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MASTER THESIS
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WATER SECURITY: HOW CAN THE NETHERLANDS CONTRIBUTE TO THE IMPROVEMENT WORLDWIDE

A CRITICAL REFLECTION ON THE FUNCTIONALITY, KNOWLEDGE POSSESSION AND KNOWLEDGE PRODUCTION OF THE DUTCH WATER SECTOR.

Utrecht University

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Water security: how can the Netherlands contribute to the improvement worldwide

A critical reflection on the functionality, knowledge possessed and knowledge production of the Dutch water sector.

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Summary

Since the Netherlands is a delta and has a relative high change of rain, a sufficient amount of water available is expected (Siepman, 2020). Nevertheless, through climate change water availability in large parts of the world is decreasing (Graaf, Gleeson, Sutanudjaja, & Bierkens, 2019). Moreover, the Netherlands has a long history of protection the country against water. Therefore, its main strategy is to discharge water as quickly as possible. From the demand side, a structural increase is shown since the industrial revolution (Nazemi & Wheater, 2015a). This illustrates a mismatch and an insecure water system (Ritzema & Loon-Steensma, 2018) which has received criticism. Nevertheless, the Dutch government aims at increasing international activity by the Dutch water sector. Their ambition (Netherlands International Water Ambition) describes to contribute to the improvement of water security worldwide.

This study's main research question therefore is: *How can the Netherlands contribute to the improvement of water security worldwide in order to fulfil the Netherlands International Water Ambition?*

Focusing on water supply management, literature illustrates numerous techniques and strategies to create a more efficient water system. To produce knowledge on these implementations in the water domain, it is often established through a triple helix structure (Edelenbos, Buuren & Schie, 2011). This structure builds further on traditional public-private partnerships, including knowledge institutes and universities (Cai & Etzokowitz, 2020; Leydesdorff & Etzokowtiz, 1998). Concerning the latter two sectors, the Linear Model of Innovation argues that basic research will have effect throughout society and economy (Godin, 2006). Besides producing knowledge, some argue that the Netherlands should import knowledge to gain more experience (Nikkels & Hellegers, 2020).

Qualitative research provided answers to the above-mentioned research question. Ample data was collected by conducting 24 semi-structured interviews, and interviewing 27 experts representing public entities, private companies, and universities/knowledge institutes of the Dutch water sector. This distinction has been made by the government and was applied into this research (Boneschansker, Tietema & Neijland, 2018). In addition, primary data was combined with secondary data.

It has become clear that the Dutch water sector is facing numerous challenges and is in need for certain improvements. Nevertheless, a lack of knowledge does not seem to be the issue. Since the Dutch water system is an old and complex system and the sector has a long history of participating in projects abroad, the sector possesses enough knowledge. Through longitudinal projects Dutch expertise is translated to local context, together with the local community. This is perceived as an effective and sustainable approach to contribute to the improvement of water systems worldwide. All in all, the Dutch water sector can contribute to the improvement of water security worldwide, by sharing its knowledge and expertise, and therefore, achieve the NIWA.

Preface

Dear reader,

Before lies the master thesis: '*Water security: how can the Netherlands contribute to the improvement worldwide'*. A critical reflection on the functionality, knowledge possession and knowledge production of the Dutch water sector. This thesis is written to complete the master programme Human Geography at the Utrecht University. This research process has started in February 2021. After 17 months of hard work, 24 interviews including 27 experts representing a wide variety of the Dutch water sector, this research has finally come to an end.

A water related topic would not have crossed my mind before 2018. In this year I became aware of the potential 'Day Zero' event in Cape Town, South Africa. After some research I found out that cities closer to home are facing similar problems. Although climate change made certain issues painfully visible, these problems are often man-made. While finishing a literature study on water scarcity, I came across an article critically reflecting the Dutch international water approach. Since I was an outsider, the critique given was refreshing. This article of J.S. Kemerink-Seyoum (2019) has stayed with me and eventually made me choose to conduct research on this specific topic.

This master thesis would not have been the same without all the passionate experts throughout the Dutch water sector. Therefore, I would like to thank all of you that have contributed to this study by sharing experiences, insights and personal opinions. Due to your willingness to contribute I have felt a lot of support. I also would like to thank my supervisor Ron Boschma, for supporting me and giving me helpful feedback throughout this process.

On a more personal note, I would like to thank Hans for his willingness to critically read through this study. It has been very useful to receive your feedback each time on such short notice. Furthermore, I also wish to thank Gijs, Lisa, and Verali for their willingness and time. Without each of your expertise and network the list of interviewees would not have been lengthy and substantive as it has become. Resulting in a large pile of data I had to analyse. Thank you, Gijs, for helping me structure the results and for your promising words. Furthermore, I would like to thank my parents and sister for their support, feedback and help in the graphic design of this thesis. Finally, I want to thank my partner, Pleun, for her infinite support and acceptance throughout this process. This research would not have been the same without your motivating and loving words. It has been a difficult but meaningful experience writing this thesis.

I hope you enjoy your reading.

Pim Isaacs

Breda, July 14, 2022

Glossary of terms

DWA	: Dutch Water Authorities, overarching institute of all Dutch water authorities.
DWPW	: Department of Waterways & Public Works (Rijkswaterstaat).
MIWM	: Ministry of Water Management.
PfW	: Partners for Water, a programme initiated by the Dutch government to stimulate Dutch activity worldwide.
Public parties	: In this research water suppliers are included in the term public parties, according to Boneschansker, Tietema, and Neijland (2018).
TW	: Top-sector Water (scope of this research).
TWM	: Top-sector Water & Maritime (official name of the Dutch water sector).
WA-L	: Water Authority Limburg.
WA-R	: Water Authority Rijn & IJssel.
WA-S	: Water Authority Scheldenstromen.
WENR	: Wageningen Environmental Research, department of Wageningen University and Research.

Table of content

1

INTRODUCTION

1. Introduction

'When you would ask a random Dutch person to describe the weather in the Netherlands in only one word, it is very likely that this word would be: 'rainy'. Nevertheless, probably the most pressing water-related problem that the Netherlands is currently facing, is drought. The year 2020 has already been the third consecutive year of drought, with several negative effects on (ground)water, ecosystems and soil as result' (Siepman, 2020, p. 1)

The Netherlands has faced periods of drought during the summers of 2018 and 2019, until spring of 2020. This has had negative effects on the water availability and therefore, on the functions in demand of water. Although water availability, such as groundwater and surface water, becomes increasingly uncertain, water demand has risen continuously after the industrial revolution (Nazemi & Wheater, 2015a). Especially 'groundwater overexploitation is a major risk for future water security' (Pronk, et al., 2021). Water security is seen as a new objective in the domain of integrated water resources management (IWRM) and has gained interest by national and transnational organisations (Gerlak & Mukhtarov, 2015). In the previous decades discussions have been ongoing regarding the definition of water security and its perspective. While some perceive the term as implication ad-hoc management whenever water insecurities are occurring, others perceive the definition more related to 'an extension of sustainable development thinking to water resources with the focus on the quantity and quality of water supply for societal and ecological needs' (Gerlak & Mukhtarov, 2015).

Although this illustrates the narrative of efficient water usage, the Dutch system is efficiently organised, aiming at the discharge of a large amount of water from the rivers and rainfall. Against, the increasing demand for water, previous summers have shown the lack of water resources as impact and consequence of climate change due to drought (RTLnieuws, 2020). In other words, while demand is increasing, water resources are being discharged into the North Sea instead of using them. Therefore, scientists publicly raise questions on the capability of Dutch water management to assure sufficient water supply (Kemerink-Seyoum, 2019; Nikkels & Hellegers, 2020).

While these questions seem relevant, the Dutch government has published the so-called Netherlands International Water Ambition (NIWA), a document containing objectives regarding water security and water safety. More specifically, the aim is to improve water security and water safety globally for people, flora, and fauna. Through Dutch contribution abroad this should optimise revenues for the Dutch government (Waterstaat, 2019). The NIWA is based on Sustainable Development Goals (SDG's) 2030 (Waterstaat, 2019) and illustrates the ambition to become involved with international projects (Büscher, 2019) thus optimising revenues from services and knowledge-sharing and expertise to improve water security and water safety.

How can the Dutch water sector improve water security globally whenever the Dutch system does not perform sufficiently? This question demonstrates the scope of this study. An analysis of the performance of the Dutch water sector regarding water security insights on this topic is given. The main focus will be on the Dutch water sector itself. More specifically, on water supply management.

1.1 Scientific relevance

Although water security has gained interest in the water domain, a clear definition seems missing since multiple interpretations are given depending on different perspectives. In the context of the Netherlands, water security is suggested to be a relatively new topic in water management. Gaining insights into knowledge possessed regarding this issue is useful and additionally, information on the knowledge production by the Dutch water sector is needed. While certain techniques and strategies are known to increase the efficiency of a water system, it is unknown which are (or will be) implemented by the Dutch water sector. On top of that, actual improvements in the water system have not been noticed yet. All in all, this study will show insight into the functionality of the Dutch water sector as well as the knowledge infrastructure regarding water security, to establish whether the Dutch water sector can contribute improving water security worldwide.

1.2 Social relevance

In line with different perspective regarding water security, the Dutch perspective is unknown since the NIWA does not define the term clearly. To understand what water security entails, the Dutch water sector can define certain objectives more directly to achieve the ambition stated in the NIWA. As described earlier briefly, the Netherlands is used to have a lot of water. By researching how the water system works and what implementations can be carried out, awareness can be created regarding changes that need to be made. Since drought and water shortages have a major impact on humanity, these changes should be communicated clearly. Although this research mainly addresses supply management, it might help to stress the importance of reducing the water consumption in the Netherlands. Overall, this study will give a clear overview of what the Netherlands is facing, learning, making, producing, defining, and implementing in regard to water security.

1.3 Research questions

Even though questions are raised about the efficiency and capability of the current water management, the Netherlands is ambitious and has a wider orientation than only domestically. To find out if criticism on Dutch water management, in particular on its water supply, is valid, the aim of this paper is to provide insights on how and what knowledge has been produced regarding water security, and if this knowledge can contribute to the improvement of water security worldwide.

This study's main research question therefore is: *How can the Netherlands contribute to the improvement of water security worldwide in order to fulfil the Netherlands International Water Ambition?*

To answer this question, the following six research questions have been defined:

RQ1: How does the Dutch water sector define water security?
RQ2: How is the Dutch water sector trying to accomplish water security?
RQ3: What knowledge does the Dutch water sector possesses on water security?
RQ4: How is the Dutch water sector producing knowledge on water security?
RQ5: How is the Dutch water sector currently trying to contribute to water security worldwide?
RQ6: What future steps will the Dutch water sector take in order to improve water security worldwide?

1.4 Overview of structure

In *chapter 2 a* variety of theories used as foundation for the interviews are demonstrated. These theories are focused on general knowledge production and innovation processes. In addition, literature specifically in water management will be combined and evaluated. Zooming in on the water domain, perspectives on water security and possible solutions to accomplish water security have been defined. Continuing with *chapter 3* the methodology of this study has been clarified. By arguing what research method is used the scope of this study becomes clear. More specifically, the Dutch water sector has been dissected resulting in a clarification about the research unit used in this research. Furthermore, through desk-research a general overview is given regarding the size and revenues of the sector. Lastly, the data collection and analysis of the data have been clearly explained in this chapter.

Chapter 4 illustrates what information was received through primary research and secondary research. Through open and axial coding, data was separated according to the six research questions defined earlier. Each of the six paragraphs show the most relevant and interesting findings. In *chapter 5* these findings are combined with literature included in the theoretical framework. In other words, the conclusion answers all six research questions. By concluding these questions based on insights gained through semi-structured interviews and literature, the main research question, *how can the Netherlands contribute to the improvement of water security worldwide in order to fulfil the Netherlands International Water Ambition* is answered. *Chapter 6* contains a critical reflection including improvements and limitations on the research. This chapter is finalised by suggesting further research topics within the domain of water management.

2

THEORETICAL FRAMEWORK

2. Theoretical framework

Since the research questions are clearly defined, theories relating to these questions will be discussed and clarified in this chapter. As mentioned above there are different strategies to accomplish water security. These different strategies will be explained individually. However, firstly theories on knowledge production and innovation systems will be introduced. Finally, a foundation of theories is created which will give sufficient basis for further primary research.

2.1 Society, knowledge, and innovation

Through climate change ecological and climatological systems are changing. These changes have an effect on humanity. An important consequence of rising temperatures and therefore rising sea levels - which might be underestimated - is the decrease in water quality (Whitehead, Wilby, Battarbee, Kernan, & Wade, 2009). To protect humanity from changes in nature and climate, knowledge and innovations are needed (Krozer, Hophmayer-Tokich, Meerendonk, Tijsma, & Vos, 2010; Ritzema & Loon-Steensma, 2018).

According to Lundvall (2007), in recent society 'the most fundamental resource in modern economy is knowledge'. However, 'meaningful knowledge can only be created on the basis of a process of joint knowledge production' (Buuren & Edelenbos, 2004). This suggests that multiple players will work together to produce knowledge and create innovative ideas. To understand the dynamics between actors producing knowledge, the concept of innovation system is used (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008). Such a system can be defined as 'a group of components' which can have various forms but serve a common goal or objective. The components can be described as 'actors, networks and institutions' contributing to the development and production of joint knowledge. The continuing process of producing new knowledge to remain innovative is the interconnection between 'technological-push and demand-pull' (Lundvall, 2007). Wehn and Montalvo (2018) distinguish two stages in innovation. Firstly, the development (the technology push) and eventually this development will be adopted (the market pull). In the past, scientists have stressed the importance of feedback between these two stages, only then innovation will be effective (Kline & Rosenberg, 1986).

The process described above is the so-called 'linear Model of Innovation' (Godin, 2006). According to this model, 'innovation starts with basic research, is followed by applied research and development, and ends with production and diffusion'. In other words, basic research will eventually impact economy and society (Godin, 2006). Important to understand when analysing innovation systems, is the kind of knowledge that is produced through the innovation process. Lundvall (2007) distinguishes knowledge on local or global context as well as tacit knowledge: knowledge that is 'embodied in people and embedded in organizations' (Lundvall, 2007). Furthermore, this perception stresses the importance of communication and interaction to combine knowledge and eventually be innovative. 'In some countries it is much easier to establish co-operation within and/or between organizations than in other countries' (Lundvall, 2007). Since knowledge is a fundamental resource, countries aim at facilitating efficient infrastructures for actors to communicate and interact with each other. Hopefully this supports knowledge production which in the end can be sold globally. By facilitating such an environment these countries follow the perspective of classic economists, given that they believe that knowledge and 'innovation [are] needed for economic development' (Lundvall, 2007).

Nevertheless, knowledge is not only produced for economic growth. Knowledge, often produced by universities or knowledge institutes, can be wider implemented and is 'necessary for social and ecological sustainability' (Lundvall, 2007). For example, innovations in technology which improve the efficient use of unrenewable resources. This type of knowledge is important for public entities to implement in their policies. To foster this process, the urge for a proactive government has been recognized (Leydesdorff & Etzokowitz, 1998). To be more specific, local and region governments have been stimulated to take a proactive role in the development of 'science, technology, and innovation policies (Leydesdorff & Etzokowitz, 1998) and maybe even more important, the development of networks nationally as well as internationally (due to digitalisation). These networks consist of the same stakeholders identified in the Linear Model of Innovation (Godin, 2006) namely, (1) universities/knowledge institutes, (2) industries, and (3) government.

Although this interaction is not particularly new, the triple helix perspective is different compared to previous perspectives because of the focus on knowledge. According to Cai and Etzokowitz (2020), previous perspectives on innovation have been focused on the companies in specific industries or the interaction between government and companies. The triple helix system can therefore be seen as 'the expansion of so-called public-private partnerships to include academia' (Cai & Etzokowitz, Theorizing the Triple Helix model: Past, present, and future, 2020). In the triple helix system universities are given a crucial role together with the acknowledgement that only the interaction between knowledge institutes, industries and government can lead to 'fostering innovation and entrepreneurship (Cai & Etzokowitz, Theorizing the Triple Helix model: Past, present, and future, 2020). The role of universities and knowledge institutes illustrates the ongoing transition of societies from industrial towards a knowledge-based society (Cai & Etzokowitz, 2020). Nevertheless, 'universities need to be guaranteed a minimum autonomy in order to give long term contributions to knowledge created and the idea that they should be completely subsumed to market forces and political control is incompatible with their role as guardians of what is 'reasonably reliable knowledge' (Lundvall, 2007).

Even though the three actors in the triple helix are clear, the interaction between these actors has different forms. Where Leydesdorff and Etzokowitz in 1998 refer to Triple Helix I, II and III, Cai and Etzokowitz (2020) define the three different types of interaction in terms of a 'statist model', 'laissez-faire model' and the 'balanced model' (*figure 1*).

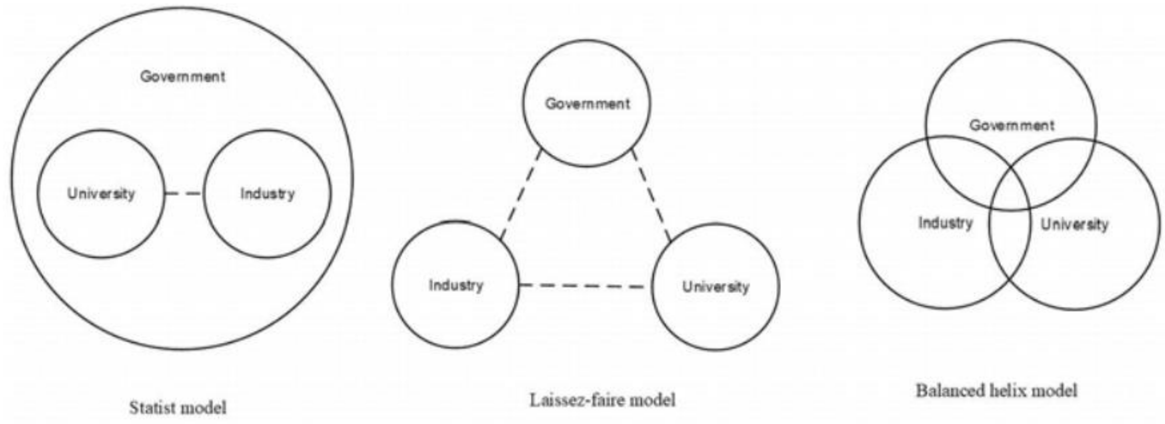


***Figure 1.** Different types of interaction (Cai & Etzokowitz, 2020).*

Figure 1 demonstrates what forms of interactions the three actors can have between each other and with each other. In the statist model, the government has the leading role and controls the universities and industries. By controlling the other two actors the government is 'expected to take the lead in developing projects and providing the resources for new initiatives' (Cai & Etzokowitz, 2020). These resources could vary from network to financial support. The second model, the laissez-faire model, illustrates a more equal dynamics between the three actors. Besides, all three actors are interacting with each other. Nevertheless, this does not mean all three do so, or at the same time. This is different from the last model, the balanced model. The intersections of the spheres create a promising situation for innovation since knowledge is shared in these intersections. Although this does not mean that all three actors interact at the same time, the model shows that is more likely to do so, compared to the laissez-faire model. Nevertheless, being realistic the balance model between the three spheres 'hardly exists in reality' (Cai & Etzokowitz, Theorizing the Triple Helix model: Past, present, and future, 2020).

In general, to start a triple helix interaction, (Cai, 2015), found out there must be some kind of need. Overall, this need is often recognized by the government or public entity. From the realisation of the need (stage 1), three other stages were distinguished by Cai (2015); stage 2: 'Intra-organisational transformation', stage 3: 'Interactions between organisations' between the three spheres and lastly, stage 4: 'Institutionalisation of the Triple Helix model'. According to these stages partnerships between the different actors can be analysed.

2.1.1 Summary

The transformation of our society in the 21st century from industrial towards knowledge-based has resulted in the dramatic urge for new information, knowledge and thus: innovation. Since our society is knowledge-based, innovation is believed to be an effective instrument for economic growth. To make sure innovation can generate economic growth partnerships are needed. These partnerships are often initiated and facilitated by governmental entities. While these partnerships initially exclusively focused on public-private partnerships, partnerships are nowadays created between the three spheres of government, industries (private companies) and universities and knowledge institutes, often defined as triple helix. These partnerships start by recognising a certain need (often by the government). The functionality of the system is distinguished by three types in literature: statist model, laissez-faire model, and the balanced model. The difference between these models is the role the government has as well as the "closeness" of the relationship between the three actors. By completing the stages of the triple helix this system can become institutionalised in a sector.

2.2 Water, knowledge, and innovation

As clearly described, a triple helix system is often initiated by a governmental entity due to the recognition of a certain need. Since climate change is becoming more and more visually present, awareness is created and thus the need for information to deal with these situations is recognised by governments as well as other actors. Regarding the theme of water, as aforementioned, this comes down to rising temperatures, rising sea level, higher fluctuation in precipitation, decline in water quality and decline in water availability. To cope with these changes to keep the planet habitable, knowledge and innovation is needed.

Although the need for innovation is recognised, Krozer, et al., (2010) state that in the water sector itself few innovations are noticed. Moreover, the sector is 'claimed to be less innovative than other sectors' (Wehn & Montalvo, 2018). This has to do with the traditional way of water management as this is 'highly centralized, which creates path dependencies that prevent more sustainable and decentralized alternatives from occurring (Bichai, Grindle, & Murthy, 2018). In their research Bichai, et al., (2018) noticed that in Australia the system changed, and innovation was introduced as reaction on the "Australian Millennium drought", a continuing episode of dry periods from 1997 to 2010. To cope with this drought Australia introduced a 'National Water Quality Management Strategy' (Bichai, Grindle & Murthy, 2018). According to Wehn and Montalvo (2018), the phrase 'water innovation' has been used for the first time in 2004 as result of the Millennium drought. Although this article focuses on the leadership and achievements, years later the lack of innovation in water management was recognised (When & Montalvo, 2018). Nevertheless, in many low-income countries the capability to be innovative and develop such a strategy regarding water issues that Australia initiated is absent (Wen & Montalvo, 2018) and thus demand for water related solutions will grow.

'Demand for innovative solutions will grow: solutions enabling more efficient use of available water resources, enhancing the quality of (drinking) water, and improving water resource planning to reconcile the conflicting trends of rising demand for water and finite water resources (When & Montalvo, 2018, p. 2).

Therefore, joint knowledge production and triple helix systems are likely to be applied more often. Nevertheless, a contradiction can be found between general theories regarding triple helix system and the joint knowledge production regarding water management. While in general literature (Cai & Etzokowitz, 2020) it is stated that universities and other knowledge institutes have been ignored in previous public private partnerships. In water management this has been the case of the private industry. According to Edelenbos, Buuren and Schie (2011) 'the field of water management has traditionally been dominated by water professionals from governmental and research organisations.' In the recent decade this has been noted and contribution of stakeholders within the sector was initiated. Due to stakeholder involvement, or private actors, local experiences and insights can be implemented. These relate to the daily life routine of local population, entrepreneurs, etc. (Edelenbos, et al., 2011). Due to the contribution of private companies, knowledge is co-produced in a new/different way which might cause fragmentation of differences in knowledge between experience of private companies and scientifical knowledge from knowledge institutes. Edelenbos, et al. (2011) have designed a framework (*figure 2*) which illustrates the co-production of knowledge between the three parties (experts, bureaucrats, and stakeholders).

