The influence of RWS's innovation strategy in the water and subsurface sector

A qualitative research approach

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TU Delft Master Thesis

The influence of RWS's innovation strategy in the water and subsurface sector

A qualitative research approach

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Preface and acknowledgements

Writing this master's thesis marks the end of years of studying. After studying Chemical Engineering for four years at the Rotterdam University of Applied Sciences, I decided to take on one final academic challenge. I was determined to apply my practical knowledge from a management perspective, aiming to bridge the gap between technical experts and managers. This journey began during my minor in Project and Program Management at the Rotterdam University of Applied Sciences and led me, through the pre-master's program, to the Management of Technology program at TU Delft. Despite the challenges of the pre-master, including studying from home due to COVID, and the significant transition from Dutch to English education, I can say at the end of this journey that it has all been worth it.

During my master's, I had the opportunity to explore various topics, from PostNL's strategy to the ethical issues surrounding nuclear energy. These projects often involved collaboration with fellow students from diverse backgrounds, which has been incredibly valuable in learning how to work in multidisciplinary teams. My broad interest in different technical contexts eventually led me to apply for a graduation position at Deltares. I wanted to immerse myself in an unfamiliar field one last time to apply the management techniques I had learned. I am extremely grateful for the opportunity to graduate at Deltares. Firstly, because I wanted to end my studies with a final practical, work-related experience to familiarize myself with a new sector and orient myself for the job market. It was not always easy since understanding the water and subsurface sector and its key stakeholders required considerable time and effort, but I can proudly say that this graduation period allowed me to discover a sector that I grew more interested in week by week.

First and foremost, I would like to thank my supervisors who made it possible for me to graduate. My thanks go to Heleen Vreugdenhil for the pleasant weekly meetings and her assistance with the literature review in the early stages of my graduation, as well as with the documentation of my thesis. I would also like to thank Nick Leung, particularly for the crucial help during the scoping of my research, for the introductions at Deltares and with staff from Deltares and Rijkswaterstaat, and for the informal yet constructive weekly catch-up sessions in Utrecht and Delft. My thanks also go to Linda Kamp, my second supervisor, for her sincere advice and critical feedback that helped elevate my thesis. Her punctuality, in particular, kept me focused throughout my graduation. Further thanks to Jill Slinger as the chair of the graduation committee for her enthusiasm and positivity during the graduation meetings, the pleasant conversations after those meetings, and the extensive feedback during my graduation. In particular, I would like to mention the meetings with the committee, which I found very useful and through which I could continue working on my thesis with enthusiasm and sufficient feedback each period.

In addition, I would like to thank the interviewees from Deltares, Rijkswaterstaat, and Royal BAM Group for their valuable time and openness during the interviews. The fact that I was helped so quickly and easily in finding interviewees was immensely helpful. I hope this thesis will be valuable and familiar to you as well. Finally, thanks to my colleagues at Deltares for the great collaboration and interesting conversations, and to the other graduates at Deltares for the enjoyable lunches and many cups of coffee. Now, it only remains for me to wish you much reading pleasure with my thesis on the influence of Rijkswaterstaat's innovation strategy in the water and subsurface sector.

Roan 't Mannetje
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Middelharnis

Summary

Many challenges related to climate change are emerging worldwide, underscoring the need for locally or regionally accepted strategies to address these issues. This is particularly true in the water and subsurface sector, where Rijkswaterstaat (RWS), as the operationally responsible public organization, faces the impacts of climate change and must prepare the Netherlands for future challenges. Innovations are essential, but the innovation process itself faces many challenges. It is RWS's task to set sector-wide goals through an innovation strategy and to collaborate in stimulating innovations.

The challenge in innovation strategies lies in bridging the gap between strategic goals and their operationalization, creating a tactical level that outlines the actions needed to achieve these goals. For a public organization like RWS, the innovation strategy is influenced by factors such as the nature of innovation, the characteristics of the public sector, stakeholder dynamics in the water and subsurface sector, and government policy processes. These elements play a role in determining the innovation strategy, which aims to positively impact resource allocation, internal and external collaboration, and the development and diffusion of innovations.

This study seeks to assess the influence of RWS's current innovation strategy on innovation processes in the water and subsurface sector through qualitative research, using semi-structured interviews with participants from RWS and Deltares with diverse backgrounds. It first explores RWS's innovation strategy and describes its development, considering internal and external factors influencing RWS's innovation strategy. The study then evaluates the potential effects of the strategy to determine its influence in the sector. Finally, recommendations are made to enhance the influence of the innovation strategy. The main research question is: '*What influence does Rijkswaterstaat's innovation strategy have on innovation processes in the water and subsurface sector?*'

The theoretical background forms the foundation for the conceptual framework, as shown in figure A. Key factors influencing RWS's innovation strategy and its development include innovation characteristics, public sector characteristics, stakeholder dynamics in the water and subsurface sector, and the governmental policymaking process. An effective strategy integrates a strategic level with long-term goals, an operational level with implementation plans, and a crucial tactical level that bridges the two by addressing what should be done to achieve those strategic goals. By aligning strategic objectives with actionable plans and leveraging resource allocation and collaboration, RWS can effectively address the sector's challenges and needs, facilitating tailored innovations that enhance the water and subsurface sector. RWS's innovation strategy intends to influence resource allocation, internal and external collaboration, and innovation development and diffusion.

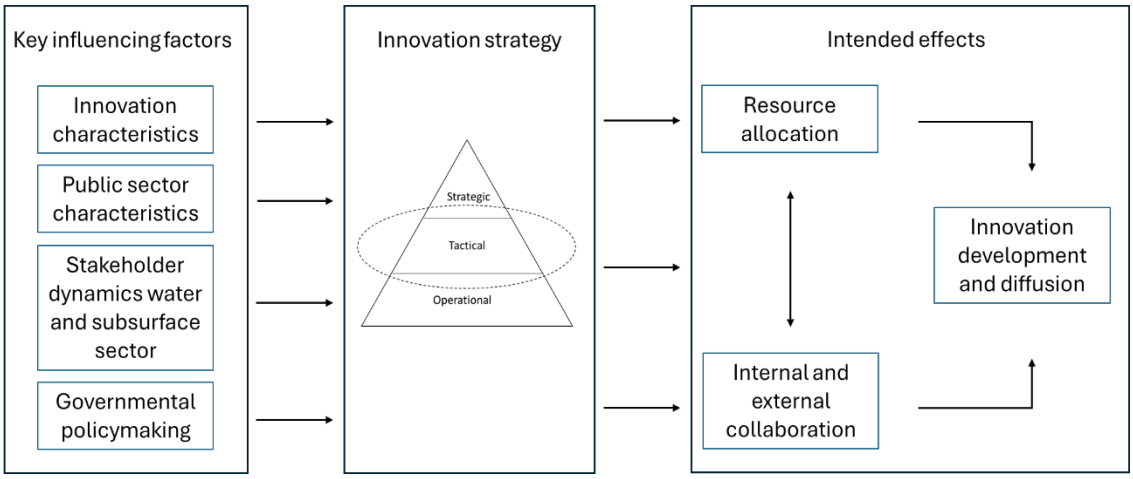

Figure A: Conceptual framework

RWS's innovation agenda 2030 is designed around key themes from Kompas I&W and Kompas RWS, including Replacement and Renovation, Sustainable Infrastructure, Climate Adaptation, Smart Mobility, and Data and Information Provision. These themes guide resource allocation and accountability, linking strategic goals with their practical implementation. The agenda aims to address RWS's challenges, facilitate dialogue with partners, and support innovation through tools like the Innovate, Standardize, Produce (IUP) Guide and the Stakeholder Readiness Level (SRL) tool. By focusing on targeted resource allocation, accelerating innovation, and enhancing collaboration, the strategy seeks to drive sector-wide innovation and underscore the urgency of addressing emerging needs.

The development of the Innovation Agenda 2030 began with a comprehensive evaluation of its predecessor, which revealed the need for a more focused and implementable strategy. This led to multiple consultations with key partners and the creation of the initial version of the agenda, which was later updated to include Climate Adaptation as a new focus. The agenda aims to improve internal and external awareness to enhance its practical impact, foster collaboration within RWS and with external stakeholders, and serve as a dynamic document with a planned midterm review in 2025. Internal factors, including RWS's focal points and organizational structure, as well as external factors like stakeholder input and political uncertainty, shaped the strategy, ensuring its alignment with sector needs and priorities.

In practice, the influence of RWS's innovation strategy is most apparent in the allocation of resources. The focal points are used to justify the distribution of budgets, time, and capacity, making it more challenging to pursue innovations that fall outside these areas. This guiding influence is also evident externally, where the focal points provide direction to partners and help them align their contributions with RWS's priorities. While the strategy has undoubtedly improved resource allocation, its impact on fostering collaboration and accelerating innovation development and diffusion is less clear. The agenda has contributed to some positive developments, such as increased collaboration and the initiation of more pilot projects, but challenges unique to the sector continue to pose barriers.

To enhance its influence, RWS should focus on maintaining continuity in the strategy's focal points while improving their visibility and clarity. Increasing awareness of the agenda, particularly among external stakeholders and regional entities, is crucial. Greater collaboration in future updates, especially during the midterm review, and providing more support for innovation processes through tools like the SRL tool and IUP Guide, could further strengthen the strategy's impact. Ultimately, while the innovation agenda has made strides in guiding the sector, continued efforts are needed to ensure that it effectively drives innovation and addresses the sector's challenges.

A key limitation of this study is the limited participant sample due to time constraints, which restricted interviews to RWS and Deltares employees. This focus excluded many other relevant stakeholders, such as ministries or private organizations whose input could have enriched the research. Additionally, the interview format, with only 10 to 15 questions per one-hour session, constrained the depth of responses and led to variability in detail across interviews. Potential misinterpretation of data and the lack of assessment of participants' familiarity with RWS's innovation strategy are also limiting factors.

Future research should include a broader range of stakeholders to provide a more comprehensive perspective on RWS's innovation strategy. An internal survey within RWS could assess how well the strategy is understood and supported across different departments. Additionally, comparative studies in other public sectors could reveal whether similar challenges and successes are experienced elsewhere and if innovation strategies across sectors share common elements, offering insights into the effectiveness of public sector innovation strategies in addressing societal issues.

Contents

Preface and acknowledgements i

Summary ii

Abbreviations 1

List of figures 2

List of tables 2

1. Introduction 3

1.1. Context 3

1.2. Research area 3

1.3. Problem statement 4

1.4. Research objective 5

1.5. Sector complexity 6

1.6. Research question 8

1.7. Reading guide 8

2. Theoretical background 9

2.1. Innovation and the public sector 9

2.1.1. The concept of innovation 9

2.1.2. Public sector innovation 10

2.2. The Dutch water and subsurface sector 13

2.2.1. Policymaking 13

2.2.2. Policy implementation 15

2.2.3. Expert knowledge 15

2.2.4. Stakeholder knowledge 16

2.2.5. Collaborative efforts in the sector 17

2.2.6. Innovation in the water and subsurface sector 17

2.3. Towards an innovation strategy 18

2.3.1. Preceding an innovation strategy: Governmental policymaking 19

2.3.2. The concept of an innovation strategy 22

2.3.3. STO framework 23

2.3.4. Innovation strategies for public organizations 23

2.4. Conceptual framework 24

3. Research method 25

3.1. Research outline 25

3.2. Research design 27

3.2.1. Research strategy 27

3.2.2. Reliability, validity, and replicability 30

3.2.3. Ethics 31

4. Research Findings – Exploring RWS's innovation strategy 32
4.1. RWS's innovation strategy 32
4.1.1. Innovation agenda 32
4.1.2. Focal points 34
4.2. Developing the innovation agenda 35
4.2.1. Preceding the innovation agenda 35
4.2.2. Developing the first version 35
4.2.3. Update 36
4.3. Main content of the innovation agenda 36
4.3.1. Resource allocation 36
4.3.2. IUP Guide 37
4.3.3. Roadmaps 38
4.3.4. Innovation conditions 38
4.3.5. Additional documents 39
4.4. Awareness 40
4.5. Collaboration 41
4.5.1. Internal collaboration 41
4.5.2. External collaboration 41
4.6. The innovation agenda in practice 42
4.7. Future view for the innovation agenda 42
4.8. Concluding remarks RQ1 and RQ2 43
5. Research findings – Analyzing the sector 44
5.1. Perspectives and roles 44
5.1.1. Background participants 44
5.1.2. Characteristics water and subsurface sector 45
5.1.3. Role of RWS 46
5.1.4. Role of Deltares 48
5.1.5. Other roles in the sector 49
5.1.6. Urgency within the sector 50
5.2. Awareness and usage 51
5.2.1. Awareness innovation agenda 51
5.2.2. Appreciation innovation agenda 51
5.2.3. Monitoring and evaluation 52
5.2.4. Water and subsurface guiding 53
5.3. Challenges and success factors 54
5.3.1. Challenges for Deltares 54
5.3.2. Challenges for RWS 54

5.3.3. Success factors for Deltares 55
5.3.4. Success factors for RWS 55
5.3.5. Concluding remarks chapter 5 56
6. Research findings - The influence of the innovation strategy of RWS 57
6.1. Resource allocation 57
6.2. Development and diffusion 59
6.3. Collaboration 63
7. Research findings – Evaluating RWS's innovation strategy 68
7.1. Reflection on the influence of RWS's innovation strategy in practice 68
7.1.1. General findings 68
7.1.2. Innovate with focus 69
7.1.3. Innovate faster 70
7.1.4. Innovate together 71
7.1.5. Market perspective 71
7.2. Future vision 72
7.3. Enhancements 74
8. Discussion 78
8.1. Conceptual framework 78
8.2. Results related to literature 79
8.3. Added value for RWS 80
8.4. Added value for the sector 80
8.5. Scientific contribution 81
8.6. Reflection on the method 81
9. Conclusion 83
9.1. Conclusion 83
9.2. Limitations 86
9.3. Future research 87
Bibliography 88
Appendix A – Interviews sub-question 1 and 2 95
Appendix B – Coding process sub-question 1 and 2 99
Appendix C - Interviews sub-question 3 and 4 100
Appendix D – Interview contractor 102
Appendix E - Coding process sub-question 3 and 4 103
Appendix F – Informed consent 105

Abbreviations

Abbreviations	*Definition*
RWS	Rijkswaterstaat
I&W	Infrastructure and Water management
STO	Strategic, Tactical, and Operational
BAM	Royal BAM Group
PBL	Environmental Assessment Agency
DGWB	Directorate General for Water and Soil
OCW	Education, Culture, and Science
EZK	Economic Affairs and Climate Policy
LNV	Agriculture, Nature, and Food Quality
BZK	Interior and Kingdom Relations
BZ	Foreign Affairs
PPP	Public-private-partnership
SME	Small and medium-sized enterprise
NGO	Non-governmental organization
NWP	Dutch Water Partnership
TKI	Top Consortium for Knowledge and Innovation
EBP	Evidence-based policy
WVL	Water, Traffic, and Living Environment department
IUP	Innovate, Standardize, Produce
TRL	Technology Readiness Level
SRL	Stakeholder Readiness Level
WUR	Wageningen University and Research
PhD	Doctor of Philosophy
PPO	Programs, Projects, and Maintenance department
GPO	Large Projects and Maintenance department
CIP	Corporate Innovation Program

List of figures

Figure 1: Exploring RWS's innovation strategy inspired by (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017) 6
Figure 2: Main stakeholder map water and subsurface sector 7
Figure 3: The linear model of innovation inspired by Godin (2006) 11
Figure 4: The penta helix model (Calzada, 2018) 12
Figure 5: The dynamics of evidence-based policy (Sutcliffe & Court, 2005) 19
Figure 6: Three lenses of knowledge and evidence (Head, 2008) 20
Figure 7: The policy cycle (Sutcliffe & Court, 2005) 21
Figure 8: The flow of evidence in the policy process (Sutcliffe & Court, 2005) 22
Figure 9: The STO framework (Bautista, 2024) 23
Figure 10: Conceptual framework 24
Figure 11: Research flow diagram 26
Figure 12: Inductive coding process (Ho & Limpaecher, 2021) 28
Figure 13: Front page Kompas RWS (Benschop & Ovaa, 2021) 32
Figure 14: Front page RWS's innovation agenda (Rijkswaterstaat, 2023) 33
Figure 15: IUP Guide (Rijkswaterstaat, 2023) 37
Figure 16: The Continuous Innovation (COIN) framework 39
Figure 17: The innovation landscape 40
Figure 18: RWS's potential roles in innovation processes (Rijkswaterstaat, 2023) – in Dutch 48
Figure 19: Metaphor illustrating the importance of innovation (Busybusy, 2020) 70

List of tables

Table 1: The main stakeholders in the Dutch water and subsurface sector 18
Table 2: List of participants sub-question 1 and 2 27
Table 3: List of participants sub-question 3 and 4 29
Table 4: Participant market party sub-question 4 30
Table 5: Example projects related to the five focal points 35
Table 6: The main challenges and success factors mentioned in the interviews 56
Table 7: Main findings of the influence of RWS's innovation strategy on resource allocation 59
Table 8: Main findings of the influence of RWS's innovation strategy on the development and diffusion of innovations 62
Table 9: Main findings of the influence of RWS's innovation strategy on internal and external collaboration 67
Table 10: Main enhancements for RWS's innovation strategy 77

1. Introduction

1.1. Context

Climate change adaptation is one of the main global challenges this century. The emission of greenhouse gasses by human actions causes global warming, which increases the occurrence and impact of weather and climate related issues such as sea level rise, reduced water security and extreme weather events (IPCC, 2023). The changing climate has a significant impact on human life, especially in vulnerable regions in the short-term. For instance, large regions of Africa are predicted to be most affected by climate-induced vulnerabilities in the water sector, experiencing diminished water supplies and reduced access to drinking water (Nyiwul, 2021). Additionally, less immediately vulnerable parts of the world like The Netherlands are also experiencing the adverse effects of climate change since the frequency and severity of flood events has increased compared to previous years (Duijndam, et al., 2023).

The imminent dangers, both short and long-term, highlight the urgent necessity for regionally accepted and effective adaptation strategies (Gyimah, et al., 2024). These strategies should prioritize adjustments to natural and human systems in response to the evolving climate and its effects (Panahi, Ng, & Pang, 2020). Despite the acknowledgement of the critical importance of adaptation to climate change and numerous encounters with adverse effects of global warming, several obstacles in the widespread implementation process persist, primarily due to the complex nature of climate change adaptation (Gyimah, et al., 2024).

Issues characterized by significant complexity are often defined as ‘wicked problems’. These problems exhibit various common characteristics, including conflicting values among stakeholders, the indeterminate nature of both the problem and the solution, and the inability to definitively solve them (Perry, 2015). In summary, the three core dimensions of a wicked problem are its high complexity, high uncertainty, and high stakeholder divergence. This advocates for climate change adaptation as a wicked problem, highlighting the challenge of addressing it with accepted strategies even on the local or regional level (Weaver, Moyle, McLennan, & Casali, 2023).

1.2. Research area

Innovations in the field of water and subsurface management, coupled with adaptive behavior, can play a vital role in adaptation strategies to climate change (Duijndam, et al., 2023). The rapidly changing environment induces people to think innovatively towards the transition of complex systems (Vreugdenhil, Taljaard, & Slinger, 2012). The definition of a transition is “a fundamental change from one stable situation to another” (Raven, van den Bosch, Fonk, Andringa, & Weterings, 2008). Pilot projects are used to stimulate transitions by applying and adapting innovative solutions to real-world situations and function as stepping stones for societal change. However, a fundamental problem with pilot projects is the development and diffusion or upscaling of the innovative solutions studied at a small scale (Vreugdenhil, Taljaard, & Slinger, 2012).

The small-scale environment of a pilot project stimulates the success of the project itself but can hamper its diffusion and practical impact. A successfully executed pilot with insightful results (internal success) is not a guarantee for practical large-scale solutions (external success). The challenge is that necessary internal success conditions are potential barriers for large-scale diffusion (Vreugdenhil, Slinger, Thissen, & Ker Rault, 2010). On the one hand, pilot projects are needed to develop knowledge and potential solutions, but they should also have a clear impact on larger scale to gain support. This contradiction between the internal and external successes of a pilot project ensures that a pilot seldom fails but also seldom scales, a phenomenon referred to as the pilot paradox (Breman, Vreugdenhil, van Buuren, Ellen, & van Popering-Verkerk, 2017).

An innovation in the water and subsurface sector can, first of all, be a new or significantly improved product (Ziolkowski & Ziolkowska, 2017). An example of this is the so-called Xstream blocks, which are used as flexible groynes to regulate water flow in rivers. These concrete blocks are easily adjustable, use less material than traditional groynes, and provide a safe habitat for plants and aquatic organisms (BAM Infra Nederland, 2024). Another example is a rejuvenation spray applied over asphalt to slow down the wear process and extend its lifespan (Rijkswaterstaat, 2024).

In addition to product innovations, process innovations are also important in the water and subsurface sector, where a process is improved or a new method is applied (Ziolkowski & Ziolkowska, 2017). The Sand Motor, located off the coast of Kijkduin, is an example, where sand is deposited in the water rather than directly on the beach to protect the coastline. This method uses wind and water currents to distribute sand naturally along the coast (Zandmotor Monitoring, 2024). Another example is the Stakeholder Readiness Level (SRL) tool, a management instrument designed to assess the readiness of organizations for the adoption of innovations, thereby accelerating the innovation process (Rijkswaterstaat, 2024).

Thirdly, organizational innovations are also significant in this sector, focusing on improving internal organizational processes as well as developing new ways to collaborate with partners (Ziolkowski & Ziolkowska, 2017). An example of this is the change in maintenance contracts between Rijkswaterstaat (RWS) and contractors, where a sustainable component is increasingly integrated, and the focus has shifted toward collaboration (Rijkswaterstaat, 2023). Finally, all these types of innovations are interconnected, as innovative maintenance contracts and process innovations, for example, have the potential to stimulate the development and diffusion of product innovations (Ziolkowski & Ziolkowska, 2017).

1.3. Problem statement

As previously mentioned, climate-adaptive innovations from pilot projects and regionally or locally accepted strategies are necessary to address the effects of the wicked issues caused by climate change. Governments worldwide are considered to have a major role in contributing to climate-adaptive innovation strategies. Public sector innovations entail the development and diffusion of new ideas of public sector organizations, mostly in cooperation with other stakeholders such as private parties, aimed at addressing societal challenges like climate change adaptation (van Hout, Braams, Meijer, & Meijer, 2024).

RWS, the Dutch governmental organization tasked with implementing policies developed by the ministry of Infrastructure and Water Management (I&W), plays a crucial role in the operationalization of climate change adaptation measures, particularly in the water and subsurface sector. The ministry integrates climate change adaptation into its overarching policies and aims for a climate-resilient and water-robust country by 2050. The primary objectives are protecting the country against floods, ensure a sustainable freshwater supply, and fostering a climate-resilient living environment (Ministry I&W, 2024). Moreover, Rijkswaterstaat incorporated climate change adaptation into its innovation agenda, designating it as one of their focal points regarding innovation (Rijkswaterstaat, 2024).

Previously, RWS has conducted research into the factors that promote or hinder the development and diffusion of public sector innovations (Heijink & Kalders, 2017). In addition, strategies for scaling pilot projects in the public sector have been identified based on the different phases during upscaling and the various factors involving in the process (van Hout M. , 2022). However, there is a lack of research focusing on the development of innovation strategies, the effect of internal and external factors on a strategy, and the influence of an innovation strategy on innovation processes. A strategic viewpoint on innovation strategies is required to address this knowledge gap, with this research specifically focused

on innovations in the water and subsurface sector and the role of RWS's innovation strategy. More specifically, the research is focused on the influence of RWS's innovation strategy on collaboration in the sector, the development and diffusion of innovations in projects, and effective resource allocation.

A broad definition of an innovation strategy in the public sector is that an innovation strategy addresses the question of how to facilitate the development and diffusion of innovations to arrive at societally desirable and sustainable solutions (Ortt & Kamp, 2022). An innovation strategy can also be described as a commitment to a set of policies aimed at achieving a specific goal. A strategy promotes alignment among stakeholders within and outside an organization, clarifies and prioritizes objectives and helps focus efforts on the aligned goals. The main question of a public sector innovation strategy is how to create value for society through innovations (Pisano, 2015).

Many organizations focus their innovation strategy solely at the strategic management level, often overlooking the tactical and operational levels. At the strategic level, companies establish foundational policies and long-term goals, while the tactical level involves short-term plans to achieve these strategic goals, and the operational level focuses on executing these plans in time. Bridging the gap between the strategic and operational level is crucial for the development and diffusion of innovations. The strategic, tactical, and operational (STO) framework, as described above provides a comprehensive approach to investigate innovation strategies by considering various organizational perspectives (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017).

1.4. Research objective

The aim of this study is to gain more knowledge on the influence of the innovation strategy of RWS in the water and subsurface sector, particularly regarding climate-adaptive and infrastructural innovations. Investigating the role of the innovation strategy is relevant as previous research has explored factors influencing the development and diffusion of innovations, as well as scaling strategies. However, there remains a gap in understanding regarding the role of the innovation strategy and its influences. This includes evaluating the influence of the innovation strategy on the water and subsurface sector, as well as analyzing how internal and external factors and actors influence the development of RWS's innovation strategy.

Therefore, part of the research is about exploring the innovation strategy of RWS and the way it developed and responds to internal and external factors. Next, the influence of RWS's innovation strategy in the water and subsurface sector are identified and discussed. Finally, recommendations for enhancements of the innovation strategy are made based on the information from previous sub-questions.

Figure 1 shows a schematic representation of the focus of analysis, which is the exploration of RWS's innovation strategy. The STO framework illustrates RWS's innovation strategy, focused on the tactical level, to influence innovation processes in the water and subsurface sector. Perspectives from the three strategic levels, briefly outlined above, are important in the development of the innovation strategy itself and the influence of the strategy in the water and subsurface sector. Both, internal and external factors and actors affects the innovation strategy of RWS.

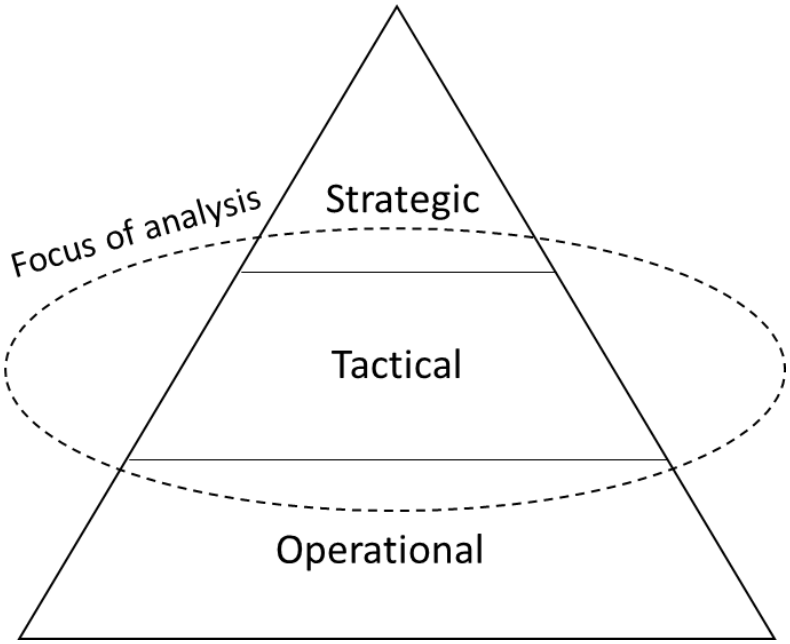

Figure 1: Exploring RWS's innovation strategy inspired by (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017)

The schematic representation illustrates that the innovation strategy of RWS and its influence in the water and subsurface sector constitutes the focal point of analysis. At the strategic level, the fundamental WHY-question must be addressed to define the long-term vision (Mulder, Hommes, & Horstman, 2011). Furthermore, at the operational level, detailed execution plans for implementing specific innovations are delineated (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017). The tactical level serves as the connection between the strategic goals and the operational objectives (Lodder & Slinger, 2022), by answering the WHAT-question and visualizing what should be achieved to comply with the strategic level. The schematic representation accentuates the critical role of the tactical level, while also highlighting the interconnections among all the three levels within the innovation strategy. Concurrently, the WHO-question is vital to identify the involved actors, examine their influence on and by the strategy, and specify their roles (Mulder, Hommes, & Horstman, 2011).

1.5. Sector complexity

In addition to the various types of innovations, there are also different actors involved in the innovation processes within the water and subsurface sector, further increasing the complexity. Actors can be involved as partners in innovation processes, but they can also be affected by the outcomes of innovations. Figure 2 provides an overview of the main stakeholders involved in innovation processes in the water and subsurface sector. This research primarily focusses on the dynamics between RWS and the knowledge institute Deltares, while also acknowledging the roles of other key stakeholders throughout the study.

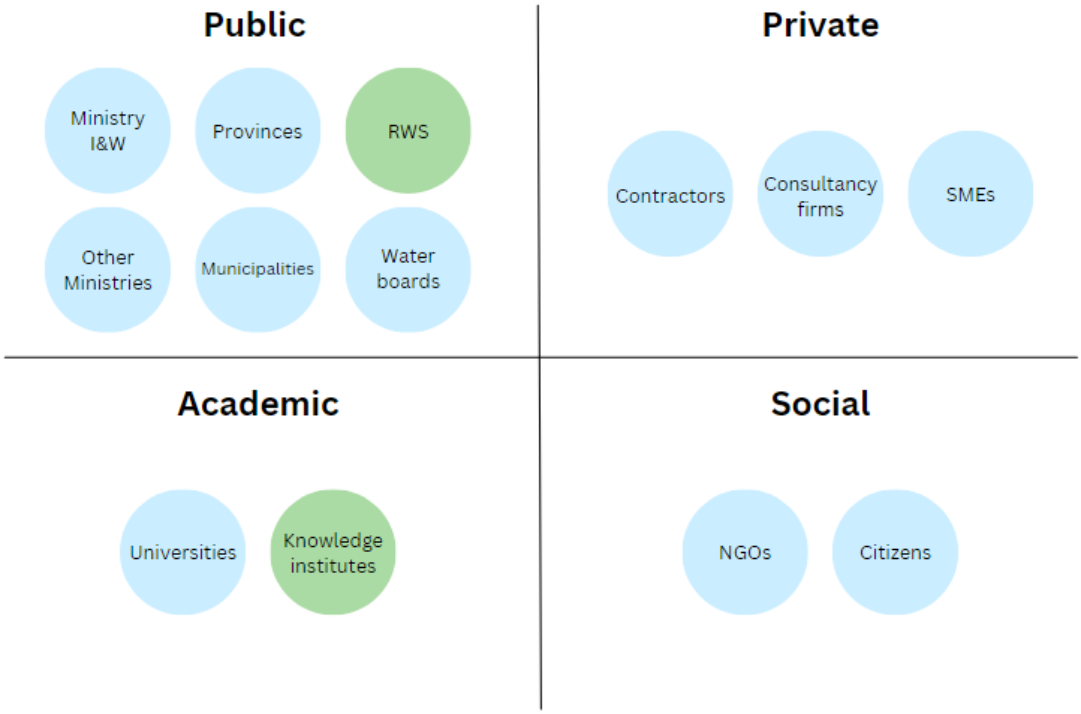

Figure 2: Main stakeholder map water and subsurface sector

The public sector serves as a central force in coordinating and promoting innovation in the water and subsurface sector. The ministry of I&W plays a crucial role by formulating and overseeing national policies aimed ad fostering innovation across the sector (Rijksoverheid, 2024). However, due to the multifaced functions of water in the Netherlands, other ministries are also involved in shaping the sector's direction regarding innovation with national policy (van der Brugge, Rotmans, & Loorbach, 2005). The decentralized nature of water management makes provincial and municipal governments critical stakeholders ass well. These entities not only implement national policies at regional levels, but also adapt them to address local needs (Edelenbos, van Buuren, & van Schie, 2011). Water boards, operating under the supervision of provinces and municipalities, are responsible for water management at a local level and have the authority to interpret and adjust national policies to suit the requirements of their specific regions (Rijksoverheid, 2024). RWS, as the national public organization responsible for policy implementation across the country, plays a crucial role in translating these policies into practical actions (Rijkswaterstaat, 2024).

The private sector is crucial to innovation processes, often collaborating with the public sector to execute and manage projects. Key private stakeholders include contractors, who contribute specialized engineering expertise to projects both as project member or initiator (NWP, 2024), consultancy firms, which provide advisory services based on their sector-specific knowledge (Arcadis, 2024), and small and medium-sized enterprises (SMEs). SMEs, such as dredgers and drinking water organizations, are essential project partners due to their practical expertise and financial investments in innovation (MKB Nederland, 2024).

The academic sector plays a critical role in generating scientific knowledge and providing expertise to support innovation. Universities contribute by conducting research that advances the theoretical and practical understanding of challenges in the sector, while knowledge institutes such as Deltares offer technical expertise and peer-reviewed data to inform other stakeholders in the sector. These actors are crucial in translating scientific discoveries into actionable innovations (Edelenbos, van Buuren, & van Schie, 2011).

Socially engaged actors, including non-governmental organizations (NGOs) and actively involved citizens, are also important stakeholders. NGOs focus on addressing and solving societal challenges within the sector, advocating for sustainable solutions (Bauer & Steurer, 2015). Meanwhile, citizens contribute valuable insights, express concerns, and are directly impacted by decisions made within the sector (Calzada, 2018). Their involvement ensures that social perspectives are integrated into innovation processes in the water and subsurface sector.

1.6. Research question

The following central question addresses the research objectives and the knowledge gaps, this is the main research question of this thesis:

What influence does Rijkswaterstaat's innovation strategy have on innovation processes in the water and subsurface sector?

1. *What is the current innovation strategy of Rijkswaterstaat?*
2. *How did Rijkswaterstaat develop its current innovation strategy within the water and subsurface sector depending on both internal and external factors?*
3. *What influence does Rijkswaterstaat's innovation strategy have on resource allocation, the development and diffusion of innovations, and collaboration within the water and subsurface sector?*
4. *How can Rijkswaterstaat enhance its innovation strategy to foster its influence in the water and subsurface sector?*

1.7. Reading guide

Chapter 2 begins by reviewing the foundational theories necessary for understanding various concepts related to an innovation strategy in the water and subsurface sector. This literature review is followed by a conceptual framework. Chapter 3 outlines the research methodology, with a focus on the rational for selecting a qualitative approach, utilizing semi-structured interviews with participants from RWS and Deltares. Chapter 4 addresses the first two sub-questions, detailing the current innovation strategy of RWS and its development. Chapter 5 examines the characteristics, roles, and responsibilities within the water and subsurface sector as perceived by the interviewees, partially answering the third sub-question. Chapter 6 further explores the influence of RWS's innovation strategy in the water and sub-surface sector, and particularly regarding internal and external collaboration, the development and diffusion of innovations, and resource allocation, thus completing the answer to the third sub-question. Chapter 7 presents the reflection and discussion, situating the study within the existing literature and reviewing the conceptual framework. Finally, Chapter 8 provides the conclusion, were the sub-questions and main research question are answered, limitations are discussed, and recommendations for future research are offered.

2. Theoretical background

In this section, the theoretical background related to the research topic will be discussed. Before examining RWS's innovation strategy, it is necessary to define certain concepts to establish the scope of the research and enhance understanding within the expansive realm of innovation. Firstly, the concept of innovation will be discussed briefly, followed by an exploration of a specific field of innovations, namely public sector innovations. Secondly, the water and subsurface sector will be introduced and elaborated upon, as this research focuses on RWS's innovation strategy and its impact on that specific public sector. Finally, the governmental policymaking process will be introduced, and the concept of innovation strategy will be examined and defined, given its widespread use in literature with varying interpretations and its potential effects.

