivers and barriers that could be applied to our research. We could have also chosen only one article’s framework as a basis, but by combining several articles they served as a validation as well as a completion to each other.

As a method, a systematic review is praised as a transparent and replicable way of doing literature research. However, it also poses limitations to the freedom of inclusion of articles, by only taking into account the articles that are found through the thoroughly chosen keywords. Since you would never be able to investigate all the combinations of key words and all search engines, you will end up with a certain selection of all possible articles, and might miss out on interesting articles found through different channels.

In this case, elaborating the search with snowballing would not have led to many other suitable articles, since we were specifically looking for review articles. The references of the articles used were not review articles themselves.

Of course, the search was done through several iterations to perfect the key words. In the end, two sets of key words were used. These did give us articles that fitted all the eligibility criteria, and helped us to answer the first research question.

The factors highlighted in these articles showed a great deal of overlap. Although they addressed different sectors, the binding criteria of innovation; public, dealing with the physical, long-term, complex, multiple-actors helped to guide us to the right articles. Sometimes, the articles different used different terms for similar processes. To find the overlap a synthesis was done in Excel, and the terms that seemed to apply most to this study were chosen.

Semi-structured interviews the Netherlands
Compared to quantitative research, qualitative research methods are more open-ended and with more emphasis on the interviewees’ own perspectives (Bryman, 2015). The decision to use qualitative research methods fitted the research aim and research question.

Within different qualitative methods, semi-structured interviews gave the chance to explore the different topics of the research framework, but not fixating the issues too much. Compared to for example a focus group, the interviews allowed for the topics to be explored in depth with the interviewees.

All interviews were held face to face. This had the advantage that body language could be taken into account during the conversation, and could also be used as cues for follow up questions. During the interviews, we often went off topic to explore the topics brought up by the interviewee. But the list of topics provided a checklist and was also used as such.

During later interviews, the researcher sometimes brought up issues from previous interviews. This could steer the interviewee into a certain direction, or a certain bias. On the other hand, it provided valuable cross check. To include ideas that were given after the recorder stopped, they were noted down and added underneath the transcription (with permission of the interviewee).

Sample
The sample was intended to include people working with innovation in dike monitoring from different perspectives, from those who are doing the work from behind the desk (calculations and policy), those in the field and from strategy. They were from three different regional water authorities.

All interviewees had a slightly different background or position. The main result of having different organizations was a view on different factors that play a role on the organizational level. All had a different organizational structure and management, resulting in slightly different challenges. The interviewees showed to be aware of these differences, calling out to things they

knew about the other water authorities, or how that compared to their practice. With this small sample and different positions it is hard to draw strict conclusions of differences in practice of water authorities. However, it does give a broader insight into different dynamics that can be encountered within different water authorities, and examples of management and organization that were adding towards or counter acting implementation of innovation.

The final sample with regard to the end-users was also influenced by factors that could not be controlled. Despite great efforts taken, not every contact was materialised into an interview. The interviews were stopped when a certain degree of information saturation was found, based on grounded theory. Also there was a time constraint. To find the potential interviewees at end-users, snowball sampling was used with two starting points. One of the interviewees was met at an event about innovation in dike monitoring.

A small bias can be noted with regard to the sample. The majority of the interviewees had an initial interest in innovation above the average level of the employees at water authorities. These were easier to find (for example at the network events) and also be tempted to talk about this topic than those not interested. In their recommendation of people to talk to they mentioned new names of people that had dealt with the implementation of a particular innovation. However, those with experience with innovation have experienced barriers first hand so have a lot to tell about these dynamics. The interview with someone from the strategy level of an organization was very helpful to put the 'implementation climate' of the organization into perspective.

In this research, the main stakeholders were defined as the technology developers and the end-users: water authorities. Over the course of the research, and through additional events, the role of other stakeholders and actors became clearer. These perspectives were not neglected and informal conversations helped to understand them, however, no official interviews were added to the research. In retrospective, a more thorough cross-section of those involved in dike monitoring would have been valuable and this can be recommended for further research.

Semi- structured interviews in Italy

The interviews in Italy were conducted in the researcher's non-native language. All interviews, besides one, were conducted in English. One interview was in Italian with the help of a translator. This had certain consequences for the interviews. Even though the interviews lasted around one hour, just like the Dutch interviews, the transcripts of the interviews are almost half of the size. The speed of talking was much slower. On the other hand, there were nearly as many codes in the Italian transcription as in the Dutch sentences. It could be that a similar range of topics was touched upon with fewer words. For the non-English interview, working with a translator also has a higher risk of information to get lost, through misinterpretation, or mistakes, or small hiatus' in memory.

The Italian hosts made the interview appointments with people within their network, based on the research proposal. The interviewees were people who had already built solid career, and were in high positions in their organization. Two out of the three stakeholders interviewed were directors of their organization, so they were talking from a very high-up point of view. Therefore there are some blind spots in the research, for example: what is the freedom for employees working in lower levels in the organization to take initiative to implement innovation (from their perspective)? This is a limitation of the case study; a longer stay with more interviews could have helped to fill in the gaps.

Being aware of this limitation in the research due to the sample is a first step in overcoming it. The conclusions about the drivers and barriers in Italy are mostly made on a societal and a generic organizational level. The directors of the organization did provide an interesting look into the overarching vision of the organization, which they have the power to implement into the organization.

Though the interviews were held with only three stakeholders from three organizations, other experts attended all these interviews. The interviews therefore were more or less group interviews, with a focus on one person, but with affirmations from multiple sources. All the interviews were debriefed afterwards with the Italian supervisors. These debriefs were helpful in putting the answers into perspective. This also helped to overcome cultural differences and gaps in the knowledge on the background of the researcher.

Additional sources

For both countries, additional sources were used. However, for Italy, there was both a time and a language constraint (given that all sources shared were in Italian), so the results are mostly based on the interviews. This is a limitation to the extent of this case study.

In the Netherlands, several events of both STOWA and Netwerk Dijkmonitoring were attended. Many interesting presentations added to the results, as well as extra reports and references that were shared. These sources also allowed for a bigger picture of the dike monitoring world, given that the interviews were only held at three water authorities, and not with other actors, such as companies and consultancies.

Unfortunately, not all of these sources have found its way into the report, although they did add to the understanding of the complete picture of the dike monitoring practice. The case study included a broad range of topics, and each of the drivers and barriers in the framework could have been a research by itself. Therefore, time limits forced a pragmatic research approach.

Analysis and synthesis the results

All interviews were recorded and transcribed, except for one where no recording was made. For this interview, notes were taken during the conversation; and the findings were checked through follow-up email. The analysis was done in Nvivo software, which helped to make sense out of the large piles of data. To not rely on the coding categories solely, the interviews were also analysed by hand, and during the analysis these printed interviews were read over and over. This way, there was a sort of 'internal catalogue' in the brains of the researcher that together with the software helped to sort the data.

Method case studies & Comparison

The case studies in Italy and the Netherlands reach to a different depth. Also, there is a difference in the amount of information sources used. The case study in the Netherlands is based on many more additional sources, and has more interviews within the water authorities. The case study in Italy is mostly based on interviews. The questions that remains is, could the case studies be compared?

Both case studies provide answer to the research question: How are the drivers and barriers perceived by the main actors/stakeholders in this field in both the Netherlands and Italy's Po Valley?

Given that in both studies, it is possible to identify drivers and barriers on all the different levels of the framework, these results can be compared. To prevent taking conclusions on things that were not known in both countries, the comparison is taken to the depth of the least elaborate case, which would be mostly the Italian case. Since there was not a lot of information about the dynamics of the organization in Italy, as well as the drivers and barriers on an individual level, there was not a lot of ground for comparison on the specifics of these levels.

The comparison and contrasting of the two cases was found to be valuable for the understanding of both case studies. Furthermore, it helped to assess the relative importance of some of the factors. This also added to the generalizability of the conclusions.

Analysis key concepts

The analysis to identify the key concept forced the researcher to make assumptions and choices, therefore making the impressions of the researcher explicit, and having to take a helicopter view on the results. The conceptualisation gives an impression of the system of dike monitoring, but in a generic/abstract way. It is based on the empirical results of the case studies of this research, but it was stripped down until the most essential concepts remained. Still, it aimed to represent the reality of dike monitoring practice. As a method, a limitation is that it is very much up to the interpretation of the researcher. "*Modeling human decisions and their environmental consequences in ABM is still a combination of science and art*" (An, 2012, p.32). To overcome this limitation, the conceptualisation references the sources from the empirical research.

2.9 CONCLUSION & RECOMMENDATIONS

Here, the conclusions as well as recommendations of part II are presented.

2.9.1 Conclusion

With the help of a theoretical framework and empirical case study research, the dike monitoring practice in both the Netherlands and Italy's Po valley was explored. In sum, it is observed that the trend is that the dike monitoring practice is slowly going towards application of more instrumental dike monitoring techniques. However, in both countries, the implementation process is not straightforward, and a transition towards the use of more dike monitoring still needs to overcome many hurdles. In both countries, similar dynamics were encountered, but with tighter boundary conditions in Italy, where especially the available financial resources leave little room for manoeuvre.

In both countries, a growing awareness of instrumental dike monitoring is noticed. The urgency to change the existing flood management is increasing and expected to keep increasing, but is not pushing towards action yet. Insights gained through instrumental dike monitoring have the potential to save money, in both countries. Also, key individuals act as game changers; with their enthusiasm and persistence they play an important role in the implementation landscape.

In the Netherlands the water authorities are found to have a conservative and risk-averse nature, which works against innovation. Also, the disconnection between different parties that work on different phases of the life cycle of the dike is a complicating factor. Money is not always directly allocated to innovation or accessible to employees, however, it is not such a restriction as in Italy.
In Italy, the water authorities are also considered to be risk-averse and conservative, furthermore the practice is found to be very bureaucratic. Additionally, responsibilities regarding flood management are spread amongst different authorities. This stands in the way of new initiatives, and also gives even more bureaucracy, cross-organization. The minimal financial and human resources limit the options to implement innovative practices. The exact regime or system of asset management of the dikes is not known, and therefore, no conclusive word can be written about the system.

The performance of an innovation is crucial for its implementation, and is not easily trusted by the end-users. Operational testing is very important in this regard. A lack of knowledge is identified with regards to the available technologies. Also, there is a need for organizational examples: experience with the actual implementation of these techniques in practice.

As for the novel optic fibre pressure sensors developed by DOMINO, they have potential for use in practice, but there is still a long way of development ahead. There are some requirements to be met, such as performance, as well as a decrease in cost. The implementation of these optic fibres should be seen in the light of the all the other monitoring techniques since the implementation would also benefit from a higher commitment from the practice towards the use of monitoring techniques in general and the choice for the required monitoring is done based on the needs of the dikes on a case to case basis.

2.9.2 Recommendations practice

Within the research, several drivers and barriers were identified that influence the implementation of innovation in to dike monitoring practice. Instrumental dike monitoring has the potential to improve the flood protection, by increasing the safety as well as by a reduction of cost needed for reconstructions, but implementation into regular practice is still limited. To stimulate the implementation of instrumental dike monitoring, the following recommendations are given.

The recommendations are listed based on the key concepts identified in Chapter 2.7 and the propositions that were put forward in the Discussion of Chapter 2.8.

Urgency

> *(4) ... the urgency and need are slowly growing, however a real push to action is missing*

. Urgency could be influenced through national policies. The pressure from national regulations to implement could give the push to action that is still lacking. Regulations could prescribe a certain degree of data coverage of the dikes.

Awareness/ knowledge / experience

> *(11) knowledge from first-hand experience could is desired*

. In the Netherlands, several network events help to spread the awareness and knowledge on dike monitoring. The advice for these events is to focus on best practices, as well as on organizational examples of how the implementation process was managed.

. Simply put, the water authorities should just start to implement instrumental dike monitoring. This is the way forward to get more knowledge on the operational and organizational aspects, as well as to gain more insights into the performance and cost-benefit.

. Another advice, that addresses a lack of overview of the available techniques, is to create a web or mobile application as an overview of the available technologies. This tool could help to give help the decision making between different options, by providing information on for example different uses for failure mechanisms, qualities, phases of implementation, monitoring goals, installation requirements and organizational requirements.

Innovativeness

> *(7/8)...the innovativeness of the water authorities is low due to the nature of the organization and flood protection and due to the complex nature of the regime in which dikes are managed*

. It would help if more organizations would start with the application of instrumental dike monitoring, for example in controlled set-ups. This could lead to a slow change in the current regime of dike monitoring.

. A long-term strategy on the board level of a water authority with regard to dike monitoring could be a push for reorganization of the system and a commitment to change. The strategy would also be a signal to other stakeholders to move into that direction.

. A pilot can be a safe and small environment to start with, but for implementation into regular practice, the complexity of the system has to be overcome. The goals should be clear for the whole organization and for everyone who is dealing with the dike in the whole life cycle.

. In that regard, it is important to make sure that everyone involved in the lifecycle of the dike can have access to the monitoring data for their specific purpose. ICT can play a key role in data availability and transforming the data into usable information. It could also play a role in the added value making clear to all those involved.

. To get from a pilot to implementation into regular practice, it is good to keep this greater goal in mind during the process. Having all the stakeholders and employees within the organization involved from the start, could help to get everyone acquainted with the new method. Also, it would help to already find proper ways to fit it into the regular practice later-on.

> *(5)… key individuals play an important role in the system*

. Key individuals play an important role in the agenda setting and pioneering of innovation, which was also encountered in this research. For organizations, it is important to acknowledge their role and creating an environment in which the employees are empowered.

Resources & Decision power

> *(9)…. In Italy the most immediate constraint for the implementation of innovation is the limited availability of resources (both financial and capacity of employees).*

Plus, in the Netherlands, resources are not so much a limiting factor; money is not always directly allocated to innovation or accessible to employees

. An organizational example as seen in Hoogheemraadschap Delfland is to make the availability of financial resources and support more accessible with an innovation fund. This is a top-down initiative that can help to materialize bottom-up ideas. It also reduces the bureaucracy involved to get something off the ground.

Added value innovation

> *(6) …. Dike monitoring could have an added value; but it needs to be tailor made to the situation (different applications; goals; techniques)*
> *(10)… The performance of innovations in dike monitoring are not easily trusted by the end-user*

. With regard to the added value, it is advised to do further research on Cost Benefit Analysis of different monitoring strategies and the different technologies.

. Operational testing is very important to improve the performance of technologies. It is important to involve different stakeholders in this process, as well as employees from different layers of the water authorities, to make the results tangible and build trust.

. Another suggestion is to work with quality marks with regard to the (un-)certainty in performance. The different stakeholders should define the quality marks together, since the perception of acceptable performance level may vary.

With regard to the technology developers (DOMINO)

> *(11)…The novel optic fibre pressure sensors of DOMINO still have a long way of development to go before implementation into regular practice, from operational testing, to a good fit into the work processes*

. The innovation is not just the instrument, but also the related data management/software. It is important to consider how the data will be used and to design accordingly.

. Apart from the technology and software, the organizational fit is also very important. It is a responsibility of the developers to work alongside practice from an early stage. Stage gating tools such as the one developed by the BRIGAID project (Sebastian et al., 2016) offer practical guidelines for this.

PART III

COMMUNICATION AND COLLABORATION RELATED PROBLEMS & INTERVENTION

The prior results provide an understanding of the factors that make the implementation of innovation in dike monitoring come about, or, due to which factors it does not come about. Having arrived at a thorough understanding of the system through descriptive analysis, it is time to get the hands dirty...
Is there a way in which the practice can be steered towards change?

The research now arrives at the second diamond, where the focus is on communication and collaboration. The research question related to this part is: *How can the implementation process of innovation in dike monitoring be influenced with a communication or collaboration oriented intervention?*

The outcome is a workshop setup that is designed for both the product developers and the end-users. The aim is to help them to embark on a successful implementation journey together.

CONTENT

3.1 METHODOLOGY PART III

After closing the first part of the research, the aim is to take a next engaging step and to try to positively influence practice through the design of an intervention. Here, the methods that were used to come to the design and the structure of this part of the report are laid out.

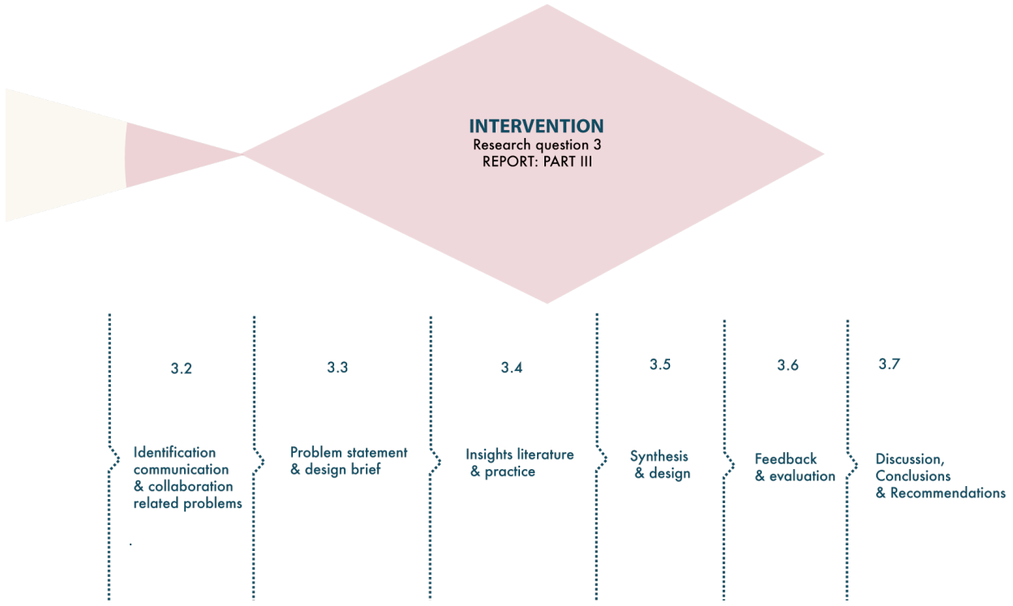


Figure 21 - Research framework and structure part III

Double diamond
The design methodology of this research was based on the double diamond of the Design Council (2015), as described in Chapter 1.3. The results as presented in part II were used as input of this part of the report. Therefore, this part starts with a converging step, followed by the second diamond (pictured in Figure 21).

Identification communication and collaboration related problems
First, all communication and collaboration related problems were identified based on the prior research phase. In the interviews, special attention was given to the identification of communication related problems and possible solutions. Then a decision was made on which of the different sub problems or combination of sub problems the focus was put. This was done by the researcher, with the help of a matrix that was based on relevance and practical criteria.

Problem statement and design brief
The aim of this divergent phase is to come to a single design goal, and then to select the appropriate form in which we can operationalize the design. A design goal was formulated as one sentence. Design criteria that relate to the design goal were composed based on the prior interviews and a follow-up conversation with one product developer and one employee from a water authority. A list of ideas and forms was composed based on the results of the interviews in which an intervention was discussed. These forms should be able to operationalize the criteria into practice. The form was selected based on the number of criteria met.

In anticipation of the results presented in the report, the outcome of this cycle was a decision to focus on a brainstorm/workshop that allows the end-users and developers to reflect on the implementation process and commit to certain actions.

Insights from literature and practice
To be able to materialise the design, insights from literature and further input from practice were sought (Figure 22). The literature search was aimed to find a review article on the design of innovation or implementation workshops. The literature was found through a Scopus search with key words 'workshop AND design', and 'workshop AND innovation' limited to review articles. Based on title and abstract, 19 articles were selected, and based on article screening one article was chosen the most appropriate. The literature provided a framework and design elements. This framework was also used to structure the insights from practice. The insights from practice were assembled on two occasions.

During an event of Netwerk Dijkmonitoring in the Netherlands, a group brainstorm with experts from water authorities was held to identify important elements for the design. They were asked for input about the aim of the workshop, the form, ways to create commitment and the exact content.