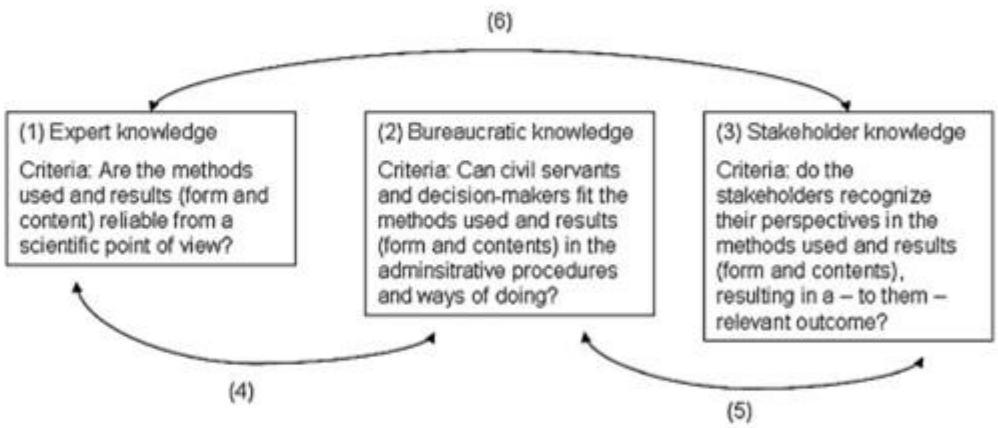


Figure 2. *Framework of co-production in a triple helix structure (Edelenbos, et al., 2011).*

Besides the types of knowledge defined by Lundvall (2007), Edelenbos, Buuren and Schie (2011) have identified three other types of knowledge. As *figure 2* demonstrates, sharing knowledge starts at knowledge institutes and universities sharing their expert knowledge with governmental entities. By doing so, bureaucratic knowledge is developed further and is used for decision-making and policymaking. Since decisions and policies will have impact on the (private) stakeholders, bureaucratic knowledge is shared in the field. This means that stakeholders must adjust to policies which will result in new insights. Furthermore, stakeholders will test the knowledge received by knowledge institutes and governmental entities in practice. These insights are defined as stakeholder knowledge and will be evaluated and shared with the other two sectors.

Since the knowledge institute is firstly sharing knowledge with governmental entities. This illustrates the delayed involvement of stakeholders in water management. Furthermore, this shows that a mismatch between policies and practice is plausible. In addition, the framework developed by Edelenbos, et al., (2011) demonstrates a certain loop that is ongoing. This contradicts the Linear Model of Innovation (Godin, 2006).

Referring to the example of Australia's reaction to its drought, the country responded with a defined strategy to 'increase resilience to climate variability' (Bichai, et al., 2018). Nevertheless, in their research Bichai, et al., (2018) conclude that by the time precipitation increased, the motivation and will to increase resilience disappeared in the Australian political system. This illustrates the importance of the first stage of the triple helix model: realisation of a need (Cai, 2015). Once the Australian government did not see the need for new innovations due to an increase in rainfall, knowledge production decreased.

2.2.1 Summary

Overall, innovation in water management is suggested to be relatively new compared to the general transition towards a knowledge-based society. According to numerous studies, innovation in water management, or water innovation was firstly defined in the 21st century since, at that point, there was a certain need for innovation in Australia. Due to recent climatological events - because of climate change - innovation becomes more urgent globally. Traditionally, universities and governmental entities dominated the water sector, however due to these climatological events new solutions became more prominent. To fulfil this demand private companies were invited to work together with governments and knowledge institutes in an ongoing process (Edelenbos, Buuren, & Schie, 2011). By sharing their practical experience joint knowledge production results in state-of-the-art solutions for regions worldwide that must deal with climate change.

2.3 Water, management, and water management

'Water is a basic need for life on Earth and is used for many purposes' (Zehnder, Yang, & Schertenleib, 2003). According to Zehnder, et al., (2003), the usage of water can be divided into four categories: '(i) water for people, services, and industries, (ii) water for agriculture, (iii) water for nature, and (iv) water for energy production. Since the demand for water has increased dramatically water management has become ‘very complex, from technological, management and governmental perspectives.’ Furthermore, the increase in water demand has caused water scarcity worldwide.

To overcome water scarcity, effective water resource management is needed. Although, ‘conceptually, water resource management (…) can be seen as integration of two fully interactive elements, related to water demand as well as water supply’ (Nazemi & Wheater, On inclusion of water resource management in Earth system models - Part 1: Problem definition and representation of water demand, 2015, p. 36), in this research the main focus will be on water supply management.

2.3.1 Water, supply, and resources

Water supply management includes managing the water resources and the utilisation of these resources. Due to water scarcity, the question is how the utilisation of water can be improved. To understand what kind of water resources there are, the hydrological cycle will be introduced.

According to Nazemi and Weather (2015a), ‘hydrology was conceptualized as a simple lumped bucket model (…), but this representation has progressively been improved’ since in such lumped bucket model, water interaction by humans had not been integrated. As aforementioned, human water interactions have intensified and are continuing to grow due to population growth and extra water demand. ‘During the past century, human water consumption has increased more than 6-fold, with around 5, 18 and 10 times increase in agriculture, industrial and municipal consumption, respectively’ (Nazemi & Wheater, 2015, p. 34). To understand what types of water is consumed, water resources have been demonstrated in *figure 3*.

In total, three main resources of fresh water can be identified (*figure 3*). These are (a) surface water, (b) rainwater precipitation, and (c) groundwater which can be found in the shallow ground layer as well as deeper underground (called aquifers) (Querner, Jansen, Akker, & Kwakernaak, 2012). Managing these resources should include ‘integrated water resources management (IWRM) and ecosystem restoration and remediation, aimed at ensuring the protection, sustainable use, and regeneration of water resources by protecting ecosystems, rivers, lakes, and wetlands and building the necessary infrastructure (e.g., dams and aqueducts) to store water and regulate its flow’ (When & Montalvo, 2018, p. 3).

Figure 3 illustrates rainwater being infiltrated in the ground or becomes surface water (in lakes or rivers). Some rainwater remains on the ground and can evaporate. Regarding water in the ground this can either flow towards surface water or can be infiltrated into soil. Water infiltrated in soil still flows.

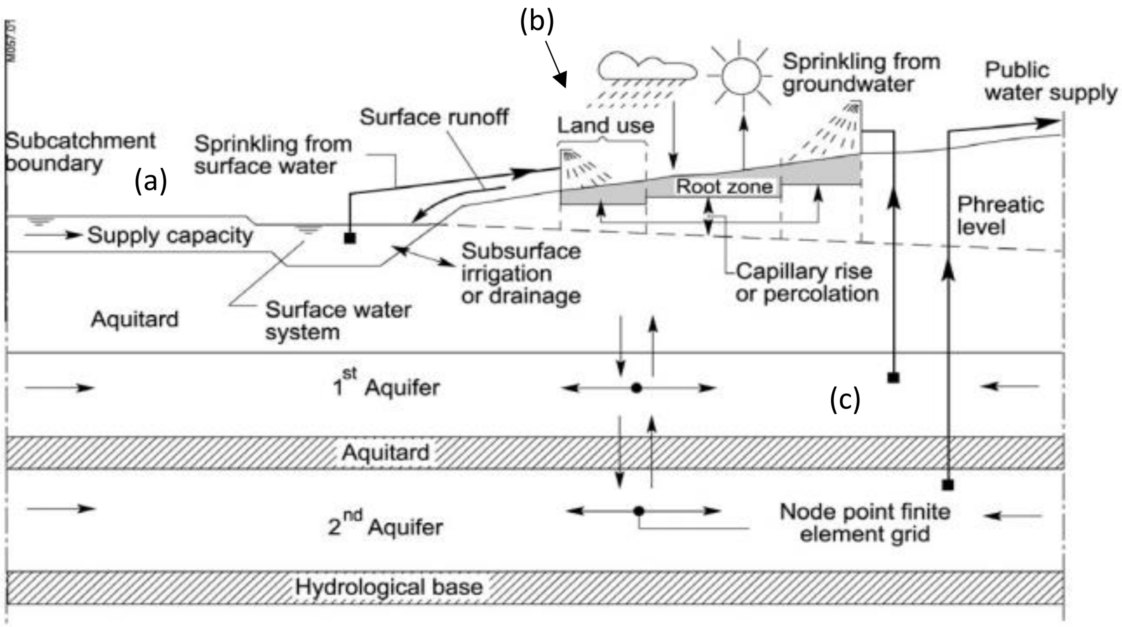


Figure 3. *Schematic overview of the flow of water according to Querner, Jansen, Akker and Kwakernaak (2012).*

Eventually this water can reach surface water, such as a lake. Besides, water can also move to places where it cannot be reached anymore (Futter, Whitehead, Sarkar, Rodda, & Crossman, 2015). As mentioned before in the introduction, overexploitation of groundwater is a serious risk in parts of the world. As *figure 3* demonstrates, groundwater is a finite resource. Although rain can naturally supply the groundwater levels, due to increasing demand the water system becomes unbalanced. This illustrates what the impact of drought can be. Nevertheless, protecting ecosystems and utilising water sustainably is difficult nowadays due to changing climates and a growing world population. Once again, this makes the availability of water more essential, depending on the local context (Nazemi & Weather, 2015). Densely populated areas increasingly face water shortages. By controlling water sustainably, the inflow of water is secured for human purposes as well as other ecosystems. How water security can be improved and what the term entails will be clarified in the following paragraphs.

2.3.2 Water security

In literature there is wide discussion on what water security should include and what not. Overall, there are different foci to which the term water security is linked. For example, Cook and Bakker (2012) illustrate four different “perspectives” on water security, namely:

1. Quantity and availability of water.
2. Water-related hazards and vulnerability.
3. Human needs (access, food security, and development-related concerns).
4. Sustainability.

The first perspective is referred to as the 'primary gauge of water security' by Cook and Bakker (2012). This perspective focuses on calculations on the water supply and demand in dry and wet periods. The foundation of these calculations is water shared per capita. Even though this is useful and necessary information, water is consumed directly as well as indirectly. Furthermore, water is not only needed by humanity but by other ecosystems as well. Therefore, this perspective on water security does not give a holistic image of water usage.

Secondly, the 'water-related hazards and vulnerability' perspective relates to what in this research will be referred to as water safety. Water security and water safety seem to be similar. Nevertheless, in literature there is a clear difference. Water safety can be explained as assuring safety against flooding (Cook & Bakker, 2012). Due to rising sea levels deltas throughout the world will have a higher risk of dealing with flooding.

Continuing with the fourth perspective, Global Water Partnership (2000, p. 1) referred to it as; 'water security at any level from the household to the global [level] means that every person has access to enough safe water at affordable cost to live a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced'. This definition illustrates a kind of baseline the Global Water Partnership implements to have a secure and sustainable water supply for each person on this globe, including the protection of natural environment. Although this perspective has a broader and more practical approach towards water security, it seems to focus only on the direct water consumption of an individual (too).

This is different for the third perspective, 'human needs'. These needs are interconnected with a wider field of industries. Witter and Whiteford (1999, p. 2) took this wider perspective by referring to it as the 'condition where there is a sufficient quantity of water at a quality necessary, at an affordable price, to meet both the short-term and long-term needs to protect the health, safety, welfare and productive capacity of position (households, communities, neighbourhoods, or nation)'. This definition has a broader scope in time, as well as a broader meaning. It not only includes individuals but also mentions wider groups of people. Nevertheless, since the definition focuses on human needs, the impact on the natural environment is ignored. Furthermore, protection of safety is included in the definition as well. This illustrates the overlap water security and water safety have. Following the definition of Witter and Whiteford (1999) water security could be seen as the overarching ambition which includes water safety among other underlying elements. This idea is illustrated by Grey and Sadoff (2007, p. 545) with their definition of water security as 'the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies'.

Although the latter definition is broad and therefore may be implemented globally, Cook and Bakker (2012) indicate that water security is used differently worldwide. In their research differences are shown between Australia, China, Middle East & North Africa (MENA). While Australia generally (solely) links water security to the quantity of available water, China has a broader perspective and focuses on the impact of available water regarding 'environment, ecology, society, politics and economy' (Ma, Liu, & Chen, 2010, p. 541). In the MENA region there is the focus 'on sharing a scarce resource amid increasing demand in an unstable geopolitical climate (Cook & Baker, 2017).

As aforementioned, in literature water security has different meanings. By analysing different perspectives and definitions of water security numerous aims are illustrated. While one perspective focuses only on mankind, another focuses on the present times or short-term future only. Besides the different meanings, Cook and Bakker (2012) have shown that context of water security differs geographically.

In this article, water security will be referred to as *'the moment water quality and quantity are sufficient and protect the health, safety and welfare of livelihoods, production and the natural environment in the short and long run'*. This definition is a combination of the third (human needs) and fourth (sustainability) perspective described by Cook and Bakker (2012). Although the meaning of the term water security is still debatable scientists, agree on certain strategies that contribute to the improvement of water security. What these strategies are will be explained in the subsequent paragraphs.

2.3.3 Water, storing, recycling, desalinating

Water security is an important matter since it creates assurance of a primary need as well as a human right. Nevertheless, due to local context, a large amount of people cannot be guaranteed the supply of water. Besides climatological changes and urbanization, political systems play an important role as well. To create a better understanding of what techniques can be applied to accomplish water security the most common options will be explained which illustrate their contribution to water security as well.

2.3.3.1 Retaining and storing water

Firstly, one of the strategies to improve water security is by controlling, collecting, and storing water. Collecting and storing are important measures to make sure enough water is available during periods of heat and drought (Claessens, Schram-Bijkerk, Breemen, Otte, & Wijnen, 2014; Nikkels & Hellegers, 2020). However, besides heat and drought, certain global regions will face an increase in precipitation. Traditionally, 'the solution to cope with increases in rainfall was to increase the pump capacity of the drainage system' (Ritzema & Loon-Steensma, Coping with climate change in a densely populated delta: a paradigm shift in flood and water management in the Netherlands, 2018). This solution relied on the drainage system. However, this has changed due to the need of seasonal balance in the water system. To do so, countries such as The Netherlands shifted towards a more controlling approach (Ritzema & Loon-Steensma, 2018). According to Ritzema and Stuyt (2015), this "new" solution is realised in three chronological steps (*figure 4*). Firstly, water will be retained as surface water or 'in the soil profile' (Ritzema & Loon-Steensma, 2018), meaning groundwater. Subsequently, water will be stored in a deeper ground level. Lastly, the overload of water will be removed.

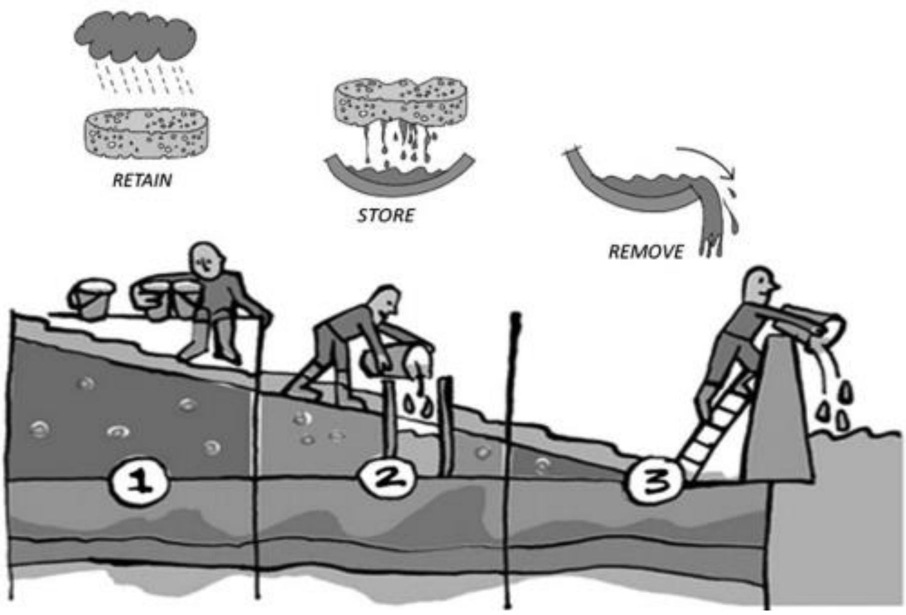


Figure 4. *Visualisation of the three steps that successfully lead to a more controlling drainage of water (Ritzema and Stuyt, 2015).*

'This approach reduces outflows during periods of extreme rainfall and increases water storage for use during period of drought' (Ritzema & Loon-Steensma, 2018). 'Greenery and open spaces (unsealed soil) contribute significantly to water storage', especially in urban areas, according to Cleassens et al. (2014). Thus, (available) ground and soil are important to collect water either on the surface (surface water) or in the ground (ground water). However, population growth makes this challenging. Not only since there are more people in need of water, but simultanously these people are in need of houses and facilitities which results in less unsealed and occupied soil. Furthermore, *figure 4* illustrates an approach which seems to be adaptable globally. Nevertheless, retaining and storing water depend highly on available space as well as the type of soil (Ritzema & Loon-Steensma, 2018). Besides storing water, two other strategies that can improve the water security are introduced in literature. These are the implementation of reusing wastewater and the implementation of water desalination which describes the process of transforming seawater into drinking water. According to Nazemi & Wheater

(2015b), these two approaches are 'widely ignored in large-scale models'. Proof can be found in *figure 3* since these potential water resources have not been included.

2.3.3.2 Recycling wastewater

To secure 'fresh water supplies for a wide range of industrial, domestic, and environmental needs', reusing water has been introduced as a strategy with a lot of potential to increase the water supply (Voulvoulis, 2015). Since industrialisation the production of goods has had an increasingly negative effect on the ecosystems. 'Water for irrigation and food production constitutes one of the greatest pressures on freshwater resources, with agriculture accounting for over 70 per cent of global freshwater withdrawals and up to 90 per cent in some fast-growing economies' (Voulvoulis, 2018, p. 32) Therefore, reusing water is seen as an attractive concept and is favoured by a growing group worldwide since 'the public are becoming more environmentally concerned' (Voulvoulis, 2015). Implementing strategies to reuse water can result in "closing the loop" (Esrey, Andersson, Hillers, & Sawyer, 2001). Meaning that due to water recycling, the hydrologic cycle has a new source of water. The current, linear process (*figure 5*) will become a loop (*figure 6*).

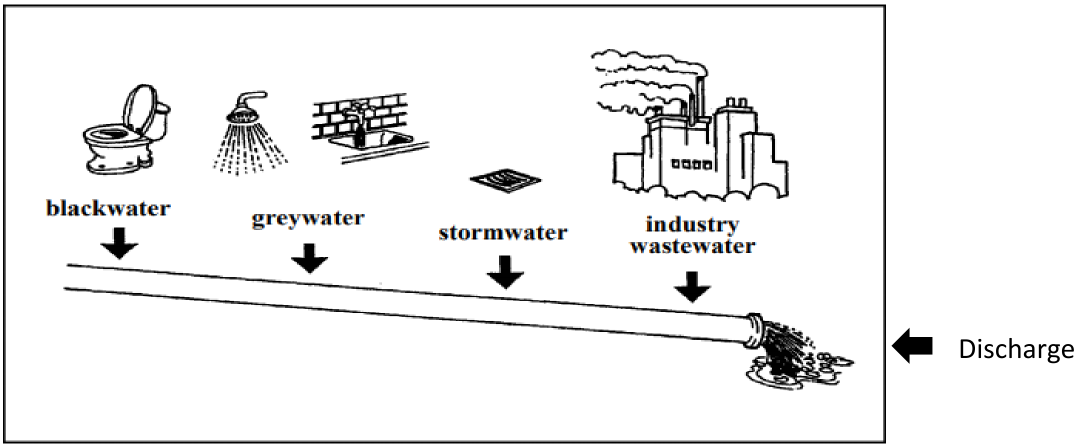


***Figure 5**. Linear water process (Esrey, Andersson, Hillers, & Sawyer, 2001). **Note,** prior to discharge wastewater is treated.*

Although wastewater is treated before discharge, it does not have the required quality to reuse it for various purposes such as irrigation. Therefore, wastewater needs an additional phase of water treatment before it can be utilised. *Figure 6* illustrates the efficient process of reusing wastewater by treating it twice and simultaneously closing the loop. 'Overall, reusing water requires physical and chemical treatment processes, pipelines, waste disposal mechanisms, and other systems. The level of treatment will depend on the water quality needed for the proposed use' (Voulvoulis, 2018, p. 34). Besides different purposes, the visualisation demonstrates the option of *operational storage* meaning that recycling wastewater not only contributes directly to the water availability, but also indirectly by storing it first. Therefore, water reusing can be seen as a potential long-term solution which can structurally improve the availability of water (Voulvoulis, 2015, 2018).

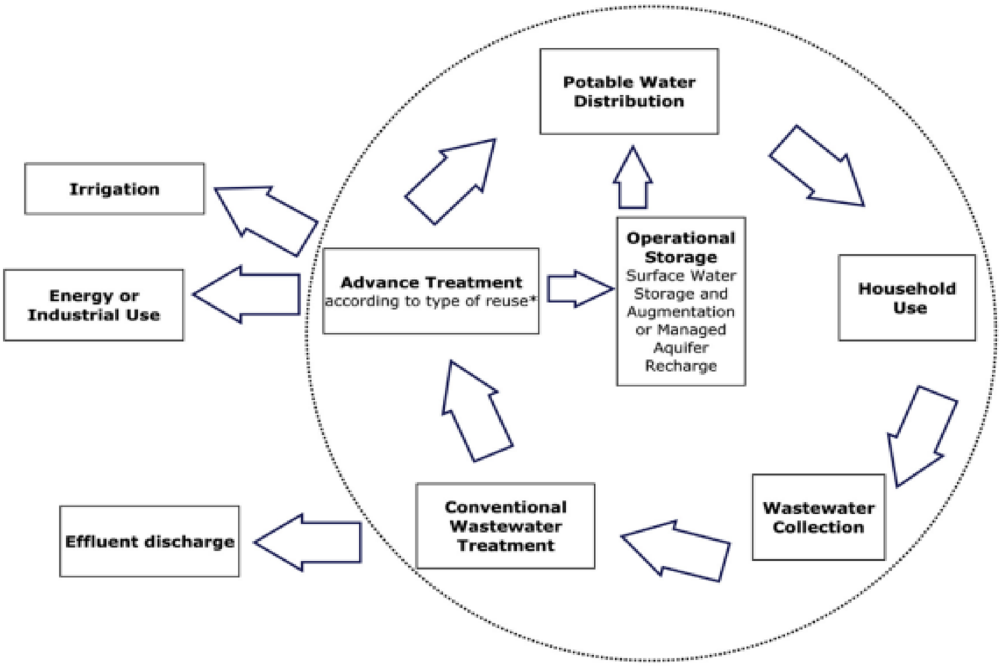


Figure 6. *Demonstration of the reusage of wastewater resulting in a closed loop (Voulvoulis, 2018).*

Although recycling wastewater is suggested to be an effective strategy to use to improve water security, some elements must be considered. For example, the socio-economic impact. Overall, water reusage can be seen as financially profitable. Nevertheless, when the usage of water is relatively cheap the motivation to invest in the reusage of water, to be more specific, in the additional treatment process, is lower (Voulvoulis, 2018). Thus, cheaper supply of water seems to influence the urge of implementing strategies to improve water security. Furthermore, the reusage of wastewater was ignored in the past due to social perceptions. Not everyone is in favour of reusing wastewater due to health risks, especially when wastewater is reused for irrigation or drinking water. Due to policies regarding the quality of water these risks should be reduced. However, these policies vary globally meaning that when transferring knowledge on reusing wastewater (Cipolleta, et al., 2021; Voulvoulis, 2018), differences in regulations on water quality should be considered.

