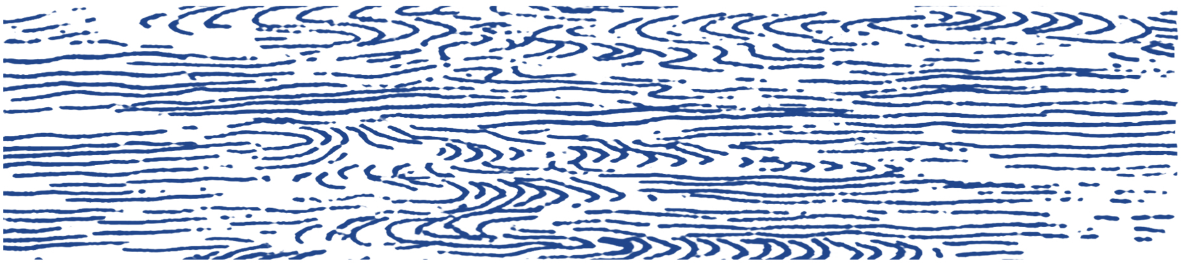
LET IT FLOW

Implementation of environmental flows in Dutch water management



MSc Thesis by
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Let it flow; Implementation of environmental flows in Dutch water management

- Identifying challenges and opportunities -

by

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Preface

The thesis before you is a result of a six month long individual process. It was a very interesting process, in which I have learned a lot about academic research, ecology in water management and the inner workings of Dutch water management organisations. Even though the thesis is an individual requirement to reach graduations, I could not have completed this research without the help of others. Especially in times of COVID-19 restrictions, both substantive and moral support was always welcome.

First of all, I would like to thank my graduation committee for guiding the process and providing feedback along the way. Michael for fueling my interest in environmental flows and being a great source of information. Erik for helping me with qualitative data collection and analysis and providing expertise on Dutch water management. Neelke for helping me to structure and strengthen the narrative of this thesis and shedding light on the topic from a different perspective.

This research would not have been possible without the interviews. I would like to thank all the interviewees for their much appreciated time and input.

For providing both feedback an moral support, I would like to thank my family and friends. Marliese, my parents and my brothers, thank you. And Quirine, Joost, Jim and Beer for joining me on campus when possible.

K.J. Ziere
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Summary

Water resources and freshwater ecosystems are under increasing pressure from a growing human population, more water-consuming lifestyles, and climate change. Furthermore, freshwater biodiversity is rapidly declining. In meeting these challenges, environmental flows (e-flows) can be an important guide, since it is defined as the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being. An example of e-flows is modifying dam flow operations to restore downstream floodplain ecosystems.

The opportunities of integrating e-flows into water management and the challenges of implementing e-flows in the Netherlands have not yet been studied. pressure on water resources and fresh-water ecosystems has risen in the Netherlands and will continue to rise, confronting Dutch water management with challenges of flow management and water allocation. This research aims to identify the possibilities of implementation of e-flows in Dutch water management. E-flows can help solve challenges in Dutch water management, and more understanding and implementation of e-flows is needed to ensure future social-ecological stability in water management worldwide.

In order to find the possibilities of implementation of e-flows in Dutch water management, it is necessary to first explore the current role of e-flows in projects, plans and policies. Data collection is primarily done through interviews. In addition to this, analysis of policy documents is used as a method of data collection. The collected qualitative data is analysed to provide an overview of the key factors of implementation in Dutch water management. Whether these factors provide challenges for implementation or act as enabling factors provides insight into the opportunities and methods for additional implementation of e-flows in Dutch water management.

The results of this research show that e-flows efforts have been made in the Netherlands, but are not defined as e-flows. Examples are meandering of rivers to increase natural flow and water retention, removing weirs to stimulate fish migration and changing creek dimensions, a drought displacement series, increasing tidal dynamics and secondary channels. The motivation behind these projects often are European policies, the Water Framework Directive and Natura 2000. Key factor influencing e-flows implementation in Dutch water management are trade-offs of water users and functions, justification and support, government, management and success. Challenges rising when implementing e-flows are navigating politics dynamics, land availability, performing proper trade-offs, no natural flow reference and sectoral administration. Opportunities present in Dutch water management are a system approach, adaptive, integral management, raising justification and support and creating a coherent narrative.

By using opportunities to navigate the challenges, recommendations for Dutch water management follow for further implementation of e-flows to reach ecological objectives. Recommendations are creating a coherent narrative around e-flows, using the nitrogen crisis and the effects of climate change to increase discussion on land use, water use and current lay-out of the water system, developing of better trade-off tools and facilitating change in government administration. In general, many similarities are present between e-flows implementation in Dutch water management and literature. These similarities mostly involve water management in general and the role of ecology in it, like the need for adaptive management, integral solutions and difficulties in measuring success. A lack of room as a large challenge for e-flows implementation is not encountered before in studies. In the USA, Australia and South-Africa, countries with the highest e-flows implementation rate, land use is much less intensive and water system modifications are more guided by the construction of (hydro-power) dams and large scale irrigation water use instead of shipping and flood control. It is likely the reason why dam flow regulation and water allocation receives much attention in e-flows literature instead of land availability.

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Acronyms

e-flows Environmental Flows. 1, 3–5, 7, 13, 17, 27

IRM Integraal Rivier Management. 20, 26

MIRT Meerjarenprogramma Infrastuctuur, Ruimte en Transport. 22, 24

PAGW Programma Aanpak Grote Wateren. 18, 20, 22, 24, 26, 27

SDGs Sustainable Development Goals. 1

WFD Water Framework Directive. 9, 11, 15, 17, 19, 20, 22, 23

Chapter 1
Introduction

Water resources and freshwater ecosystems are under increasing pressure from a growing human population, more water-consuming lifestyles, and climate change (UNESCO, 2020). This results in increasingly high water-related risks to society (World Economic Forum, 2019). Furthermore, freshwater biodiversity is rapidly declining (Verweij, 2013). In an effort to stop the degradation of water-related ecosystems and mitigate water scarcity, the UN Sustainable Development Goals (SDGs) include goals for water management. In achieving these SDGs, environmental flows (e-flows) can be an important guide, since it is defined as "the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being" (Arthington et al., 2018). An example of e-flows is modifying dam flow operations to restore downstream floodplain ecosystems (Simonov, Nikitina & Egidarev, 2019).

The definition was given by scientists and practitioners working in water management at the 20th International River symposium and Environmental Flows Conference in Brisbane in 2018. The definition is part of the Brisbane Declaration and Global Action Agenda, which also includes the progress and direction of e-flows science, practise and policy. In the Brisbane Declaration, it is stated that "Strengthening scientific understanding and evidence of the different benefits of environmental flows for ecosystems, economies and people under emerging planetary pressures is essential to guide water management toward social-ecological resilience in the future" (Arthington et al., 2018). Furthermore, the growing pressure on water resources and freshwater ecosystems "intensify the urgency for action to implement e-flows" (Arthington et al., 2018). In general, priority actions include accelerating implementation of e-flows (Tickner, Opperman et al., 2020). Most research has been conducted on e-flows assessment in past decades, whereas studies on e-flows implementation are far less common. Recommendations for further e-flows implementation research are stated in the Brisbane Declaration, including investigating mechanisms for integrating e-flows implementation in broader water resource management systems and identifying obstacles to implementation of e-flows in different world settings (Arthington et al., 2018).

The opportunities of integrating e-flows into water management and the challenges of implementing e-flows in the Netherlands have not yet been studied. For centuries, Dutch water management has been concerned with heavy water regulation supporting "separating land and water and maintaining this separation" (van Stokkom, Smits & Leuven, 2005), so Dutch government acted mostly on flood risk management to ensure safety. But pressure on water resources and fresh-water ecosystems has risen in the Netherlands and will continue to rise, confronting Dutch water management with challenges of flow management and water allocation. In combating these challenges, e-flows can be an important guide.

1.1 Research Outline

In this section, the research goal is presented, after which the research questions are formulated and the scope of the research is given.

1.1.1 Research Goal

This research aims to identify the possibilities of implementation of e-flows in Dutch water management. As described in the previous section, e-flows can help solve challenges in Dutch water management, and more understanding and implementation of e-flows is needed to ensure future social-ecological stability in water management worldwide and reach the UN SDGs. This research follows the Brisbane Declaration recommendations of investigating mechanisms for integrating e-flows implementation in broader water resource management systems and identifying obstacles to implementation of e-flows in different world settings.

1.1.2 Research Questions

The following research question is formulated in line with the research goal:

What are the challenges and opportunities
of implementing environmental flows
in Dutch water management?

In order to find the possibilities of implementation of e-flows in Dutch water management, it is necessary to first explore the current role of e-flows in projects, plans and policies. Through these projects, plans and policies, key factors must be identified which influence the implementation of e-flows in the Netherlands. Whether these factors provide challenges for implementation or act as enabling factors provides insight into the opportunities and methods for additional implementation of e-flows in Dutch water management. This leads to the following sub-questions:

1. **How do projects, plans or policies provide evidence of environmental flows implementation in Dutch water management practise?**
2. **What are the key factors for implementation of environmental flows in Dutch water management?**
   (a) What are the challenges in implementing environmental flows?
   (b) What are enabling factors?
3. **How can additional implementation be achieved in Dutch water management?**

1.1.3 Scope

This scope will specify the parameters in the research questions.

- **Implementation of environmental flows** In discussing implementation of e-flows, several aspects are included. These aspects include definitions and methods used, stated goals and motivation, process, and the ultimate effects reached. The focus is on implementation action and the factors influencing these actions.
- **Dutch water management** For Dutch water management, several different layers are discussed. The focus is on the Ministry of Infrastructure and Water Management and Rijkswaterstaat (national level) and water boards (local level). Trans-boundary basin and flow management will not be a focus in this thesis, but it is taken into account where necessary.
- **Evidence** A project, plan or policy is selected as evidence when goals, terms, key factors or methodologies are similar to the concept of environmental flow.

1.2 Research strategy and structure

To be able to start answering the research questions and put the results into perspective, a framework is first constructed using literature and policy documents. This framework includes the origin, definition and objectives of the e-flows concept and key factors of e-flows implementation. Furthermore, Dutch water management is explored, including history, organisation, European policy and e-flows related changes in the Netherlands.

The research strategy most applicable for answering the research questions follows the case study strategy (Sekaran & Bougie, 2016). The case study strategy is used to investigate e-flows implementation examples in the Netherlands and aims to identify key factors and their influence. Case studies can be defined as "a research strategy that involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple methods of data collection" (Yin, 2009). For this research, the country of the Netherlands is used as the case study, in which several project case studies will be used as examples of national policy and action. Data collection is primarily done through interviews. In addition to this, analysis of policy documents is used as a method of data collection. The collected qualitative data is analysed to provide an overview of the key factors of implementation in Dutch water management and whether they provide challenges or opportunities. A discussion to explain these results follows, including the implications for the concept of e-flows and possibilities for future additional e-flows implementation in Dutch water management. In fig. 1.1 below, a visual overview of the research strategy is presented.