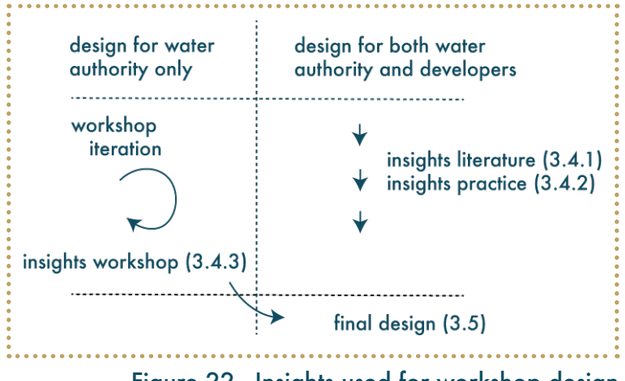


Figure 22 - Insights used for workshop design

Parallel to the other sources, an opportunity came up to organise a workshop at the water authority of Delfland. Given that the attendees were only employees from the water authority, the design goal of the workshop had to be altered slightly. However, insights from this workshop could still be used as input for our final design. It was evaluated with the innovation manager of Hoogheemraadschap Delfland.

Synthesis and final design
All insights were synthesised into a final design. This was an iterative process, with different brainstorm sessions, both alone and with a fellow student. In this stage, the concept was elaborated and crafted to the detail.

Feedback and Evaluation
To evaluate the relevance of the designed workshop, an outside expert from Deltares working with stakeholder readiness was consulted, midway in the process. This feedback could still be included in the final design.

A small focus group with three students was held in which the concept was evaluated for its use and in order to find flaws in the workshop. The students had a background in Water Management, Hydraulic Engineering and Science Communication and Industrial Design (master: Design for interaction). The mixed backgrounds of the students were consciously selected to cover different perspectives related to this workshop, and thus be able to capture a wide range of feedback. Based on the evaluation, ideas for further development were listed.

Discussion and conclusion
Finally, the results and research process are discussed and a conclusion of this part is given.

3.2 COMMUNICATION AND COLLABORATION RELATED PROBLEMS

First, the drivers and barriers in which communication and collaboration play a role are identified, so that later we can come to the design of an intervention. Both the technology developers and the potential end-users at water authorities were specifically asked in which ways communication and collaboration influence implementation of innovation. In this chapter, this information is synthesised.

3.2.1 Drivers and barriers

Many challenges linked to communication and collaboration did arise during the research.
Some communication related problems appear in different settings and moments in the implementation process and apply to both the Dutch, as well as the Italian context.

Language barrier
One of the most mentioned problems is a 'language barrier'. This is due to people having different backgrounds and working in various disciplines, each having a completely different perspective and jargon. One of the people working at a Dutch water authority said:

> *"We have lawyers here, people from the purchasing group, as well as a political board. It is a political and technical organization at the same time. (...) I see that it can really cause problems when people are stuck in their jargon." (NL3)*

It was also mentioned by several of the researchers, language is a barrier amongst them as well.

> *"It was really interesting, that meeting, because we are six experts in different fields trying to communicate in the same language. So what is for me normal language is maybe not well known, or what is for them easily understandable language about fibre optics... But still, I think these meetings are super important. At the end of the day, everybody wants to get something out of these experiences." (NL8)*

As one of the researchers in Italy said about a previous project he had worked on:

> *"When I arrived there, I felt the problem of communication, between the people that look from geo-hydrological view, and those with a sensor development view. Different dictionary, different needs, the activity needs to be triggered by different elements." (IT7).*

One of the Italian stakeholders mentions the difficulty of understanding one another during the meetings that he has with local citizens and municipalities:

> *"I have difficulties to understand them, they have difficulties in understanding me. These are very difficult meetings. (...)" (IT5).*

Different interests / motivation:
Another differentiating factor is the range of motivations or interests in the project. One of the researchers, when talking about working in an interdisciplinary team:

> *"Maybe the way I install the sensors is not the best way for them to test the sensitivity of the sensor. So we need to get to a common agreement. (...). We have different backgrounds and different interests. As a scientist all of us want the project to be successful, but what you want to prove and to publish is different from each point of view." (NL8).*

The developer's and the organization's perspective also differ. Researchers need to ensure new ways of funding their research, driving them into different directions or applications of their work. Also, they will think from the perspective of their specific product, whereas the potential end-user wants the best product from a range of all options, and wants to choose the most suitable of all those options (NL1).

Short-term perspective; lack of overview
From a meta-perspective, it is noted is that the different stakeholders often do not think about the whole implementation process from start to the end-goal. They tend to think about the steps that lie within their own interest, or the tasks that have priority for the short term.

Misperception
Stemming from different backgrounds and different points of view, misperceptions are nearly inevitable. One of the Italian researchers mentioned that people have the perception that with hydrology and monitoring systems everything is possible, whereas in fact, *"hydrological stuff is not deterministic, what you can do, is collecting as much information as you can. But it is still not enough to provide the picture. Not enough to prevent or even to predict. It is hard to express this to people or to stakeholders."* (IT7)

Knowledge gap
From the perspective of the Dutch water authorities, several knowledge gaps were mentioned. One of them explicitly states the lack overview of all monitoring options: *"I think that we do not know about all the possible options."* (NL1).

Even though some technologies may be proven to worth, it is still hard to know how to set it up within the organization.

> *"That is often the hardest step, to pick it up within the organization and to get it off the ground. Where do you get the money from, where do you get the people and the time to further deepen your knowledge? Which parties did you use, what did the board think about it?"(NL4).*

On the one hand, this can be gained with a pilot project, but also from example stories of other water authorities (NL1,4,5). Also, there is a lack of knowledge about the technical specifications and possible risks are unclear (NL4).

Uncertainty/fear/trust
Sometimes fear gets in the way. This is for example mentioned about the fear of machine learning with data and artificial intelligence. *"They find it a bit black box like. (...) Now it's changing, people see that everything is automatized."* (NL6) A similar process is mentioned about using fibre optics as sensors, since it is very new, people do not understand it so well yet (IT10). It is noted that the decision maker wants to minimise the uncertainty. The acceptable uncertainty in performance or the perception of this performance is different for the end-user and the developer.

Network
The network can be a driver or constraint for the implementation process. The word spread through the network and collaborations are set up through the network. In the Netherlands, there is not so much contact between the universities and water authorities on a regular basis (NL1, NL4).
Within the different authorities and companies, there are several formal network groups that organise events and workshops to share knowledge and bring people together (NL1, NL4,

NL6). For the researchers working on fibre optics in Italy, it is harder to establish lasting bonds with the authorities since the applications of the optic fibres vary constantly. For the applied researchers this is easier, since their work is mostly used for the same types of applications (IT11).

Lack of skills/person's characteristics
On an individual level, several skills that have to do with communication are mentioned. This is this ability to translate different 'languages' (NL:3,6), but also the ability to convince people to do something (NL6). It is also about courage and perseverance.

Time constraints
For both the sides of developers and employees of water authorities, a lack of time is a constraint to the possibilities to collaborate (NL:4,6). Even though people are willing to collaborate, there is not a lot of time, so it does not happen that much.

> *"Ideally you just start working together. Which means, you have a project and you really work together. But this is not feasible in practice, because people from different organizations are involved in the same project, you can have some calls, contact but it's not the same building working together. You are not just working on a single project, you have to survive and keep many different projects at the same time, and in some sense you're not able to work together." (IT11)*

Also for other researchers, the DOMINO project is not the only occupation, and only part-time (NL7).

Innovation: compatibility
A risk of too little communication between the technology developers and the end-user is that the product does not match the needs of the stakeholder.

> *"It's very tricky to think that you have a really nice idea, and start working on it, but in the end the customer is not interested at all. That's a very big pitfall of technicians in general." (NL6)*

3.2.2 Implementation journey

To provide an overview of the results, the results are visualized in a scheme, on the next pages of the report (Figure 23). The different actors are represented in different fields and are set out to a time dimension. The implementation follows a certain path, and in all interactions, 'touch points' in time, certain barriers (or drivers) are could play a role. For all these barriers one can link different solutions that would be suitable for that specific point in time.

Time dimension
The development and implementation of innovation is not a static process. The chances of later implementation can be influenced from the very first start of the idea until the implementation into regular practice. In different stages of development and implementation, different communication related problems are encountered.

KNOWLEDGE GAPS IN DOMINO

Some knowledge gaps are mentioned that are of importance the research team. Especially in the development process, the knowledge can be crucial. In this regard, one Italian researcher speaks about several types of knowledge and how it applies to the DOMINO project:

"Known knowns, is about something you know you know. Known unknowns, this is the part you know you don't know, and that could trouble but you know there are some issues. Like the way in which the underground will interact with the sensor. The principle is telling me that the water is flowing inside the sensor and it will be able to detect pressure measurements, the pressure gradient. But I know that I never saw this in practice and so, I am sort of trusting. Then there is the category, the unknown unknowns. Here, you don't know what could happen. You simply cannot imagine what could happen in the field. Then there is the strange one, the unknown knowns. Something you don't know you know. These are usually related to missed evaluations, plain errors, something you should have expected. Hopefully, there aren't any. We had all these meetings and discussions. Just to see these unknown knowns. So that everyone is on the same track and you are not neglecting anything." (IT11)

Box 5 - Knowledge gaps in the DOMINO project

Field of actors
The field of actors is bigger than solely communication between developers and end-users; there is also a field of external actors that influence the implementation of innovation. Communication problems exist in all possible links within all different groups.
The scheme gives an overview of the communication and collaboration over time and in which settings. It helps to grasp the whole process from idea until implementation into regular practice.

3.2.3 Summary

In this chapter different communication and collaboration related barriers were identified. Examples of these barriers are limitations in terms of language, jargon, or perspective. Different interests can also play a role. Furthermore, the long term perspective is often neglected. Challenges also arose due to knowledge gaps, or fear of a certain innovation, or change. Communication skills are important but sometimes lack. From all sides, the available time is limited. The risk of not communicating is a product that does not match the needs of the stakeholder.

These barriers are encountered across different groups of stakeholders and collaborations, and in different moments in time, from the very first idea until the adoption and implementation stages.

In the next chapter, a set of sub problems is selected in order to come to the design of an intervention that is aimed to help overcome these barriers.

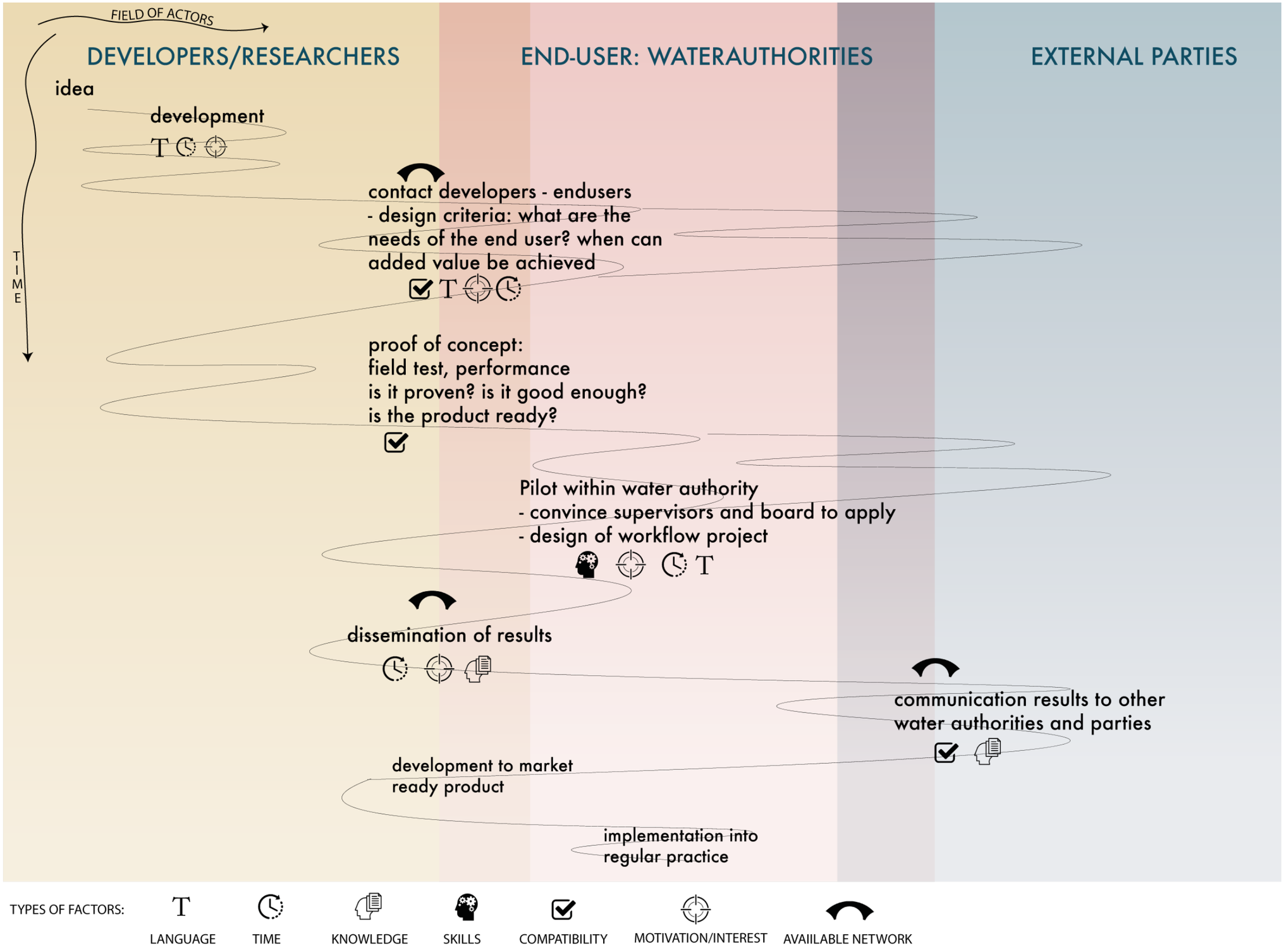


Figure 23 - The implementation journey

3.3 PROBLEM STATEMENT & DESIGN BRIEF

Now that there is an overview of the implementation process, the aim is to take a next, engaging, step and to try to positively influence practice. Since it is impossible to influence all issues over the whole process, a smaller and more tangible sub problem has to be selected. In this chapter, we work towards the selection of an appropriate design form.

3.3.1 Problem statements

Based on the prior analysis, several sub problems were identified. These were evaluated with the help of criteria based on practical criteria and their relevance. The elaborate description of this process can be found in Appendix D.

Practical criteria are the available time and resources; the intervention should be feasible to influence practice with relatively low budget and within a limited time frame. The intervention should also be related to the research question: it should be able to influence with communication or collaboration. For relevance, the criteria are that the intervention should be applicable to both the end-users and developers, and have a focus on interaction.

The outcome of this filtering step is two sub problems, namely:

1. Lack of time and commitment to communication and collaboration between developers and end-users
2. The different stakeholders appear to have a limited view and tend to forget about the long-term and bigger picture.

Design goal

The two problem statements are merged into one design goal, presented in box 6.

DESIGN GOAL:
To design an intervention that allows both end-users and developers to oversee the bigger picture of the implementation process, while enabling them to reflect and act up on their commitment to collaborate.

Box 6 - Design goal

3.3.2 Ideas & forms

A list of ideas and forms was composed of the results of the interviews in which an intervention was discussed. These forms can be found in Appendix D. Some examples of possible interventions were:

. brainstorm early-on in the process
. workshop
. game
. event
. 'export' and update concept innovation lunch
. stage gating tool for researchers
. video
. positive stories/best practices

The form was selected based on the number of criteria met. The intervention should be able to operationalize the criteria into practice.
The design criteria were composed based on the prior interviews and follow-up conversation. It involved practical criteria, such and time and resources to develop an intervention, the relevance, the impact it can make, as well as some desired features by stakeholders. The form selection is elaborated in Appendix D.

The outcome of this cycle was a decision to focus on the design of a brainstorm session/workshop that allows the end-users and developers to reflect on the implementation process and commit to certain actions.

3.3.3 Summary

By filtering the different subgoals and possible forms, it was decided that a workshop would be designed, aimed at end-users and developers, for them to see the bigger picture of the implementation process, and to make them reflect and act upon their commitment to collaborate. In the next chapter, insights from literature and practice are presented that have helped to shape the design of this workshop.

3.4 INSIGHTS FROM LITERATURE & PRACTICE

Before a final design could be made, several ways were used to serve as insights for the design of the workshop. First the insights from literature (3.4.1) and practice (3.4.2) are given. Then the key insights taken from an initial workshop (3.4.3) are presented.

3.4.1 Key insights from literature for the design of the workshop

In this part, literature is consulted to explore the theoretic context of the organization of stakeholder workshops. Although many articles in the context of deliberate communication and stakeholder workshops in responsible research and innovation deal with the why and not many give practical examples of how.

Nielsen, Bryndum and Bedsted (2017) try to fill this gap by providing both an overview of theory, as well as experience from practice of the organization of deliberative dialogue processes. The article presents essential considerations for the design of such workshops. In this section, some of the key insights from this article are discussed.

Context
A deliberative process can bring different actors together. Stakeholder workshops can inspire dialogue, whilst working towards responsiveness. In this regard responsiveness is both a mindset emphasizing a willingness to listen and collaborate, as well as understanding actor positions and possibilities for collaboration. The article examines how stakeholder workshops can be conducted to support responsiveness among actors. It gives general advice, given that "*every aspect of the workshop is affected by the aim and the context" (p.*5).

There are three categories of advice, dealing with:
1. Creating the framing conditions of the workshop
2. Designing and facilitating the workshops
3. Collecting the conclusions as well as procedural lesson from the workshop

Framing conditions
It is very important to decide on the aim, the content and design, and defining the relevant stakeholders. The design should correlate with the stakeholders that would be attending. *"There needs to be well-considered correlation between the aim, content and participants of the workshop for it to be fruitful" (p.7).* This type of workshop is not only purely aimed at the improvement of policy or a certain outcome, but also aims to create an environment where participants can develop awareness and understanding of the other's positions. Thus, the first level objective of the workshop should be: understanding the other's positions, and the second-level objective is making transformation and joint action possible.

Organizing workshop interaction
The main challenge is to get participants engaged, while making sure that relevant perspectives are listened to and adequately considered. Furthermore, allowing room for self-interest is important, and at the same time making sure that participants are open to learning about other perspectives. Leaving room for emotions is important since it is an unavoidable part of dialogic practices. Finally, creating commitment and ownership of the workshop is important. A trick is to have the participants feel ownership for more than just their own contribution. Furthermore, to create dialogue, the participants need to be activated as early in time as possible, so no lengthy presentations.

Collecting conclusions and evaluation
Working towards consensus is considered important, but the disagreements should be documented in the process. Strong outcomes can make participants feel that they have influenced and benefited from the process, but nuances should not be forgotten. Furthermore, one should find ways to evaluate the workshop.

Practice
The article also discusses challenges from the practice they have encountered while organizing 5 stakeholder workshops. The main challenge they faced was opening up a good dialogue and asking the right question. Also, finding ways to give participants ownership of the process was a challenge. Some participants were representing their organization and were not open to exploring their personal preferences. As a moderator, it is necessary to find a balance between steering the dialogue and letting the participants take responsibility for the process. The language and material were also regarded as difficult by the participants.
To document the workshop, the participants themselves kept notes on flipcharts. There was one person appointed to take notes. Also, for most participants, it was rare to work across disciplinary and institutional boundaries.

Summary
The insights are summarised in Table 11.

AIM	CONTENT	WORKSHOP INTERACTION DESIGN	FORM
1. Understanding one another's positions 2. Making transformation and joint action possible		1. Engagement to workshop 2. Self interest as well as common goal 3. Room for emotions 4. Commitment 5. Ownership of the workshop	1. Relevant stakeholders 2. Time 3. Location 4. Resources
OVERARCHING TIPS "There needs to be a well-considered correlations between the aim, content and participants of the workshop for it to be fruitful." (Nielsen et al., 2017, p.5)			
COLLECTING CONCLUSIONS Work towards conensus, but document disagreements in the process.			
EVALUATION It is very important to evaluate the workshop			

Table 11 - Framework for the design of workshop: literature

3.4.2 Key insights from dike monitoring practice for the design of the workshop

For the purpose of this research, a group brainstorm was held with experts from water authorities during an event of Netwerk Dijkmonitoring, with the aim to identify important elements for the design.

The brainstorm was 20 minutes and attendants included people from dike monitoring practice from several types of organizations: people from water authorities, people from monitoring companies, people from engineering offices, people attached to a university. They were asked to brainstorm in groups of two or three people about input on the following topics:

Aim: What would you like to gain from such a meeting?
Form: Who should be the relevant people attending, how much time can it take? Where should it take place?
Commitment: How can you create enduring commitment in such a meeting?
Content: Which topics should be discussed during such a workshop?