Based on climate change, water shortages have been increasingly witnessed globally. Therefore, 'the public are becoming more environmentally concerned, and as a result recycling water is increasingly perceived as natural as any other recycling, and more environmentally friendly than big dams, diverted rivers and desalination' (Voulvoulis, 2018, p. 37). This trend is positive for the implementation of strategies to reuse wastewater. However, the latter indicates that desalination is seen as environmentally unfriendly. If this is correct and why this technique is (even so) seen as a valid strategy to improve water security, will be clarified in the following paragraph.

2.3.3.3 Water desalination

As aforementioned by Nazemi & Wheater (2015b) and Voulvoulis (2015), water desalination is perceived as technique that could potentially improve water security. Nevertheless, Voulvoulis (2015) has also given reason to believe that desalination is environmentally unfriendly. An elaboration on the latter and why this technique (still) might been seen as an effective technique to improve the water security will be given in this paragraph.

Firstly, water desalination can simply be explained as the transition of seawater (salt water) to fresh water. Refering back to the social acceptance of reusing wastewater, Dolnicar and Schäfer (2009) agrue that desilnation has a higher acceptance rate. This has to do with the ability to treat seawater resulting in' a [water] quality higher than required for most water applications' (Dolnicar & Schäfer, 2009). To be more specific, both (new) sources of water have similar water treatment systems. Dolnicar and Schäfer (2009) state that water desalination 'usually achieves a water quality better than most tap or bottled waters' which is partly the the reason why deslination is perceived as a technique that improves water security.

However, besides the effective treatment and relative positive image of desalination, there are concerns about the ecological footprint of this technique. The concerns are mainly focused on one particular aspect namely, the energy consumption. Multiple studies have been conducted on the energy consumption and its cost during the treatment of seawater (Dolnicar & Schäfer, 2009). In comparison to the treatment of wastewater, the overall cost for desalination are estimated to be over twice as much (2.21) (Côte, Siverns, & Monti, 2005). However, as Dawoud (2005) illustrates 'the demand for water is greater than that for energy', it may therefore be that until then (2005) the energy consumption was not taken into account when considering desalination. This, logically, depends on the source of energy that is used for such installations. As (Raluy, Serra, & Uche, 2006) indicated, using renewable energies, for instance solar energy, can solve the concerns on energy consumption. Shatat, Worall and Riffat (2013) confirm this in their article. They state that in the past the majority of desalination plants were driven by fossil fuel. However, this has changed over time due to perceptions as well as the increase in fossil fuel prices (Shatat, Worall, & Riffat, 2013). Instead of fossil fuel, solar energy is nowadays often used to operate these desalination plants. Therefore, Shatat, Worall and Riffat (2013) argue that 'water desalination can be recognised as a sustainable water resource alternative'.

Since desalination receives an increasing interest worldwide, more studies on environmental impacts are conducted. Fortunately, due to the increase of research, new designs have been developed in order to protect the impingement and entrainment of marine organisms. Furthermore, research has resulted in numerous techniques on the intake of seawater which are more environmentally friendly

(HuntsMarine, 2018, Missimer & Maliva, 2018, Yamaguchi, et al., 2003). Furthermore, increasing interest causes a reduction in installation costs of such systems (Darre & Toor, 2018). This means that not only high-and-middle-income countries can afford to implement desalination in their water resource management but low-income countries. Since 97% of the earth's water is salt, this source of water seems to be inexhaustible. Therefore, desalination is perceived as a promising technique to improve water security (Bundschuh, Kaczmarczyk, Ghaffour, & Tomaszweska, 2021).

In short, the three most common approaches to improve water security have been explained. According to Voulvoulis (2018), meeting the global water challenges requires 'a combination of approaches including water conservation, recycling and treatment of impaired water from non-traditional resources to "create" new water'. Thus, to improve water security, a combination of the above techniques will help.

2.3.4 Summary

Water management is complex since it aims at controlling a natural resource. Three resource types of fresh water can be distinguished, namely precipitation, surface water and groundwater. Although the amount of fresh water available on earth has not changed, the dramatic increase in the world's population has increased human-water interactions simultaneously. Additionally, climate change has shown its impact globally, for example through longer periods of drought as well as heavier rainfall in shorter periods of time. This suggests that knowledge and innovation is needed to cope with these changes. Therefore, water management, especially water supply management, has become even more complex than it already was. The overall aim at solving water shortages and improving water security seems clear. Nonetheless, the definition of water security strongly varies depending on different perspectives as well as on locations worldwide. In this article, water security will be referred to as *'the moment water quality and quantity are sufficient and protect the health, safety and welfare of livelihoods, production and the natural environment in the short and long run'*. Although a universal interpretation cannot be given, scientists agree on three different kind of techniques that will help to improve water security. These are storing and retaining water, recycling water and water desalination. Realistically, the improvement of water security can only be realised through implementing a combination of aforementioned techniques into one water system.

3

RESEARCH METHOD

3. Research method

In the previous chapter an overview of scientific literature related to the research topic is given. Therefore, the theoretical foundation for this study has been clarified. Subsequently, in this chapter, the research approach will be described. Throughout research numerous decisions were made to answer the research questions in the best possible way. Meaning that the research method chosen for this research improves the chance of answering the question how the Netherlands can contribute to the improvement of water security worldwide. As explained before, this was done through analysing the functionality of knowledge production and partnerships within the Dutch water sector.

According to Lundvall (2007), studies on innovation systems and the dynamics of joint knowledge production tend 'to stick to the idea that only quantitative [research] can be accepted as scientific'. This is due to the easier way of developing and analysing data such as R&D and patents. For this research, to answer the main question, a decision was made to conduct qualitative research. Reasons for this are the need for a better understanding of what water security means to the Dutch water sector, how techniques that improve water security are implemented, and how joint knowledge production regarding water security keeps innovating. To gain insights, numerous interviews have been conducted with people active in water resource management, particularly in water supply management and water security. Even though qualitative research has been conducted, quantitative data have been used to create a topic list as preparation for the interviews (*appendix A*). Furthermore, to have a clearer overview of the case study of this research, quantitative data have been used as well.

3.1 Case study: The Netherlands – "water-land"

The Netherlands is known for its water management. However, the main reason for its fame regarding water management is related to delta-technology through engineering some impressive constructions (Büscher, 2019). These constructions are built to protect the country from flooding. As this relates to the second perspective 'water-related hazards and vulnerability' defined by Cook and Bakker (2012), this is identified as water safety. According to the Netherlands, water safety is reached whenever the chance of individually dying due to flooding should not exceed 1 on 100,000 each year (0.001%) (Deltacommissioner, 2017). The aim is to achieve this by 2050.

Nevertheless, the main question for this research is what knowledge on water security the Dutch water sector possesses and how their contribution can improve water security worldwide. This question was formulated after analysing the NIWA. In 2019 the Dutch government defined their ambition to contribute to water security worldwide. Furthermore, this contribution through sharing knowledge and innovative techniques should lead to an optimalisation of revenue (Waterstaat, 2019). To remain important as market player, the Dutch government has stimulated joint knowledge production by initiating partnerships between numerous parties in the Dutch water sector (Topsector Water & Maritiem, N.D.).

One way to do so was the introduction of Top-sector Water and Maritime (TWM) which is based on the triple helix principle represented by universities, public entities and private companies (Rijksdienst voor Ondernemend Nederland, 2014) (Topsector Water & Maritiem, N.D.). This illustrates the aim to invest in partnerships to become a competitive player in the water sector worldwide.

Just a decade before the start of TWM, the Dutch water sector was not seen as an innovative-seeking industry according to Krozer, Hophmayer-Tokich, Meerendonk, Tijsma and Vos (2010). Prior to the TWM another partnership was initiated. According to Krozer, et al., (2010) 'these actions did not invoke a stream of innovations, or substantially improved Dutch competition in water chain'. In the years before conducting their research data regarding R&D on water issues showed only little interest from water supply companies or water boards. Approximately 90% of R&D funding for water related issues was financed by the government. 'The water utilities spend an average of 2.5% of their turnover on R&D, compared to a 5.3% average in Dutch industry. The water boards were even less interested, before 2002 they did not commit any funds to R&D' (Krozer, Hophmayer-Tokich, Meerendonk, Tijsma, & Vos, 2010, p. 443). Krozer, et al., (2010) concluded their research with the statement that even though the Netherlands will have to deal with 'serious challenges' in the future, its water management does not seem to focus on innovations. Nowadays, this is different.

TWM consists of three clusters. Water is separated into 'delta technology' (construction of dikes), and 'water-technology' (water supply management), and Maritime focused on harbour development and maritime eco-system and engineering (Rijksdienst voor ondernemend Nederland, 2019). Regarding this research Maritime is not relevant for this research and has therefore been omitted. Therefore TWM (Top-sector Water & Maritime), will now be referred to as TW (Top-sector Water). To understand what water-technology covers, Panteia (2020) has created an overview.

Water-technology

- Water supply (drink water facilities and treatment, transportation and distribution of water, industrial water supply and treatment, industrial water transport and distribution).
- Wastewater (collecting and sanitation, industrial wastewater, domestic wastewater, and reuse of wastewater).

Although delta technology was to some extent linked to this research, the main focus has been on water technology. Besides, the overview of Panteia (2019), the Netherlands Water Partnership (NWP) has contributed to the specification of water technology. According to NWP (2018), water technology is defined as 'the innovation or implementation of knowledge, technologies, techniques and processes in transportation, water treatment and changes or monitoring water(flows)'. To create a better understanding of the scope of this research. An overview of the categorisation has been made (*table 1*). The blue column illustrates the scope for this research.

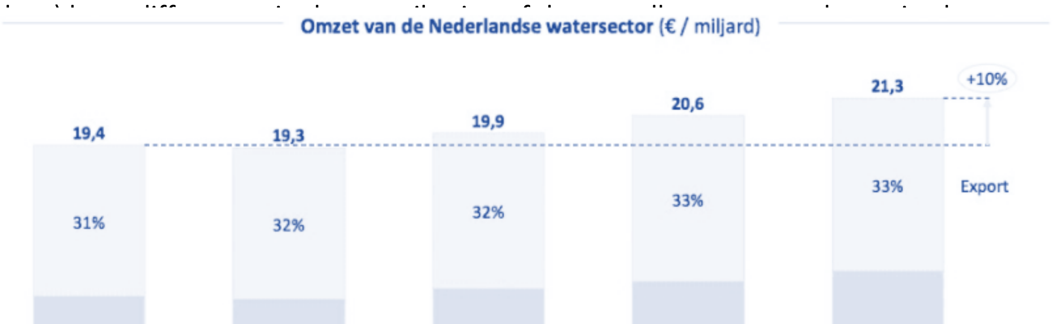
<table>
<tr><td colspan="4">Dutch water sector</td></tr>
<tr><td></td><td colspan="2">Top-sector Water & Maritime</td><td></td></tr>
<tr><td colspan="2">Water</td><td>Maritime</td><td></td></tr>
<tr><td>Delta-technology</td><td>Water-technology</td><td></td><td></td></tr>
</table>

Table 1. Overview categorisation themes.

3.1.1 Top-sector Water in numbers

According to Panteia (2020), it is difficult to define the water sector in numbers since this sector has a multidisciplinary character. Meaning that entities involved in water management are spread through different sectors. In addition, VNO-NCW, the biggest association of undertakings in the Netherlands, states that due to the lack of data from the Central Bureau of Statistics (CBS), numbers TWM are unambiguous. This is surprising since multiple engineering companies and knowledge institutes are considered as part of the global top (VNO-NCW, N.d.). Fortunately, research firms such as Ecorys or Panteia analyse accessible data regarding companies involved in water management throughout different sectors. Due to their contribution certain statistics are available.

Overall, an increase in revenue can be noticed through the period of 2010-2014 (*figure 7*). Especially, due to export activities, revenue has grown. In 2016 Ecorys concluded that the TWM had an overall revenue of 21.3 billion euros in 2014. This revenue has increased by ten per cent since 2010 (*figure* 8) (Consultancy.nl, 2016). Between the three subsectors (Maritime, Water (water technology & delta-techn



The subsector Water only contributes fifteen per cent (3.2 billion euros) to the overall revenue in 2014 (*figure 8*). The contribution to export revenue was only thirteen per cent of the overall revenue (Consultancy.nl, 2016). The TWM generated 86.000 jobs in total in 2014 (*figure* 9). Eighteen per cent of these jobs were generated by subsector Water (Consultancy.nl, 2016).

Although the above figures illustrate the total revenue generated including the contribution for each sub-sector, it does not demonstrate any comparison to other Top sectors in the Netherlands. For the period of 2010 – 2015, according to numbers by the CBS, a comparison has been made with the eight other Top sectors (Bedrijvenbeleid in beeld, 2016). Nevertheless, as described before by NVO-NCW, data from the CBS regarding the dimension of water is not clearly incorporated. Therefore, this overview has been omitted in this study.

Concerning the TWM, in 2018, Netherland Water Partnership published new data. This time, these statistics were solely focused on subsector Water. According to (Boneschansker, Tietema, & Neijland, 2018) this sector had generated a revenue between 7.5 and 8.0 billion euros and created roughly 35,000 jobs in 2016.

	2014	**2016**
Revenue	3.2 billion euros	7.5 – 8.0 billion euros
Number of jobs	15,480 jobs	35,000 jobs

Table 2. *Overview of revenue and the number of jobs regarding the TW in 2014 (Ecyros, 2016) and 2016 (Boneschansker, Tietema & Neijland, 2018).*

In *table 2* a significant increase can be seen in the number of jobs generated by this subsector as well as the overall revenue. This can be explained by the dramatic increase in water related issues worldwide. The number of these issues is expected to grow in the future due to climate change and population growth (Boneschansker, Tietema & Neijland, 2018; Panteia, 2020). The suggestion was confirmed by Panteia (2020) (*figure 10 (see next page)).*

Since 2009-2010 an increase in the export in water technology can be detected. The export is expected to decrease a little due to the start of the Covid-19 pandemic (Panteia, 2020). Nevertheless, overall estimations for the TKI Water technology are still positive compared to earlier data (*table* 3).

	2014	**2016**	**Estimation 2020**
Revenue	3.2 billion euros	7.5 – 8.0 billion euros	9.3 billion euros
Number of jobs	15,480 jobs	35,000 jobs	-

Table 3. *Overview of revenue and the number of jobs regarding the TW in 2014 (Ecyros, 2016) and 2016 (Boneschansker, Tietema & Neijland, 2018), and estimation for 2020 (Panteia, 2020).*

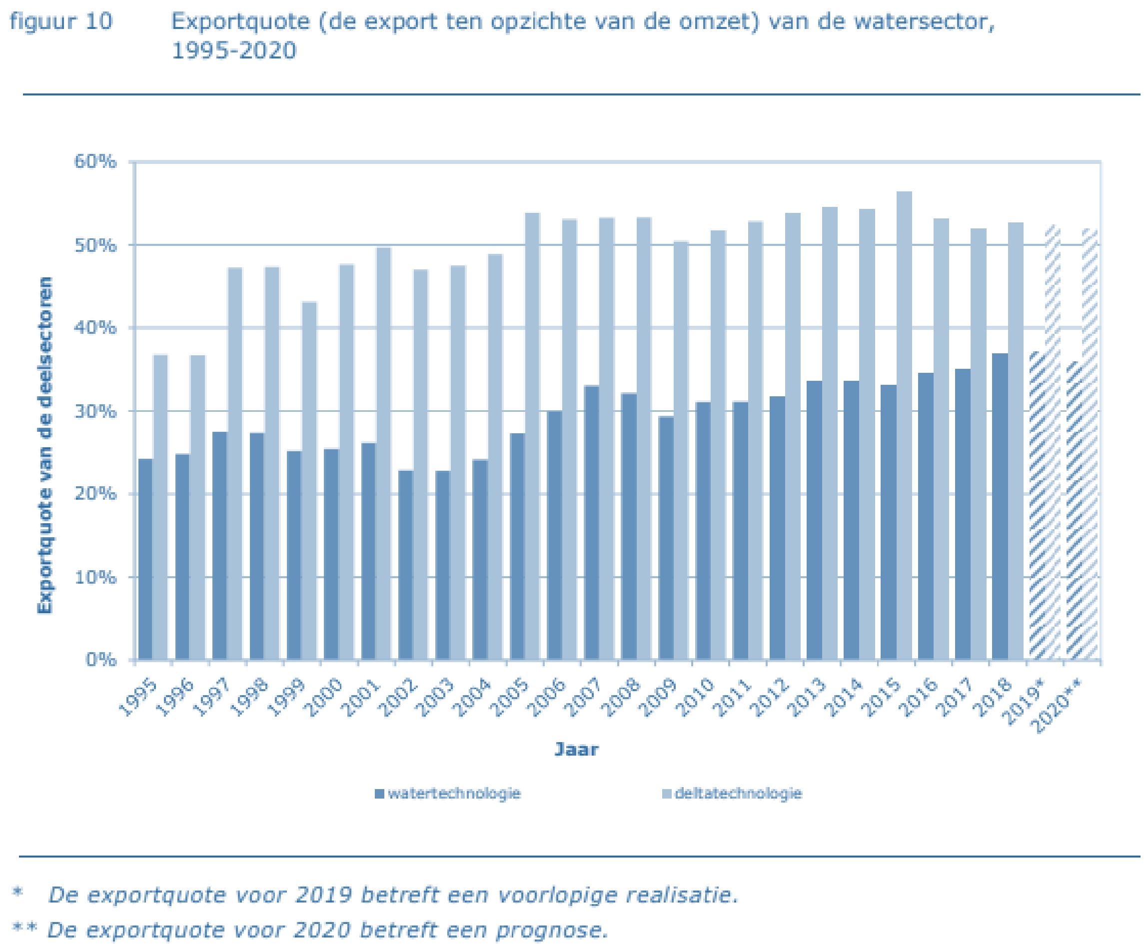


Figure 10. *Export ratio of TW (Panteia, 2020)*

All in all, through qualitative research an increase in the Dutch water sector can be noticed. Through the last decade TKI Water technology has expanded their export and therefore partly the overall revenue of this subsector.

3.2 Data collection

Based on the content of the theoretical framework and desk-research conducted earlier, a topic list (*appendix A*) was created. In this topic list the most important elements of the theories and data were categorised in different themes, or topics. This overview was used as the foundation through the interviews. Overall, the interviews were semi-structured which made probing possible. Meaning that more questions on specific topics were asked. In this way, without structuring the interviews completely, additional information was received. Nevertheless, the researcher was aware of the fact that semi-structured interviews have a lower validity since there is a higher risk of systematic errors. Therefore, multiple semi-structured interviews were designed and used depending on the type of organisation the interviewee was employed. Additional information on the different types of organisations will be given in subsequent paragraph.

3.3 Research units

According to Boneschansker, Tietema, and Neijland (2018) TW can be divided into three categories namely (1) knowledge institutes, (2) public parties[1], and (3) private companies, which is illustrates the triple helix principle. In their study Boneschansker, et al., (2018) created an overview of the number of partners in each category:

1. Knowledge institutes: 35 partners
2. Public parties: 31 partners
3. Private companies: 970 – 1,100 partners

Besides this overview, the authors have created a list with the most important players in TW (*appendix B*). This list has been used as framework to contact potential stakeholders in the TW.

Almost 50 per cent of the companies and institutes linked to TW have invested in R&D in the past which resulted in an increase in patents, improvement or new products and services. Furthermore, introducing TWM in 2012 caused an increase in the number of private companies by approximately 13% (Boneschansker, Tietema, & Neijland, 2018). In their research a distinction was made between four types of private companies:

a. Core businesses (suppliers of equipment, systems or software which invest in R&D).
b. Service providers (consultants, R&D companies, and contractors)
c. Suppliers without R&D
d. Engineering companies.

According to Boneschansker, et al., (2018) 80 - 90 per cent of the core businesses invest in R&D. However, in their study only 81 companies answered positively on the question whether companies invested in R&D. Investing in R&D has resulted in improvements of products services and in the future will lead to higher revenue. Eight out of ten companies that focus on R&D utilise knowledge, which is produced by different companies or institutes, 50 per cent of this knowledge is produced abroad. This "external" knowledge production is mainly done by universities, suppliers of goods as well as specialised consultancy firms (Boneschansker, Tietema, & Neijland, 2018).

Throughout the interviews questions were asked regarding the production of knowledge as well as how knowledge was shared and eventually used within the TW. These questions were based on the

[1] While water suppliers can officially not be seen as public body, in this study, following the same categorisation as Boneschansker, Tietema, and Neijland, the public parties consist of national, regional, and local government, water authorities, and water suppliers.

theories stated in the theoretical framework as well as data demonstrated above. The kinds of institutes and companies interviewed, and the selection of interviewees will be clarified in the following paragraphs.

3.4 Research course

As aforementioned, to answer the main research question interviews were conducted. The goal for this research was to conduct 12-15 interviews. Thus, for each sector approximately four or five interviewees were selected and approached. From the beginning a non-response was considered. To make sure that in each category (knowledge institutes, private companies, and public parties) the same number of interviews would be conducted the number of approached employees was higher. Furthermore, in some cases multiple employees from the same company were approached with the request for an interview. Surprisingly, the response rate and the willingness were significantly higher than expected. Only five companies that were approached did not respond. Eventually, this has resulted in a total of 27 interviewees. Meaning that five or six interviews in each category have taken place. All interviews have taken place digitally via Microsoft Teams and lasted roughly 45 minutes with some outliers to one and half hour. Prior to the interviews, the interviewees were informed about the desire to record the conversations.

At the beginning interviews with companies in each category were planned to take place in a certain order. In this way information would be filtered efficiently. Nevertheless, due to the high response rate (although some companies took more time before they responded) and a "snowball effect" of new potential interviewees, the scheduled order did not work out in practice. Nevertheless, since the process was iterative, changes and adjustments were implemented into the semi-structured interviews throughout the data collection process. Furthermore, a clear coding tree was designed afterwards which resulted in an efficient overview of all data collected. Clarification on data analysis will be given later in this chapter.