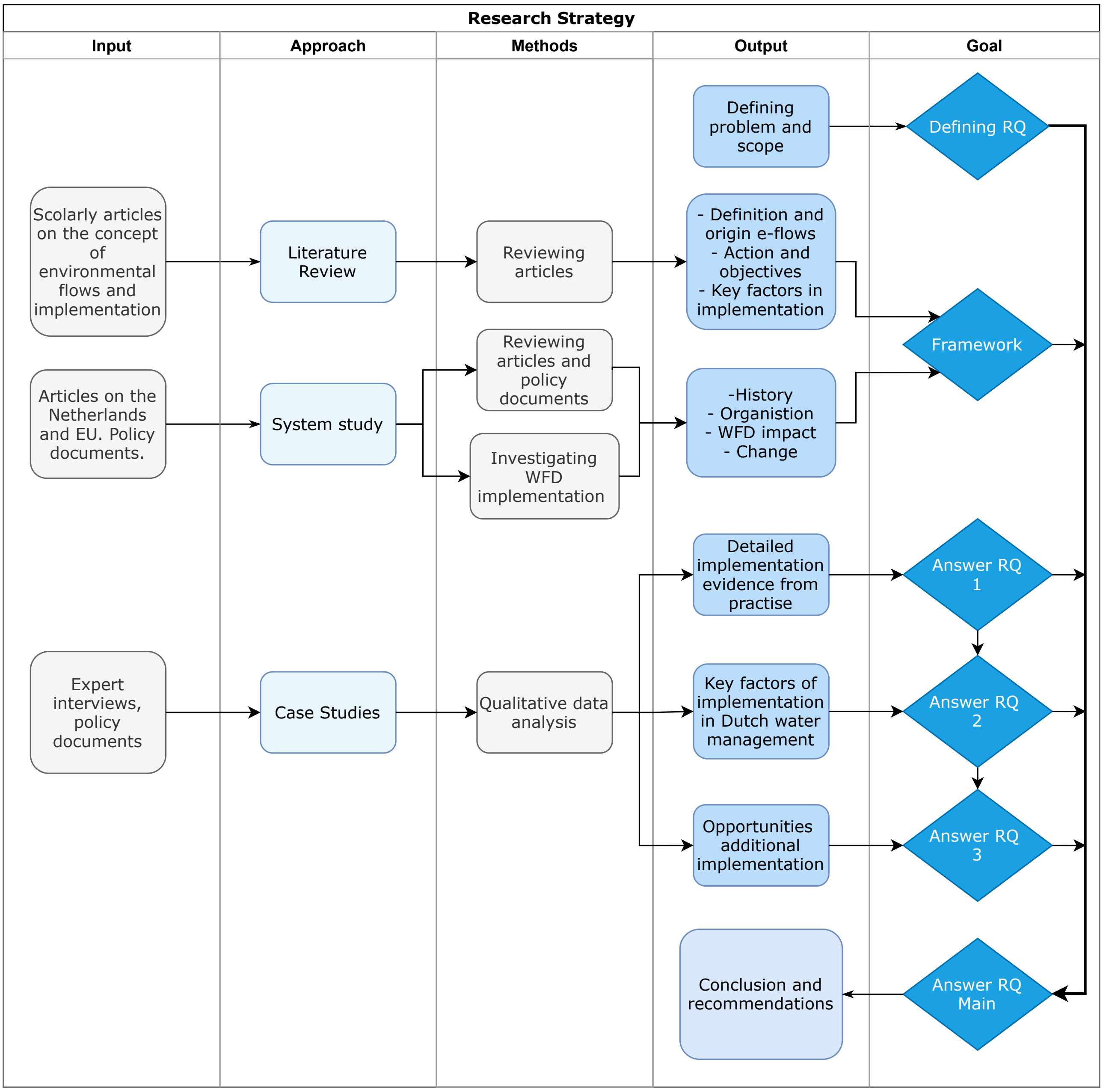

Figure 1.1: Research strategy

Chapter 2

Framework

In this chapter, the framework for this research is presented. It is divided in two sections. The first section will explore the concept of environmental flow. A description of Dutch water management follows, including the influence of European policy and climate change.

2.1 Environmental flows theory

In this section, the definition and origin of e-flows are discussed. These are followed by the current objectives and action recommendations in the field of e-flows. Lastly, key components of e-flows implementation according to literature are presented.

2.1.1 Definition

As explained in the introduction, the Brisbane declaration defines environmental flows as “the quantity, timing, and quality of freshwater-flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being” (Arthington et al., 2018). This definition is broad, which is visible in the implementation of e-flows. For e-flows assessment, 207 different methodologies have been found worldwide in 2003 (Tharme, 2003) and this number has risen in 2016 (Acreman, 2016). It can be stated that the "process to define environmental flows is fully and explicitly embedded within the broader process of water management decision making" (Tickner, Kaushal, Speed & Tharme, 2020). This means that many different definitions are possible for e-flows. As a starting point for this research, the definition from the Brisbane convention is used when describing e-flows, primarily because it is broadly accepted in the academic field. A distinction can be made between e-flows assessment or studies and e-flows action. E-flows assessment can be described as the scientific hydro-ecological study to find the necessary flows and water level objectives to reach ecological goals, whereas e-flows action can be described as the actions taken to reach the objectives.

2.1.2 Origin

The need to maintain some minimum level of flow in rivers has been recognised, studied and communicated in different forms for more than a century. The origins of environmental flow practise are not clear, but can be found in public health and fisheries biology literature between 1850-1950. In the case of public health, dilution and self-purification of rivers in which waste was transported called for minimum water levels (Chandler, 1873). For fisheries, a minimum flow for fish during droughts was explored. In 1870, the Fish Act in California "created a de facto year-round minimum flow requirement for dams with fishways" (Bork, Krovoza, Katz & Moyle, 2011). This fish act already faced compliance difficulties by dam operators when it was implemented.

By the 1950, in both public health and fishery sectors, knowledge and science on flows had advanced significantly, but apart from each other. Requirements for public health were easy to implement due to strong public health interests. In some parts of the world, methods shifted from using the river as waste treatment to constructing waste treatment plants and regulating waste discharge into the river according to the river flow. Regulation goals changed from riverine health to pollution levels, yet basic minimum water levels remained the only form of legal flow protection in many parts of the world. In the field of fisheries, regulation was difficult to implement because of opposing interests with for example hydropower, irrigation and drink water supply. Biologists were researching the relationship between flow levels and the characteristics of fish habitats and their food resources, which resulted in possibly the first e-flows assessment in 1951 at Granby Dam (Eustis & Hillen, 1954). In this assessment, daily and average monthly recommendations for flow release to preserve fishing and recreational facilities and scenic values of the Colorado River were presented. After being presented with this assessment, operators did not follow the recommendations, giving an early example of a gap between assessment and action.

After 1950, the pace of development increased rapidly for ecology based flows. Development was linked to operation of dams, and an increase of pace of dam construction was present between 1950 and 1980. By the 1990's, an active and highly collaborative international community of e-flows scientist and practitioners had formed. Developments in recent decades have varied according to particular circumstances in different countries, as well as different conceptual approaches. These approaches evolved through the years and are a product of co-developments of expanding scientific knowledge and tools with changing legal and management systems. USA, Australia and South-Africa produced the most recognised and adopted innovations in e-flows approaches.

2.1.3 Objectives

Environmental flow studies have traditionally been triggered around the world by evident indicators of environmental declines, and have therefore led to reactive solving of specific issues affecting species, habitats, ecosystems and/or, to a lesser extent, human well-being (Arthington & Pusey, 2003; N. L. R. Poff, Olden, Merritt & Pepin, 2007). To reach ecological targets, conventional objectives of environmental flow management have been delivering flows to restore historical flow regimes (N. L. R. Poff et al., 2007; N. L. R. Poff, 2018). These objective of restoring historical flow regimes might currently be insufficient, since climate change prompts a current need to develop multiple integrated objectives for e-flow that incorporate the socio-economic and cultural aspects of ecosystems (Dunlop, Parris, Ryan & Kroon, 2013). This means that in creating e-flow targets, a greater emphasis should be laid on ecosystem functions and services valued by society like water filtration and cultural values (Capon & Capon, 2017).

As stated in chapter 1, many studies on e-flows assessment have been done in the last decades (Tharme, 2003; Opperman et al., 2018; Chen & Wu, 2019; Simonov et al., 2019; O'brien, Dickens, Baker, Stassen & van Weert, 2020; Salinas-Rodríguez et al., 2021; O'Keeffe, Graas, Mombo & McClain, 2019), but studies on the current worldwide state of e-flows implementation action are far less common. Some implementation examples have been documented, but these are "isolated successes" (Tickner, Opperman et al., 2020). More action is needed to mitigate environmental problems in fresh-water systems and priority actions include accelerating implementation of environmental flows (Tickner, Opperman et al., 2020). Research on the implementation of e-flows can help this acceleration process. Recommendations on e-flows implementation action have been stated in the Brisbane convention of 2018, meant for leadership, management and research. Relevant recommendations are presented in table 2.1.

2.1.4 Key factors of e-flows implementation

Even though studies on the current worldwide state of e-flows implementation action are not common, and no central repository of information on the level of environmental water regime implementation across the globe is present (Horne et al., 2017), some theoretical key factors can be identified. These factors are described below.

2.1.4.1 Flow regimes

Environmental flows have relied on the concept of flow regimes, which capture long-term flow averages. Water flow regimes consist of magnitude, frequency, timing, duration and rate of change, and are critical in ecological responses and ecological integrity (N. L. Poff et al., 1997). Natural flow regimes are considered variable for virtually all rivers, and this variability is critical for aquatic ecological functionality and biodiversity (N. L. Poff et al., 1997). In e-flows assessments, two approaches are present, both serving different essential roles. One approach is to use natural flow regimes as a guide to find a desirable flow regime for a specific water body and ecological goal. In more recent studies, the reliance on the concept of regimes to predict ecological responses has been questioned, and the critical need for a more process-based understanding of ecological responses to individual hydrological events or sequences of events is raised (N. L. R. Poff, 2018). Yet, natural systems are

Table 2.1: Action recommendations (Brisbane convention 2018)

Declaration statements	Management	Research
E-flows have been compromised and today many aquatic systems around the world are at risk	Apply systematic planning tools to achieve cost-effective protection and restoration of healthy freshwater ecosystems. Base protection and restoration of e-flows on scientific and local knowledge within an adaptive management framework that balances human and ecological water requirements	Identify obstacles to implementation of e-flows in different world settings. Improve systematic planning tools and trade-off processes that can guide the location, design, and operation of new dams/other water infrastructure, for social-ecological benefit
Implementation of e-flows requires a complementary suite of policy, legislative, regulatory, financial, scientific, and cultural norms and values to ensure effective delivery and beneficial outcome	Establish environmental water allocation mechanisms appropriate to basin conditions and governance structures. Establish a system to manage consumptive water uses at basin and local scales. Utilize basin and system-scale infrastructure planning, design, and operation to protect and enable e-flows even where dams and other types of water infrastructure are needed, as well as in cases of infrastructure retrofitting and decommissioning	Investigate existing, and propose new, mechanisms for integrating e-flows implementation in broader water and related resource management system. Research effective design, monitoring, and reporting of e-flows implementation projects and programs, treating them as experiments where feasible

"complicated and variable, posing significant analytical challenges" (Harwood et al., 2018). The other approach in e-flows assessment is to apply designer flow regimes which aim to achieve ecological and ecosystem outcomes by supplying necessary flows and considering the current conditions of the water system. When the system involves rivers with high competing water demands and severely altered flow regimes and morphology, the designer flow approach is more applicable (Acreman et al., 2014). In this approach, e-flows can fill roles of providing additional flow during dry periods, enhance connectivity of rivers and floodplains with multiple values and benefits in mind by for example permitting active water management, limiting abstractions and prescribing dam releases (Acreman et al., 2014).

2.1.4.2 Socially valued benefits and function trade-offs

On top of challenges in finding a desirable flow, different socially valued benefits of aquatic ecosystems like recreation, cultural value and aesthetic value may require different flows (Acreman, 2016). In the decision-making process of water management, this results in a trade-off between benefits when trying to reach certain goals. Furthermore, different industrial, domestic and agricultural functions can be prioritised differently by different stakeholders. This often results in a low priority for water that is left in the river for environmental purposes (O'Keeffe et al., 2019). To increase the priority for environmental purposes, a general change of mindset is needed from seeing ecosystems as water consumers to ecosystems as an "essential component of water security" (Parker & Oates, 2016).