Insights

Aim

Like in the theoretic framework, a natural division arose between the aim to work on relationships and awareness of each other's interest on the one hand, and on the other hand to work on concrete plans of action.
The first has to do with creating understanding. Two groups mentioned awareness of each other's interest as an important aim. Other points that were brought up are about learning to speak and understand each other's language, building trust, creating total commitment and coming to satisfaction of both parties. In the second category, the aim of the workshop relates to creating up to date knowledge and making an action plan to come to successful project realisation.

Figure 24 - Participants during brainstorm

Content

To create an understanding of each other and the process, topics that were suggested are the goal of the meeting, different interests and resources, the project goal and the question behind, and other questions one may have.
To create transformation and joint action, things that have come up in the brainstorm are: discussing the different stakeholders and actors, the prerequisites and boundary conditions, the added value of innovation (2x), risks (3x) (climate; earthquake). Some topics mentioned relate to planning, such as creating a timeline, as well as the budget and financial risks. Furthermore there should be some agreement on the responsibilities and how to report the products.

Design:

Commitment

To create commitment, the most stated suggestion is to create something common, a win-win situation. Others referred to being honest and transparent, and if it is not working: to stop in time. Further suggestions are making sure to anchor it into the organization, involving future users, ensuring that it can be implemented later, doing what you have promised and listening to each other's interest.

Form

Relevant stakeholders

Relevant stakeholders to be involved that were mentioned are all future users with a breadth over the organization, from both sides (end-user and developer): asset managers, experts and people with experience, project managers, contract managers, the decision makers.

Time

The preferred time slot varies from part of a day to several sessions with a few weeks apart, or several two-hour sessions.

Location

For the location, only one suggestion is given: to choose a neutral place, close to the area of interest (monitoring area for example).

Overarching tips

A brainstorm is regarded as a proper form. It could start very broad, you could do the fine-tuning later. One suggestion is to "*Think in yes, provided that, and not no, unless.*" Another is awareness of the barriers and including them as boundary conditions.

Collecting conclusions

The advice is: make sure to report the workshop.

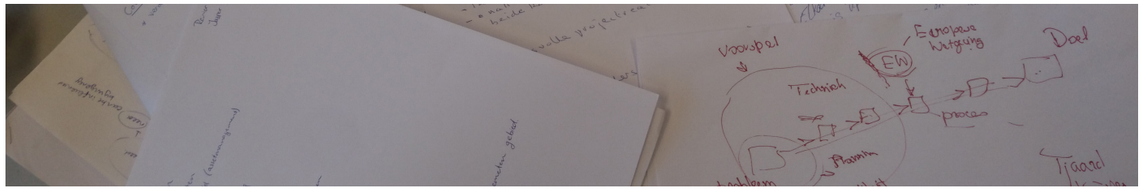


Figure 25 - Notes of the brainstorm

Summary

The insights are combined with the framework from section 3.4.1 in Table 12.

The numbers, such as (2x) inidicate by how many groups the suggestion was given.

AIM	CONTENT	WORKSHOP INTERACTION DESIGN	FORM
1. Understanding one another's positions *- Awareness in each others interests (2x) (getting to know each other)* *- Learning to speak and understand each others language* *- Building trust (2x)* *- Satisfaction of both parties* *- Total commitment* 2. Making transformation and joint action possible *- Having knowledge up to date* *- Making a plan of action to get to successful project realisation (2x)*	1. Understanding one another's positions *- goal of the meeting* *- what can we offer each other* *- what is your goal in the project (2x)* *- what is the problem and how do we deal with it (2x)* *- which chances do we have?* *- what are the interests behind* *- on which questions do you want answers* 2. Making transformation and joint action possible *- stakeholders and other actors and environment* *- prerequisites* *- added value innovation (2x)* *- risks (3x) (climate; earthquake)* *- timeline (3x)* *- costs vs. payment who carries the financial risks and how do we deal with it when the result is not satisfactory* *- budget (2x)* *- responsibilities* *- reporting and products*	1. Engagement to workshop 2. Self interest as well as common goal *- listening to each others interests* *- be honest and transparent (3x)* *- do what you have promised* 3. Room for emotions 4. Commitment *- anchoring it into the organization; involving the future users* *- making sure that it can be implemented later* *- creating something common, a win-win, if not, stop in time (4x)* 5. Ownership of the workshop	1.Relevant stakeholders *- future users* *- 'beheerders'* *- asset managers* *- experts (4x)* *- people with experience* *- people from mandaat* *- Breadth over organization* *- small committee* *- project managers* *- contract manager* *- from both sides: end-user and developer* *- decision makers* 2. Time *- part of day (2x) well prepared* *- a few sessions of two hours per session* *- day* *- after two weeks again* 3. Location *- somewhere neutral close to project location* 4. Resources
OVERARCHING TIPS "There needs to be a well-considered correlations between the aim, content and participants of the workshop for it to be fruitful." (Nielsen et al., 2017, p.5)			
COLLECTING CONCLUSIONS Work towards conensus, but document disagreements in the process.			

Table 12 - Framework for the design of workshop: insights gained through a brainstorm with practice

3.4.3 Initial Workshop organized at Hoogheemraadschap Delfland

A first workshop was organised in collaboration with the Water Authority of Delfland, on November 6, 2018, during their monthly Innovation Lunch. The full description can be found in Appendix E. Here, a summary of the workshop is presented, with the main aim to evaluate the workshop and draw conclusions on the input for the final design.

Since the workshop was organised for the staff of the water authority only, the aim of the workshop was adjusted to their needs. There were ten attendees that were mainly (senior) policy advisors from several sections of the Water Authority. They were not solely working on dikes and embankments, but also came from other departments, such as Wastewater Chain, Spatial planning, etc. Therefore, the focus of this workshop on the implementation of innovation into water authorities in general, and not a focus on dike monitoring.

Design criteria workshop
The design criteria for the workshop were based on elements identified in the first phase of this research and the interviews. They were fine-tuned for this occasion through interaction with the innovation fund manager.

The manager of the innovation fund mentioned that the water authority has a lot of focus on innovation. They provide the money through a separate innovation fund, however, they tend to forget to think about the bigger picture; the implementation process from beginning until the goal of implementation and how this fits into the organization. Also, after the money is allocated, there is too little focus on evaluation, follow-up and enabling implementation into regular practice. *"We tend to stop halfway" (innovation fund manager, pers.comm.)*. The current innovation practice could more deliberation about the long term.

Workshop design
Goal of the workshop
How can the water authority enhance the implementation of innovation?

. If we look at the whole implementation process, starting at the development of the product, execution of a pilot onto implementation of a market-ready product, which barriers do we face?
. What can we do about these barriers? What responsibility does the water authority carry? How can developers and water authorities complement each other?

Means
The workshop was designed as an interactive session, where the attendees reflect through discussion and brainstorming techniques. Another aim is some practical ideas for concrete actions that the water authority can take.
By reflecting on the problems and potential solutions, the stakeholders should become aware of their own role and responsibilities in the implementation process. By co-designing solutions, the aim was to create support for these

In short, there was an introduction, followed by two brainstorms. The first brainstorm was based on an individual exercise, in which the participants had to map the implementation journey of a project they had worked on. Which barriers for implementation had they faced? This was used for input for the discussion. The second brainstorm was focused on overcoming some of these barriers, and thinking about solutions.

Evaluation and lessons learned
Despite the hour passing by very quickly; the workshop sparked a good discussion and was positively received. The key insights are based on the feedback from the participants (p), the innovation fund manager (ifm), the senior innovation manager (sim) and evaluation of personal impressions (pe).

Aim
With respect to the aim of the workshop, it was well perceived that the workshop also focussed on solutions to certain barriers. This was constructive (p, sim, pe).

Content
Some feedback and suggestions for the content of the workshop were given. The first suggestion was to provide an overview of the workshop content at the start, so that people know what to expect (ifm). For the design of collaboration between the developers and end-users, it was suggested to define the aim of the innovation project (p). Furthermore, it is important to keep in mind what comes after the pilot project, how can it be implemented in regular practice? And what kind of action does that require at the start of a pilot project? Another suggestion is to keep the bigger picture in mind, but also think about smaller steps to get there (p).

Workshop interaction design
The discussion was very energetic and constructive; the exercises seemed to work well (ivm). The time was limited and therefore the role of the workshop leader was important, to define the time to move onto the next exercise. The discussion evolved naturally but needed to be steered into the right direction sometimes. It is therefore taken as a lesson to appoint the responsibility of a conversation leader (pe). Another suggestion was to use different perspectives of thinking, such as the Disney model (idealistic, realistic and critical thinking) (p). Furthermore, the design in two parts worked well, the first brainstorm defined the input for the second brainstorm and helped the participants to feel ownership over the topics discussed (pe, p).

Form
The most important limitation was the time, one hour passed by very quickly, especially given the startup time. Timekeeping is very important (pe).

Collecting conclusions
The conclusions were collected by taking notes, the notes of the participants and notes on flip overs during the second brainstorm. This worked well, but could be improved with another person documenting the process and taking notes on the conclusions.

Evaluation
Feedback was asked at the end of the workshop; however, there was limited time. This should be given more attention in a later workshop.

Summary
A summary of the findings from this initial workshop combined with the framework from theory (3.4.1) and is provided in Table 13.

AIM	CONTENT	WORKSHOP INTERACTION DESIGN	FORM
. making the participants think about potential solutions worked well	. provide an overview what will follow in the workshop . discuss the aim of the innovation project . discuss what will happen after the pilot . bigger picture as well as smaller steps	. the discussion was very energetic and constructive, exercises seemed to work well . leading/ not leading the conversation is a tight balance, should you appoint a conversation leader . use of different perspectives: idealistic, realistic, critical . defining the topics with the participants made them feel ownership over the workshop	1. Relevant stakeholders 2. Time *. time passes by very quickly, you have to be tight on this or design it differently* 3. Location 4. Resources
OVERARCHING TIPS "There needs to be a well-considered correlations between the aim, content and participants of the workshop for it to be fruitful."			
COLLECTING CONCLUSIONS - Work towards conensus, but document disagreements in the process. - Appoint someone to take notes			
EVALUATION . It is very important to evaluate the workshop . Evaluation should be planned and prepared well			

Table 13 - Framework for the design of workshop: insights gained through an initial workshop

3.5 SYNTHESIS & FINAL DESIGN

Based on the insights of the different sources a workshop was designed. This was an iterative process, while trying to knit all the elements together.

3.5.1 Synthesis of insights

To bring the different elements together this section gives an overview of the insights that are taken accounted for in the final design.

Design goal

To design an intervention that allows both end-users and developers to oversee the bigger picture of the implementation process, while enabling them to reflect and act upon their commitment to collaborate.

Just like the in the framework that was built up in section 3.3 of this research; the design goal already includes these two aims:
1. Understanding one another's positions
2. Making transformation and joint action possible

In order to create the correct setting for the workshop the scope was narrowed by choosing a certain moment in time within the process that the workshop should take place.

Figure 26 - Moment in time that the workshop should take place

This is when the concept of the product is ready, and the technology developers and end-users have decided to collaborate: a pilot will be run (pictured in Figure 26). The workshop would help them to kick-off the process and anticipate challenges on the road ahead. This scope was based on the insights from conversations prior to and after the initial workshop (3.4.3), that pointed out that after there was still room for improvement of the process after the allocation of money for a pilot.

Content

The brainstorm with stakeholders 3.4.2 filled in the specifics of the different topics that the workshop should contain. Therefore, it is important that the workshop deals with the following topics:
- . Aim of the project
- . Interests of stakeholders
- . The envisioned process of project
- . Potential barriers/problems
- . Solutions to these problems
- . Working towards a plan of action: timeline/ budget/ repsonsibilities/ reporting and products

Workshop design

The workshop should contain different brainstorm techniques and switching plenary discussions with individual exercises and exercises in small groups (3.4.1/3.4.2/3.4.3).

Form

Relevant stakeholders:

The stakeholders that are envisioned to attend this brainstorm session are 6-10 people from both the developers and the end-users. It should reflect a certain breadth over the organization (3.4.2):
- . Technology developers
- . Policy/decision makers
- . Innovation department or experience with innovation
- . People in the field: operators
- . Project managers.

Time

The envisioned time is two times a workshop of 2,5 hours, either morning/afternoon or with a week in between. This fits the time indicated by the stakeholders (3.4.2).

Location

Advised is a neutral location, close to the project area (3.4.2).

Resources

The workshop material should be prepared in advance. A workshop facilitator that is experienced with balancing the free discussion with the steering of the process is needed. The resources that are needed:
- . post its
- . flipovers
- . markers
- . the workshop material

Collecting conclusions

Someone should be appointed to take notes throughout the workshop. Furthermore; all the rounds end with a conclusion, which is written down.

Evaluation

The evaluation is an important part of the workshop and is done by answering a set of questions in smaller groups.

3.5.2 Design process: ideation

The ideation for the design was both a structured and spontaneous process. Slowly, throughout the process of insights, ideas came up. Inspiration came from engaging with practice, but also from books, articles, walks outside, etc. The initial idea was sharpened with a brainstorm session with a fellow student (Figure 27). This helped to make the idea tangible, as well as to substantiate the idea. This helped to give it a logical fit with the research. Later iteration sessions helped to shape the idea into a concept that can be tested in practice. Making a physical form of the design also helped to shape it, because it helped to direct choices.

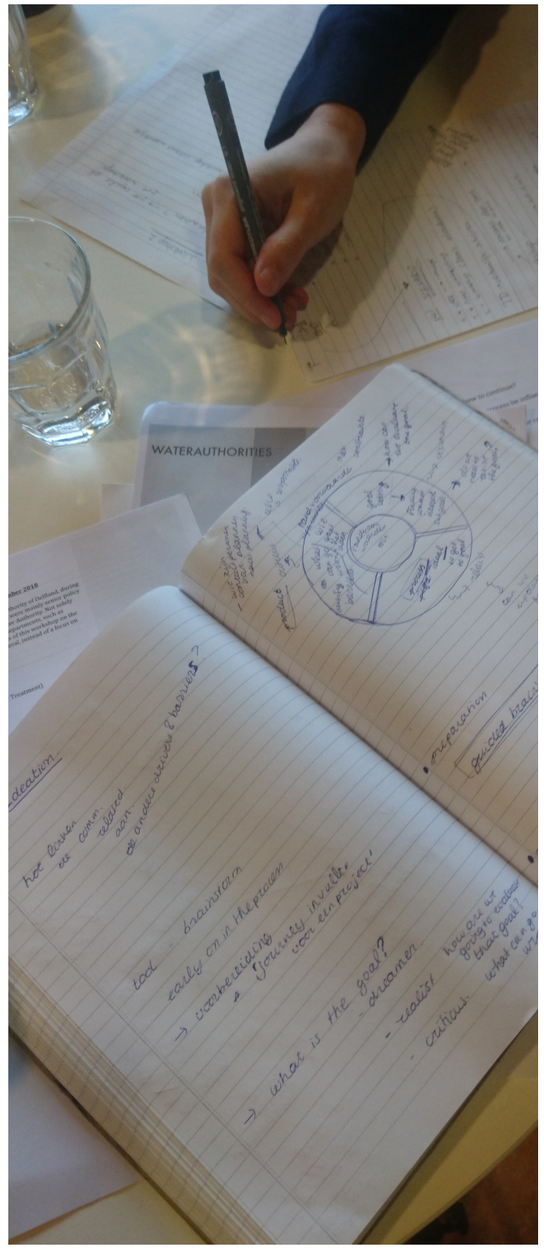


Figure 27 - Brainstorming on ititial design

3.5.3 Final design

The design process resulted in a set of two workshops. The first workshop is meant to be strategic/visionary, while the second workshop works towards a plan of action, based on the results of the first workshop.

The workshops are guided by the *'Implementation Donut'* (concept shown at the end of the chapter: Figure 31). The Implementation Donut represents both the iterative process, as well as the boundary conditions that are faced. The iteration is brought in by having several cross-checks as well as the opportunity to go through the phases of the Donut several times, with different perspectives (visionary, realistic, critical).

The Implementation Donut is meant to be placed as a version of 1-meter diameter in the centre of the table on a rotating platform, to provide visual guidance for the workshop, as well as the opportunity to map all progress and results on the donut. In this way, the Donut is used as a reference throughout the two workshops. The rotating platform makes it possible for everyone to easily access all the results throughout the workshop.

Background

The Implementation Donut is meant to give support to the workshop. It is designed to provide a way for the participants to engage with the workshop, as well as feel ownership over the results. Also, it is designed as a visual mapping of the process and helps to collect the conclusions (insights from section 3.4.1). Furthermore, visualization is an important aspect of Design Thinking (Tschimmel, 2012), and suits the creative, visionary nature of this workshop.

3.5.4 Workshop 1: Strategize

The first workshop is called strategize. The workshop focuses on getting to know each other, on creating understanding for each other's positions, and on defining a vision and strategy for the project. In Table 14 the different exercises and the corresponding time schedule are presented.

EXERCISE 0 **0:00 – 0:20** **20 MINUTES**	Introduction
EXERCISE 1 **0:20 - 0:50** **30 MINUTES**	Goal setting & mapping of interest
EXERCISE 2 **0:50 - 1:20** **30 MINUTES**	Ideal Process -Identification of drivers
BREAK **1:20 - 1:40** **20 MINUTES**	
EXERCISE 3 **1:40 - 2:10** **30 MINUTES**	Expected barriers or challenges
EXERCISE 4 **2:10 - 2:30** **20 MINUTES**	Brainstorm on solutions
EVALUATION & WRAPPING UP **02:30 - 02:45** **10 MINUTES**	

Table 14 - Overview Workshop 1: Strategize

Exercise 0 - Introduction [20 minutes]

1. At the start of the workshop, the workshop leader gives a short introduction to the workshop. Everyone will receive the schedule with the different exercises.
. The workshop facilitator thanks the attendees for coming
. He or she states the goal of the meeting and shortly mentions what is to be expected in the two sessions.
. He or she introduces shortly introduces the exercises of this workshop: the goal setting & mapping of interest, brainstorm on the ideal process, defining the expected barriers, and a brainstorm on solutions.

2. All attendees now receive one intro card. These cards have a question that they will use during their introduction. The attendees introduce themselves, their affiliation and answer the question on the card. The question cards have questions like:
. If you would have unlimited budget, what would you do with this project?
. What is the most innovative project you have ever worked on?
. If you could rewrite the law with regard to dike monitoring, what would you change?
. Can you give an example of a useful innovation you came across in your work?
. Who is your 'hero', or role model in the dike sector?

3. The workshop leader thanks everyone and appoints the one who is taking notes.

Background Exercise 0

The introduction responds to the need for participants to know what they can expect (insight 3.4.3). As Nielsen et al. (2017) point out, stakeholder workshops can inspire dialogue and responsiveness is both a mindset emphasizing a willingness to listen and collaborate, as well as understanding actor positions and possibilities for collaboration. Also, room for emotion is emphasised. The introduction questions aim to spark a connection between the participants.

Exercise 1 - Goal setting & mapping of interest

Exercise 1a [15 minutes]

This exercise starts group discussion on what should ideally be the goal of this project.

In principle, the goal is to run a successful pilot, but the question remains, what is wanted beyond that? The idea is to explore different elements that each add up to the goal of the workshop.

The notekeeper keeps track of the elements during the discussion on a flipover. After 12 minutes of discussion, everyone can give three votes to what is in his or her perception the most important elements of the project. This gives an indication of relative importance, and these will be taken into account during the rest of the workshop.

Exercise 1b [15 minutes]

For each of the chosen elements, the interests of the stakeholders are discussed through a moderated conversation, with questions like:
. What is our common interest?
. Are there any other interests of stakeholders that we should keep in mind?
. What could potentially be conflicting interests?

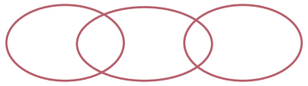


Figure 28 - Value mapper

The notekeeper maps the interests on the value mapper (Figure 28), in which different circles represent different stakeholders, and in which the overlap represents common interest.

Background Exercise 1

This exercise is meant to provide a way to materialize the requested content 'goal of the project' and 'what are the interests behind' as mentioned in the brainstorm with stakeholders (3.4.2). The value mapper was an idea that came up in conversation with the expert consulted (3.6.1).