3.5 Interviewees

As mentioned before, to answer the research question qualitative research has taken place. To be more specific, 27 experts were interviewed. However, what are experts? According to Audenhove and Donders (2019), this is mainly a European discussion. In their research they have analysed multiple definitions of expert (in the context of qualitative research). From standard: 'interviewee as a source of information', towards more detailed: 'person who has privileged access to information about groups of persons or decision processes' (Audenhove & Donders, 2019). An interview with such a person therefore suggests that 'exclusive knowledge' can be received. According to Audenhove and Donders (2019) expert knowledge can be generated as result of a person's:

a. experience, education, and scholarship (in the right context).
b. responsibility or power, or.
c. specific position in certain processes or in a group.

For this thesis the above-mentioned factors have been used as criteria for the search of experts in the Dutch water sector. A detailed overview of the institutes and companies that participated as well as a description of all experts can be found in *appendix C*. Overall, it was agreed upon that the experts remain anonymous throughout this thesis.

3.6 Data analysis

After the interviews were conducted all interviews were transcribed and coded. By doing so, data received by the experts was related back to certain themes and theories described earlier in the topic list. According to Pandit (1996), there are 'three types of coding: open coding, axial coding, and selective coding'. Through the analysis of data, the first two types of coding were used.

Regarding the first type, open coding, general themes, and categories were distinguished. For instance, (1) water security, (2) strategies/techniques, (3) Dutch water sector, (4) knowledge production, et cetera. These can be regarded as the 'basic building blocks' of the data analysis (Pandit, 1996). Afterwards, connections between the main categories and sub-categories were detected (axial coding). For example, by analysing the data a connection between the term (1) water security and (a) water quantity, (b) water availability, (c) water resilience was found and defined as 'defined other'. To complete these three types of coding the software NVivo was used. A detailed overview of all codes (including colours) can be found in *appendix D*.

4

RESULTS

4. Results

In this chapter the data gathered by means of 27 interviews will be demonstrated. This will be done chronologically to the research questions defined in the first chapter of the thesis. As to the 27 interviews, all interviewees that have participated in this study are in some way argued to be an expert according to Audenhove and Donders (2019). In *appendix C* an overview of interviewees as well as their linkage to the definition as being an expert is illustrated. Furthermore, the experts representing three different sectors have – due to their role and background – caused collecting a variety of information.

In the previous chapter, to be more specific the final paragraph, the approach chosen to analyse the data is discussed. According to the types of coding that have been used, in this chapter the first and second type are implemented. In other words, the results in this chapter have been assembled through open coding and axial coding. Besides primary data, secondary data has been included in this chapter as well such as books related to Dutch water management, and grey literature published by (or in request of) the Dutch government as well as global entities.

4.1 Water security: what does it entail?

How does the Dutch water sector define water security?

As aforementioned in the theoretical framework, discussion about the definition of water security is ongoing. In this framework four perspectives have been summarised. To have a clearer understanding of what the definition entails, each expert was asked to personally define water security. Through individual expertise, background, and experiences in the Dutch water sector each answer was different, however somewhat relatable to one another. Although the experts were able to define water security, no one of the experts used this term commonly. Throughout all response two main elements were detected. While defining water security most experts stressed out the importance of quantity and quality of water.

According to many experts, water security describes the availability of water. However, it not only consists of the quantity, but also the availability of water with the correct quality. While some experts explicitly mentioned the quality of water, others related implicitly to water by relating water security to drinking water. The expert of Sweco is one of the interviewees that related water security to drinking water in the Netherlands. This expert defines it as: 'delivering a sufficient amount of water with an impeccable quality for 24 hours a day, seven days a week, 365 days per year' (transcript of each interviewee can be found in *Appendix E*).

'Wij verstaan onder waterzekerheid het 24 uur per dag, zeven dagen in de week, 365 dagen per jaar het leveren van voldoende water, met onberispelijke kwaliteit' (Sweco 1).

The reason for the link between water security and drinking water has to do with the level of assurance that can be given by the sector. According to STOWA expert 1, drinking water has a certain amount of security. However, water demanded by agriculture and nature cannot be guaranteed. STOWA expert 1 perceives water security as a jurisdictional term. When asking an expert at a water supplier, two other terms came up. These are: assuring delivery and cooperate assurance. Water suppliers work in accordance with the Drinkwater Act. By doing so, a certain assurance of delivering water is realised. The cooperate assurance is related to the maintenance and management of installations, and the treatment techniques utilised to produce drinking water.

In addition to drinking water, some experts included or excluded other functions when defining water security. For instance, some experts excluded agriculture for the definition (Arcadis 1), while others specifically included this domain (Partners for Water 1 (PfW, 1); TU-Delft 1).

Since water security is not an often-used term, multiple alternatives and synonyms were identified throughout the interviews. Alternative terms that were used in interviews are: – resilience, robustness, drought, water scarcity, climate adaptation, water stewardship – circular/ sustainable water usage, climate resilience, water availability.

‘Water security, sufficient water in the systems so that we can maintain all out applications in the long run. These are living, agricultural, recreation but also supplies of drinking water and so on. Therefore, it cannot be lumped together in one word.’

‘Waterzekerheid, voldoende water in de systemen zodat we ook langdurig al onze gebruiksfuncties op kunnen uitoefenen. En dat is dan wonen, agrarisch, recreatie, maar ook drinkwatervoorziening en dat soort zaken. En daarom is het ook niet onder één noemer te vangen’ (Antea Group 3)

All in all, data have been gathered on the definition of water security. Prior to the elaboration of strategies how to accomplish water security, some experts have given insights on what a system should contain prior to the implementation of strategies on improving or accomplishing water security. It is believed that without certain elements in a system, water security cannot be guaranteed. These elements are related to the infrastructural, financial, jurisdictional, and socio-cultural domains.

A system should have a robust infrastructure. This means that, an infrastructure should be able to supply water in the right amounts at the right place. According to multiple experts, certain regions worldwide have a sufficient water availability, however, due to structural leakages in the pipes water is spilled (Arcadis, 1; Wavin, 1). Leakage and quality of water can have a negative effect on the image of water suppliers and its product. Subsequently, this will influence behaviour and consumption about water. For example, Americans do not trust Dutch tap water since it did not include the taste of chloride (PfW 1). Furthermore, Dutch households that do not trust their own tap water and prefer bottled water from the supermarket (WML 1). These are cultural perceptions that have an impact on the distribution and consumption of water. To improve the image of water suppliers and water itself awareness must be created (WML 1).

Moreover, as water is distributed it should be done fairly. It is a problem when people do not pay for the water they use. Parts of the world deal with informal water infrastructures which makes it possible for people to use water without paying (Invest International 1). Because of informal draining the demanded amount by customers paying cannot by guaranteed. This is a continuing issue in low-income countries which strive to meet one of basic human rights: each person should have access to safe drinking water (UNECE; WHO, 2019). However, other countries have decided to systematically lower water prices to make it accessible for everyone (PfW 1). Since this human right has a jurisdictional component, legislation in the particular country is needed. Besides, the guarantee to supply each one an equal amount of and possibility to water, legislation has to be created regarding water collection (WML 1) and the allocation of water.

When the elements illustrated above are implemented, they are more likely to improve the system and accomplish water security. Unfortunately, due to climate change and an increasing demand for water other strategies have to be implemented.

4.1.1 Conclusion

Although each expert has defined water security by their personal perception, the term is uncommon. Alternative terms were more popular, though there was common ground with the definition of water security. Regarding the definition, both quantity and quality are considered by most of the experts. Furthermore, a distinction in definitions can be made by defining through narrow or broad scope, as well as a short-term or long-term perception. While the narrow definition only entails the aim at accomplishing a sufficient availability of drinking water, the broader definition includes several functions in need of water. Examples of these functions are agriculture, industry, and nature. Besides implementing technical or technocratic elements, water security is assumed not to accomplish when certain requirements are not in place. Thus, besides the natural availability of water, there must be a legal right to win it, treating it to a quality that is trusted by households, transporting, and distributing the right amount of water, according to legislation, to the right place where is appropriately paid for. If this structure is solid, experts believe water security can be accomplished. It has become clear that aiming for water security is a complex goal to aim for. Let alone what a great challenge it is in times of climate change.

4.2 Water security: how to accomplish?

How is the Dutch water sector trying to accomplish water security in the Netherlands?

As previously clarified according to numerous experts, before water security can be accomplished certain infrastructural, cultural, financial, and jurisdictional elements must be incorporated into the system. In addition to these elements, experts have identified multiple strategies that can be applied individually as well as simultaneously to guarantee water security.

Before answering this question, through primary data and secondary data, the Dutch water system will be briefly explained. The Netherlands is a delta meaning a lot of water is transported through the country. Furthermore, the country has to deal with a surplus of rainfall (WENR 1). At a certain point in time the Netherlands had decided to expand agriculture to economically grow. To do so, the country transformed: wetland had to become dry in order to perform agricultural activities (STOWA 1). Drying out the surface meant that surface water as well as precipitation had to be discharged as soon as possible.

'Around 1850, it took a drop of water in a river from Germany sixteen days to reach the Ijsselmeer. Nowadays, this drop of water will reach it in nine hours.'

'Een druppel rivier water deed er rond 1850 zestien dagen over om vanuit Duitsland het IJsselmeer te bereiken. Nu is die druppel er in negen uur' (Didde, 2021, p. 153)

Especially during wintertime discharging into the North Sea was important (Water Authority Rijn & Ijssel 1 (WA-R 1). But what about the functions that are in need of water? Water management in the Netherlands is separated into different functions. For example, the function agriculture, function nature and function households (STOWA 1). All these functions need water. According to PfW expert, currently agriculture is responsible for 70% of the water consumption in the Netherlands. This seemed possible since there was enough water. Nevertheless, throughout time each function in the Netherlands has grown, and demand has risen. Concerning the consumption of agriculture, a dramatic increase is demonstrated by Didde (2021). In the province of North Brabant, in 2009 the water consumption was estimated on 36 million cubic meters. In 2017 this has increased to 54 million cubic meters. Subsequent year, consumption is estimated on 100 million cubic meters of water since the farmers had to deal with drought (Didde, 2021).

Besides an increasing demand, multiple experts have mentioned the structural fall in groundwater levels since the '60/70's (Deltares 2, STOWA 1). Groundwater is the most important source for the water system in the Netherlands. Roughly 70% of the water used to produce drinking water is groundwater. The remaining percentage is mainly surface water. Although groundwater levels were dropping and the Netherlands had to deal with drier periods of time, sooner or later it always had an inflow of rainwater (PfW 1). In 2018 this was structurally different until spring 2020. There was no sufficient inflow of water that supplemented the groundwater level. Water security for certain functions and in particular regions could not be guaranteed any longer. Consequently, awareness was created on the unsustainable and insufficient water system that was active at that time. According to expert 2 of the Ministry of Infrastructure and Water Management (MIWM), the Netherlands was used to have "too much" water and "all functions will have enough". Recently the message has changed to "we will try to deliver enough, but unfortunately there will be exceptions".

'Eigenlijk waren we natuurlijk het land van 'we hebben te veel water' en 'we kunnen alles' en ik denk nu dat we meer gaan naar een ook, ja, dat je kan zeggen 'tot hieraan kunnen we soms leveren maar soms ook minder' (MIWM 2)

Even though much of the Netherlands has faced problems due to structural drought, regional differences have been detected throughout the interviews. The country can be separated into two areas: high and low, or east and west. The main reason the country can be separated has to do with geographical differences such as structure and soil.

The higher region in the east of the Netherlands has to deal with agricultural damages, bush fires and streams drying out. This has to do with the lack of natural inflow of water. In the eastern region certain parts are dependent on precipitation. On the contrary, the majority of western region in the Netherlands has enough water. However, it does not have the right quality (Antea 1). The recent weather changes have effect on seawater level as well as the groundwater level. The rising seawater level causes an increase of salinity in groundwater. Therefore, water cannot directly be used by agriculture or other functions and must be treated first.

All in all, experts state that water security is currently impossible to guarantee in the Netherlands due to the mismatch between water supply and demand. This is the main reason the term has not been used often throughout the Dutch water sector. WML expert 1 clarifies the challenges on both the demand and supply side. Regarding the demand of water, there will be total rise of water consumption yearly, daily, and hourly due to higher temperatures. Climate change can bring on structural problems since the supply is decreasing. Especially water inflow from the surface (WML 1). Due to this imbalance the Netherlands cannot assure water security (WA-R 1).

'Water nuisance and drought are caused by the disproportionate human interventions in the water system. Increasingly, climate change makes these problems painfully visible.'

'Water overlast én droogte zijn het gevolg van een doorgeschoten menselijk ingrijpen in het watersysteem. En de klimaatverandering maakt beide problemen steeds vaker schrijnend zichtbaar' (Didde, 2021, p. 43).

Concerning the term water security, the expert from the Department of Waterways and Public Works (DWPW) states that it is not realistic to guarantee water. Therefore, the water sector and government should keep away from the term water security. In addition, when asked on this issue expert 1 of MIWM reacted: 'choose your words carefully'. Continuing with the expert from DWPW, this expert explained that the goal of accomplishing water security should be seen as a collective commitment, thus efficiently using water, instead of guaranteeing water. 'Because nobody is capable to do so' (DWPW 1).

'Uhm, het is meer die inspanningsverplichting, (…), *resources* zo optimaal mogelijk beheren en alloceren. Minder garanderen. Want dat kan namelijk niemand' (DWPW 1).

To improve the water system and fulfil this commitment, strategies are suggested by the experts. The preferred strategy in the Netherlands is keeping fresh water clean as long as possible and consume the water efficiently (DWPW 1). This is stated as well in a document published by the Dutch government. In this document cross-over objectives between three Top sectors have been demonstrated. (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021). The aim is to achieve these future goals by 2030 or 2050. Concerning water storage, STOWA expert 1 has noticed the urgency to change the water system from discharging towards retainment, storing and afterwards discharging. However, this has to be done structurally. In case storing water starts whenever it is needed, it will not be effective (Water Authority Limburg 1 (WA-L 1)).

'The Netherlands should convert from World Champion 'draining water' and allowing every intervention at each location towards World Champion 'storing water' and analysing in advance which intervention can take place where.'

'We moeten van wereld kampioen 'water afvoeren' en overal alles maar toestaan naar 'water vasthouden' en van tevoren kijken wat, waar kan' (Didde, 2021, p. 153).

Water can either be stored underground by infiltrating water or at the surface through a "hardware" construction (Deltares 2). Furthermore, by storing water, rain, snow and arriving surface water can be stored and used as an additional source of drinking water. Since the Netherlands is a densely populated and built country there is not much space to store water on the surface. Therefore, underground storage will be a helpful option during the winter period (Deltares 2). Nevertheless, this illustrates the importance of a safe and "healthy" soil. WML expert 1 stresses the close link between the water and soil domain. By utilising groundwater, the surrounding soil should be protected from certain drug residues and other chemicals (WML 1). Although through water treatment these residues and chemicals can be filtered out, it is more time consuming. Besides the water domain, protecting soil is an important element in improving the overall environment.

Filtering residues and chemical takes place when recycling wastewater as well. This technique is perceived as alternative approach contributing to water security (Arcadis 2). Recycling water or efficiently treating water will help to increase the water availability. According to the expert of Sweco, the Netherlands is leading in wastewater treatment. Besides, multiple experts have indicated that industries are aware of the decreasing availability of water. 'Nowadays, large companies in the Netherlands such as Heineken recycle and reuse their wastewater'. Concerning industries, recycled wastewater can be used for process or cooling water as well (Arcadis 2). Nevertheless, other companies are still consuming drinking water throughout the production of goods. Main reason is the contracts with water suppliers (MIWM 1). Sweco expert 1 states that the (financial) trigger to reuse treated industrial wastewater is growing, Besides, a financial trigger, this expert includes that it can be seen as strategical implementation, since industries have to search for new or additional water resources in times of water scarcity, 'you cannot put all your eggs in one basket'.

'Bedrijven die afhankelijk zijn van maar één soort ruw waterbron. (…) Die zijn toch echt wel om zich heen aan het kijken of er alternatieven zijn. Want even heel simpel gezegd, op één paard moet je niet wedden' (Sweco 1).

Sweco expert 1 ends with stating that the goal is to close the water cycle and create a circular water consumption. This is stated as objective by the three Top sectors as well (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021). However, psychological issues regarding recycling wastewater remain existing. Arcadis expert 2 mentions that people still find it unpleasant to consume their excrements even though, according to the expert from WML the techniques are available and of sufficient quality to do so. To be more specific, it is possible to make drinking water from each type of water. However, the level of radicalness to use it as drinking water depends on the urgence of the water availability. Arcadis expert 2 states that this is not the case in the Netherlands yet. Therefore, willingness to utilise treated wastewater is lower. Consequently, it is advised to companies not to include the term recycling wastewater during the production of goods (Arcadis 2).

Although closing the loop seems positive, the implementation of wastewater recycling could result in a moral dilemma. Meaning, when closing the loop, it seems like water is infinite what will have a negative impact on consumption of water and the behaviour towards water discharge (WML 1).

Deltares expert 1 states that treating wastewater should not be applied in the water system just to increase the water availability. The expert states that by treating wastewater the entire water system will thrive and has a better quality. Furthermore, treating wastewater can be done on a small-scale. This means that, wastewater does not have to be distributed elsewhere and can be used for greenery or to infiltrate into the ground (Antea 1). Furthermore, Didde (2021) creates a bigger picture of the implementation of recycled wastewater.

'Do not discharge treated wastewater in rivers but reuse it wisely. This will safe clean and fresh water, decreases the consumption of groundwater and will contribute to prevent drought.'

'Schoongemaakt rioolwater niet langer lozen maar nuttig hergebruiken en daarmee schoon water sparen, minder grondwater gebruiken en de droogte bestrijden' (Didde, 2021, p. 88).

Another strategy that can give the impression of an infinite water sources is water desalination (Sweco 1). Both techniques create the image of artificial water. The expert from PfW relates and states that with the introduction of desalination plants water has become engineerable. By the implementation of the desalination plants, it has become possible to distribute water to regions known for water scarcity such as the Middle East. Nevertheless, this technique has a high energetic component (PfW 1; DWPW 1). Besides the energy consumption, which is costly, the utilisation of a desalination plant itself is costly as well according to some experts (STOWA 1; Sweco 1). Though the technique is becoming more affordable (Water Authority Scheldenstromen 1 (WA-S 1)), at this point the costs do not equal the urgence of an additional water resource in the Netherlands according to some experts (Antea Group 3; Arcadis 2). Nevertheless, in the western region, as aforementioned, the level of salt in the soil is increasing. According to Arcadis expert 1, it is possible to use brackish water (water layer between the fresh and saltwater layers) for the treatment to reduce the level of salinity in the ground. Furthermore, this technique will be lower in costs (Arcadis 1).

The last strategy that is introduced by the experts is classifying functions and their required quality of water. According to expert 2 of Arcadis, the Netherlands needs to decide how the country sees its environmental or city and country planning. What functions does the country wish to prioritise and where? This includes the design for energy infrastructure, sewerage infrastructure as well as water quality infrastructure. This means that households and industries can have different infrastructures. More specifically, households can be connected to different water quality infrastructures. In some industries water it is important, however, that performances are not affected by a lower quality of water (Arcadis 2). Like nature or agricultural irrigation, quality of water can differ without having a negative impact. This illustrates a more efficient way of consuming high-quality (drinking) water which is perceived to be highly prioritised for drinking purposes (MIWM 2). Even on the scale of households only, different infrastructures can be constructed. For instance, one is connected to the washing machine, shower, and toilet (so-called grey water infrastructure), while the traditional infrastructure distributes drinking water to the taps.

An additional water source that can be included in this concept is rainwater (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021; WML

1). In the Drinking water Act of the Netherlands, it is prohibited to use rainwater for drinking purposes. However, it could be used as an extra source in the grey water infrastructure (WML 1). Furthermore, rainwater can be stored and used efficiently to supply nature.

In line with the spatial design of the Netherlands, WENR expert 1 states that Dutch water management should be designed differently. Dutch water management has always prioritised agriculture and this should change. The expert of STOWA indicates that overall, the mindset in the sector is to facilitate water to other sources than agriculture only. Thus, aiming at protecting nature, prevent subsidence (due to the structural fall of the groundwater level). This illustrates new incentives to change to a more efficient system: away from discharging and going towards storing water.

> 'Dus je wil ook die natuur beschermen, of huizen tegen verzaking beschermen, dus nu komen er eigenlijk nieuwe *incentives* om niet alleen op afvoeren in te zetten. Dus dat is eigenlijk een beetje de omslag die je ziet. Van afvoeren naar vasthouden' (STOWA 1).

4.2.1 Conclusion

Overall, it has become clear that the Netherlands cannot guarantee water security since there is an imbalance between supply and demand. Therefore, there is suggested not to use water security as term. Due to prioritising agriculture the water system and landscape have been transformed significantly. Besides climate change, the country faces certain problems that have been created by itself. Nevertheless, the sector illustrates a wide variety of techniques and strategies that can be implemented to improve the system. This implementation is described as collective commitment to secure water. Instead of draining water towards the North Sea, the preferred strategy appears to be focusing on efficiency and storing natural water resources a water buffer can be created. Simultaneously this means that soil should be protected carefully against medicine residues and other chemicals. Furthermore, efficiency of water consumption will be improved when infrastructure has been implemented, separating different qualities of water to several functions. In addition to the natural water resources, water desalination and recycling wastewater are seen by the sector as potential sources. By implementing alternative sources, the overall water balance can be improved. Nevertheless, all three strategies bring their own disadvantage. While water desalination and recycling wastewater are more costly and bring psychological issues, water storage can become an issue in a densely populated country like the Netherlands. To make sure how to implement these techniques, the country must rethink and replan their functions.

4.3 Dutch knowledge about water

What knowledge does the Dutch water sector possesses on water security?

To accomplish water security, the previous paragraph has clarified certain techniques and practical implementations that are being considered by the Dutch water sector. According to the expert of WA-R 1, awareness on the urgency of change has been created in the last decade. Sweco expert 1, illustrates that only in the last ten years changes in the sector are noticed. Before, there was a sufficient water availability, water was cheap and easily accessible.

'Ja, ja. Ik zit er nu 30 jaar in. De eerste 20 jaar had je het daar niet over. Er was water genoeg, het was goedkoop, het was simpel, het was voorhanden' (Sweco 1)

However, this is in contradiction with what was said before regarding the structural decline of the groundwater level. Besides, Didde (2021) indicates that signs of "drying out" have been known for decades. 'Nevertheless, alarming reports and policy measures have not put a stop to it' (Didde, 2021)**.** Nowadays this is different and structural measures are taken.