2.1. Innovation and the public sector

Globally, the frequency and intensity of extreme events caused by climate change increased over the years. Urgent adaptation measures are imperative to protect populations worldwide from both imminent and long-term impacts, such as flooding and diminished water security (Gyimah, et al., 2024). Climate change due to human activity is happening faster than before, which advocates for innovative, deliberative and regionally accepted adaptation plans. The government and public organizations play an important role in defining, enabling and executing adaptation plans regarding climate change. Particularly significant is the innovative aspect, given the lack of experience with climate change adaptation and the high degree of urgency (Trittipo, Samandari, Hatami, & Mysore, 2023). Complex challenges like climate change adaptation require creative and novel ways of thinking in terms of knowledge, persuasion and decision-making (Rogers, 2003). However, what precisely constitutes the concept innovation and what distinguishes innovations in the public sector?

2.1.1. The concept of innovation

Innovation has been a widely studied concept over the years, resulting in various definitions and diverse perspectives on the subject. The lack of a common definition undermines the understanding of the nature of innovation, potentially giving rise to issues of ambiguity (Baregheh, Rowley, & Sambrook, 2009). Misunderstanding the concept of innovation is detrimental, particularly as organizations often incorporate it into their vision and objective statements, thereby impacting organizational processes and outcomes (Kahn, 2018).

Joseph Schumpeter is one of the first pioneers in the study of innovation, emphasizing the significance of revolutionary change driven by innovation for economic development (Sledzik, 2013). He described innovation as creative destruction, wherein structural changes are induced by innovative entrepreneurs who translate new ideas into practice in response to economic opportunities (Block, Fisch, & van Praag, 2017). With his economic perspective, Schumpeter categorized innovation in five types: The introduction of new products, the adoption of new methods, the exploration of new markets, the acquisition of new sources, and the establishment of new industry structures. In essence, he described innovation as encompassing the processes of invention, innovation, diffusion, and imitation (Sledzik, 2013).

Rogers described innovation as an idea, practice, or object that is perceived as new by an individual or unit of adoption (Rogers, 2003). An idea does not directly lead to change since communication among members of a social system is needed to diffuse a particular innovation. The innovativeness of an innovation indicates the degree to which an individual or unit of adoption is earlier to adopt than others (Rogers, Singhal, & Quinlan, 2009). Rogers' description is written from a market perspective and argues for innovation as the creation of new knowledge and the diffusion of existing knowledge (Popa, Preda, & Boldea, 2010). Both, Schumpeter's and Rogers' theory emphasizes on the creation of an idea

and on its diffusion. Furthermore, innovation is described by Schumpeter and Rogers as a process and not a discrete act. Also from an organizational perspective, innovation is often described as a multi-stage process whereby organizations translate ideas into new products, services or processes (Baregheh, Rowley, & Sambrook, 2009). Innovation is in various theories described both as an outcome and a process (Kahn, 2018).

A third important aspect of innovation is the supportive culture within an organization or among individuals towards innovation, in other words the mindset. In the first place, cross-functional and interdepartmental thinking supports the innovative culture since knowledge spillovers occur and the views of different perspectives are used (Kahn, 2018). Secondly, the necessary resources need to be in place to stimulate the support for innovation within the organization such as budgets, technology, and creative employees (Baregheh, Rowley, & Sambrook, 2009). Furthermore, individuals and organizations known for innovation have five features pushing new ways of thinking (Dyer, Gregersen, & Christensen, 2011);

- *Associating*: Drawing connections between questions and problems from unrelated fields.
- *Questioning*: Posing queries that challenge common wisdom.
- *Observing*: Examining stakeholder behavior to identify new ways of doing things.
- *Experimenting*: Constructing experiences to see what insights emerge.
- *Networking*: Meeting people with different ideas and perspectives.

In conclusion, innovation is a widely used concept in literature with various discipline-specific definitions, but a more generic definition is lacking (Baregheh, Rowley, & Sambrook, 2009). Three aspects of the concept innovation recur in many perspectives, namely innovation as an outcome, a process and a mindset. Innovation as an outcome is characterized by the question what an individual or organization want to achieve, for example the innovation of a specific product or service. Innovation as a process is about how to make that achievement happen. Finally, the culture within the organization and the individual mindset underlies the third aspect, namely innovation as a mindset (Kahn, 2018).

2.1.2. Public sector innovation

In a market perspective, innovation is a response to innovations in a competitive company, with the goal to create new profit opportunities and develop new ways of creating value. However, the public sector refers to the coordination and production of products and services by publicly owned organizations (Potts & Kastelle, 2010). In general, an innovation in the public sector is about the responsiveness of public organizations in offering products or services that meet the expectations of public in a specific area to solve existing problems (Hilmawan, et al., 2023). In this section, the characteristics of public sector innovations will be described to gain more knowledge regarding this specific field.

Problem solving over profit

The competitive incentive in the market perspective is a weaker force in the context of public sector innovation since the public sector is generally speaking not a market context but an institutionalized monopoly. Public organizations do not compete to gain a higher market share; the public sector sells to the government and only the government buys from the public sector (Potts & Kastelle, 2010). The goal of public sector organizations is solving particular issues in the community, which are often neglected by the private sector (Hilmawan, et al., 2023).

Public sector organizations need to innovate to create or increase public value rather than market value (Clausen, Demircioglu, & Alsos, 2020). Fundamentally in public sector innovations is improving

social welfare, environmental sustainability, economic performance, and organizational efficiency to tailor services to citizens and drive better-quality solutions (Alves, 2013). For example, Rijkswaterstaat is operationally responsible for the Dutch infrastructure and water management to keep citizens safe (Rijkswaterstaat, 2024). Specifically organizational efficiency improves the effectiveness and problem-solving capabilities of organizations in the public sector, which in addition also higher the trust of public organizations among citizens (Clausen, Demircioglu, & Alsos, 2020). In extreme cases, it is rather about avoiding disasters than creating value (Potts & Kastelle, 2010).

Sector interactions

Public sector innovations are characterized by the interaction and collaboration between the public, private, and academic sector to address specific challenges. These sectors establish networks and exchange knowledge to achieve shared or sector-specific objectives (Werker, Ubacht, & Ligtvoet, 2017). The academic sector, comprising universities and research institutes (Bhatta, Vreugdenhil, & Slinger, 2024), plays a crucial role in fostering the advancement of knowledge, skills, attitudes, and behaviors within the workforce. Meanwhile, the ingenuity of public sector employees paves the way for innovation (Hilmawan, et al., 2023). Collaboration between the private and public sectors, stimulated by research conducted in academia, facilitates the development of innovative solutions to issues within society. However, a notable barrier in the relationship between the private and public sectors is the divergence in values, such as the contrast between profit-making and societal service (Alves, 2013).

The linear model of innovation, as shown in figure 3, encompasses four stages driven by various sectors. The initial stage involves basic research conducted by the academic sector to uncover fundamental knowledge. The second stage, applied research, focuses on acquiring practical knowledge related to the private and public objectives of a specific innovation. Subsequently, the third stage entails the refinement of existing knowledge to innovate in terms of the development of new products and services. In the final phase, innovations are integrated into the visions of private and public organizations (Godin, 2006). However, the model faced criticism for its lack of linkages between the different stages, absence of non-linear processes during research, bottlenecks in knowledge creation and dissemination, and the lack of sector interactions. Additionally, a later iteration of the model, incorporating feedback loops, continues to draw criticism (Balconi, Brusoni, & Orsenigo, 2010).

Figure 3: The linear model of innovation inspired by Godin (2006)

The triple helix model provides a detailed framework for understanding the relationship and interaction between the three sectors. It describes an interconnected system, also known as an innovation system, where each sector assumes roles typically associated with the others, creating hybrid organizations (Etzkowitz & Leydesdorff, 2000). For example, the academic sector is not solely responsible for the basic research but actively participates throughout the entire innovation process. Furthermore, the private and public sectors influence basic research by identifying market opportunities or societal needs. Emphasizing an innovative environment for all three sectors, the triple helix model highlights phenomena such as university spin-offs, strategic alliances among firms, and governmental laboratories (Etzkowitz & Leydesdorff, 2000).

The triple helix model, which focuses on interactions among the public, private, and academic sectors, follows the three sectors outlined in the linear model of innovation, but additional actors are incorporated in the model over time. The quadruple helix model introduces civic society as a fourth actor, while the penta helix model, shown in figure 4, includes an additional fifth actor known as assemblers, including social entrepreneurs, activists, brokers, and NGOs (Calzada, 2018). Civic society represents the users and the public affected by the problem or the innovation and advocates for a user-centric innovation approach by prioritizing their feedback preceding, during, and after the innovation process to enhance user involvement and engagement (Bhatta, Vreugdenhil, & Slinger, 2024). Narrowing the knowledge gap among actors in the innovation system promotes transparency and potentially fosters the social impact of innovations (Spaapen & van Drooge, 2011). Assemblers embody a proactive citizenship that incorporates a transformative element into the innovation system, underscoring the importance of societal support (Calzada, 2018). The interaction and collaboration among all these actors foster a collective dynamic that potentially leads to innovative solutions (Bhatta, Vreugdenhil, & Slinger, 2024).

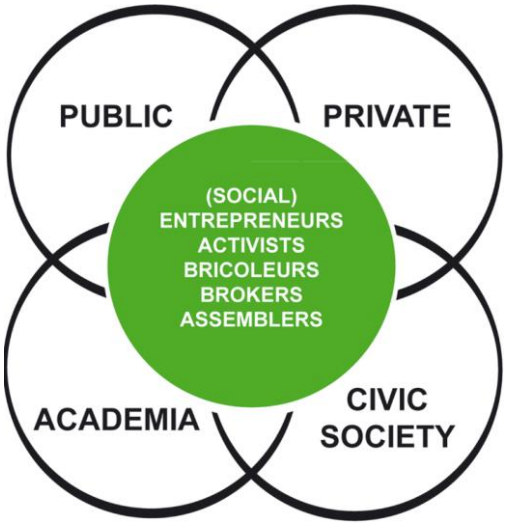

Figure 4: The penta helix model (Calzada, 2018)

Limited resources

The public sector faces pressure to provide new public products and services to adapt to the changing climate with increasingly scarce resources (Clausen, Demircioglu, & Alsos, 2020). The primary constraint is the availability of budgetary resources, as governments cannot allocate unlimited funds to every project. Consequently, managing budgets becomes crucial to minimize waste and maximize outcomes (Potts & Kastelle, 2010). While the pressure on public budgets and rising citizen expectations steer innovation in the public sector, they also necessitate difficult decisions regarding budget allocation (Alves, 2013).

Additionally, time poses a significant constrain, especially concerning urgent environmental challenges like climate change. With global climate change effects evolving rapidly, public organizations require flexibility to address emerging issues promptly. Prioritization becomes essential as some problems demand immediate attention while others may vary in urgency over time (Trittipo, Samandari, Hatami, & Mysore, 2023).

Finally, humanpower presents another limited resource within the public sector. Increasing societal problems have led to a growing workload across public organizations, underscoring the importance of effective workforce allocation and strategic planning. Given the finite number of personnel available, decisions must be made to allocate humanpower efficiently (Bennett, Kleinman, & McConnell, 2022).

Public funding

Public funding plays an important role in public sector innovation since public organizations rely on revenues primarily derived from taxes, underscoring the responsibility of the public sector to its community (Hilmawan, et al., 2023). This financial foundation establishes the link between the public sector and citizens, emphasizing the importance of accountability and transparency (Clausen, Demircioglu, & Alsos, 2020). The government uses funding on the one hand to control and own a public sector organization, but on the other hand stimulates its growth strategy (Koch & Hauknes, 2005).

Public funding obligates public organizations to operate in a responsive way focused on the needs and expectations of the public (Hilmawan, et al., 2023). The public funding stimulates responsible use of public money but may also cause risk averse and a critical disincentive to innovation. In other words, private organizations are more likely to accept the failure of projects since they experience less short-term pressure than public organizations (Koch & Hauknes, 2005).

Policy and regulations

A last critical aspect of public sector innovations lies in their susceptibility to political influence, given that public organizations are formally governed by policy decisions, including financial support, laws, and regulations (Koch & Hauknes, 2005). The public sector is characterized by legislative limitations and ongoing discussion over policy directions, which often hampers innovation (Alves, 2013). Regulatory policies serve as the bridge between governmental control and ownership over public organizations, on one hand, and the potential for organizational growth, on the other (Koch & Hauknes, 2005).

Legislation can either facilitate or hinder the development of public sector innovations, depending on its nature. National and international laws can provide clear guidelines that support the innovation process, but they can also impose limitations due to their stringent nature (Koch & Hauknes, 2005). Permissive laws are designed to encourage the emergence of new ideas, while sanctioning laws aim to induce behavioral changes within society, both of which can have a positive impact on enabling public innovation. However, the downside of laws and legislation is the increase in administrative tasks, which inevitably consumes additional time and resources (Farazmand, 2018).

2.2. The Dutch water and subsurface sector

Various publicly owned organizations exist, encompassing sectors such as education and safety. One sector significantly impacted by climate change is the water and subsurface sector. In the Netherlands, the ministry of I&W oversees policies pertaining to this sector and aims for a climate-resilient and water-robust country by 2050. Furthermore, the ministry has integrated climate change adaptation in its overarching policies, focusing on protecting the country against floods, ensuring sustainable freshwater supply, and fostering a climate-resilient living environment as main objectives (Ministry I&W, 2024). RWS, a public organization, is tasked with implementing those policies and has also incorporated climate change adaptation within its innovation agenda, designating it as one of their focal points regarding innovation (Rijkswaterstaat, 2024). This section of the theoretical background explores the characteristics of the water and subsurface sector. Furthermore, it delves into the main players in the field and their roles in driving climate change innovations.

2.2.1. Policymaking

Governments worldwide have incorporated climate change adaptation into their existing policies, which is also the case for Dutch policies in the water and subsurface sector (Bauer & Steurer, 2015). The rising sea level and subsidence of soil have intensified pressure from water on land, while increasing social demands have added pressure from land to water. Social (reduced safety), financial (compensation after floods), and ecological (drought) damage is expected to increase substantially in

the near future, underscoring the need for clear policies in the water and subsurface sector (van der Brugge, Rotmans, & Loorbach, 2005). However, climate change can be defined as a wicked problem according to its high complexity, high uncertainty, and high stakeholder divergence, highlighting the challenge of addressing it with regionally accepted policy (Weaver, Moyle, McLennan, & Casali, 2023). Several sector-specific issues complicate the policymaking process for the Dutch ministry of I&W, with the interaction between human ambitions and the earth's limits as a recurring theme (Cosgrove & Loucks, 2015).

The ministry of I&W has a coordinating and stimulating role in climate change adaptation regarding the sector (Rijksoverheid, 2024). The overarching policy of the ministry of I&W emphasizes that water and soil should serve as the foundation for spatial design policies to preserve the effectiveness of the water and subsurface system (Rijksoverheid, 2023). What complicates matters is that water serves various functions within society. It serves an economic function, such as in agriculture; an ecological function, such as in sustaining ecosystems; and a social function, such as supplying drinking water or ensuring safety (van der Brugge, Rotmans, & Loorbach, 2005). Adding to the complexity, the functions of water vary by location, and actors hold differing perspectives on which function is most crucial to them (Edelenbos, van Buuren, & van Schie, 2011).

Several public organizations are organizationally part of the ministry of I&W and are stakeholders in the water and subsurface sector. One such organization is the Dutch Environmental Assessment Agency (PBL), which conducts multidisciplinary research to analyze and evaluate national policies. PBL provides independent, scientifically validated recommendations aimed at enhancing the quality of policies to benefit the environment, nature, and spatial planning (PBL, 2024). Another example is the Directorate General for Water and Soil (DGWB), which is responsible for developing policies related to the water and subsurface sector, partially focused on climate change adaptation (Rijksoverheid, 2024).

The ministry of I&W is not the only ministry involved in the water and subsurface sector, given the variety of functions water has in The Netherlands (van der Brugge, Rotmans, & Loorbach, 2005). Firstly, the ministry of Education, Culture and, Science (OCW) is responsible for establishing the infrastructure for scientific research to foster innovations. Meanwhile, the ministry of Economic Affairs and Climate Policy (EZK) oversees applied research in climate adaptation related to the water and subsurface sector (Loesink, Meibergen, & Valkman, 2021). Additionally, the ministry of Agriculture, Nature, and Food Quality (LNV) collaborates with stakeholders on projects concerning water systems and the quality of soil (Postma, 2020). The ministry of LNV and ministry of Interior and Kingdom Relations (BZK) also partner with the ministry of I&W on various initiatives, such as the Delta Program, which aims to protect the Netherlands against flooding, secure sufficient fresh water supplies, and ensure a climate-neutral design of the country (Rijksoverheid, 2023). Lastly, the ministry of Foreign Affairs (BZ) participates in several water-related projects, for instance those related to global fresh water supplies (Postma, 2020).

This diversity among locations and actors is why provinces and municipalities both implement national policy while also having the autonomy to develop policies tailored to specific municipalities or regions. Similarly, water boards have the authority to tailor national policy to meet the region-specific needs (Edelenbos, van Buuren, & van Schie, 2011). This flexibility in policymaking, known as policy freedom, allows provinces, municipalities, and water boards to interpret national policies according to their unique circumstances and advocate for the needs of their residents to balance local authority and national governance (Social Studies, 2023).

2.2.2. Policy implementation

RWS, the public organization responsible for the implementation of both the national and regional policies, operates under the ministry of I&W with the aim of ensuring a safe, livable, and accessible country (van den Brink, 2021). Tasked with the technical execution of projects initiated by the ministry of I&W, RWS is for example responsible for maintenance on public works such as dikes and the renovation of infrastructure such as tunnels (Rijkswaterstaat, 2024). In addition to the operational responsibilities, RWS prioritizes innovation, with climate adaptation being one of its focal points. Recognizing the changing climate, RWS endeavors to advance the water and subsurface sector rapidly through targeted innovations in collaboration with various stakeholders (Rijkswaterstaat, 2024).

Another governmental institute tasked with implementing policies are the water boards. These decentralized entities, supervised by provinces and municipalities, are responsible for water management in a specific area of the Netherlands. Their primary responsibilities include regulating water levels, treating wastewater, maintaining dikes, managing nature reserves, and monitoring water quality. Water boards collaborate closely with stakeholders in the water and subsurface sector, including RWS, provinces, and municipalities (Rijksoverheid, 2024).

Both RWS, as the executive arm of the ministry of I&W, and the water boards, as operationally independent entities, play significant roles in the switch from a reactive top-down governance approach with an anticipatory nature to an interactive approach with a long-term perspective. The decentralized governmental bodies have strong regional connections and can incorporate cross-sectoral insights from the field into large-scale national programs (Bauer & Steurer, 2015). While the ministry uses bureaucratic knowledge about political processes and administrative procedures to underpin their arguments, operational public sector organizations contribute essential practical knowledge to the process (Edelenbos, van Buuren, & van Schie, 2011).

2.2.3. Expert knowledge

Apart from the policymaking ministry, which contributes bureaucratic knowledge, and operationally responsible public sector organizations, which offer practical insights from the field, expert knowledge is necessary in addressing complex problems like climate change adaptation. Expert knowledge, also referred to as scientific knowledge, is typically generated by the academic sector and relies on scientific validity to expand the existing knowledge base (Edelenbos, van Buuren, & van Schie, 2011). It is derived not only from research conducted by universities, but also from experts of independent knowledge institutes (Bhatta, Vreugdenhil, & Slinger, 2024). The rigorously tested and peer-reviewed knowledge foundation provided by the academic sector contributes technical expertise to the development and implementation of policies regarding the water and subsurface sector (Edelenbos, van Buuren, & van Schie, 2011).

Research enables stakeholders in the water and subsurface sector to gain insights into constantly evolving opportunities for sectoral improvements. Altering the path to a desirable future requires a new way of thinking and the development of new technologies, tools or methods, warranted by investigation and testing (Cosgrove & Loucks, 2015). The academic environment provided by universities offers a conductive learning space for acquiring knowledge through experimental research, examining observations from experimental facilities, and testing hypotheses (Edelenbos, van Buuren, & van Schie, 2011).

Furthermore, knowledge institutes provide specialized and reliable expertise to the sector. For instance, Deltares engages in numerous projects in collaboration with the ministry of I&W and Rijkswaterstaat, offering guidance on addressing challenges in the field of water and subsurface. Deltares aims at creating impact and works on innovative solutions in the sector by leveraging the

expertise of their specialists (Deltares, 2024). Similarly, TNO partners with public and private organizations in the sector, providing expert advice on among others infrastructure and sustainable mobility (TNO, 2024).

2.2.4. Stakeholder knowledge

Stakeholder knowledge encompasses context and location-specific insights, incorporating the experience from day-to-day activities within the sector. Primarily, this knowledge stems from private sector organizations collaborating with other stakeholders in the water and subsurface sector (Edelenbos, van Buuren, & van Schie, 2011). The private sector contributes resources and practical knowledge to projects in the sector (Bhatta, Vreugdenhil, & Slinger, 2024). For instance, the port of Rotterdam engages in projects with public organizations to safeguard and enhance the harbor of Rotterdam (Bauer & Steurer, 2015).

The private sector is connected with the water and subsurface sector through public-private-partnerships (PPPs). These partnerships often entail long-term contracts, knowledge sharing, and shared project ownership. Common activities within PPPs include defining, financing, executing, and maintaining projects (Debaere & Kapral, 2021). SMEs play a significant role in these projects, contributing to innovation, economic growth, and sustainability (WE&B, 2015). SMEs, such as dredgers, private drinking water organizations (MKB Nederland, 2024), and university spin-offs are globally engaged in water and subsurface sector projects (WE&B, 2015). The development of distinctive technological innovations is particularly valuable for SMEs, providing both financial benefits and increased customer satisfaction (MKB Nederland, 2024).

Consultancy firms and contractors are frequently involved in the development and diffusion of innovations within the water and subsurface sector (NWP, 2024). Consultancy firms, through their sector-specific knowledge and advisory role, stimulate innovation across the entire sector (Arcadis, 2024). Additionally, contractors play a crucial role in executing and managing projects, offering specialized engineering and technical expertise, both as project initiators and as project members (NWP, 2024).

PPPs potentially provide better value for money and secure investment funds, which are essential for sector projects due to their extensive nature, high sunk costs, and significant risks associated with uncertainty (Lima, Brochado, & Marques, 2021). Private organizations often invest in publicly owned mutual funds, allowing private investors to diversify their portfolios with investments in various water-related projects, thereby capitalizing on industry growth and contributing to sustainability efforts. Another form of private investment is venture capital, where private organizations fund early-stage projects to access new resources otherwise unavailable. Lastly, impact investments are made by private organizations seeking both financial returns and social impact, often involving the acquisition of assets or water rights (Debaere & Kapral, 2021).

Secondly, stakeholder knowledge is acquired through the active engagement of the civic society. The involvement of citizens in complex projects regarding water and subsurface management is often used by the public sector, as citizens are directly affected by governmental decisions (Calzada, 2018). Their insights and concerns have the potential to shape policy decisions and serve as valuable input for evaluating existing policies, either in terms of social validity or in formulating new policies (Edelenbos, van Buuren, & van Schie, 2011).

A final stakeholder in the water and subsurface sector are the so-called assemblers, including NGOs and activists contributing to the sector dynamics as social entrepreneurs (Bauer & Steurer, 2015). This proactive citizenship by NGOs or activists can have significant impact on projects within the sector

(Edelenbos, van Buuren, & van Schie, 2011). On the one hand, societal issues within the sector are brought to the light more promptly through information from proactive citizens. However, activists may also impede the advancement of projects that are deemed detrimental to their interests (Calzada, 2018).

2.2.5. Collaborative efforts in the sector

As previously explained, the water and subsurface sector is characterized by the variety of stakeholders, with all kinds of perspectives. The Delta Program represents a collaboration involving various stakeholders, including the ministry of I&W, provinces, municipalities, water boards, Rijkswaterstaat, and several other public and private organizations. The primary goal of the Delta Program is protecting The Netherlands against floods and ensuring fresh water supply with a reduced risk of overspending or underinvestment by involving multiple stakeholders and adopting a flexible approach (Zevenbergen, Khan, van Alphen, Terwisscha van Scheltinga, & Veerbeek, 2018). The adaptive approach involves short-term monitoring criteria to keep track of the development and requires policy adjustments since external conditions will change over time (Bloemen, Van Der Steen, & Van Der Wal, 2019).

A commissioner delegated by the government coordinates the program, creates support, advises those involved, and reports back to the ministry of I&W (Rijksoverheid, 2023). The ministry of I&W coordinates the financing of the program with a specific Delta Fund (Bauer & Steurer, 2015). The availability of funding is crucial for the Delta Program, as climate change necessitates an increasing number of initiatives, thereby requiring greater financial support (Rijksoverheid, 2023).

Another example of collaboration in the sector is the Dutch Water Partnership (NWP), a network of actors from both public and private organizations that join forces to achieve sustainable water solutions worldwide (Dutch Water Sector, 2024). NWP maintains strong connections across the sector, engaging with a variety of organizations such as NGOs, SMEs, government organizations, and knowledge institutes to promote cross-sector collaborations. It builds coalitions around key themes, utilizing a connected platform to create opportunities within the water sector (NWP, 2024). As an independent, non-governmental foundation with a supervisory board comprising members from various public and private organizations, NWP is known for its professional responsiveness to the needs of their members, particularly in enhancing sector collaboration and managing water-related programs (NWP, 2024).

A final example of collaboration in the water and subsurface sector are the Top Consortium for Knowledge and Innovation (TKI), which promotes knowledge and innovation in a specific technological field. Core teams, comprising experts from public and private organizations, work on various innovations within their area of expertise, such as water technology, maritime technology, and delta technology. Their primary goal is to collaboratively develop innovations with a high market potential. These projects are initiated by TKI partners and funded by the consortium under an innovation policy contract. TKIs are established by the government to stimulate collaboration between private organizations, public organizations, and the academic sector, fostering the development and diffusion of innovations (Water & Maritime, 2024). The TKI Water Technology mainly focuses on innovations related to water quality and availability (Water & Maritime, 2024), while TKI Delta Technology enhances among others flood protection and balances water and land (TKI Deltatechnologie, 2024).

2.2.6. Innovation in the water and subsurface sector

Stakeholder engagement plays a crucial role in driving innovation within the water and subsurface sector. Given the sector's multifaceted nature and diverse stakeholder interests, effective collaboration and dialogue among stakeholders are essential for identifying challenges, co-creating solutions, and

fostering innovation (Edelenbos, van Buuren, & van Schie, 2011). Stakeholders encompass a broad spectrum, including public sector organizations, private sector organizations, the academic sector, civic society, and social entrepreneurs, each bringing unique perspectives, expertise, and resources to the table (Calzada, 2018). The main stakeholders in the Dutch water and subsurface sector are shown in table 1. Engaging stakeholders facilitates the exchange of knowledge, fosters mutual understanding, and builds consensus around shared goals and priorities (Cosgrove & Loucks, 2015). Furthermore, involving stakeholders throughout the innovation process ensures that solutions are relevant, socially acceptable, and environmentally sustainable, ultimately enhancing the effectiveness and resilience of water and subsurface management practices (Bauer & Steurer, 2015).

Table 1: The main stakeholders in the Dutch water and subsurface sector

Stakeholder group	**Stakeholder**
Public sector	Ministries, provinces, municipalities, water boards, PBL, DGWB, RWS
Private sector	SMEs, consultancy firms, contractors
Academic sector	Universities, knowledge institutes
Civic society	Proactive citizen
Social entrepreneurs	NGOs, activists

Innovations in the water and subsurface sector are driven by a complex interplay of policy, stakeholder collaboration, and scientific expertise. The Dutch approach, characterized by integrated policies, decentralized implementation, and strong PPPs, sets a robust framework for addressing climate change challenges (Edelenbos, van Buuren, & van Schie, 2011). However, the sector faces significant uncertainties, particularly due to the impacts of climate change, which introduce variability in water levels, soil subsidence, and extreme weather events (Cosgrove & Loucks, 2015). These uncertainties necessitate flexible and adaptive policy frameworks that can accommodate changing conditions and emerging risks. Additionally, the financial requirements for sustaining innovations and implementing large-scale projects further contribute to the sector's uncertainty (van der Brugge, Rotmans, & Loorbach, 2005).

The complexity of the water and subsurface sector arises from the intricate interactions between natural systems, technological developments, and diverse stakeholder interests. Policymaking is complicated by the need to balance economic, ecological, and social functions of water, which vary by location and stakeholder priorities (van der Brugge, Rotmans, & Loorbach, 2005). This complexity is further compounded by the necessity for continuous technological innovation to address emerging challenges and improve resilience. Collaborative efforts, such as those seen in PPPs and initiatives like the Delta Program, are essential for navigating this complexity. By leveraging the collective expertise of stakeholders and fostering integrated approaches, the Dutch water and subsurface sector aims to develop sustainable solutions that enhance the country's capacity to adapt to the impacts of climate change (Bauer & Steurer, 2015).

2.3. Towards an innovation strategy

Innovations in the water and subsurface sector, which is dominated by the government, can only arise if they comply with strict regulations made by the ministry of I&W. Therefore, the governmental policymaking process is vital for innovations in this specific sector. Furthermore, as discussed earlier, innovation is a broad, often misunderstood, and sector-specific concept. Additionally, innovation is a frustrating process with high failure rates due to inherent uncertainty, and without a strategy, innovations can easily become a bunch of projects based on random best practices. Organizations regularly define their overall business strategy and specify how departments such as marketing and

finance support the goals, but an innovation strategy is often lacking (Pisano, 2015). Such an innovation strategy for public organizations also depends on governmental policymaking.

2.3.1. Preceding an innovation strategy: Governmental policymaking

An organization seeking to develop and implement a particular innovation typically requires support (Wandersman, Chien, & Katz, 2010). In the water and subsurface sector, innovation is highly influenced and supported by public policies, making the innovation strategy also dependent on strategic policies (van der Brugge, Rotmans, & Loorbach, 2005). Another crucial factor for innovation in this sector is the reliance from the academic sector, which provides research insights, and the private sector, which offers practical expertise and experience (Edelenbos, van Buuren, & van Schie, 2011). Additionally, the direction of innovations is shaped by changes such as the increasing impact of climate change (Trittipo, Samandari, Hatami, & Mysore, 2023). Consequently, the development of policy and the utilization of knowledge are essential steps preceding the formulation of an innovation strategy.

Evidence-based policy

Public policy is in essence an authoritative course of action by a governmental body in response to the needs and problems of society. It involves a decision to take action, or to refrain from action, based on the belief that a particular elaborated approach or strategy will address the identified need or problem. Furthermore, a public policy should be well-reasoned and goal-oriented, aiming to serve society as effectively as possible (Young & Quinn, 2002). The rationale and justification of policy are well-studied subjects in literature, with policy reasoning generally grounded in either opinions and ideologies or evidence (Head, 2010). As illustrated in figure 5, increased pressure over time leads to a shift from opinion-based policy to evidence-based policy (EBP) (Sutcliffe & Court, 2005). Pressure is a significant factor in the water and subsurface sector, as issues related to climate change have a high degree of urgency, thereby increasing the pressure in policymaking processes (Trittipo, Samandari, Hatami, & Mysore, 2023).

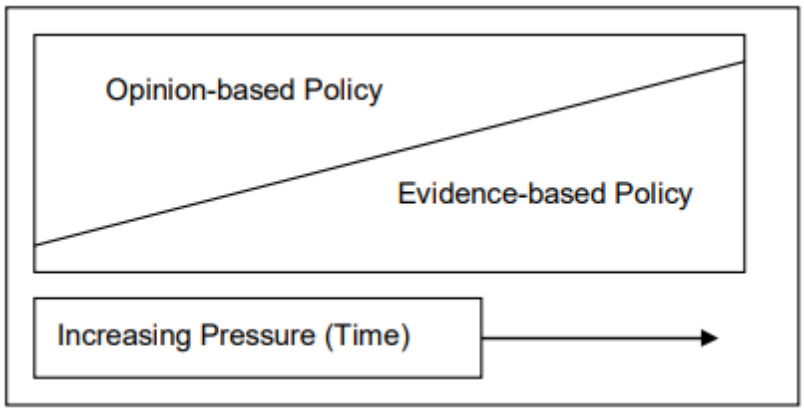

Figure 5: The dynamics of evidence-based policy (Sutcliffe & Court, 2005)

EBP is an approach that facilitates well-informed policy decisions by utilizing the best available evidence (Sutcliffe & Court, 2005). Unlike Opinion-based Policy, which relies on selective evidence or untested views often inspired by ideological standpoints (Davies, 2004), EBP aims to improve advice on the efficiency and effectiveness of public policy and its alternatives by employing reliable knowledge, such as qualitative data and experimental methods (Head, 2010). Policymakers in governmental departments must recognize the value of evidence, become informed about the available evidence, know how to excess the knowledge, and critically appraise it. Enhanced communication between researchers and policymakers through discussion forums and public research funding is essential (Sutcliffe & Court, 2005).

According to the EBP approach, policy should be based on high-quality, sound evidence from diverse sources (Head, 2010). One such source is research-based evidence or expert knowledge (Head, 2010), which should be collected through a systematic process of critical investigation and evaluation, theory building, data collection and analysis, and practice. Expert knowledge provides policymakers with high-quality, accurate, and objective evidence derived from cross-disciplinary research, thereby explaining current and past conditions and trends, and adding credibility and relevance to the available knowledge (Sutcliffe & Court, 2005). This knowledge comes from various research directions, including ethical research, economic research, or statistical modeling (Davies, 2004). While sources of expert knowledge are often complementary, they can also compete, underscoring the importance of multiple evidence types in the EBP approach (Head, 2008).

The second necessary type of evidence in the EBP approach is stakeholder knowledge (Davies, 2004), derived from professionals in the public, private and non-profit sectors who apply expert knowledge in their practice (Head, 2008). This source of evidence is crucial for advising policymakers on feasibility and effectiveness, as it adds practical experience to the available scientific evidence (Head, 2010). It bridge the gap between expert knowledge and policymakers' priorities (Oliver, Lorenc, & Innvær, 2014), who also consider organizational and cultural factors in their decisions (Head, 2008), making the available evidence more accessible and applicable (Sutcliffe & Court, 2005).

A third type of evidence necessary for public policymaking is political know-how and justification (Head, 2008). While accurate evidence, derived from various sources, is essential for developing business strategies and directions, political judgement provides the personal intuition and power needed to implement research findings (Head, 2010). The dialogue between researchers and policymakers, supported by practical evidence, is crucial as policymakers may have different definitions of evidence compared to researchers due to varying priorities and perspectives (Oliver, Lorenc, & Innvær, 2014). Political know-how also involves resource management, values, traditions, and institutional knowledge (Sutcliffe & Court, 2005).

In conclusion, public policymaking is characterized by the interplay between diverse stakeholder interest, each with their own perspectives (Head, 2008). The EBP approach emphasizes the need for evidence in policymaking processes rather than relying solely on the opinions of governmental bodies (Sutcliffe & Court, 2005). Figure 6 summarizes these findings and highlights the importance of varied evidence sources. This perspective aligns with the key stakeholders in the water and subsurface sector, namely the public, private, and academic sector (Edelenbos, van Buuren, & van Schie, 2011). The EBP approach aims to enhance the quality of policymaking, although the integration of evidence into public policies is a complex, non-linear process (Head, 2010).