Exercise 2 - Ideal process [30 minutes]
With the help of different cards that indicate possible drivers for implementation, the ideal process is mapped on to the implementation journey (Figure 29, Appendix F).

This exercise is done in groups in duos. Every duo receives the card deck of 'drivers'. The implementation journey shows the field of actors, and a time dimension. It represents different moments in the process, with different actors involved.

First, everyone fills in the end goal and briefly fills in different stages of the process that is envisioned. Then, with the help of the driver cards the strengths within the process are identified. They are asked to think about the impact of the drivers on the process.

[last 10 minutes]
The most important drivers are discussed in a group setting and mapped on the Implementation Donut.

Exercise 3 - Expected barriers and challenges [30 minutes]

The barriers are identified with the help of the Stakeholder Readiness method and with the help of barrier cards. The group is split into groups of 2 and each group will fill in a part of the method [20 minutes]. Then the main barriers are identified with the group [10 minutes]. Two of those are chosen to discuss in Exercise 4.

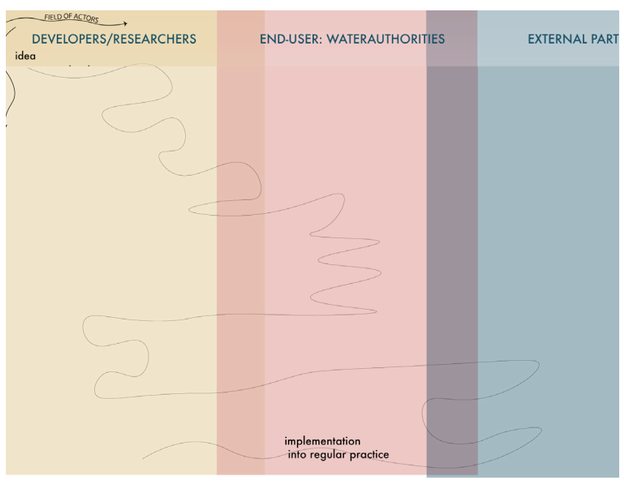


Figure 29 - Exercise 2: implementation journey

Background Exercise 2 & 3
The workshop starts with an exercise that is aimed at identifying the strengths within the process, to think without constraints. The iterations in this workshop aim to spark different ways of thinking. Examples of these are for example the six different thinking hats (de Bono, 1985), and the Disney model as for example explained in 'Creative thinking for dummies' by Cox (2012).

The implementation journey is meant to give a visualization (Tschimmel, 2012) of the process and the different paths that can be taken to get there.

The driver and barrier cards are based on the theoretic framework of this research (Chapter 2.2), as well as guiding questions based on the empirical findings of the research. The framework showed to be a good help to identify strengths and potential challenges in the process.

The stakeholder readiness method is a method developed by Deltares which helps to identify points of attention within the implementation process, by assigning red, orange and green colours to each factor. It works like a traffic light: the red points would be a barrier and need to be overcome, green is accounted for and orange is in between (Karstens, 2018). It is a visual way of mapping the strenghts and points of attention.

Exercise 4 - Brainstorm on solutions [20 minutes]
The brainstorm will be on three barriers. Two of these are chosen in Exercise 3. The third question to think about is: *how can we upscale from a pilot to regular practice?*

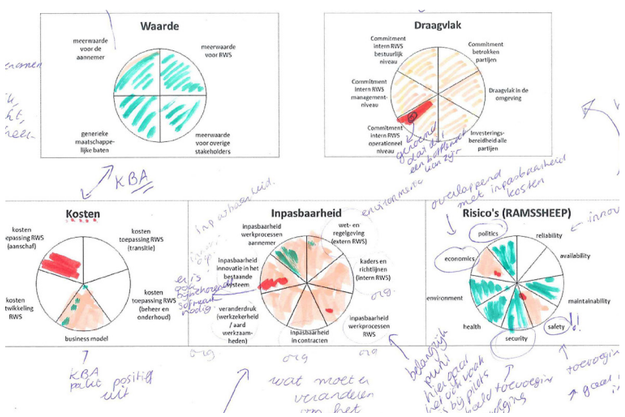


Figure 30 - Exercise 3: Stakeholder readiness method

The brainstorm is done in three groups, for three times 5 minutes, and after each round, the groups are switched. The workshop facilitator will say when to change. The first two time slots the groups brainstorm on solutions and in the third round; the most interesting as well as feasible ideas from the previous two rounds are organized and assembled.

Background Exercise 4
The participants can influence the selection of barriers for the brainstorm round. This is a way to give them ownership of the content of the workshop (insight from Nielsen et al. 2017 in 3.4.1). This also worked well in the initial workshop (3.4.3).

Brainstorming is a participatory idea generation session. The ideas are not thoroughly discussed. The objective is to produce many ideas in a short time. A variant on brainstorming is brainwriting, in which the participants use Post-its to stick their ideas on the sheets (Tschimmel, 2012). This variant is recommended as it gives the possibility to categorize the ideas in the third round of the workshop.

Evaluation & Wrapping up
The workshop is evaluated through questions. Like the introduction, each participant gets a question card and a quick round the table is done.

3.5.4 Workshop 2: Operationalize

The second workshop is meant to make joint effort possible through concrete steps. It builds on the results of the first workshop. The structure of the workshop is more formal.

It starts with an introduction and recap of the first workshop. The next step is setting the boundary conditions. Where the first workshop worked without limitations, this workshop is meant to create a plan of action that can be conducted within the boundary conditions of the project.

The participants then work on the concrete plan of action, and try to come to agreements on responsibilities, the timeline, the budget, the products, communication and meetings.

The plan is then checked with the input of the first workshop: if there is anything that can be taken from this workshop, it can be added to the plan of action. The exact design of the workshop is not developed within the scope of the research.

Background of Workshop 2
The topics of the second workshop flow from the insights that were taken from literature (3.4.1) and the brainstorm session with stakeholders (3.4.2). The second workshop adds to the first in making a concrete action plan, and materializing the ideas of the first workshop. It is important that it builds on the results of the first workshop: so it should be scheduled within a week from the first workshop.

EXERCISE 0 **0:00 – 0:20** **20 MINUTES**	Introduction Short recap of the first workshop.
EXERCISE 1 **0:20 - 0:50** **30 MINUTES**	1.Evaluation criteria
EXERCISE 2 **0:50 - 1:20** **30 MINUTES**	2. Boundary conditions
BREAK **20 MINUTES**	
EXERCISE 3 **1:40 - 2:10** **30 MINUTES**	3. Plan of action
EXERCISE 4 **2:10 - 2:30** **10 MINUTES BRAIN-STORM** **10 MINUTES CON-CLUSIONS**	4. Checks
EVALUATION **2:30 - 2:40** **10 MINUTES**	

Table 15 - Overview Workshop 2: Operationalize

THE IMPLEMENTATION DONUT

WORKSHOP 1: STRATEGIZE
WORKSHOP 2: OPERATIONALIZE

4. CHECK:
Do we get to the goal?

0. INTRODUCTION

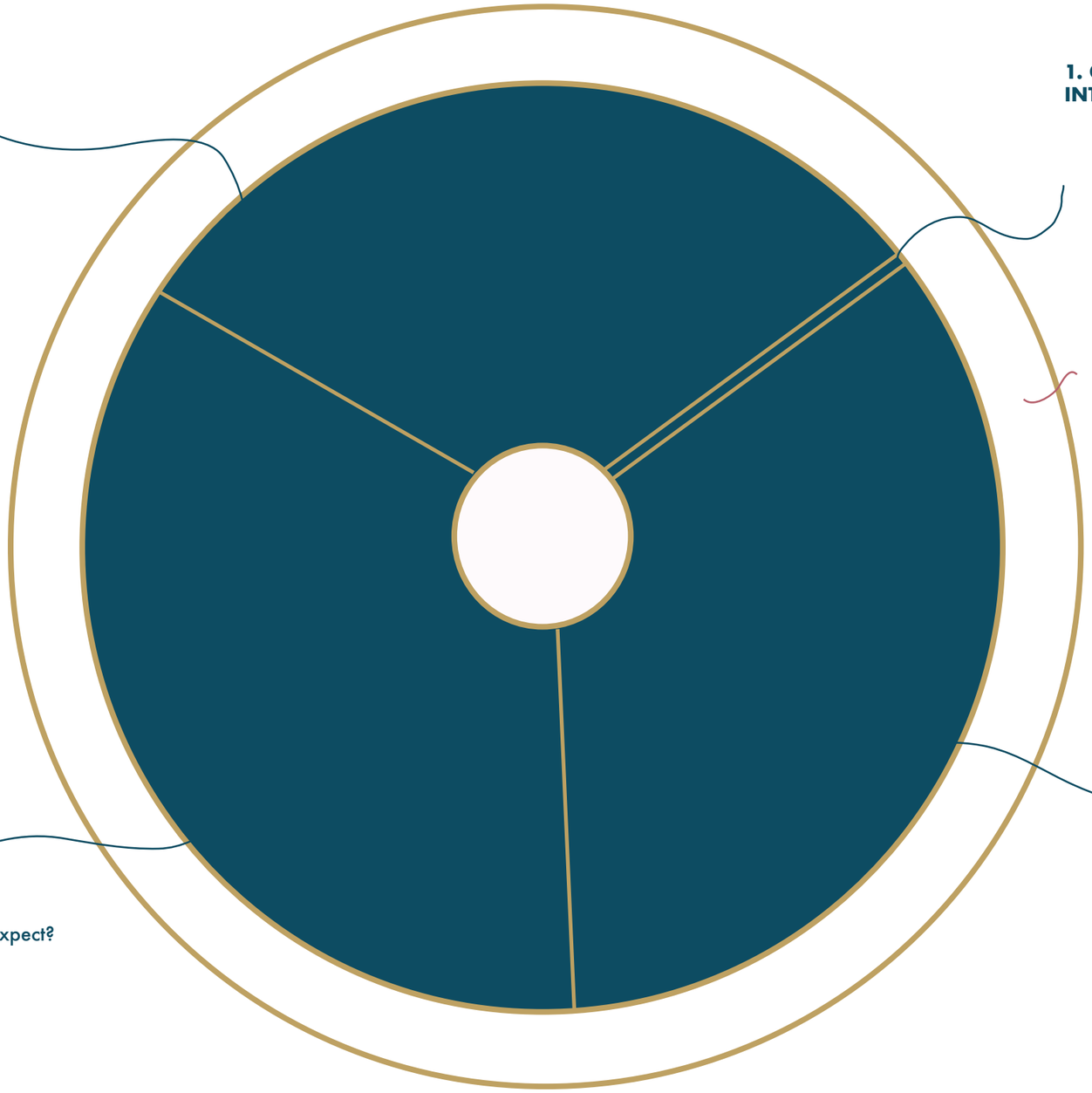
0. INTRODUCTION

1. GOAL SETTING & INTEREST MAPPING

1. GOAL EVALUATION:
how will we evaluate the goal?

4. HOW DO WE OVERCOME THESE BARRIERS?
-Brainstorm on solutions

4. CHECK:
Are there any extra things we can do in the plan, or people we can take into account?



2. BOUNDARY CONDITIONS

2. PROCESS
What are driving forces for the process?
- implementation journey
- driver cards

3. PLAN OF ACTION

3. BARRIERS:
Which barriers or challenges do we expect?
- Stakeholder readiness method
- Barrier cards

4. CHECK:
Do we take the barriers into account?

Figure 31 - Layout concept Implementation donut & corresponding exercises

3.6 ITERATION & EVALUATION OF THE DESIGN

To evaluate the relevance of the designed workshop, an outside expert from Deltares working with stakeholder readiness was consulted, midway in the design process (3.6.1). The final design was evaluated with fellow students and ideas for further development were listed (3.6.2).

3.6.1 Initial feedback & iteration

An expert of Deltares, in the field of innovation management in multi-actor settings gave feedback on the design.

The insights from this conversation were:

1. Goal: to discuss the goal is super important, but is often forgotten.
2. Common interest: not only the common interest is important, but also those that differ. This was incorporated into the design.
3. Evaluation of goal: think about when it is ready to be implemented in regular practice.
4. We discussed the number of people that would attend the workshop. She advised thinking about splitting into smaller groups for some exercises.
5. She advised to collect the conclusions and get to a fairly realistic level in the first workshop. It would be a shame if your results are too abstract, so that the conclusions cannot be taken into account into the work plan made in the second workshop.

This feedback was taken into account for an updated version of the design.

3.6.2 Evaluation & Recommended changes

During a small focus group with three fellow students (Figure 32) of different backgrounds the final design of the general outline workshop, as well as the different exercises, were discussed. The aim was to go through the different elements of the workshop and see if they resonated. The result is an impression of the functioning of the workshop, as well as recommendations for adjustments.

Workshop 1:

General comments

The concept is clear, and it was considered a good idea to have the physical and visual element of the Implementation donut on the table. The suggestion was given to move the exercise 'mapping interest' [Exercise 1, Workshop 1] to the second workshop, because it might be too constraining for the first workshop to discuss conflicting interests.

The order of the exercises was working well, however, the exact execution and details of the exercises can still be reconsidered and tweaked.

Some general remarks:

. Make sure to keep track of the results during the workshop. In the end, some time could be added to gather with the participants and shortly summarize the results altogether.
. In some exercises the participants should be led a bit more gradually into the exercises, with some extra steps in between.
. Size of the group: if you have a bigger group than ten you could split them up.

Exercise 0:

The introduction with question cards was considered a good idea. A suggestion was made to keep track of the time, to make sure that people will not start to tell half-hour stories, because otherwise it would take too long, since there are only 20 minutes set for this exercise (or only choose a few people to answer the question).

Exercise 1a:

The exercise was clear. Suggestions made were:

. Give the participants two votes instead of three votes for the election of the goals, this may be enough to point out three goals.
. You could vote with small round stickers that the participants stick next to the sub goal they prefer, then it will very visual which goals stand out. Furthermore, people can do it themselves, so you do not need to moderate it.

Exercise 1b:

Discussing interests can potentially be conflicting and the suggestion was made to move this exercise to the second workshop:

. You may not want to start this workshop from tension and voting for the end goals already implicitly takes the stakes into account.
. In the case it is moved, there is more time for the discussion about the goals.
. The value mapper is very leading, you could also do the mapping without it, in a more intuitive way without the circles

Exercise 2:

It was considered a good idea to start with the process and to identify the strengths. However, there should be more time to map the process at first. An idea is to think about the different stages before you start with the driver cards. There could also be cards to help to map the different stages of the process, with ideas of the different phase in the process. This also gives the participants the time to get used to the implementation journey concept.

Exercise 3:

The Stakeholder readiness method is a nice and visual way to identify barriers. However, it is not just about barriers, there are also drivers or strengths identified with this method: the drivers and barriers are not independent. With further research and testing the best way to identify the barriers should be found. A question asked was whether the barriers should also be linked to the implementation journey, together with the drivers.

Exercise 4:

This exercise is now set for 20 minutes, but it could be longer. Furthermore, it was strongly recommended to indeed use post-its for the brainstorm, because it is a more free way of brainstorming, and helps to involve everyone. Also, the post-its can be moved and reorganized. A suggestion was made to have a different perspective (stakeholder or 'optimistic'/'realistic') for each of the different brainstorm rounds.

Workshop 2:

You could add the exercise 'interest mapping' from the first workshop to this workshop.
Furthermore, it is important to link the two workshops, so maybe the second workshop should be held the day after the first workshop, so that all the ideas are still fresh in mind.

3.6.3 Conclusion

With the help of fresh perspectives, the design was shaped and evaluated. The concept of the workshop was evaluated to be solid, although the exercises in the workshop need further fine-tuning. In the next chapter, the outcome and relevance of the design process are further discussed.

Figure 32 - Feedback session with fellow students

3.7 DISCUSSION & CONCLUSION

In Part III of the research, communication and collaboration problems related to the implementation of innovation in dike monitoring were identified, and an intervention was designed. In this chapter, the the design process and outcome are discussed.

3.7.1 Discussion outcome

The result of this part of the research is the design of a two-folded workshop that aims to guide the implementation process of new technologies into dike monitoring practice. Through insights of various sources and design iterations, the final design came about.

After iteration and evaluation (sections 3.6.1 & 3.62), the concept of the workshops still stands strong. Basing the design on challenges and needs that were indicated in practice, and further basing it on insights derived through both theory and practice secured the relevance of the design.

With the help of fresh perspectives, the workshops were shaped and evaluated. The concept of the workshop was well perceived, although the exercises in the workshop need fine-tuning. For now, the design provides the shape and the important elements, and the suggestion for the exercises to reach the design goal. The next step would be to test and evaluate the workshop in a real setting.

Another question is whether the design is feasible for use in practice: can it be done? One of the concerns is whether the needed time two times 2,5-3 hours workshop is too long; given that one of the challenges found in the research is the limited time of all parties ('time constraints' in section 3.2.1 of this research). However, the insights from stakeholders of the brainstorm held for the purpose of this design all (section 3.4.2) all propose at least a few sessions of several hours, or part of a day.

Apart from a facilitator, the workshop does not need many materials. The 'implementation' donut, and cards can be made available and even printed and prepared by the workshop organizer himself. A facilitator is important because the workshop has many different steps that need to be guided. The importance of the facilitator is also emphasised by the innovation management expert of Deltares (pers.comm.). The facilitator should be accepted by both the developers as well as the end-users.

The Implementation donut's design should be seen as a visual guiding to map the progress of the workshop and to keep track of the findings. The reactions to this concept were positive (3.4.1 & 3.4.2), however, given that it was only discussed with a small pilot version, it should still be evaluated for its practical value. This brings up questions such as: Can everyone really see the results? Does it have enough space for the answers? Can it be mapped on the donut without delaying the workshop? Do the participants appreciate the implementation donut?. The operational testing of this design is a crucial step; similar to the development process of the innovations discussed in Part II of this research.

To guarantee the use of this workshop, it would be wise to embed it in existing practices, such as the innovation fund of one of the water authorities (NL3, Part II of this research). The workshop would then be part of the starting up after the innovation fund has provided money for a project.

3.7.2 Discussion research methods

The double diamond approach (Design council, 2015) helped to guide the process. First, all communication and collaboration related problems were identified and then filtered into one tangible design goal. The appropriate form was selected in which to operationalize the design of an empirical intervention. Designing is a creative process, which was sometimes hard to structure. In reality, the process was much more fluid than presented in this report. However, the subsequent diverging and converging stages of the double diamond helped to structure different phases, and helped to make choices. It also helped to make the process more transparent.

The added value of the Double diamond approach is that the design is both theoretically and empirically embedded. Both theory and practice were continuously revisited in the process, which helped to build a deeper understanding of the needs of the stakeholders.

In Chapter 3.3 and Appendix D, the choices for the design goal and form are justified with a choice matrix. The matrix is based on the interpretation of the researcher and could therefore be a bit biased, but it was based on insights from practice as much as possible. The case is quite complex and many different things could have been chosen, you can only look at a small sub problem. It helped to structure the options and criteria, also to make a definite decision.

3.7.4 Conclusion

Many of the challenges in the implementation process link to communication and collaboration. Examples are limitations in terms of language, jargon, or different perspective and interests, limited commitment to collaborate or a knowledge gap. These barriers are encountered across different groups of stakeholders and collaborations, and in different moments in time, from the very first idea until the adoption and implementation stages. In this part of the research, the aim was to design an intervention that can overcome these kinds of challenges. Following the guidelines of the Design Council (2015), the design process followed a divergent and convergent pattern.

To ensure a feasible design that could be made within the scope of this research, a focus was chosen. The design goal was: to design something that allows both end-users and developers to oversee the bigger picture of the implementation process, while enabling them to reflect and act upon their commitment to collaborate.

Based on both practical criteria and criteria related to relevance and preferences indicated by the stakeholders, a workshop with brainstorm elements was chosen as the appropriate form. Insights from literature and practice were sought to fill in the elements that the workshop needed to contain, with relation to its aim, content, workshop exercises, and form. These insights also helped to secure the relevance of the workshop.

The final design is a set of two workshops. The first workshop is meant to be strategic/visionary, while the second workshop works towards a plan of action, based on the results of the first workshop.

The workshops are guided by the 'Implementation Donut'. The circular shape represents both the iterative process, as well as the boundary conditions that are faced. The iteration is brought into the workshops through crosschecks of the previous results. The implementation donut also provides visual guidance for the workshop, as well as the opportunity to map all progress and results. In this way, the Donut is used as a reference throughout the two workshops.