The implementation of new or improved techniques is building further on the old and complex system based on the Dutch vision. This means that instead of civil engineering projects, such as canals, reservoirs and dams, adjustments have to be harmonised with nature and the surroundings (DWPW 1). Although the current situation might not indicate that the water system is effective to assure water security, this does not mean that important knowledge is not possessed by the Dutch water sector or cannot be produced. This was argued by multiple experts representing all sectors.

Although due to the performance of the system water security cannot be guaranteed, the Dutch water sector remains advanced in its water quality (Sweco 1; WML 1). Moreover, because of experiences in the past, the Dutch water sector is perceived as capable of successfully transitioning into a more efficient water system (WA-R 1). This is needed since a lot of water is currently unnecessarily discharged. KWR expert 1 defines the Dutch system as "spilly". The expert continues by mentioning, 'when the Dutch system will be applied in another country with smaller water resources the population will show their dissatisfaction and the need to change'.

'Als je dat in een land zou doen waar weinig water is dan word je meteen aangesproken of dan is men daar veel feller op dan in Nederland '(KWR 1).

Arcadis expert 2 states that innovating and transforming the system is part of the DNA of the Dutch water sector. Quick changes or innovations are created since the sector is "techy" and is eager to perform "top of the bill". Expert 1 of Antea Group indicates that the Dutch water sector is aware of what it entails to make certain changes. Furthermore, it is already possible to do so, through modelling, to detect the added value of certain measures taken to create a more efficient water system.

According to multiple experts, the Dutch water sector is advanced in the creation of such models and utilizing it as a foundation for measures and legislation. One of the reasons why these models can be created has to do with the Dutch Royal Climatological Institute which has demonstrated certain scenarios on climate change. Based on these scenarios the Dutch water sector can continue calculating on what kind of measures are needed.

'We hebben natuurlijk die klimaatscenario's en de klimaatsignalen van het KNMI. Die externe kennis passen wij dan toe en maken we concreet in onze modellen en technieken' (Antea Group 1).

Moreover modelling, Antea expert 2 illustrates that the Dutch water sector utilises integral models which include water flows, sewerage, infrastructure on ground level, water storage in nature. Another reason these models can be designed has to do with the fact that the Netherlands is one of the most "information dense" countries in the world. Therefore, the country collects an enormous amount of data (STOWA 1). According to both experts from STOWA and Royal HaskoningDHV, the Netherlands is leading in digitalisation, analysing, and translating data into actions. DWPW expert 1, indicates that adjustments in the water system are and, in the future, will be made based on calculations and forecasts.

The rich number of data that is collected by the sector, together with existing knowledge regarding the hydrology of the country is an effective combination. By merging these two sources, calculations can be made on the availability and levels of groundwater and surface water. Although these calculations are described as 'no rocket science' by Antea Group expert 3, without the data actions and measures would be less effective. By utilising these models and calculations the Dutch water sector has created a better understanding of the general national water system. Nevertheless, regional water systems still have to be investigated. Concerning these calculations, reason why these are no rocket science has to do with the advanced level of education at technical universities in the Netherlands. Multiple experts have mentioned the added value of these universities for the Dutch water sector.

Besides collecting data and modelling, the Dutch water sector develops and innovates in drinking water. In this sector all developments and innovations in techniques are done by the suppliers of drinking water together with knowledge institutes (Antea Group 3). According to Sweco expert 1, all Dutch drinking water suppliers can deliver water of the correct quality, even though the quality of the source (ground or surface water) has changed.

'Alle waterbedrijven zijn in staat om perfect drinkwater te kunnen maken ook al veranderd de kwaliteit van hun bron' (Sweco 1).

Especially the quality of surface water can change. This happens throughout the year but is highly influenced by the rise of temperatures (Sweco 1; WML 1). By treating the water successfully, Arcadis expert 2 states that the Netherlands is advanced in drinking water treatment as well as wastewater treatment. According to this expert, the Dutch sector is leading in developments on wastewater treatment as well as reclaiming raw materials out of wastewater, this is agreed by TU-Delft expert 1.

'Ja, ik denk dat zowel voor het drinkwaterbehandelingsdeel als voor het afvalwateringsdeel die kennis is heel hoog in Nederland. Dat wij daar *leading* in zijn, in alle ontwikkeling in afvalwaterbehandelingssystemen, het terugwinnen van grondstoffen uit afvalwater' (Arcadis 2).

One of the companies active in wastewater treatment as well as the reclamation of raw materials is DeSaH. This company is specialized in vacuum toilets which has a positive impact on water consumption (reduction of 30%), a smaller amount of wastewater, as well as more reclaimed materials from waste (DeSaH 1). According to the expert, implementing vacuum toilets is the cheapest solution to reduce drinking water consumption.

Besides knowledge on recycling wastewater, knowledge on the other two main strategies (storing water and water desalination) that can improve water security is possessed by the Dutch water sector as well. However, these two strategies are implemented on a much lower and more local level than recycling wastewater.

Regarding water desalination, according to Royal HaskoningDHV expert 1, the Dutch sector has knowledge on this technique. Nevertheless, data illustrate that only in the Caribbean Islands which are part of the Netherlands utilises water desalination plants (Arcadis 2). The main reason why this technique has not been implemented in a larger scale has to do with the lack of urgency to create other (artificial) water sources. To improve water security in the Netherlands, storing water is believed to be most effective. By storing water, precipitation and surface water can infiltrate into the ground which creates a certain buffer for dry periods. These adjustments in the system have been made on small and local scale, however the effects of storing water cannot be observed in practice very well yet (WML 1).

'Tegenwoordig zie je een tendens om het water eigenlijk vast te houden en weer te laten infiltreren. Ja, de effecten daarvan zijn nog niet zo goed waarneembaar' (WML 1).

4.3.1 Conclusion

The Dutch water sector possesses a wide variety of knowledge. Due to a complex system and high-quality (technical) education the system is perceived to be advanced. Besides the presence of several technical universities, responses from experts indicate the large focus on technical knowledge and modelling. Although the country is perceived as leading worldwide, it is not clear if local issues are solved by any of these approaches. Furthermore, assumingly, other type of knowledge and approaches are needed to improve situations regionally. For instance, by implementing water storage. Knowledge and practical experiences on this technique appears to be lacking in the Dutch water sector. This seems to be a contradiction since certain experts have illustrated that storing water is the technique most preferred by the sector to accomplish water security in the Netherlands. This means there is still a lot of work waiting to be done.

4.4 Dutch water knowledge: how is it produced?

How is the Dutch water sector producing knowledge on water security?

While the previous paragraph has indicated what knowledge the Dutch water sector possesses, in this paragraph the production of this knowledge is demonstrated. According to most of the interviewees, knowledge is produced by working together. In this way research can be conducted and certain problems faced by the Netherlands can be tackled. Nevertheless, some companies in the private sector develop their own knowledge and inventions. An example of a company innovating individually is Sweco. According to the expert, the company has several technological developments that can be sold in packages. The expert continues saying that Dutch water authorities do not often innovate themselves. The authorities leave this task to the market.

Regarding the innovations, often these entail developments and improvements of existing technologies. For example, more efficient membranes to reduce the amount of wastewater. Sweco expert 1, indicates that ground-breaking innovations, especially in the dimension of drinking water, are rarely due to the advanced performance of the sector. Concerning drinking water, the water suppliers and knowledge institutes possess important knowledge about the treatment and the supply of drinking water. According to the expert of WML, when research is needed, these are merely conducted by universities and knowledge institutes. However, when information is needed specifically on drinking water, engineering companies and consultancies such as Royal HaskoningDHV and Witteveen + Bos are requested to help. Whenever the request entails more technological issues and implementations in the system, local engineering companies are often capable to help.

‘En naar mate je van onderzoek. Onderzoeken zit meer bij de universiteiten en kennisinstituten. Ontwerpen, als het echt drinkwatergerichte vraagstukken zijn, dan kom je echt wel bij dat soort bedrijven als Royal HaskoningDHV en Witteveen + Bos, en dergelijke terecht. Als het meer het puur technische ontwerpen is, dus een stukje toepassing dat kunnen lokale ingenieursbureaus zijn die vooral technische poot hebben waar je iets mee kunt’ (WML 1).

These partnerships are either formed due to the need of specific knowledge, or parties more experienced at a certain location or in a particular context. This is in line with secondary data. A study initiated by Netherlands Water Partnership shows that partnerships are perceived as necessary (by

67%) (Boneschansker, Tietema & Neijland, 2018). For example, since it can help combining knowledge and experiences. The above-mentioned study shows a similarity since ‘smart combinations of techniques’ is the option mentioned most often (93%) when asking about the market opportunities in the Dutch water sector (Boneschansker, Tietema, & Neijland, 2018). Besides combining techniques, ‘development of new techniques’ had a high score (88%) as well. Nevertheless, as mentioned before, this will not often take place in the domain of drinking water.

Throughout the interviews it became clear that public entities are often the initiator of developments and innovations. Consequently, it appears to result in the formation of a consortium (Wavin 1). Although the production of new knowledge contributes to the advanced level of the Dutch water system and the level of knowledge throughout the sector, it has an apparent disadvantage. According to the expert of Wavin, an engineering company active worldwide, the progress in such a consortium is unprejudiced and inflexible. The expert explains that the expertise of companies in the consortium affect the development of innovation eventually. Instead of an open-minded approach, the approach chosen is frequently fixed and in favour of the companies involved due to specific research that has to be conducted or what solutions are implemented.

Contrary to the above, DWPW expert 1, indicates that partnerships initiated by public entities are formed with an open mind. Additionally, knowledge possessed by large individual companies or institutes is monitored to be not monopolistic. Therefore, eventually knowledge is shared with other parties (DWPW 1). According to the expert of DWPW, water authorities are an important player in the development and production of knowledge. The main reason is their urge for new knowledge. This can either be for specific situations or serve as a foundation for new regulations and policies. According to water authorities, the regional governments are actively involved as well. According to WA-S expert 1 and Deltares expert 2, the province of Zeeland initiates a lot of innovative projects to produce knowledge as well as implementing practical innovations through introducing pilots. Throughout numerous interviews, local or regional initiatives were mentioned, such as in Limburg and Achterhoek (a region managed by WA-R).

One important player in the knowledge infrastructure of the Dutch water sector is Deltares. Almost each expert has mentioned Deltares as a crucial stakeholder in the knowledge production phase. This is quite logical as Deltares is one of the TO2-entities, so-called Research & Technology Organisations (RTO’s). This means that together with four other organisations Deltares is obligated to conduct research and produce knowledge in favour of the Dutch government.

To do so, Deltares aims at working together with universities to put knowledge produced by these universities into practice. Referring to the creation of data-based models, Deltares contributes to the development of these. As expert 1 of Deltares clarifies, Deltares shares their knowledge with (private) companies throughout the sector. By utilising these models, the companies will contribute to the quality of the model which will be commercialised afterwards.

> ‘Er zijn natuurlijk, er vinden op allerlei ontwikkeling plaats. Een hele belangrijke taak van Deltares is samen te werken van universiteiten waar kennis ontwikkeld wordt en om dat te vertalen in de praktijk’ (Deltares 1).

Transforming academic knowledge that is produced by universities into practice is illustrated by the expert of DWPW as well. According to this expert, the knowledge network performs in the following way: starting with academic knowledge that often is produced through government funding or government initiates this knowledge will be translated into advanced instrumental knowledge. This is the point where knowledge institutes contribute and put the knowledge into practice. Securing this knowledge is done through publications in scientific peer-reviewed journals. Knowledge institutes are capable to publish as well, which happens occasionally. Whenever knowledge is put into practice by knowledge institutes subsequently this knowledge will be accessible for consultancy firms to collect and implement in their work. From this moment, the knowledge produced will find its way into grey literature.

> ‘Ja, je hebt een heel kennisnetwerk is het eigenlijk van academische kennis (…). Die wordt toepasbaarder gemaakt door de kennisinstituten en soms ook vrij snel parallel door de adviesbureaus’ (DWPW 1).

This view contradicts somewhat the experience of other interviewees. WENR expert 1 indicates the organisation is seeking partnerships with companies in the practical field of the water sector. This seems to be mutual for the practical field. In their study Boneschansker, Tietema, and Neijland (2018) asked private companies in the Dutch water sector what market opportunities there are in the Netherlands. 72% of the private companies have answered ‘make better use of knowledge and knowledge institutes.’ Throughout the interviews certain experts have agreed on this statement. According to expert 3 of Antea Group, knowledge sharing throughout the sector should be improved. Furthermore, KWR expert 1 illustrates the lack of knowledge institutes participating in projects. Especially when projects aim at achieving new innovations knowledge institutes are ignored (KWR 1). Overall, this has to do with the commissioner of the project since time and costs are prioritised. This means that instead of involving knowledge institutes to innovate, traditional solutions are implemented (KWR 1).

This illustrates, as expert 2 of WENR mentions, the need for specialised knowledge as well as knowledge on a wider spectrum have to be combined to be innovative. Therefore, the knowledge institutes are essential to the knowledge production. The approach clarified by WENR expert 2 relates to the approach defined by the Dutch water sector as ‘Blue Route’. ‘The Blue Route is a definite breaking point with the more traditional linear innovation process: innovations will take place in an open network to co-create together between science, society, and industries' (Topsector Water & Maritiem, 2018). Although this might be the aim, expert 1 from STOWA states the difficulty to achieve a so-called 'Golden Triangle' structure between government, knowledge institutes, and private companies. Which leaves out society. Since the introduction of TW small developments have been made (WENR 1). Nevertheless, due to an unfair financial structure, private companies are financially subordinated compared to knowledge institutes. While the TW tries to attract private companies by "being involved" in the process of new innovations, the companies are aware of the long and time-consuming trajectory until knowledge can be commercialised. To work more often in a triple helix structure, the expert of STOWA suggests redesigning the financial structure of the TW.

Even though it seems important to include knowledge institutes to produce new knowledge, this will go along side some challenges, according to WENR 1.

'Though it is worth it working together there will always be a difference in speed and objectives. Private companies are aiming to develop something to commercialise it as soon as possible, while knowledge institutes or universities are aiming to find an answer to a certain question. To put it bluntly, the objective of a knowledge institute is not to sell innovations as soon as possible' (WENR 1)

'Dat is ook wel de moeite waard, maar je blijft toch met verschillende snelheden en doelstellingen. Je ziet dat bedrijven, die willen zo snel mogelijk iets ontwikkelen wat ze dan weer verder kunnen verkopen. Terwijl vanuit de onderzoekswereld heb je vaak een vraag en daar willen we het antwoord op weten. Hè plat gezegd: we hoeven niet zo snel te maken wat verkocht moet worden want dat is helemaal onze doelstelling niet' (WENR 1).

This mismatch in objectives and time can cause problems. Nevertheless, whenever specific or specialised knowledge is needed often universities or smaller companies become involved. Throughout the study of Boneschansker, Tietema, and Neijland (2018), it was noticeable that small companies had difficulties to be included in current partnerships.

While partnering with universities and knowledge institutes is more common, the expert of Royal HaskoningDHV clarifies the main reason to invite small companies to work together. According to this expert whenever a specific technique is needed in a project, or the companies' expertise is perceived as an added value to the project, smaller companies will be invited. This is, again, in line with the answer mentioned before: 'make better use of knowledge and knowledge institutes.'

Nevertheless, the invitation to contribute depends on the individual according to KWR 1. Through experience and role this expert has observed that people perceive the inclusion of small companies differently. While some enjoy working together with new and young start-ups or spin-off companies, others are more conservate and aim at doing it themselves. According to STOWA expert 1, the current struggle the sector has to deal with is the question in which capacity innovation takes place. 'I think we are struggling with the question where innovation takes place. Does it take place at larger companies which are institutionalised or more at the small spin-off companies?'.

The opinion of the STOWA expert 1, is the latter. Therefore, the smaller companies should get the chance to be included in consortia. Moreover, the expert of WML states that from the perspective of efficiency and time consumption it would be helpful to include smaller companies that are less bureaucratic and institutionalised to remodel the current approach. This suggest that the current model is not perceived as efficient. The reason why this approach is time consuming has to do with prioritising the quality of the system. According to Sweco 1, developments are slow since all new techniques or technologies have to be tested endlessly before implemented. Others have criticised the level of implementation as well. The Netherlands is dealing with the question 'how to implement knowledge, innovation, and techniques? '(KWR 1).

Besides the focus on the quality of the system, other reasons are given on why implementation in the Netherlands is slow and time consuming. Starting with knowledge itself, experts seem to be positive about the quality and amount of knowledge possessed and produced by the Dutch water sector. However, some even indicate that it can be perceived as too much. According to the expert of WA-R there is no lack of knowledge production. There are enough developments ongoing. As a matter of fact, it seems impossible to keep track of all the ongoing projects. Due to the large number of projects, it is difficult to decide in which project will be participated (WA-R 1). Due to a knowledge production and project spill over, the perception of knowledge dispersion can come up, which is stated by Boneschansker, Tietema, and Neijland (2018) as well.

When the experts were asked regarding their perception of knowledge dispersion, most of them did not have any experience with this issue. Nevertheless, some recognised this feeling. Especially in decision-making processes when the preferred approach or measure has to be agreed on. The expert of DWPW agreed on knowledge dispersion in times of decision-making. Since the Dutch water sector possesses a wide variety of knowledge multiple strategies are plausible to implement. This is something of a luxury, however, since a preferential strategy must be decided on it takes a lot of time (DWPW 1). WENR expert 1 gives an example of a project currently working at. The consortium consists of 24 stakeholders including seven Water Authorities, three provinces and five knowledge institutes. The expert indicates that working together with a large group of stakeholders, dispersion can occur. It has taken two years before everyone is on the same page and decisions can be made on a preferential strategy (WENR 1).

To take all interests into account, it takes a long time and is difficult process, according to Deltares expert 2. All these functions such as agriculture, nature and households have their own demands that must be considered. As to the farmers, they are often well-represented in the water authorities (Didde, 2021). This can lead to friction since the farmers' interest is different from the interest the Dutch water management has. Nevertheless, their economic contribution to the Dutch economy is enormous which suggests the country's traditional focus on agriculture. Furthermore, the agriculture possesses a lot of knowledge themselves. Therefore, they are an important party to work together with in the process of knowledge production and innovating.

4.4.1 Conclusion

Although certain companies innovate individually there is a diversified image regarding the knowledge production and knowledge infrastructure. While some experts praise the Dutch approach for creating partnerships and consortia in order to solve problems successfully, others prefer a more equal and flexible system. The course of knowledge described by the expert from DWPW is perceived as more traditional. In this linear knowledge sharing structure Deltares has an important role as intermediary between the government (RTO), the universities, and the private companies. Nevertheless, the approach defined as Blue Route includes additional actors. One of these actors is assumed to be the smaller companies. By inviting these smaller and often specialised companies, new technologies will be more likely to be invented. Furthermore, these smaller companies can bring new life into the existing bureaucratical structure of partnerships. An additional actor that is important for the Dutch water sector is the agricultural sector. As mentioned before, farmers possess a lot of knowledge. Besides, they are well-represented in the Water Authorities. Yet, the more traditional triple helix structure cannot be accomplished. Besides the fact that knowledge institutes are ignored in certain projects, private companies are financially subordinated. The reason why knowledge institutes are ignored has to do with (1) more traditional and simplistic solutions are preferred, or (2) the challenges of working together since knowledge institutes often have different objectives throughout the projects.

Even though the knowledge production does not always seem to be smoothly, some perceive the amount of knowledge produced by the Dutch water sector as to much. Therefore, it is difficult to keep track on all ongoing projects. Furthermore, knowledge sharing throughout the sector should be improved to create more awareness of developments in the sector.

4.5 Contribution worldwide

How is the Dutch water sector currently trying to contribute to water security worldwide?

Data received in relation to the previous two research questions have shown the knowledge possessed and produced by the Dutch water sector. This information is used as a foundation to analyse the possibility of executing the NIWA. To answer this question, experts were asked about their perception of Dutch activity worldwide regarding water security. As already mentioned, some experts have different perceptions to the term water security and its scope. While in the Netherlands the experts relate water security to drinking water, internationally this is somewhat different.

As described in the previous questions, the knowledge possessed by the Dutch water sector has a relative high standard. Experts have explained that this is because of the utilisation of advanced techniques in a complex system. Nevertheless, currently the design of the system is not sufficient for all functions that need water.

'Countries elsewhere do not understand why we are dealing with drought and water scarcity, since we are a delta with an incredible amount of water, why water scarcity? As a result, you come to think are we managing our water cleverly?'

'Als je kijkt in het buitenland begrijpen ze niet dat wij een droogteprobleem hebben want we zitten in een delta er komt ontzettend veel water ons land in, dus hoezo een droogteprobleem? Dan zou je denken, hebben wij wel, zijn we wel slim genoeg met het water om dat te beheren' (Deltares 2).

In addition to knowledge needed in the Dutch context, some experts have indicated that the Dutch water sector is active on a wider scope. Certain innovations by the Dutch are not aimed at helping their own system but to contribute to improvements abroad by exporting knowledge and techniques. This is in line with the content of NIWA since both contribute to improvements in the system as well as generating financial benefits. However, this can be perceived as contradictory (WENR 2). While on the one hand the country aims at contributing (generously), on the other hand the country seeks commercialisation of knowledge and innovations produced by the sector. Prior to the elaboration on how the Dutch water sector can contribute to the NIWA, the organisational structure used to be active internationally will be clarified.

According to the expert of Royal HaskoningDHV the Netherlands has government-to-government partnerships worldwide. With these partnerships the government aims to export the Dutch knowledge and help the specific countries.

'Nederland heeft gewoon overal in de wereld eigenlijk al wel samenwerkingsverbanden, *government to government* samenwerkingen met landen waarin ze Nederlandse waterkennis proberen, nou ja, te ver-markten en daarmee ook die landen te helpen' (Royal HaskoningDHV 1).

Even though governmental partnerships exist, the Ministries of Foreign Affairs, including Foreign Trade and Development Cooperation, and Infrastructure & Water Management perform separately. Although the Ministries try to cooperate and merge goals, each Ministry has an individual list of countries that the Dutch water sector should seek as partnerships. This means that the goal of each Ministry as well as the prioritised countries where these goals have to be achieved vary heavily (Dutch Water Authorities 1 (DWA 1)). The expert of the DWA indicates the Blue Deal - one of the Dutch international programmes - works in accordance with a list created by the water authorities, and the two Ministries mentioned above. For this reason, the DWA expert describes the list of countries as "hodgepodge".

The Blue Deal is active worldwide and consists of experts from all water authorities in the Netherlands. This programme aims to develop water systems together with local water operators worldwide. The expert of the DWA has described the aim to provide 'safe, clean, and sufficient amount' of water, which is in line with the international description of water security. Many countries where the Blue Deal is involved are listed by the Ministry department of Development Cooperations. They aim for partnerships in Western Africa, as well as Latin America (DWA 1). Regarding the Ministry of Infrastructure and Water Management, countries such as Vietnam and Indonesia are prioritised with an additional emphasis.