2.1.4.3 Legitimacy

The term legitimacy is used often in e-flows literature (Hirji & Davis, 2009; Horne et al., 2017; O'Donnell & Garrick, 2017b, 2017a), but the exact use of the term differs. It is used to describe justification for e-flows action in terms of politics and management, but also support for e-flows implementation action in politics, management organisations and involved stakeholders. For this research, the distinction between the use of legitimacy as justification and legitimacy as support is made where possible. Legitimacy is "crucial to the long-term success of environmental water programs" (Horne et al., 2017). Legitimacy is formed by a multitude of factors, but in the case of e-flows, a "shared awareness and acceptance by stakeholders that the environment itself needs water in particular quantities, timing and qualities" (Horne et al., 2017) is needed to increase legitimacy. Since involved stakeholders are specific for each action taken, raising both justification and support is also specific for each different implementation action. In general, legitimacy depends on the output and the process of e-flows implementation, and can be enhanced by stakeholder engagement (Conallin, Dickens, Hearne & Allan, 2017).

2.1.4.4 Adaptive management

Adaptive management is crucial in the implementation of e-flows to manoeuvre changing specific circumstances and uncertainty (Allan & Stankey, 2009). These changing circumstances may be caused by "changing social values, changing climate, or new knowledge" (Horne et al., 2017). Adaptive management is a management strategy centered around an iterative learning cycle and results in improvements in management. In the iterative process of adaptive management, monitoring is important to facilitate learning by ensuring careful documentation of hypotheses, decisions and outcomes (Allan & Stankey, 2009). Monitoring of e-flows implementation can be difficult due to the complexity of aquatic ecosystems, variability in response variables and sustained financial cost (Harwood et al., 2018).

2.1.4.5 Government

Because water management is largely done by governments and implementation of e-flows is mostly a political decision, government is considered a key factor. Governance is important, which in e-flows science is considered as developing "legislation, policies, regulations and funding mechanisms to institutionalize e-flows" (Arthington et al., 2018) in different levels of government. The type of government regime is also important. A government regime can either be characterised as being a prediction-and-control regime or an integrated adaptive regime (Pahl-Wostl et al., 2007). As described before, changing circumstances and uncertainties surround e-flows implementation, making it difficult to predict and control. This means that an integrated, adaptive regime is more suitable when implementing e-flows. It is not only important that the regime is integral, but the type of managerial administration is also important. Administration can be sectoral or integrated, which has an effect on the type of assignments, funding structures, collaboration and management in government.

2.1.4.6 Collaboration

In literature, collaboration is mostly related to stakeholder management. Involving stakeholders in environmental flow assessment can help raise awareness (Acreman, 2016) and can increase the lack of implementation (O'Keeffe et al., 2019). "Collaboration ensures that stakeholders understand the need for e-flows and how trade-offs between conflicting demands are assessed, and are engaged in the decision-making process" (Harwood et al., 2018). Collaboration should not only be informative to raise support, but participation from stakeholders leads to more effective and durable decisions in environmental management (Reed, 2008). On top of stakeholder management and participation, collaborative arrangements between scientists, managers and other stakeholders is required to reap the full benefit of adaptive management (Horne et al., 2017). Collaboration between countries involving trans-boundary water basin management also has an influence on the implementation of e-flows through it's effect on water quantity and quality.

2.1.4.7 Success

In general, environmental flow implementation is successfully when a sustained improvement in aquatic health is achieved over time through delivering water regimes (O'Donnell & Garrick, 2017a). But it is difficult to define general success criteria for e-flows implementation action, because implementation must be "assessed in the specific context in which the environmental water program is taking place, including the broad aims and trade-offs of each specific program" (O'Donnell & Garrick, 2017a). In an effort to generalise this assessment, a multi-criteria framework is developed by O'Donnell, involving implementation capacity criteria and policy criteria. Implementation criteria consist of legal frameworks, organisational capacity and partnerships. Policy criteria consist of effectiveness, efficacy and legitimacy. Case studies show the need to use all the six criteria, but it is acknowledged that these criteria are difficult to define and measure (O'Donnell & Garrick, 2017a). As described in section 2.1.4.4, monitoring of e-flows implementation effects is difficult, making monitoring of implementation success difficult too. Because success of e-flows implementation action must be assessed and monitored specifically for each specific e-flows implementation program, large monitoring capacity is required.

2.2 Dutch water management

In this section, a description of Dutch water management is presented, including the role of ecology, European policy and changes in water management.

2.2.1 History and culture

Much of present-day land area of the Netherlands is under sea level, but habitable due to renewal and maintenance of a complex water system to hold off the sea and rivers. As can be seen in fig. 2.1, currently 59% of the Netherlands faces flood risk, with 26% below sea level and 29% facing river flooding.

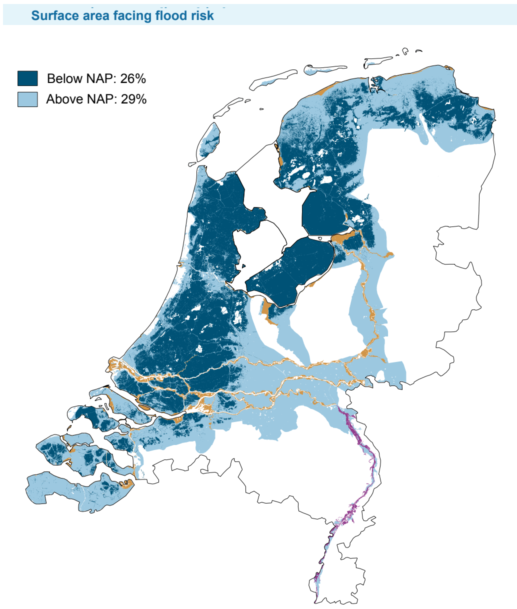

Figure 2.1: Land area in the Netherlands facing flood risk (Planbureau voor de Leefomgeving, 2009)

Claiming and reclaiming of land to increase habitability led to a hydraulic tradition that conceived nature, especially water, as an antagonist (Disco, 2002). This hydraulic tradition aimed to replace the natural situation with a controlled one. This tradition changed in the 1970's with an environmentalist wave, in which the development of technologies aimed to fulfil both the conventional criteria of safety and prosperity and new criteria of ecological conservation (Disco, 2002). Discussions about a large project in the Oosterschelde was characteristic of this new broadening of criteria and showed that the criteria were "not essentially opposed but could be technologically aligned" (Disco, 2002). From this moment on, not only engineers but also biologists and ecologist had a role in Dutch water management.

Even though the role of ecology increased, Dutch water management has typically focused on flood protection, resulting in a large expertise in regulating rivulets and rivers (van Stokkom et al., 2005). Furthermore, agricultural water use and shipping receive high political priority. The Dutch value flood protection, shipping and industrial water use most, which can be explained as residual from a long and proud tradition once called "masters of the floods" by important Dutch water engineer Johan van Veen, and economic prosperity through shipping and agriculture. In addition to low priority in water management, aquatic ecology suffers from large amounts of land reclamation and water system modifications. Land that was once available for natural flow, has been put to other uses a long time ago and the water system is intensely regulated. Up until 2015, these land uses were not questioned in politics (Mostert, 2020).

Even though it is challenging to observe and measure interactions between surface water and groundwater, management and exploitation of these components affect sustainability of both the water resource itself and the ecosystems it supports (Liu et al., 2020). The influence of management and exploitation is large when groundwater levels are shallow and water flows more easily between the ground and surface. In the Netherlands, groundwater levels are shallow in most areas, less than 1-2 m below the surface (Witte, Zaadnoordijk & Buyse, 2019). The effects of management and exploitation of groundwater are visible through adaptations in the water system to achieve meeting the demands agricultural land-use and groundwater abstractions, which led to a decline in groundwater levels in natural areas next to agricultural land, resulting in a significant loss of conservation values (Witte et al., 2019).

Many people refer to the history of water management in the Netherlands as the essence of Dutch tradition and culture, and the foundation of the Dutch polder model (Schreuder, 2001). This collaboration model, based on direct participation in dialogue, compromise and consensus building between social groups is broadly considered the result of the need to cooperate in order to combat flooding (van Tielhof, 2009). The model is uniquely Dutch since the legacy of consensus building and democratic government is closely tied to formative events in the formation of the Dutch country, as well as the concept of cooperation at its most powerful and cohesive during times of great peril (like the construction of the Delta Works) (Schreuder, 2001). It is not possible to be fully certain on the origin of the polder model in Dutch water management, but participation of all parties has often been a large factor in water management (van Tielhof, 2009; Brusse, 2018).

2.2.2 Water Framework Directive and Natura 2000

Although the Netherlands has a long history of water policy, the Dutch system had to cope with implementation of the European Union Water Framework Directive (WFD) (Van Rijswick, 2011). This directive is, like all EU directives, binding upon Member States in terms of results, and aims to prevent deterioration of the water status and where necessary protect, enhance and restore all water with the aim of achieving a "good status" of water using a river basin management approach. Good status of water encompasses good chemical status and good ecological status. The status is different for every water body across Europe, so a set of procedures for identifying and establishing particular standards is provided. Furthermore, a system for ensuring that each Member State interprets the procedure in a consistent way is provided to ensure comparability. Good ecological status is defined as a small deviation from established reference conditions, except when the water body are designated as highly modified or artificial. In that case, ecological potential is considered. From an ecological viewpoint, reference conditions are difficult to establish, due to constantly evolution of the environment and no consideration for long-term interactions between humans and nature (Bouleau & Pont, 2015). This does not prevent the use, a pragmatic approach can be used to establish reference conditions based on networks of undisturbed sites (Bouleau & Pont, 2015). Due to low amount of undisturbed sites in the Netherlands, finding reference conditions can be difficult.

The WFD entered into force in 2000, after which in 2003 it had to be transposed in all member states into national legislation. After the characterisation of river basins, Member States had to present a draft of their first river basin management plan in 2008. After 2015, every 6 years a new version of the river basin management plan should be presented. The Netherlands presented their first river basin management plan, in which 723 surface water bodies were marked, of which 711 were designated as heavily modified or artificial. For 625 surface water bodies and seven groundwater bodies, the deadline for reaching good ecological status or potential was extended, an idea repeated in the second river basin management plan in 2015 (Mostert, 2020). By extending deadlines, environmental objectives had to be either reached in 2027 or lowered in the third river basin management plan in 2021.

Even though efforts to improve the status of waters have been made in the Netherlands, which will be discussed in chapter 4, the Netherlands does not comply to WFD targets. As can be seen in fig. 2.2, 1% of the surface water bodies have either good or high ecological status or potential, which is much lower than the European average (assigned with (*) in the figure) of 44%. 61% of surface water bodies are in either poor or bad condition, which is much higher than the European average of 46%. Even though the ecological status or potential in the Netherlands is lower than average, comparison between countries is difficult because Member States are themselves responsible for establishing standards and monitoring. As can be seen in fig. 2.3, assessment confidence for the ecological status or potential is very high compared to the European average, 91% high confidence in the Netherlands compared to 27% on average in Europe. Furthermore, the assessment confidence is highly variable in different Member States, making comparing ecological status or potential difficult. For the Netherlands itself, it means that monitoring is functioning well, but results are poor.