The first evaluations of the design are promising, and the next step after fine-tuning of the design would be an opportunity to try and evaluate the workshops with practitioners. Once further developed, the workshop could be used as a kick-off for innovation projects, preferably linked to existing procedures.

PART IV

FINALE

This chapter is a conclusion to the whole research. It discusses the generalizability of the results and the significance of the results in the light of other research.

CONTENT

4.1 FINAL NOTE

As a conclusion to the whole research, the findings are discussed and placed into a wider perspective. What can be said about the generalizability of the results, (4.1.1) and the significance within a wider frame of research? (4.1.2).

4.1.1 Generalizability of the research

The case studies in this research are focused on the implementation of innovation into dike monitoring practice. Are the results also applicable outside of the dike monitoring practice?

Over the course of the research, the results were also discussed with employees at water authorities working on different tasks than dike monitoring. For example, the discussion during the workshop organized for part III (Section 3.4.3) with employees from all types of background in the water authority, showed that many of the drivers and barriers on societal, organizational and innovation level could be similar in these cases. Barriers mentioned for different innovation projects were: a lack of urgency, lack of capacity, difficulties to scale-up pilots due to resistance to change, the complex nature of collaborations, etc. (Appendix E). The innovation manager at Delfland (pers. comm.) also confirmed this in a follow-up conversation.

The different case studies are a way of analytic generalization (Yin, 1989). They helped to build theory by exploring different cases. These were not only the main case studies in Italy and the Netherlands, but also the smaller differences in dynamics at different water authorities in the Netherlands that were encountered. Also, adding up to the case studies, all along the process, discussions with several experts helped to put the research in perspective and helped to build up the conclusions. These were short informal talks at Network Events that are not explicitly quoted in the research, but also longer discussions with employees from BZ Ingenieurs & Managers, Deltares and Fugro.

Furthermore, the empirical part of the research was based on a theoretical framework. The theoretical framework was combined from implementation frameworks on public, risk-averse settings that need long-term planning types. It has shown to be applicable to dike monitoring. In Chapter 2.7 a new framework is presented, with the key concepts that were derived through the research within the context of dike monitoring. It would be interesting to build further on this framework and see if it applies in different contexts of implementation. This is recommended for further research.

In Part III of the research, an intervention was developed. It was made for dike monitoring practice in particular, but could be applicable to a wider range of contexts. The framework (3.4.1) used here applies to different types of stakeholder workshops, and also here the initial workshop (3.4.3) was held with actors from different parts of the water authority, and confirmed similar challenges throughout the organization. Furthermore, the workshop was evaluated with an innovation expert with experience of innovations, and the challenges addressed and the purpose of the workshop was recognized as serving broader applications.

Therefore, it is plausible that the findings of the research apply to similar contexts: implementation of innovation into public, risk-averse settings that need long-term planning.

4.1.2 Significance of the research

This research adds to literature that aims to understand the factors that influence the implementation of innovation, at least in similar settings. The empirical insights that were found, guided by the broad theoretical framework, give a deeper understanding of the drivers and barriers at play. Earlier research on the implementation of innovation in dike monitoring was a thesis by a master student (Woldring, 2016) and the Lessons Learned report in which the IJkdijk project is evaluated (Stoorvogel-van der Horst, 2016). The results of this research do not contradict the findings in these studies. Woldring (2016) emphasises the need for cooperation between stakeholders (which this thesis addresses in part III), and too little awareness of the cost-benefit analysis at the water authorities. The research by Woldring concludes that water authorities see little urgency to implement dike monitoring techniques on a regular basis. In 2.7.1 of this thesis the proposition (4) is that urgency is growing slowly, but currently a push to action is missing. Stoorvogel-van der Horst (2016), emphasises that the fit into the working processes at the water authorities need more attention and that dike operators are crucial in this regard. In this thesis, the importance of fit into the current regime is also found (proposition 8).

With respect to these earlier findings, this thesis adds a solid theoretical and empirical foundation, and covers a cross-section of factors and perspectives from two countries, and therefore contributes a unique and broad view on the dynamics of implementation in dike monitoring practice. In this regard, this thesis also successfully addresses two research gaps discussed in the articles used for the theoretical framework: the empirical use of the theoretical framework as well as assessing its use across cultures and countries (De Vries et al., 2016; Kim & Chung, 2017).

During the research, a few other frameworks related to (implementation of) innovation in similar settings were encountered. For example, the framework by Gieske et al. (2016) for the assessment of the innovative capacity of an organization. It also distinguishes the network, organizational and individual perspective. The innovative capacity can be linked to the innovativeness in the framework this research presented in Chapter 2.7. However, the framework by Gieske only represents a part of the spectrum of factors that this research touches upon.

Another link can be made to transition theory (Geels, 2002; e.g. Baumgartner & Jones, 1991 in Gieske et al., 2016). Also, in transition theory different levels are distinguished. The landscape level is similar to the societal level in this research, and the regime to the organizational level. The DOMINO project as a case study would then be considered a niche within the transition towards the use of instrumental dike monitoring on the big scale. Understanding the system in such a way, also shows the interlinkages between the niche and the change in the rest of the system, just like also was encountered in this research. It could be an interesting way of framing the dike monitoring sector, and is recommended for future research.

The research can also be seen in the light of Responsible Research & Innovation (RRI) (e.g. (Fisher et al., 2015; Owen, Macnaghten, & Stilgoe, 2012; Von Schomberg, 2011). RRI aims to anticipate on societal values and opinions within the development of innovations. One of the ways to ensure responsible innovation is by bringing together stakeholders to discuss the risks and benefits of new technologies, and optimising the societal fit from both sides through a deliberate process. The execution of this research, in which a connection was made between a potential innovation developed by a research consortium and practice, can be seen as part of this deliberate process and the follow-up.

Many of the drivers and barriers to implement innovation were communication related. The aim of Part III of the research was to take a next step

and to try to positively influence the challenges when implementing innovation through active engagement with practice. Where the first part of the research gives a thorough, descriptive, analysis of dike monitoring practices, this part of the research concerns intervening in practice based on the prior research. The article by Nielsen, Bryndum and Bedsted (2017) identifies a gap between the theory and practice of stakeholder workshops. The design of the workshop in this thesis research addresses this gap.

The results of the research show that implementing innovation is more than optimizing the innovation characteristics: the implementation process is largely influenced by different factors on societal, organizational and individual level. Originally, the focus on innovation development was mainly on the technical readiness of a product, for example the TRL levels developed by NASA, assessing the readiness of a product based on its technical performance and development (Mankins, 1995). The findings of this research point towards the significance of the drivers and barriers that are not inherent to the innovation characteristics only.

The need to take the societal and organizational conditions into account within development of new technologies, as well as the need of a more guided implementation process is slowly finding its way into practice. Different frameworks and 'stage gating' tools are developed to address this process. During the research, two examples of this type of tools were encountered. The stage-gating tool developed in the BRIGAID process, is mainly aimed at guiding the technology developers towards the development of a society-proof product (Sebastian et al., 2016). The Stakeholder Readiness Level method developed by Deltares is a way to identify early on the bottlenecks that could hinder the implementation of innovation into the organization of the end-user. This method was based on their experience with the implementation of innovation within Rijkswaterstaat (Karstens, 2018).

The framework created for this research stands out for its application to both end-users and technology developers. Furthermore, it looks at both the process and product dimension. By looking at the drivers and barriers from these different perspectives, an interesting overview of the current dynamics of implementation of innovation could be created.

All in all, the research gathered theoretical insights and created a small ripple in practice. The insights can be further build on for the implementation of innovation in dike monitoring and related sectors.

On a last note, as was also found within the research, the goal of the innovation remains very important: it is not innovation in itself that is of value, but the contributions that it can make, and in the case of this thesis, the contributions to flood safety.

REFERENCES

Aguilar-López, J. P., & Bogaard, T. A. (2016). DOMINO Technical report "Dike Failure Mechanisms" Report number: WP1-D0.1-V1.0-06-12-2016.

Aguilar-López, J. P., & Bogaard, T. A. (2016). DOMINO Technical report "Expertise interviews on monitoring" Report number: WP1-D0.2-V1.0-06-12-2016.

An, L. (2012). Modeling human decisions in coupled human and natural systems : Review of agent-based models, 229, 25–36. https://doi.org/10.1016/j.ecolmodel.2011.07.010

Baars, S. Van, & Van Kempen, I. M. (2009). The Causes and Mechanisms of Historical Dike Failures in the Netherlands The Causes and Mechanisms of Historical Dike Failures in the Netherlands, 1–14.

Baumgartner, F. R., & Jones, B. D. (1991). Agenda dynamics and policy subsystems. The Journal of Politics, 53(4), 1044–1074.

Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems.

Bonzanini Bossle, M., Dutra de Barcellos, M., Marques Vieira, L., & Sauvée, L. (2016). The drivers for adoption of eco-innovation, 113. https://doi.org/10.1016/j.jclepro.2015.11.033

Bryman, A. (2015). Social Research Methods (5th ed.). Athenaeum Uitgeverij.

Consortium Flood Control 2015. (2015). Flood Control 2015.

Consorzio di Bonifica Adige Euganeo. (2013). Il consorzio Adige Euganeo.

Cox, D. (2012). Creative Thinking for Dummies. John Wiley & Sons.

Curtis, D. R., & Campopiano, M. (2014). Medieval land reclamation and the creation of new societies : comparing Holland and the Po Valley , c . 800 e c . 1500. Journal of Historical Geography, 44, 93–108. https://doi.org/10.1016/j.jhg.2013.10.004

De Bono, E. (1985). Six Thinking Hats: An Essential Approach to Business Management. Little, Brown, & Company.

de Vries, H., Bekkers, V., & Tummers, L. (2016). Innovation in the public sector: A systematic review and future research agenda. Public Administration, 94(1), 146–166. https://doi.org/10.1111/padm.12209

Deltaproof. (2018). Stabiliteit veenkade m.o. klimaatverandering. Retrieved from http://www.deltaproof.nl/Publicaties/deltafactIframe/Stabiliteit_veenkade_m_o__klimaatverandering.aspx?rId=19

Design Council. (2015). The Design Process: What is the Double Diamond? Retrieved from https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond

DOMINO. (2014). Dikes and Debris Flows Monitoring by Novel Optical Fiber Sensors, WaterWorks2014 Cofunded Call.

DOMINO. (n.d.). Homepage. Retrieved from http://domino.dei.unipd.it

Fisher, E., O'Rourke, M., Evans, R., Kennedy, E. B., Gorman, M. E., & Seager, T. P. (2015). Mapping the Integrative Field: Taking Stock of Socio-Technical Collaborations. Journal of Responsible Innovation, 2(1). https://doi.org/http://dx.doi.org/10.1080/23299460.2014.1001671

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. Research Policy, 31(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Ghorbani, A. (2013). Structuring Socio-technical Complexity: Modelling Agent Systems Using Institutional Analysis. TU Delft.

Gieske, H., Buuren, A. van, & Bekkers, V. (2016). Conceptualizing public innovative capacity : A framework for assessment, 21(1), 1–26.

Havekes, H., Koster, M., Dekking, W., Uijterlinde, R., Wensink, W., & Walkier, R. (2015). Water governance: The Dutch water authority model.

Herle, S., Becker, R., & Blankenbach, J. (2016). Smart sensor-based geospatial architecture for dike monitoring. IOP Conf. Series: Earth and Environmental Science, 34. https://doi.org/10.1088/1755-1315/34/1/012014

Hill, M. (2013). A Starting Point: Understanding Governance, Good Governance and Water Governance. In Climate Change and Water Governance. (pp. 17–28). Springer. https://doi.org/http://dx.doi.org/ 10.1007/978-94-007-5796-7_2.

Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). Cultures and Organizations: Software of the Mind (3rd Editio). McGraw-Hill USA.

Hogeschool Rotterdam, Hoogheemraadschap van Schieland en Krimpenerwaard, & BZ Ingenieurs & Managers. (2018). Werk-leernetwerk en studentenopdracht HHSK Dijkmonitoring in de werkpraktijk: Versie Definitief concept d.d. 5 september 2018; bijgesteld nav 1e bespreking 220518.

Hoogwaterbeschermingsprogramma. (n.d.). Retrieved November 21, 2018, from http://www.hoogwaterbeschermingsprogramma.nl/Nieuwe+normering/default.aspx

Hopman, V., Kruiver, P., Koelewijn, A., & Peters, T. (2010). How to create a Smart Levee. In Proceedings of the 8th international symposium on field measurements in GeoMechanics (pp. 12–16).

Inspectie Waterkeringen. (2018). Professionaliseren Inspecties Waterkeringen 3.0. Retrieved from https://www.inspectiewaterkeringen.nl/content/content.asp?menu=1002_000000_000000_000000

IPCC. (2014). Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (L. L. W. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, Ed.). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Jansen, J. J. P., Volberda, H. W., & Van Den Bosch., F. A. J. (2005). Exploratory innovation, exploitative innovation, and ambidextrousity: The impact of environmental and organizational antecedents. Schmalenbach Business Review, 57(4), 351–363.

Jong, P., & Brink, M. van den. (2017). Between tradition and innovation: developing Flood Risk Management Plans in the Netherlands. Journal of Flood Risk Management, 10(2), 155–163. https://doi.org/10.1111/jfr3.12070

Karstens, S. (2018). Naar een routeplanner voor innovaties. Geotechniek, 22(1), 45–46.

Kim, J. S., & Chung, G. H. (2017). Implementing innovations within organizations: a systematic review and research agenda. Innovation, (June), 1–28. https://doi.org/10.1080/14479338.2017.1335943

Koelewijn, A. R., & van der Meer, M. T. (2018). The use of fibre optics in water retaining structures – report of an expert workshop, rapportage 1230123-010-GEO-0004, Projectoverstijgende Verkenning Macrostabiliteit, Cluster Monitoring van Sterkte, Project 3.2A4. Tiel.

Lou, H., Luo, W., & Strong, D. (2000). Perceived critical mass effect on groupware acceptance. European Journal of Information Systems, 9, 91–103.

Manieri, F. (2016). The Po River Basin : Managing a Complex System. Lessons from the Past, Recommendations for the Future. Uppsala,. Uppsala.

Mankins, J. C. (1995). Technology Readiness Levels: a White Paper.

March, J. G. (1991). Exploration and exploitation in organizational learning. Organization Science, (2), 71–87.

Middendorp, H. (2016). Dijkdoorbraak in Wilnis in 2003. Retrieved from https://nietbangvoorwater.info/dijkdoorbraak-in-wilnis-in-2003/

Mostert, E. (2014). Who should do what in environmental management? Twelve principles for allocating responsibilities. Environmental Science and Policy, 45, 123–131. https://doi.org/10.1016/j.envsci.2014.10.008

Mostert, E. (2018). An alternative approach for socio-hydrology: case study research, 317–329.
Neijenhuis, P. (2018). Meetstrategie Sterke Lekdijk. Amersfoort.

Netwerk Dijkmonitoring. (2018). Netwerk Dijkmonitoring: Verslag Workshop Glasvezelmonitoring voor waterkeringbeheer. Tiel.

Nielsen, M. V, Bryndum, N., & Bedsted, B. (2017). Organising stakeholder workshops in research and innovation – between theory and practice. Journal of Public Deliberation, 13(2), Article 9.

Nikolic, I., & Ghorbani, A. (2011). A Method for Developing Agent-based Models of Socio-technical Systems, (April), 11–13.

NWO. (2018). Glasvezelkabels meten real-time kwaliteit van dijken. Retrieved February 3, 2019, from https://www.nwo.nl/onderzoek-en-resultaten/cases/glasvezelkabels-meten-real-time-kwaliteit-van-dijken.html

OECD. (2009). Sustainable manufacturing and eco-innovation: towards a green economy. Policy Brief June 2009. Retrieved from http://www.oecd.org/sti/42944011. pdf (accessed 20.11.10.)

Ons Water. (n.d.). Bescherming tegen hoogwater. Retrieved December 27, 2018, from https://www.onswater.nl/bescherming-tegen-overstromingen

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. Science and Public Policy, 39(6), 751–760. https://doi.org/10.1093/scipol/scs093

PBL. (2010). Balans van de Leefomgeving 2010.

Rinsema, J. G., Stokkum, J. van, Zomer, W. S., Koelewijn, A. R., & Veendorp, M. (2017). Meetstrategie Sterke Lekdijk.

Rip, A., & Kemp, R. (1998). “Technological change.” pp. 327-399 in Human choice and climate change. (Vol 2) Resources and technology. (S. Rayner & E. L. Malone, Eds.). Columbus, OH: Batelle Press.

Rogers, E. M. (2003). Diffusion of innovations. New York: Free Press.

Sabatier, P., Hank, A., & Jenkins-Smith, C. (Eds.). (1993). Policy change and learning: An advocacy coalition approach. Boulder, CO: Westview Press.

Savenije, H. H. G. (2009). “The art of hydrology.” Hydrology and Earth System Sciences, 157–161.

Schede di Geografia. (n.d.). Rivers of Pianura Padana. Retrieved from http://www.schededigeografia.net/Italia/Pianure/pianura_padana.htm

Swart, L. M. T. (2007). Remote sensing voor inspectie van waterkeringen. Rijkswaterstaat.

Schwarz, N., & Ernst, A. (2009). Technological Forecasting & Social Change Agent-based modeling of the diffusion of environmental innovations - An empirical approach. Technological Forecasting & Social Change, 76(4), 497–511. https://doi.org/10.1016/j.techfore.2008.03.024

Sebastian, A., Lendering, K. T., van Loon-Steensma, J. M., Praprotny, D., Bellamy, R., Willems, P., … Wysocka-Golec, J. (2016). A Testing and Implementation Framework (TIF) for Climate Adaptation Innovations. Delft University of Technology. Retrieved from https://www.narcis.nl/publication/RecordID/oai:tudelft.nl:uuid:ed1a387e-d61d-432c-9d29-73370ce19603

Sips, R.-J., van der Vlis, A., Nagel, R., & Havers, B. (2013). A case for evidence-based levee management using sensor technology. IBM Journal of Research and Development, 57(5), 5:1-5:12. https://doi.org/10.1147/JRD.2013.2261213

Slomp, R. (2012). Flood Risk and Water Management in the Netherlands. Rijkswaterstaat.

Stoker, G. (1998). Governance as theory: five propositions. Int. Soc. Sci. J., 50, 17–28. Retrieved from http://dx.doi.org/10.1111/1468-2451.00106.

Stoorvogel-van der Horst, S. (2016). Lessons Learned Stichting FloodControl IJkdijk.

Swart, L. M. T. (2007). Remote sensing voor inspectie van waterkeringen. Rijkswaterstaat.

Tschimmel, K. (2012). Design Thinking as an effective Toolkit for Innovation. In Proceedings of the XXIII ISPIM Conference: Action for Innovation: Innovating from Experience. Barcelona.

Twynstra Gudde. (2018). Eerste resultaten enquête instrumentele dijkdata.

Unie van Waterschappen. (2018). No Title. Retrieved from https://www.uvw.nl/publicatie/waterschapskaart/

van Dam, K. H., Nikolic, I., & Lukszo, Z. (2013). Agent-Based Modelling of Socio-Technical Systems. Springer.

van der Meer, M. T., Koelewijn, A. R., Weijenborg, A., & Konstantinou, M. (2016). Handreiking Life Cycle Monitoring, 1.

Verschuren, P., Doorewaard, H., & Mellion, M. J. (2010). Designing a research project (Vol. 2). the Hague: Eleven International publishing house.

Visuele technieken blijven belangrijkste vorm van dijkinspectie. (2004). H2O.

VNK2. (2014). VNK2, 2014. De veiligheid van Nederland in kaart: Eindrapportage VNK, Rijkswaterstaat, projectbureau VNK.

Von Schomberg, R. (2011). Prospects for Technology Assessment in a Framework of Responsible Research and Innovation. SSRN Electronic Journal, (March 2012). https://doi.org/10.2139/ssrn.2439112

Woldring, G. (2016). Inspection methods of water retaining dikes inspected - Master thesis Water Science and Management, Utrecht University

Xue, X., Zhang, R., Yang, R., & Dai, J. (2014). Innovation in Construction : A Critical Review and Future Research, 6(2).