To accomplish contribution to the improvement of water security worldwide and to share knowledge, Royal HaskoningDHV expert states that Invest International is a key player. Although multiple entities are facilitating projects worldwide, Invest International facilitates the biggest projects (Royal HaskoningDHV). The expert of Invest International that has contributed to this study is responsible for development capital in developing countries worldwide. Besides the various lists of countries mentioned before, the expert of Invest International mentioned another, namely DGGF (Dutch Good Growth Fund). Most countries on this list are emerging countries (Invest International 1).

Throughout the interviews it has become clear that, the Dutch water sector participates in projects in developed countries as well. For example, the expert of PfW - another instrument initiated by the Dutch government - illustrates that through this programme the water sector has contributed to projects in countries such as Switzerland and Dubai. Although this seems contradictory to what is mentioned before, the programme of PfW is based on a different vision. The expert states that fundings are applicable in this programme whenever certain criteria about innovation are met. For instance, realistically digging wells is not seen as a project that will be approved by PfW. On the contrary, the expert of PfW indicates that in favour of improving water security traditional and general known solutions have been implemented. Nevertheless, in these situations the traditional solutions were organisational innovations.

> '(…) het één en ander hebben gedaan aan waterzekerheid en soms zelfs met nog betrekkelijke traditionele oplossingen of bekende oplossingen. Maar dan soms net weer, ik zou bijna willen zeggen, innovatief georganiseerd (PfW 1).

Referring to secundary data, according to Panteia (2020), the Dutch water sector has distributed services to the countries demonstrated in *figure 11* in 2019 and 2020. This overview illustrates that the sector works in a wide variety of countries in different economic situations.

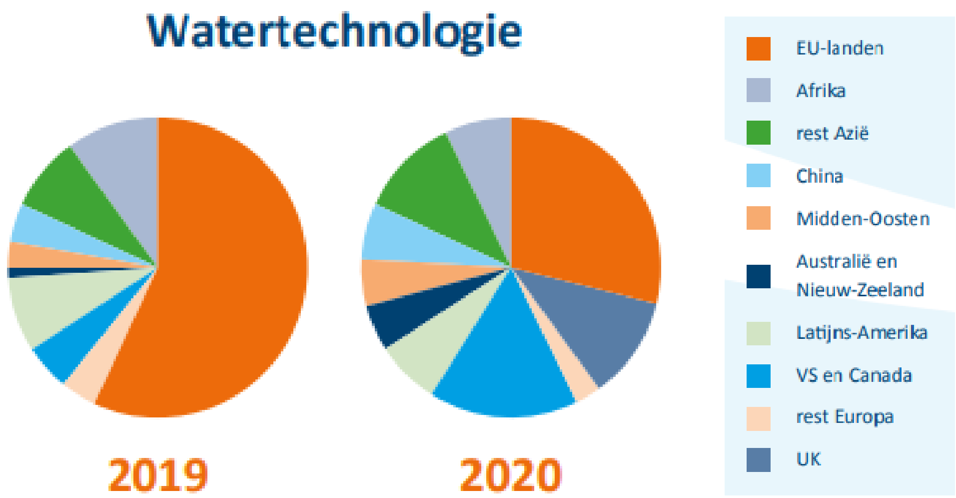


Figure 11. *Overview of regions worldwide the Dutch water sector is active in 2019 and 2020 (Panteia, 2020)*

Distributing services, as said before, does not only entail sharing knowledge and innovation. Through Invest International and PfW countries receive certain fundings. Therefore, these programmes are perceived as instrument contributing to the NIWA (WENR 2). Nevertheless, as expert 2 of WENR indicates, the objectives of the NIWA are not clearly distributed. The reason is that often the objectives are not taken into consideration in either the preface or throughout the project.

Concerning the NIWA, multiple experts have mentioned different characteristics of the Dutch ambition. Defining the NIWA at first was done based on the Sustainable Development Goals (SDG's) (DWA 1). Examples of characteristics of the NIWA are (1) mainly focused on developing countries (Arcadis 1) and the projects in line with this ambition are (2) primarily longitudinal (TU-Delft 1). Although criticism is given on the term water security due to its unrealistic impression of securing water, the expert of Invest International states that – considering the knowledge the Dutch water sector possesses – the NIWA is a realistic goal to aim for. According to a variety of experts in the Dutch water sector, the sector possesses a rich variety of knowledge on water management. Zooming in on the types of knowledge the Dutch water sector shares, the expert of TU-Delft indicates that it is merely stakeholder and expert knowledge. In some projects, in case the Dutch government is involved, bureaucratic knowledge is utilised as well. However, usually knowledge produced by engineering companies, consultancies, or institutes like Deltares is involved in the projects (TU-Delft 1).

When asked whether the Netherlands can contribute to the improvement of water security every expert agreed on the capability to do so. Each interviewee has indicated that the Dutch water sector can contribute in some way to the improvement of water security.

'There is a lot of potential and a lot of new developments to really contribute to the improvement of the liveability, at lease the quality of life, improving circumstances to live in. For instance, water security, clear drinking water. That is quite important.'

‘We hebben een enorm veel potentie en heel veel nieuwe mogelijkheden om daadwerkelijke ook waarde te bieden om het leven beter te maken, tenminste de kwaliteit van het leven, levensomstandigheden te verbeteren. Denk maar aan waterzekerheid, schoon drinkwater. Nou dat is toch wel erg belangrijk’ (Arcadis 1).

Although, the Dutch water sector can contribute worldwide, criticism on the Dutch system is understandable since not everything goes well (Royal HaskoningDHV 1). However, even though mistakes are made the quality of the Dutch systems makes it possible to contribute by sharing knowledge about the system elsewhere in the world. Furthermore, contribution to improve water security worldwide is realistic since most of the knowledge possessed by the Dutch water sector is the result of decades of practising. This knowledge is useable both to maintain the Dutch systems as well as to export and help improving systems abroad (DWPW 1).

Besides knowledge about techniques, WML expert 1 mentions that the Dutch sector can contribute to the infrastructure and behaviour towards discharging wastewater. By sharing knowledge about this topic, it might not solve the problem completely, but it will make the problem smaller. Furthermore, the expert illustrates that problems regarding water security vary extremely. This is highly dependent on the type of country since the conditions are different in each country (Arcadis 1). This means that the actual contribution is not only depending on knowledge possessed by the Dutch water sector, but also the status of the water system of the specific country.

In addition to the water system itself, data collection is an element often lacking in other regions worldwide. According to the expert of DWA, no measures are taken to collect data in certain countries. Therefore, often data collection is still at a very early stage while the Dutch systems is advanced. Therefore, it is fairly easy to contribute, and consult in necessary actions that have to be taken. As described before, such data collection can be used as foundation of policies and legislations. The expert of Wavin has illustrated an example in South America where necessary regulations were lacking. In this particular project the company could both contribute by demonstrating certain techniques as well as sharing knowledge on policy making. Nevertheless, institutional weaknesses can have a crucial impact the water system as well. In some countries the government is lacking power resulting in difficulties to contribute (Wavin 1).

As described by the expert of Wavin, the combination of so-called hardware (techniques & installations) and software (knowledge, information & data) systems has been noticed more often throughout the interviews. Numerous experts that are active internationally explained the mixture of hardware and software systems.

‘Ik weet wel dat er heel veel projecten lopen rondom drinkwatervoorziening bijvoorbeeld. Ja, daar speelt Nederlandse kennis een rol in. Er wordt technologie geleverd, maar in combinatie met de expertise die daarbij hoort’ (TU-Delft 1).

Hardware systems are described as less time consuming than software systems. Examples of hardware systems are for example wastewater recycling plants, infrastructural implementations or adjustments that improve the efficiency of the system. Although these projects are perceived to be less time consuming, the costs of realising these implementations are often much higher. A program like Partners for Water states that such hardware projects are impossible to fund. It is much more likely to do small-scale projects on hardware or longitudinal projects on software systems (PfW 1).

Contributing to a software system has a broad range. As explained before, this could be through explaining certain regulations (Wavin 1), through demonstrating collaborations with potential stakeholders (PfW 1) or helping to improve the "information system management" (DWA 1). These contributions are only effective and sustainable whenever it is a long-term project. Consequently, current Dutch policy includes the aim to participate in longitudinal projects to change the system instead of small-scale hardware implementations (DWA 1).

> 'Dat zie je terug in al die beleidstukken inderdaad. We gaan langjarige samenwerkingen aan. Er wordt eigenlijk ook echt ingezet op systeemverandering in plaats van 'nou we gaan drie waterputten slaan en dan zijn we lekker bezig met ons allen' (DWA 1)

However, changing the system might give the impression that Dutch parties are in control and will change what is needed in their opinion. Experts have indicated that this will not be effective since the local context is needed. Some experts have given examples of projects and situations where Dutch parties were in control without fully understanding the local context.

> 'Dus het is niet meer zo dat je alleen maar Nederlandse kennis hebt. Iemand die goed weet hoe het in Nederland werkt, hier een goede opleiding heeft gehad en die gaat naar een land en die gaat vervolgens vertellen hoe het zit. Ja, die kwam na een maand erachter dat het niet zo zit, en wat dan wel' (Arcadis 1).

After multiple incidents, the Dutch water sector has realised that in order to effectively share knowledge another approach was needed. It is not sustainable to 'wrap Dutch knowledge into a present, send the present and the problem will be solved' (WENR 2). The expert indicated, however, that this is still done by some parties. Currently, according to multiple experts, solutions are not implemented like some kind of "blueprint" anymore. Nowadays, existing Dutch knowledge is combined with the local context and knowledge possessed by the host country. For example, culture differences and sensitivities in a community can be applied to this approach. In this way it will be easier to assess whether certain knowledge is relevant and applicable in the context of the project (TU-Delft 1).

To understand and implement the local context, two different approaches have been noticed. While the expert of TU-Delft and Deltares are talking about Dutch employees working for a longer period in a certain country, experts from Arcadis and Royal HaskoningDHV describe the inclusion of and partnership with local businesses and experts. Furthermore, Royal HaskoningDHV describes the advantage of working with the local society. By working together with local communities, the Dutch water sector aims at both bringing and receiving knowledge (MIWM 2). Boneschansker, Tietema, and Neijland (2018) have stated that almost 50% of the knowledge produced by the Dutch water sector has taken place abroad. In this way the knowledge can be implemented in the Netherlands or abroad (PfW 1). Besides traditional hardware systems, the Dutch water sector can learn from software structures as well. Although this knowledge might not be implemented in the Dutch system itself, it can still be valuable knowledge to utilise in other regions worldwide.

'Als we wat hebben geleerd in Mozambique dat dat ook in Ghana gebruikt kan worden' (Invest International 1).

According to the expert of the DWA, in Columbia the Dutch water sector has learned from the Columbian way of implementing stakeholder participation and invite people to think about the value of water quantity and quality. This is something that can be very helpful for the Dutch environmental management. Nevertheless, as to projects in Africa, most projects are sending knowledge. Through these partnerships the local society becomes more advanced in their understanding the water system. This means that implementations initiated by the Dutch water sector will be more sustainable (Royal HaskoningDHV 1). Consequently, the contribution of the Netherlands becomes smaller.

'Je ziet toch ook wel dat er steeds meer kennis op nationaal niveau komt bij de landen waar we werken, die gewoon hartstikke goed is. Dus ik denk dat we onze projecten steeds meer, eigenlijk dat onze eigen inbreng steeds kleiner moet worden' (Royal HaskoningDHV 1)

As aforementioned, through multiple programmes the Netherlands funds countries using different criteria. While the expert of Royal Haskoning DHV perceives the Dutch funding as efficient and strategic, the expert of Invest International thinks differently. The expert states a large number of programmes initiated by the Dutch government (*table 4*)

1. Partners for Water	5. Kenya Pooled Water Fund
2. Blue Deal	6. KIFFWA
3. Water as a Leverage	6. Aqua for All
4. WaterWorks	

Table 4. Overview of some of the programmes initiated by Dutch government in the water domain (Invest International 1)

All these programmes have different goals and different criteria, and a large amount of money is invested in each of these programmes. Concerning Invest International, their goal is to create impact whenever a Dutch company is contracted to work abroad and implement their knowledge or innovation. The expert of Invest International indicates the feeling of a lack of consistent overlapping strategy between their work and other programmes. Therefore, the potential to contribute and create impact is currently not met by the Dutch water sector. An example was given that took place in Kenia just before the Covid-19 pandemic started. This expert met someone in Nairobi that was analysing projects to invest another five million. This amount of money had become available. However, to invest this amount of money in Kenia is ridiculous according to the expert of Invest International. 'If there is one country to name that has received already an incredible amount of money it is Kenia'. According to this expert, this illustrates why fundings should be assessed more critically.

'En dan denk ik 'nou als er één land is waar al ontzettend veel geld in is gegaan voor dan is het Kenia en dan is daar nu weer vijf miljoen bijgekomen'. Nou dat vind ik echt van de zotten' (Invest International 1).

Situations like the example above have been described by multiple experts. Countries receiving a lot of attention and funding are so-called donor darlings. Besides Kenia, Jordan can be classified in this category as well (Invest International 1). In these countries competition on funding takes place. 'In these countries we see an unrealistic situation that due to the competition it almost seems to suffice that there is pleasure in being allowed to work together (PfW 1).

'Laat ik zeggen, daar doet zich soms de gekke situatie voor dat we al blij mogen zijn dat we met ze mogen samenwerken want er is ook een donorcompetitie in sommige landen gaande' (PfW 1).

Analysing the water sector, it contains a lot of civil work which is relatively easy to realise locally (Invest International 1). Therefore, Dutch consultancies are often involved only in the preface of the project. Actual impact in later stages is lacking (Invest International 1). This sums up the reason why the expert of Invest International is frustrated by the current strategy, 'an enormous amount of money just goes to the consultancies.'

The reason why Dutch companies are often only contracted in the preface has to do with the supply chain. The Dutch supply chain is 'cut into pieces' (Arcadis 1). There are the knowledge and research institutes, the consultancies, the subcontractors, contractors, and operators. Although, each of these stakeholders has a high quality, the connection between the stakeholders is missing. Furthermore, the chain is not complete (Arcadis 1). Dutch operators are not that active outside of the Netherlands, except for two or three. The expert of Arcadis and Invest International indicates that numerous operators that have been active internationally before are now closing their international department. Even though certain companies are still active, compared to big multinationals, they are lacking body. Multiple examples are given of French or American companies that possess similar knowledge, but in size have a larger impact worldwide. For instance, the French water sector is very active in the North African region (PfW 1).

Besides the countries above, some other countries have been mentioned due to their specific knowledge, such as Israel as the largest desalination plant in the world is located here. Therefore, they are perceived as the leading country in water desalination (Arcadis 2). According to the expert of Sweco, from each potential water source Israel creates water. Next to engineering new water sources, Israel is known for its efficient agriculture and aquifer management (DWPW 1).

Another country that is mentioned for their water use on agricultural activities is Spain (MIWM 1; PfW 1). For instance, due to the utilisation of drip irrigation. Both countries have a Mediterranean climate and since long have been dealing with drought and water scarcity on a structural basis. DWPW expert 1 states that historically these regions – with a more structural water scarcity problem than the Netherlands – they have adjusted themselves to dealing with these problems. Their agriculture, their urban development and their economic activities are different (DWPW 1).

To increase Dutch impact internationally, large companies such as Deltares and Arcadis sometimes work together (TU-Delft 1). By partnering these companies have a better chance of being contracted. In addition, while global competition is ongoing, the Dutch water sector performs – considering the size of the country and its industry – relatively well. However, the Dutch approach described earlier in this paragraph is not always praised internationally. PfW expert mentions Dutch contribution has been rejected in the past since the approach was too inclusive or complicated because of the inclusion of local interest. Moreover, multiple experts have mentioned the "dialectics of lead" (Arcadis 1; Deltares 1; KWR 1). Based on an old and complex system the Dutch water system has always been (and will be) in development. Nevertheless, this means that the Dutch water system and its ongoing developments are too advanced compared to the water system of other countries (Arcadis 1).

'Of het is té goed, wat past binnen die hoge technologische geavanceerde Nederlandse omgeving. Ja, de rest van de wereld is daar nog niet' (Arcadis 1).

According to expert 1 of Deltares the main challenges is to watch out to not "fall asleep". Although the Dutch system is more sophisticated than others, the sector should not stop innovating due to the global competition. Concerning this global competition in the domain of water, China is a big and active player. Compared to the Dutch approach the one China implements is more simplistic since it does not ask that many questions. Besides not asking many questions, China, Japan, and Korea are known for offering more attractive financial constructs (PfW 1). These countries are very active in the Philippines, Indonesia, and Vietnam. According to PfW expert 1, Japan, Korea and China use their own human resources throughout the project which explains the lower offers. The approach of Korea or China can be seen as 'disguised operating aid'.

4.5.1 Conclusion

According to the experts, the Dutch water sector possesses a wide range of knowledge due to a long history of developing their own water system. Since this system is perceived as advanced the country aims at generating financial benefits and helping other countries improve their water system. Nevertheless, experts have agreed on certain failures and inefficiencies in the Dutch system. As the Dutch water sector has been working in government-to-government structures for decades it is not new to help countries globally. Many programmes have been introduced in line with the NIWA, to contribute to water systems worldwide. The goal is to provide a safe and clean water system with a sufficient amount of water. Nevertheless, there appears to be an absence of consciously distributing the objectives of the NIWA. Furthermore, these programmes lack a consistent coherence due to different priorities defined by multiple Ministries.

Although improvements in water systems are needed, this is not the only urgent help countries seek. It appears to be important to assist in systematic change, including policies, legal frameworks, behavioural changes, and the presence of stakeholders. Thus, instead of a technology knowledge transfer, embedding the local context is essential to be successful. Especially when thinking of cultural differences and certain sensitivities. This means that traditional as well as innovative solutions, and hardware systems and software systems must be combined. Overall, stakeholder and expert knowledge produced by engineering companies, consultancies or knowledge institutes is utilised and combined. In this way not only, technical implementations can be seen as innovative, but also the way a certain approach is applied can be seen as innovative (organisational innovation).

To do so, longitudinal projects have been introduced to transfer knowledge sustainably by coproducing with local government, businesses, knowledge institutes and population. In this way, the Dutch water sector makes sure that the community of the region becomes more knowledgeable about their own system. Nevertheless, such longitudinal projects are time-consuming. Due to a global competition, the inclusive (and complex) approach of the Netherlands sometimes works against them. The worldwide competition illustrates the innovation and knowledge production in the domain of water by other countries. Some countries seem to be ahead of the Dutch water sector regarding the prevention of drought. The main reason is that these countries are more used to such conditions due to their geographic position.

4.6 What does the future hold?

What future steps will the Dutch water sector take in order to improve the water security worldwide?

In the previous paragraphs a large quantity of information has been demonstrated according to the current functionality of both the Dutch water sector as well as the Dutch system. Although the sector and system are both advanced, there is still a lot of work to do. This is especially the case since the Dutch water sector cannot guarantee water security.

In the second paragraph (potential) strategies the Dutch water sector might implement have been explained. However, at this stage, specific and necessary future steps to improve the water system are clarified. Furthermore, future steps regarding the distribution and implementation of the NIWA are described. Therefore, this paragraph is divided into a "national" and an "international" part.

National

In the context of the Netherlands, besides, infrastructural, cultural, financial, and jurisdictional elements, other elements seem to be required to create a water secure system. Currently, the Dutch water sector seeks to combine the strategy of storing water and consuming water more efficiently to improve the water system (DWPW 1).

According to the expert of Wavin, the biggest challenge is the change the consumption by large users, such as agriculture and industries. While water suppliers used to (unnecessarily) deliver drinking water to industries, awareness has been created regarding more efficient use (DeSaH 1). Expert 2 of Arcadis has indicated that water suppliers are nowadays adjusting their distribution whenever an industry can function with a low-grade application of water. Concerning households, Antea expert 2 has given example how to use water more efficiently and effectively namely, by disconnecting the rain pipes from the sewerage. By doing so, the pipes, rainwater can infiltrate in the ground. However, a transition in the behaviour of industries as well as households is suggested to only work when the urgency is "felt" (Antea 2).

'Dus de burger zou echt iets moeten gaan voelen, zoals Heineken dat het gaat voelen zodra er geen water beschikbaar is om echt die transitie te maken' (Antea 2).

This urgency is felt when the water availability is insufficient or when a financial trigger occurs (Wavin 1). Nevertheless, a transition in the financial system is controversial and brings up an ethical issue since everyone has the basic human right to have access to clean water (MIWM 2). In line with this basic human right, water is charged without income dependent. Yet, maintaining the current financial system will not result in new incentives to search for alternatives and change consumer behaviour. However, awareness must be created with regards to the critical water availability.

Although behavioural changes and storing water are the two strategies preferred, the Dutch water sector can implement more drastic and technological measures such. Although the overview of objectives by the three Top sectors includes the importance of utilising recycled wastewater

(Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021), throughout the interviews actual large-scale operations on this technique have not been observed.

Another more drastic measure is water desalination. As mentioned earlier, this technique is costly. Since the urgency appears to be lacking (Sweco 1) the Dutch water sector has thought about the implementation of this technique but has put it aside for now (DWPW 1). This lack of urgency was mentioned by multiple experts. An example of this lack was given by explaining the distribution priority sequence. This sequence was defined by the government. Through this priority it becomes visible for each function until what stage water is accessible (DWPW 1; WA-S 1). Nevertheless, expert 1 of the MIWM states that this sequence has never been used before. In the perception of this expert situations will have to change dramatically before the distribution priority sequence will be applied.

This is in line with a statement of DWPW expert 1, as this expert does not perceive the current situation as urgent. Since this is no real urgency, concrete decisions on improvements in the water system will not be realised soon. 'The perception of engineerable water is still existing'.

'Die besluitvorming die gaat nu nog zo en die blijft ook nu nog zo omdat we, uhm, nog niet gemerkt hebben dat we nog echt harde keuzes moeten maken. We denken nog steeds dat het maakbaar is' (DWPW 1).

Antea expert 1, explains that flooding in the summer of 2021 disrupted the urgency and focus on water security. Therefore, small steps are taken, but the issue water insecurity has to put on the agenda again. Nevertheless, water authorities have mentioned to be aware of the problems that have to be dealt with. By transforming into a more efficient water system this should work. Additional to strategies mentioned earlier, an increase in groundwater levels (Deltares 2) or increasing the surface water capacity is perceived as a solution. In this way a water buffer can be created. As to the increase of groundwater levels, expert 2 of Deltares explained that this strategy suggests implementing an extra amount of water in the system. According to the expert of WA-R, this strategy will be implemented in their region. By adding 100 mm of water the current groundwater levels will rise. Although this might sound positive, this increase of water can have a negative impact on agricultural activities since the soil can become too wet.

In agriculture - the largest consumer of water in the Netherlands - changes in consumption are needed as well (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021). In the last couple of years, due to drought, using groundwater directly for water crops has increased dramatically. According to Deltares 2 knowledge on this topic is present. For instance, monitoring the groundwater levels and calculations can be done. Nevertheless, this knowledge is not sufficiently possessed by the water authorities (Deltares 2). Regarding the western region of the Netherlands this is different since salinity endangers to the utilisation of groundwater (STOWA 1). According to expert 2 of WA-S, regulations on extracting groundwater are helpful. Although some farmers still use this water source illegitimately, without any regulations the problem regarding water availability would have been a bigger in the province of Zeeland.