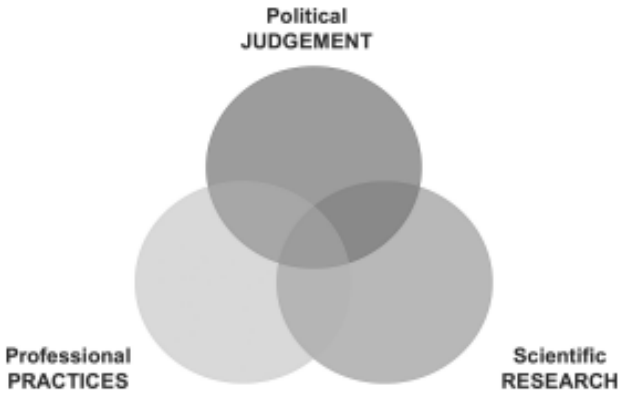

Figure 6: Three lenses of knowledge and evidence (Head, 2008)

The policy cycle

The policy cycle is a widely used approach to study public policy and the implementation of evidence. As depicted in figure 7, the policy cycle highlights various stages and elements of the policymaking process, although actual policy processes are rarely as linear or cyclical as implied in the model (Sutcliffe & Court, 2005). The model's strength lies in its ability to guide policymakers, as each stage of the cycle can potentially inform another stage. However, a notable weakness is that it cannot provide specific actions per stage due to its simplicity (Young & Quinn, 2002). Overall, the policy cycle effectively demonstrates the potential role of research or evidence at each stage of the policymaking process. Additionally, it illustrates that different stages may require different sources of evidence (Sutcliffe & Court, 2005).

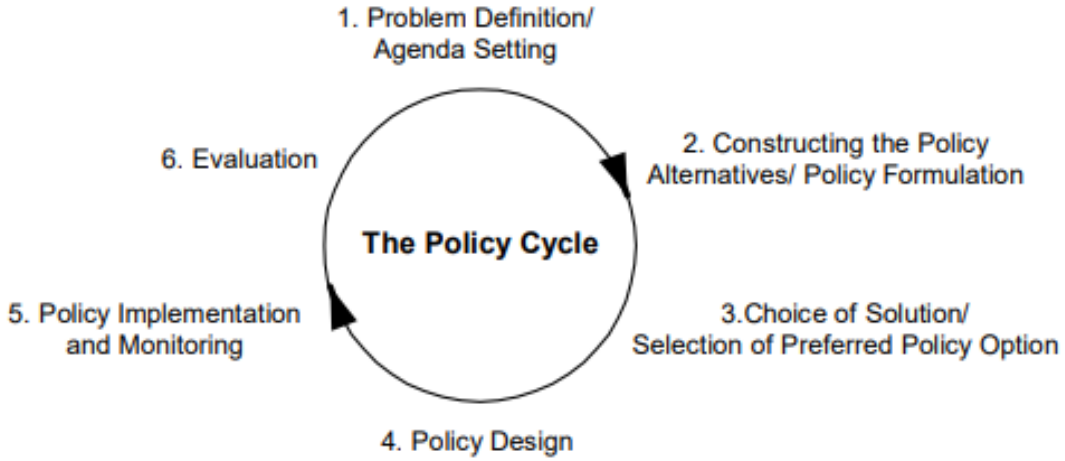

Figure 7: The policy cycle (Sutcliffe & Court, 2005)

The starting point in the policy cycle is the problem definition or the agenda setting. Typically, a societal problem or need is identified by a group of individuals who demonstrate the existence of an issue requiring governmental action, thereby elevating its priority on the government's agenda (Young & Quinn, 2002). This step necessitates clearly communicated and credible evidence to make policymakers aware of a particular problem (Sutcliffe & Court, 2005). Once the problem is identified and placed on the government agenda, the next step is to consider all possible options and formulate policy. In the third step, the options will be evaluated, and the preferred one will be chosen (Young & Quinn, 2002). In the previously mentioned two steps, the quantity and credibility of evidence is important since policymakers should make informed decisions about policy directions (Sutcliffe & Court, 2005). In the fourth step, the government determines how to effectively implement the policy by selecting policy instruments and partners. This is followed by the implementation and monitoring stage, where progress will be tracked (Young & Quinn, 2002). Operational evidence from both expert knowledge and practical experience is crucial to improve the effectiveness of implementation (Sutcliffe & Court, 2005). The evaluation of the effectiveness of the implemented policy is the last step of the cycle, which is also the basis for future policymaking processes. This stage should involve not only policymakers but also partners from participating public, private, and non-profit organizations (Young & Quinn, 2002). The evidence used at this stage should be objective, thorough, and relevant for a comprehensive evaluation, and it should be communicated effectively to enhance the ongoing policy processes (Sutcliffe & Court, 2005).

A slightly different model, shown in figure 8, generalizes the flow of evidence in policy processes. This diagram similarly distinguishes between agenda setting, formulation, and monitoring, as seen in the policy cycle, but places greater emphasis on the varying time constraints between evidence needed

for pressing policy questions and that for longer-term strategic policy objectives. Different sources of evidence are often required at various parts of the policymaking process (Sutcliffe & Court, 2005). Both models share the commonality that multiple sources if evidence are essential in policymaking. In another context, innovations can be implemented or adopted to improve quality and enhance the outcomes in practice settings, with evidence playing a crucial role in the development and diffusion of innovations (Wandersman, Chien, & Katz, 2010). Therefore, the policy cycle and the diagram depicted in figure 7 can serve as preliminary steps in the formulation of a public sector organization's innovation strategy.

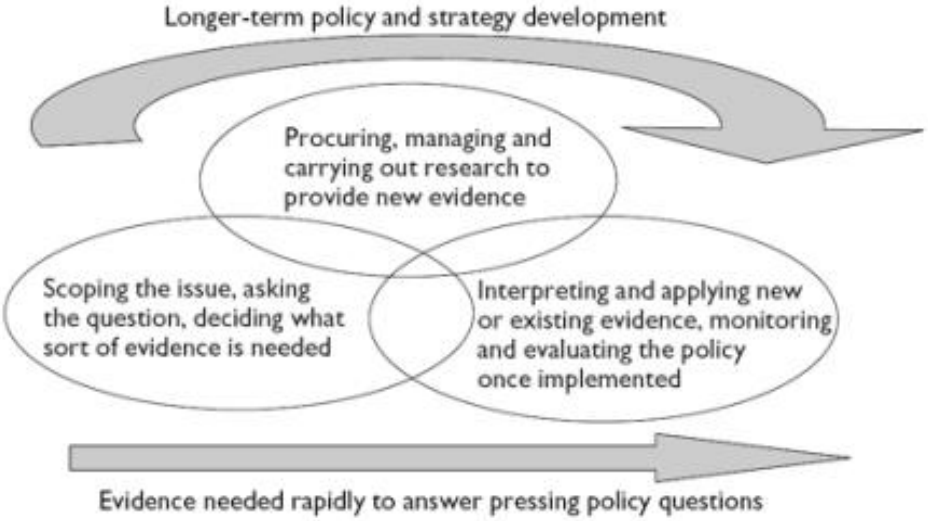

Figure 8: The flow of evidence in the policy process (Sutcliffe & Court, 2005)

2.3.2. The concept of an innovation strategy

The first notable aspect of an innovation strategy is that organizations are in general limited by scarce resources such as funding and capacity (Pisano, 2015). Organizations must decide how to distribute their innovation resources, which constitutes the innovation strategy (Karlsson & Tavassoli, 2016). As a result, organizations should identify potential chances to enhance their corporate objectives, construct clear innovative goals, make trade-offs, and allocate the available resources by applying focus on innovation directions (Lendel & Varmus, 2011). In that sense, the innovation strategy must be a roadmap which guides an organization towards achieving its innovative goals (Chen, Huang, Liu, & Zhou, 2018).

Secondly, an innovation strategy should be the sum of the strategic choices the people within an organization make regarding the innovation activities (Lendel & Varmus, 2011). Therefore, an innovation strategy is also a commitment to a set of policies or behaviors aimed at achieving the innovative goals. A comprehensive innovation strategy should promote the alignment among diverse groups within the organization but should also enhance the collaboration with other partners to stimulate the innovation process (Pisano, 2015). So besides keeping track of your own innovation process, an innovation strategy should also take into account the objectives of the partners outside the company (Adner, 2006).

Finally, an innovation strategy should facilitate the development and diffusion of the chosen innovations to, especially for public organizations, arrive at societally desirables and sustainable solutions (Ortt & Kamp, 2022). This facilitating mean of the innovation strategy should help organizations to overcome potential barriers during the innovation process (Pisano, 2015).

2.3.3. STO framework

A framework widely used for the structuring and implementation of innovation strategies is the strategic, tactical, and operational (STO) framework, shown in figure 9. The STO framework provides a comprehensive approach to investigate innovation strategies by considering various strategic perspectives. During or at the end of the innovation process, this framework can also be used in evaluating the effectiveness of an innovation strategy at aggregated levels. At its core, the STO framework provides a hierarchical approach to innovation strategies, delineating three distinct levels: strategic, tactical, and operational (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017).

Figure 9: The STO framework (Bautista, 2024)

The WHY-question should be answered by the definition of the strategic level, this determines the long-term vision and context. The tactical level should answer the WHAT-question, describing in more detail what should be achieved to comply with the strategic level. The HOW-, WHEN-, and WHERE-questions should be answered in the operational level, which are specific execution plans for the implementation. In parallel to the three levels of the innovation strategy, a WHO-question is crucial to investigate the actors involved, how they influence the strategy, and what specific actors should do (Mulder, Hommes, & Horstman, 2011).

A major pitfall in innovation strategies is that broad strategic goals are described, but the operational implementation plans are missing (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017). The tactical level is crucial, being the link between the strategic goals and operational objectives. In other words, the tactical level of a strategy can serves as the visualization of the relationship between the strategic and operational goals, at an intermediate level. The tactical level should mediate the connection between the strategic and operational levels (Lodder & Slinger, 2022).

2.3.4. Innovation strategies for public organizations

As previously mentioned, important aspects of an innovation strategy are; allocating of available resources, addressing the development and diffusion of innovations by overcoming barriers and leverage opportunities, and fostering the collaboration within and outside the organization. In addition, the policymaking process is particularly important in the public sector as the preceding step of an innovation strategy.

In conclusion, the innovation strategy for a public organization is a comprehensive plan that aligns strategic policy goals with implementation plans by applying focus through resource allocation, fostering internal and external collaboration, and ultimately facilitating the development and diffusion of innovations.

2.4. Conceptual framework

The theory presented in the theoretical background serves as the foundation for the conceptual framework illustrated in figure 10. Key factors influencing an innovation strategy and its development include the characteristics of innovations, public sector characteristics, stakeholder dynamics within the water and subsurface sector, and governmental policymaking. RWS must consider these factors, as outlined in the theoretical background, to develop an innovation strategy that addresses the sector's challenges and needs.

An effective innovation strategy comprises a strategic level with long-term goals and an operational level with implementation plans and targets. Often missing in organizational innovation strategies is the tactical level, which addresses WHAT-questions to bridge the gap between the strategic and the operational levels. This tactical level is crucial as it provides the necessary link, focusing on what is required to achieve strategic goals through operational execution.

The theoretical background outlines the intended effects of an effective innovation strategy tailored to the needs of RWS and the water and subsurface sector. Effective resource allocation, given the scarcity of resources, should provide focus. The strategy should also foster both internal and external collaboration to accelerate innovation processes. Furthermore, the development and diffusion of innovations should be supported not only by the innovation strategy but also by resource allocation and enhanced collaboration. Resource allocation and collaboration are interdependent and jointly influence the development and diffusion of innovations. However, while innovation development and diffusion do not directly impact resource allocation and collaboration, the latter are essential for fostering innovation.

In conclusion, based on the conceptual framework, the innovation strategy of RWS should be a comprehensive plan, influenced by innovation characteristics, public sector characteristics, stakeholder dynamics within the water and subsurface sector, and governmental policymaking, that aligns strategic goals with implementation plans by applying focus through resource allocation, fostering internal and external collaboration, and ultimately facilitating the development and diffusion of innovations.

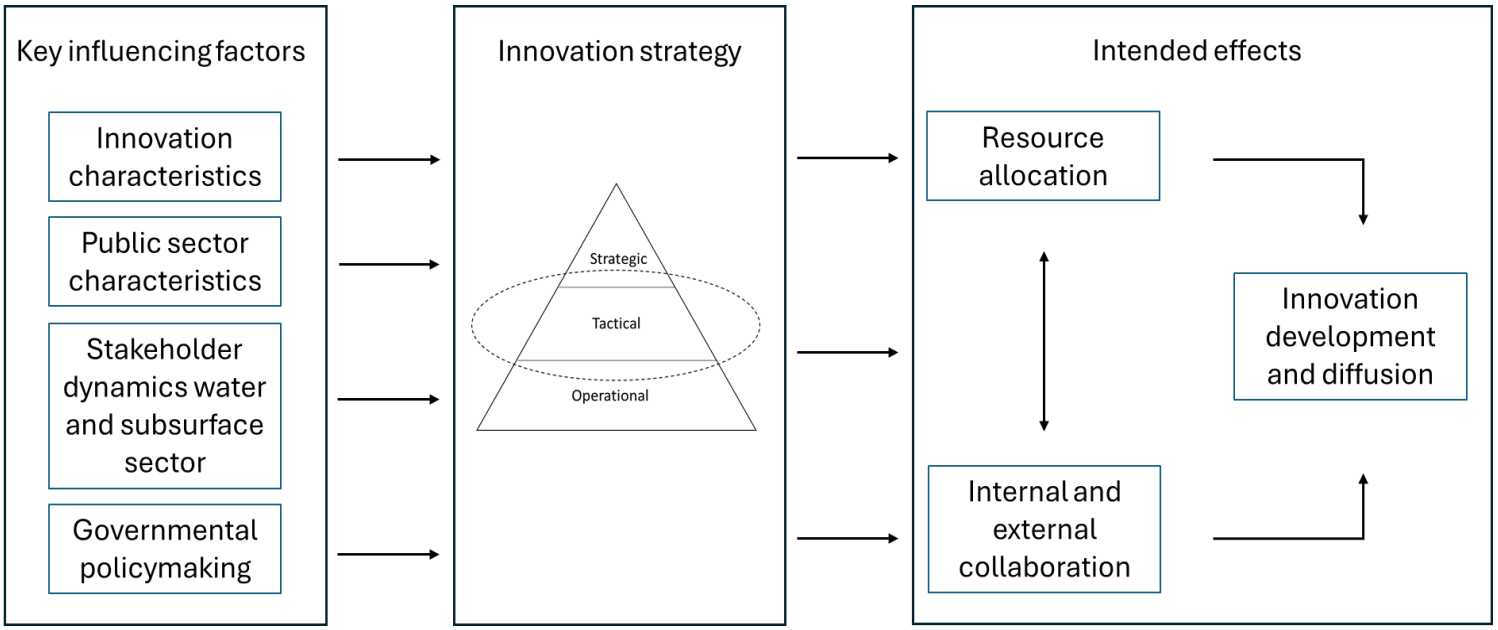

Figure 10: Conceptual framework

3. Research method

This chapter outlines the research method and explains the choices made during the research phase. The research outline provides a general overview of the research process, summarized in figure 11. The research strategy details the specific steps taken and the methods of data collection and analysis. Additionally, the third sub-chapter discusses the validity, reliability, and replicability of the research. The final sub-chapter reviews the Human Research Ethics policy of TU Delft and describes shortly the measures to safeguard participants from privacy and ethical concerns.

3.1. Research outline

Figure 11 illustrates the research flow diagram, describing the research process. The line of reasoning behind the sub-questions and the activities necessary to investigate them are explained. The diagram is used to explain how the questions are addressed.

The research process started with the problem definition, where literature study is conducted on public sector innovation strategies and the key influencing factors of such a strategy. The main research topics for the literature study are: characteristics of innovation, public sector characteristics, stakeholder dynamics in the water and subsurface sector, governmental policymaking, and innovation strategies. Literature review, internet sources, and RWS documents are mainly used during the literature study. At the end of the problem definition phase, the conceptual framework is constructed and the main research question and four sub-questions are defined.

The initial two sub-questions aim to give an outline of RWS's current innovation strategy and the way RWS developed it. This part starts with a thorough study on innovation strategies in general, the current innovation strategy of RWS and the processes preceding the current strategy. Both internal and external factors influencing the (development of the) innovation strategy of RWS are identified and discussed. Additionally, information is gathered through semi-structured interviews with four RWS experts closely engaged in RWS's organization and their innovation strategy. Insights not available from literature, but shared by individuals within the organization, complement the literature-derived information. The interviews are used to gain insights in the innovation strategy of RWS in as objective a way as possible. The experiences of actors with this strategy are addressed through the next sub-questions.

Next, the influence of RWS's innovation strategy in the water and subsurface sector is examined and analyzed. Insights from the previous sub-questions and the literature review are used to construct interviews for project leaders of RWS and Deltares who are working on innovations in the field of water and subsurface management, particularly regarding climate adaptation and sustainable infrastructure. In addition, more strategically oriented RWS and Deltares employees are questioned about the influence of RWS's innovation strategy on the sector. Climate Adaptation and Sustainable Infrastructure are two of the focal points of RWS regarding innovations and this narrows the research scope to a specific group of innovations characterized by urgency due to climate change. This delimitation results in comparable cases during the research. Also an interview with a contractor, was conducted to reflect on the other findings. Finally, enhancements for RWS's innovation strategy are given. This evaluation provides recommendations for the enhancements of RWS's innovation strategy to foster its influence in the water and subsurface sector. The third and fourth sub-questions are addressed in this part of the research. The final step of this research involves reflecting upon the research and drawing conclusions. Taken together, the answers to the four sub-questions enable answering the overall research question.

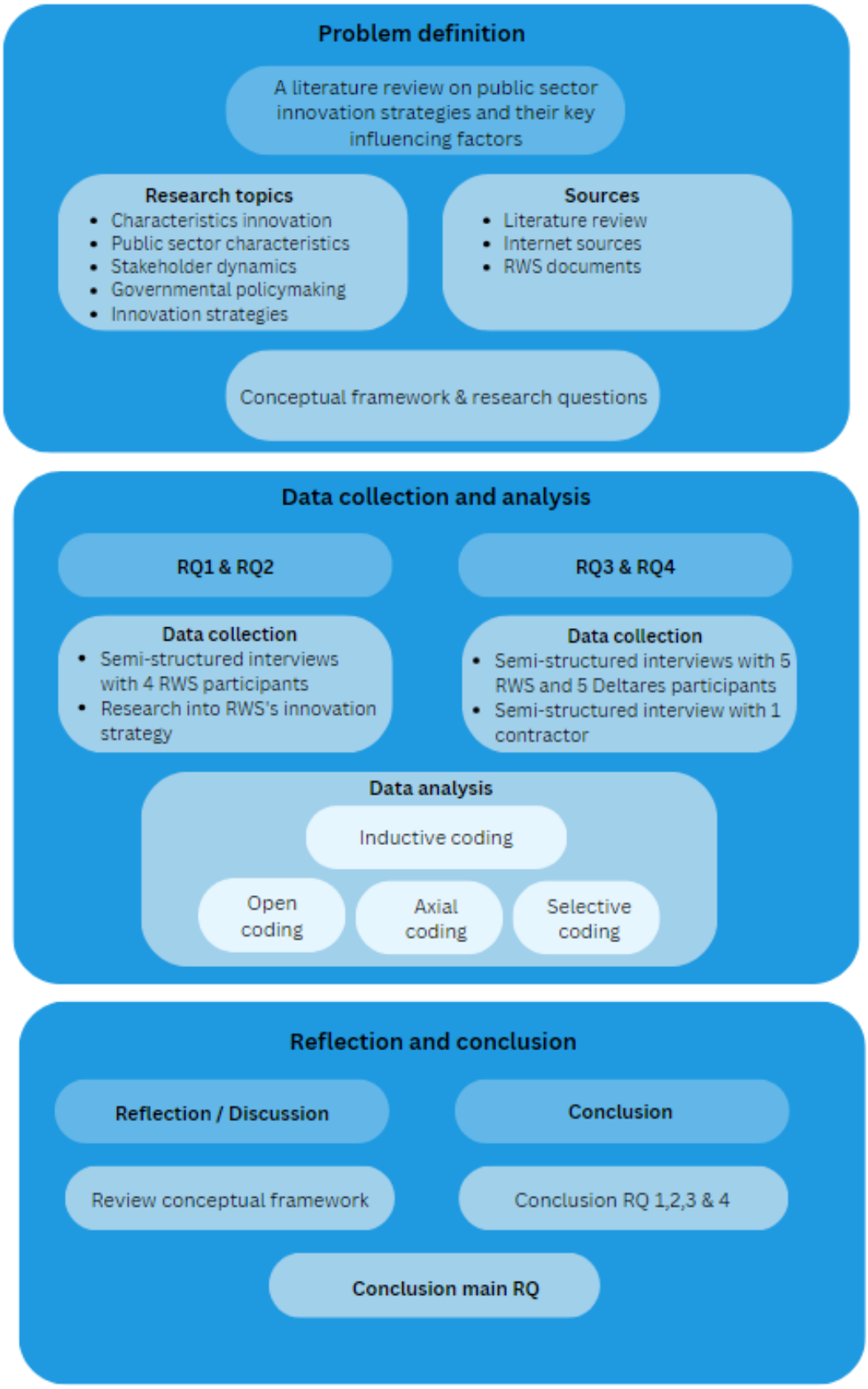

Figure 11: Research flow diagram

3.2. Research design

The research design outlines the methodical framework, serving as the structured plan followed to answer the sub-questions and the main research question, which is: '*What influence does Rijkswaterstaat's innovation strategy have on innovation processes in the water and subsurface sector?*'. While the research outline provides a broad overview of the study, the research design details the research method comprehensively.

3.2.1. Research strategy

Data collection – RQ1 and RQ2

This study employs a qualitative research approach aimed at theory development. Initially, a thorough literature review provides the theoretical background necessary to understand the situation. This includes examining RWS as a public organization in the water and subsurface sector, influenced by various factors and actors, and aiming to improve the development and diffusion of innovations with their innovation strategy. Once this background is established, the research shifts focus to RWS's innovation strategy.

The first part of the research examines the current innovation strategy of RWS and its development, considering internal and external factors. Before conducting interviews, official RWS documents and additional literature on the RWS innovation strategy are reviewed to formulate a general understanding of the innovation strategy. Additionally, the study seeks to answer WHY-questions and HOW-questions to uncover the origins and rationale behind the strategy. This information is often missing in literature, but obtainable through interviews.

Semi-structured interviews were conducted both online and face-to-face, each with a duration of approximately one hour. The interviews were semi-structured to allow for unforeseen remarks during the conversation and the questions are mostly based on literature or gaps in literature. The interview questions for sub-question 1 and 2 are shown in Appendix A. The advantage of semi-structured interviews is their ability to gather significant, often missing, additional information on a certain topic. However, a potential disadvantage is that the interviewees can significantly influence the direction of the interview, complicating data analysis and reducing data comparability.

For this phase, four interviews with RWS employees were conducted: Two with managers from the Innovation and Knowledge department and two with Innovation and Knowledge advisors. The managers provided a general overview of the innovation strategy, while the advisors offered specific information on two themes within the strategy. The first theme is 'Climate Adaptation', a relatively new theme in RWS's innovation strategy. The second theme is 'Sustainable Infrastructure', a more developed one. This theme is also often referred to as 'Sustainable Living Environment', but in this study, 'Sustainable Infrastructure' is used for consistency. These themes are comparable since climate adaptation was previously part of the infrastructural theme, climate change influences Sustainable Infrastructure, and employees working on both themes frequently collaborate. Table 2 lists the participants of the semi-structured interviews.

Table 2: List of participants sub-question 1 and 2

Interview	Organization	Profession
1	RWS	Manager Innovation & Knowledge management
2	RWS	Manager Innovation & Knowledge management
3	RWS	Advisor Innovation & Knowledge management Climate Adaptation
4	RWS	Advisor Innovation & Knowledge management Sustainable Infrastructure

The purpose of this phase is to compare the information from a few interviews with existing literature to develop knowledge about RWS's innovation strategy and its overall development. Potential interviewees were selected through theoretical sampling, focusing on information-rich cases to enhance the generalizability of the data. The interviewees were approached by email, asked to complete an informed consent form, and interviewed. The interviews were audio-recorded and transcribed into anonymized interview data. After the interviews, an email was sent to thank all the participants, reminding them that the anonymized interview data was available for review and adjustments until the publication date. This research is a case study, with RWS's innovation strategy as the unit of analysis. The strategy is described and explained inductively based on a few cases, and comparing existing literature with new interview data.

Data analysis – RQ1 and RQ2

After conducting the interviews, the anonymized interview data was utilized to address the first and second sub-question. These questions are not answered separately; instead, all necessary information is provided within the chapter on sub-questions 1 and 2 (chapter 4). A wrap-up at the end of the chapter concludes and answers both questions individually.

Inductive coding was employed to analyze the interview data. This approach allows the researcher to interpret new data and compare it with existing literature. The coding process, illustrated in figure 12, consists of three steps. Given that this part of the study includes only four interviews, the coding process was done manually.

Firstly, during the open coding phase, the interviews were individually scanned and read, with insightful information highlighted and potential categories formulated. Secondly, in the axial coding phase, relationships between the categories were investigated by comparing the potential categories across interviews. Finally, selective coding was applied to define the core categories for answering the first and the second sub-questions. These selected categories correspond with the sub-chapter titles in the relevant chapter. A summarized and anonymized version of the coding process is shown in Appendix B.

The new information gathered from the anonymized interview data, combined with existing literature, allows the researcher to objectively answer the first two sub-questions. This process involves collecting the necessary information about the innovation strategy, serving as a foundation for the next phase of the study.

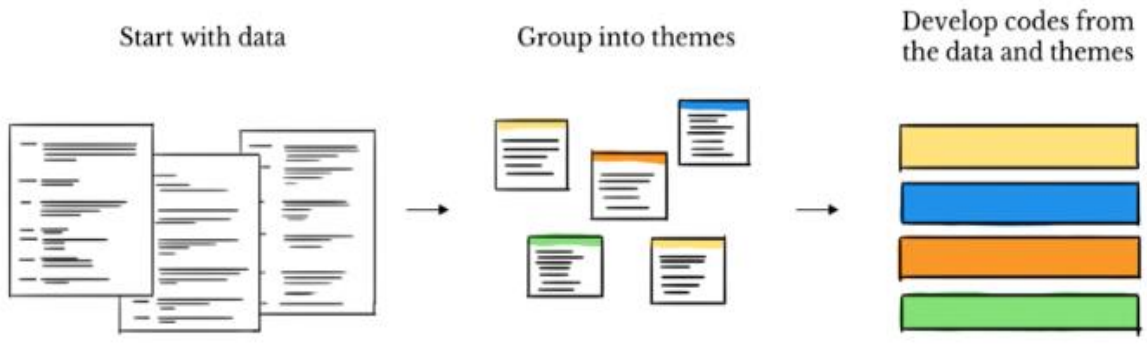

Figure 12: Inductive coding process (Ho & Limpaecher, 2021)

Data collection – RQ3 and RQ4

Similar to the first phase of the research, a list of interview questions was constructed based on literature. Additionally, data from the previous phase informed the construction of relevant questions addressing the third and fourth sub-questions. While the previous phase focused on data to describe

the innovation strategy, this phase shifts perspective. The innovation strategy of RWS remains the unit of analysis, but now the emphasis is on its influence on innovations in the water and subsurface sector, specifically examining collaboration among different actors, the development and diffusion process, and the role of the innovation strategy in providing focus.

Once again, semi-structured interviews both online and face-to-face were conducted, with a duration of approximately 30 to 60 minutes. These interviews allowed participants to discuss the noticeable influence of the innovation strategy in the sector and share any additional insights. The interview questions, detailed in Appendix C, were based on literature and previous interviews, focusing on the intended effects of the strategy as mentioned above (focus, collaboration, and innovation development and diffusion) while leaving room for unforeseen additions from practical experience. This phase heavily oriented towards theory development and follows a grounded theory approach, using a significantly large number of interviews to develop theory by closely connecting data collection and analysis.

A limitation of the research is the selection bias introduced by the researcher, as information-rich cases were sampled. Additionally, personal biases can influence the interview questions and the participants' responses, potentially leading to biased data collection. Selection bias was minimalized by including participants from different organizations with varying perspectives and goals. Subjectivity was managed by interviewing a significant number of people and asking both open and literature-based questions.

For this phase, ten interviews were conducted with experts in climate adaptation or sustainable infrastructure. Participants included experts from both Deltares and RWS to provide a diverse range of perspectives. The participants were selected based on their expertise, using a purpose sampling strategy. The interviews were audio-recorded and transcribed into anonymized interview data. Following the interviews, participants received an email to thank all the participants, reminding that the anonymized interview data was available for review and adjustments until the publication date.

RWS participants were chosen based on their current or past collaboration with Deltares on projects related to climate adaptation and sustainable infrastructure. Similarly, Deltares participants were selected based on their work for RWS on climate adaptation and sustainable infrastructure projects. Some interviewees held strategic positions, while others were project leaders or advisors. The semi-structured interviews were tailored to each participant's professional expertise, aiming to gain insights into the influence of the innovation strategy in their daily work. The collected data will also inform potential enhancements to the innovation strategy of RWS. Table 3 lists the participants of this phase of the study.

Table 3: List of participants sub-question 3 and 4

Interview	Organization	Profession
5	Deltares	Expert advisor sustainable infrastructure
6	Deltares	Administrative advisor
7	Deltares	Expert coastal and estuarine policy management
8	Deltares	Expert climate adaptation
9	Deltares	Expert river engineering
10	RWS	Project manager waterway maintenance
11	RWS	Advisor innovation
12	RWS	Innovation manager river management
13	RWS	Senior advisor climate adaptation
14	RWS	Expert nature-based solutions

For the fourth sub-question, which involves reflecting on the innovation strategy to provide areas for improvement, an additional interview was conducted with a market party. A department head from Royal BAM Group (BAM), a contractor related to the water and subsurface sector who has experience working with RWS and Deltares on innovation projects, answered the questions shown in Appendix D. BAM is a large Dutch construction company, and the participant particularly works on coastal engineering and water management. Table 4 lists the participant and their profession. This interview does not provide a complete picture of the market parties in the sector and is insignificant compared to the interviews with RWS and Deltares participants. However, market parties, and in particular contractors, were frequently mentioned in the responses to the interview questions. Therefore, it provides valuable information that can support the other interview results, used only for the reflection.

Table 4: Participant market party sub-question 4

Interview	Organization	Profession
15	Royal BAM Group	Head of the water department

Data analysis – RQ3 and RQ4

The interview data for sub-questions 3 and 4 is used to answer these questions separately. First, the influences of RWS's innovation strategy are analyzed. Following this, an evaluation suggests potential enhancements for the strategy. As before, the anonymized interview data and existing literature are utilized to address the questions.

The same coding process is employed to analyze the data, but this time it involves a significantly larger number of interviews than in the previous phase. The process still includes open, axial, and selective coding, but Excel software is used for support and control. The interviews are scanned, potential categories highlighted, relationships between categories investigated, and core categories defined. Excel assists in validating the categories by testing word counts to ensure they align with the interview data. A summary of the data analysis is shown in Appendix E. After the analysis was achieved, the data is used to build a narrative story. Three of the innovation examples mentioned in the introduction are used in building the narrative story and applies the results directly to practical situations. The Xstream blocks (product innovation), the SRL tool (process innovation), and the addition of sustainability in maintenance contracts (organizational innovation) are used to clarify the results.

The data from the interview with the contractor is used to support the data from participants of RWS and Deltares in the fourth sub-question. Interviewing a single market party provides too little information to draw the same conclusions as those derived from the interviews with RWS and Deltares participants, but it can be added for support in reflecting on RWS's innovation strategy and the information that emerged from the interviews with RWS and Deltares participants regarding market parties. On the other hand, market parties are frequently mentioned by the participants, and the information can be partially confirmed in this way. The data was coded in the same way as the other interview data, using the three steps of open coding.

3.2.2. Reliability, validity, and replicability

Reliability pertains to the consistency of assessment and whether results can be repeated. Given that interviews are used for data collection and participants responses can vary, the results will inevitably differ somewhat and thus are not entirely repeatable. The selection of participants can improve the repeatability but cannot guarantee it (Sekaran & Bougie, 2016).

Inter-rater reliability is ensured by coding all the interviews in the same way, to ensure that the data interpretation remains consistent. Content validity is ensured by executing a thorough literature study

in advance and by consultations with experts in the field before the interviews to make sure that all relevant aspects are addressed. Furthermore, data triangulation ensures criterion validity since results of different data sources are compared (Sekaran & Bougie, 2016).

Interview research has inherent challenges that affect its replicability. Since interviews rely heavily on the individual responses of participants, which can vary due to personal perspectives, experiences, and context, the exact replication of results is difficult. Even if the same questions are asked, the answers can differ each time, leading to variability in the outcomes. Additionally, factors such as the interviewer's influence, interview conditions, and the specific timing of the interviews can further contribute to the differences in results. These elements make it challenging to achieve perfect consistency in interview-based research.

However, certain measures can enhance the replicability of interview research. Standardizing the interview protocol, including using the same questions and interview structure, helps maintain consistency. Using one method for data analysis ensures uniformity in analyzing responses, reducing subjective bias (Sekaran & Bougie, 2016). The careful selection of participants and thorough documentation of the research process, including detailed notes on the interview context and conditions, also contribute to improving replicability. While these steps cannot eliminate all variability, they help create a more consistent framework for conducting and replicating interview research.

3.2.3. Ethics

To ensure compliance with the Human Research Ethics policy at TU Delft, approval was obtained, and interview participants signed an informed consent form. The example form of the informed consent is shown in Appendix F. Protecting participants' privacy is crucial, as the disclosure of sensitive information and controversial quotes may potentially harm their professional careers. Even though personal data is not included in the research, privacy issues could still arise. Therefore, several measures have been implemented to safeguard the participants' privacy.

Firstly, all interview data is stored offline to minimize the risk of data breaches. Furthermore, audio-recorded data are transcribed and anonymized immediately after the interview, and the original recordings are deleted afterwards. Additionally, access to the data is restricted to individuals directly involved in the project. No one else can access the data without explicit permission from those individuals. Finally, interview participants have the opportunity to review and revise their anonymized interview data until the publication date. For more information on privacy and ethics measures, please refer to the informed consent form, the data management plan, and the Human Research Ethics checklist.