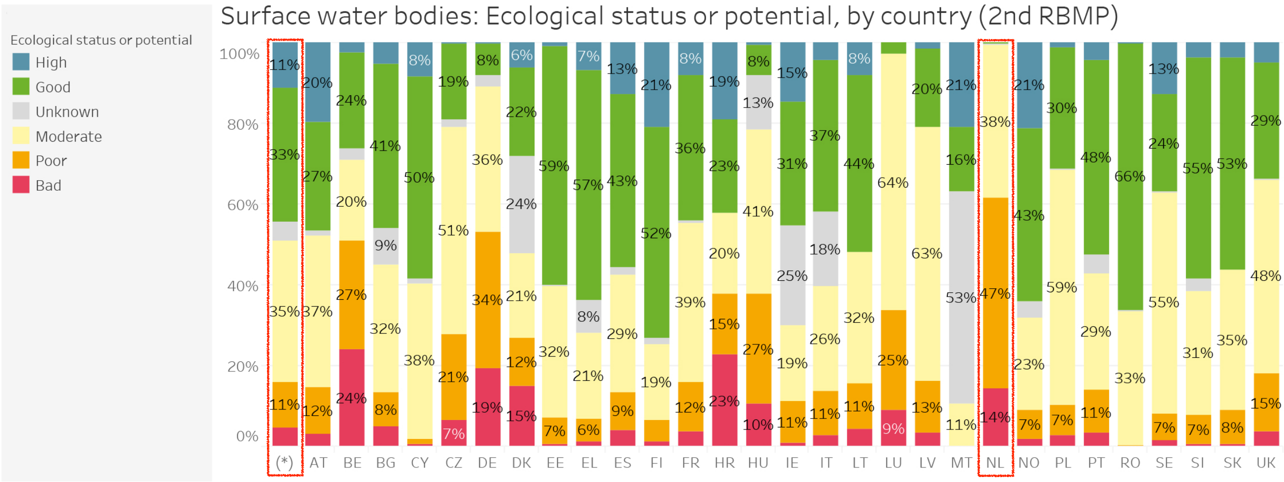

Figure 2.2: Ecological status or potential by the European Environment Agency (Kristensen et al., 2018)

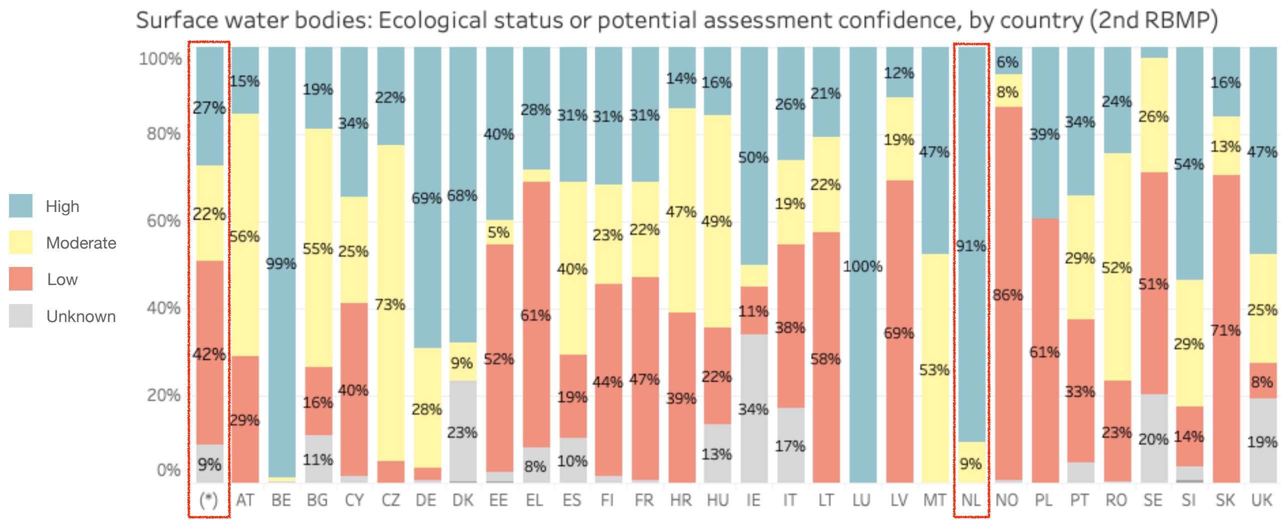

Figure 2.3: Assessment confidence by the European Environment Agency (Kristensen et al., 2018)

This can be explained by lobbying of the agricultural sector, low political priority for environmental issues and previous problems with implementing EU directives (Mostert, 2020). The Netherlands ranks 131st in surface area, while the agricultural sector in the Netherlands is the second largest exporter in the world, worth 95.6 billion Euros in 2020 (Jukema & Ramaekers, 2021), illustrating the economic importance of agriculture.

In addition to the Water Framework Directive, ecological EU policy is present in Natura 2000. It is an EU-wide ecological network of nature conservation areas, covering 18% of Europe's land area, which lies at the heart of EU Nature Directives. Member States need to designate natural areas as Natura 2000 areas, after which the Member States are duty bound to prevent deterioration of habitats and species. Member States must also apply conservation measures to improve the condition within these Natura 2000 sites where necessary (European Environment Agency, 2020). To implement Natura 2000 goals in the Netherlands, provinces have the responsibility to make management plans and guide execution of measurements. Implementation of Natura 2000 in the Netherlands followed a failure narrative and an "all is locked" mantra was visible (Beunen, Van Assche & Duineveld, 2013). This means that the Natura 2000 directives were considered too strict by media and representatives of different interests and sectors (Beunen et al., 2013). Currently, 20% of freshwater Natura 2000 designated habitats have a good conservation status (European Environment Agency, 2020).

2.2.3 Organisation

Due to an extensive history in water management, the Netherlands has a well developed water governance system (Mostert, 2020). This governance system involves several levels. At the national level, water policy and practise is governed by the Ministry for Infrastructure and Water Management and its agency Rijkswaterstaat, responsible for the large water bodies like the Rhine. Ecology is represented in the Ministry of Economic Affairs and Climate Policy and the Ministry for Agriculture, Nature and Food Quality. On a regional level, spacial planning and supervising is the responsibility of the 12 provinces. On a local level, 22 water boards are responsible for managing and maintaining most local surface waters and water treatment. When the WFD was introduced, all these different levels of government had "their own policy plans and management plans, but there was no system of river basin management as required by the WFD" (Mostert, 2020). This makes it difficult to pinpoint what parts of the organisations are responsible for implementation and managing of environmental flows. The responsibility for e-flows implementation follows the WFD and is specific for different water bodies. When implementation of e-flows in the large rivers or estuaries is considered, Rijkswaterstaat can be designated as responsible, but collaboration with other large stakeholders will always be needed. When implementing e-flows on a small, local scale, waterboards can be designated as responsible, but are dependent on province policy as well. It is doubtful that WFD targets can be reached with resources and powers spread out over many different administrative bodies, water authorities, and those with responsibilities in other policy fields, and authorities in the Netherlands are eager to leave the existing administrative structures and powers unchanged (Van Rijswick, 2011). When e-flows implementation follows the same way as WFD implementation, this doubt might also apply to e-flows.

2.2.4 Climate change and nitrogen crisis

Effects of climate change in the Netherlands will increasingly be felt in water management. The sea level will rise and weather events will become more extreme. These will increase flood risk in the Netherlands. Furthermore, in multiple scenarios, drought will occur more frequently leading to water shortage and lower water quality. Climate risks for nature are highest in ecosystems dependant on precipitation and surface water (KNMI, 2015). The effects of droughts were significant between 2018 and 2020, in which very high deficits built up as can be seen in fig. 2.4.

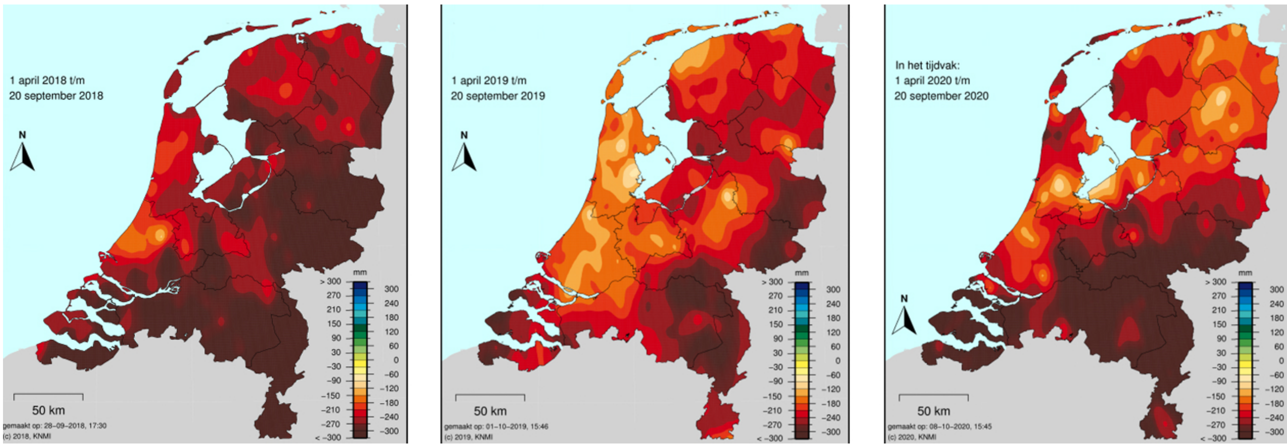

Figure 2.4: Precipitation deficits in mm between April and September in 2018, 2019 and 2020 (Source: KNMI)

Along with climate change, the recent nitrogen crisis in the Netherlands and it's impact on agricultural land use is of importance to water management. This crisis involves the ambition to decrease deposition of nitrogen in sensitive Natura 2000 areas in the Netherlands to below defined critical deposition levels. The nitrogen crisis and the possible solutions have been analysed by the national institute for strategic policy analysis in the fields of environment, nature and spatial planning (Planbureau voor de Leefomgeving, 2021). In this report, it is stated that the nitrogen deposition ambitions are translated into strict targets, more strict than other ecological risks like drought and lack of space. In reaching these targets, a necessary, historically unequalled transformation of agricultural land area is probable in the Netherlands, even when taking into account biological, circular or nature-inclusive agriculture practises. On top of nitrogen challenges, ambitions to combat green-house emissions and the recent biodiversity strategy of the European committee which implies the need for more natural area, present more challenges. These challenges against the backdrop of the current cultural landscape in which 66 % of the land area in the Netherlands is used for agriculture can result in major changes in spacial planning. In order to navigate agricultural interests and political feasibility, it is important to create analysis tools for (financial) efficiency of measures, area-specific targets, a strengthening of monitoring and scientific ecological understanding.

Chapter 3
Methodology

In the following chapter the applied data collection and data analysis methods are presented.

3.1 Data collection

This section explains the methods of data collection necessary to answer the research questions. To find evidence of e-flows implementation in Dutch water management, information is needed on policy, plans and practise. In order to identify key factors of implementation, detailed information on ecological water management is necessary. As a source of information on policy and plans, policy documents are analysed. Because the focus is on studying implementation action of e-flows in Dutch water management, the primary source of information for this research is gathered through interviews with Dutch water management experts.

3.1.1 Policy documents

To collect evidence of e-flows implementation in policy, plans and projects, policy documents are a useful source of data. Examples of relevant policy documents are the national Fresh Water Delta Decision, which resulted in the national Fresh Water Strategy and Fresh Water Delta Plan. A smaller scale example is a Water Board Water Management Plan. Policy documents are obtained through organisation websites.

3.1.2 Interviews

To find intricacies of implementing e-flows in water management, interviews are used as a data source. Expert water managers are interviewed about their identification and perception of key factors influencing the implementation of e-flows,challenges and opportunities present in Dutch water management and possibilities of future implementation. The interviews are held in a semi-structured fashion. This way of structuring supports the goal of obtaining specific information on implementation of e-flows without losing the possibility of obtaining other interesting information. Interviews can be prone to bias (Sekaran & Bougie, 2016), which can be limited by using an interview guide. The interview guide is based on findings in literature and several exploratory conversations with experts. The guide used in this research is presented in table A.1. Interviews took between 50 and 75 minutes and were recorded. Afterwards, the interviews were processed, resulting in an interview narrative report. These reports contained between 4 and 5 pages of text and were sent to the interviewees for a narrative check.

3.1.3 Sample and quality

The sample of the data collection consists of experts working at Rijkswaterstaat, two separate water boards, Brabantse Delta and Vechtstromen and the nature conservation organisation WWF. These experts have different experiences with ecology, water systems, management and policy. Saturation of data, which is a way of checking data sufficiency, is checked by keeping track of the amount of new information per interview. This is further elaborated on in section 3.2.2. Several options are available to further ensure sufficient quality in qualitative research (Merriam & Tisdell, 2016), of which triangulation and narrative validation are used in this research. Using information from policy documents and interviews is a form of triangulation and narrative validity of the results are ensured through an interview report check by the interviewees.

3.1.4 Selected experts

An overview of selected experts is presented in table 3.1. The selected experts have diverse functions in different companies and departments. Also, diverse experience and different specialities are represented in this sample.