One of the techniques that has been proposed by multiple experts to consume water more efficiently by the agricultural sector is drip irrigation (Arcadis 2; WA-L 1; WA-S 2). Instead of watering over the surface, irrigating crops just below the surface reduces evaporation significantly. Besides evaporation, the total amount of water needed decreases as well. Overall, through groundwater extractions and drip irrigation the close relation between water and soil can be noticed. According to STOWA expert 1, there is an ongoing urgency to make the domain of water and soil more managerial.

Furthermore, Water Authorities are aiming to raise awareness by farmers how to improve their soil in order to naturally store water more effectively (WA-S 1). The message to the agricultural sector is to analyse what solutions can be implemented in one's own territory to create a closed loop (DWPW 1).

Nevertheless, strict regulations to do so are missing. Therefore, the governmental institutions involved are required to step up their efforts. Furthermore, to create awareness and support behavioural changes the government should take the lead. Especially regarding drought and the urgency of consuming water more efficiently (Antea 1; DeSaH 1; WA-L 1). While local initiatives have been implemented to do so, discussion is ongoing about which public body is responsible for these actions according to the expert of WA-L.

Wavin expert 1, states that to stimulate behavioural changes and adjustments in engineering future neighbourhoods, the water authorities should define regulations and criteria for permits. Moreover, the government should oblige developers and households to comply with certain criteria regarding the use of water. In the case these criteria are not met arguments must be given instead of complimenting the initiatives (Wavin 1).

> 'Ja, mijns inziens zou er veel meer een regierol vanuit de overheid moeten zijn om dat gewoon te gaan eisen van 'je moet dat overwegen en je moet met argumenten komen als je het niet doet'. In plaats van, 'hartstikke leuk dat je dit wil doen, succes ermee' (Wavin 1).

The governmental entities are developing certain communication methods to create awareness. Nevertheless, all parties indicate that knowledge is required since a better understanding of the water system is needed before awareness can be created. A better understanding of the system can be created by the collection of data. According to the experts of WA-S the national government as well as the provincial government are working together on initiating studies to create new models through measuring and monitoring the system. By doing so, the government tries to get a better understanding of allocating water (MIWM 2) and getting a grip on the system (WA-S 1).

The expert of WA-R explained that data have been collected on a national scope. However, as mentioned before, the regional systems are still in need of a better understanding of the water balance (WA-R 1). Therefore, additional implementation of models is needed. Furthermore, referring to the cross-over objectives of three Top sectors, there is stated that research will be conducted until 2023 in order to understand what potential consequences there are when changing the system as described before.

In addition, and in line with the vision of consuming water more efficiently, the expert of Sweco illustrates ongoing developments in techniques. By developing traditional installations, treatments, and technologies each drop of water will be used more sustainably. Nevertheless, innovating completely new technologies is unlikely (Sweco 1).

Regarding knowledge production, as said before, achieving a triple helix does not always work. While on the one hand knowledge institutes have been ignored until now (WENR 1). On the other hand, the financial structure applied by TW is perceived as unfair towards the private companies (STOWA 1). However, due to the introduction of TW small steps in the right direction are taken. According to WENR expert 1 this is promising for the future. Although implementing a triple helix system can be difficult, the Dutch water sector initiates a lot of projects together. While this might be effective, some perceive that knowledge production too often takes place in partnerships. A future step that must be taken, according to WML expert 1, is finding the balance between autonomy and synergy. The expert explains that to be able to produce knowledge, partnerships are important. Nevertheless, the individual parties have a justified need for autonomy in order to develop. All in all, the expert of WML concludes, that the lack of knowledge is not the problem. The problem is enforcement, decision-taking, and regulations.

‘Ik denk niet dat het probleem bij kennis zit maar meer bij handhaving, besluitvorming en regelgeving’ (WML 1).

However, since not all consequences of potential regulations and measures are identified, knowledge has to be produced (WA-R 1; WML 1). Besides the expert of WML, expert 2 of Deltares states that the Dutch water sector possesses a sufficient and substantive knowledge. However, the common issue in the Netherlands is the lack of decisiveness. To make an envisaged decision and potentially reach a consensus, often a rich variety of stakeholders are involved which normally takes a lot of time. According to DWPW expert 1, reaching a consensus works effectively in the Netherlands. This process is the so-called ‘Polder Model’ described as the approach in which ‘one speaks with one another until one has reached some form of agreement and all responsibilities have evaporated. Thereafter we have 'done it together' and no one can be held accountable for the outcomes, not even if these outcomes are failing policies' (ECE, 2022). The evaporation of responsibilities indicates that responsibilities and risks are spread between numerous actors involved.

Although this makes the Polder Model successful (PfW 1, MIWM 2), this approach is highly time consuming according to multiple experts (Arcadis 2; Deltares 1; Deltares 2; Invest International 1; Sweco 1). DeSaH expert 1 relates the slow functionality partly to the Water authorities. Even though the Netherlands is praised for these public entities it slows down the decision-making phase and consequently the implementation of knowledge or innovation (DeSaH 1).

The risk of utilising the Polder model is that too many problems are solved by working together with different parties. Which means, there is a lot of talking and listening without making progress (WML 1). The expert of WA-L states that at a certain point concrete agreements must be made. There is no good in trying to reach consensus in many instances. At some point the stakeholders should realise that whenever they do not follow the common vision it will have consequences.

'Op een gegeven moet je ook inderdaad komen tot concrete afspraken en concrete maatregelen. En je moet niet blijven hangen in het toch maar iedereen mee proberen te krijgen. Op een gegeven moment zal je een stap verder moeten nemen. En dan moet je denk ik ook wel zorgen dat bij alle partijen het besef is van 'ja, we gaan nu verder en als je niet meegaat, ja, dat kan wel bepaalde consequenties hebben' WA-L 1.

Referring to implementation of drip irrigation, the expert of WA-L has indicated that some farmers have implemented drip irrigation already. Nevertheless, these farmers are ahead of regulations since these are non-existing. Therefore, it is uncertain what impact the implementation has on the quality of (ground)water. Especially in the surrounding area of nature. Therefore, the expert of WA-L perceives an urgency for additional research. Besides regulations, water authorities have indicated the need for new knowledge before they are able to communicate correctly to households. The expert of WA-R states that currently, the water authority cannot give an estimation of a sufficient amount of water. Hence, knowledge and a better understanding of the system is needed.

Besides drip irrigation, throughout the interviews other issues have been mentioned regarding inflexible and non-existing regulations. In general, experts have noticed that three years of drought caused for an urgency to change policies (Sweco 1). According to expert 1 of the MIWM, inefficiencies in the system were known before, however, because of other issues drought did not have priority before. However, as the expert of DWPW illustrates, times are changing. Whereas in previous years the Dutch water sector was reactive towards the system, nowadays the sector has gained enough insights to become proactive by making attempts to improve the system. This process is called ‘learning by doing’. Knowledge and theories were prioritised in the past. Now is the time to take this into practice and see if it works.

> ‘Dat proces daar zitten we nu in. Dat noemen we lerend implementerend. Ik denk, het is nu heel erg vanuit de inhoud ingestoken, in de theorie werkt het. In de praktijk gaan we uitvinden of het werkt’ (DWPW 1).

While things are changing for the greater good, some regulations have received certain criticism by the experts. In addition to Dutch regulations, the Dutch water sector seeks adjustments in current transnational regulations as well. Both, Dutch and European regulations are strict and lack any flexibility (Arcadis 2; MIWM 2). Furthermore, Dutch regulations are not quite the same as, for instance, Belgian regulations (WML 1). Concerning Belgian regulations, the expert of WA-R criticizes the force. According to this expert, the Belgian regulation will cause environmental problems. Therefore, the WML expert advises to create partnerships on regulations, since discharged water will flow through the Netherlands.

Although these strict rules make the process of treating wastewater more difficult, technologies are available (KWR 1; WML 1). Nevertheless, implementing such technique becomes very expensive (WA-R 1). This is suggested to be one of the reasons why in the study of Boneschansker, Tietema, and Neijland (2018) two of the obstacles (1) financial bottlenecks for projects/investments, and (2) too few investments in innovation, prevent companies from successfully innovating.

Concerning the strategy discussed by the expert of WA-R regarding the addition of 100mm ground water, directives are lacking. ‘The increase water availability we would like to infiltrate water into the sandy soils, however directives are unclear’.

> ‘Als we het gewoon willen infiltreren in een zandrug dan zijn eigenlijk de kaders niet duidelijk’ (WA-R 1).

Nowadays, the provincial government is aware of lacking regulations and will develop these directives. The above-mentioned urgency of adjustments or defining regulations illustrates the reason why these techniques to improve the water system cannot be implemented yet. An additional water source is rainwater. Although it is prohibited to utilise this source of water for drinking purposes (WML 1), it can be operational for other functions (Wavin 1). Small-scale pilots have been introduced to produce knowledge and insights on this (new) source.

Another problem that needs regulation is the presence of medicinal residues and chemicals. According to the expert of WML 1 there are no standards defined for the quantities of these substances. While regulations are missing, the Dutch water sector can monitor and collect data regarding the presence of these substances (WML 1). Furthermore, the expert of STOWA indicates that purification techniques on filtering out medicinal residues are being developed.

Although technically much is possible, the main problem in the Netherlands is the increase of choices regarding the spatial planning of the country (KWR 1). This makes decision-making in the water domain even more difficult.

'The reason why the implementation of changes does not go smoothly is related to the density of the Netherlands. There are a lot of different interests for the same piece of land. There is groundwater, underground infrastructure with a pipe network with houses on top of it. A farmer seeks a low groundwater level in order to grow vegetation. Because of these interests, political decisions are made continuously. However, this has nothing to do with a lack of knowledge because the knowledge is available'.

'En waarom het niet zo snel gaat is omdat we in Nederland heel dichtbevolkt zijn en heel veel belangen stapelen op diezelfde vierkante meter grond. We hebben grondwater onder de grond zitten, we hebben ondergrondse infrastructuur met pijpleidingen zitten en dan hebben we weer huizen daarbovenop staan. De boer wil een meter daarnaast een lagere grondwaterstand want die wil aardappelen telen en dat maakt dat we in de politiek allerlei keuzes continue aan het maken zijn. Maar dat is niet een gebrek aan kennis, want die kennis zit er' (Antea Group 3).

As Antea Group expert 3 illustrates agriculture plays an important role in the spatial adaptation of the Netherlands. A critical question that should be asked, according to KWR expert 1 is: 'although salinity will increase in the coastal region of the country, is agriculture still tolerable there?'. According to Deltares expert 2 and the experts of WA-S, research has been conducted on more salt-tolerant crops (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021). This means that the demand of fresh water reduces. Besides, both experts of the MIWM link the presence of agriculture to the country's problems with nitrogen.

'At a lot of places agriculture has reached a point where technical measures and implementations are not enough to solve the current problems. Agriculture has reached is boundaries.'

'Landbouw is op veel plaatsen op een punt gekomen dat het met technische maatregelen en ingrepen niet meer te redden is. De landbouw stuit op zijn grenzen.' (Didde, 2021, p. 162).

According to WENR expert 1, the actual challenge for the Netherlands is, is to not solely analyse the water system, but tackle the problems more integrally by including other dimensions. Examples given are climate challenges, biodiversity as well as the current issue about nitrogen.

Additional domains where choices must be made are the locations of new neighbourhoods: 'is it acceptable to build houses in regions where flooding is more likely to take place? (MIWM 1), and regarding water storage: 'in order to achieve the ambition of storing more water, where can this water be stored?' (KWR 1).

In addition to the design of the Netherlands, expert 2 of Deltares states that alternative vegetation can improve the water system as well by means of decreasing evaporation (Topsector Agri & Food; Topsector Tuinbouw & Uitgangsmaterialen; Topsector Water & Maritiem; Rijksoverheid, 2021). As explained before, this is possible by implementing drop irrigation. However, types of trees can have a significant impact on groundwater levels as well. According to Deltares expert 2, deciduous trees are more environmentally friendly in terms of evaporation. Therefore, the transition from coniferous trees to deciduous trees seems to be effective.

Deciding on these choices cannot be done by the Dutch water sector only but needs a multidisciplinary approach. An example of this is the cross-sectoral document described certain objectives. Although knowledge production is ongoing it shows that working together with other domains appears to be easier nowadays since thinking in boxes is a thing of the past (MIWM 2). Nevertheless, by improving the Netherlands more holistically through involving additional actors or experts in other domains new challenges will be faced (MIWM 2; KWR 1).

International

As mentioned above, the Dutch water sector produces knowledge both in and outside of the Netherlands. This is either produced because the Dutch water sector is lacking knowledge about certain problems and potential solutions (PfW 1; TU-Delft 1), or the approach in the particular country is different which could be enriching (DWA 1). The former reason has been while referring to inexperience regarding drought. The Dutch water sector is not that familiar with certain problems of drought because eventually it will start raining again in the Netherlands. Obviously, we are dealing with drought as well, but eventually the problems will disappear due to rainfall (PfW 1).

> 'Kijk, sommige problemen van droogte die kennen wij in Nederland eigenlijk te beperkt. Omdat het dan vroeg of laat bij ons misschien toch wel weer een keer gaat regenen. We hebben natuurlijk droge periodes, maar het lost na loop van tijd zich weer op' (PfW 1).

Therefore, expert 1 of the MIWM states that it will be useful to learn from countries that are more experienced in dealing with drought. After aiming at discharging water, how can the Netherlands govern these changes? Similarly, regarding techniques, how can these be implemented and managed? Furthermore, the expert of WA-L indicates that the water authority has produced knowledge abroad to gain experience in the prevention of flooding. In addition, multiple experts have stated that learning from countries in the Mediterranean region will be helpful (MIWM 1 & 2; PfW 1; TU-Delft 1). Another country that was mentioned is Poland since its physical geography is comparable to the eastern region of the Netherlands (PfW 1).

However, after producing knowledge abroad facilities to share these new insights are missing. According to the expert of the TU-Delft, experts that had been working abroad and gained new insights were seeking to share these findings, however there was nowhere to go. Throughout the study the expert of TU-Delft conducted, Netherlands Water Partnership[2] had been mentioned as facilitator. When asking this organisation about their involvement it became clear that there was no overall learning community to share this knowledge. During the interview with the expert of Partners for Water, the expert mentioned that it would be a useful element to add to the evaluation of projects.

'In the final report a question can be included regarding the knowledge and experience gained by this expert and how this potentially can be implemented in the Netherlands. That is certainly interesting. I will discuss it'.

'Jullie hebben dit project gedaan, gericht op het buitenland en we kunnen daar misschien in de eindrapportage een korte vraag; 'zit hier ook kennis of ontwikkelingsvoordeel voor toepassing Nederland in?'. Dat is wel aardig. Dat zal ik even voorleggen' (PfW 1).

The expert of DWA described the following (and earlier mentioned) experience as useful to implement in the Dutch sector. Especially for the water authorities managing the (water) environment in the Netherlands. According to the expert, involving local communities in the process of planning and organising the water system will be useful for the water authorities in the Netherlands since the Dutch water sector is currently frenetically prioritising data controlled by the government as foundation of its water system. Therefore, the way communities are involved in other parts of the world is enriching (DWA 1).

'Mensen in het gebieden mee laten denken over de waarde van waterkwaliteit en kwantiteit in hun gebied. Dat wij dat, in onze eigen omgevingsmanagement als waterschap heel goed kunnen gebruiken. En wij gaan daar veel krampachtiger mee om, 'ja, data, data, moet je de overheid laten doen. Dat mag niet geregeld worden met burgers. Maar die hele manier van denken is daar heel anders en dat is eigenlijk een verrijking voor de waterschappen in Nederland' (DWA 1).

Besides receiving knowledge or gaining experiences abroad, the Dutch water sector shares knowledge and contributes to the improvement of a country's water system as well. As mentioned earlier by numerous experts, the Dutch water sector can contribute to the improvement of water security worldwide in some way. Nevertheless, experts have indicated that often Dutch parties are solely involved in the preface of projects due to missing links in the Dutch supply chain. To improve and increase (long-term) impact, a potential strategy has been discussed. According to Arcadis expert 1 (and Chairman International of TW), there is a need to interconnect all chains. Especially in a later stage between knowledge institutes and consultancies to create a clear moment of transferring knowledge. That is why progress falls apart after research is conducted while eventually it must be rebuilt by the Dutch water sector. Hence, connecting these chains will solve this problem.

'Als we er beter in slagen de schakels van de keten aan elkaar te knopen dat we dan heel erg veel kunnen verbeteren. Ik denk iets meer in de latere fases, maar ik denk vooral tussen onderzoeksinstellingen en de adviesbureaus, waar eigenlijk nu geen duidelijk overdrachtsmoment is. Het valt in mekaar na het onderzoek en

[2] The Netherlands Water Partnerships has been contacted multiple times to participate in this study. Unfortunately, an interview has not taken place.

daarna moeten we als Nederlandse sector weer de boel opbouwen terwijl we dat eigenlijk makkelijk aan elkaar hadden kunnen verbinden' (Arcadis 1).

In addition to connecting the chain more closely, Arcadis expert 1 illustrates another strategy that might increase the likelihood of contributing to a later stage in an international project. Prior to an international trade mission, a potential coalition has been created by TW. This coalition consists of a university, consultancy firm, and suppliers of certain products, including the support by an embassy. In this way the coalition is responsible for the functionality, however, by sending such a coalition, particular conditions can be discussed already. By doing so, another issue of improvement can be tackled, namely, making clearer agreements between the two countries and its parties involved. At this point clear agreements are missing as well as statements who is responsible for which part of the project (Royal HaskoningDHV 1). Therefore, discussion agreements prior to the project might help. By illustrating the above, the performance internationally is depending on the initiatives by the government. Wavin expert 1 and Invest International expert 1 state that the government should take the leading role more often regarding international projects.

Besides new trade missions, Arcadis expert 1 illustrates the importance of continuity in the approach to improve the water systems abroad. The Dutch water sector should be committed to projects for a long-term, like a decade.

'Ik denk wat belangrijk is de continuïteit in landen aanpak, dat je dus niet van de één op het andere jaar stop, maar dat je een soort commitment aangaat van 10 jaar bijvoorbeeld' (Arcadis 1).

Apart from improvements that can potentially lead to a better contribution to the improvement of a water system abroad, the approach to contribute can be adjusted as well. According to the expert of Wavin software systems will be developed more. Instead of short-term projects, the country prioritises long-term projects nowadays. However, the expert of Royal HaskoningDHV argues that the involvement of local knowledge and expertise will become even more important in the future. The main reason for the importance of local knowledge is to adjust the implementation to their expertise. In this way the Dutch water sector can contribute substantially to the improvement of a water system in a sustainable way (Wavin 1). By doing so, the NIWA appears to be achievable. Nevertheless, a solution to the lack of distributing the objectives inherent to the NIWA is not given.

Gaining local knowledge appears to be done through two slightly separated approaches. While some companies work together with local offices, other companies have started offices and place employees in certain countries temporarily to participate. According to TU-Delft expert's own observations additional value of Dutch experts residing in the specific country for a longer period has been noticed. However, throughout the project involvement of local offices is sought. This approach is similar to the one of Deltares and Royal HaskoningDHV. Both companies have international offices. According to

Royal Haskoning expert 1, the country has around 50 offices worldwide with a significant difference in size depending on the country. On the contrary, according to Diercks, et al., (2018) Deltares does not aim at opening many offices worldwide.

‘Deltares is reluctant on opening offices or R&D-facilities permanently abroad. The organisation recognises the added value of local participation but combines their expertise primarily with the placement of employees in the particular country temporarily.’

‘Deltares is terughoudend met het openen van permanent vestigingen or R&D-faciliteiten in het buitenland. De organisatie erkent het belang van lokale aanwezigheid, maar vult dit voornamelijk in door tijdelijke plaatsing van werknemers in het buitenland’ (Diercks, Koens, Diederen, & Faasse, 2018, p. 49).

Arcadis expert 1 criticises this approach. By placing Dutch experts in another context for several years, ‘as sector we should think about this approach, is this the model we want to keep implementing?’

‘Nederlanders die zoveel jaar daar woont. Daar moeten we wel over nadenken, is dat nou het model wat we willen houden?’ (Arcadis 1).

The main reason for questioning the approach of Dutch employees stationed abroad, has to do with the goal of reducing the contribution by the Dutch water sector. Eventually, the communities should become more knowledgeable about their own water system. By working together and educating local communities, instead of placing experts, this progress will be more effective. Eventually, the aim is to run projects successfully only by locals. The only contribution the Netherlands has is by pro-actively thinking along.

4.6.1 Conclusion

All in all, the Dutch water sector has proposed a wide range of steps that will be undertaken from now into the future. To improve the Dutch water system and achieve water security certain strategies are chosen to be implemented. However, new knowledge and a better understanding of the system is needed. Although some difficulties in implementing a triple helix structure were noticed, the introduction of TW seems to be effective. Nevertheless, a balance between synergy and autonomy should be found. By doing so, individual development of stakeholders can be fostered. Regarding the necessary knowledge, it appears to be merely about additional and regional data. By collecting extra data, the governmental entities can communicate correctly towards households, industries, and agriculture. These different functions have to become aware of the critical situation and change their behaviour in water consumption. Nevertheless, regulations are needed. Therefore, the government should define regulations and act more strongly. On the contrary, according to water authorities and other stakeholders in the Dutch water sector, the government should adjust certain regulations due to inflexibilities. By doing so, innovations will be easier implemented more easily and will be cheaper.

Although the Netherlands is changing their policies, decisions are made slowly. Therefore, it takes a long time before produced knowledge is put into practice. This must become quicker, however, the slow process illustrates the little urgency there is. Nevertheless, the country needs clear decisions on a wider spectrum than only water management. Due to density issues, efficient spatial planning seems to be an important theme in the Netherlands.

Although the aim to create a water secure system might not be that urgent, experts have indicated that learning in and with other countries will be helpful. Especially regarding the prevention of drought. Nevertheless, whenever knowledge is produced or experiences have been gained, sharing these new insights is difficult since facilities to do so are lacking, but will be developed by a governmental institution.

Besides gaining insights, the main goal of the stakeholders of Dutch water sector that are internationally active is to contribute to the improvement of the water system. To do so, and to increase impact, the Netherlands should organise their supply chain more effectively. In addition, it seems to be important to focus on the involvement of local communities while trying to improve the water system. Through the inclusion of communities their understanding of the system will increase which will make improvement more sustainable. This illustrates the effectiveness of participation by locals. Nevertheless, throughout these projects, the aim defined in the NIWA does not seem to be distributed. Furthermore, the Dutch sector should decide what approach it seeks to apply internationally. In general, to approaches can be used. One is the involvement of locals, however, the projects are primarily operated by Dutch experts stationed temporarily in the specific country. The other is leaving locals in charge. The Dutch experts are only present to facilitate implementations and think along throughout the process.