4. Research Findings – Exploring RWS's innovation strategy

The first part of the research findings addresses RWS's innovation strategy and its development, answering the first two sub-questions. As outlined in the methods chapter, four interviews were conducted with RWS managers and advisors who are closely involved in the development of their innovation strategy. This chapter focuses on the innovation strategy in general and two specific so-called focal points of that strategy: Climate Adaptation and Sustainable Infrastructure. Quotations from the interviews are presented in italics and between quotation marks. It is important to note that only RWS employees participating in the four interviews have been referenced in this chapter. Additionally, various reports and other literature have been utilized to complete the narrative and ensure consistency in interpretation. The two sub-questions for this chapter are:

- *What is the current innovation strategy of Rijkswaterstaat?*
- *How did Rijkswaterstaat develop its current innovation strategy within the water and subsurface sector depending on both internal and external factors?*

4.1. RWS's innovation strategy

4.1.1. Innovation agenda

The climate is changing rapidly, mobility is growing, space is becoming scarcer, energy consumption needs to be cleaner, and infrastructure such as bridges and tunnels reaching the end of their lifespan (Rijkswaterstaat, 2023). Developments in RWS's work area are happening faster than ever. *"We have a RWS strategy for the entire organization, called the Kompas RWS. The Kompas is an exploration of what is happening in the Netherlands and how it affects RWS. From this exploration, we identified five themes where we need to focus more effort because they represent the most significant changes. These themes align, in part, with the transitions occurring in the Netherlands."* The five themes, also known as focal points, are: Replacement and Renovation, Sustainable Infrastructure, Climate Adaptation, Smart Mobility, and Data and Information Provision (Rijkswaterstaat, 2023). RWS utilized the expertise of various stakeholders in the water and subsurface sector during the exploration to identify these focal points. *"The exploration is a societal analysis based on trends and future expectations. The insights come from an exercise that lasted about a year, during which we spoke with many different groups, from young people to businesses to politicians."*

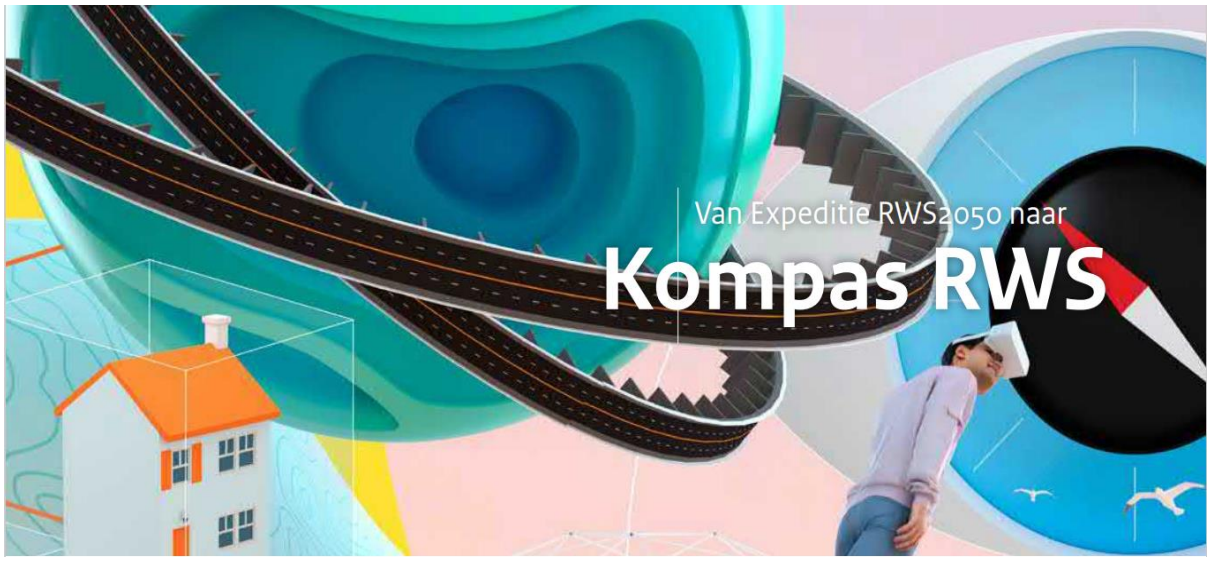

Figure 13: Front page Kompas RWS (Benschop & Ovaa, 2021)

The Kompas RWS, its front page shown in figure 13, guides along two key lines, namely continuity and development. Continuity is essential because most of RWS's work must remain balanced to ensure the safety of the country, while development is necessary because fundamental changes are required in specific areas to guide the future. A specific priority, in addition to the five mentioned focal points, is task-oriented collaboration, as this is seen as a crucial condition for following the RWS strategy. The Kompas RWS is based on future scenarios, societal expectations, and the goal of creating societal value (Benschop & Ovaa, 2021).

Apart from the Kompas, RWS does not have a separate strategy dedicated to innovation. *"We do not have a separate innovation strategy. In fact, our innovation agenda serves as our strategy."* The front page of the innovation agenda is shown in figure 14. The Kompas focuses on continuity and development, while the innovation agenda primarily focuses on the development. This agenda is a document published by RWS, updated every 2 years, that outlines their short-term and long-term ambitions and priorities in innovation. *"We do have an agenda for 2030, but we also outline what we are going to do in the next two years. We typically look back on what we have achieved in the past two years, and ahead to the next two years to prioritize what needs attention and what we need to actively pursue."* According to RWS, this timeline is logical given the nature of their activities. *"I think that what we are currently doing, setting a target on the horizon for the coming 9 or 10 years, and updating it periodically, is the only thing that works. The projects we work on typically take a very long time. Innovations often take up to 10 years. It would be strange to have a 2-year agenda in such cases. So, I believe you need to ensure it is well organized at various levels."*

Figure 14: Front page RWS's innovation agenda (Rijkswaterstaat, 2023)

Additionally, the innovation agenda aims to inform the outside world about its challenges, providing guidance for the dialogue with their partners (Rijkswaterstaat, 2023). *"We at RWS are on the demanding side, which is why we need to effectively utilize innovation projects to mobilize the market and achieve various goals. We are confronted with a public task, and as long as people perceive that the government is not taking action, the market will also remain inactive. RWS often encounters bottlenecks during implementation, but solutions usually come from the market."* This also highlights the aim of the innovation agenda to steer its own organization. *"The agenda should help us to indicate our needs in an increasingly concrete and targeted manner, in order to send a signal to the market and authorities to collaborate and invest."* Especially market parties need a clear signal to collaborate and invest since *"market parties always remain each other's competitors, so it is a challenge to continuously innovate together."*

4.1.2. Focal points

The Kompas I&W and the Kompas RWS were launched in parallel to ensure alignment between them, which is why a corresponding approach was chosen. The Kompas I&W serves as a strategy for the entire department, while the Kompas RWS provides input and contributes to the Kompas I&W. The main points of Kompas I&W include: An innovative balance between safety, livability, and accessibility; climate adaptation, sustainable infrastructure, digitalization, and information provision as key themes; strengthening manageability of projects; professionalizing the collaboration between policy and implementation; more task-oriented work; and increased transparency to the public (Benschop & Ovaa, 2021).

So, the five focal points in RWS's innovation agenda align not only with the Kompas RWS but also with the Kompas I&W, which outlines the main challenges in the Netherlands. *"We are the operational organization of the ministry of I&W, so it is logical that the Kompas RWS and Kompas I&W align."* One of the key themes in the Kompas I&W is climate adaptation, which is also a focal point in RWS's innovation agenda since the update in 2023. *"At I&W, climate adaptation had long been a focal point. So, we decided that we should also include it, enabling better and easier collaboration between execution and policy."*

The focal points stem from policy decisions and play a fundamental role in shaping the innovation agenda. *"The only thing we received from the board was that the innovation strategy had to be drawn up along the specific focal points."* They form the foundation of the innovation agenda and are essential for developing the innovation portfolio. Additionally, they are intended to identify areas with less innovation, but also ensuring that existing innovations not mentioned in the agenda not deemed less valuable. *"Within those focal points, RWS has the freedom to focus on certain topics where innovation is less visible since many innovations are already there."* The focal points serve as guidelines but are not definitive barriers to innovations outside the main themes. *"If someone comes with a very strong proposal and wants to start something outside the focal points, there is limited space for it. However, the mainstream approach is to innovate along the focal points. It is not that we completely rule out anything that does not fit into a focal point; again, it has to be a very compelling proposal."*

The main focal points in this study are Sustainable Infrastructure and Climate Adaptation, but table 5 shows examples of innovation projects fitting to each focal point. Many innovations are not limited to one specific focal point since there is often overlap between different focal points. However, there are also many innovations that are driven specifically by a single focal point (Rijkswaterstaat, 2023).

Table 5: Example projects related to the five focal points

Focal Point	Innovation projects 2023-2024
Sustainable Infrastructure	Rejuvenation spray to extend the lifespan of asphalt.
Climate Adaptation	Test location to assess the resilience of roads against extreme weather.
Replacement and Renovation	Data-driven asset management to predict the lifespan of tunnels.
Smart Mobility	AI-driven detection in bridge operation.
Data and Information Provision	Virtual representation of water barriers using a digital twin.

4.2. Developing the innovation agenda

4.2.1. Preceding the innovation agenda

*"There has been an innovation agenda before in the past, but it was never really widely supported by RWS, and no implementation plan was attached to it. The predecessor of the current innovation agenda (*2030*) is the innovation agenda 2015-2020. The recalibration of the formal agenda was also the start of the development of the current innovation agenda."* RWS's Water, Traffic and Living Environment department (WVL) is responsible for (the development of) the innovation strategy, but that has not always been the case. "*In the past, the Innovation and Market department was responsible for the innovation strategy since RWS believed that the link between innovations and the market was so significant that someone from that department should set the innovation agenda. WVL is responsible for Knowledge and Innovation."*

WVL employees involved in setting the innovation agenda have consulted those responsible for the formal innovation agenda to learn from their practical insights. "*One of the lessons was that people, internal as well as external actors, were given too much opportunity to make additions. This resulted in an innovation agenda with 10 focal points, which was far too broad to provide direction. As an example, social challenges was such a theme, which indicates how broad the themes were."* Besides the lack of direction, another important lesson emerged about the implementation of the innovation agenda. "*The implementation of the formal innovation agenda has never been actually followed up. That is the reason why this agenda must also have an implementation plan attached to it. So, we wanted the board not only to agree on the agenda, but also on the implementation plan to prevent us for ending up in the same situation. Because then you once again have an innovation strategy without power, because you cannot implement it."*

4.2.2. Developing the first version

As mentioned, the innovation agenda has been made on the basis of the focal points set by policymakers. *"Those focal points were used to organize consultation meetings per theme, where also people from private organizations and knowledge institutes were asked to provide input. This was the first step towards the current innovation agenda."* Thus, the focal points played a crucial role in the initial phase of developing the new innovation agenda. *"The input from the consultation meetings was used to formulate the first version of the roadmaps, which indicates what RWS wants to achieve in 2030 for several prioritized innovation directions per focal point and how."* For example, the focal point Sustainable Infrastructure has four transition paths, which are the roadmaps, focusing on climate neutral and circular work processes in fields that have the most impact: "*Transition path Pavements, Transition path Sustainable engineering constructions, Transition path Road, Dyke, and Rail Equipment, and Transition path Maintenance of the coastline and fairways."*

During the consultation meetings, RWS learned from the lessons of the previous agenda. The focal points were fixed, allowing partners only the opportunity to share their knowledge and provide feedback on these topics. *"Now RWS only asks for advice on the prioritized tasks, which are*

unchangeable. Everyone could provide feedback and advice, but the final decisions are made by RWS." This led to the creation of the first version of the innovation agenda 2030 in 2021. *"The results from the consultation meetings and the first version of the roadmaps were used to formulate a first version of the innovation agenda in 2021. This version was discussed with all kinds of branch organizations like Bouwend Nederland, Koninklijke NLingenieurs, and Techniek Nederland to involve as many people as possible."* Subsequently, RWS campaigned vigorously among internal and external partners to raise awareness by launching the agenda in 2021. *"We launched the agenda during an innovation festival, which was quiet a happening even though we had to do it online due to Covid."*

4.2.3. Update

"When publishing the 2021 version of the innovation agenda, we already decided to update the document every two years. The first update was in 2023, where the roadmaps in particular were evaluated and rewritten." Another major update was adding the focal point Climate Adaptation, which was not one of the focal points before. *"During the consultation meetings, a lot of criticism from among others private partners and knowledge institutes appeared on the fact that climate change adaptation was not one of the focal points yet. Also, policymakers criticized this since it was already an important theme for the ministry of I&W. It became very clear that we had to add that point into the new version of the innovation agenda."*

Climate adaptation was initially part of the focal point Sustainable Infrastructure, which was named Climate-neutral and Circular Infrastructure in the 2021 agenda. Adding Climate Adaptation as a separate focal point slightly altered the scope of this original focal point. *"The main objectives stayed the same, but for example nitrogen is added to the objectives. A small difference in scoping is one reason why RWS changed the name of the focal point."* Besides a shift in scope, there were also some organizational changes within the focal point. *"Several programs were merged to foster collaboration. Sometimes a new and more recognizable name helps."*

Updating every two years means that the next update is approaching. *"The next update will be in 2025 and we are already preparing that update. This will be a midterm since the current innovation agenda extends until 2030. The update will mainly focus on what we achieved so far compared to what we should have done according to the roadmaps. Furthermore, we will outline what we will do to achieve the goals and what we may need to do extra."*

4.3. Main content of the innovation agenda

4.3.1. Resource allocation

RWS is tasked with innovating within the scope of the focal points, which also guides resource allocation. However, this process is not without its complexities. "*Innovations come from different directions, which means that they will be assessed in multiple ways."* The following paths are mainstream for innovation: *"Firstly, an innovation may be initiated by a private or market partner of RWS through our 'Innovatieloket'. In that case the innovative idea will be assessed by experts of RWS and will be bounded to a focal point and a specific project with an available budget. Secondly, the ministry could ask RWS to do additional research into a certain topic and allocates monetary resources. A last trajectory is via financial resources from the department for national tasks, for example knowledge development and innovation. An annual amount of money is available to start new innovations to gain more knowledge into specific parts of the roadmaps."*

"The focal points lower the chances for additional innovations, but with such a large organization as RWS it is never excluded that innovations will start and continue via other routes." RWS endeavors to evaluate new innovations using a standardized weighing framework. *"This framework evaluates new*

innovations in a standardized manner, considering factors such as project ownership and subsidies." On the other hand, RWS cannot ignore the necessity for innovations outside the established focal points. *"National safety and accessibility became important themes that do not completely fit into a specific focal point. However, sometimes we try to incorporate them into existing focal points. These are examples of urgent themes outside the current focal points which cannot be disregarded."*

4.3.2. IUP Guide

The updated innovation agenda lists several tools aimed at assisting innovators throughout the innovation process. One of these tools is the 'IUP (Innovate, Standardize, Produce) Guide', as illustrated in figure 15. *"The IUP Guide is launched in 2019 by the board of RWS and aims to support the innovation process, specifically the shift from innovating to standardizing and the step from standardizing to producing an innovation. Especially the standardization phase turned out to be a difficult path with general recurring challenges."*

"RWS as an organization is relatively good at piloting, introducing new innovations, and technical validation. But a lot of employees working on innovations have problems with upscaling and the production employees often have a lack of knowledge regarding processes in the innovation phase." This makes it difficult in practice to scale an innovation to a different phase, although per phase enough expertise is present. The IUP Guide can help as a tool in the process, but on the other hand also causes more work. *"The IUP Guide could bridge that gap by providing support to start thinking about upscaling already in the innovation phase. This creates more organizational work for the innovator but increases the chances that an innovation enters a next phase in the process."*

"That innovating is not enough to speed up the innovation process is recognized by a lot of RWS employees, standardization and the production of innovations are the vital steps." The tool's recognition is increasing, however it is not yet widely used across the organization. *"The awareness among RWS employees is growing since a lot of employees working on innovations were involved in the development of the tool, but on the other hand, the IUP Guide is far from a common good at RWS yet."* Nowadays, it is merely an optional tool, but that could change in the future. *"In the future RWS should decide whether to use the IUP Guide as a prescriptive requirement or as it is now, a helpful tool."*

Figure 15: IUP Guide (Rijkswaterstaat, 2023)

"The I-phase of the IUP Guide can be divided into different Technology Readiness Levels (TRLs)*, which indicate how far an innovation is in the first phase of the IUP Guide."* The I-phase is often divided into three categories corresponding the TRL levels: exploration (TRL 1-3), development (TRL 4-6), and piloting (TRL 7-9). *"Stakeholder Readiness Level* (SRL) *is another part of the IUP Guide, which can be used to indicate how an innovation is accepted within organizations through a visual impact analysis."* The awareness of both tools is growing throughout the years. *"Within RWS it is noticeable that both TRL and SRL becoming more and more known."*

4.3.3. Roadmaps

Each focal point has or will have roadmaps for key subjects, featuring a timeline with activities and goals. The four roadmaps mentioned for the focal point Sustainable Infrastructure are *"continuously evaluated with a critical view on the progress regarding the predetermined priorities and goals."* At RWS, there are specific roles for employees to oversee innovations at a more detailed level for each roadmap. *"Each roadmap has its own transition path leader, responsible for the day-to-day progression of a specific roadmap and the bundling of gained knowledge from projects associated to the roadmap."* Looking to the future, having a long-term vision is particularly important, despite the uncertainties that exist. *"There is need for even sharper roadmaps with a vision towards 2040 to 2050 and these will be included in the next update. There is more available knowledge then before, but at the same time if you look into the future, you will encounter the same uncertainties as before. That is why it is also good to be clear and honest about the existing uncertainties."*

The focal point Climate Adaptation is relatively new since it was added to the innovation agenda in the 2023 update. *"At the moment, the innovation portfolio will be composed, and roadmaps will be made for the main bottlenecks encountered by RWS regarding climate adaptation. The definitive subjects for the roadmaps are not clear yet but are probably about dealing with extreme weather conditions on the main road network, dealing with drought and low river levels, the maintenance of the freshwater supplies and shipping, and the impact of climate change on water quality and ecology."* There are several significant challenges related to climate adaptation, but not every important subject in this area will have a roadmap. Climate adaptation is a broad field, and some innovations are already making good progress without one. *"If a certain topic is already going well, a roadmap is unnecessary since these topics often already have a route. The program regarding sea level rise is such a topic, which does not make it less important than topics with a roadmap."* The roadmaps for Climate Adaptation should also be in line with the goals of the Delta Program, which makes the process more difficult. *"RWS is willing to set the ambition for 2030, which is a challenge since it should be in line with the objectives of the Delta Program for 2050."*

4.3.4. Innovation conditions

The innovation agenda emphasizes three vital conditions to stimulate innovation processes. The first one is focus. *"A lot of innovations exist within RWS and the sector since there are large issues to be solved. Budget is a problem, but humanpower is even a larger one. That is the reason why RWS in general chooses for the innovation that contribute to their goals and priorities the most."* Sustainable Infrastructure is a focal point with a lot of focus due to the extensive description of the roadmaps, while Climate Adaptation is broader at the moment. *"The focus for Climate Adaptation is that everyone, regardless of what kind of innovative project they do at RWS, has to deal with climate adaptation. The impact of climate adaptation must be included in their work. However, do not get lost in the focus, because climate adaptation also has a very broad application."*

The second condition is to move faster from pilot to implementation. *"All kind of organizations have problems with upscaling since it is very challenging. Faster is not always possible, but efficient upscaling*

increases the enthusiasm of investing private organizations and ensures that objectives stay achievable." This condition is also vital for the focal points Sustainable Infrastructure and Climate Adaptation. *"The maintenance tasks are large and the fact that climate adaptation is a focal point highlights the need for faster innovation since the climate is currently changing faster than our networks."*

The last vital condition for innovation is collaboration. *"We at RWS never innovate alone, but always in consultation and collaboration with other parties. We wanted to emphasize new ways of collaborating in the innovation agenda to make it more widely known."* Those three conditions are specifically mentioned in the innovation agenda as important, but other conditions were also taken into account. *"Of course there are more points of interest, but we wanted to go an extra step on the previous three points. The innovative capacity of our organization and learning from innovations are also very important and are included in a separate chapter of the agenda."*

4.3.5. Additional documents

Within RWS there are two other documents that are used to indicate the innovation strategy. The reason for this is that it is difficult to make one document leading throughout the entire organization. *"Then we would be working on that full time, which is a waste of valuable time. For a large organization as RWS, working with 3 documents is workable. These two extra documents provide some extra guidance."*

Figure 16: The Continuous Innovation (COIN) framework

The first additional document is the Continuous Innovation (COIN) framework. "*This is an overview of all the activities needed in an innovation process. It is actually a framework for project leaders' innovation strategy, an innovation management process, emphasizing on the level between the strategic and the operational level.*" The second additional document is the innovation landscape, *"which is a general overview of how innovating within RWS is organized, how choices are made, and how we innovate with partners*." The additional documents are shown in figure 16 and 17. *"You could actually say that the innovation agenda, together with the COIN and with the innovation landscape, summarizes our innovation strategy."* Much of the information from the additional documents is also included in the innovation agenda, but the innovation agenda takes precedence for the organization. Nevertheless, the other documents are used effectively, and it is challenging to get 10,000 people aligned with a single document, making it unnecessary for RWS to completely eliminate them.

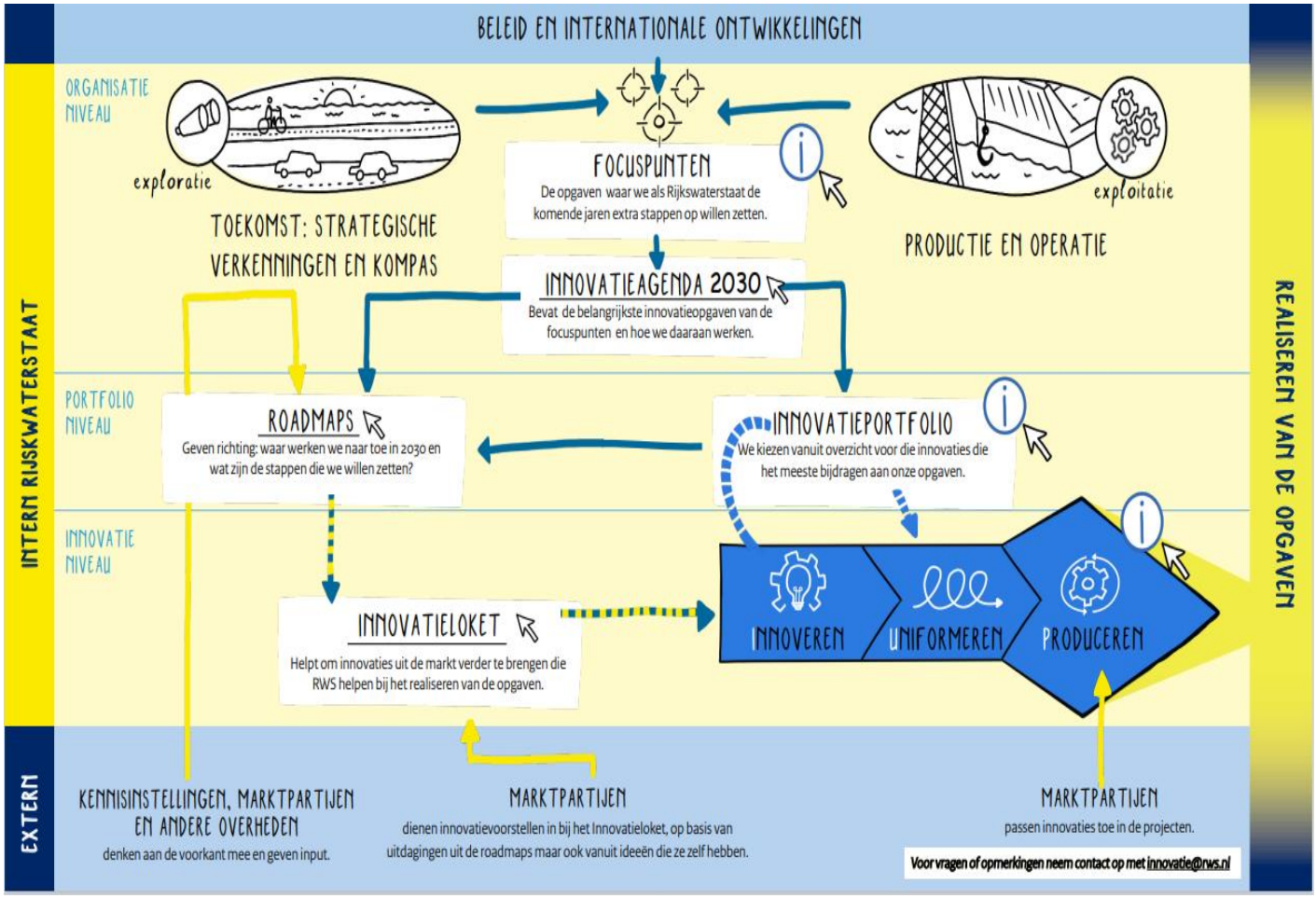

Figure 17: The innovation landscape

4.4. Awareness

RWS puts a lot of effort in increasing the awareness of the innovation agenda among employees within the organizations and external parties. *"We are trying our best to make the innovation agenda as widely known as possible, for example by innovation consultation hours, morning debates, internal and external presentations, and by campaigning when the agenda was launched with an innovation festival."* However, it is a difficult process in an organization like RWS. *"We do not have the illusion that everyone in the organization is on the same page, that is impossible for an organization with 10,000 employees. That is the fact of live. It is a huge challenge to reach all employees of RWS, let alone reaching external parties."* Yet it is already having effect. *"It is noticeable that the awareness spreads clearly throughout the organization and among external partners."*

Within the focal points, efforts are also being made to raise awareness of innovations in specific directions. Some innovations are more likely to gain awareness among internal and external actors in the sector than others. *"There is no resistance for innovations regarding climate adaptation since people understand the need for change, especially when the lifespan of for example tunnels visibly increases due to climate adaptive measures. You never have to motivate people for this, only time and resources can be limited."* Sustainable Infrastructure actively increases the awareness by facilitating and steering in programs. *"We facilitate and advice projects from our program to take sustainability into account. That is how we ensure greater awareness and clarity within the organization. We as a focal point play a leading role in this."*

4.5. Collaboration

4.5.1. Internal collaboration

The department WVL, and mainly Innovation and Knowledge which falls under that department, invests in the collaboration between the focal points. *"There are monthly meetings between the leaders of the focal points where both content-related and organizational issues are discussed. The conditions focus, collaboration, and faster are vital in those conversations. Furthermore, we try to organize a yearly meeting where each focal point has the opportunity to show their innovations in depth."* But finding collaboration between focal points is not always easy. *"There is more and more synergy, but it is difficult to keep them together. Things can always be better, but it is not that they cannot find each other."*

An example is the focal point Data and Information Provision. *"The focal point Data and Information Provision has a facilitating role towards other focal points by providing support in projects by developing new warning systems. On the other hand, RWS has a data backlog and people working on innovations related to sustainability do often not know the capabilities of the IT department. The collaboration is therefore often hampered because we do not fully understand each other."* The collaboration between Sustainable Infrastructure and Climate Adaptation has also its strengths and weaknesses. *"The role of the focal point Climate Adaptation is to show the impact of climate change. Sustainable Infrastructure uses the analysis in their responsibility for improving the spatial domain." "On the other hand, the two focal points have fewer similarities than could be possible since they are in different organizational phases."* Climate Adaptation has for example no roadmaps yet and is formulating its innovation portfolio. *"This also shows that collaboration in terms of strategy formation is limited, we often do things differently among focal points."*

4.5.2. External collaboration

RWS has a specific role in the water and subsurface sector regarding innovations. First of all, RWS encounters challenges during implementation and is responsible for communicating this to partners to stimulate innovation. *"We must clearly communicate the challenges we are facing to foster effective collaboration."* However, RWS also expects proactivity from other partners in the sector. *"Taking action and questioning the market through various forms like hackathons is essential, but it remains a challenge due to our large organizational structure and the competitive nature of the market, where parties often hesitate to engage openly to protect their innovations or patents."* Besides market parties, RWS also expects valuable research of knowledge institutes that is applicable and considers multiple perspectives. *"Knowledge institutes need to focus on these tasks to discover new opportunities, pushing beyond their traditional boundaries. Deltares, for example, faces the challenge of looking outside its own box, as many problems cannot be solved with its knowledge alone. This necessitates collaboration with other organizations such as TNO or Wageningen University and Research* (WUR)*. Despite increased collaborative efforts, these partnerships are not yet daily business."*

Not only within the sector collaboration should be stimulated, but also outside the sector. *“I would like it if we could eventually collaborate with an atypical sector, as the biggest innovations never come from within our own sector because it unconsciously maintains its own system. This also means working in different ways than with our usual partners.”* But also, within the sector things can be done differently to solve challenges innovatively. *“While there is extensive research, it often leads to more research rather than practical applications. Our efforts must align more closely with the tasks of I&W and Rijkswaterstaat, particularly within new collaborations such as the SITO-PS program, which has a budget of 30 million per year. Although improvements have been made to adopt a more task-oriented approach, we still fall into the trap of process improvement without significantly enhancing our research programming. Reflecting on this, it becomes evident that a shift towards more task-oriented and application-focused collaboration is necessary to truly advance our objectives.”*

4.6. The innovation agenda in practice

There are several reasons why innovation in the sector is not as successful as it could be. A significant reason relates to costs. *“When something cannot be replaced one-by-one, modifications or new techniques are often required, which are usually more expensive and take longer. Therefore, you prefer to replace something one-by-one if that is possible.”* This is closely tied to the available budgets. *“The budget is a limiting factor. Extra risks need to be covered with additional funds, which are not always available. For certain programs, a fixed amount is allocated, and it is not supplemented once it is exhausted.”*

There are also several things that RWS could have done better to stimulate innovations. Firstly, it involves having a clear vision. *“In recent years, neither we nor the ministry of I&W have excelled in making clear choices regarding the future direction of the water system. Once you know the direction you want to go, you need to provide clarity.”* Additionally, it involves a difference in perspective between those working on innovations and the operational personnel of RWS. *“People working on climate adaptation have a long-term perspective, whereas those working on maintenance focus on shorter time horizons. This is inherent to the nature of the work within RWS.”* RWS should also take on a more leading role towards innovations. *“If we can be innovative, it can inspire others, in the sense that if RWS is willing, we can make progress together.”*

It is already visible that the innovation agenda is having an impact in practice. *“It serves as a communication tool and a strategic document that sets the direction. We are seeing more targeted innovations coming to us, and it is starting to pay off.”* However, not all improvements can be attributed to the innovation agenda. *“It is not just the innovation agenda but also the approach and the way we work now that fosters innovations.”* A final reflective point concerns the distinction between knowledge and innovation, which is both important, but not always clear. *“We should be more precise about whether we are developing knowledge or driving innovations.”*

4.7. Future view for the innovation agenda

Significant progress has been made with the innovation agenda, but RWS expects to achieve more in the future. This primarily involves roles within the sector and collaboration. *"Sometimes we find that RWS is not ideally positioned to drive certain innovations. For knowledge-related issues, it would be beneficial for knowledge institutes to play a more prominent role. This is easier for knowledge institutes than for the market, which faces competition."* This also requires forward-thinking from a knowledge institute like Deltares. *"I would challenge Deltares to capitalize on the momentum. It would be great if we had project plans with solutions ready to implement when the time is right. RWS aims to initiate this in the coming period."*

To stimulate innovation, RWS needs to offer perspective to the market. *"RWS must demonstrate that scaling up is achievable and that investing in new innovations is worthwhile."* This can be accomplished through genuine collaboration. *"Exploring joint goals and ambitions for the entire sector and working together increases market involvement."* Additionally, RWS needs to be clear despite existing uncertainties, making innovation more accessible for market participants. *"We would like to create a clearer vision through diagrams that show the effects of climate change on our networks and assets. These diagrams will make the focal point more accessible and illustrate potential measures for emerging impacts."*

Finally, various external factors could influence future innovation in the water and subsurface sector. One example is political uncertainty. *"When a new government changes goals, it impacts the market."* Political decisions can affect the operations of a government organization like RWS. *"I fear we might get sidetracked by other major challenges, such as housing development, but that should never be an excuse to neglect climate adaptation."* Another factor is uncertainty. *"You want to make issues more concrete because you have more knowledge than before and can prepare for a solution, but there is always tension due to uncertainty. This is why we must sometimes trust in the sector's innovative capacity."* This innovative capacity comes from academic knowledge development, but the market also plays a crucial role since that is where innovations ultimately originate. Engaging the market is a challenge. *"Major contractors have the resources to be innovative but are often hesitant when their current equipment is still adequate. Smaller players can react quickly and flexibly but are often too small. Contractors are also cautious because, during exploration, we may not know whether a particular project will be offered extensively to the market."*

4.8. Concluding remarks RQ1 and RQ2

The current innovation strategy is the innovation agenda 2030, based on the key themes from the Kompas I&W and the Kompas RWS, where the long-term and short-term goals of RWS regarding innovation are described. The focal points are particularly important because they are used as justification for allocating resources. Additionally, there is a strong emphasis on internal and external collaboration, and on accelerating the scaling of innovations into implementable solutions. Several tools, such as the IUP Guide or the SRL tool, have been added to the innovation agenda to provide support in the innovation process.

The development of the innovation agenda began with the evaluation of the previous agenda, which was managed by a different department. Key lessons learned from this process were the need for more focus and the necessity for the strategy to have the power to be implemented. Various consultation rounds with key partners ultimately led to the innovation agenda 2030, which has recently been updated with Climate Adaptation added as an additional focal point. An important consideration is to increase the internal and external awareness of the document so as to have a bigger impact on practice. Additionally, the goal of the innovation agenda is to stimulate internal and external collaboration, also to raise its practical impact. Finally, a new update is scheduled for 2025, serving as a midterm review that will look forward as well as reflect on the past years.

The internal factors that played a role in the development of the innovation strategy include the focal points initiated by RWS, based on the key priorities of I&W. Additionally, many people within the organization worked on and evaluated the innovation strategy. The structure of RWS and the associated challenges in collaboration also constitute an internal factor. External factors include input from stakeholders, the major challenges facing RWS, and the roles and responsibilities of stakeholders in the water and subsurface sector.

5. Research findings – Analyzing the sector

The second part of the research findings analyzes the influence of RWS's innovation strategy on innovation processes in the water and subsurface sector, including answering the third sub-question. Chapter 5 focuses on the awareness of the innovation agenda and the different roles and perspectives in the sector, while Chapter 6 delves into the influences of RWS's innovation strategy. The reason that these three specific influences were chosen stems from the three key conditions of the innovation agenda, as explained further in Chapter 5 where participants were asked what the specific success factors and challenges in the water and subsurface sector are. As outlined in the methods chapter, ten interviews were conducted with both Deltares and RWS employees in various functions. All participants collaborate with various stakeholders in the sector and share a common knowledge about the way RWS innovates. Quotations from the interviews are presented in italics and between quotation marks. Additionally, various reports and other literature have been utilized to complete the narrative and ensure consistent interpretation. Additionally, three main examples are used for clarification at the end of the chapter. The third sub-question answered in the next two chapters is:

- *What influence does Rijkswaterstaat's innovation strategy have on resource allocation, the development and diffusion of innovations, and collaboration within the water and subsurface sector?*

5.1. Perspectives and roles

Before delving into the practical influences of RWS's innovation agenda, it is essential to determine whether all participants share a common perspective on the sector and their respective roles and responsibilities. Additionally, it is important to determine if the participants' views align with the information provided in the innovation agenda. This sub-chapter begins by introducing the participants and providing some background information with examples. It then offers an overview of the sector's characteristics. Following this, the roles and responsibilities of the key stakeholders in the sector are discussed. Finally, the sense of urgency within the sector is addressed, as this topic emerged during the interviews.

5.1.1. Background participants

The participants from Deltares involved in this study are all engaged with innovations in their professional roles. Some deal with innovations on a daily basis, while other engage with them less frequently. One participant focuses on strategic aspects of innovations, some work on modeling, and others are more involved in the implementation phase. All participants have experience working on projects with RWS and other sector stakeholders. Their field of expertise include climate adaptation and sustainable infrastructure.

As a knowledge institute, operating without profit as a primary goal, Deltares serves the needs of society. *"We, as a knowledge institute, are obligated to society and our status to serve RWS as best as possible and continuously improve our expertise."* Deltares primarily aids RWS by developing knowledge related to water and subsurface management. *"Deltares develops knowledge to increase the understanding of complicated or new processes in the sector and to investigate how to measure or model certain things."* For example, the Sand Motor, constructed in 2011 off the coast near The Hague, is a notable project where RWS, Deltares, and Province Zuid-Holland collaborated. The project aimed to create a dynamic and innovative coastal maintenance structure to strengthen the Dutch coast more cost-effectively, with the added benefit of creating a new nature and recreation area (Zandmotor Monitoring, 2024). *"In the past, we would add sand directly to the beach, but it is more cost-effective to deposit it underwater just before the beach and allow the wind and water currents to distribute it along the coast. We participated in the research program, tested this method in The Hague, observed*

its effectiveness over time, and are now exploring the potential to apply it in other situations." This example illustrates a research project where Deltares and RWS collaborated, tested the potential solution in The Hague, and concluded that it could potentially be applied in other contexts.