Table 3.1: Selected experts for interviews

	Organisation	**Position**	**Experience**
1	Rijkswaterstaat	Senior advisor ecology and water quality	16 years
2	Waterschap Vechtstromen	Team leader	20 years
3	Waterschap Vechtstromen	Senior advisor water system	10 years
4	Waterschap Brabantse Delta	Expert water management	13 years
5	Waterschap Brabantse Delta	Advisor water management	20 years
6	Rijkswaterstaat	Senior policy advisor	15 years
7	Rijkswaterstaat	Senior advisor water distribution	19 years
8	Rijkswaterstaat	Cluster coordinator rivers and policy advisor fresh water	11 years
9	Rijkswaterstaat	Senior technical manager	36 years
10	WWF	Program manager delta and rivers	17 years

3.2 Data analysis

In this section, used data analysis methods are discussed. Collected information from policy documents and interviews surround the same subjects, policies, plans and projects and therefore are considered complimentary. These sources of information and will be analysed together where possible.

3.2.1 Coding

Since interviews and policy documents yield large amounts of information, an ordering of data is performed as a necessary first step. This is done through coding and categorization. Coding is defined as "the analytic process through which the qualitative data that you have gathered are reduced, rearranged, and integrated to form theory" (Sekaran & Bougie, 2016). Codes are labels that are assigned to words, sentences or whole paragraphs of text. These codes are grouped together in categories. Coding is an iterative process, which calls for structuring and monitoring. The first step in the iterative process of coding is selecting preliminary codes of important topics and themes before starting the data collection. From literature and some exploring conversations with experts, the developed preliminary codes are presented in fig. 3.2. A tree structure is used to visually show clusters, categories and relations. During the analysis progress, the amount of codes and changes are monitored after each new document to ensure proper analysis because coding "not only involves reducing the data but also making sure that no relevant data are eliminated" (Sekaran & Bougie, 2016).

3.2.2 Saturation

To make sure enough data is collected, saturation of information is tracked. In the field of qualitative research, four different approaches to saturation exist (Saunders et al., 2018). Because coding is used in this research, the inductive thematic saturation approach, rooted in grounded theory, is used. This means that the collected and analysed data is considered saturated when no significant amount of new codes follow from an new document. The tracking of saturation can be seen in fig. 3.1. In this figure, a decline in new codes per subsequent interview is visible. In the last interviews, no significant amount of new codes are present, which indicates that the data is saturated and enough interviews have been conducted.

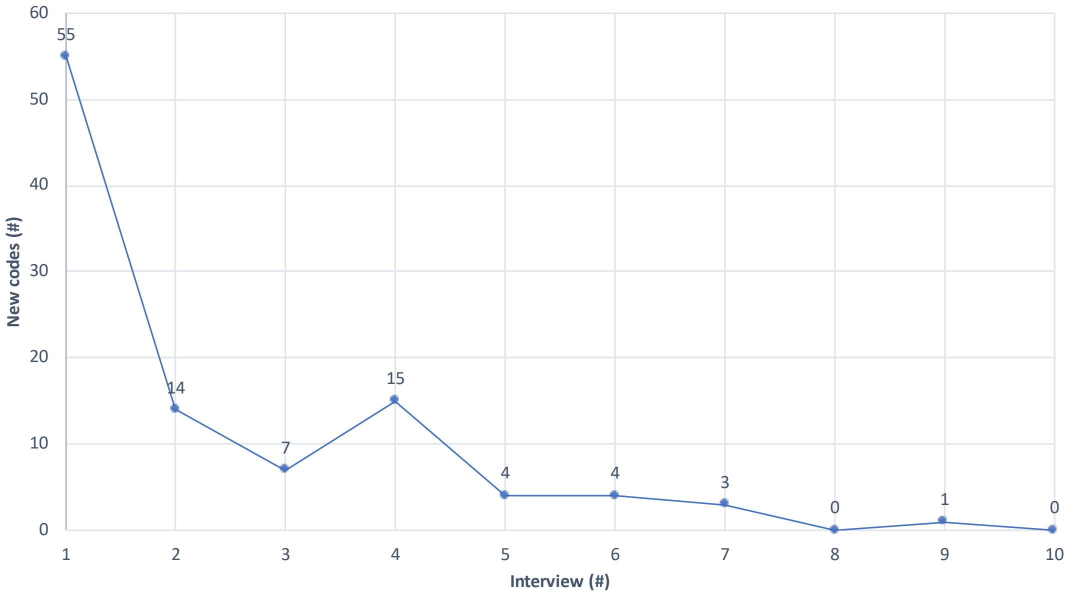

Figure 3.1: Amount of new codes per consecutive document

3.2.3 Quantitative and qualitative analysis

After the coding of documents, further qualitative analysis is needed to produce understandable results. But a quantitative analysis of codes provides a first impression of the results. To identify the key factors of e-flows implementation in Dutch water management, necessary for answering the second research question, the occurrence of codes gives an indication of which factors are key factors. The occurrence of codes in itself is not enough to state which factors are key factors, since the perception of the interviewees on the factors is important as well. The occurrence of codes is presented in table B.1 in appendix B. Co-occurrence of codes with "challenge" and "opportunity" helps identifying which aspects of these factors are considered challenges or opportunities in the Netherlands. A visual representation of challenges and opportunities is presented in fig. B.1 in appendix B. Co-occurrence of codes with key factors shows some insight into the discourse surrounding these key factors in interviews. Two examples can be found in table B.2 and table B.3 involving WFD and Natura 2000 in the first table and legitimacy in the second table.

In further data analysis from documentation and interviews, no more quantitative substantiation can be given. The information and literal quotes provided by the interviewees along with information from policy documents are used to generalise assumptions about the implementation of environmental flows in Dutch water management.

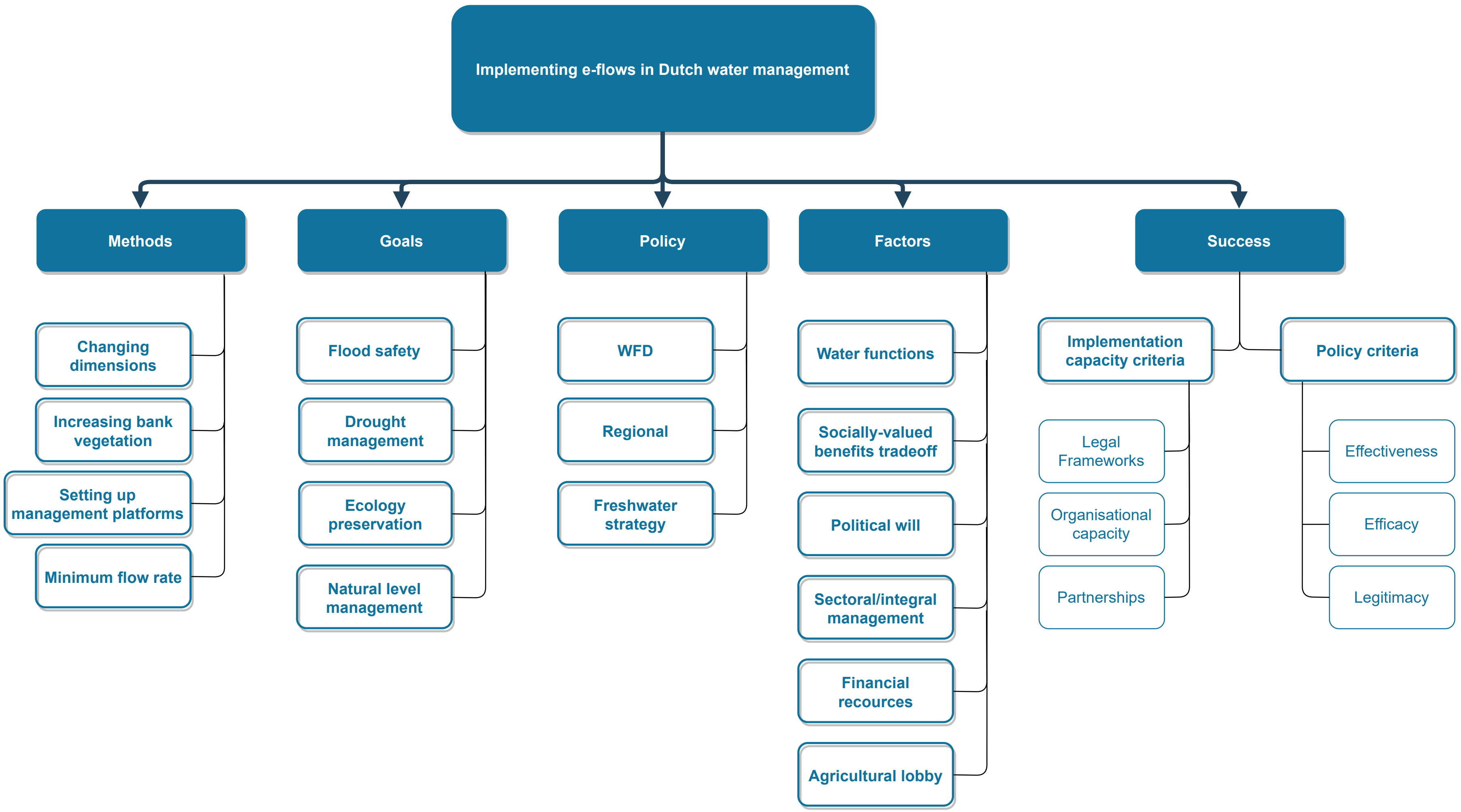

Figure 3.2: Preliminary codes

Chapter 4

Results

In this chapter, the results of data collection are described. In order to answer the first research sub-question, data on the current role of e-flows in Dutch water management will be discussed. The second research sub-question is answered by identifying key factors of e-flows implementation and describing what facets of these factors provide challenges or opportunities for e-flows implementation action.

4.1 Current role environmental flows

To kick off discussion about e-flows in the Netherlands, interviewees were asked to express their familiarity with the concept of e-flows. Six out of ten interviewees had not heard the term 'environmental flows' before, three out of ten had heard the term before from international collaboration but were not familiar with the definition and use and one interviewee was very familiar with the definition used in this research. But, after some introductory information was provided, all interviewees expressed familiarity and experience with the goals, spirit and methods of e-flows. This means that the lack of awareness of the term 'environmental flows' is a definition problem and not a concept problem. This created a strong enough foundation for using their expertise in water management as input for this research. In Dutch policy documents, the term environmental flows was not encountered. Interviewees agreed that in the historically heavily regulated Dutch water system, using natural flow as a guide is very difficult and even impractical, since the river conditions and dimensions and are often heavily modified and far from natural. But, within the current boundary conditions, efforts have been taken to restore aquatic ecology and increasing flow dynamics, following the designer flow approach in various ways. These efforts will be described in the rest of this section.

At water boards, e-flows efforts show the strongest resemblance to natural redevelopment of water ways in order to reach the WFD goal of good ecological status of water (Waterschap Vechtstromen, 2021; Waterschap Brabantse Delta, 2022). Redevelopment measures include increasing meandering of rivers to increase natural flow and water retention, removing weirs to stimulate fish migration and changing creek dimensions to better cope with not only large but also small discharges. When redevelopment is not possible, some control measures are decreased where possible. This includes less riverbed vegetation mowing and leaving tree trunks in the water as a form of wood supplementation.

As described in section 2.2, droughts have been a major problem in the Netherlands. To cope with water allocation problems, a drought displacement series has been put in place.[1] This is a national policy in which the hierarchy of water functions is prescribed in times of drought to minimize societal and economic damage. Hierarchy in this displacement series is divided in 4 categories, starting from the most important functions to the lowest. Ecology is represented both in the most important category and the lowest category. An interviewee explained *"when ecological damage is irreversible, it is considered part of the most important category together with safety. When damage is not irreversible it is placed in the category with the lowest importance, together with shipping and recreation"*. An other method used to decrease the ecological damage of droughts in the Netherlands is increasing water retention in the water system. This includes increasing retention time of surface water by redevelopment of water ways, increasing groundwater infiltration in winter to ensure larger surface flows in summer and imposing water abstraction bans.