Yin, R. K. (1989). Case study research: Design and methods. London: Sage Publications.

Zhihua, S. (n.d.). DOMINO Technical Report: “The QDPS characterization” version 1.0.

APPENDICES

CONTENT

A INTERVIEW QUESTIONS

A.1 Interview questions semi-structured interviews end-users

The interviews start on a broad note and will be more specific on the case-study (optic fiber) towards the end. It is semi-structured, so there is also room for spontaneous questions.

Introduction
Thank you very much for your participation tot his interview. I will shortly explain about the context. I am a masters student from the Technical University in Delft the Netherlands, in Water Management and Science Communication. My master thesis research is about the implementation of innovation in dike monitoring.

Through this interview I want to learn how dike management is organised in the Netherlands/ Italy, which actors are involved and to map the types of monitoring that are employed, and how innovation is implemented.

I would like to record the interview. Are you giving your permission to record this conversation?
I will not use your names in the report, so the information will be used anonymously.

My questions are grouped into four categories. They are about the organization, about the environment/context, your own experience as well as the optic fiber case study.
The interview should last around one hour.

Introductory questions
. (concepts from literature:- experience/ tenure)
What is your job position within this organisation? What are your responsibilities?
How long have you been working in this organization? How did you get to this point, what is your background?
Can you describe the team you work in? How does it relate to other teams within the organization?

Organization
. (concepts from literature):Management / leadership /strategy
. (concepts from literature) implementation climate

How is flood safety organised in this region? What are the responsibilities of your organization? Which activities are done? How many kms of dikes do you have to control?
Which other actors are of importance?

Is your organization interested in innovation? Is innovation stimulated within the organization? Do you have an example of an innovation that was implemented recently? Do you think some people in your team are more willing to innovate than others?

. (concepts from literature) Slack resources (financial resource availability, talented personnel and ICT)

How does your organization receive knowledge about new technologies? Does your organization do its own research?
In which ways is it influenced by finance? Is there money available to try new technologies?

Network
. (concepts from literature) environmental pressures
. (concepts from literature: regulatory pressures)

Are the citizens that live in your area involved in decisions you make?

. (concepts from literature: competition with other organizations

Do you also cooperate with other regions in Italy? Do you think that their practice is more or less the same? Or different? Or is it not possible to compare the regions?

. (concepts from literature: participation in networks

Do you have a lot of partners/collaborations (for example, with other governmental organizations, universities, companies, consultancies…) Do you have a lot of contacts outside of the organization yourself? For example with CNR?
If you work with universities, do you also contribute or collaborate to develop new technologies? Do you think such a collaboration would be beneficial?

Individual
. (concepts from literature: psychological concepts
. (concepts from literature: personal innovativeness

What is your personal perception of innovation? Did you ever witness the implementation of innovation from close by, and what was your experience?

Innovation
-(concepts from literature: compatibility)

Do you think there is an urgency or pressure to innovate the dike monitoring practice?
What is important in dike monitoring? What kind of data do you need?

. (concepts from literature performance oriented evaluation/ - effort oriented evaluation)

Do you know any new technologies for dike monitoring? What are the requirements for these? Should they be tested and proven to work?

Case study
Currently, within the DOMINO project new pressure sensors are developed that would be used to measure water pressure within a dike, either quasi distributed, or as the aim is, fully distributed. It is an optic fiber cable that should placed within the dike by either drilling it in, or by digging a small trench. The data can be used as a monitoring system for detection of piping or macro stability. Also, the data can help to provide insights on the internal conditions of the dike itself.

Do you measure water pressure in dikes at the moment? In which way, and for what do you use the data?
Would this kind of technology be interesting for you? For which reasons would you choose to apply dike monitoring methods, and in specific this kind of technology?

How do you decide to adopt such a technology? How does this go in practice, who makes the decision?
Which data is important for you?
When is the technology proven to be ready? Do you want to see an example from practice first? Or would you also be the pioneer when it is tested in the field?
Who would be responsible to take care of the data? Do you have a system to save and visualise this kind of data?

Would there be any regulatory issues involved in the implementation of this technology? Any laws that prohibit to put sensors inside the dike?

Are there any people living close to the dikes and embankments that could not be happy with this kind of changes?

In what kind of way would you like to collaborate with the developers, should this contact already be established while they are developing their technology?

Concluding questions to prioritise:

What are the core reasons that new technologies are implemented or not?
In which way can collaboration with product developers be organised to ensure that the product is developed according to your needs?
What kind of collaboration would you prefer?
Which aspects are most important for the design of this product, according to you?

End
Thanks a lot for your participation. I will write a report about these interviews. If you want, this can be shared with you.

A.2 Interview questions semi-structured interviews developers

Introduction
Thank you very much for your participation tot his interview. I will shortly explain about the context. I am a masters student from the Technical University in Delft the Netherlands, in Water Management and Science Communication. My master thesis research is about the implementation of innovation in dike monitoring. I would like to record the interview. Are you giving your permission to record this conversation?
I will not use your names in the report, so the information will be used anonymously.

Introductory questions
. (concepts from literature:- experience/ tenure)
What is your job position within this organisation?
What are your responsibilities?
How long have you been working in this organization? How did you get to this point, what is your background?
Can you describe the team you work in? How does it relate to other teams within the organization?

When did you enter the DOMINO project? Were you there from the start?

What kind of obligations do you have towards the funder?

Specifications and Expectations product
Which part of the development is your responsibility?
What are the most important specifications of the product you are making? How effective is it now, and do you have any hopes or expectations of where to get to?
-Do you think there is any competition making similar products? Is it important to keep the intellectual property?
What do you think will be the most important applications product?

Impacts
Do you expect any negative impacts from the sensor?

Network /Collaborations
. (concepts from literature) environmental pressures
. (concepts from literature: regulatory pressures)

Are the citizens that live in your area involved in decisions you make?

.(concepts from literature: competition with other organizations

Do you also cooperate with other regions in Italy? Do you think that their practice is more or less the same? Or different? Or is it not possible to compare the regions?

. (concepts from literature: participation in networks

Do you have a lot of partners/collaborations (for example, with other governmental organizations, universities, companies, consultancies…) Do you have a lot of contacts outside of the organization yourself?
If you work with universities, do you also contribute or collaborate to develop new technologies? Do you think such a collaboration would be beneficial?

Drivers/bariers
What kind of drivers and barriers do you expect for the implementation of this product?
What kind of knowledge would you need from the end-user in order to develop the product?
- organization
- network
- individual
- innovation related (examples)

Did you participate in any conversations/ workshop/event with stakeholders? What was your experience with this?

Technology readiness
Role of testing
What do you think is important for the testing in September. What is the goal? What is important?
How is the field test different from tests in the lab?
What is the outcome of the discussion in Delft in the second week of June?
Did you prefer another test setting and why? Why are you still satisfied with this result?

For the others:
What is the role of testing a product before it is sold? Why is it important? What kind of tests?

What do you think will happen when the project ends? Will the pressure sensors be further developed? Will it ever become a real project?

End
Thanks a lot for your participation. I will write a report about these interviews. If you want, this can be shared with you.

B CONTEXT CASE STUDIES

B.1 Context dike monitoring in the Netherlands

Geo-hydrological conditions & history of flooding of the Netherlands

The Netherlands has a long history with water management and land reclamation. The dike system is very important to prevent the land from flooding. Flood-safety is crucial, given that 60% of the country is protected from floods by dikes, dunes and dams (Ons Water, n.d.). Almost 26% of the Netherlands lies below sea level (PBL, 2010 in Slomp, 2012) and two-thirds of the Gross National Product of the Netherlands is produced in 55% of the flood prone land surface area (Slomp, 2012).

Big flood events in the past have prompted the building of major engineering projects, such as The Delta Works that were built after 1953 storm surge that caused over 1800 casualties. In 1926 the last large river flood happened, resulting in the reinforcement of many dikes (Slomp, 2012).

In 1995, 250 000 people were evacuated when the Meuse valley flooded, however the dike did withstand in the end (Slomp, 2012). The last major dike breach was in Wilnis in 2003 (Figure B.1), which was due to drought. In 2004 an embankment subsided in the south of the Netherlands (Inspectie Waterkeringen, 2018).

Figure B.1 - Dike breach in Wilnis
Source: Middendorp, 2016

Characterisation of dikes in the Netherlands

Dikes in the Netherlands are being built ever since the 11th century. Today, the dikes are designed and reconstructed according to the safety norms handled in the Water Law. On the 1st of January of 2017, this Water Law was renewed with respect to the norms for flood safety. The norms are now based on the chances of inundation, as well as the consequences of the inundation. Formerly this was based on the dike safety with respect to a certain water level. The new norms require a higher safety, thus many of the primary dikes currently need to be reconstructed.

The dikes are examined every 6 to 12 years. The model to base the calculation on is also prescribed by law. If the dike does not comply with the norm, the model parameters can be further investigated. If after further investigation, the dike still does not comply with the norm, reconstruction and maintenance have to be done ("Hoogwaterbeschermingsprogramma," n.d.)

Main dike failure mechanisms in the Netherlands

77% of all the registered historical dike breaches in the Netherlands were due to storm surges and high water levels. In 67% of the cases resulting in erosion of slopes and crest due to wave overtopping (Baars & Van Kempen, 2009 in Aguilar-López & Bogaard, 2016). One of the conclusions of a recent Flood Risk assessment study is that piping failure is more important than estimated in the past; in combination with overtopping and macro-stability may account for more than 50% of the total failure probability for many dike rings of the Dutch flood defence system (VNK2, 2014 in Aguilar-López & Bogaard, 2016)

Current monitoring & Examination in the Netherlands

Traditionally, the monitoring is done by visual inspection. In daily practice, the operators check the dike for irregularities. In most cases, the operators walk or drive along the dike and register the irregularities spotted in a dike monitoring application on phone or tablet (Swart, 2007). So far, in the Netherlands, some full-scale field experiments have been conducted to do further research on failure mechanisms of dikes, as well as the validation of monitoring equipment. The most known example is the 'IJkdijk', translated to 'Calibration levee'. Operational use of new sensor techniques remains scarce within the practice of dike monitoring (Sips, van der Vlis, Nagel, & Havers, 2013).

B.2 Context dike monitoring in Italy

Geo-hydrological conditions

The geography and climate vary from the north to south of Italy and therefore the geo-hydrological conditions and the related hazards and challenges differ over Italy. Our study area, North East Italy, contains both lowland as well as mountain ranges. In the regions Veneto and Friuli-Venezia Giulia the floodplains are 60 to 70 kilometres wide, and especially the last 30 to 40 kilometres are flat. Around Venice some regions are below sea level, and constant action has to be taken to keep the water levels stable. Here, the main geo-hydrological risk is that of inundation (IT: 1,2,6).

The flood characteristics are different compared to those of the Netherlands. A high water level in the Netherlands can for last several days. In Italy, the maximum flooding can already be reached within 8 hours, because the lowland and the mountains are strongly linked. For example, in the river Po, after heavy rainfall in the west side of the country, floods can arise 600 km to the east,. The rivers are relatively short and the mountain range close by increases the risk of flash floods. (IT: 1,2,6)

A difference between the lowland and mountainous areas is also due to the higher stream gradient and the related energy of the water. Upstream, in the mountainous areas with a higher stream gradient, the water would transports more material and erosions or changes in bed elevation take place. If the river carries a lot of debris this can cause clogging at narrow parts, at for example bridges. In the steeper areas floods occur more sudden and are more dynamic, whereas flooding in the lowland develop in a more controlled way (IT1). The presence of the mountains also encompasses the presence of other risks, such as those linked to land subsidence and debris flows (IT2). This is important to note in the light of measures against hazards, since attention has to be given to the mitigation of all these different risks.

A recent example of flooding occured with the Bacchiglione river, where a flood occured after two sides in the dike broke, most probably because of failure of concrete structures already present in the river. The damage of this event was recorded at 213 millions euros (IT4).

Characterisation of dikes Italy

The design of the dikes is based on empirical rules. For example, the design rule for the dikes of the Po River is based on having to handle a phreatic line within the dike that has an inclination of one over six. For other rivers the inclination of one over four. First the maximum flooding of the river is defined, and then a design for the width of the dike is made based on the prescribed inclination (IT3). This is supposed to be a very safe rule, which was taken into action after a big flooding of Venice 1951 (IT:1,3). The rules are determined in the basin plans that are revised every six years (IT3).

Main failure mechanisms of dikes in Italy

The main failure mechanisms are overtopping, piping and in some cases and also the disruption by animals. Water rodents, badgers and foxes make large holes insid the dike and these can be the base of seepage pathways into the dike that can cause its collapse (IT:2,6).

According to one of the interviewees the dikes are pretty safe for overtopping due to the design standards; the height of the dikes of the Po river is one meter above the level that was reached during the flood of 1951. The return time for the capacity is more than 200 years (IT3).

Current monitoring & Examination in Italy
The authorities' main method for monitoring is through visual inspection, workers driving by the dikes with a car. They do not make strength estimations for every dike stretch and instrumental monitoring is only done in exceptional cases (IT:1,3,6).

> *"We are in a very, very, early stage; there are not that many activities towards that direction" (IT3).*

An example given is the lower part of the Tagliamento river, where reinforcements were needed. In that case some measurements will be made first (IT1). For the Po delta there is legislation that prescribes the visual inspections, however, this is done less and less (IT3).
The consorzium Adige e Euganeo has an emergency number that civilians can call when they notice something familiar on an embankment. The weekend before the interview, there had been such an incident, where a small dike came close to failure. Emergency reconstruction had to be carried out (IT5).

B.3 Organizational structure in the Netherlands

The Netherlands has 3 levels of governance, consisting of the national level, 12 provinces and 380 municipalities. Above that there is the European level. The organizational structure is pictured in Figure B.2.

Although many of the governmental layers deal with parts of water management related tasks, the responsibility for the dikes is mainly in hands of the regional water authorities. There are 21 Regional Water Authorities that have responsibility flood protection, as well as the quality of surface water. The Regional Water Authorities have a council that is chosen through election, a board chosen that is by the council members and a "president", called the "Dijkgraaf". Rijkswaterstaat, the National Water Authority, manages a few of the primary dikes from a national level. The Ministry of Infrastructure and Water Management is responsible for spatial planning, as well as flood protection. They set the safety standards that the dikes have to meet. These are formally issued in the Water Law. Another related Ministry is that of Security and Justice, which is responsible for emergency services and civil protection issues for disaster management. Furthermore, there are 25 "safety regions" that work together for emergency response (Slomp, 2012).

In principle, the regional water authorities jointly have the responsibility for all dike reconstruction projects, allocated by area. However, they do not stand alone in this. Often, external consultants are hired to prepare designs and create plans for maintenance, and private engineering companies carry out the reconstruction work. The water authorities are self-financed through taxes, with the exception of large dike reconstruction projects that are funded separately from national funds. Until 2031, there are 7.9 billion euros available to reconstruct 1100 km of dikes (Rijkswaterstaat, 2018)

B.4 Organizational structure in Italy

There are many layers of authority involved in securing flood safety and dike operation in Italy.
As a result of the 2007 European Food Directive, there has been a recent reorganization of the river basin authorities. Prior to the reorganization, each river had its own river basin authority, but these are now grouped into eight river basin areas over Italy, which saves money and people (IT1).

The institutional layers are on national, river basin, regional and sub-regional level. The river basin authority does the planning and makes the policies for the river basin, such as the planning in terms of risks, or how to use the water resources (IT1). On the regional level the plans are implemented in Regional Water Protection plans enacted.

The Genio Civile is the engineering board on regional level that also overlooks the 'Consorzia di bonifica e irrigazione' that form the sub-regional level. These are based on sub-basins and cross borders of different provinces; some have recently merged into bigger areas. The Veneto region consists of 7 provinces, and has 10 consorzia, some of which are overlying different provinces (Consorzio di Bonifica Adige Euganeo, 2018). The consorzia are funded by local taxes for the day-to-day work, as well as money from the region that can be used for extraordinary projects (IT5). In case of emergency the national Civil Protection starts to act IT6).

As institutions, the authorities are not very technically oriented.

> *"The authorities are mostly based on management, they are not geotechnical institutions. They have expertise, but not as deep as the universities." (IT2)*

Therefore, universities are often consulted for their expertise. Private parties commonly do the maintenance and engineering (IT2).

The organizational structure with regard to authorities dealing with flood protection in Italy is pictured in Figure B.3.

Figure B.2 - Organizational diagram of authorities in the Netherlands

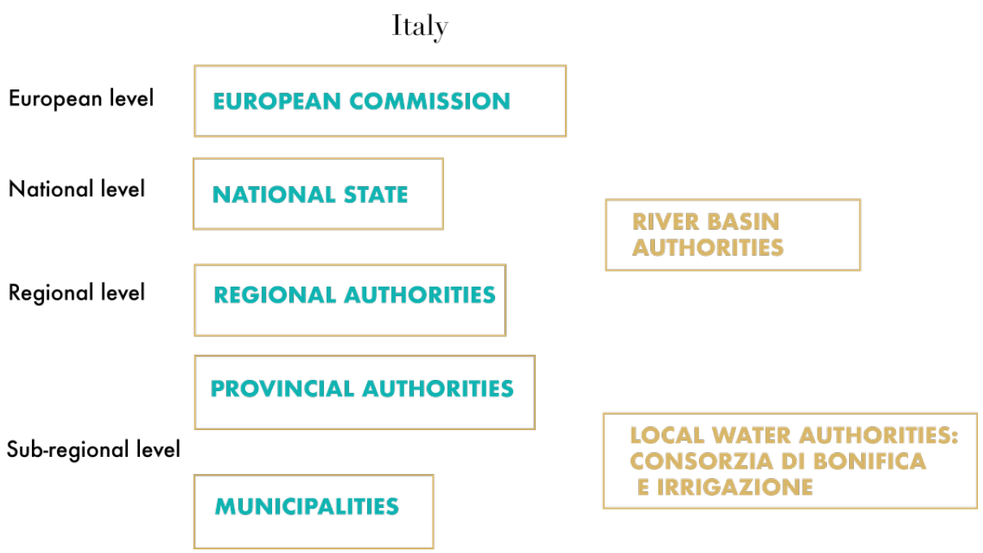


Figure B.3 Organizational diagram of authorities in Italy

C CONCEPTUALISATION & AGENT-BASED MODEL

This Appendix contains the exploration to conceptualize the dike monitoring practice as a socio-technical system, and modeling it in agent-based modeling software. Altough there were no significant results within the scope of this research, it could be an interesting approach for future research.

C.1 Introduction & methodology

A socio-technical system can be simulated in modelling software. Agent-based modelling is a way to approach the simulation of socio-technical systems. It uses 'heterogeneous entities' called agents to build the simulation. An agent can represent individuals, companies, government and also technical artefacts. They interact with each other and with the environment, make decisions and all these behaviours together form patterns and structures (Ghorbani, 2013). In the case of this research, a toy-model was made in Netlogo software. The model gave the possibility to visualise the system and 'play' and see the effect of certain factors. Although no significant results were obtained within the timeframe of this research, this method could potentially give more insights into the system, and into possible ways to intervene or change the systems dynamics. The work is presented in this Appendix. There are different approaches to the modelling. Either, a toy-model is made that can help to explore the system by playing with the input parameters. A model can also serve as an empirical representation of reality, used to run certain scenarios or to evaluate the effect policy alternatives (Nikolic & Ghorbani, 2011).

An related study by Schwarz & Ernst (2009) tries to identify future scenarios for diffusion of water-related technologies among German households. Especially the way the system is broken down is interesting for this research. The researchers distinguish four conceptual features of the domain: Individual innovativeness, communication, Innovation characteristics and decision-making processes.

With regard to decision making mechanisms there are many different options. One of those is Maximization of utility; in which agents make decisions to maximise profit, making use of microeconomic models (An, 2012). Multi criteria decision-making incorporates criteria to properties of concepts that define the decision. Criterion weight factors determine the relative importance of the normalized scores (Ghorbani, 2013).

Psychological and cognitive models represent *"the net effect of people's thought processes."* (An, 2012, p.29). These can be both based rational or irrational decision making. Irrational decisions can be modelled as random choice (Ghorbani, 2013) Institution-based models are linked to psychological models but are based on social norm (governmental policies or legitimacy) (An, 2012).