RWS, as an operational public organization, also devotes significant capacity to innovation. Participants in this study work as innovation advisors, experts in the field of climate adaptation or sustainable infrastructure, and as project managers in climate-adaptive or infrastructural projects. For most of the participants, innovation is central to their professional roles within RWS, while for others, innovation is an additional aspect driven by intrinsic motivation. *"Maintenance contracts are traditionally structured, but there are opportunities for innovation. Alongside my regular work, I am intrinsically involved in innovation and challenge contractors to approach tasks differently and more effectively. Nowadays, contracts also include provisions related to innovation and sustainability, encouraging contractors to take an additional step towards achieving innovative progress."*

Innovative projects are sometimes immediately recognizable, such as the example of the Sand Motor, where a completely new approach was applied. At other times, innovation is less conspicuous and integrated into existing processes. An example of this is the use of a lighter-colored road surface during the maintenance of the Spijkenisser Bridge. *"Recently, with the heat in mind, we chose a lighter color for the road surface to extend the lifespan of the Spijkenisser Bridge. This is because the bridge now potentially expands more slowly, delaying the need for major adjustments when the bridge begins to jam."* While addressing the third sub-question, numerous additional examples will be provided to support the narrative and to add practical insights. Specifically, the Xstream blocks, the SRL tool, and the sustainable maintenance contracts will be referenced frequently to make the results more visual and relate them to practical applications.

5.1.2. Characteristics water and subsurface sector

The government plays an important role in the water and subsurface sector. *"Especially the water sector is dominated by the government; they are the primary problem owner."* Generally, the ministry of I&W sets the policy, while RWS, water boards, provinces, and municipalities are responsible for operationalization and the public domain. *"Innovations in the water and subsurface occur in the public domain, which increases the role of the government."* RWS maintains and owns the Dutch roads and waters, giving it significant influence over innovations.

The importance of the public domain makes this sector particularly challenging for introducing new innovations since roads and water safety are too critical to experiment with, as they affect everyone. *"This sector deals with assets of social importance that are used by a wide public, and therefore, there are numerous interests to consider."* This is why a public organization like RWS is primarily responsible for the public domain; safe deployment of these assets is essential. However, according to Deltares, this also means that decisions are made more slowly. *"Decisions about managing space in the public domain are much more democratically charged, which makes innovating more difficult."*

However, this sector is precisely where innovations can make a significant impact. *"We are facing major challenges in sustainability, circularity, and CO2 neutrality that we have set for 2030. With our current processes and assets, we will not meet these goals."* These goals should also be met in a small country with limited space. *"We are a compact country with limited space, so we must do things differently than before."* This limited space also means that the water and subsurface sector is not a mass market where various new innovations can be readily introduced. *"For example, when designing an innovative tunnel, someone must be willing to purchase it. It is a very different landscape from the mass market, as perhaps only one tunnel will be built every 10 years. This makes innovation challenging."*

An innovation must have additional value to be introduced. A significant value is related to the costs incurred by RWS. *"An innovation can emerge if it proves to work better, but it must also be clearly cost-effective; otherwise, a trusted solution is often chosen."* In many cases, RWS must recognize its added value regarding budget and time. *"Often, RWS opts for an existing solution because they are simply relieved they can achieve it within the planned timeframe and budget."*

Furthermore, innovations in this sector are more about systems than products. *"We are dealing with large natural systems, often involving various civil engineering techniques."* For these systems, sufficient knowledge is essential. *"Innovation and knowledge development are intertwined, and decisions are largely made on developed knowledge."* Additionally, it is important to test innovative systems, but that can only be done within the protected public domain. *"Innovations must be tested in the field, where the environment is poorly controlled, and it is difficult to investigate multi-year effects. However, many ideas can only be tested outside, where water safety must always be guaranteed."*

The sector is described by both RWS and Deltares as conservative and traditional, but it is gradually changing. *"RWS has gone through 15 years of market liberalization, meaning RWS sets the requirements and the market had to come up with solutions and managed them."* This approach was not effective in truly stimulating innovation and led to a conservative sector. *"Especially at the regional level, the water sector consists largely of family businesses that do well by sticking to what they have always done."* There are practical reasons for this; *"Large market parties that have the resources to innovate are often too hesitant because their existing expensive machines still work."* On the other hand, it also relates to risks; *"If an engineering structure fails, a market party can easily go bankrupt, and the risks falls on RWS."* There is now increased scrutiny from RWS towards society. *"There is a gradual shift in the sector where RWS is developing its knowledge and better assessing whether the things they request add value to the sector."*

5.1.3. Role of RWS

The interview results broadly illustrate the roles and responsibilities of RWS concerning innovations in the sector. Both Deltares and RWS participants emphasize several fundamental responsibilities of RWS. The interview results are also compared to the highlighted desirable roles of RWS as described in the innovation agenda.

The first role of RWS in the water and subsurface sector is managing and owning the public domain, including rivers, deltas and roads. RWS acknowledges its responsibility for addressing problems in the public domain and the consequent benefits from new innovations. *"As the owner of public domains such as river areas, we are also the primary task and problem holder, which means we benefit most from the outcomes of new innovations."* Deltares underscores that this role carries specific responsibilities. *"RWS is responsible for managing the networks and should recognize where changes are needed. It is their task to have a clear understanding of the innovation needs."* RWS also recognizes the need to go beyond problem identification. *"We have a responsibility to stay updated with knowledge gathering and to follow new developments."*

A second major responsibility of RWS, according to both Deltares and RWS participants, is facilitating the innovation process. Deltares asserts that RWS must be open to external ideas contributing to sector improvements. *"RWS should accept ideas from market parties. For example, the construction company BAM developed Xstream blocks for cheaper hydraulic engineering structures such as groynes. They pitched the idea to RWS, among others, and were given the opportunity to test and develop it."* Additionally, RWS should also facilitate by creating an environment where innovations can occur and develop. RWS participants emphasize increasing stakeholder involvement in the water and subsurface

sector by challenging them, while Deltares participants highlight the importance of budget allocation and the availability of test locations. Facilitating through budgetary support involves subsidizing and investing in pre-competitive research. Furthermore, Deltares stresses that stakeholders, including market parties, are always dependent on RWS. *"RWS decides what they request from the market and also determines whether something will be implemented."*

Deltares also points out another specific facilitating responsibility of RWS regarding regulations and permits. *"RWS should remove innovation hurdles, and a significant one is providing permits when necessary."* This again underscores RWS's role as the dominant player, influencing the pace of innovation by issuing permits since innovations must be tested in their public domain. *"RWS is a launching customer and can use its power as a large organization to bring people together and make decisions."*

According to RWS's innovation agenda, RWS is responsible for addressing challenges in the water and subsurface sector, as the government is accountable for social issues. Additionally, RWS is tasked with stimulating market parties to innovate. Thus, the two major responsibilities for RWS in the realm of innovations are facilitation and sectorial responsibility, which align with the interviewees' responses. During the innovation process, RWS can assume various roles depending on the phase and the nature of the innovation, as depicted in figure 18. The possible roles during the innovation process, based on the level of involvement and the difference between an active and reactive role, are as follows (Rijkswaterstaat, 2023):

- *Participating*: RWS is actively engaged in collaboration with other parties.
- *Partnering*: RWS shares joint responsibility for an innovation with its partners.
- *Leading*: RWS acts as the leader, executor, and initiator of an innovation.
- *Following*: RWS monitors the progress while the implementation is carried out by others.
- *Facilitating*: RWS enables an external initiative for innovation to proceed.
- *Stimulating*: RWS encourages others to realize a desired innovation.

The two roles that particularly emerge from the interview results are facilitating and stimulating, although the other roles are also mentioned between the lines in the interviews. The main characteristics of the facilitating role are creating an innovative-friendly environment and providing permits. RWS in its stimulating role uses its role as launching customer to foster innovation.

In conclusion, Deltares identifies RWS as the dominant player in the sector, with major responsibilities including creating an innovation-friendly environment and facilitating the overcoming of barriers. RWS sees itself as the owner of the public domain, capable of stimulating innovation by challenging other stakeholders and acting as the sector's largest client. The major responsibilities mentioned in the innovation agenda correspond with the answers of both Deltares and RWS participants. It is noteworthy that both RWS and Deltares recognize the role of RWS in the sector, although they differ on specific responsibilities.

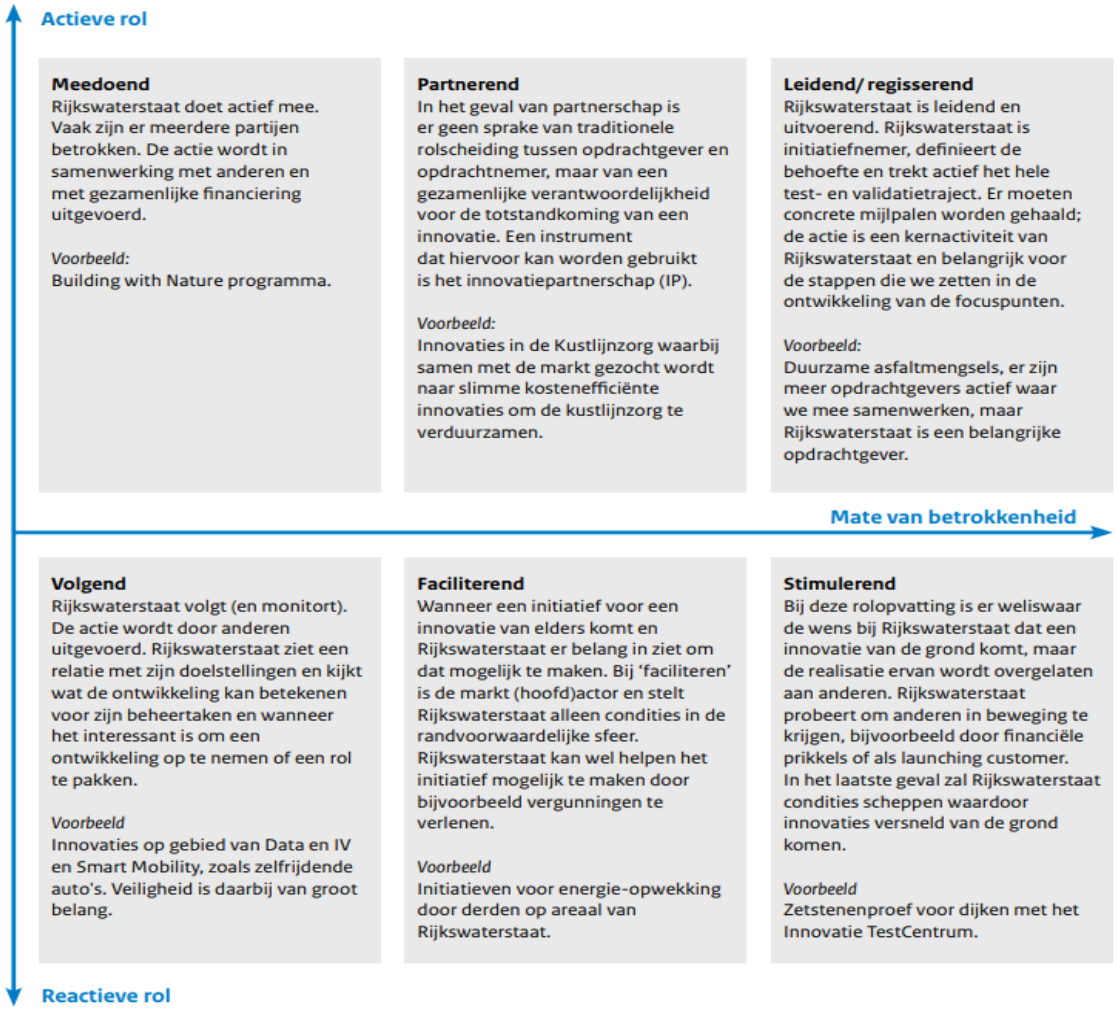

Figure 18: RWS's potential roles in innovation processes (Rijkswaterstaat, 2023) – in Dutch

5.1.4. Role of Deltares

According to Deltares participants, their primary role is to provide RWS and other stakeholders in the sector with comprehensive knowledge. First, this knowledge is instrumental in aiding others to make informed decisions. *"We deliver new knowledge to help RWS or the ministry to form opinions, make decisions, and develop or change policy."* Secondly, the knowledge assists in identifying and addressing problems within the sector. *"As a knowledge institute, we gather information to identify problems and brainstorm possible solutions, primarily in collaboration with RWS."* Deltares also ensures stakeholders stay updated and supports them throughout the innovation process. *"Deltares should keep others informed of new developments and provide the knowledge needed to test the safety and applicability of innovations."*

RWS participants acknowledge the role of Deltares as a knowledge provider and also highlight their collaborative role. *"Sometimes we ask Deltares to provide us with knowledge, but at other times, we ask them to actively help us develop new innovations."* Additionally, RWS participants emphasize Deltares' impartial stance. *"Deltares understands the sector's dynamics without financial interests, allowing them to often recognize sector trends better than RWS."*

The collaboration between RWS and knowledge institutes such as Deltares and TNO is crucial for fostering innovation. Knowledge institutes focus on fundamental knowledge development to devise innovative solutions, benefiting RWS by informing decision-making in the innovation process

(Rijkswaterstaat, 2023). This perspective from RWS's innovation agenda is generally acknowledged by both RWS and Deltares participants. They emphasize the importance of collaboration between RWS and Deltares, mentioning various examples of noticeable improvements. *"In the past, we at Deltares only provided knowledge to RWS. Nowadays, they ask us to identify problems, collaboratively think about solutions, and test solutions initiated by for example private organizations. We are no longer just contractors; we are now true partners."*

However, Deltares is not solely dedicated by the assignments of RWS. *"Deltares also collaborate for example with water boards, NGOs, and private organizations."* Furthermore, Deltares also provides RWS with information in cases they did not ask. *"We offer knowledge advice for demand-driven needs of RWS, but we also frequently provide unsolicited advice. That is pro-activity on our part."* RWS recognizes and appreciates this proactivity. *"Sometimes Deltares conducts scientific research driven by curiosity or scientific interest. This research role helps us identify problems we have not yet seen."* Nonetheless, there are instances where Deltares' proactivity is lacking. *"Deltares has a large portfolio of information, but sometimes they do not proactively share that knowledge."*

Improving proactivity and sharing data are recurring themes. *"Deltares should report their findings and should share information more frequently to enhance sector-wide intelligence."* On the other hand, Deltares notices that not all RWS personnel are aware of when to seek their expertise. *"Sometimes RWS views us merely as 'model farmers' or 'knowledge carriers', but we can offer much more value."* In general, the role of Deltares is well-defined, focusing primarily on gathering knowledge and conducting research for the water and subsurface sector. However, there are instances where the expectations of RWS and Deltares do not fully align.

5.1.5. Other roles in the sector

The theoretical background of this report outlines the primary stakeholders in the water and subsurface sector. In addition, several participants have provided insights into the roles of these stakeholders. Below, the main roles of these stakeholders, as highlighted by the participants, are described. A recurring theme is the importance of collaboration across the sector. *"We should always approach each other to strengthen the whole sector, even if past experiences have not always been successful."* This underscores a general responsibility for all stakeholders in the water and subsurface sector.

The first frequently mentioned stakeholder is the ministry of I&W. According to the participants from Deltares and RWS, the ministry's role is to design regulations that facilitate, rather than hinder, new innovations. *"Regulations should not impede innovative initiatives. The ministry should at least consider what evidence is necessary to revise regulations for the benefit of the entire sector."* Currently, regulations often pose barrier to innovation. *"Regulations are too much focused on protecting the public domain rather than improving it."* Additionally, the ministry should allocate funds for sector improvements. *"The ministry must ensure funding is available to address societal issues with new ideas, as the benefits will extent beyond a single stakeholder to the entire sector or even the whole country."* The ministry must demonstrate progressiveness and act accordingly. *"When the ministry recognizes the value of an innovation, funding will be provided, and it will be prioritized on the political agenda."* Thus, the role of the ministry of I&W is to create an innovative-friendly environment by providing budgets, changing regulations, and giving societal issues the necessary political attention.

Universities, as part of the academic sector, also play an important role in gathering knowledge and conducting research, as discussed in the theoretical background. This example demonstrates the importance of universities in the sector: *"The Rivers Tomorrow Program is a knowledge program funded by the government, through RWS and DGWB, where PhD students from universities address*

fundamental knowledge questions in the field of river management and monitor pilots to understand the implementation possibilities. Deltares often participates in this collaboration as supervisors for the PhD students and as additional researchers."

Private organizations, starting with consultancy firms, are another key stakeholder group. *"Consultancy firms often provide additional capacity for RWS in projects. Deltares frequently participates in such projects as an independent knowledge source and to test potential solutions. We can also provide tools like models used in the projects."* According to Deltares, employees of RWS sometimes do not fully understand the role of Deltares compared to consultancy firms. *"Not everyone has a clear understanding of Deltares' role, often due to personnel changes. Deltares operates differently from consultancy firms as it is a foundation and not focused on profit."* However, the role of consultancy firms is generally well-understood at the national level. *"Consultancy firms have an executive role, while Deltares has an advisory role. RWS should engage consultancy firms for their expertise and turn to Deltares when consultancy firms lack the necessary knowledge."*

Contractors are also private organizations working in the water and subsurface sector. *"Primarily, contractors execute the tasks assigned by RWS, but sometimes the design and approach to an issue are also delegated to the contractor."* Contractors have various motivations for innovating or participating in innovative projects. *"Many contractors innovate from a commercial perspective as a new business opportunity, others innovate due to the sense of social responsibility, and some aim to demonstrate their commitment to sustainability or climate adaptation."* RWS expects contractors to participate in innovation projects. *"RWS has revised contracts with contractors to encourage innovation, so we expect contractors to invest efforts in this area, even if private investments do not immediately yield significant profit."* Additionally, RWS recognizes the significant role of SMEs. "*SMEs are the driving force of the whole sector; they often develop the technical innovations."*

5.1.6. Urgency within the sector

The sector's urgency is evident overall, but interview results indicate that Deltares exhibits more ambition compared to RWS. *"Knowledge institutes, universities, and private parties have been suggesting for some time that innovation can proceed more rapidly, but the government sometimes slows progress for safety reasons, or they believe sufficient efforts are already done."* Deltares understands these concerns but believes the government could take additional steps. *"RWS should address issues like climate change while also managing and safeguarding the public domain. The urgency is noticeable within the sector, but RWS could do more."* Deltares generally believes that much can be improved given the sense of urgency. *"There are so many challenges in our sector, and much more is possible than what we currently observe."*

Within RWS, the urgency is more pronounced at the national level than at regional level, a discrepancy acknowledged by RWS itself. *"In the decision-making process, requirements such as the objectives of the innovation agenda 2030 or the Delta Program are included. This needs to be better implemented regionally, as not every region adheres to these guidelines yet. Some employees of RWS remain comfortable with their traditional methods despite the threat of climate change."* Nonetheless, Deltares also observes positive developments. *"Sustainability is more frequently addressed in permits than before."* RWS also notices advancements in innovation. *"The urgency is certainly felt within RWS, and we see that many small innovations are now being implemented or tested instead of one large one with a lot of uncertainty."* Finally, RWS's national Knowledge and Innovation department aims to increase the urgency within RWS. *"Innovating in this sector is complex, but we want to demonstrate how relevant and impactful it is."*

5.2. Awareness and usage

As discussed in the previous chapter, WVL places significant effort on raising awareness of the innovation agenda among RWS employees and also aims to reach and inform external partners. This sub-chapter will address the level of awareness among Deltares and RWS employees with various backgrounds. Secondly, the participants were asked whether and when they utilize parts of the innovation agenda, such as its tools. Another critical aspect of the innovation agenda is its potential use as a guide for monitoring and evaluating innovation projects, which will also be discussed in this sub-chapter. Finally, the concept of 'water and subsurface guiding' will be introduced and examined, as it is becoming increasingly important as a policy instrument in the sector.

5.2.1. Awareness innovation agenda

Deltares participants indicate that while the innovation agenda itself is known, its content is not. One time, it was even mentioned that the innovation agenda is entirely unknown. Most participants acknowledge having encountered the agenda during meetings with RWS and are familiar with the RWS colleagues involved in it. However, none of the participants have heard of or read about the IUP Guide. Regarding the roadmaps, participants generally know of their existence but have not seen them or are unaware of the specific themes covered. The focal points are generally well-known and largely align with the topics deemed important by Deltares. Some individuals are familiar with the concept of roadmaps, either because they use them themselves or encountered them in projects often involving WVL. No one has thoroughly read the current innovation agenda, having only skimmed through or read outdated versions.

This aligns with WVL's remarks about the awareness of the innovation agenda. It was already a significant challenge to raise the awareness within RWS due to the organization's size, let alone involving external partners. On the positive side, the existence of the agenda is known among Deltares employees, indicating that Deltares participants know that RWS is actively prioritizing innovation within certain parts of the organization.

Among RWS employees, all participants are aware of the innovation agenda's existence, and most have a clear understanding of its main points. The focal points are known to everyone, and the existence of roadmaps is also familiar. About half of the participants are aware of the IUP Guide, with one person having used it in a project context. Therefore, the innovation agenda appears to be well-accepted and known among RWS participants. WVL's efforts to raise awareness of this innovation agenda seems to have been successful, based on responses from individuals with diverse backgrounds within RWS. However, it is important to note that all participants work in roles related to innovation, so this may not necessarily reflect the awareness level across the entire RWS organization.

5.2.2. Appreciation innovation agenda

What stands out is that the tools of the innovation agenda, such as the IUP Guide, are largely unknown at Deltares, and a recurring reason for this emerges. *"The innovation process cannot be standardized, and those who are enthusiastic about innovation often dislike control mechanisms."* Nevertheless, these tools are perceived as useful at the management level. *"Innovation managers can use these tools to zoom out, reflect, and assess whether long-term goals are being met. In that sense, they can provide a solid framework."*

Within RWS, there is more positivity regarding the IUP Guide. *"The IUP Guide offers structure and ensures a smooth transition between different phases of the innovation process."* However, there is also criticism from RWS. *"The IUP Guide is a guideline, not a rigid framework. Go and no-go moments between phases in the innovation process align with the culture of RWS, but I find it problematic because it burdens directors with technical knowledge they should not need. There is a lack of trust in*

this aspect." Nonetheless, it is seen as a useful tool for monitoring progress. *"The IUP Guide creates information points with more structure, allowing a project to be monitored or evaluated effectively."*

The focal points of the innovation agenda are used by RWS employees to allocate resources responsibly. *"It provides a mandate if you can use the focal points for accountability."* Deltares also recognizes the necessity of focal points. *"For an organization, it is helpful to have insight into which themes are underrepresented and to allocate financial resources accordingly."* There is also substantial support for roadmaps within RWS. *"Roadmaps are used to keep objectives clear and to make adjustments when necessary."* In practice, this proves to be necessary. *"At RWS, there is too much focus on the short term because funds are available at a point in time, and people want to see quick results. Roadmaps are important for achieving long-term goals."*

A tool frequently used within RWS is the SRL tool. *"This tool helps to address stakeholder positions early in a project."* As previously mentioned, RWS has made efforts to increase the awareness of this tool, and it seems to be effective in practice. *"I worked with the SRL tool before since it can clarify the demands and desires of stakeholders and ensures that projects do not stall. It could foster open communication among all parties."* It can also be used as an evaluation tool. *"The SRL tool can demonstrate whether an organization is ready to advance an innovation."*

The primary function of the innovation agenda, based on the interview results of both RWS and Deltares participants, is its role as a communication tool. Firstly, for internal communication. *"The innovation agenda can get people on board top-down to get things done. With the agenda, resources can be available more easily, and there is more flexibility."* But also externally. *"RWS must project itself as an innovative organization with a need for innovations. Furthermore, RWS should demonstrate that innovation pays off."*

However, there is skepticism among Deltares participants regarding an innovation agenda. *"RWS had an innovation agenda 20 years ago as well. It seems that it needs to come to the organization's attention periodically."* There are also doubts about the innovation agenda's support within RWS. *"The difficulty with RWS's innovation programs is that they are often not adopted by the whole organization. I hope this time is different, but I am not sure."* Overall, Deltares holds a positive view. *"It is important for RWS to continually ask themselves if they are an organization where good ideas can be developed and implemented."*

5.2.3. Monitoring and evaluation

The possibility to use tools from the innovation agenda as aids for monitoring and evaluating projects often arises in the interviews, which underscores that parts of the innovation agenda are used in practice, but in specific cases and with positive as well as negative outcomes. Within RWS, the process of monitoring and evaluation is not yet fully streamlined across the organization. *"We do a lot of new things at RWS, but unfortunately, evaluating, reporting, and sharing outcomes is still insufficient across the entire organization."* The reasons cited for this include time and budget constraints, as well as the mindset of the employees of RWS. *"At RWS, we do not reflect enough on our past work, and there is still much we could learn from it. Of course, monitoring and evaluation take time and money, but it is also true that many people are busy with their own tasks and do not share their results."*

Besides sharing results, monitoring and evaluation are crucial for project accountability. *"You cannot just start projects and freewheel because doing new things is costly and risky. RWS wants guarantees and quality, which does not necessarily lead to more innovation."* This perspective is somewhat contradicted by a respondent from Deltares, suggesting that the importance of accountability through monitoring and evaluation is not yet uniformly recognized across RWS. *"We are not held accountable*

by RWS for monitoring and evaluation, although we do have deadlines. If we respond to a request or contribute to a project, RWS is generally a satisfied client."

Monitoring and evaluating should not always need to be done with the tools from the innovation agenda, but the agenda does provide inspiration. Various tools are used within RWS. *"I personally use RAMSSHEEP to evaluate projects, but I do this only on a sample basis and not frequently."* RAMSSHEEP (Reliability, Availability, Maintainability, Safety, Security, Health, Environment, Economics, and Politics) is a risk-driven maintenance concept that evaluates projects on both project performance (RAMS) and societal aspects (SHEEP) (Wagner & van Gelder, 2014). *"For the operators, the RAMS part is very important, while the SHEEP part is more relevant at the management level."*

Participants from Deltares, in particular, criticize the emphasis on accountability through monitoring and evaluation, offering several reasons. *"Monitoring does not add direct value; it is only for accountability purposes. That does not directly advance innovation."* This lack of added value is recognized by several participants. *"Monitoring seems to be for show and is actually a burden for those who genuinely want to innovate. Innovation is not a linear process you can simply follow, and the tools are really for those trying to gain control over it."* Ultimately, the focus on accountability can hinder innovation. *"Accountability does not lead to the most risky and challenging innovations, especially when reporting becomes a goal in itself."* Finally, an example is given of what might work better than standard reporting tools. *"Case-oriented descriptions, with reports of evaluation conversations among stakeholders about what went right and wrong during a project, are much more important than a standard list of indicators to evaluate innovations. Every project is different, but you can still learn from each other."*

5.2.4. Water and subsurface guiding

Besides specific parts of the innovation agenda like tools, also policy concepts mentioned in the agenda gain more recognition in practice. The ministry of I&W has indicated that water and subsurface should be the guiding principles in the design of the Netherlands. This policy line must guarantee sufficient and clean drinking water and healthy soil and was proposed by the formal State Secretary and Minister of the previous Cabinet. The decision was adopted by the Cabinet in 2022 (Rijksoverheid, 2022). The policy line should also protect the Netherlands against climate change and universities already worked with this principle for a while. In practice, it is difficult to implement this policy line since a lot of societal issues and solutions are not in line with the 'water and subsurface guiding'. It is important for the whole sector to understand the concept and align in definition (de Rooij, Woolderink, Budding, de Graaf, & van Rooij, 2023).

The concept of 'water and subsurface guiding' is mentioned in RWS's innovation agenda, where it is seen as the basis for developments in spatial planning (Rijkswaterstaat, 2023). This policy line is recognized among the RWS participants as well. *"I can see that things are happening, and we are letting nature take its course more often. For example, dredging in the Netherlands is now often done in a different and smarter way than before by considering the predictability of nature."* Deltares also acknowledges this concept. *"We have been working on it for several years, and it is starting to take hold in the sector. Just look at the increase in nature-based solutions."*

However, most Deltares and RWS participants find it challenging to implement this policy line for several reasons. Firstly, this policy conflicts with existing policy measures. *"The 'water and subsurface guiding' principal clashes with the limited space available in the Netherlands; it cannot always be applied. Just consider the housing crisis, which requires a lot of construction all around the country."* Secondly, it is not yet concrete enough to be fully adhered to. *"It is too general and still sounds like management jargon. Currently, it does not stimulate innovations because it is not specific, and it is too*

vague." Lastly, the implementation is complicated due to the many stakeholders in the sector with different interests. *"There are many different stakeholders, which makes this policy line difficult to execute."* In conclusion, it can be summarized that *"The awareness is present in the sector, but we still need to learn how to apply it in practice."*

5.3. Challenges and success factors

After gaining a clearer understanding of how the participants view the sector and RWS's innovation agenda, it is important to assess what is currently going well and what is less successful in the process of innovating in the water and subsurface sector. Therefore, this sub-chapter will identify the challenges and success factors in innovation processes. This sub-chapter aims to highlight the tangible influences of RWS's innovation strategy as seen in practice. Many challenges and success factors have already been discussed in the previous (sub-)chapters, but they are highlighted separately here. The challenges and success factors identified by participants from Deltares and RWS are listed separately to provide an understanding of the situation and to highlight what is important for each party individually. A success factor is defined as something that happened in practice with a positive impact on innovation, but also as something that should have happened in reflection.

5.3.1. Challenges for Deltares

The primary challenge in innovation processes within the water and subsurface sector, according to participants from Deltares, is the allocation and availability of budget and capacity. *"There are often budgetary constraints because people are sometimes just relieved to be able to replace something on a one-to-one basis within the planned time and available funds, let alone work on new innovations."* In terms of capacity, this challenge is largely due to the significant maintenance tasks that exist in the sector. *"We face enormous tasks in this sector, and we have to accomplish them with less money and fewer resources. Just look at the shortage of humanpower in this field."*

A second frequently mentioned challenge is implementing innovations in practice, or in other words, scaling up pilot projects into practical solutions. *"It is difficult to eventually turn new ideas into techniques that are actually feasible in practice. This does not happen automatically, and many innovations fail at this stage."* A challenge that further delays the scaling process are regulations that hinder certain innovations. *"Regulations are often not suited for the application of new things. This is a clear barrier to innovation, which is characteristic for this sector."* Additionally, the permitting process within RWS does also not facilitate the scaling of innovations. *"An organizational issue within RWS is the slow permitting process where too many people are involved. The mentality of 'we will just get it done' is not part of the organization's culture."*

The final challenges that were significantly highlighted in interviews with Deltares participants pertain to the sector itself. *"The water and subsurface sector is extremely conservative and risk-averse, which makes it not particularly easy for innovations."* Politics also creates uncertainties and challenges regarding the potential for innovation. The new Cabinet is in particular an uncertain factor. *"We have to wait and see what happens with the next Cabinet. On the other hand, we have strong governmental bodies, and certain decisions are not easily reversed. We will see what happens."*

5.3.2. Challenges for RWS

Similar to the challenges faced by Deltares participants, budget and capacity are also encountered as frequent obstacles for RWS during the innovation process. *"You may have good reasons to do things more sustainably or efficiently, but that requires additional personnel, and that costs money. So, it is definitely a barrier when financial constraints get in the way."* Moreover, the availability of funds is expected to decrease in the near future due to political decisions that need to be made. *"Budget cuts are coming, which will affect the funds available for potential innovations."* In addition to capacity and

funding, time pressure is another significant barrier to innovation. *"Often, innovation is not part of our internal mandate, and it takes time that we simply do not have due to the extensive maintenance tasks we need to handle."*

The other two frequently mentioned challenges relate to the innovation process itself. Scaling up innovations is also a practical challenge for RWS. *"Standardization is a difficult concept within RWS. At some point, an innovative idea needs to be adopted by other departments within RWS, and that often proves challenges in practice."* One reason for this is decision-making and regulatory issues, such as the permitting process. *"Innovations are often hindered by existing laws and regulations that do not allow for innovative solutions."* For example, pilots need to be tested in RWS-controlled areas, which is not always easy. *"It is difficult to get approval to test something new in the public domain because there are various stakeholders with different interests."*

5.3.3. Success factors for Deltares

In addition to identifying the obstacles to innovation, participants were also asked about positive experiences. Specifically, the factors they see as success drivers in the innovation process were asked. The most frequently mentioned factor is collaboration with partners, where trust and a shared drive to innovate are particularly important. *"Innovating together, as a team, with a collective drive to make innovations truly applicable, is of immense importance in this sector."*

RWS plays a crucial role in this collaboration, as it is essential to test innovations in areas managed by RWS. *"Making test locations and prototyping spaces available through RWS is extremely important for collaborative innovation."* Furthermore, openness to new ideas within the collaboration is necessary. *"New challenges are constantly arising, so it is important that everyone is receptive to new techniques and ideas. We have to approach things differently than we did in the past."* Key aspects of this collaboration include the courage and freedom to innovate. *"People are willing, but there needs to be space created to take action. This also requires boldness and bravery, as the stakes are high in this conservative sector."* Finally, the integration of different types of knowledge is essential for successful innovation. *"People with technical expertise and those with policy knowledge need to work together. This connection can be incredibly valuable."*

5.3.4. Success factors for RWS

For RWS as well, collaboration within the sector with all involved partners is crucial for successful innovation. *"If you cannot get all the necessary partners to the table to collaborate, you will never succeed in creating a business case and working on innovations in a project-based manner."* A key aspect of this is having people who are intrinsically motivated to engage in innovation. *"People who are committed and do not let obstacles stand in their way need to find each other and strengthen one another."* Additionally, the openness of organizations to innovate together is important. *"People need to be open to trying new things, but RWS also needs to provide perspective for taking action on new initiatives."*

Furthermore, there are several other factors within RWS that can contribute to successful innovation. First, past projects should be evaluated, and that information should be shared and made available so that lessons can be learned from the past. *"Evaluate past projects and see what can be done with those results. Share that information to innovate better together in the future."* Another important factor is the connection within RWS, given that it is such a large organization. *"The role of RWS as a maintainer and RWS as a forward-thinking, innovative organization must be closely linked to increase the chances of innovation success."*

5.3.5. Concluding remarks chapter 5

It is noteworthy that many challenges and success factors in the innovation processes within the water and subsurface sector are mentioned by both parties. This indicates that there is considerable practical experience within the sector and a shared understanding of what works well and what can cause problems during innovation. One difference is that Deltares identifies the sector's conservatism as a challenge, indicating that people are unwilling or hesitant to innovate, while RWS sees time pressure as a challenge, suggesting that sometimes innovation simply is not feasible. A summary of the most frequently mentioned challenges and success factors is presented in table 6.

Table 6: The main challenges and success factors mentioned in the interviews

Challenges for Deltares: • Budget and capacity • Implementation of innovations • Regulations and permits • Conservative sector • Political uncertainty	**Success factors for Deltares:** • Collaboration in the sector • Availability of pilot locations • Openness to new ideas • Policy and technical knowledge • Courage and possibilities
Challenges for RWS: • Budget and capacity • Implementation of innovations • Regulations and permits • Time pressure due to regular work • Political uncertainty	**Success factors for RWS:** • Collaboration in the sector • Innovative employees • Openness to new ideas • Evaluation and knowledge sharing • Internal cohesion within RWS

Furthermore, it became apparent that resource allocation, upscaling, and implementing innovations are significant challenges during the innovation process. Collaboration is viewed as the most important success factor. Many other success factors, such as openness to new ideas, the provision of testing spaces, and internal cohesion within RWS, are also linked to collaboration. This aligns with the three prerequisites outlined in RWS's innovation agenda as crucial conditions for stimulating innovation in the sector, namely: the allocation of resources, faster development and implementation of innovations, and collaboration with partners in the sector. For this reason, the next sub-chapter will further elaborate on these three conditions as influences of RWS's innovation strategy in the water and subsurface sector.