[1] Verdringingsreeks in Dutch

On a national level, similarities with e-flows can be found in the Programma Aanpak Grote Wateren (PAGW).[2] To provide impulses in the efforts of reaching WFD and Natura 2000 goals, this program has been set up by Rijkswaterstaat in 2015 in a joint effort by the Ministry of Infrastructure and Water Management and the Ministry of Agriculture, Nature and Food Quality. From this program, several projects have followed in which measures are based on a system challenges report. In this report, nature is not considered a consumer of water, but nature itself is considered part of the system. Several ecological key factors are defined, which include habitat size, place for food, shelter, but also river dynamics (Rijkswaterstaat, n.d.). Projects following the PAGW program include increasing tidal dynamics and connection to the sea at the Haringvliet and Grevelingen lake in the Southwestern delta of Zeeland to increase fish migration and resolve an ecological problem of a dead lake bed resulting from a lack of oxygen.[3] Furthermore, multiple secondary channels have been created in the large river systems and more room has been created for the Meuse between Ravenstein and Lith to increase flood safety and create more natural area.[4] The Ministry of Infrastructure and Water management is also trying to change sedimentation management to broaden river bedding en mitigating drought effects in floodplains.

Often, a long time is spent in Dutch water management between defining ambition, developing plans and actual execution through action. In an effort to accelerate action, multiple organisations including the WWF have tried to increase attention to aquatic ecological recovery challenges. To raise awareness, these organisations have threatened with lawsuits and tried to inform the general public with protests. Furthermore, these organisations have tried to accelerate action by supplying Dutch water management with suggested solutions in the 'Ruimte voor Levende Rivieren' report.[5] These suggested solutions are endorsed by multiple sectors, including shipping. Examples of solutions to stimulate aquatic ecological recovery are more dynamic flow management by increasing cyclic and variable management in larger management areas, moving agriculture, increasing water seepage and forest conversion (Barneveld, Boon & Sloff, 2018).

4.2 Key factors of implementation in Dutch water management

In this section, key factors of e-flows implementation in Dutch water management are presented, which answers the second research sub-question.

4.2.1 Trade-offs

The topic most discussed in interviews is the trade-off between different functions of water bodies. In the Netherlands, a lot of pressure is put on both surface and ground water due to intensive water use and high population density. All water bodies have multiple functions, which results in an often difficult trade-off. Functions of rivers and creeks most commonly mentioned are flood safety, agriculture, ecology, shipping, discharging waste water, recreation and providing drinking water. This trade-off is different in different hydrological situations. Interviewees stated that the trade-off was traditionally made in a situation of water excess. In this situation, the trade-off between functions in water management is not difficult in terms of quantity, since enough water is present to fulfill all different functions. Still, decisions have to be made on how to direct the water, and in the Netherlands the prevailing decision entailed discharging water out of the system as fast as possible due to high flood risk.

In general, the role of ecology in the trade-off of functions is relatively small but growing, according to the interviewees. In general, water safety and agricultural use are still prioritised over ecological functions. This is partly caused by a long tradition of water safety issues and a large agricultural lobby. In addition to these causes, it is difficult to objectively compare and weigh the different water functions for both Rijkswaterstaat and water boards. In order to navigate this, *"a system approach is essential"*. Six interviewees acknowledged the need for this system approach, in which ecology is not a water user, but a part of the water system as a whole. Only in times of drought, when water allocation problems rise, it is not possible to consider the whole system, but should each function receive a certain amount of water based on the displacement series. In addition to a trade-off in functions, a trade-off between benefits of action is often discussed. As one Rijkswaterstaat interviewee put it, *"actions that are easier to express in costs-benefits more often take precedence over ecology, where this expression*

[2] Translates to Programmatic Approach to Large Waters
[3] 'Getij Grevelingen', which translates to 'Tide Grevelingen'
[4] 'Meanderende Maas', which translates to 'Meandering Meuse'
[5] Translates to Room for Living Rivers

is more difficult and uncertain." and *"there should be an objective way in which you can value nature and compare it as a function"*. Creating a method of objectively comparing different functions and benefits for the whole water system is being developed, but it is considered very difficult due to the long time-scale, large uncertainty and measuring difficulties of ecological goals. The function trade-off is less difficult for water boards, because the system is smaller with less functions and WFD goals are concrete and more easily measured. For broader ecological goals outside the WFD, the same difficulties as Rijkswaterstaat rise at the water boards.

4.2.2 Justification and support

All interviewees expressed that implementation of e-flows is a political decision. This applies to both national and local water management. National water management through Rijkswaterstaat is largely influenced through the Ministries by decisions of elected governments. On a more local level, provinces and municipalities are governed through elections. Water boards are governed by an elected board. Because e-flows action is a political decision, justification and support is of critical importance. Several factors influencing justification and support are discussed by interviewees. First of all, land use has a large impact on support. Interviewees argue that the water system is generally designed for high discharges and rivers are highly adapted to shipping. This results in a highly modified water system, consisting often of straightened, deep canals. Redevelopment of rivers and creeks will therefore often require a broader river bed and an increase of floodplain area. Since the Netherlands has a high population rate, a long history of land reclamation and high agricultural land usage, it is very difficult in all parts of the country to acquire the necessary land for a more natural water system. An interviewee stated that *"projects more often fail than succeed due to a lack of land availability"*. When no land is available, available options to stimulate aquatic ecology are according to interviewees only present in decreasing control measures like less mowing on the river banks and wood supplication. The possibilities are low of these types of efforts, because they often face difficulties with recreational and agricultural water use. As one interviewee put it, *"for the safety of canoeing, we have to remove collapsed trees, but for the sake of ecology you actually want to leave them in the stream"*. The agricultural sector has a strong lobby and vote in politics, especially in rural regional politics. This decreases the support for ecological action in these areas, since e-flows goals commonly do not currently align with intensive (agricultural) land use. Five interviewees suggest that this might change in the near future. Circular agriculture and a diminishing livestock nationwide might decrease the intensity of land use in the Netherlands, which can provide opportunities for larger hydro-ecological surface area. But, *"against the backdrop of the nitrogen crisis and energy transition, farmers are already a societal punching bag, resulting in an increase of response and opposition to measures"* according to an interviewee.

In addition to land use, interviewees agree that climate change has a large impact on justification and support of e-flows action. All interviewees experience increasing impact of climate change on the water system and its ecology as increasing the support for action. This climate change impact is mostly experienced through several drought events between 2018 and 2020, along with a growing public debate on climate change. Interviewees describe a major change in mindset both in Rijkswaterstaat and water boards due to these drought events. Before these events, ecological policy was considered a progressive hobby instead of a problem, but drought damage to the water system changed this view. A realisation in water management came of not discharging all water in the system as quickly as possible, but retaining water in the system. This realization has increased justification of e-flows action. An interviewee mentioned *"due to climate change, the WFD is pushed aside a bit"*, which indicates the impact climate change has on justification. Two interviewees stated that climate change could also decrease justification of e-flows actions, or action in general. One interviewee described climate change studies, which function as a base for measures as *"a snapshot in time in which we think we know what the climate will do, but a considerable uncertainty remains"*. An other interviewee experienced lethargy due to the long-term view on climate change in relation to current policy and described it as "if we come up with measures that can mitigate climate change effects, we will have to justify whether it fits within the current strict legal regulations, for example nitrogen deposition".

When discussing support, all interviewees agree on the major influence of stakeholders. Support of e-flows action is increased when stakeholders are involved in an early stage. Furthermore, eight interviewees described the positive value of *"selling a story"*. This includes cost and benefits, but also motivation and vision of actions. When actions can be placed in a greater strategy, are clearly explained and also capture the imagination of stakeholders, support can be raised. An example presented by an interviewee included the "Building with Nature" concept. It is not considered a silver bullet, but it helps to change the mentality on water management. It tells the story of a natural system that can carry it's own weight without human intervention.

A distinction can be made when discussing justification and support of e-flows action between problem solving and ambition. All interviewees conclude that both justification and support is easier to raise when a concrete problem arises. This is exemplified by the Grevelingenmeer project. Damage in the lake was evident and was reported by water managers, divers, fishermen and swimmers. This resulted in higher support and quicker planning. In general, *"After high flow and flooding events, safety programs were started. After low flows and drought in the past years, programs were started as well. Extreme water conditions always result in a high position of water management on the political agenda"*. For future ecological ambitions which increase ecological value of the water system, it is harder to increase support, because the benefits are less evident to most stakeholders. Both in water boards and Rijkswaterstaat, a sense of long-term responsibility for ecology has only recently emerged. Since both government bodies traditionally were established for water safety, the sense of responsibility and ambitions for ecology were low. All interviewees agree that when justification and support are raised, the sense of long-term responsibility and ambitions for ecology will rise and it will become a more embedded in 'the fibre' of the organisations.

4.2.3 Government

Government has a large influence on implementation of e-flows through policies, plans, administration structure and financial structure. The European Water Framework Directive (WFD) is mentioned by all interviewees as a large policy factor on e-flows action. Both Rijkswaterstaat and water boards are working with the WFD, but it is most influential in the water boards, because water boards have a major duty of care for the WFD goals. One water board interviewee described the WFD as *"an obligation"*. According to six interviewees, the concrete goals of the WFD present an opportunity for e-flows action, since it is an ecological an biological task meant to increase the intrinsic value of nature. Furthermore, the WFD has *"helped enormously to not only view water quality as chemical quality, but to create good conditions for ecosystems"* according to an interviewee. In the Netherlands, WFD goals are set high and the quality of surface water is monitored extensively. Interviewees describe the layout of the water system as the largest challenge for the WFD, because the layout is most adapted to shipping and water safety. This means that in reaching the WFD goals, redevelopment of water ways is highly important. Redevelopment presents a large opportunity for implementation of e-flows. Another European policy factor is Natura 2000. This is a network of natural areas, and strict regulations aim to ensure the survival of threatened species and habitats. According to all interviewees, Natura 2000 is a positive factor for ecology protection in general. But, Natura 2000 regulations aim for conservation of a specific ecological status, which can have a negative impact on implementation of e-flows. When taking e-flows action to increase the ecological value of a river system, the status-quo is changed and a more dynamic status is created. Some species might not be suitable for this new situation, so e-flows action might result in violation of Natura 2000 conservation goals. Four interviewees have experienced difficulties with this. An interviewee described it as *"a natural system is flexible by definition. If you frame everything in strict policies, you make it harder for yourself"*.

A distinction in managerial administration is made by interviewees between sectoral and integral administration. The choice between these methods in assigning and executing projects has a large effect on implementation of e-flows. Rijkswaterstaat interviewees agree that when assignments are sectoral, it is very difficult to solve assignment in an integral way. This means that responsibility for integral execution not only lies with executors, but also with the assigning party. Furthermore, it becomes easier to apply the integral system approach described above when the assignment is also integral. The PAGW projects are a good example of the positive effect of integral assignments and execution. As described in section 4.1, it is set up by two separate ministries. These ministries both have different goals and targets which are incorporated in the assignments for PAGW projects. Three interviewees experience both challenges and opportunities with this type of administration. It is described as *"the content of projects becomes more difficult because interests differ"*, *"the two ministries do not always speak the same language"* and *"it clashes sometimes"*, but also *"the result is ultimately better"* and *"it makes sure we make progress due to diversity".* In efforts to increase the chance of reaching PAGW goals, interviewees discussed creating a connection between PAGW and the Integraal Rivier Management (IRM) initiative.[6]

IRM is initiated by the Ministry of Infrastructure and Water Management, to stimulate shipping in policy. In IRM, the main goal is improving sediment management and discharge capacity. To achieve these goals, integral analyses of the river system are conducted. From these integral analyses, the 'Beeld op de Rivieren' report has been created.[7] This reports includes ideal scenarios for the river system, including goals and dilemmas.