In participatory agent-based modelling real-world people tell the modeller directly what they do under certain circumstances, and the modeller tries to capture this. (An, 2012) Lastly, empirical rule can be derived from empirical data and observations. *"Even though also based on data, researchers usually have to go through relatively complex data compiling, computation, and/or statistical analysis to obtain such rules."* (An, 2012, p. 31)

Methodology

To come to the conceptualisation, the method proposed by Nikolic and Ghorbani (2011) was used. They have proposed a method for developing conceptualisations of socio-technical systems for agent-based models.

Conceptualisation & Theory development

The first two steps of the method by Nikolic and Ghorbani (2011) are the system analysis and system identification and decomposition. By conceptualizing the system, a next step of analysis is made. The results were analysed on a slightly higher level of abstraction which helped to relate the different theoretic concepts and to come to a representation of the most crucial concepts (Chapter 2.7). Apart from the key concepts, the most important actors and their behaviour are identified.

Formalisation & Experimentation

The conceptual model was formalised into agent-based software Netlogo. The formalization translates the model into computer primitives. The aim was to make a toy model that can be used for explorative options. A model balances precision, realism and generality (Mostert, 2018). In this case, generality and realism were held above precision, resulting in an uncalibrated toy model: to come to the conceptualisation, the findings from the case studies were stripped to its most simple and general representation. Still it aimed to represent the dike monitoring practice.

Discussion

Lastly the relevance is discussed: How realistic is this model? What can we do with the model?

C.2 Conceptualisation

What is the problem?

The main lack of insight addressed is the question which are the critical factors affecting implementation of innovations into dike monitoring practice and how this can be overcome. The observed emergent pattern is technologies in the field of dike monitoring which are not implemented into regular use, despite a general awareness and increasing interest of the potential of these technologies.

a. Relevant actors

The technology developers want to further develop their techniques and implement them. Water authorities are the main end-users. Innovation is implemented either top-down or bottom-up. Employees that work related to dikes form networks that cross-over to other water authorities and practitioners.

Furthermore there are network groups that try to capture the information and spread this through workshops and reports. There are also some consultants and engineering companies from the private sector that steer towards change (e.g. BZ I&M, Deltares, Fugro, Arcadis).
On a higher level there are both the EU and national government whose regulations are influencing the landscape. Furthermore, there are funding parties that decide to give money to further develop a technique or not.

b. Relevant concepts

This section explains the underlying relations presented in the causal diagram, based on the prior empirical research.
The main concepts influence the decision to adopt new monitoring techniques: The analysis can be found in the report in Chapter 2.7

- Innovativeness company
- Urgency
- Slack resources

- Knowledge level
- Characteristics innovation (added value)
- Decision making power

c. Relevant behaviour

The technology developers:

. They can make a connection with stakeholders; form new links and improve network (or use an existing connection)
. They can interact with stakeholders and take this as input for design criteria, making the technology more compatible to the needs of the stakeholder
. They can create links.
. They can disseminate the technology
. They can cooperate with water authorities for a pilot
. They can develop and update the technology.
. They can decide to stop further developing or working on the technology.
. They can decide to ask for more funding.

Water authorities:

. They can attend network events about dike monitoring
. They can communicate with other stakeholders; or neighbouring water authorities about dike monitoring
. They can decide to run a pilot of a technology
. They can decide to implement the technology
. They can decide to change their innovation strategy within the organization

The Network:

. Can organize a dissemination workshop about the technology
. Can disseminate knowledge through reports
. Can induce a sense of urgency (more parties adopting the technology)
. Can induce a sense of urgency
. Can set regulations that stimulate certain practices

In the final conceptualisation the main role is assigned to water authorities are the main decision makers to adopt innovation and can inform each other. The agent is chosen as an entity on the organizational level. There is one technology developer. Above described behaviour are all possible extensions to the model.

C.3 Formalisation

The timestep can be seen as 1 tick is 1 year, but the time does not have a real meaning, apart from the relative speed compared with different settings.

There are 20 water authorities created in the model, that are randomly assigned a position, and get assigned their values for each of their attributes. There is 1 technology developer.

The base model is kept simple, and mostly based on the diffusion of te awareness of the technology amongst the water authorities. The technology is static. The technology developer purely disseminates the technology.

Given it is a toy model, different layers of complexity or 'experiments' can be done to see what the effect is on the outcome, some examples:
1. Different decision making mechanism
2. Difference between variables Italy / Netherlands
3. Dynamic urgency and link with resources: if urgency goes up + more money made available
4. Technology development: stage of technology updated through interaction with stakeholders

The decision mechanism is chosen as multi-criteria decision rule, based on the main concepts identified. They are not coupled or dependent on each other, unless this layer of complexity is added. In the base case; all weights are considered the same.

Model parameter	Definition & Data source	Data, Rule or formula
Urgency	The societal pressures that influence the importance of immediate change.	Value between 1-100
Slack resources	Availability of monetary resources, ICT and human resources that can be dedicated to innovation	Value between 1-100
Innovativeness	Innovativeness describes the attitude towards innovation, as well as the fit into a certain regime.	Value between 1-100
Decision making power	The power an organization has to make the final decision on implementation of innovation	Value between 1-3 High: 1 Middle 2: Low: 3
Awareness	Aware of technology yes or no	True or false
Awareness/knowledge/experience level	Amount of technical and tacit knowledge within water authority with regard to dike monitoring	Value beteween 1-100
Implementation	Decision mechanism to implement, based on three action: to decide and to innovate	a*urgency+b*resources > threshold1 (a*urgency+b*resources+ c*innovativeness+ d*knowledge + e*opinion added value) / (decisionmaking power) > threshold2
Behaviour technology developer: - makelink - disseminate	the technology developer can inform a water authority to which he is linked	recipient from link will set awareness to true
Behaviour water authority - inform - network - consider [implementation]	- to inform the water authority can check with neighbours within a certain radius what they know about dike monitoring and update the knowledge - by attending network events the knowledge level goes up - once aware, the decision mechanism i in place	- can set awarenes true and knowledge level +2 if the neighbour has implemented (direct experience) and +1 if he or he is aware - there is a random element in the attendance of a network event, if attended then knowledge level +2

Figure C.1 - Formalisation parameters and behaviour model

Code base model

```
breed [was wa] ;water authorities
breed [tds td] ; technology developer

was-own [
 urgency
 resources
 innovativeness
 decision
 awareness
 knowledge
 implemented ;implemented yes or no ]

tds-own [
technology
 awareness
]

globals
[numberwas
radius ;radius of network
conider1 ;threshold to conider
dec
networksize
 ]

to setup
clear-all

set numberwas 20
 ;; define amount of water authorities
set conider1 100 ;; define first threshold (can alo be a slider)
set dec 200; define second threshold (can alo be a slider)
set networkize 1 ;networksize value between 1-10 - influences the knowledge gathered by water authority

create-was numberwas
 [set awareness false
  definewas1 ]
 create-tds 1
 [definetd]
reset-ticks
 clear-all-plots
end

to definewas1
;assign attriubtes to water authorities
 setxy   random-xcor random-ycor
 set size 2
 set resources random 100
set innovativeness random 100
set decision (random 2 + 1)
set knowledge random 100
set urgency random 100
set implemented false
end
 ]
end

to definetd
;assign attriubtes to technology developer
 setxy random-xcor random-ycor
 set size 2
 set awareness true
end

to go

 if all? was [ size = 10 ] [ stop ]
 ask tds [ makelink ]
 ask tds [ disseminate ]
 ask was [ inform ]
 ask was [ network ]
 ask was [ recolor ]
 ask was[ reshape ]
 ask was [consider]
 tick
end

to makelink
 if not any? links
 [create-link-with one-of was ]
end

to disseminate
 let recipients out-link-neighbors
 if awareness
 [ ask recipients [ set awareness true ] ]
end

to inform
if knowledge <= 100
 [ let candidates was in-radius networksize with [awareness]
 if any? candidates
 [set awareness true]
 ifelse any? candidates with [implemented]
 [set knowledge (knowledge + 2 )]
  [set knowledge (knowledge + 1 ) ]]
 fd 1
end

to network
 if knowledge <= 100 and ( random 10 > 5 )
 [ set knowledge ( knowledge + 2 ) ]
end

to recolor
 ifelse awareness
 [ set color red ]
 [ set color blue ]
end

to reshape
 ifelse awareness
 [ set shape “house two story”]
  [ set shape “turtle” ]
end

to consider
 if awareness
 [decide]
end

to decide ;first decision rule with threshold to conider implementation
  if (resources + urgency ) > consider1
 [ innovate ]
end

 to innovate ;decision rule to make decision to implement innovation
     if ((resources + innovativeness + urgency + knowledge ) / decision ) > dec
 [ set size 10
  set implemented true]
end
```

C.4 Example of Results

The results of different experiments with the model showed that the pacing of diffusion of innovation can be influenced by changing the parameter set, as well as by adding or removing initial rules. These outcomes reflect the expected outcomes.

Here the results of two experiments are shown.
1. The effect of the network size on the implementation rate (C.1 & C.2). This shows that both the number of water authorities that have awareness (a) of the technology and the water authorities that have implemented (i) is reaching its maximum value faster when the network size is bigger.

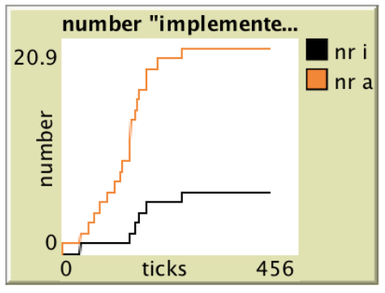


Figure C.1 - Number of water authorities aware (a) and implemented (i) new technology over time- with network size 1

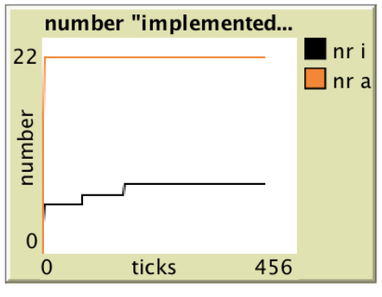


Figure C.2 - Number of water authorities aware (a) and implemented (i) new technology over time- with network size 10

2. The effect of adding an urgency feedback into the model (C.3 & C.4). It shows that with increasing urgency, and increasing amount of resources implementation will take place at faster pace

These results are examples of single runs and are meant to show the general outcome of different trials and extensions tried on the model.

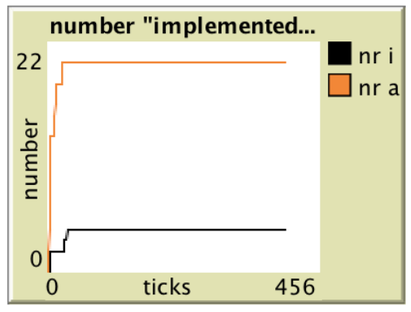


Figure C.3 - Number of water authorities aware (a) and implemented (i) new technology over time- static urgency

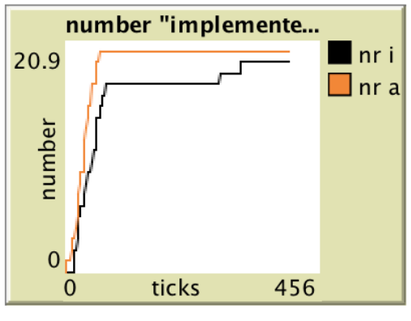


Figure C.4 - Number of water authorities aware (a) and implemented (i) new technology over time- with growing urgency and growing resources

C.5 Discussion

Discussion model

A model should find a balance between precision, realism and generality (Mostert, 2018). In this case, generality and realism were held above precision. This was partly influenced by the available data and the order in which the research was conducted: the idea for this part of the research was based on the results of the case studies.

Due to the simplification of the results, surely some nuances in the system have been lost in the generalisation. For example, when choosing to have the agent as an entity representing a whole organization, the sum of all individual behaviour had to be accounted for as the emergent behaviour on this level. At least, according to (Bonabeau, 2002) it is possible to model the emergent collective behaviour of an organization as such: *"One promising area of application for ABM is organizational simulation (12). It is clearly possible to model the emergent collective behaviour of an organization or of a part of an organization in a certain context or at a certain level of description. At the very least, the process of designing the simulation produces valuable qualitative insights."* (Bonabeau, 2002, p. 7284). The simplification and crossover of several layers is also important to consider. The interviews within water authorities were conducted on an individual's level, whereas the agent was chosen as a water authority as a whole. However, all the interviews and sources together form an impression of the system, and the most important mechanisms at play.

Discussion formalization & validation

Just as in the conceptualisation, in the formalisation many choices had to be made. The parameters were based on the researcher's estimation and impression of the system, based on the earlier research. The system contains many degrees of freedom. This is definitely a drawback, and can only be solved by keeping the system simple and basing it on empirical data as much as possible. In this case, as it concerns an exploratory toy model, this drawback may be less important, however a check with the qualitative data is needed to make sure that the parameters are realistic (Mostert, 2018). In this research, the model was based on the results of the case studies.

A major assumption was made when pinpointing the decision mechanism. It was decided to use a multi criteria decision mechanism, because this was assumed to be in line with the emergent behaviour on organization level: a result of different forces at play. A drawback is that this decision mechanism assumes rational choice, however, there can also be irrational or random dynamics (An, 2012). Also, you could also argue in favour of other decision mechanisms and weights. An opportunity for further research would be to explore this through participatory modelling.

Discussion results model

The results of the different levels of complexity in the model show that the pacing of diffusion of innovation can be influenced by changing the parameter set, as well as by adding or removing initial rules. However, the outcomes reflect the expected outcomes, while agent based modelling has the potential of unexpected 'emergent' patterns based on a set of simple rules. Within the scope of this research, this level was not reached, and it could be interesting to work towards more complexity and precision within further research.

Conceptualising human behaviour, which is complex and can be irrational, it is difficult to quantify, calibrate and justify relations between them. This also makes it hard to assign meaning to the outcomes of the simulations (Bonabeau 2002).

The practical value of the results of the model are minimal given its limitations with regard to its simplicity, as well as the lack of calibration and validation. However, the conceptualisation as well as the modelling created a deeper understanding of the system, and it was appreciated as a way of thinking about the system. It contributed to the discussion and conclusions of part II and the input of part III of this research. This is reflected in the literature as well, as stated: *"Agent-based models contribute to the process of learning and thereby to finding more complete answers."* (van Dam, Nikolic, & Lukszo, 2013, p.5)

D PROBLEM STATEMENT & FORM SELECTION

This Appendix shows how the problem statement and form of the intervention were selected.

D.1 Problem statements selection

First we make a decision on which of the different sub problems or combination of sub-problems we will focus. Now that there is overview of the implementation process, the aim is to take a next engaging step and to try to positively influence practice.
Since it is impossible to influence all issues over the whole process, we will first have to filter towards a smaller and more tangible sub problem that we can design for. In this chapter, we work towards an appropriate the selection of an appropriate design form.

First we make a decision on which of the different sub problems or combination of sub-problems we will focus. Based on the prior analysis, several sub problems were identified. These were evaluated with the help of criteria based on practical criteria and their relevance.

Based on the prior analysis, the following sub problems were identified:
. There is a gap of understanding between people of different disciplines and backgrounds
. There is a lack of time and commitment for communication and collaboration between developers and end-users
. The different stakeholders tend to have a short-term perspective and forget about the long-term goal and the whole implementation process.
. Often, there is a lack of support for innovation within the organization and fear to change
. There is a knowledge gap and lack of a clear overview of the different techniques.
. There is no focus on evaluation, follow-up of a pilot and enabling implementation into regular practice
. There is a fear for the innovation and new technologies
. The technology does not match the demand of the stakeholder

Practical criteria are the available time and resources; it should be feasible to influence practice with relatively low budget and within limited time. It should also be related to the research question: it should be able to influence with communication or collaboration. For relevance it was defined that it should be applicable to both the end-users and developers, and have a focus on interaction.

The outcome of this filtering step is two sub problems, namely:

1. Lack of time and commitment for communication and collaboration between developers and end-users
2. The different stakeholders appear to have a limited view, and tend to forget about the long-term and bigger picture.

Design goal
The two problem statements are merged into one design goal.
To design an intervention that allows both end-users and developers to oversee the bigger picture of the implementation process, while enabling them to interact and reflect on their commitment to collaborate.

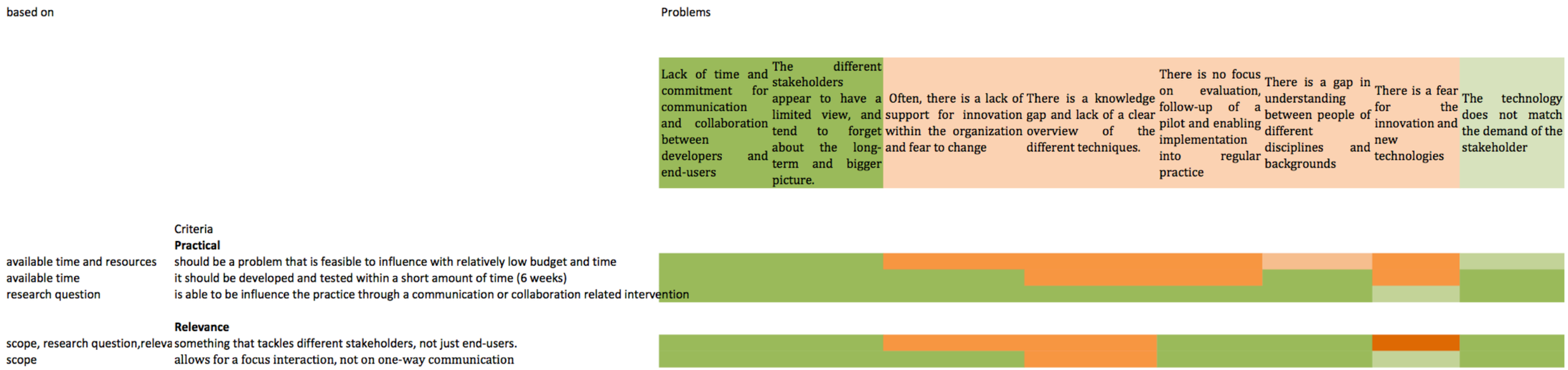


Figure D.1 - Selection of sub problems intervention

D.2 Form selection

A list of ideas and forms was composed from the results of the interviews in which an intervention was discussed. These forms should be able to operationalize the criteria into practice. The form was selected based on the number of criteria met, pictured in Figure D.2.

Forms

Methods/solutions

Within the interviews, also different ways to deal with communication and collaboration related problems were discussed. These provide several 'methods' to deal with communication and collaboration.

Workshops

Workshops can be used for discussion about the product that is being developed and also as a means of dissemination.

Video

One researcher mentions the need for a video that shows the workings of the optic fibers, to convey the message of the product and also to show that optic fibers are a common way to monitor. (IT10)

Reports

Within the Dutch network of STOWA, often reports are written and shared within the water authorities. However, it is also mentioned that does not always give a tangible feeling of how to implement the innovation oneself, there is also a need for organizational examples.

Positive story

The best is to have a positive story that can counter the objections of people that will be present. (NL6)

Committee

One employee from a Dutch water authority recommends forming a supervising committee including people from authorities and the researchers. They can offer feedback every once in a while. Given the time constraint it would be best to connect this to already existing network groups, or existing meetings, to save time.

Scientific papers

Through scientific papers the research can be picked up by other groups that may add and help to develop the technology further.

Overview

Several interviewees ask for a overview of the different techniques available.

Outcome: form selection

The outcome of this cycle was a decision to focus on a brainstorm/workshop that allows the end-users and developers to reflect on the implementation process and commit to certain actions.