6. Research findings - The influence of the innovation strategy of RWS

In this chapter, the practical experiences of employees from Deltares and RWS are utilized to gain deeper insights into the influence of RWS's innovation strategy in the water and subsurface sector, and the question whether intended effects are achieved in practice. The first part explores the allocation of resources, the second part delves into the development and diffusion of innovations, and the third part focuses on collaboration within the water and subsurface sector. It is again important to note that the participants hold various roles within their respective organization, offering a diverse range of perspectives. The sub-question that will be addressed in this chapter is:

- *What influence does Rijkswaterstaat's innovation strategy have on resource allocation, the development and diffusion of innovations, and collaboration within the water and subsurface sector?*

6.1. Resource allocation

The central question in this part of the research is whether RWS's innovation strategy has impact on what happens in practice. In other words, are the focal points considered when starting new innovations, and are resources effectively allocated. Additionally, the roadmaps are examined, as these are intended as long-term objectives to guide decision-making, also regarding resource allocation.

Overall, most participants view the focal points as guiding principles that provide a solid foundation for innovation. *"The focal points ensure that people do not just do things randomly. They help those with an intrinsic motivation to innovate and provide direction. Ultimately, people innovate to improve the organization, and through these focal points, people contribute easier to RWS's goals."* The focus on Sustainable Infrastructure is universally seen as logical and necessary, given the many infrastructural challenges, such as bridge maintenance and dike reinforcement. *"Sustainable Infrastructure is a logical focal point. It is an issue that inevitably arises."* Climate Adaptation is also recognized as a critical and urgent focus. *"It is crucial that an urgent issue like climate change is prioritized and prominently featured as a focal point."*

The first observation is that there is a consensus on the need to allocate resources in a controlled manner. Deltares emphasizes the numerous problems and challenges that RWS faces. *"RWS receives all the issues and must prioritize what is essential and what genuinely needs to be addressed through innovations."* The main reason for this is related to funding. *"The focal points allow RWS to strategically allocate funds to under-addressed themes."* This is recognized by RWS as well. *"When an innovation contributes to a focal point, it opens up possibilities, particularly regarding financial resources and humanpower."* This prioritization through focal points is evident in practice. *"It is clear that certain criteria are set based on the focal points that must be met to access financial resources. Having shared goals outlined in an innovation agenda is incredibly helpful."*

However, there are instances where innovations within the RWS organization do not directly contribute to any of the focal points, as also mentioned in a previous chapter. In some cases, this is understandable, as important innovations that do not fit precisely within a focal point can emerge. In practice, it is challenging to justify the allocation of resources for such innovations. *"Anything that does not fit a focal point is often dismissed as unimportant, even if you can justify its significant relevance. This is, of course, intentional because a line should be drawn somewhere, but I wonder if the current level of specificity is right for the sector."* One example is aquathermy, which involves sustainably heating and cooling buildings using surface and wastewater (STOWA, 2024). *"RWS initially found this topic quite daunting because it was relatively new and immature. We spent a lot of time figuring out*

how to explicitly align this theme with a focal point. Once it fit under Sustainable Infrastructure, it created opportunities, and now we are in the implementation phase."

Aquathermy is also used by RWS in another context, namely, to illustrate that the focal points are still too broad*. "The pitfall of the current focal points is that they are not yet clearly defined. Placing the theme energy under Sustainable Infrastructure without having a clear roadmap, for example, weakens the focus points' delineation."* This sentiment is shared by Deltares, where the general consensus is that the focal points do not provide enough specificity. *"The focal points are so broad that almost anything fits to a focal point if you want. If you really want to allocate resources effectively, you need to be specific about the themes and issues where you want input."* However, there is also a positive response from Deltares regarding the focal points. *"These focal points align well with Deltares' priorities, so I think they are perfect. We at Deltares can provide valuable input, and we are eager to contribute to RWS's major challenges, which have been clearly defined, allowing us to channel our energy into specific areas of innovation."*

The lack of clear delineation also leads to skepticism from Deltares, where the expectation is that RWS should first demonstrate how these focal points will translate into visible outcomes in practice. *"Honestly, I do not expect much from the innovation agenda and the delineation it provides. I am not convinced this will change the world, often it does not."* For example, the focal point Climate Adaptation presents challenges in terms of clear delineation, according to Deltares. *"You could develop a project that reduces emissions by minimizing dredging, and then argue that this is good for the climate and fits to Climate Adaptation. But the design of shorelines that adapt to rising sea levels seems more like a typical topic for that focal point. But where sets RWS its boundaries? That is still unclear to me."*

One clear influence of the innovation agenda with its focal points is the impact on perception, both internal and external. *"RWS's internal effort to focus increases visibility and clarifies what is expected across the sector."* It is also positive that RWS's focal points align with the priorities of the ministry of I&W. *"It is crucial to give attention to areas that are also politically prioritized."* However, RWS must also be aware of the negative side of perception that emerges in practice, as certain focal points may resonate less with people. *"Some focal points have less appeal in practice, often because they do not project enough clarity externally. For example, it is unfortunate that a focal point like Data and IV is deemed important by RWS, but I see and hear so little of it in practice."*

The national-level perception is important, but it is also crucial that it translates to the regional level. This is happening in practice, but it needs to evolve over time. *"At the regional level, the direction provided by the innovation agenda is appreciated because it feels like we can contribute to RWS's main goals, and it also helps us justify the allocation of resources."* However, it is noted that the innovation agenda is not the only important factor since the people involved are also crucial. *"It is crucial to have a dedicated group of people actively engaged with the themes we aim to innovate in, ensuring proper guidance and direction."*

The focal points also generate additional energy within RWS, even when innovations are somewhat hindered by the way they are delineated. *"Focal points are not really a hindrance in practice because you should try harder and perhaps redirect your valuable energy to other innovations when you do not meet the criteria."* The roadmaps also play an important role, as they outline long-term and short-term goals, making it clearer where people can contribute to making progress.

RWS's innovation agenda also emphasizes the importance of coherence between different focal points. For example, Climate Adaptation is a cross-cutting focal point that requires significant interaction with other focal points, and data analysis under the Data and Information Provision focal point is crucial for

reducing energy consumption in infrastructural projects (Rijkswaterstaat, 2023). This coherence is also noticed in practice and is seen as positive. *"Sometimes you contribute to two different focal points, which can be confusing, but I find it also beneficial because you are contributing to multiple goals."*

In summary, it is observed in practice that RWS allocates its resources in a controlled manner based on criteria, which is generally seen as understandable and beneficial. The focal points play a significant role in the accountability. However, it is also noted that the focal points are still quite broad, which does not provide enough specificity for targeted innovation. The challenge here is determining the appropriate level of delineation, as further refinement has both advantages and disadvantages. A clear influence is that the innovation agenda highlights the important aspects for RWS, both internally and externally, increasing visibility. This is already evident at the national level, but more time is needed for regional alignment. Finally, the focal points are sufficiently coherent to facilitate cross-cutting innovations in practice. The main findings are shown in table 7.

Table 7: Main findings of the influence of RWS's innovation strategy on resource allocation

Main findings regarding resource allocation
The focal points serve as guiding principles in practice, providing a solid foundation for innovation.
There is sector-wide consensus on the need to allocate resources in a controlled manner due to the numerous challenges the sector faces.
The focal points play a significant role for RWS employees in ensuring accountability for scarce resources.
The focal points are too broad and lack sufficient specificity for targeted innovation.
The absence of clear delineation of these focal points creates uncertainty and skepticism, particularly from Deltares.
Key challenges for RWS are to increase visibility at the regional level and determine the appropriate level of specificity for the focal points.
The focal points are sufficiently coherent to facilitate cross-cutting innovations.

The product innovation of the Xstream blocks is a clear example where the innovation agenda, in this case through the SRL tool, has assisted in resource allocation. The SRL tool was used to analyze the innovation process of developing the Xstream blocks through a pilot project. It provided insights, based on reflections from multiple involved stakeholders, for creating an action plan that prioritized key elements and identified what should take precedence when making decisions in the next steps of the innovation process (Vreugdenhil, 2020). The SRL tool, which is itself a process innovation and was used for one of the first times during this project, helped provide clarity in focusing efforts and allocating scarce resources.

A second example involves the maintenance contracts, where, in addition to a sustainable component, greater emphasis is placed on collaboration, including through learning spaces. *"A learning space is set up to work with knowledge institutions and contractors on innovations, with a specific budget and time allocated for innovation through this type of contracting."* These scarce resources are effectively utilized through such contracts, with the focus areas also being used for accountability.

6.2. Development and diffusion

The second key condition outlined in RWS's innovation agenda for stimulating innovation is a faster innovation process, specifically the development and diffusion phases. This is a critical condition since all participants identified at least one challenge associated with it. The literature also acknowledges that upscaling pilots is a crucial yet challenging process (Breman, Vreugdenhil, van Buuren, Ellen, & van Popering-Verkerk, 2017).

The primary issue in the development and diffusion of innovations lies in the numerous challenges inherent in the process. These challenges are well-documented in the literature and widely recognized by participants. *"Everyone is aware of the challenges during the innovation process but overcoming them remains difficult."* One prominent reason for these difficulties, evident in practice, stems from the nature of RWS's responsibilities and the resources available. *"Many innovations fail because RWS often opts for the lowest-cost or fastest solution. Renovation projects, in particular, are frequently done with one-to-one replacements, which RWS commonly prefers."*

Additionally, it is observed that many innovations struggle to pass through the so-called 'Valley of Death'. The Valley of Death is a metaphor describing the gap in available resources during the development phase of innovations, while more resources are typically available for discovery and commercialization of the innovation (Markham, Ward, Aiman-Smith, & Kingon, 2010). *"Innovations often fall into the Valley of Death due to high initial costs, even though many could lead to long-term cost savings."*

A participant from RWS suggests a potential solution that has already been implemented to some extent, partly through the strategic allocation of resources using the criteria of the focal points. *"RWS could further stimulate innovation by increasing funding specifically for development, which they have been gradually doing over the years. This would allow RWS to take more risks in favor of innovation."* Beyond resource allocation, the innovation agenda can guide the development phase. *"Roadmaps can support the development of the right innovations by providing project leaders with clear long-term goals and short-term objectives."* Moreover, the SRL tool could enhance the development phase by identifying obstacles to innovation from various perspectives. *"The SRL tool should be employed to diagnose why a particular innovation is challenging to develop by addressing issues from different angles."* Participants from RWS reported positive experiences with the use of this tool in this context, while most of the Deltares participants never used it in practice.

The IUP Guide, in theory, should aid in the development and diffusion of innovations, but in practice, it has not yet proven effective. As highlighted in a previous chapter, almost none of the participants seemed to really understand what the IUP Guide entails, and this is further emphasized here. *"The IUP process is supposed to help us with scaling innovations, but I cannot find anything beyond a few scattered pieces of information. This makes it hard to use at the moment."* This indicates that the innovation agenda provides insufficient information on the IUP Guide, which is understandable given that it only includes an image and a minimal description.

A challenge that becomes more evident when attempting to standardize innovations relates to decision-making and regulation. A vital part of the diffusion of innovation is the transfer of knowledge from pilots into practice and policymaking (Vreugdenhil, Taljaard, & Slinger, Pilot projects and their diffusion: a case study of integrated coastal management in South Africa, 2012). Overcoming this in practice requires a particular mindset from key players in the sector. *"Regulations often hinder the implementation of innovations or even the initiation of pilots. The only way to create positive momentum is if everyone in the sector adopts an attitude that demonstrates a collective willingness to achieve things that were previously unattainable due to existing laws."* Although there seems to be movement in the right direction, this attitude is still not widespread. *"The challenge lies in incorporating a proven innovation into maintenance plans, that is an incredibly complex and time taking process. While it is encouraging that more people are now considering potential challenges early on, the situation remains frustrating."* Sometimes, the obstacles are not regulatory but contractual too. *"New techniques often do not fit within the traditional way of working, and this is frequently due to contractual issues."*

Sustainable sediment use serves as a good example of this challenge. *"Deltares, in collaboration with dredging companies and RWS, successfully completed a sustainable groyne replenishment, which we can scale up. However, scaling up is difficult because it does not fit within existing contracts, and those contracts need to be amended first. Meanwhile, dredging ships pass by the destinations daily, ready to address the issue directly, but they cannot due to the contractual situation. The motto 'we will just do it' is impossible because of RWS's culture and its contract structure."* Another example is cross-border dredging. *"It appeared to be more efficient to dredge in Flanders than in the Westerschelde for several reasons, but this is extremely challenging due to various contracts and permits. This problem even arises when dredging in different regions within the Netherlands, due to differences in contracts between RWS and water boards."*

One way to stimulate the development and diffusion of innovations involves the WVL department, which is responsible for the innovation agenda. *"Innovation managers are extremely important since they can give mandates and invest time in guiding project leaders through the innovation process."* Additionally, Deltares has observed a genuine need for the implementation of innovations from WVL, and thus RWS*. "In recent years, there has been a shift at RWS, making it easier to initiate pilots in the field of sediment management. We have always been good at coming up with new ideas together, but now WVL is also clearly expressing its need to apply the knowledge gained in practice."*

Contractors are also increasingly recognizing the need to implement innovations more quickly, but they can also slow down the process when the conditions are not favorable enough for them*. "When contractors lack the drive to innovate, whether due to financial constraint or other motivations, the process remains very slow."* For Deltares, their way of working does not always promote the implementation of innovations according to RWS participants. *"Deltares is a knowledge institute, and what sometimes happens is that they focus too much on reinventing the wheel and writing as many publications as possible, rather than helping to implement existing good ideas."*

What is also evident in practice is that the departments within RWS responsible for innovations are not always well-aligned with each other*. "Different departments within RWS have their own set of criteria that technologies must meet."* Several departments play prominent roles when it comes to innovations*. "Currently, innovations move from WVL to GPO or PPO and then to project teams in the regions, which leads to significant fragmentation of knowledge and disruptions in the process. It is definitely not a smooth process yet."* This issue is particularly seen by Deltares participants as a practical problem in scaling up innovations, which needs to be addressed. *"At GPO and PPO, people think differently than at WVL, where innovations with low TRLs begin. I notice that a lot of work is done in the initial phase, but at some point, WVL is no longer involved in the innovation, and it moves to PPO or GPO. The handover and the realization in execution are not always well managed."*

According to Deltares, this problem is difficult for WVL to solve on its own. *"WVL is a too small player within the organization to effectively convey its vision. They do not have the position for that. We at Deltares try to promote this vision by engaging in discussions, but we also cannot take on that role."* Another participant emphasizes the cultural differences between the different departments. *"The cultural differences between WVL and GPO or PPO seem so significant that they appear to operate separately from each other. This does not project a sense of uniformity."* It is also acknowledged within RWS that the collaboration does not always go smoothly*. "People at PPO and GPO are involved in the innovation projects, whereas at WVL, it seems like they only talk about them. They want to do a lot of research and provide scientific backing, but the DGWB itself says that we need to simplify everything, focus on doing things, and learn from that."* However, problems do not always arise due to a lack of collaboration, it also depends on the individuals involved. *"There is sufficient interaction between WVL*

and PPO or GPO, but people should actively search that interaction. People need to recognize and accept the differences in thinking and take action to address them rather than avoid them."

The RWS innovation agenda's willingness to stimulate faster development and diffusion of innovations faces significant practical challenges, which are widely recognized but difficult to overcome. The process is often hindered by a preference for low-cost solutions, resource constraints, and the Valley of Death, where innovations struggle due to high initial costs. Additionally, misalignment and cultural differences between RWS departments, along with contractual and regulator barriers, complicate the scaling of innovations. While efforts like strategic resource allocation and tools like the SRL tool show promise, there is still a lot to improve. However, it is generally acknowledged that RWS made small steps in the right direction over time. Finally, other key players in the sector should also improve the development and diffusion of innovations by providing more input. The main findings are shown in table 8.

Table 8: Main findings of the influence of RWS's innovation strategy on the development and diffusion of innovations

Main findings regarding the development and diffusion of innovations
Many innovations struggle to pass through the Valley of Death because resources are limited during the development phase, leading RWS to opt too often for one-to-one replacements.
The roadmaps, SRL tool, and IUP Guide have the potential to stimulate the development and diffusion process, but these tools are not yet well-known both internally and externally.
The innovation agenda does not provide sufficient information about the roadmaps, SRL tool, and IUP Guide.
Contractual and regulatory constraints frequently hinder the development and diffusion of innovations in practice.
The departments within RWS responsible for innovations are not always aligned with each other.
While there is still much to improve, RWS has made small steps in the right direction over time.
Other key players in the sector should improve the development and diffusion of innovations by providing more input.
The influence of the innovation agenda on the development and diffusion of innovation will need more time before it becomes more evident in practice.

As an example, the SRL tool, which was used during a pilot project with the Xstream blocks, had a significant impact on the development and diffusion of this innovation. Stakeholders were explicitly asked to provide their perspectives on the implementation of the Xstream blocks, with the SRL tool serving as a evaluating tool (Vreugdenhil, 2020). In addition, the SRL tool in general potentially stimulates the development and diffusion of innovations. *"The SRL tool provides timely insights into the steps that still need to be taken in the future during an innovation process. This can accelerate the process, as it helps avoid unexpected challenges later on and allows stakeholders to challenge each other at an early stage."* The SRL tool itself is also an example, as its use in various pilot projects has contributed to its further development (Vreugdenhil, 2020).

Maintenance contracts are another clear example of the influence of RWS's innovation agenda on the development and diffusion of innovations. *"Through learning spaces, it becomes possible to learn across projects, facilitating both the learning and development of innovations."* Additionally, other maintenance contracts without learning spaces also stimulate the development of innovations through their sustainability component. *"Forward-thinking contractors go the extra mile because maintenance contracts challenge the market in terms of sustainability, prompting additional efforts to advance innovations."*

6.3. Collaboration

Collaboration is recognized as a key success factor by the participants, and RWS also underscores its importance in the innovation agenda. The study explored various aspects of collaboration, including the partnership between Deltares and RWS, the broader cooperation across the water and subsurface sector, and the internal collaboration within RWS. This chapter also provides a clear example that illustrates the possibility to collaborate within the sector.

Collaboration Deltares and RWS

RWS emphasizes in its innovation agenda that it relies on others to innovate. Previously, initiatives had to come from the market, but now the government acknowledges its crucial role in enhancing the sector's innovation capacity. The importance of collaboration with knowledge institutes is also highlighted as essential for conceiving and developing new innovations (Rijkswaterstaat, 2023). Deltares participants have observed a positive effect since the market no longer dictates innovation in the sector. *"Things are slowly improving because after 15 years of market-drive approaches, RWS now possesses more in-house knowledge, allowing us to work more often as sparring partners on innovations. Of course, there are occasional tensions because RWS sometimes assumes that this knowledge means they know everything, and a bit of tension is fine, but this approach at least fosters innovation in the sector."*

RWS also aims to seek collaboration with its partners, including Deltares, earlier in the process and for a longer time (Rijkswaterstaat, 2023). Deltares views this as extremely important, and progress has been observed compared to the past. *"Involving Deltares early in projects provides a more realistic picture of the situation sooner."* However, this does not always go smoothly, leading to mistakes that could have been avoided with closer involvement from Deltares. *"In replacement and renovation projects, things still often go wrong. Deltares is either consulted only for preliminary advice or brought in as a crisis manager when it is already too late, and something has gone wrong. For example, during the renovation of the Afsluitdijk, we were only able to provide input beforehand, and ultimately, significant issues arose, resulting in a costly damage operation worth millions. In such projects, it becomes clear that we are not yet the strategic sparring partner we could be in every situation. While the collaboration is gradually improving, there is still work to be done."* That role of crisis manager is sometimes unavoidable in emergency situations. *"In the event of an emergency, RWS knows to find us quickly, and we are promptly brought to the table to advice them and take urgent actions."*

Collaboration meetings or knowledge-sharing meetings like conferences are seen as important by both RWS and Deltares participants for improving their partnership. *"Collaboration days are opportunities where people can inspire each other, but also express and listen each other's frustrations. I strongly support these days."* At Deltares, the opportunity to share knowledge with partners is particularly valued. *"An innovation project where there is room to share knowledge with others is, in my view, a clear success."* All participants agreed to the fact that such days are valuable and organized more often than before.

The collaboration at the project level is regarded as important by Deltares, although it must be noted that it is highly dependent on the individuals involved. *"The project-level collaboration between Deltares and RWS counterparts needs to be strong, but that is not always the case because not everyone works well together. That is fine, but Deltares and RWS need to manage and coordinate this better at a higher level to improve collaboration."* A practical example is provided: *"At CIP* (Corporate Innovation Program of Deltares and RWS)*, the collaboration seems to be weakening recently. This is partly due to personnel changes on both sides, making roles and responsibilities less clear. I certainly do not blame RWS, because we at Deltares could have taken more responsibility in this as well."*

Triangular cooperation

Besides Deltares and RWS, the private sector and other government agencies are often involved in innovative projects. While other government agencies have already been discussed in the sub-chapters focusing on regulations and creating an innovative-friendly environment, the private sector is also crucial. The collaboration between the private sector, academic sector and public sector is often called a triangular cooperation (Werker, Ubacht, & Ligtvoet, 2017). As mentioned, the financial aspect plays a significant role and influence the collaboration frequently. *"The different interests among stakeholders should be considered, so also that some contractors may step out a project if there is a lack of commercial gain, which can cause the failure of an innovation."* A recent example from the perspective of Deltares explains the possible problems. *"Recently, a sediment management project failed because a dredging company participated in an innovative project that would ultimately reduce the need for dredging. Although this was a positive outcome, the dredging company stepped out the project, which highlights the conflicting interests that can arise."*

Deltares can also play a role when interests threaten to conflict due to its independent position. *"Bringing people together is important to foster innovation, even if it seems conflicting at first. Deltares can have a mediating role in this, as has happened in the past, leading to interesting collaborations that initially seemed impossible."* Contractors often play a crucial and indispensable role in innovations with their practical knowledge. *"Inviting private companies in projects early is vital since their critical view on practical feasibility is essential. Often it is a triangular collaboration between contractors, Deltares, and RWS, and that keeps everyone focused."* A consultancy firm is also needed for practical expertise and therefore adds value to innovation projects. *"Consultancy firms are important partners, providing RWS with extra practical support while Deltares can focus on what they do best, namely offering independent advice and gathering scientific knowledge. This collaboration generally works very efficiently."*

In practice, collaboration is not always easy, but both parties agree that it is the only path to success. It is also clear that these collaborations never happen automatically. *"If we do not collaborate in this sector, nothing happens. So, it is essential to freely communicate with each other and seek opportunities for collaboration."* This requires a certain attitude for all key players. *"Effective collaboration is all about attitude, acceptance, behavior, and enthusiasm. It does not all need to be written down, although historical awareness from experience is also important."* This attitude also means that sometimes a partner takes on tasks that are technically someone else's responsibility. *"Sometimes at Deltares, we see that stakeholders have not been sufficiently informed, so we take on the role of informing them because it can be crucial to the innovation's progress. Everyone needs to be aware. That should be RWS's task, but we can certainly play a role when needed."* Finally, it is crucial to build a team with all the stakeholders involved. *"We need to create a team spirit, but always with a solid business foundation."*

Trust

These joint projects require a level of trust that must be present during innovation processes. This is particularly important given that RWS is a large organization with a specific culture where trust is crucial to being heard. According to Deltares, this culture is dynamic. *"I have worked in coastal projects for a long time and have built a network within RWS. That is partly about trust, as it is a cultural thing. Sometimes collaboration hampers due to personnel changes, but other times it creates new opportunities. I particularly notice that knowledge flows both ways as a result."*

Trust also increases the visibility among RWS employees. *"A certain project often has a person associated with it, and some people are easier to find than others. At Deltares, we therefore also sell trust. If you suddenly place someone new into a prominent position, it is less certain whether RWS will*

immediately invest in a project." When trust is lacking, it directly impacts collaboration. *"In some specific cases, we see that RWS people ask consultancy firms and universities for knowledge, when they could have found better knowledge at Deltares. That is partly about having a good relationship."* Still, it is clear that collaboration is more likely to succeed when parties put in the effort. *"People are always open for collaboration, but you need to proactively build your network."*

In practice, it is also noticeable that the relationship has increasingly come under strain lately, with trust seemingly lacking. While there are many successful innovations, there is also recognition of failed collaborations. *"We need to be careful because, after a few incidents in recent years, there has been a growing trend of mistrust. We need a sector that trusts each other and has room for ideas, but in recent years, things have been structurally heading in the wrong direction."* This is partly due to some knowledge programs contradicting each other in placing importance on different conditions. *"In lifespan studies for storm surge barriers, solutions are often proposed that require changes to the water system before they can work. Conversely, in the Sea Level Rise Knowledge Program, solutions are suggested that require significant infrastructural changes. This results in two studies that completely conflict with each other, leading to internal competition rather than mutual trust."*

Collaboration within RWS

Collaborating within a large organization like RWS comes with several distinctive challenges. One of these is the fact that people work at different levels, which can make collaboration complex in some cases*. "Within RWS, there are national departments like WVL, which focuses on broader policy-driven ambitions and objectives. On the other hand, there are also regional departments that are often just glad to complete regular work within budget and time; they work much more in the present to, for example, keep a flood defense system operational. The national departments, which are more focused on the long term, are therefore more involved with innovation, and this difference can lead to friction in practice."* However, this collaboration has improved compared to the past, thanks to several positive developments, including a regional reorganization. *"In the past, each region had its own project teams with their own ways of working. Now we have moved to a limited number of systems and have more standardized procedures. Contract managers now also share knowledge among themselves and collaborate much better than before."*

At the national level, there are also employees working to help the organization move forward and prepare for innovations. *"Many people are working internally to steer the large organization of RWS in the right direction. We need people who put effort into this process, and there are more of these at the national level than at the regional level."* What works in practice is that there are currently many more people involved in innovation who are intrinsically motivated to do so, and it is important to note that they are also being given more space by RWS. *"Placing innovative people on projects helps improve collaboration. It would also help to give these people more targeted assignments and support, ensuring all the conditions are in place for successful innovation."*

Despite this, internal collaboration problems persist, even among intrinsically motived innovators. There is still a pervasive culture where people focus on their own projects and only share results with those directly involved. *"I feel that projects are very focused on their own tasks, so in my view, collaboration outside of these projects is too weak. People do talk to each other, but it is often coincidental or within their own networks."* However, what is also visible in practice is that the various transition paths do encourage collaboration, partly because people are involved in multiple projects. *"Between transition paths, I notice a lot of collaboration and knowledge exchange, also because employees are often working on multiple projects, which leads to knowledge spillovers."*

Learning spaces

An intriguing method of collaboration is the Self Supporting River System (SSRS), where innovative ideas are continuously tested in a structured environment with room for innovation, contributing to sustainable and reliable river management (Rijkswaterstaat, 2024). This is a specific way of collaboration for innovative replacement and renovation projects but underscores that the sector is capable of finding innovative ways for collaborations. Among the projects that have emerged from this collaborative framework is the previously mentioned project involving Xstream blocks for groynes, along with several others. In these so-called 'learning spaces', budget is available to scale up innovations, and these innovations are separated from regular project teams that are bound by various contracts. Deltares frequently plays a role in these spaces. *"In learning spaces, Deltares contributes by monitoring, evaluating, and reporting on projects. Additionally, they are responsible for the scientific knowledge generation."*

Learning spaces are designed to facilitate better collaboration between the private sector, academic sector, and public sector, thereby creating opportunities for innovation. *"Learning spaces are established to work collaboratively with the private sectors, such as contractors, and research institutes on innovations that help achieve objectives. The purpose of a learning space is to remove an innovation trajectory from a project team, which is primarily focused on time and budget constraints, as a measure to enhance collaboration."* Another example of a learning space is the grazing with sheep initiative, which is also an innovative project. The advantage of a learning space is that it generates shareable knowledge. *"Each project adds to the collective learning capacity, allowing knowledge to be passed on continuously, so we can learn from every project."*

However, the individuals within the teams are also crucial in the learning spaces. "*In a learning space, it is important to maintain a multidisciplinary team over time and to speak with one voice, as this reflects unity. As a consortium, you learn to innovate and develop together, which fosters collective growth."* Furthermore, an annual meeting is held to inform everyone about the progress of ongoing projects. *"We ensure cross-learning between the different learning spaces, including through an annual open meeting for interested parties and stakeholders."*

Concluding remarks

Collaboration is critical for success in the water and subsurface sector, particularly between Deltares and RWS. Shifting from a market-driven approach to a more collaborative one has allowed RWS to harness in-house knowledge, enabling a more balanced partnership with Deltares. Despite progress, challenges persist in ensuring early and consistent involvement of all stakeholders, which is crucial to preventing costly errors and enhancing project outcomes. Trust, open communication, and the right attitude are essential for fostering effective collaboration, both within partnerships and across the sector.

Triangular cooperation between the public sector, private sector, and academic sector plays a significant role in driving innovation, though conflicting interests can create challenges. Within RWS, internal collaboration has improved but still faces obstacles, particularly between national and regional departments. Learning spaces like SSRS offer a promising solution by providing a structured environment where innovative ideas can be tested and scaled up, free from the constraints of regular project teams. These spaces promote cross-sector collaboration and ensure continuous knowledge generation, contributing to the sector's overall innovation capacity. The main findings are shown in table 9.

Table 9: Main findings of the influence of RWS's innovation strategy on internal and external collaboration

Main findings regarding internal and external collaboration
RWS now engages with partners earlier in the innovation process, which positively influences both innovation and sector-wide collaboration.
Effective communication at the project level is crucial, as it is where close collaboration takes place.
The triangular partnership between knowledge institutes, public organizations, and private parties is highly valuable and has strengthened over time.
Collaboration does not happen automatically and can be difficult, but it remains essential for innovation success.
A lack of trust in innovation projects directly hinders collaboration.
Internal collaboration within RWS is challenging due to differences between the national and regional level and misalignment between departments.
Learning spaces are created to enhance collaboration between the private, academic, and public sectors, opening up more opportunities for innovation.
The influence of the innovation agenda on internal and external collaboration will need more time before it becomes more evident in practice.

The influence of RWS's innovation agenda on collaboration during innovation processes is clearly reflected in the learning spaces. *"In learning spaces, the focus should not be on large initial gains. RWS provides funding, but contractors must also contribute financially in the early stages of a new innovation. This fosters true collaboration."* The SRL tool, as a process innovation from the innovation agenda, is used to enhance mutual understanding between partners working together (Vreugdenhil, 2020). Additionally, the development of the SRL tool involves both internal and external collaboration to further improve it. *"Several workshops are organized to raise awareness of the tool and collaborate on its further development as a process innovation."*

The pilot project with the Xstream blocks is an example of a collaborative project where sustainable contracts also play a crucial role, emphasizing the importance of cooperation. Royal BAM Group, RWS, and Deltares, along with various consultancy firms and contractors, collaborated to gain insights into this innovation and work together on creating an implementable product (BAM Infra Nederland, 2024). This pilot, which also utilized a learning space, has led to the planning and execution of multiple projects involving Xstream blocks (Anvik, 2021). Effective collaboration played a significant role in this, as did the way the project requirements were initially set. *"In the tender process, we as contractors had to meet certain conditions, but we were free to come up with an innovative solution to the problem. This method of tendering encourages contractors to devise smart solutions that meet the pre-set requirements of RWS."*

7. Research findings – Evaluating RWS's innovation strategy

The third part of the research findings evaluates RWS's innovation strategy based on the impact in practice. The ten interviews, as outlined in the methods chapter and also used for the previous chapter were used in the evaluation. In addition, a market party interview is used in the evaluation. The first part of this chapter considers the reflective answers of the participants on innovating in the water and subsurface sector and the impact of the innovation strategy. Secondly, the participants were asked what could be improved in the future. Finally, the overall judgement of the participants contributes to a set of recommendations to enhance RWS's innovation strategy. Quotations from the interviews are presented in italics and between quotation marks. Additionally, various reports and other literature have been utilized to complete the narrative and ensure consistency in interpretation. The fourth sub-question answered in this chapter is:

- *How can Rijkswaterstaat enhance its innovation strategy to foster its influence on the water and subsurface sector?*

7.1. Reflection on the influence of RWS's innovation strategy in practice

7.1.1. General findings

Most participants not only answered the interview questions but also reflected on the innovation strategy and its practical impact. Furthermore, some reflective questions were also already part of the interview questions. Although the specifics of the innovation agenda were often not fully known to the participants, they were generally familiar with RWS's strategy and the general objectives. How the sector responds and whether the information from the innovation agenda aligns with the actual situation is of interest. Such reflections provide a basis for evaluating the current situation and formulating recommendations and potential enhancements.

The first point of reflection is that an innovation strategy, such as the innovation agenda, can be valuable for communication, both internally and externally. Internally, the ideology of the innovation agenda is gradually gaining traction within the organization, indicating that WVL's efforts are being rewarded. However, while there is a noticeable increase in awareness at the national level, awareness at the regional level remains generally insufficient. As one participant noted, *"It is clear that WVL has put significant effort into a new innovation program for RWS, the question is whether it is integrated across the entire organization."* This turns out to be difficult since the organization RWS is so large.

Both Deltares and RWS participants appreciate WVL's effort and encourage them to maintain their current level of enthusiasm. A Deltares participant remarked, *"I can see that RWS is doing a lot and making efforts, so they should keep up the good work and not slow done."* Similarly, a RWS participant commented, *"Our innovation team is doing great and are working with a lot of energy, they should definitely keep going and absolutely not stop."* The similarity in responses from both organizations highlights the recognition and appreciation of WVL's work.

Several influences attributed to RWS's innovation strategy can be observed in practice. First, the importance and necessity of such an agenda are evident, primarily because RWS as an organization occasionally requires reminders to bring certain issues back into focus. As a participant noted, *"I can see that an innovation agenda is particularly necessary internally for RWS because there is a constant need to stir things up to highlight the urgency."* This has proven true in practice, as the innovation agenda is increasingly being used for accountability purposes. Another participant commented, *"The current innovation agenda is very effective in providing a broad overview of the ongoing developments. For internal personnel, it can also assist with accountability and help people connect with one another. Knowing what is already being done prevents reinventing the wheel."*

However, the tools associated with the agenda seem to not fully integrate into the organization, as indicated by the participant's responses. Still, there is an acknowledgment of the potential value of some tools. One RWS participant remarked, *"Hopefully, people will start to utilize the SRL tool to challenge each other in that area."* Furthermore, the awareness among external partners is lacking, based on the answers of Deltares participants.

The sense of urgency is also increasingly recognized, as reflected in the interview responses. This is partly due to the attention the topic receives through the innovation agenda, which also highlights the reasons why traditional processes are no longer viable. One participant observed, *"The innovation agenda provides some direction and explains why we cannot continue with our current methods but must innovate. This definitely fosters greater understanding."* While short-term goals can be helpful, the agenda also emphasizes the importance of long-term objectives, which are crucial. However, there is suggested that WVL should focus more on guiding long-term goals. *"There is too much emphasis on short-term goals without considering long-term objectives, and that is something the innovation department should address more."*

There is considerable support from both RWS and Deltares for a document that articulates the organization's innovation strategy. However, there is some doubt as to whether it has yet reached the appropriate level. As one participant stated, *"At the moment, it still has the feel of a bureaucratic accountability document, as it is far too broad to truly convey that RWS is an innovative organization where the needs for innovation are clear, and where innovation is rewarded."* This quote suggests that there is still uncertainty regarding the scope of the agenda. These discussions indicate that there is no definitive answer to how narrowly defined an innovation agenda should be, making this a complex issue.