[6]Translates to Integral River Management
[7]Translates to 'View on the Rivers'

To make a decision on which programs and projects will surface from this report, several integral alternatives are weighed in the 'Nota Kansrijke Alternatieven'.[8] According to two interviewees, it is important for e-flow implementation to include ecological goals in this note, which has partly succeeded. Ecological key factors from PAGW are considered in the weighing of alternatives in sedimentation management.

When discussing the influence of government on the implementation of e-flows, finance is mentioned by all interviewees. In large projects, the largest financial resources are provided by ministries and smaller contributions are done by water boards, provinces or local stakeholders. All interviewees experience difficult financial constructions when projects are commissioned by multiple ministries and financed by multiple parties. Different parties have different goals, conditions and budgets, but the project as a whole must be executed. Four Rijkswaterstaat interviewees agree that financial resources are not a typical barrier for ecological action when considering the current objectives. But, all interviewees agree that if e-flows implementation and the role of ecology in general must be increased, more financial resources are necessary. The greatest costs for e-flows implementation, both on a national and local scale, are made by acquiring the land required. Due to intensive agricultural land use in the Netherlands, land must often be acquired from farmers. This means that land use not only has an effect on legitimacy, but also on financial possibilities of e-flows action. Picking a location for a secondary channel to increase water quality was provided as an example by an interviewee. In this process, the flow characteristics were not used to pick the most effective location, but rather the costs of acquiring the required land area.

4.2.4 Management

In the implementation of e-flows, operational management is considered a key factor by interviewees. Several aspects of management were discussed, including the positive effect of a system approach. If you analyse different specific targets on sedimentation and ecology separate and purely technical, combining may not be obvious. But if you analyse the system as a whole, common solutions may appear that satisfy both targets. This approach ask for broad analysis and knowledge of multiple facets of the system.

Interviewees describe an other management strategy to combine different targets or goals as "meekoppelen".[9] In this strategy, goals with low justification are linked up with other stated goals with high justification. In attempting this connection, goals with lower justification are still (partly) reached. Interviewees suggest opportunities for e-flows implementation when e-flows goals are linked up with water safety and recreational goals. But, a possible challenge also surfaces when multiple goals are 'stacked' in a project. A good example of this is the Doorbraak redevelopment project in the east of the Netherlands, which is a constructed naturally arranged artificial stream. An interviewee discussed difficulties in this project due to multiple goals for the project, goals that also changed over time. The project was started more than 20 years ago to prevent flooding in Almelo and to separate rural, clean rain water and urban effluent. Over time, ecological and recreational goals were added to the project. Furthermore, the quality of urban effluent increased due to purification technology achievements. This changes in goals, together with difficulties in land acquiring, resulted in delays in the project. Because the water quality is not distinctive from both sources anymore, the goals were not water quality related anymore. In the end phase, the recreational and ecological quality of the Doorbraak itself were the main goals, resulting in a water allocation challenge, which is an e-flows challenge. This shows that possibilities for e-flows implementation can be created by linking up e-flows targets to other targets, but it can also create difficulties in the form of delays.

A way to apply the integral system approach while navigating sectoral government administration is described by interviewees as the 'bottom-up' management approach. In the words of an interviewee, this approach *"forces integral solutions for sectoral assignments on a local level"*. In this approach, local steering committees are employed and have the responsibility to analyse the whole system in a specific area and come up with integral solutions. The exact composition of these committees is dependent on the type of project and environment and will consist of project managers, local collaborators and stakeholders. When all parties work together in a committee, all functions, goals and targets will be discussed and weighed to find the best alternative for the region as a whole. For this management approach to work properly, an interviewee explained that several conditions must be met. First of all, targets and goals of the assignment must be general and not to detailed. This helps the committee to successfully combine several targets. Furthermore, steering committees must be able to combine all different sources of finance, after which the entire budget can be used to implement the

[8] Translates to 'Note on Promising Alternatives'
[9] Dutch management term which translates to 'link up'

best alternative for the region. This helps the committee to navigate the sometimes difficult financial structures. Furthermore, Dutch government bodies traditionally have a tendency of serving all different interests as much as possible in a compromise (polder model), but all interviewees agree that this mindset does not always have a positive impact on the process when difficult decisions have to be made. As an interviewee remarked, *"as a water board, we are aware that we can no longer serve all stakeholders and function fully with current water management"*. This means that strong project management leadership is required in the steering committee to ensure proper collaboration without falling into the polder model. When these conditions are met, steering committees (bottom) will be able to formulate an integral solution, which can be approved by different commissioners (up). Three interviewees describe the positive impact of enthusiastic project managers when applying this management approach. The more passionate and persuasive these project managers are, the better the bottom-up approach works which increases the quality of the project.

In order to be able to apply an integral, systemic, bottom-up management approach, stakeholder management is very important according to interviewees. Collaboration with stakeholders not only raises support as described in section 4.2.2, but is also important in the management process. For this aspect, differences can be found between Rijkswaterstaat projects and water board projects. For Rijkswaterstaat projects, the project management process is specified in the Meerjarenprogramma Infrastuctuur, Ruimte en Transport (MIRT) guidelines.[10] The MIRT provides clear guidelines, which two interviewees describe as *"helpful in moving projects forward"* and *"ensures that enough input and participation of stakeholders is reached"*. At water boards, all interviewees state that stakeholder management is more dependent on the type of project and location and no one-and-done approach is applicable. This means that more responsibility and local expertise is required from project managers in a water board.

To cope with the dynamic nature of a water system, adaptive management is recommended by seven interviewees. By implementing e-flows, a system will become more dynamic and the uncertainties of climate change further increase the importance of adaptive management. According to the interviewees, recent efforts have been made to make management more adaptive. These efforts include pilot projects and *"lessons learned sessions"*. Interviewees agree on the importance of evaluating collaboration and management structures, effects of redevelopment measures and *"implementing by learning"*. In order for this to work, monitoring and documentation is important. As one interviewee put it, *"Implementing measures in small steps with constant evaluation is a key factor for success"*. Several interviewees state that even though efforts of adaptive management have been made, improvements will have to be made on monitoring and documentation.

4.2.5 Successful implementation

All interviewees agree on the difficulty of quantifying the success of e-flows implementation. First of all, monitoring and measuring ecological values can be time-consuming and expensive. All interviewees agree that water management organisations do not have enough capacity, both in finance and personnel, to structurally measure and monitor effects of e-flows actions. Furthermore, most e-flows actions have long-term effects, which means that it can take a very long time before success can be defined. Interviewees also raise the distinction between outcome or output. The outcome of measures is the ecological response, which frequently has as a high degree of uncertainty. The output is the actual measures itself, which means output goals are effort goals. In the Netherlands, actions related to the WFD have outcome goals concerning ecological status. These actions are considered successful when the WFD goals are met. Programs based on an ecological ambition like the PAGW often have output goals, which means that a project is considered a success when it is realised. When discussing successful implementation, six interviewees questioned the ability of Dutch water management to decrease some control over the water system by restoring a more natural dynamic. Since water safety has historically been the greatest challenge, water management in the Netherlands has tried to gain as much control over the water system as possible. Organisations and managers are hesitant to consider decreasing control over the water system as successful action. Furthermore, agricultural water use depends on steady water flow. As one interviewee put it, *"to reach ecological goals, we redevelop creeks. But the farmers want a system which is controllable"*. According to two interviewees, the difficulty of quantifying success is not necessary a barrier for e-flows implementation, as long as the ambition for reaching ecological goals is high enough. One interviewee even stated that defining success beforehand can *"kill innovation"*. It is only a disadvantage when other actions get prioritised over e-flows actions due easier quantifying in terms of success.

[10] Translates to Multi-annual program Infrastructure, Spacial planning and Transportation

4.3 Challenges

In this section and the following section, results of the interviews described in the previous section will be categorised as challenges and opportunities for e-flows implementation in Dutch water management.

Politics

Implementation of e-flows is a political choice and politics dynamics are difficult to navigate. A large agricultural lobby in national and local politics reduces ecological ambitions in politics due to the often opposing preference of water system behaviour. Rigid directives and policies like conservation policy in Natura 20000 provide challenges for creating a modified, more dynamic water system. Focusing on the WFD when implementing e-flows often results in focus on water quality, which can be a challenge if action is necessary for an entire aquatic ecosystem.

Land availability

Intensive (agricultural) land use in the entire country of the Netherlands leads to very small available room, needed to reach e-flows targets. It is very expensive and often very time-consuming to acquire more land area.

Trade-offs

A high pressure on water bodies following a multitude of functions results in difficult trade-offs, in which ecological value and benefits are difficult to define. Because historically, priority has always been on shipping, flood safety and agriculture and benefits and value of these functions are easier to define, the voice of ecology is small in the trade-off conversation. Trade-off in rivers is often based on Rivierkundig kader, which is not based on socially-valued benefits and in which very little flexibility is present. Furthermore, the Dutch culture of 'polderen', in which participation of stakeholders is very high, often results in a compromise and a long process. Stacking of goals or changing goals over time increases this challenge of project duration. These challenges are present in water resources management in general, but this is especially challenging for ecological action due to the increasingly high pressure on aquatic ecology. Furthermore, restoring more natural dynamic flow conditions is considered giving up control. This goes against the culture of fighting against the water to ensure flood safety by ever increasing control over water flow. Also, more flow variability is often opposed by the agriculture and shipping sectors, who prefer steady conditions of depth and irrigation. Uncertainties of ecological responses to measures further make trade-offs challenging. Defining and reaching successful ecological action and measures is difficult due to uncertain, long term ecological responses and a lack of monitoring capacity. This makes justifying e-flows implementation action challenging, especially in a trade-off situation with other water system functions.

Natural flow

It is very challenging to use natural flow as a guide to reach ecological goals, because since a very long time, the majority of the water system in the Netherlands is heavily modified to increase shipping possibilities and ensure flood safety. These functions require river dimensions and characteristics for quick water discharge with low variability and canals as straight as possible. These characteristics run counter to characteristics necessary for aquatic ecology. Furthermore, few natural reference sites are present in the Netherlands.

Sectoral administration

Administration on a national level is often sectoral and hierarchical, which makes finding integral solutions and bottom-up management challenging. In current water management in the Netherlands, e-flows implementation actions have a higher rate of success when an integral solution is attempted for the whole system including ecology instead of solutions for all different sectoral assignments, conditions and goals. These types of solution have the highest quality when an adaptive bottom-up management approach is used. Hierarchical administration and sectoral assignments and financial structure make the possibilities for project scale steering committees with mandate to take adaptive action small, which makes adaptive bottom-up management challenging. Waterboards have historically been mainly in charge of ensuring flood safety, water quality and agricultural water use. It takes time before the integration of other ambitions including ecology and climate adaptation into the fibre of the organisations is completed.

4.4 Opportunities

System approach

Because the priority and role of aquatic ecology is low compared to other functions in a trade-off, a system approach can provide opportunities for e-flows implementation. Instead of specific function problem solving, the entire water system is analysed and integral solutions benefiting the system as a whole can be found. In weighing different functions and benefits, opportunities lie with the creation of objective tools. These tools can be used to find alternatives to reach goals based on social benefits while monitoring economic safety. Until these tools are available, opportunities for reaching e-flows targets rise when linked up with other targets with higher justification. This might not result in the highest possible ecological impact, but it can make sure some action is taken.

Adaptive integral management

Even though challenges are great in implementing adaptive and integral management in government and projects, opportunities are present. The use of small-scale pilots and corresponding lessons learned can create an opportunity for experimentation, monitoring and adapting without a lot of risks. What is learned from pilots can then be used in larger projects with larger impact. Furthermore, opportunities for integral solutions rise when collaboration is increased in the creation of assignments and conditions of action. The joint ministerial program of PAGW and IRM are examples collaboration efforts which are promising. In addition to this, a bottom up management approach makes the opportunities of a system approach and adaptive integral management larger when a local steering committee with enough mandate and participation is used.

Raising justification and support

Using targets of the Water Framework Directive, the public debate on climate change, the Dutch nitrogen crisis, the occurrence of drought and flooding events creates justification for aquatic ecological action. Because reconsideration about the current state of water management rises and a change in mindset from fast discharge to water retention, opportunities rise for e-flows implementation action. Furthermore, extensive stakeholder management and participation like the MIRT process increases support and helps project management processes.