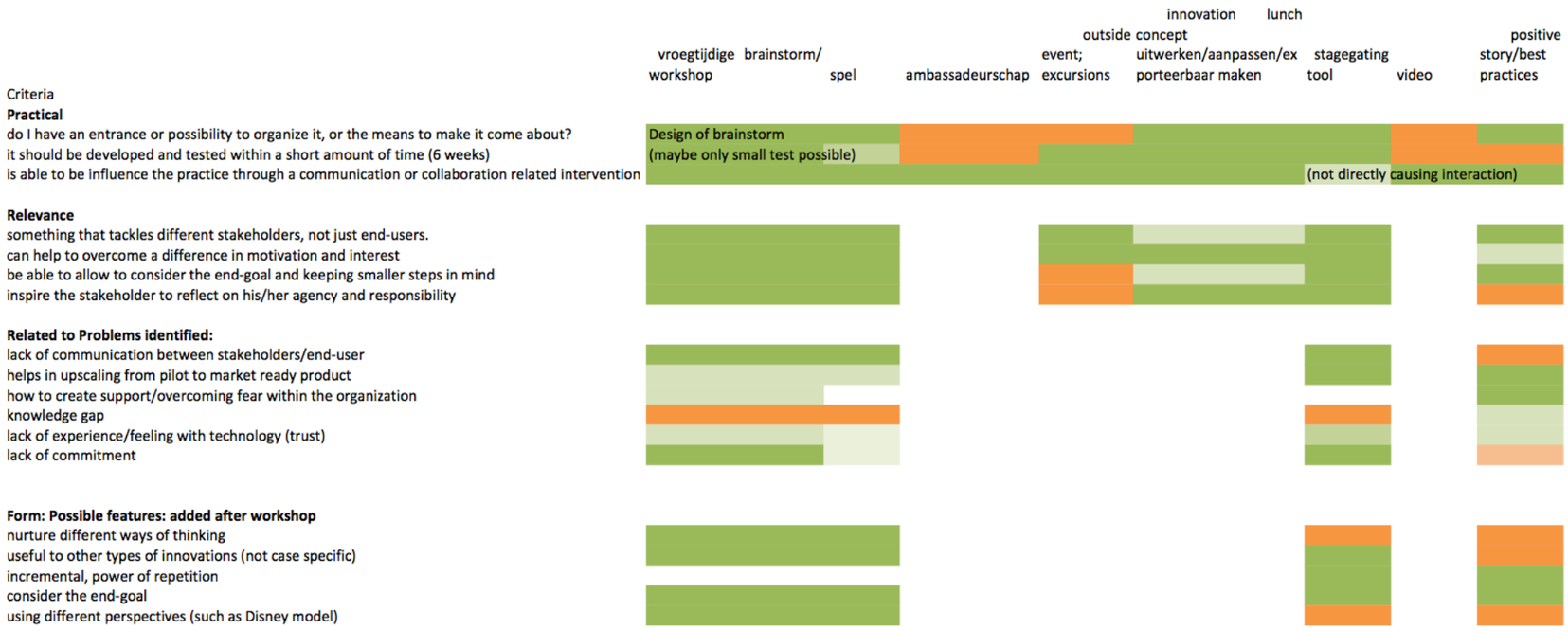


Figure D.2 - Selection of form intervention

E INITIAL WORKSHOP DELFLAND

A workshop was organized in collaboration with the Water Authority of Delfland, which was used as input for the final design in Part III of this research.

E.1 Introduction Workshop

A workshop was organised in collaboration with the Water Authority of Delfland, during the monthly Innovation Lunch, on the 6th of November 2018. There were ten attendees that were mainly senior policy advisors and policy advisors from several sections of the Water Authority. Not solely working with dikes and embankments, but also from other departments, such as Wastewater Chain, Spatial planning, etc. Therefore, the focus of this workshop on the implementation of innovation into water authorities in general, instead of a focus on dike monitoring.

Attendees were:
. Head Strategy & Innovation
. Senior policy advisor innovation
. Trainee Water Awareness (x2)
. Senior policy advisor Energy (previously Water Treatment)
. Senior policy advisor spatial planning
. Senior policy advisor Water system quality
. Program coordinator Climate Adaptation
. Policy advisor Water Management
. Policy advisor wastewater chain

Design criteria workshop:
The design criteria for the workshop are based on elements identified in the first phase of this research and the interviews. They are fine-tuned for this occasion through interaction with the innovation fund manager.

The manager of the innovation fund mentioned that they work a lot on innovation, and provide the money through their innovation fund, but rarely think about the bigger picture; the implementation process from beginning until the goal of implementation and how this fits into the organization. Also, after the money is allocated, there is no focus on evaluation, follow-up and enabling implementation into regular practice. "We tend to stop halfway". The current innovation practice could use some deliberation about the long term.

This corresponds with the barriers identified in the previously conducted interviews; stakeholders should be made more aware of their role in the process of implementation and seeing the whole picture. All stakeholders have their own interests, and these do not always match those of other parties. They can be complementary, but they can also cause gaps in the implementation process.

Therefore, the following design criteria are used:
. Something that concerns different stakeholders, not just end-users. In this case; although developers were not present, they were still taken into consideration.
. Inspire the person to reflect on his/her agency and responsibility
. Useful to other types of innovations (not case specific)
. Nurture different ways of thinking; identifying problems but also make a bridge to solutions
. Allow for reflecting on the big picture and keeping smaller steps in mind: solutions should be focused on the role of the water authority in different sub problems that act as barrier for the implementation of innovation.
. Limited time: from previous research outcome it is also seen that time is limiting factor for all stakeholders. In the context of the available workshop timeframe this is one hour.

Research goal:
Concerning the research goals, this workshop is a trial for the design of an empirical intervention. It is meant to influence practice by enabling people of the water authorities to share their ideas on the implementation of innovation and come up with plans on how to overcome the barriers.

By co-designing solutions, we aim to create support for these. By reflecting on the problems and potential solutions, the stakeholders should become aware of their own role and responsibilities in the implementation process. This way, they can reflect on their current practice, and what they can or should do in an ideal situation. The outcomes of the brainstorm also serve as criteria for further development of the intervention.

E.2 Design of the workshop

Goal of the workshop
How can the water authority enhance the implementation of innovation?
o If we look at he whole implementation process, starting at the development of the product, execution of a pilot onto implementation of a market ready product, which barriers do we face?
o What can we do about these barriers? What responsibility does the water authority carry? How can developers and water authorities complement each other?

Means
The workshop is aimed to be an interactive session, where the attendees reflect on this question and the sub questions through discussion and brainstorming techniques. Another aim is some practical ideas for concrete actions that the water authority can take.

Design of workshop:

Time
11:30 – 11:35 Reception
11:35 – 11:45 Short introduction researcher, research & workshop
Round of introduction attendees
11:45 – 11:50 Exercise: Implementation journey
Take in mind an implementation process: which barriers did you face during the development, pilot, follow up, use, further steps?
11:50 – 12:05 Discussion results
12:05- 12:15 Brainstorm
Based on outcome exercise: how can these barriers be overcome? 3 barriers chosen.
12:15-12:30 Discussion results and feedback

Introduction
Given the limited time, the introduction was kept short. It briefly introduced the background of the researcher, the main research question, and an overview of possible drivers and barriers according to the literature review. Also, the attendees were asked to introduce themselves.

Exercise
The concept of the implementation journey was used as an individual exercise to give all attendees some time for reflection on the bigger picture, and things they had faced in earlier projects. After 5

minutes, the results were discussed in the group.

Brainstorm
Brainstorm questions are prepared but also left open for ideas. Then, the group was split in three, with the aim to rotate the questions after two minutes.

Wrap-up
The solutions are presented and discussed. Feedback is asked about the workshop.
Reflection on Choices made:
Interactive instead of lecture
It was chosen to make the workshop interactive session with a mayor role for the participants.

Start with solutions directly
One of the design choices was whether to start directly with the brainstorm or solutions, or to identify problems as well. Since the time was limited and prior research had already identified barriers for implementation, this could have been skipped. However, the goal of the workshop was to let the water authorities reflect on the process. The exercise with barrier identification was meant to get the conversation started, and also to make them identify with these barriers. When they think about solutions to problems they have identified themselves, it is meant to make them identify with these problems.

Individual exercise instead of group
The choice for an individual exercise at the start was meant to engage each individual, and his or her experience first. This collection of individual experience gives a larger pool of ideas for discussion.

Whole journey instead of a part
Given the short amount of time, we could focus on only a part of the journey. However, given the design criteria, seeing the bigger picture, it was chosen to start with the whole implementation journey; from idea until regular implementation.

E.3 Results of the workshop

1. Discussion Implementation journey:
Different barriers for implementation of innovation
. The goals of an innovation can be diffuse, or they do not comply with the core tasks of the water authority
. Although it helps to be conscious about the implementation process, it does not guarantee a successful implementation
. Urgency is mentioned as a very important driver. If this misses it is hard to get a project through. 'Sometimes it follows an incident, and then something is back on the agenda'.
. The added value of an innovation should be better than the product that is current practice. Sometimes people don't know that they need it and the demand can still arise from the innovation. Sometimes it does not match the practice's needs.
. There can also be technical legislative reasons why the innovation never comes about.
. The circumstances can change; this can lead to an innovation to be implemented at a later point in time. Then it has to be stacked for a while, and the idea 'kept warm', which doesn't always happen.
. People are afraid of change. How can you deal with this, how can you create support for the change?
. Capacity; people need to get time to commit to a problem, they do not always get the time for this.
Other insights:
. It is important to keep the bigger picture in mind, but also to see the small incremental steps.
. The innovation goal is very important to keep in mind. Do you want to change the existence practice, or is the goal a showcase, or to create awareness? You need to evaluate the outcome on this goal.

2. Brainstorm three themes:
How do you nurture support within the organization? How can you make sure people are not afraid of change?
. Ambassadorship (internally)
. Experiencing/seeing/feeling (events and workshops)
. Opening up the conversation
. Incremental steps, repetition is driving force

How do you scale up from a pilot to bigger scale?
. You need an ambassador, preferably from the high management level
. Taking along the executive parties
. Making sure that you think about a phase B from the start; enabling commitment. A pilot is non-binding

How do you manage the communication between the end-user and other stakeholders (technology developers)?
. Brainstorm early in the process, before the idea is finished.
. Phased development with different expertise, and someone who is able to bridge the types of expertise. Also: using different perspectives (Disney model)

E.4 Evaluation

Personal evaluation
The time was passing by very quickly; because the room was not open yet and people were still arriving, we started 10 minutes later than planned. Since it was a quite tight planning, it confirmed the need to be really strict on the time. After the first exercise, the conversation got started really well. Everyone had his or her share in the conversation and it was certainly a good discussion. It was actually hard to pause it and move on to the next part of the workshop. However, it was good that I did and that we also discussed solutions; this was a very constructive part. I did feel that by discussing possible barriers first, they were also very motivated for the brainstorm on solutions. However, given the limited amount of time, we could not rotate all the groups. We did get to discuss the results, which gave some new ideas.
I asked for feedback at the end; and heard that it was useful and appreciated. However we could not go into the details. It went well and I had the feeling that I could steer the conversation at the right moments.

Evaluation participants
Despite the hour passing by very quickly; the workshop sparked a good discussion and was positively received. The key insights are based on the feedback from the participants (p), the innovation fund manager (ifm), the senior innovation manager (sim) and evaluation of personal impressions (pe).

Aim
With respect to the aim of the workshop, it was well perceived that the workshop also focussed on solutions to certain barriers. This was constructive (p, sim, pe).
Content
Some feedback and suggestions for content of the workshop were given. The first suggestion was to provide an overview of the workshop content at the start, so that people know what to expect (ifm). For the design of collaboration between the developers and end-users, it was suggested to define the aim of the innovation project (p). Furthermore, it is important to keep in mind what comes after the pilot project, how can it be implemented in regular practice? And what kind of action does that require at the start of a pilot project? Another suggestion is to keep the bigger picture in mind, but also think about smaller steps to get there (p).

F FINAL DESIGN SUPPLEMENTS

This Appendix contains some supplements of the Final design of the implementation donut. The driver cards (F.1), Worksheet implementation journey (F.2), worksheet SRL method (F.3).

DRIVER SOCIETAL LEVEL: **SOCIETAL PRESSURES** - is there any public attention for the topic? - Is there a sense of urgency to change from society or national government?	**DRIVER ORGANIZATIONAL LEVEL:** **MANAGEMENT, LEADERSHIP, STRATEGY** - Does the management support innovation? - What are the strenghts in the management that we can hold onto?
INDIVIDUAL LEVEL: **PERSONAL INNOVATIVENESS** - Which people are the pioneers? Who are the ones who will be the first to change? - How can we make sure that these people are supported?	**DRIVER INNOVATION LEVEL:** **EFFORT ORIENTED EVALUTION** Is it easy to implement the innovation? - to install it? - to implement it into the working processes? - into contracts?

Figure F.1 - Proposed driver cards

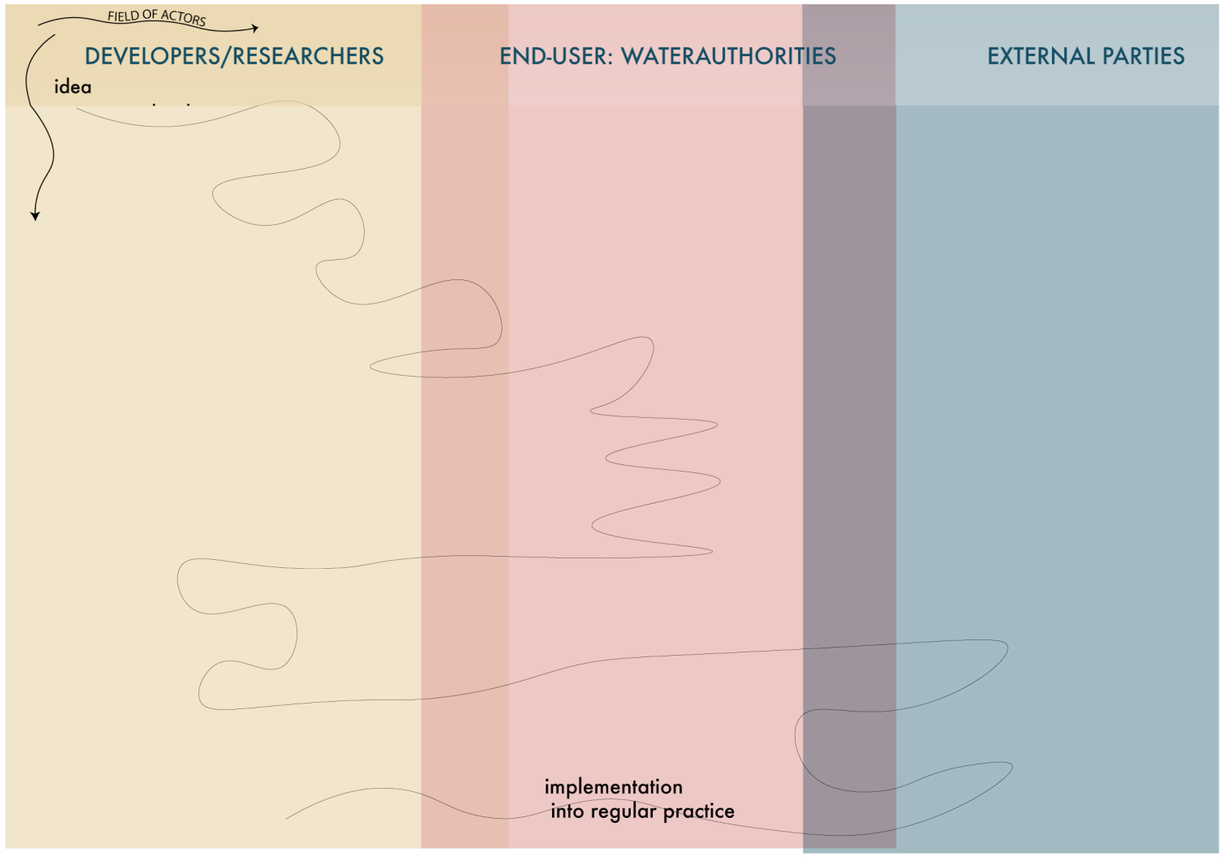
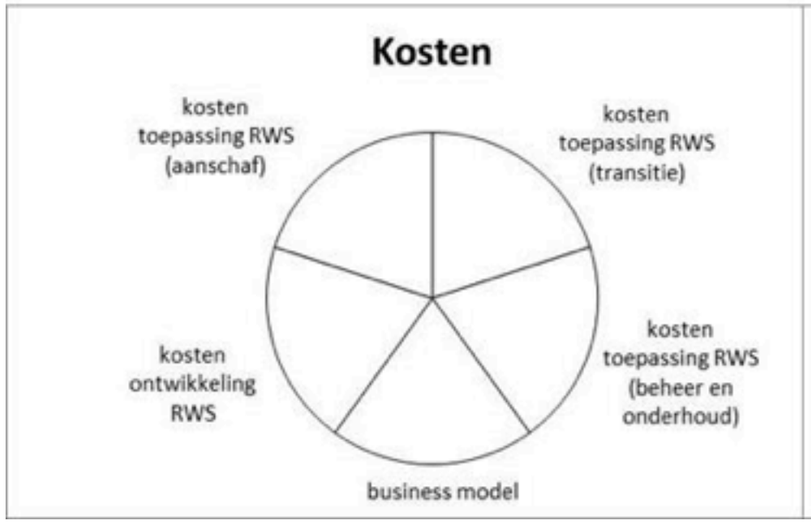


Figure F.2 - Worksheet implementation journey



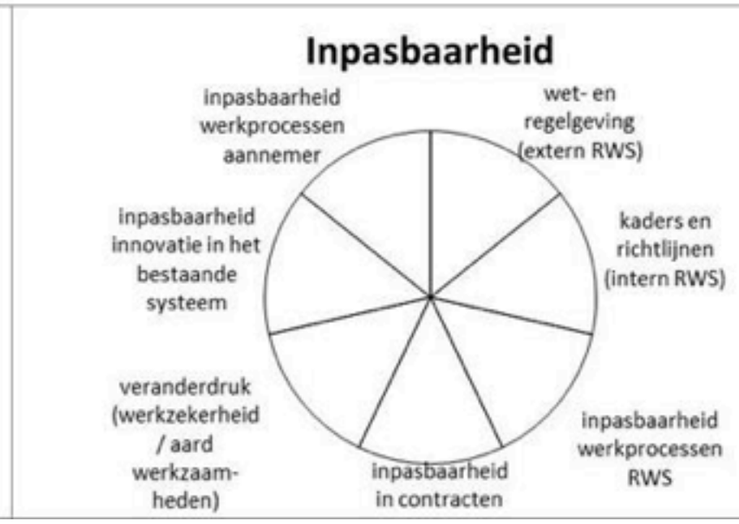


Figure F.3 Worksheet SRL method (Karstens, 2018)

G REFLECTION RESEARCH

This Appendix contains a reflection on the added value of the double master degree perspective on the research process and a personal reflection.

G.1 Added value double degree perspective

This thesis was written as the end product for the masters Water Management and Science Communication. The double degree perspective on this thesis steered the thesis into a certain direction. Where my civil engineering background helped to understand and apply the case studies to the dynamics in the dike sector and an easy way into the network, the science communication background gave me the tools and language to address the implementation of innovation. The implementation process is abstract, and the double diamond and design based approach as taught in science communication enabled me to iterate between theory and practice, and work towards the end result of this report. In this way, this research offered a new perspective with the combined flavours of both disciplines.

G.2 Personal reflection

Now that I am closing of the year with my own thesis product soon printed in my hands, I can look back on the process. With regard to the research and research process there were many elements that I have enjoyed.

Conducting the interviews was definitely such an element: it was always a pleasure to talk to the interviewees, while filling my brains with so much information. I kept the notes of all the appointments in a digital notebook, and even though I attended all these meeting myself, I am still surprised how many people I got to speak. The combination of practice and theory within this research suited me well. The analysis and retrieving the information from the data needed concentration but was definitely satisfying (just like the writing).

There were definitely some learning points. In the process, I often had to switch my mind-set quickly. For example, only one week before I went to Italy this trip was actually planned. I organised workshops and brainstorms in practice, to which the opportunities often arose spontaneously. This flexibility was a good skill to train.

In the Netherlands, I arranged al the interviews and data by myself, sometimes calling people for days in a row, I really had to put myself out there. On the first page, I wrote one sentence of a speech by Theodoore Roosvelt quote “The credit belongs to the man who is actually in the arena.” Which inspired me to take action and I am proud of the opportunities I created.

The topic of my thesis was quite abstract, and at times I did question myself why I did not started a thesis with straightforward formulas. But of course, in the end I followed my interest towards this topic and it was an interesting experience to navigate these abstract waters, bite by bite.

I think that the companionship with my fellow students and friends writing their thesis was something also helped to keep me on track with the work, as well as the free time spent to everything unrelated to the thesis, after which you could always start with a fresh mind.

All in all, it was a productive and fun year, and now, very excitingly, only the finishing touches are needed before this thesis can be printed and I can literally hold it.

Eat the elephant one bite at a time