7.1.2. Innovate with focus

The innovation agenda, with its five focal points, primarily provides a framework that helps the organization internally justify the allocation of resources. *"You need to ensure that you are contributing to RWS's goals and not wasting the innovation budget."* Additionally, the innovation agenda offers guidance on how to innovate more effectively than in the past. *"Focus is crucial because, in the past, we often fell into the trap of doing too many things out of enthusiasm. It is more effective to tackle one thing intensively over a longer period of time."* This focus is also driven by the pressure and urgency that comes with the numerous challenges RWS faces, necessitating strategic choices. *"Focus comes with the pressure to make the right decisions at the right time. It is also important to understand RWS's needs."*

The interview results indicate that Deltares is ready to support the focus that RWS is setting and understands its importance. It is also recognized that the entire sector is working with a strong sense of focus, driven by the choices that RWS has made, particularly through the innovation agenda. *"I think the sector is now sufficiently focused, but ultimately, everything is done for the government as the primary problem owner, so they need to establish that focus, especially internally, to accelerate progress."* This internal focus should lead to more innovations moving in the right direction, a process that is currently underway and progressing steadily. However, one recurring issue that complicates this focus on innovation is that *"We are often too busy in the sector to also innovate, but it is necessary."*

The interview results reveal that the focal points are generally seen as logical and necessary, given the significant challenges the sector faces. In practice, there is also evidence that more investment is being made in innovations that align with these focal points, while innovations that do not fit are harder to initiate due to the criteria RWS applies. A common critique is that the focal points are still too broad,

allowing too much to fit within them. This is something that RWS should improve in the next version of the innovation agenda, according to the participants from both Deltares and RWS.

7.1.3. Innovate faster

The interview data shows that, for Deltares and the private sector, progress can never be fast enough, but it is the government that sets the pace. *"No one should worry about the willingness of knowledge institutes and the private sector to go faster, that is what we always want. The government sets the pace, so the message of the innovation agenda to innovate faster is primarily directed at themselves."* RWS disagrees with this, as the research earlier in this study has shown that knowledge institutes can hinder progress by conducting excessive research and that private parties may focus solely on high profits. However, Deltares emphasizes the importance of removing obstacles and, in particular, promoting the testing and implementation of innovations. *"Removing the well-known barriers to innovation, such as issues with permits and regulations, must be prioritized to accelerate innovation."* Additionally, the sector's dynamics and prevailing culture need to change. *"Everyone knowns that things need to move faster, but there is still risk-averse and traditional behavior in the sector that causes delays."*

In practice, the biggest challenge lies in implementing innovations, particularly in using existing knowledge to develop innovations through pilots. *"The crucial point is that we need to apply knowledge more quickly to develop and implement innovations, but this process seems to be extremely challenging in practice."* Although there has been an increase in successful pilot projects compared to the past, the reduction of certain challenges during the innovation process is not yet evident. The metaphor described in figure 19 illustrates how the large volume of regular tasks hinder innovation. *"The problem in the sector can be depicted with an image of two people pulling a cart with square wheels. There is also someone holding round wheels, trying to draw attention to them, but it does not work because they are too busy with the heavy task of pulling the cart. In other words, people are overwhelmed with their regular duties, which underscores the importance of innovating to make those tasks more manageable."*

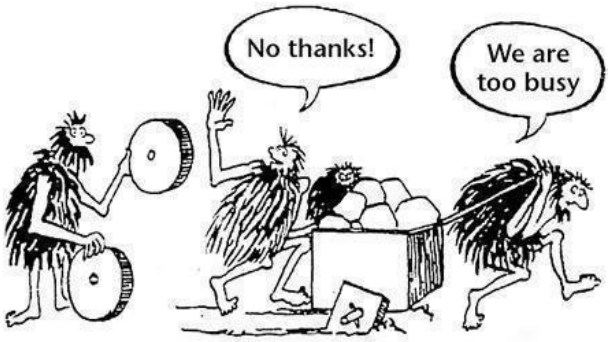

Figure 19: Metaphor illustrating the importance of innovation (Busybusy, 2020)

It is also evident that accelerating the process is not always possible since sometimes things simply take the time they require. However, the ambition to speed things up is commendable. *"The idea of moving faster is twofold. While pilots should be scaled up more quickly, some processes just take as long as they take. Nevertheless, the ambition should be to ensure the process runs smoothly and efficiently."* What is crucial for developing innovations more rapidly and ensuring their practical application is decisiveness. *"Decisiveness would help accelerate innovation trajectories."* The innovation agenda could play a larger role in this by, for instance, giving the IUP Guide more visibility and providing more information about it, as the lack of knowledge about this tool among participants suggests.

7.1.4. Innovate together

Collaboration is seen by everyone as indispensable in this complex sector, and it starts with bringing stakeholders together. *"If we do not work together, innovation will never progress faster, which is why it is crucial to keep bringing parties together. Deltares is not particularly strong in maintaining energy around a specific topic and in networking, but RWS has the people who are capable enough to do that."* The innovation agenda outlines various roles that RWS can assume during innovation processes, which should assist RWS employees in managing innovations, particularly in the area of stakeholder management. Especially the facilitating and stimulating roles of RWS are noticeable in practice. Tools like the SRL tool can also support this effort. However, there appears to be insufficient knowledge to fully leverage the innovation agenda for this purpose, though it is evident that collaboration is improving compared to the past. *"We need each other to move forward. In the past, RWS dedicated what the market should do, but now it is more of a collaborative effort, and I can see significant progress being made in this area."*

The urgency of collaboration is strongly felt. *"Collaboration is the most important aspect and should be at the forefront of the innovation agenda. It is essential that we work together, and this is generally happening across the sector."* That is also the point Deltares wants to make, that the innovation agenda should be a document that shows how important it is to innovate together. Collaboration is even described as a success factor by many participants. *"Working together enables faster innovation; this is where we can truly make a difference."* Despite the positive developments in practice, forming these collaborations remains complex due to the differing interests within the sector, and as a result, things still often go wrong. *"Collaboration is happening, but it does not always go smoothly. Practice sometimes shows that we still have much to learn."*

This is the moment to innovate, and it is an opportunity that the sector must take together. *"There is momentum for innovations at this moment, but it requires continuous effort, which is why the vision of faster, together, and with focus is both perfect and ambitious."* However, there is also a critical point to consider since the key players must demonstrate it in practice. *"Innovate faster together, with focus is a vision that captures the essence, but it is not the case that the impact is as noticeable in practice as it could be."*

7.1.5. Market perspective

Market parties have been repeatedly identified as essential partners in innovating within the water and subsurface sector, each with its own roles. Contractors, in particular, are expected to practically address the questions posed by RWS through contracts. The participant working for BAM acknowledges that role and adds they must also be prepared for the needs of the whole sector. *"The entire sector should expect us not to be conservative and always to be at the forefront of technical development to meet RWS's innovation needs. People should expect smart and practical ideas because there are many challenges, and in our view, stagnation means moving backward."* Innovative solutions can be requested by RWS, but they can also arise from the contractors' own perspectives. It is especially noted that RWS is becoming more open to ideas originating from market parties. *"In the past, we used to submit ideas to the Innovatieloket and would not even get a response, but now it is better, and people at RWS are more willing to discuss them."*

The contractor expects RWS to actively stimulate innovation and provide opportunities to innovate. *"RWS has the role of driving innovations so that everyone is encouraged to come up with smart ideas. After that, it is up to the contractors to demonstrate that something works so it can be tested and eventually implemented. Sometimes we initiate projects, but RWS provides the opportunities to apply ideas on a larger scale."* Deltares plays a crucial role in advising on the feasibility of innovative ideas

and in promoting the right innovation direction. *"Deltares provides independent advice with an objective perspective, considering the interests and benefits of multiple stakeholders. Moreover, Deltares always wants to move faster when it comes to innovation, which aligns with what we as a market party also want."*

Competition within the sector also plays a significant role in driving innovation, with RWS deciding who wins the competitive battle since they are the major client. This is why the competition in this sector is perceived as serious. *"Competition is intense and difficult, but it is fair and keeps everyone sharp. However, there needs to be enough margin to continue innovating."* The innovation agenda helps to provide focus so that contractors know which urgent problems need solutions.

The innovation agenda also reflects RWS's desire to innovate, but the contractor believes this could be better translated into practice. Two issues are highlighted: intellectual property rights and managing investment risks. *"The commercial aspect is significant because we also need to survive, and that is where conflicts could arise. Market parties want to make profit, and RWS wants to own and protect the innovation after the implementation phase. In such case, the contractor is only paid to develop and diffuse the innovation, after which they lose all rights and can no longer earn from it. This type of arrangement is still too often hidden in contracts and does not encourage innovation. As a market party, we need to be very careful and make good agreements about this."*

The second point is shared risks, which is also mainly related to contracts. *"There are positive developments happening because we now sometimes work with two-phase contracts where the assignment is first jointly determined, and then the price is set."* According to the contractor, this is an improvement compared to standard contracts. *"At RWS, prices are often determined within three months, and then the price is stuck for the entire project. Contractors can lose a lot of money because of such an agreement."*

Shared risks are present in learning spaces, which the contractor views positively. *"It is beneficial to work in a learning space with enough room for innovation, and the SRL tool is useful in bringing various perspectives to light."* So, the SRL tool is also mentioned by the contractor as known and very useful for highlighting different perspectives. In the learning spaces, the importance of collaboration and trust within an innovation project is particularly emphasized. *"We need to trust each other an understand each other's roles to see why people do certain things."*

Collaboration has clearly improved over the years, although not everything always goes smoothly. *"It can be seen that collaboration has increased, although we still sometimes feel that we are being obstructed by other parties. Collaboration also means that contract managers are not only focused on getting the best possible deal but on finding the best solution together."* There is a sense of urgency among market parties that more should be done, and they are eager to contribute to this, even though financial considerations are also important for survival.

7.2. Future vision

The participants' vision for the future of RWS's innovation strategy highlights a pressing need for rapid and efficient innovation, because humanpower is limited and projects are urgent. As one participant noted, *"We do not have enough people, and with major tasks like raising water barriers and replacing delta works, everything must be done faster and more efficiently."* This urgency underscores the importance of collaboration and a more targeted approach to innovation. Another key suggestion is for RWS to involve knowledge institutes and the market more actively in developing the innovation agenda, particularly on critical themes. *"Hopefully, RWS will ask more specific innovation questions on certain topics and involve knowledge institutes and the market more in writing the innovation agenda,"*

remarked a participant. This approach could lead to the creation of an innovation agenda that resonates across the entire sector. Additionally, there is a call for the agenda to address common innovation obstacles, such as regulatory and procedural challenges, to accelerate the implementation of new solutions.

In the future, it would be effective if the national departments of RWS were to take a more directive role and impose stricter standards on the regional departments. *"Some regions are already meeting the goals set for 2030, but this is not the case everywhere. The innovation agenda should enforce these standards more strictly. Of course, there are significant maintenance tasks and urgent situations, but if action is not taken now, we will not meet the 2030 goals at all."* On the other hand, fostering a culture that encourages collaboration and innovation is essential. *"It would be ideal to create a sector-wide culture where innovations can be proposed, embraced, and given the freedom to fail. Currently, the environment is too risk-averse and legalistic to foster a positive atmosphere for innovation."* This culture can be reinforced by small actions, such as recognizing innovators' successes and demonstrating that RWS is open to new ideas. *"Celebrating innovations and showing that they are beneficial for career advancement can motivate people to go the extra mile, and this should be more strongly reflected in the innovation agenda."*

The challenges faced by the regional departments are complex and addressing them require consideration of the differences between the national and regional perspectives. *"The experiences and priorities of the regional and national departments are so different. We need individuals who can bridge these gaps and bring people together. This should be integrated into the innovation agenda to ensure it resonates with all RWS employees."* Learning spaces can also provide an innovative environment that empowers regional departments to participate in the innovation process. *"More frequent use of learning spaces could significantly advance innovations without requiring extensive humanpower."* While improvements are still needed to make these spaces more effective, progress is expected in the coming years with the support of the innovation department. *"We aim to achieve concrete results in learning spaces that enhance current processes. Additionally, I hope we can streamline the process by reducing the need to search for innovation leaders, fostering smoother and more confident project execution. It would be beneficial if the innovation department could help secure an investment budget for the preliminary exploration in learning spaces, accelerating the scaling-up process."* Ideally, in the distant future, separate learning spaces might no longer be necessary, but for now, this remains a unique situation. *"I hope that in the future, learning and developing will be integrated into projects themselves, making separate learning spaces obsolete. Hopefully, this can be achieved by integrating them into specific contracts aligned with regulations."*

Deltares participants have suggested several additional options, including an out-of-the-box idea to link a high-profile position to innovation programs. *"Perhaps one day we or RWS will have a CIO, Chief Innovation Officer, to signal that innovation is top priority for the organization."* However, the first priority is to create an environment conducive to innovation, which also involves streamlining the permitting process to allow for quicker and easier testing of innovations. *"Pilots often require a separate procedure with various permits because they are currently treated as construction projects, necessitating a lengthy process. It would be beneficial to implement a policy change that simplifies this process."*

Finally, RWS participants have shared some future visions, such as investing time and resources into the IUP Guide to better support the scaling of innovations. *"The IUP Guide is a good first step in mapping out the different phases of scaling, but it is still somewhat abstract, and its effectiveness should be assessed. The same goes for the SRL tool. Both tools currently lack practical guidance, which seems necessary to truly support innovation. These tools should be critically reviewed and further*

developed." Additionally, it would be ideal if, in the future, Climate Adaptation no longer needed to be a specific focal point. *"I hope that Climate Adaptation will no longer need to be a standalone goal because it touches every aspect of our work at RWS. For now, it is essential to emphasize it because of the urgency and lack of awareness. In ten years, the question will no longer be if, but how we deal with a changing climate. In the future, it should simply become a standard consideration."*

7.3. Enhancements

Now that the structure and origin of RWS's innovation strategy, the noticeable influences in practice, and reflective feedback from participants with practical experience have been described, the next step is to make specific recommendations for improving the innovation strategy. Through an objective study of the information, several potential areas for improvement have been identified, not only for the innovation strategy itself but also for the department responsible for it.

Continuity and clarity

As stated in RWS's innovation agenda, the innovation strategy is never complete, which is beneficial because it is important to continually reassess whether the strategy aligns with emerging challenges, and to periodically evaluate and improve it. For continuity, it is advisable to maintain the focal points while remaining open to criticism from practice. Interview results show that there is internal and external support for the focal points, but there is a need for clearer delineation. Therefore, the recommendation is to include roadmaps, or summarizing figures, in the appendix of the next innovation agenda, outlining not only the topics but also short-term and long-term goals. This provides readers with insight into RWS's expectations and where specific innovation needs lie. The innovation agenda should also emphasize the urgency felt by the sector, highlighting themes where the sector is truly lagging. Additionally, it is important to emphasize uncertainties, as this can attract the necessary support.

Following the clarification of the focal points with roadmaps, it would be beneficial to provide more specific examples of innovations fitting each focal point. Currently, descriptions are too cryptical, offering little information on what is happening within each focal point. Providing clear examples would make the innovation agenda more informative and valuable.

Adding another level of detail would increase the document's value, especially by answering relevant HOW-questions. For example, risks are a significant concern for market parties, and while the innovation agenda mentions that RWS assists in this area, explaining the available methods would build trust and make the innovation agenda clearer. In addition, also specific WHAT-questions should be answered more frequently, as the innovation agenda should bridge the gap between the strategic and organizational level by emphasizing on what should be done to reach the goals of 2030.

Appearance

The second point of focus is to give the innovation agenda more external visibility now that it has gained better traction internally. This can be achieved by actively and enthusiastically presenting the innovation agenda to key players in the sector, with the message that RWS is seeking collaborations to foster innovation in the sector. Another approach is to write an innovation agenda that applies to the entire sector, serving as a central document that everyone can rally around to advance the sector.

An important aspect is to emphasize that both knowledge development, supported by universities and knowledge institutes, and testing and implementing innovations, where contractors and local governments play a role, are crucial for stimulating innovation in the sector. This way, external partners can see where they can contribute and add value to the sector. It is also important to write the innovation agenda in a way that portrays the water and subsurface sector as an open environment for

innovation, highlighting that collaboration with RWS on innovation projects is rewarding. In addition to the previously mentioned risks, the added value for the private sector should be clearly visible in the innovation agenda to make it attractive to market participants. This approach would help shift the sector's reputation from being traditional and conservative to being progressive and profitable to some extent.

Collaboration

When updating the innovation agenda, it is crucial to seek collaboration in drafting the new strategy. While the innovation department indicates that many people, both internally and externally, were involved in developing the innovation agenda, interview results reveal that participants from Deltares and other RWS departments are unaware of such collaborations. RWS should collaborate with partners with various expertise and backgrounds to foster collaboration within the sector.

The next version in 2025 will be a midterm update of the current innovation agenda 2030, where forward-looking and reflective aspects must both be prominently featured. This will demonstrate the goals set for 2030 and show the extent to which the sector is on the right track. Goals must also be set fort the further future since 2030 is no longer long-term as it is already 2025 when the updated innovation agenda will be released. The midterm update is also the moment to invite key players who frequently collaborate with RWS on innovation projects to join in reflecting on the past and planning for the future. This would bring diverse perspectives and critical insights that can be used in the new version. This approach would make the innovation agenda more inclusive for the entire sector, ensuring that all partners feel heard.

Another point in collaboration is to involve regional departments more in updating the innovation agenda, as it has not always been well-received in those areas. This seems to be partly due to the significant differences between national and regional services. However, since innovations often occur in or involve regions, it is important for these departments to recognize themselves in the innovation agenda to increase engagement and unity across RWS.

A final point related to collaboration relates to the differences between WVL, responsible for Knowledge and Innovation, and GPO or PPO, responsible for Innovation and Market. WVL, GPO, and PPO are all part of the innovation process. In the past, it has been shown that having a separate innovation agenda for the Innovation and Market department is not the ultimate solution, and now it appears that while the innovation agenda is in good hands with WVL, looking at all the positive developments in practice, it is still not fully embraced by other departments. Knowledge, innovation, and market processes should be well-integrated to give innovations a chance to be implemented. Therefore, the strategy must be supported by all departments involved in innovation, regardless of the innovation project's phase. It is unbeneficial when the criteria of different department are not aligned or do not complement each other. This also causes that the innovation agenda is neither well-known nor fully adopted by other departments within RWS. Therefore, it is important to involve other RWS departments in updating the innovation agenda, as this would convey unity and clarity, giving the innovation agenda more substance and authority.

Facilitating the innovation process

Much research has been done on the obstacles to innovation, and these challenges are well-known within the sector. Often, these issues are dismissed as something that simply exists, so it would be valuable to describe the most common obstacles to innovation in the agenda, along with RWS's role in overcoming them. The current innovation agenda does show developments in for example contracts, but it would be beneficial to address other typical barriers, such as restrictive regulations and lengthy permit applications for pilots.

Reporting and evaluation should also play a more significant role in the innovation agenda. This would enable learning from one another to optimize the innovation process and accelerate the implementation of innovations. A standardized approach would be helpful and would add value to the innovation agenda, even though there will always be criticism from innovators who view standardization and evaluation as unimportant and obstructive. Additionally, it is important to describe in the innovation agenda what is done with evaluations and reports, emphasizing that learning across projects is crucial to tackle the significant and new challenges we face.

Tools can also be used to streamline the innovation process, but the way they are currently described in the innovation agenda is insufficient. This is evident in the minimal awareness of tools like the IUP Guide, even though it was launched in 2019. The same goes for the limited awareness of the SRL tool. This problem partly arises from the observation that people are not fully familiar with the innovation agenda, but it also stems from the minimal descriptions of these tools within it. These tools deserve a prominent place in the innovation agenda, where they are explained step by step, clearly outlining their intended purposes. Practical examples and experiences could help to shape perceptions of these tools.

Additionally, a decision needs to be made to either elevate the importance of these tools by emphasizing them and communicating them internally as the standard tools for use in innovation projects or to choose to stop using them and focus on something else. Both tools have the potential to play a significant role in innovation processes and hold great potential value, but by under-emphasizing them as optional aids, the tools lose their effectiveness and momentum, as now is the time innovating is urgent, and the innovation process is challenging.

Finally, if you want more innovation then the innovation agenda also conveys that failures are a part of innovation and that a failed pilot does not necessarily mean a failed project outcome, as valuable lessons can be learned from unsuccessful attempts and can be applied to other situations. It therefore is advisable that it becomes easier to test innovations, and that information about this is included in the innovation agenda. Sometimes, several innovations may need to fail before one is successfully implemented. In such cases, it is counterproductive to require everything to be fully justified and documented in advance.

Main enhancements

In this chapter, various enhancements have been suggested to improve RWS's innovation strategy. These include both improvements to the innovation agenda itself and recommendations for developing the strategy. Table 10 summarizes the main findings.

Table 10: Main enhancements for RWS's innovation strategy

Main enhancements for RWS's innovation strategy
Continuously reassess the alignment of the strategy with emerging challenges and periodically evaluate and refine the innovation agenda.
Ensure continuity by keeping the focal points consistent, but critically review their delineation in the next update, and maintain the ongoing efforts currently invested by WVL.
Incorporate roadmaps and provide more information about the SRL tool and the IUP Guide within the innovation agenda.
Decide to elevate the importance of the SRL tool and the IUP Guide to leverage their momentum and potential effectively.
Provide more concrete examples of innovations that align with the focal points to enhance clarity.
Enhance the detail of the innovation agenda, as it serves as the tactical level of the innovation strategy and should focus on addressing the WHAT-questions.
Increase the external visibility of the innovation agenda to increase its influence in the water and subsurface sector.
Foster both internal and external collaboration when updating the innovation agenda, particularly during the reflection and planning phases for the 2025 update.
Strengthen the role of reporting and evaluation within the innovation agenda to facilitate learning from experiences.

8. Discussion

8.1. Conceptual framework

The conceptual framework, as outlined at the end of the chapter on the theoretical background, is illustrated in figure 10. The theoretical analysis identified several key factors that influence the formulation of an innovation agenda for RWS. These factors include the characteristics of innovations, the distinctive features of the public sector, the dynamics between stakeholders within the water and subsurface sector, and the governmental responsibility for policy formulation. The research findings confirm that these are indeed critical considerations. The water and subsurface sector are generally characterized as unique, in part due to the significant influence of the government, which underscores the importance of understanding public sector innovation and policy processes. For example, regulations and political uncertainty were frequently mentioned as challenges, highlighting the importance of knowledge about governmental policymaking while constructing an innovation agenda or while participating in an innovation project in the water and subsurface sector. Moreover, the varying roles of key actors within the sector play a crucial role in fostering collaboration.

The RWS innovation strategy is encapsulated in a document, the innovation agenda, which outlines the challenges within the sector and the necessary actions to address these challenges through innovation. This agenda addresses the WHAT-questions, providing insights into how the strategic vision should be operationalized, which aligns with the tactical level as explained through the STO framework. Furthermore, interview feedback on practical experiences suggests that the innovation agenda could benefit from greater clarity in articulating expectations, further emphasizing the importance of the tactical level. Therefore, the differentiation between strategic levels is essential for both RWS and external stakeholders. The importance of collaboration and stakeholder engagement is also recognized by participants from Deltares and RWS, which justifies the importance of the WHO-questions while developing an innovation strategy.

The RWS strategy is designed to facilitate effective resource allocation and decision-making, which is evidenced and valued in practice by participants. Another intended outcome is the promotion of collaboration, both internally and externally. This objective is also reflected in practice, as there is generally increased collaboration within the sector, and it is progressing more smoothly. A final anticipated outcome is the accelerated development and diffusion of innovations. The sector has seen an increase in pilot projects and a greater number of innovations reaching the implementation phase. However, barriers within the innovation process continue to impede and still delay progress. It is evident that the effective allocation of resources and strong internal and external collaboration are crucial to the development and diffusion of innovations, according to the participants.

Another overarching influence that emerged from the interview data is the importance of both intrinsic and extrinsic motivation. Individuals with intrinsic motivation are guided by the innovation agenda in the right direction to contribute to the goals of RWS, transforming their internal drive into productive outcomes. This intrinsic motivation is increasingly felt within the sector, partly due to the growing urgency of imminent challenges. Interviewees also emphasized the significance of extrinsic motivation, particularly in the form of rewards and recognition following a successful innovation project. Another form of extrinsic motivation involves incorporating sustainability and collaboration more prominently in maintenance contracts. The two types of motivation contribute not only to partnership collaboration but ultimately to the development and diffusion of innovations. However, in practice, it is often found that while people may be sufficiently motivated, limiting resources such as time and funding tend to hinder their motivation.

The literature also identifies motivation as a driver of innovation. Specifically, individuals working in the public sector feel a responsibility to maintain societal well-being (Casebourne, 2014). Additionally, motivation to innovate can stem from intrinsic factors, such as the attractiveness of the work and personal reputation, as well as from extrinsic factors, such as financial rewards and job security (Koudelková & Milichovský, 2014). The link between motivation and resource allocation is also highlighted in literature, as it underscores the importance for organizations to understand how employees like to innovate and how this can be leveraged to achieve organizational goals (Casebourne, 2014). Furthermore, motivation positively influences collaboration, ultimately fostering the innovation process (Fischer, Malycha, & Schafmann, 2019). However, despite some observable practices, the relationship between motivation and innovation is not sufficiently covered in the literature (Koudelková & Milichovský, 2014).

In summary, there are observable practical effects that may stem from RWS's innovation strategy. The interviews reveal that the innovation agenda is not always widely recognized, which suggests that these potential effects may also be attributable to other factors. One recurring theme from the interview results is the effort of the innovation department to support individuals throughout the innovation process. Therefore, the observed effects cannot be attributed fully to the innovation strategy, it is apparent that the desired outcomes articulated in the innovation strategy are manifesting in practice. This indicates that the innovation strategy does exert an influence on achieving the desired outcomes. Since innovation is not an end in itself for RWS's innovation department, having an influence on the desired outcomes is sufficient, as the ultimate goal is the enhancement of innovation within the sector, irrespective of the specific means by which it is achieved. The innovation agenda does not necessarily need to receive full credit for these developments.

8.2. Results related to literature

As mentioned, the results align with the conceptual framework and the literature used in this study. The literature-derived factors influencing RWS's innovation strategy were also significant for the interviewees, highlighting the importance of considering these factors when developing an innovation strategy. Innovation in the public sector, the dynamics between actors in the water and subsurface sector, and policy processes were key concerns for participants, significantly impacting innovation in the sector.

The STO framework, already in use within RWS (Lodder & Slinger, 2022), is also part of RWS's innovation strategy. The tactical level plays a crucial role in bridging the gap between strategic goals and their operationalization (Arababadi, Moslehi, El Asmar, Haavaldsen, & Parrish, 2017). This is particularly important for a large organization like RWS in informing its employees and sector partners about the challenges and the roadmaps to address them. This framework could be applied in other public sectors, where a clear explanation of the steps needed to achieve governmental goals could be equally beneficial.

Participant's emphasis on the importance of monitoring and evaluation aligns with the literature. In the public sector, monitoring and evaluation are seen as success factors for using collaboration and feedback to improve future innovation processes (Agolla & Van Lill, 2013). The significance of tools like the IUP Guide and the SRL tool is also typical for the public sector, where accountability and evidence-based decision-making are crucial (Lascoumes & Le Gales, 2007) as is reflected in this research.

The importance of resource allocation, collaboration, and promoting the scaling of innovations are potential effects of innovation strategies in general (Pisano, 2015). This fits well with the influence of RWS's innovation strategy in the sector. The growing impact of the innovation strategy in practice is partly due to its increasing recognition, but also because the water and subsurface sector has

historically been a domain of significant transitions and developments (van der Brugge, Rotmans, & Loorbach, 2005). Collaboration has been evolving in the sector for years, with the Delta Program as a primary example (Bauer & Steurer, 2015), and innovation in climate adaption has been ongoing (Bloemen, Van Der Steen, & Van Der Wal, 2019). Thus, while RWS's innovation strategy indeed influences these processes, it is not the only reason for progress. Interviews clearly indicate that significant progress has been observed in recent years.

8.3. Added value for RWS

Within RWS, extensive research has been conducted on the success factors and challenges typical of innovation projects in the water and subsurface sector (Heijink & Kalders, 2017), as well as on various techniques and tools to aid in scaling up pilots (van Hout M. , 2022). The research that has already been done must also be applied and communicated, with internal communication being important to assist the employees within RWS, but also externally to inform and involve key partners. This study helps RWS to gain more insight into the awareness of the innovation agenda, both internally and externally. In addition, it demonstrates whether the efforts of RWS's innovation department are paying off.

Additionally, this study reveals whether the intended effects of the innovation agenda are also noticeable in practice and what developments are taking place, which speaks to its effectiveness. Based on this study, RWS can see which aspects of the innovation agenda have been well-received both internally and externally, and which aspects require extra attention. It also demonstrates whether RWS employees and partners appreciate, support, and use the innovation strategy. Moreover, it provides insight into the opinions of those who have to work with the concepts of the innovation strategy. The reflections gathered from the interviews give RWS the opportunity to incorporate the needs and priorities of the water and subsurface sector into the new version of the innovation agenda, which will be launched in 2025. It also gives RWS the opportunity to take another critical look at certain aspects of the innovation agenda that have not been assessed positively.

The new version of the innovation agenda in 2025 will be a midterm update, where it is important to reflect at what has been achieved in recent years and where the sector is lagging behind. Additionally, it is necessary to look ahead at what still needs to be done to achieve the 2030 goals. In this study, reflections on the past are shared from different perspectives, and future visions are provided, which is useful information during the update of the innovation agenda. Among other things, the identified areas for improvement can help in the process, as these points are suggested by parties working on innovations with or within RWS. These individuals, with diverse backgrounds, possess the practical knowledge and experience needed to further develop the innovation agenda and ensure broad sector approval and alignment.

8.4. Added value for the sector

This research highlights the critical importance of collaboration within the water and subsurface sector, a sentiment shared across various stakeholders. Given this, it is essential for all parties to be aware of each other's innovation strategies. Especially RWS's strategy is important since it is the dominant player in the sector. This study provides an overview of RWS's innovation strategy, examining how it is manifested within the own organization and how it has been developed. Additionally, interviews were conducted with participants not only from RWS but also from Deltares and with a contractor, which demonstrates how the strategy is manifested throughout the sector. These interviews allowed individuals to critically reflect on the practical influence of RWS's innovation strategy and to assess their own awareness of it.

The study reveals how different stakeholders in the sector perceive their roles and responsibilities. While there is broad agreement on the responsibilities associated with specific players, there is often an expectation for greater contributions from others to ensure the effective implementation of innovations in practice. This research also aids the sector in understanding RWS's innovation strategy and assessing its alignment with their own strategies, thereby fostering deeper collaboration. Furthermore, it enables partners to identify RWS's priorities and align their efforts more effectively. For knowledge institutions, this provides opportunities for targeted research on themes prioritized by RWS. For other governmental bodies like the ministry of I&W or water boards, it shows how they can assist RWS in their work. Similarly, market players can tailor their products and services to meet RWS's needs, increasing their chances of securing contracts and expanding their market share.

The study also offers insights into the practical effects experienced by the sector. By linking sector developments to RWS's innovation strategy, it can enhance collaboration across the sector. Moreover, the findings from this research can extend beyond the water and subsurface sector. Organizations working on their own innovation strategies can learn from the experiences with RWS's strategy. This is particularly relevant in emphasizing the importance of the tactical level as a bridge between strategic goals and operational execution. Other public sectors, especially those heavily influenced by the government such as defense or healthcare, can draw valuable lessons from these practical experiences, particularly in the areas of communication and PPPs.

8.5. Scientific contribution

This study provides a practical example of the importance of the tactical level in an innovation strategy, contributing to support for the STO framework. By addressing the WHAT-questions in the innovation strategy, it offers strategic goals more practical insights, aiding in the operationalization of these goals. While this framework is applied in other parts of the RWS organization (Lodder & Slinger, 2022), this study specifically highlights the tactical level as a communicative aid. Additionally, various practical experiences are presented that support the usability of the STO framework.

Secondly, this study contributes to the existing literature on partnerships between government, the private sector, and the academic sector in developing and implementing innovations related to climate adaptation and infrastructure. Numerous examples are provided where these partnerships are described and evaluated. The study underscores the dynamic relationships within this particular public sector and further emphasizes the importance and practical challenges of collaboration.

Finally, this study adds to the literature on innovation strategies. As discussed in the theoretical background, there are many different perspectives on the concept of innovation and the potential effects of an innovation strategy. Studies on the effects in the public sector are particularly lacking. This research provides insights into the practical utility of an innovation strategy and the role of communication in its success. The findings are potentially useful in defining an effective innovation strategy for the public sector and understanding the impact of such a strategy on an entire sector.

8.6. Reflection on the method

The first thing that became evident during the interviews was the openness and willingness to participate on the part of the interviewees, despite some of the interview questions having a somewhat reflective or critical tone. Initially, I perceived finding a diverse group of interviewees was perceived as a challenging aspect of this research, but the enthusiasm of the participants proved me wrong. They saw it as an urgent and interesting topic, and were eager to share their opinions to advance the sector. At times, it seemed I had not found the right person who was fully knowledgeable about RWS's innovation strategy, but this often led to an open and substantively useful conversation.

This is one of the reasons why I believe a semi-structured interview approach was particularly appropriate for this research.

Secondly, the research revealed that despite many differences between organizations and the observation that things do not always go as desired, every participant spoke with great respect about each other, emphasizing collaboration. Criticism from participants was almost always followed by a potential solution, and it was always offered with the aim of fostering better understanding and more effective collaboration. The sector is described as conservative, but the participants in these interviews demonstrate that those involved in innovation within the water and subsurface sector are all committed to progress through collaboration, with a strong emphasis on the value of each partner in the process.

Thirdly, the study is heavily grounded in a Management of Technology perspective, as innovation strategies are designed to facilitate the technical implementation of objectives. It also explores the intersection of strategy and innovation processes within the public sector, an area previously unfamiliar to the researcher. By utilizing qualitative data from participants with diverse backgrounds, the research addresses a strategically focused question and offers practical insights, demonstrating the application of management concepts within a technical context.

Lastly, during the data analysis, I noticed that while Excel is a useful tool for quickly organizing and sorting data, the more traditional method of highlighting the text provided a clearer view of cross-connections, conflicting opinions, and relationships between the interviews. Particularly, the observation that the interviewees largely agreed on major points and mentioned similar effects complicated the data analysis process, but a comprehensive understanding of the issues affecting the entire sector resulted. Adding a market party to the interview list further substantiated this observation, as the relationship between a market party and RWS, and Deltares and RWS, is different.

9. Conclusion

9.1. Conclusion

This study has provided a deeper understanding of the influence of RWS's innovation strategy in the water and subsurface sector through a qualitative approach, utilizing semi-structured interviews with participants from RWS and Deltares. In this chapter, the sub-questions are addressed and the main research question is answered.

Sub-question 1: What is the current innovation strategy of Rijkswaterstaat?

RWS's current innovation strategy, encapsulated in the Innovation Agenda 2030, is grounded in key themes identified in the Kompas I&W and the Kompas RWS. These themes, articulated as focal points are: Replacement and Renovation, Sustainable Infrastructure, Climate Adaptation, Smart Mobility, and Data and Information Provision, and serve as the foundation for resource allocation and accountability. In essence, the innovation agenda connects strategic goals with their operationalization by clearly outlining the objectives necessary to achieve both short-term and long-term targets.

The agenda also seeks to raise awareness about the challenges RWS faces, offering a framework for productive dialogue with partners. To support the innovation process, tools such as the IUP Guide and the SRL tool have been integrated into the agenda. The strategy emphasizes the importance of targeted resource allocation, accelerated development and implementation of innovations, and strengthened internal and external collaboration, all of which are crucial for fostering innovation. Ultimately, the goal of the strategy is to facilitate innovation across the sector, highlighting both the opportunities and the pressing need to innovate.

Sub-question 2: How did Rijkswaterstaat develop its current innovation strategy within the water and subsurface sector depending on both internal and external factors?