5

CONCLUSIONS

5. Conclusion

In this chapter the main findings of primary qualitative research are combined with general literature and theories demonstrated in the second chapter of this study. By doing so, each research question can be resolved. The conclusion of these research questions will eventually contribute to answering the main research question: *'How can the Netherlands contribute to the improvement of water security worldwide in order to fulfil the Dutch International Water Ambition?'*

5.1 How does the Dutch water sector define water security?

Although the term water security is stated in an official document by the Dutch government defining a national ambition, it is not commonly used in the Dutch water sector (read subsequent paragraph for explanation). Nevertheless, water experts have defined the term themselves. By doing so, certain components have been observed as to what water security consists of. According to Zehnder, et al (2003), water consumption can be divided into four categories. Three of these have been detected: (1) water for people, services, and industries, (2) water for agriculture, and (3) water for nature. Those functions have either been used individually or combined by most of the experts. Water for people was mentioned mostly individually. Doing so, it relates to the first (quantity and availability of water) and third perspective (human needs), defined by Cook and Bakker (2012). However, elements such as health and welfare – included in the definition of Cook and Bakker (2012) - were not defined precisely by the experts. Though, some mentioned the importance of clean and safe water when referring to an international scope.

Overall, the fourth dimension, defined by Cook and Bakker (2012) as 'sustainable' is comparable to the most definitions received by the experts. Nevertheless, the definition of Cook and Bakker (2012) only contains the short-term situation. Experts in the Dutch water sector have indicated the importance of analysing the water system in the long run. Additionally, Cook and Bakker (2012) have illustrated that defining water security can differ depending on the geographic position. This has been noticed throughout the study as well. Concerning the Dutch context, most experts focused on drinking water. This means that, the definition considered and defined in *chapter 2* is comparable. However, due to the fact that drinking water has been specifically mentioned numerous times the definition will be adjusted.

To conclude, in general the Dutch water sector defines water security as: *the moment water quantity and quality are sufficient to make sure clean and safe (drinking) water is disturbed and received by households, industries, agriculture, and nature in the short and long run.*

5.2 How is the Dutch water sector trying to accomplish water security?

As concluded in the previous paragraph the Dutch water sector does not use water security often. Although this seems contradictory, some experts have explained why. Since the term water security implies a certain form of assurance, governmental entities are not in favour of this phrase since it cannot be guaranteed at the moment. Accomplishing water security seems to be a difficult challenge. Especially with climatological changes and their additional repercussions. Nonetheless, the sector appears to have a clear vision on how to improve the current system in order to accomplish water security.

As Ritzema and Loon-Steensma (2018) have stated, the country will focus on storing water (instead of discharging). However, as the Netherlands is a densely populated country, underground storage seems to be most efficient. This means that water level management and soil protection are important specialities to be taken into account. Besides, efficient water consumption by households, industries and agriculture is seen as another strategy. Regarding agriculture, drop irrigation is mentioned as an effective technique to implement. These strategies seem to be more in line with water demand management.

Furthermore, adding extra water into the system seems effective to improve the balance between demand and supply. Especially for the Dutch regions where a natural flow of water is absent, such as the eastern part of the country. By adding more water to the groundwater levels, it will be more likely to meet the demand.

Other techniques such as wastewater recycling and water desalination, have been considered and are applied on a small-scale on a small-scale. While the Dutch water sector is capable of treating water sufficiently, as Dolnicar and Schäfer (2019) stated, social acceptance is confirmed to be an issue. Nonetheless, experts have stated that an additional source for drinking water is not needed due to a lack of urgency. Therefore, it can be used for other purposes.

This lack of urgency is observed in regard to water desalination as well. Even though the Netherlands is able to implement a water desalination plant, the construction and operationalisation of such a plant is costly, as stated by Darre and Toor (2018). Numerous experts have stated that since urgency is lacking, these plants are currently not perceived as an added value. The statement of Dolnicar and Shäfer (2009) regarding the higher acceptance of consuming water treated by a desalination plant than a treatment plant cannot be confirmed.

While the implementation of water desalination and wastewater recycling seem to be an effective solution to achieve the basic human right to realise accessibility to safe and clean water for everyone.

Nevertheless, according to both literature and expert interviews, some are hesitant. These The main reason is the possibility to engineer an infinite water source. By closing the loop by wastewater recycling or using sea water which is 97% of the earth's water (Bundschuh, Kaczmarczyk, Ghaffour, & Tomaszweska, 2021), behaviour and perceptions on water will change negatively. Nevertheless, like Voulvoulis (2015; 2018), some experts mention the added value of such an artifical water source since additional water can be implemented into the water system. Therefore, treated water from a general treatment or desalination treatment plant can be utilised directly and indirectly by the Dutch functions.

Overall, as Voulvoulis (2018) argues to be most effective, the Dutch water sector combines certain techniques into the water system trying to accomplish water security. Nevertheless, the scale of these techniques differs heavily in operationalisation. Besides, the three strategies mentioned in literature regarding water supply management, the Dutch water sector aims at adding more water into the system through groundwater infiltration. This should improve the water balance too. Nevertheless, besides supply, demand management should support changes as well to consume water more efficiently. This confirms the statement by Nazemi and Wheater (2015) regarding the integration of both supply and demand management.

5.3 What knowledge does the Dutch water sector possesses on water security?

Although not all strategies discussed in scientific literature are implemented in the Dutch system, it does not mean that knowledge is absent. According to most of the experts the Dutch sector possesses a wide range of knowledge since the Dutch system is characterised by a continuous development. Therefore, the system is defined as complex and hard to adjust. Furthermore, as Krozer, et al., (2010) have stated, only a few innovations in the sector are noticed. According to some experts this is mainly the case for drinking water. Since the quality of drinking water in the Netherlands is defined as 'impeccable', it is difficult to innovate and initiate new techniques. Hence, the sector continues development on basis of an old system.

Besides, the Dutch water sector possesses useful knowledge in techniques as well as data collection. According to the experts, the Dutch sector is leading in analysing and subsequently implementing data into the water system. Through models, these data can be included which in turn helps understanding the water system. With these models, consequences of potential measures taken can be calculated. Although these calculations can be perceived as difficult and complex, some experts, working on and with these models, indicate that it is no rocket science. This relates to what Lundvall (2007) has defined as tacit knowledge. Through education and habits this knowledge becomes 'embodied in people and embedded in organizations' (Lundvall, 2007). Analysing the types of knowledge possessed by the Dutch water sector all three types (expert knowledge, bureaucratic knowledge, and stakeholder knowledge) defined by Edelenbos, et al., (2011) were detected.

Overall, according to the experts, the Dutch water sector possesses enough knowledge on water security to understand what improvements are needed to create a water secure system. Nevertheless, technical, and digital (hardware) knowledge seems to be prioritised over the organisational experiences regarding the implementation of this knowledge (software).

5.4 How is the Dutch water sector producing knowledge on water security?

Although some experts have mentioned the aim at working in the 'Golden Triangle', others – including grey literature – illustrate the ambition to "break through" this linear and traditional way of knowledge production. Nevertheless, primary research and secondary research illustrate that in practice this does not always work. Although Cai and Etzokowitz (2020) state that universities and knowledge institutes have a crucial role in a triple helix system, according to multiple experts, these are the parties often ignored during knowledge production. This has to do with the fact that traditional and more simplistic solutions are preferred.

Following the concept of an innovation system by Bergek, et al., (2008), 'a ground of components' works together and can have different forms but will have a common goal or objective'. This appears to be difficult when working with a knowledge institute or university. Especially the short-term goals appear to differ heavily due to individual added values and urgency to commercialisation. In the long run this seems to be less the issue due to the collective commitment to improve problems or inefficiencies in the water system.

The exclusion of knowledge institutes is contradiction to literature regarding water management stating that it was the inclusion of private companies that was perceived as advanced (Edelenbos, Buuren, & Schie, 2011). By analysing the findings, development of innovation appears to be related more strongly to general literature about triple helix systems, than to literature specific on joint knowledge production in the domain of water (Edelenbos, et al., 2011). Furthermore, financial incentives to take part into a triple helix system seems unequal between knowledge institutes and private companies.

Regarding the water suppliers, their development is in line with the framework Edelenbosh, et al., (2011). Whenever knowledge is needed, the supplier will reach out to universities and knowledge institutes. Whenever, more technical issues occur private stakeholders - nationally as well as regionally active – become involved. This illustrates somewhat parallel developments instead of a combining development including the types of knowledge marked by Edelenbos, et al., (2011) as expert knowledge, bureaucratic knowledge, and stakeholder knowledge. The loop, and sharing this knowledge continuously seems missing since existing knowledge is not shared or possessed by the stakeholders in most need of this. This demonstrates a mismatch in the possession of expert knowledge, bureaucratic knowledge, and stakeholder knowledge.

Referring to Deltares, the technology push and eventually the market pull (in other words Linear Model of Innovation) have detected (Godin, 2006; Kline & Rosenberg, 1986). Collecting and analysing data together with universities creates new models. Afterwards, these are shared with private companies throughout the sector. By doing so, feedback can be given, and the workability can be tested. After trials these models are sold internationally. As Kline and Rosenberg (1986) have stated, feedback is an important element in the development of innovations. This means that stakeholders and expert knowledge are produced (Edelenbos, et al., 2011) which leads to different forms of innovation. Even though it is profitable for Deltares to improve their services by receiving feedback from different companies, the company is obliged to do so by the Dutch government anyway. Being one of the RTO's in the Netherlands, Deltares must share knowledge throughout the water sector to improve the environment. This proves that knowledge possessed by universities and knowledge institutes is important for 'social and ecological sustainability' (Lundvall, 2007).

The above-mentioned situation regarding Deltares, illustrates the operationalisation of the statist model defined by Cai and Etzokowitz (2020). In this type of triple helix, the government takes 'the lead in developing projects and providing the resources for new initiatives' (Cai & Etzokowitz, 2020). Besides the national government (in this case), regional governments (water authorities, provinces, and municipalities) actively initiate projects as well, as described by Leydesdorff & Etzokowitz (1998).

As to international projects, the sector seeks a similar role of the government, thus a statist model. Nevertheless, this is not the case as described by certain experts. Therefore, throughout international projects each stakeholder seems to have a more equal role. This is defined as the laissez-faire model, according to Cai and Etzokowitz (2020). Concerning international projects, the Dutch water sector produces knowledge in different contexts as well. Due to partnerships with local communities, new knowledge is produced. Often these insights are related to software systems.

Although the triple helix system does not function effectively (yet), the government has an active role in initiating projects domestically as well as regionally. The introduction of TW has improved partnerships. Nevertheless, since the Dutch water sector possesses a lot of knowledge, multiple approaches can be implemented to solve problems. While this seems something of a luxury, it can cause knowledge dispersion. Furthermore, requiring partnerships does not (always) seem to be the answer to produce knowledge. As described by one of the experts, as well as by Lundvall (2007), a certain level of autonomy is needed in order to foster individually. Therefore, a balance should be found.

Besides the evaluation of the intensity of partnerships, the stakeholders involved are criticised as well. Some experts have indicated the importance of involving a larger variety of stakeholders, including the agricultural sector as well as citizens to receive new insights.

To conclude, the Dutch water sector aims at producing knowledge in a triple helix structure. Whenever a triple helix system is utilised, this is in line with the statist and/or laissez-faire model. Through governmental initiatives the sector has gained a lot of knowledge and experiences. Furthermore, through developments over the past centuries the system has become complex and difficult to adjust. By continuously developing the system technical experience has been gained. However, the government might focus on partnerships too much. By balancing autonomy and synergy, the individual stakeholders in the Dutch water sector will foster. Nevertheless, since the triple helix system is often incomplete due to absence of universities, knowledge institutes and private companies, and other suggested actors, the knowledge production does not seem to perform to its full potential.

5.5 How is the Dutch water sector currently trying to contribute to water security worldwide?

While knowledge has been produced internationally, the main goal of the Dutch water sector is to contribute to the improvement of the water system in other parts of the world. Regarding these projects, these differ in location, duration, size, and goal. Although this might seem logical, experts have illustrated the incoherent approach of certain Ministries. Since different goals and priorities have been defined, programmes operate alongside which influences the process of innovation negatively. (Bergek, et al., 2008). Furthermore, it affects the efficiency and effectiveness of Dutch fundings as well. Additionally, the objectives defined in the NIWA should be distributed more clearly throughout the Dutch water sector.

Nevertheless, lacking experiences abroad is not the issue. According to multiple experts, the Dutch water sector has a long history in international partnerships. Besides their technological and digital knowledge, the sector understands the importance of local context and knowledge. Therefore, the sector strives to work together with local communities. Nevertheless, while some companies place Dutch employees abroad to work with local communities, other companies are hiring local offices to include local knowledge. Furthermore, because of experiences, the Dutch water sector is aware of local cultures and potential sensitivities. Additionally, the Dutch sector seeks educational projects to educate communities. By doing this, implementations proposed by the Dutch water sector will be sustainable since the local communities are able to maintain them. Eventually this should lead to a smaller contribution by the Dutch water sector. Although all these experiences seem to be positive and add value to the Dutch position in the international competition, the approach and inclusion of multiple actors can be perceived as complex and slow. Therefore, other countries have been more likely to be contracted for certain projects since critical questions have not been asked.

All in all, the Dutch sector tries to contribute to water security worldwide by sharing knowledge on technologies, stakeholder participation and information system management. Furthermore, through educating local communities, a more sustainable approach is applied since a better understanding of the water system is sought. Although this is in line with the NIWA, there is a lack of distributing this objective. Lastly, through funding, the Dutch water sector supports improvements in the water system financially. Nevertheless, through more coherent policies between different public bodies, the contribution can be improved.

5.6 What future steps is the Dutch water sector planning to take in order to improve water security worldwide?

In the previous paragraphs certain improvements in the current system or functionality of the sector have been found. Regarding the improvements in the Netherlands itself, the most important one seems to be a quicker decision-making process. Although new knowledge is needed to make certain future decisions, knowledge production is not the issue. Apparently, the main issue is the lack of decision-taking and the lack of implementations. While knowledge is present, decisions based on knowledge are taken slowly, as well as practical implementations. Although times seem to be changing, even after three periods of drought, urgency to make quick changes seems too weak. This is comparable to the situation in Australia, defined by Bichai, et al., (2018), and Wen and Montalvo (2018). Nevertheless, the Dutch water sector is aiming at "learning by doing". In this way the knowledge possessed by the Dutch water sector will be put into practice. Concerning the decision-taking process, regulations regarding water need certain adjustments, or must be defined.

Although there is a low level of urgency, the government aims at creating awareness of the problematic situation among industries, farmers as well as households. Communication methods have been analysed. Nevertheless, additional knowledge is needed to educate these above-mentioned actors and to communicate the correct and complete story. By doing so, changes in consumption behaviour are sought. To be effective and achieve a more efficient water system, the government should imply regulations concerning consumption.

In secondary data only the actors included in the triple helix have been mentioned. Nevertheless, some have argued that other actors should be included as well. For instance, the farmers or households. By doing so, breaking through the traditional way of knowledge production and policymaking (Blue Route) can be achieved. This illustrates that the triple helix will become out-dated in the domain of water management.

All in all, the government is seen as an important stakeholder in initiating future steps both nationally and internationally. Regarding the contribution abroad, the Dutch water sector is aiming to improve its supply chain. By working together more closely with, especially knowledge institutes and consultancy firms, the Dutch water sector should be able to have more impact internationally. Besides the functionality of the sector, the approach applied by the sector will be improved as well. In the future, local knowledge will be used even more to improve the sustainability of the project and reduce the contribution by the Dutch water sector.

Referring to knowledge production, experts have suggested working together with other countries with a historic urgency to prevent their environment against drought. By working together and gaining experiences, the Dutch water sector can accomplish a more efficient water system.

To conclude, the government will take multiple future steps in order to improve the Dutch water system as well as the functionality of the Dutch water sector. Through initiating new partnerships nationally and internationally and improving the connections in the Dutch supply chain, new knowledge can be produced regarding the (regional) water system(s), regulations, and structural developments.

5.7 Main conclusion

The objective of this study is to answer the main research question. By combining primary and secondary data the above-mentioned research questions have been concluded. These conclusions contribute to give answer to the question: *'How can the Netherlands contribute to the improvement of water security worldwide in order to fulfil the Netherlands International Water Ambition?'*

Although qualitative research has resulted in an overall definition of water security, the term itself lacks popularity. The reason is the implicit assurance of water at each point in time which cannot be guaranteed by the Dutch water sector. This illustrates why the system has received criticism. While this criticism is correct and logical, according to experts, the Dutch water sector illustrates that a wide range of knowledge is possessed due to the development of an old water system. Therefore, it is not perceived as the Netherlands is structurally lacking knowledge. Furthermore, the Dutch education level in the domain of water is perceived as advanced and technical. Nevertheless, the Dutch water sector understands that knowledge and experiences regarding software systems are necessary too. While a triple helix has been sought, according to primary and secondary data, the sector is suggested to go beyond the triple helix and include actors such as farmers and/or households. By doing so, the Dutch water sector becomes multidisciplinary which can result in a coherent problem solving between different domains. Nevertheless, applying the triple helix system does not seem to be as effective as possible due to inequal financial structures as well as the exclusion of knowledge institutes.

Moreover, to solve problems, practical experience is needed. Nevertheless, this is perceived to be missing in the Dutch water sector. This means that, while knowledge is possessed by the Dutch water sector, it has not been implemented, resulting in the current inefficient water system. Although a lot of knowledge has been produced in the past, implementations and decision-making processes are known to be slow. While certain reasons are given, such as the need for additional knowledge or the need for new regulations, the lack of implementation results criticism.

In conclusion, even though, the Dutch water sector has to improve multiple issues in its system as well as in its functionality. This demonstrates the reason why criticism has been given. Nevertheless, the sector seems capable of contributing to the improvement of water security worldwide. A lot of technical and digital knowledge is embedded in the sector which can help countries elsewhere. Moreover, the Netherlands appears to be leading in analysing data as well as treating water. Therefore, the Dutch water sector is able to improve water systems in other countries. Aiming at longitudinal projects and including local knowledge means that the contribution will be more contextual. Furthermore, through the education of local communities and the focus on software systems, the Dutch contribution is definitely of use to improve water security worldwide. This means that, the Dutch water sector is able in some way to achieve the NIWA.

6

DISCUSSION & REFLECTION

6. Discussion & reflections

In order to answer the research questions, qualitative research has been conducted. Although research on joint knowledge production is often done through quantitative research, in this study a better understanding on the functionality of the Dutch water sector and how knowledge is produced was needed. Therefore, qualitative research seemed to be more applicable. After analysing numerous theories semi-structured interviews were created. Overall, 27 experts have been interviewed representing all three sectors of the Water-technology domain in the Netherlands prioritising the field of water supply management. Therefore, by utilising semi-structured interviews and interviewing the same or comparable stakeholders within the Dutch water sector, a recurrence will result in similar results regarding knowledge production and the functionality of the Dutch water sector.

Analysing the results has shown that knowledge production does not seem to be the issue. While knowledge about potential improvements in the water sector is present, the lack of decisiveness and practical experience seem to be the bigger issue. Reasons given for the slow decision-making processes have been mentioned and are quite surprising. Apparently, urgency is lacking which was unexpected based on literature. Although in 2018, 2019 and 2020 the sector has been dealing with periods of drought, and inefficiencies in the water system have become visible, the urgency to quickly adjust the system is perceived as little.

A possible explanation for this, was explained by numerous experts namely, sooner or later it will rain. Furthermore, the Netherlands is located in a delta meaning that there is a lot of water in the country and underneath its surface. Since the Dutch water sector utilises advanced techniques to treat water, the quality of groundwater and surface water is not crucial. This means that each type of water can be used which affects the urgency for additional or new water sources. Furthermore, throughout the study local parties have not been included. Actors interviewed that manage the smallest scope are the water authorities. Since context differs heavily within the Netherlands, only a small number of local examples have been received. By including other and more local orientated public bodies, the level of urgency to change the system might have been different.

Reflecting on the methodological choses made throughout this research, an equal representation of each sector is somewhat lacking. As demonstrated in *appendix B*, only one water supplier participated in this study. Furthermore, a wider variety of knowledge institutes would have increased the validity. Nevertheless, interviewing 27 experts, defined according to Audenhove and Donders (2019), a representational image of the Dutch water sector has been gained.

Concerning new water sources illustrates the focus on water supply management. Consequently, water demand management has been excluded from this study. The main reason to prioritise supply management was to illustrate what problems the Netherlands is facing due to a potential decrease in supply and a structural increase in demand. Although new sources such as water desalination and wastewater treatment are not implemented on a large-scale yet. Water storing and using water more efficiently, are the two strategies selected. The latter is in line with water demand management. Therefore, except some examples and knowledge gaps, further statements regarding consuming water more efficiently have been left out.

In line with this is the absence of municipalities and developers, though some experts mentioned the importance of these two stakeholders. The reason to the exclusion is the fact that these are more relatable to water demand management. Both actors were stated in the context of stimulating behavioural changes on a municipal level. While the government could define certain regulations, developers of construction projects should be more aware of new technological possibilities to reduce water consumption. A follow-up study regarding this topic on the water demand aspect seems to be useful.

Therefore, follow-up research is advised. This can be done by conducting a comparable study on this one, with the inclusion of municipality and developers. Awareness of the current water issues can be tested as well as what their precautions are to reduce water consumption. Do these actors feel the urgency to adjust? What possible regulations or incentives can be applied to create awareness by households and engineers to decline water demand? These kinds of research questions can be defined as foundation for qualitative research on the Dutch water sector specialised in water technology in the field of water demand management.

Furthermore, during this study a governmental programme was initiated: the so-called Delta-programme Fresh Water in which the Dutch water sector proposes certain action points and knowledge gaps that have to be dealt with. Another potential follow-up research is to compare this study and its actions points with the points of the development defined in this Delta-programme, this programme is a combination of supply and demand management. Therefore, the categorisation defined in the third chapter should be used.

Finally, throughout this study other potential research areas have been detected. These are:

- Financial/jurisdictional research on the right of having access to clean and safe water and sanitation. Although multiple experts have mentioned that drinking water – due to a certain standard – can be seen as assurance, a Dutch judge has declared that the right to have access to water is not absolute (Soudagar, 2022). What does this mean for Dutch households who cannot afford to pay their water bills?

- Financial/organisational research on the governmental goals, objectives, and priorities regarding the NIWA. By doing so, a coherence between different Ministries can be found. Furthermore, the criteria for fund certain projects need to be analysed and defined more strictly to fund projects abroad more efficiently and more effectively.

- Organisational/ economic research on a clearer categorisation of the Dutch water sector. Although some research institutes have tried to create distinctions between subsectors in the water domain, this has not been effective since clear distinctions as well as economic data regarding the performance of the sector is still lacking. Therefore, data demonstrated in *chapter 2* is outdated.

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