The development of the innovation agenda 2030 began with a thorough evaluation of the previous agenda, which was overseen by a different department, namely Market and Innovation. This evaluation highlighted the need for a more focused approach and emphasized the importance of creating a strategy that could be implemented effectively. The process involved multiple consultation rounds with key partners, ultimately leading to the formulation of the first version of the innovation agenda 2030. This agenda has since been updated to include Climate Adaptation as an additional focal point, reflecting the evolving priorities within the sector.

A critical consideration in this development was the need to enhance both internal and external awareness of the document to maximize its practical impact. The agenda not only aims to stimulate collaboration within RWS but also seek to foster partnerships with external stakeholders, thereby amplifying its effectiveness in practice. The agenda is designed as a living document, with a scheduled update in 2025 that will serve as a midterm review, providing an opportunity to assess progress and recalibrate strategies.

Internal factors that influenced the development of the innovation strategy include the focal points initiated by RWS, which are aligned with the strategic priorities of the ministry of I&W. The involvement of numerous individuals within the organization in the development and evaluation process underscored the importance of internal collaboration. Additionally, the organizational structure of RWS and the challenges associated with inter-departmental collaboration were significant internal considerations.

Externally, the strategy was influenced by input from stakeholders, who offered valuable insights into the significant challenges confronting RWS, along with the roles and responsibilities of key actors in

the water and subsurface sector. These challenges, along with factors such as political uncertainty, represent external influences that shaped the strategy. By incorporating these considerations, the innovation strategy was anchored in the broader context of the sector, enhancing its relevance and responsiveness to the needs of both RWS and its partners.

Sub-question 3: What influence does Rijkswaterstaat's innovation strategy have on resource allocation, the development and diffusion of innovations, and collaboration within the water and subsurface sector?

In general, the influence of the innovation agenda is becoming increasingly visible in practice, but the question remains as to how much of this can be attributed directly to RWS's innovation agenda. The agenda is generally known among RWS and Deltares employees, though not all are familiar with its specific details. As a result, it is not possible to conclusively link RWS's strategy with the effects observed in practice, making the term 'influence' more appropriate than 'effect'. In addition, although RWS is a large player in the sector, many external factors do play a role as well, including other parties innovating, governmental policies, and available budgets. However, certain elements of the innovation agenda, such as the importance of monitoring and evaluation, and policy concepts like 'water and subsurface guiding', are well-known among all participants. That is why RWS's innovation strategy influences the water and subsurface sector as a communication document.

The influence of the innovation strategy is most evident in the practice of resource allocation. Within RWS, the focal points are used to justify the allocation of scarce resources such as budgets, time, and capacity, and it has become more challenging to initiate innovations that fall outside these focal points due to the criteria RWS has set. In this way, the strategy exerts a guiding influence. For external partners, the focal points provide direction, as they indicate where RWS is focusing its efforts and where input can be provided. While there is still room for improvement, there has been a noticeable improvement compared to several years ago, demonstrating that the focal points are an effective tool.

In terms of accelerating innovation development and diffusion, as well as improving internal and sector-wide collaboration, it is less demonstrable that RWS's innovation strategy has contributed to these outcomes. The conditions are clearly outlined in the agenda, but as mentioned, not everyone is fully aware of them. Nevertheless, in practice, there is evidence that collaboration has improved, both within RWS and across the water and subsurface sector, indicating that the innovation agenda has had some influence. Learning spaces are a good example of these positive developments, even as the sustainability component in maintenance contracts. Those types of contracts are an influence of the innovation strategy on the water and subsurface sector and are related to the development and diffusion and collaboration. The use of the SRL tool, IUP Guide, and the roadmaps is also an small observable influence since still lots of people are not aware of them.

Additionally, the development and diffusion of innovations have demonstrably increased compared to the past, though sector-specific challenges continue to pose barriers. For instance, RWS is now more supportive in innovation processes, and more pilot projects can be launched than before given the increased rate of completed pilot projects and increased number of test locations. Overall, while there have been noticeable improvements in both key conditions for stimulating innovation, it is not always clear whether these improvements are due to RWS's innovation strategy or simply a more informed sector. However, this is not necessarily a problem, as familiarity with the innovation agenda is not a goal in itself; what ultimately matters are the visible outcomes that contribute to improving the sector.

Sub-question 4: How can Rijkswaterstaat enhance its innovation strategy to foster its influence in the water and subsurface sector?

There are several areas where RWS can improve its innovation strategy, based on the reflections and future perspectives of the participants. The first is to maintain continuity by not changing the focal points in the next update and by continuing the efforts that WVL is currently investing. Minor improvements could include critically reassessing whether the focal points are sufficiently delineated, and enhancing the overall perception by including roadmaps in the agenda's appendix along with examples of projects that align with the focal points.

One key area of focus is the visibility of the innovation agenda. While internal awareness within RWS has increased, external stakeholders seem to be less familiar with the agenda. Additionally, knowledge of the agenda is lower at the regional level compared to the national level. Active communication is necessary to effectively share the strategy with partners in the sector. Emphasizing the importance of knowledge development, innovation implementation, and ensuring that innovation efforts are rewarded can help in this regard. Moreover, it would be beneficial to frame the innovation agenda as a sector-wide agenda to foster a sense of unity.

There is also a prevailing sentiment that the next update, which will be a midterm review, should involve greater collaboration in drafting the innovation agenda. In practice, there is a noticeable feeling among regional services, other national departments, and RWS stakeholders that they have not been sufficiently heard. Stakeholder sessions to gather input and reflect on past experiences can address this, as can more consistent collaboration between WVL, GPO, and PPO.

Finally, RWS should place greater emphasis on providing resources to support innovation processes. More information and clarity about the SRL tool and the IUP Guide are crucial, as these tools have the potential to contribute positively. Additionally, it would be beneficial to explicitly address known challenges in the agenda, along with how RWS can assist in overcoming them. Lastly, a standardized tool for reporting and evaluating innovations could contribute to increased knowledge in the field of innovation.

Main research question: What influence does Rijkswaterstaat's innovation strategy have on innovation processes in the water and subsurface sector?

The study reveals that RWS's innovation agenda 2030, rooted in the key themes from Kompas I&W and Kompas RWS, plays a significant role in guiding innovation processes within the water and subsurface sector. The strategy focuses on critical areas such as Replacement and Renovation, Sustainable Infrastructure, Climate Adaptation, Smart Mobility, and Data and Information Provision. These focal points serve as a framework for both resource allocation and strategic planning, ensuring that short-term and long-term goals are clearly defined and pursued. The inclusion of tools like the IUP Guide and SRL tool within the agenda underscores the strategy's aim to enhance both internal and external collaboration and to accelerate the development and implementation of innovations across the sector.

The development of the innovation agenda 2030 was shaped by a combination of internal and external factors, including feedback from various stakeholders and a comprehensive evaluation of the previous agenda. The process emphasized the need for a focused and implementable strategy, resulting in an agenda that not only aligns with the strategic priorities of the ministry of I&W but also addresses the evolving challenges within the sector. The agenda's continuous evolution, as seen in the inclusion of Climate Adaptation as a focal point, reflects RWS's responsiveness to emerging issues. However, the

effectiveness of the agenda hinges on increasing awareness and fostering collaboration both within RWS and with external partners.

In practice, the influence of RWS's innovation strategy is most apparent in the allocation of resources and as an communication document. The focal points are used to justify the distribution of budgets, time, and capacity, making it more challenging to pursue innovations that fall outside these areas. This guiding influence is also evident externally, where the focal points provide direction to partners and help them align their contributions with RWS's priorities. While the strategy has undoubtedly improved resource allocation, its impact on fostering collaboration and accelerating innovation development and diffusion is less clear. The influence of the innovation agenda on the development and diffusion of innovations and on internal collaboration is noticeable in practice, especially through the sustainability component in maintenance contracts such as learning spaces, and also to the small-scale use of the SRL tool, the IUP Guide, and the roadmaps. The agenda has contributed to some positive developments, such as increased collaboration and the initiation of more pilot projects, but challenges unique to the sector continue to pose barriers and clear influences needs more time.

To enhance its influence, RWS should focus on maintaining continuity in the strategy's focal points while improving their visibility and clarity. Increasing awareness of the agenda, particularly among external stakeholders and regional entities, is crucial. Greater collaboration in future updates, especially during the midterm review, and providing more support for innovation processes through tools like the SRL and IUP Guide, could further strengthen the strategy's impact. Ultimately, while the innovation agenda has made strides in guiding the sector, continued efforts are needed to ensure that it effectively drives innovation and addresses the sector's challenges.

9.2. Limitations

A first limitation in this research concerns the sampling of the participants, as only a limited number of people could participate in the research giving the limited time. Several techniques were employed to narrow down the potential participants to a specific group, aiming to contact individuals with diverse backgrounds, yet all linked to innovation projects where RWS and Deltares collaborated with other stakeholders in the water and subsurface sector. At Deltares, employees from various departments were contacted, some possessing more strategic insights into RWS's innovation strategy, while others encountered it more directly in practice. In the case of RWS participants, Deltares's network was leveraged to identify individuals with both strategic and practical knowledge. It was important to interview not only those from WVL, the department responsible for the innovation agenda, but also individuals from other departments and levels, both national and regional, within the organization. This approach broadened the participant sample as much as possible, but it also excluded a significant number of people who could have contributed to the research. Additionally, the decision to focus on two specific focal points further narrowed the potential participants, and thus limited the options.

Secondly only about 10 to 15 questions were posed to each interviewee during a one-hour interview. This limited the depth of the interviews, resulting in certain topics being extensively explored in some interviews, but less in others. As a result, the interviewer sometimes had to prioritize which questions were most relevant to each interview, often based on the responses given by the participant and their expertise. This made it more challenging to establish strong connections between topics, as not every participant was asked all the same questions.

A third limiting factor is that only employees from RWS and Deltares were interviewed in this research. Due to time constraints, it was not possible to include multiple perspectives in this study, although one contractor was added to the interview list to avoid completely neglecting other viewpoints. However,

this does not mitigate the fact that numerous important stakeholders, such as ministries, water boards, regional governments, other research institutes, consultancy firms, universities, or NGOs, were unable to provide input, which could have offered a more comprehensive overview of the sector.

Another limitation is that interview data may sometimes be interpreted differently by the interviewer than intended by the interviewee. Factors contributing to this include the use of figurative language or the tone in which words were spoken. Directly transcribing audio data can lead to quotes being understood differently than intended when taken literally. Efforts were made to account for his as much as possible, including comparing quotes with statements made by other interviewees and by giving each participant the opportunity to review their anonymized transcripts. Finally, a limitation is that the level of knowledge that participants had about RWS's innovation strategy was not assessed, which may have resulted in some critical responses being based on a lack of knowledge rather than a well-informed opinion. This is also highlighted by instances where participants responded with a question, indicating some uncertainty, which could reduce the reliability of certain quotes. Again, comparing data from other participants was crucial for verification.

9.3. Future research

The first area for future research relates directly to the aforementioned limiting factors, it would be highly beneficial if a study on the influence of RWS's innovation strategy also included data from other key players in the sector. Based on the interview data, the relationship between RWS and Deltares appears to be strong, which often results in participants agreeing with one another. This is likely because Deltares is an independent knowledge institute that has the overall interests of the sector in mind and primarily focuses on innovation, an observation of which RWS is well aware. The dynamics between RWS and other stakeholders, such as ministries or market parties, might be different, thereby introducing diverse perspectives that could enrich the research. Furthermore, not only their perspective on RWS is important, but also to map the sector as a whole and better understand innovation in the sector.

Another approach would be to narrow the scope of the research and focus specifically on the impact of RWS's innovation strategy within their own organization. Previous versions of the innovation agenda were not always widely recognized across the entire organization, and even with the current version, it remains challenging to ensure that all 10,000 RWS employees are familiar with the strategy. A large-scale survey to assess internal awareness across various departments and levels within RWS would provide valuable insights into how the innovation department's efforts are perceived within the organization. For an organization to consistently project its innovation strategy, it is crucial to build internal support, ensuring that external parties encounter a unified approach in practice.

A final recommendation for future research would be to conduct a similar study in another public sector to explore whether aspects such as sector dynamics, challenges, and successes are also present elsewhere. Additionally, it would be interesting to examine whether an innovation strategy in another public sector shares similarities with that in the water and subsurface sector. PPPs are essential for addressing societal issues, which is why an innovation strategy could be valuable across different sectors.

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Appendix A – Interviews sub-question 1 and 2

Interview general innovation strategy

Theme 1: The focus of the innovation strategy

1. Wat is the goal of RWS's innovation strategy and how is the innovation agenda used?
2. Why are the 5 focal points important innovation directions for RWS?
    - (Replacement and Renovation, Sustainable Infrastructure, Climate Adaptation, Smart Mobility, and Data and Information Provision)
    - What made RWS decide to add 'Climate Adaptation' as a focal point in the update of the innovation agenda?
    - Why is the focal point 'Climate Neutral and Circular' changed to 'Sustainable Infrastructure' recently?
    - How is the coherence between the focal points guaranteed and why is that important?
3. How does RWS determine which innovation projects will receive funding and which do not?
    - What happens to a proposal for a new innovation that does not fit in the focal points?
4. 'Innovate faster together, whit focus' consist of three conditions: Complementary collaboration, faster transition from pilot to implementation, and establishing focus. Why are these three conditions particularly important for innovation in this sector?
    - How did you determine these conditions, and are there any additional ones that are important?

Theme 2: The development of the innovation strategy

5. How is the innovation strategy developed, and what steps precede this process?
    - Is there any feedback and evaluation based on insights from the past?
6. How is the translation of strategic and policy goals into procedures and operational tasks taken into account when developing the innovation strategy?
7. Who play a role in developing the innovation strategy of RWS, and what where their roles?
    - Are there also indirect roles for other stakeholders in the sector?
8. How and by whom was the innovation strategy of RWS developed in the past?
    - Did the same parties play a role as they did with the current innovation strategy?
9. When do you consider an innovation strategy to be successful, and are there any aspects of the current innovation strategy that you would like to further develop?

Theme 3: Parts of the innovation strategy

10. What is the purpose of the roadmaps, and how are they developed?
    - How is it determined which topic will have a roadmap, and are these also updated?
    - Who uses the roadmaps?
11. What is the purpose of the IUP Guide, and how is it developed?
    - How is it determined which phase an innovation is in?
    - Who uses the IUP Guide
12. How can the roadmaps and the IUP Guide stimulate the development and diffusion of innovations, and what effects have you observed in practice?
    - How successful have these tools been so far?

Theme 4: Effects of the innovation strategy

13. What is the effect of portfolio management on the development and diffusion of innovation projects?
14. What impact does the innovation strategy have on innovation in the water and subsurface sector?
    - And specifically for ministries, private organizations, the academic sector, and other stakeholders?
    - How is it monitored or measured whether the innovation strategy is having impact?
15. How would you describe the role of RWS in relation to innovation in the sector, and has RWS always had the same role?
    - Hoe are other parties approached for participation or involvement in innovation projects, and can RWS be approached?

Interview innovation strategy climate adaptation

Theme 1: Climate Adaptation as a focal point

1. How would you describe innovations related to the focal point 'Climate Adaptation', and could you provide some examples of projects that fit the focal point?
2. Why was "Climate Adaptation" recently added as one of the focal points of RWS's innovation strategy?
3. Are the projects under this focal point all recently started, or are there also projects originating from other focal points?
    - How is the decision made to reassign projects between focal points?
    - From which other focal points are projects originating, and do you see overlaps with other focal points (in specific 'Sustainable Infrastructure')?
    - How does the collaboration between focal points proceed, and how important is it?
4. What does 'water and subsurface guiding' specifically mean for this focal point?

Theme 2: The development of the innovation strategy

5. How has the innovation strategy for the focal point 'Climate Adaptation' been formulated and developed?
    - How did this development proceed, and what challenges had to be overcome?
6. Which parties are involved in drafting the innovation agenda fort his specific focal point, and how has that process unfolded?
    - What roles did ministries, private organizations, and the academic sector play specifically?
7. Currently, there is no roadmap for this focal point included in the innovation agenda. How are roadmaps developed within this focal point?
    - Who is involved in drafting the roadmaps, and which topics receive their own roadmap?
8. What are your experiences with the IUP Guide, and what does the tool contribute to innovation projects for the focal point 'Climate Adaptation'?
    - Is the IUP Guide also used to monitor project progress?
9. Since 'Climate Adaptation' has only recently become a focal point, what steps still need to be taken to improve the innovation strategy on this focal point?
    - When is an innovation strategy considered successful in your opinion, and is the strategy also evaluated?

Theme 3: Effects of the innovation strategy

10. How is this focal area and its associated innovation strategy communicated within the organization and to other stakeholders in the water and subsurface sector?
    - Specifically, to ministries, private organizations, residents, and the academic sector.
11. What is the impact of the 'Climate Adaptation' innovation strategy on RWS and on the water and subsurface sector?
12. How would you describe the role of RWS in the sector with regard to climate adaptation, and has this role always been the same?
    - What are the roles of other actors in the water and subsurface sector?
    - Does RWS mainly pose research questions and approach parties, or does this happen in the reverse direction as well?
13. What are factors that complicate or delay the development and diffusion of innovation projects?
    - Ask for both internal and external factors.
14. How did you become aware of these factors, and how were they incorporated into the development of the innovation strategy?
15. How can the innovation strategy ensure that innovation projects develop and diffuse more quickly?
16. What effect scan be observed as a result of the whole innovation strategy?
    - In various aspects, such as policy, research, project outcomes, market.
    - What are your expectations regarding the innovation strategy in the future?

Interview innovation strategy sustainable infrastructure

Theme 1: Sustainable Infrastructure as a focal point

1. How would you describe innovations related to the focal point 'Sustainable Infrastructure', and could you provide some examples of projects that fit the focal point?
2. Why has 'Sustainable Infrastructure' been chosen as one of the focal points of RWS's innovation strategy?
3. What is the reason for the change from 'Climate Neutral and Circular' to 'Sustainable Infrastructure' as the name of the focal point?
4. Which focal points intersect with 'Sustainable Infrastructure', an on what topics?
    - Specifically ask for 'Climate Adaptation'.
    - How is the collaboration between different focal point?
5. What does 'water and subsurface guiding' specifically mean for this focal point?

Theme 2: The development of the innovation strategy

6. How has the innovation strategy for the focal point 'Sustainable Infrastructure' been developed, and how did the change from 'Climate Neutral and Circular' to 'Sustainable Infrastructure' occur?
    - How has the strategy evolved over time, and what challenges have been faced during this development process?
7. Which parties are involved in developing the innovation agenda for this specific focal point, and how has this process been carried out?
    - Specifically ask for ministries, private organizations, and the academic sector.
8. How has RWS identified the 4 specific transition paths within this focal point, each with separate roadmaps?

- Transition path Pavements, Transition path Sustainable engineering constructions, Transition path Road, Dyke, and Rail Equipment, and Transition path Maintenance of the coastline and fairways
- How were these roadmaps created, and who was involved in that process?
- Are roadmaps also evaluated and updated?

9. What are your experiences with the IUP Guide, and what contribution does this tool make to innovation projects for the focal point 'Sustainable Infrastructure'?
    - Is the IUP Guide also used to monitor project progress?
10. What steps still need to be taken to improve the innovation strategy for 'Sustainable Infrastructure'?
    - When is an innovation strategy successful in your opinion, and is the strategy also evaluated?

Theme 3: Effects of the innovation strategy

11. How is this focal area and its associated innovation strategy communicated within the organization and to other stakeholders in the water and subsurface sector?
    - Specifically, to ministries, private organizations, residents, and the academic sector.
12. What is the impact of the 'Sustainable Infrastructure' innovation strategy on RWS and on the water and subsurface sector?
13. How would you describe the role of RWS in the sector with regard to sustainable infrastructure, and has this role always been the same?
    - What are the roles of other actors in the water and subsurface sector?
    - Does RWS mainly pose research questions and approach parties, or does this happen in the reverse direction as well?
14. What are factors that complicate or delay the development and diffusion of innovation projects?
    - Ask for both internal and external factors.
15. How did you become aware of these factors, and how were they incorporated into the development of the innovation strategy?
16. How can the innovation strategy ensure that innovation projects develop and diffuse more quickly?
17. What effect scan be observed as a result of the whole innovation strategy?
    - In various aspects, such as policy, research, project outcomes, market.
    - What are your expectations regarding the innovation strategy in the future?

Appendix B – Coding process sub-question 1 and 2

Open coding

During the open coding phase, the interviews were individually scanned and read, with insightful information highlighted and potential categories formulated. This process is not shown due to the privacy of the participants.

Axial coding

In the axial coding phase, relationships between the categories were investigated by comparing the potential categories across interviews. The process per interview is again not shown for privacy reasons.

Categories per interview	Categories per interview
Campaign for the innovation strategy	Innovation agenda = innovation strategy
Internal and external input	Focal points from Kompas RWS and I&W
Developing innovation version 1	5 Themes correspond to Dutch transitions
Awareness innovation agenda	Long-term perspective
Update innovation agenda (2023/2025)	Climate adaptation
Monitoring	Funding
Conditions: Focus, Faster, Together	Collaboration between focal points
IUP Guide → TRL/SRL	COIN
Preceding innovation strategy	Reflection and future vision
Short-term and long-term goals	Focus focal point Climate Adaptation
Climate adaptation	Goal of the focal point Climate Adaptation
Sustainable Infrastructure	Collaboration
Collaboration between focal points	Urgency
Innovation landscape	Water and subsurface guiding
Reflection and future vision	Conditions: Focus, Faster, Together
Strategy in development	Barriers and success factors developing phase
Internal and external communication	Reflection and future vision
Role knowledge institutes and RWS	Effects of the innovation strategy
Transition paths Sustainable Infrastructure	Collaboration
Development innovation agenda	Internal and external awareness
Barriers and success factors developing phase	Roadmaps
IUP Guide	Reflection and future vision
Effects innovation strategy	Role RWS and key players sector

Selective coding

Selective coding was applied to define the core categories for answering the first and the second sub-questions. These selected categories will correspond with the subchapter titles in the relevant chapter.

Categories after selective coding
Developing the innovation strategy
Parts of the innovation strategy
Internal and external awareness
Expected effects
Reflection and future vision

Appendix C- Interviews sub-question 3 and 4

Interview participants RWS and Deltares

Theme 1: Effects of the innovation strategy

1. How are you involved in innovation in the water and subsurface sector, and what are your general experiences?
2. To what extent are you familiar with RWS's innovation strategy and the innovation agenda?
3. What role does RWS play in innovation within the water and subsurface sector, and what responsibilities does this entail?
    - What can RWS expect from other stakeholders in the sector, such as Deltares?
4. What is your opinion on RWS focusing innovation efforts through 5 specific focal points, and what impact does this have on innovation projects?
    - Sustainable Infrastructure, Climate Adaptation, Smart Mobility, Replacement and Renovation, and Data and Information Provision
    - Does this provide direction, act as a guide, or is it a hindrance to innovation in this sector?
    - Is there collaboration within the focal points and across different focal points?
5. What do you perceive as the effect of RWS's innovation strategy on the water and subsurface sector?

Theme 2: Support of the innovation strategy

6. To what extent are you familiar with the IUP Guide and the roadmaps that are part of RWS's innovation strategy, and how do you use them?
    - Are there other tools you have used to support innovation projects (SRL or TRL)?
    - How can such tools stimulate the innovation process?
7. How does RWS monitor and evaluate progress in innovation projects you are involved in or have been involved in?
    - Are you satisfied with this, or could it be improved?
    - Is there feedback provided by RWS during innovation projects, and does this relate to the innovation strategy?
    - Do you feel supported by RWS during innovation projects?

Theme 3: Challenges in innovation projects

8. What challenges do you typically encounter during the innovation process?
    - What hindering or stimulating factors for the development and diffusion of innovations have you experienced in innovation processes?
    - How does RWS support you with these factors?
9. Do you think the development and diffusion of innovations in practice is difficult and time-consuming? Why or why not?
    - What does RWS do to facilitate this process?
    - What do you specifically do to further develop and diffuse innovations in practice?
10. How do you experience the collaboration between different stakeholders in innovation projects you have been involved in?
    - What do you do to ensure this collaboration works as effectively as possible?
    - What do you expect from other parties, such as RWS, to ensure the success of innovations?

- What impact does effective collaboration have on innovation in the sector, and how does the innovation strategy support this?

Theme 4: Reflection on the innovation strategy

11. Climate adaptation and the sustainability and renovation of infrastructure create additional urgency and uncertainty. Do you think there is currently enough attention to innovation in the water and subsurface sector, and what does the sector need?
    - What makes innovation in this sector different from other sectors?
    - What does 'water and subsurface guiding' mean to you when considering innovation projects?
12. What can RWS do better or differently to stimulate innovation in the water and subsurface sector?
    - What can RWS do to help project leaders with innovation?
    - RWS summarizes its innovation strategy with 'Innovate faster together, with focus'. Is this evident in practice, and is it what the sector needs?
13. Finally, are there any important effects of RWS's innovation strategy that have not been mentioned?

Appendix D – Interview contractor

Theme 1: Effects of the innovation strategy

1. How are you involved in innovation in the water and subsurface sector, and what are your general experiences?
2. To what extent are you familiar with RWS's innovation strategy and the innovation agenda?
3. What role does RWS play in innovation within the water and subsurface sector, and what responsibilities does this entail?
4. What can RWS expect from other stakeholders in the sector, such as Deltares and contractors?
5. What is your opinion on RWS focusing innovation efforts through 5 specific focal points, and what impact does this have on innovation projects?
    - Sustainable Infrastructure, Climate Adaptation, Smart Mobility, Replacement and Renovation, and Data and Information Provision
    - Does this provide direction, act as a guide, or is it a hindrance to innovation in this sector?
    - Is there collaboration within the focal points and across different focal points?

Theme 2: Challenges in innovation projects

6. What challenges do you typically encounter during innovation projects?
    - Do you also experience scaling up innovations as a common challenge?
    - What success factors for the development and diffusion of innovations have you encountered in innovation projects?
7. Are you satisfied with the way you collaborate with RWS and other partners on innovations?
    - Does RWS bring issues to the table, or is there also room for your own initiatives?
    - Are you familiar with learning spaces, and what are your experiences with them?
8. How are things contractually arranged between BAM and RWS?
    - What does the way RWS works and innovate mean for contractors?
    - What could be improved in these arrangements in the future?
    - What is the effect of competition with other market parties on innovation?

Theme 3: Reflection on the innovation strategy

9. What makes innovation in the water and subsurface sector different from other sectors?
10. Do you think there is sufficient urgency across the sector to innovate together in practice?
11. What do you think RWS could do better to stimulate innovation in the sector?
12. Where do you hope to be in the future, for example in 10 to 20 years, in terms of innovation in the water and subsurface sector?
13. RWS summarizes their innovation strategy as 'Innovating faster together, with focus'. Is this noticeable in practice and is it what the sector needs?

Appendix E - Coding process sub-question 3 and 4

Open coding

During the open coding phase, the interviews were individually scanned and read, with insightful information highlighted and potential categories formulated. This process is not shown due to the privacy of the participants.

Axial coding

In the axial coding phase, relationships between the categories were investigated by comparing the potential categories across interviews. The process is shown per interview, but the interviews are anonymized and randomized for privacy reasons.

Interview A	Interview B	Interview C	Interview D	Interview E
Involvement innovation	Involvement innovation	Involvement innovation	Involvement innovation	Involvement innovation
Awareness innovation agenda	Awareness innovation agenda	Upscaling innovations	Role Deltares innovation	Knowledge development
Reflection innovation department RWS	Role RWS innovation	PhD students	Conservative sector	Large replacement tasks
Changing role RWS in innovation	Role Deltares innovation	Budget as challenge	Knowledge spillovers	Role RWS innovation
Water boards	Role government innovation	Awareness innovation agenda	Collaboration in the sector	Difference national and regional level
Role Deltares innovation	Funding as a challenge	Role RWS innovation	Role RWS innovation	Capacity as barrier
Challenging during innovation	Regulations as a challenge	Role Deltares innovation	Launching customer	Focus on daily practices
Reaction RWS on innovation challenges	Collaborative drive as success factor	Collaboration RWS and Deltares	Permits as barrier	Communication as challenge
Upscaling innovations	Collaboration RWS and Deltares	Regulations as challenge	Policy processes as challenge	Courage and space as success factors
Position WVL	People as success factor	Permits and contracts as challenge	Upscaling innovations	Role Deltares innovation
Replacement assignments and capacity	Space to innovate as challenge	Risk-averse sector as challenge	Innovation agenda unknown	Policy and practical knowledge needed
Subsidies	No active communication innovation agenda	Mentality different actors in sector	Innovate with focus	Innovate with focus
Test locations	Upscaling innovations	Collaboration as success factor	Innovation agenda for communication	Collaboration in the sector
Faster collaboration	Monitoring and evaluation innovations	Innovation in the water and subsurface sector	Accountability as challenge	IUP Guide unknown
Role market parties innovation	Innovation with focus	Nature-based solutions	Evaluating and reporting	Evaluating and monitoring
Competition in the sector	Appearance innovation agenda	Increased innovative capacity sector	Faster collaboration in the sector	Communication in the sector
Unclear roles in the sector	Difference WVL and GPO/PPO	Innovation successes	Trust as success factor	Share with presentations
Innovation with focus	RWS as facilitator	Upscaling innovations	Innovate for policymaking	Focus, Faster, Together
IUP Guide unknown	IUP Guide unknown	Urgency in the sector	Share with presentations	Future vision
Tools	Tools are for managers	Innovate with focus	Urgency in the sector	Roadmaps
Support RWS in innovation projects	Portfolio management	Accountability innovation projects	Water and subsurface guiding	
Water and subsurface guiding	Innovation in the water and subsurface sector	Stakeholder management	Political uncertainty	
Innovation in the water and subsurface sector	Urgency in the sector	RWS as facilitator	Innovation in the sector	
Success factors innovation	Water and subsurface guiding	Water and subsurface guiding	Window of opportunity	
Focus, Faster, Together	Future vision	Future vision	Young professionals important	
Urgency in the sector	Reflection on RWS and innovation	Focus, Faster, Together	Political level important	
Future vision	Focus, Faster, Together	Sharing at conferences	Celebrating successes	
Difference WVL and PPO/GPO			Future vision	
			Focus, Faster, Together	

Interview F	Interview G	Interview H	Interview I	Interview J
Involvement innovation	Involvement innovation	Involvement innovation	Involvement innovation	Involvement innovation
Upscaling innovations	Traditional sector	Awareness innovation agenda	Sustainability challenges	Learning spaces
Awareness innovation agenda	Role RWS innovation	Role RWS innovation	Learning spaces	Contracts as challenge
Role RWS innovation	Awareness innovation agenda	Role Deltares innovation	Awareness innovation agenda	Connectedness as success factor
Role Deltares innovation	Innovate with focus	Innovate with focus	Role RWS innovation	Awareness innovation agenda
Role market parties innovation	Collaboration RWS	Internal collaboration RWS	RWS as launching customer	Innovate with focus
Innovation agenda for communication	Communication	Evaluation and monitoring	Role market parties innovation	Difference WVL and GPO/PPO
Innovate with focus	Role Deltares innovation	Quality control	Role Deltares innovation	Role RWS innovation
Collaboration between focal points	Role market parties innovation	Budget as challenge	Regulations as challenge	Role Deltares innovation
IUP Guide	IUP Guide	Quality and scheduling important	Pilitical uncertainty as challenge	Role market parties innovation
Monitoring and evaluation	SRL tool	Accountability projects	Collaboration as success factor	Acceptance as challenge
Roadmaps	Evaluation and knowledge sharing	Upscaling innovations	Innovating in the public domain	Attitude as challenge
SRL tool	Money as barrier	Urgency in the sector	Capacity/Funding as challenge	Innovation in the water and subsurface sector
Policies in practice	Space as success factor	Innovative capacity RWS	Collaboration in the sector	Standardization as challenge
Stakeholder management	Capacity as challenge	Collaboration in the sector	Guiding innovation strategy	IUP Guide
Reflection on RWS and innovation	Policymaking as challenge	Openness for new methods	Evaluating innovations	Evaluating innovations
Connectedness as success factor	People as success factor	Collaboration as success factor	Urgency in the sector	Internal knowledge sharing RWS
RWS as facilitator	Upscaling innovations	Curiosity as success factor	Upscaling innovations	Roadmaps
Innovation in the water and subsurface sector	Urgency in the sector	Communication RWS	IUP Guide	Urgency in the sector
Offering perspective for innovation	Collaboration in the sector	Future vision	Pilots in the public domain	SRL tool
Focus, Faster, Together	Portfolio management	Focus, Faster, Together	Knowledge sharing	Future vision
	Innovation in the water and subsurface sector		SRL Tool	Focus, Faster, Together
	Water and subsurface guiding		Roadmaps	
	Time pressure		Innovate with focus	
	Guiding innovation strategy		Internal collaboration RWS	
	Focus, Faster, Together		People as success factor	
			Innovation successes	
			Innovation strategy	
			Focus, Faster, Together	
			Innovation in the water and subsurface sector	

Selective coding

Selective coding was applied to define the core categories for answering the first and the second sub-questions. These selected categories will correspond with the subchapter titles in the relevant chapter.

Categories after selective coding
Innovation in the water and subsurface sector
The innovation policy
Challenges and barriers
Success factors
Effects in practice
Reflection
Future vision

Appendix F – Informed consent

Participant information

You are being invited to participate in a research study titled 'The role of RWS's innovation strategy in the water and subsurface sector'. This study is being done by Roan 't Mannetje from the TU Delft and Deltares. I am currently doing the MSc graduation project for the study Management of Technology.

The purpose of this research study is to describe, analyze, and evaluate (the effects of) RWS's innovation strategy, and will take you approximately 60 minutes to complete. The data will be used for exploratory research. I will be asking you approximately 15 open questions based on your field of expertise.

As with any online activity the risk of a breach is always possible. To the best of my ability your answers in this study will remain confidential. I will minimize any risks by storing only your name and other (indirectly) identifiable information, such as your position at the organization, on the TU Delft OneDrive until completion of the study. Quotations from the interview can be included in the thesis report at the time of publication, after anonymization of the answers. The audio recordings will be transcribed immediately after the interview and will be deleted afterwards. The transcripts will be processed into anonymized interview data, which will also be stored on the TU Delft OneDrive.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. The anonymized interview data can also be reviewed and can be removed per request at any time until publication (preliminary planning 24-09-2024).

Researcher contact details:
Roan 't Mannetje

Explicit consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves:	☐	☐
• An audio-recorded interview about your professional experience.		
4. I understand that the study will end 24-09-2024.	☐	☐
• Preliminary publication date is 24-09-2024		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed.	☐	☐
• Name, position, company		
6. I understand that the following steps will be taken to minimize the threat of a data breach, and protect my identity in the event of such a breach:	☐	☐
• The audio file will be saved on the TU Delft OneDrive and deleted immediately after transcription. • The transcription will be saved on the TU Delft OneDrive, processed into anonymized interview data, and deleted afterwards. The anonymized interview data will be archived on the TU Delft OneDrive and is only accessible for my TU Delft supervisors Heleen Vreugdenhil and Jill Slinger. No one else has access to the research data without their permission. • You can always review the anonymized interview data and all data can be removed per request at any time until publication. • Only quotations from the anonymized interview data will be used in the thesis document and will be archived in the open TU Delft repository.		
7. I understand that personal information collected about me that can identify me, such as name, position, and company, will not be shared beyond the study team.	☐	☐
8. I understand that the (identifiable) personal data I provide will be destroyed after publication.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
9. I understand that after the research study the de-identified information I provide, which are anonymized quotations, will be used for publication.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
10. I give permission for the de-identified interview transcript that I provide to be archived in TU Delft Education repository so it can be used for future research and learning.	☐	☐
11. I understand that access to this repository is open.	☐	☐

Signatures

_____ _____ _____

Name of participant Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____ _____ _____

Researcher name Signature Date

Study contact details for further information:

Roan ‘t Mannetje
R.tMannetje@student.tudelft.nl