Selling a story

In order to raise support for e-flows implementation and increasing opportunities, a cohesive set of definitions, goals and methods can be used. At the moment, multiple different aquatic ecological efforts are taken, but due to different labels in policy and action, no solid e-flows 'story' is present. Generalizing e-flows actions under a coherent narrative helps create support, understanding, enthusiasm and ambition. In this narrative, other aspects and solutions can be included like circular agriculture, providing tools to increase water use efficiency and the impact on shipping and flood safety.

Chapter 5
Discussion

In this chapter, a discussion on the results and research is presented. First, the implications of the results for Dutch water management will be discussed, including answering the third research sub-question by presenting recommendations to increase e-flows implementation action. Thereafter, a discussion on the results in relation to the concept of environmental flows is presented. Furthermore, limitations of the research and a reflection on the research are stated.

5.1 Dutch water management

The results clearly present implementation of environmental flows in Dutch water management as a political choice through priorities in policy and performing trade-offs. Political feasibility for e-flows implementation action and (aquatic) ecology in general has not been a main focus of this research, but some insights are given. According to interviewees, the sense of responsibility in water management organisations for ecology has only recently emerged, which is in conflict with the increasing environmental role in water management since the 70's described in section 2.2.1. This might indicate a decrease of the role of ecology between the 70's and past years. It could also be a result of the personal experiences from interviewees or a recently increased general ecological ambition.

Similarities can be found between the Dutch water management culture described in section 2.2.1 and the results. Priorities are largely on shipping and flood protection, sectoral spreading of resources and powers over multiple different administrative bodies, criticism of strict EU policies WFD and Natura 2000 and the use of the polder model. In the results, avoiding conflict between stakeholders and reaching a compromise in a long process without making hard decisions is considered a challenge for e-flows implementation. But on the other hand, reaching consensus on an integrated solution with participation of stakeholders is considered as a positive influence on e-flows implementation.

In several arguments raised in the results, a situation of "can't or won't" by Dutch water management organisation rises. This is most present in the arguments about policies being are too strict, a lack of monitoring capacity, uncertainties of ecological responses to action and determining socio-economic value of nature. By interviewing executive employees of water management organisations instead of top policy makers, the experience of "can't" can be explained. Policies, monitoring capacity and uncertainties are also a part of for example flood control management, but it does not stop action in that sector. Furthermore, when evident ecological problems rise, like in the Grevelingenmeer and in times of drought, action can be taken. Technological challenges in modelling, monitoring and redevelopment are not raised often, so when political ambition is raised many challenges should be manageable. This also includes the challenge of land availability. As described in section 2.2.1, the nitrogen crisis, climate change in general and EU policy can help increase political discussion and ambition.

Even though the majority of interview data from both Rijkswaterstaat (national level) and water boards (local level) can be generalised, some difference can be noted. First of all, the amount of functions in a water system and the pressure of land and water use was lower in the water boards than in Rijkswaterstaat. Furthermore, due to a more direct connection with the agricultural sector in project execution, stakeholder management and local politics, the role of agricultural land use and water use is larger in water boards. Also, some cultural differences in organisation appeared. Water boards are in the middle of a transition from managing surface water quality and quantity mostly for safety and agriculture to managing climate robustness and drought, which has influence on the workings of a water board. At Rijkswaterstaat, the scale of policy and projects is larger, with larger stakes and and pressures, which makes decision making and action more difficult. Even though these differences exist, the presented challenges and opportunities are applicable to both water boards and Rijkswaterstaat.

5.1.1 Recommendations e-flows implementation

As stated in chapter 1, e-flows can be an important guide for water management towards social-ecological resilience in the future, mitigating growing pressures on water resources and freshwater ecosystems. To achieve additional implementation of e-flows in Dutch water management, the presented challenges must be navigated by using the opportunities.

The first recommendation is creating a coherent narrative around e-flows. Ecologists and water managers of Ministries, Rijkswaterstaat and water boards should set up a team to create an e-flows policy and action umbrella narrative. Under this narrative, it should be clear how e-flows are necessary to meet ecological goals, what the benefits of e-flows implementation are and what the implications for other water uses and the water system are, like irrigation security, flood safety and shipping depths. It should be transparent and cover the argumentation, including the way e-flows assessment can take place even without natural flow as a clear guide. Goals for freshwater ecosystems and success criteria for e-flows implementation action, which are now spread out over the WFD, Natura2000 and other policies in different sectors and administration bodies, can all be put under this single umbrella narrative. This will help increase support, awareness and ambition in all levels of Dutch water management.

Furthermore, ecologists and managers in water management should use the nitrogen crisis and the effects of climate change to increase discussion on land use, water use and current lay-out of the water system. The largest challenge in the Netherlands is to find room for e-flows implementation, and the largest opportunities rise when more land will become available. But, this will require political justification and support, which can be increased by using evident problems as points of discussion.

The third recommendation is to develop of better trade-off tools, which can be done by the Integral River Management platform. Trade-offs of costs and benefits for water system uses should not be made between the different uses, but with goals for the system as a whole as a basis. These goals should be based on an ethical combination of socially-valued benefits and economic benefits.

As a fourth recommendation, the Ministry of Infrastructure and Water Management, together with Rijkswaterstaat management, should facilitate change in government administration towards an integral, adaptive bottom-up management approach. This is not possible in one go, but by expanding on lessons-learned and success of integral examples of PAGW and IRM. Sharp decision making, adaptive capacity and leadership must become a part of management.

As long as political support and justification is not high enough for e-flows action, managers responsible for ecological targets should link up e-flows targets with other targets ("Meekoppelen") as much as possible. Exemplified by the efforts of PAGW managers to include environmental goals into integrated river alternatives, the high justification of flood safety and shipping can be used to at least get some level of ecological action taken.

5.2 Environmental flows concept

The term and definition of environmental flows did not show up in policy documents, which is a large part of the reason why it was unknown to most interviewees. Interviewees that were familiar with the term had heard the term outside of the context of Dutch water management, for example through international collaboration. Links with the concept of e-flows are present in Dutch water management, but in multiple different forms. The heavy link with EU policy targets and corresponding measures indicates low intrinsic ambition for aquatic ecology. Using the approach of using (historic) natural flow regime as a guide for e-flows assessment is considered impractical in the heavily modified water system in the Netherlands. This means that e-flows objectives in Dutch water management should be focused on maximizing the possibilities in the current conditions of policy and water system layout while trying to increase the role of ecology in future decision making, which makes the designer flow approach described in section 2.1.4.1 much more practical. This approach should include groundwater measures, because the links between surface water, aquatic ecology and groundwater tables are strong in the Netherlands.

When focusing on e-flows implementation action, several points of discussion can be risen. First of all, the system approach opportunity in Dutch water management strengthens the broader recognition described in section 2.1.4 of viewing aquatic ecology as a component of the water system instead of a consumer of water. In this system approach, trade-offs provide large challenges, which is a challenge already acknowledged in literature. Creating objective trade-off tools is suggested as an opportunity for e-flows in this trade-off, but the feasibility of creating such tools is questionable. Trade-offs in water management will always be a political decision both on national and local scale and stakeholders will have different views and interest. Furthermore, it is questionable whether alternatives can be weighed be based on socially valued benefits and ethical values on top of economical and safety benefits.

Both literature and the results from data analysis agree on the critical need for adaptive management when implementing e-flows. This research shows further opportunities when it is combined with a bottom up approach in which integral solutions can be provided. Collaborative use of steering groups has shown to facilitate this bottom up approach, but the current hierarchical organisations makes getting enough mandate to reach full potential of a bottom-up approach difficult. Major differences in management culture will be needed before a full integral bottom up management approach will be possible. Furthermore, the need for monitoring and difficulty of proper monitoring capacity in literature to facilitate adaptive management is strengthened by challenges, especially financially, in Dutch water management.

A major change in culture will also be necessary in government regime and administration. As described in section 2.1.4, an integrated adaptive regime and administration instead of sectoral prediction-and-control increases opportunities for e-flows implementation. Current government water management culture in the Netherlands is presented as sectoral and hierarchical with a preference of control and priority on agriculture, shipping and flood safety. This makes the challenge of changing the culture large, but the opportunities are equally large. Efforts like PAGW have shown both the difficulties and positive impact of a more integrated adaptive approach, which can be used as an example to evoke change.

According to literature, challenges in raising justification and support for e-flows are specific for each situation and implementation action. The results of this research substantiates this claim as it is mentioned often as a major challenge with different specific challenges in each example. Yet, some general elements are present in all results which can be applicable to e-flows implementation in general. First of all, increasing stakeholder engagement and participation helps raising support, which is also broadly acknowledged in literature. But, results show that it can increase the duration of projects significantly, which must be taken into account. Justification for action is low due to low priority on ecological goals, especially when no apparent problematic events occur. But, e-flows implementation action justification will continue to rise with larger visible impact of climate change and corresponding problems like extreme weather events and droughts. System adaptation to climate change can provide opportunities for a larger role of e-flows.

A lack of room as a large challenge for e-flows implementation is not encountered before in studies. Due to the situation described in section 2.2, very little land area is available which is needed to restore aquatic ecology due to intensive land use and a unique cultural relation with water and land. In the USA, Australia and South-Africa, countries with the highest e-flows implementation rate, land use is much less intensive and water system modifications are more guided by the construction of (hydro-power) dams and large scale irrigation water use instead of shipping and flood control. It is likely the reason why dam flow regulation and water allocation receives much attention in e-flows literature instead of land availability.

In general, many similarities are present between key factors of e-flows implementation in Dutch water management and literature. These similarities mostly involve water management in general and the role of ecology in it, like the need for adaptive management, integral solutions and difficulties in measuring success. When using the definition of “the quantity, timing, and quality of freshwater-flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being", opportunities for implementing e-flows as a concept should be present in Dutch water management. But, rather than using (historic) natural flow dynamics as a guide, challenges specific of Dutch water management call for applying specific designer flows.

5.3 Limitations

In the execution of this thesis research, several limitations are present. Because data collection has been done through interviews, interview bias can have an influence on the results. Despite efforts taken to minimise influence of bias by using an interview guide in a semi-structured setting, direction of questions influences data and results. Furthermore, the choice to interview mostly government water management experts has implications for the results. It is the most valuable source of information, because inner workings of Dutch water management are quite important for implementation of e-flows, but it can possibly yield one-sided results. One interview with a nature conservation group employee did provide a different and valuable view on the workings of government. Even though saturation of data has been shown, more interviews with water managers in different parts of government and experts from the agriculture, shipping and nature conservation sectors would increase diversity of data and increase the generalisability. Interviews with political experts would yield more information on the political feasibility of embracing e-flows implementation as a tool to achieve ecological objectives.

Subjectivity of the analyst can have influence on qualitative data analysis. Narrative of interview reports were checked with interviewees, but coding was executed through interpretation. Monitoring of codes and using codes as consistently as possible minimise the influence of interpretation on the results. Subjectivity of qualitative data analysis also has a negative effect on replicability of the research.

Furthermore, recommendations for further e-flows implementation are not extensively validated with Dutch water management experts. The presented recommendations follow the results and the discussion, but other researchers might provide different recommendations.

Lastly, the exclusion of trans-boundary water basin management in the focus of this research provides a limitation. Quantity and quality of water flowing into the Netherlands is influenced by water management in surrounding upstream countries, which means the implementation of e-flows in Dutch water management is influenced by trans-boundary conditions.

5.4 Reflection

The goal of this research was to identify the possibilities of implementation of e-flows in Dutch water management, aiming to increase understanding and implementation of environmental flows by investigating mechanisms for integrating e-flows implementation in broader water resource management systems and identifying obstacles to implementation of e-flows in different world settings. Considering the research limitations and time constraints, this goal has largely been achieved by identifying the key factors, challenges and opportunities in Dutch water management. Hopefully, this achievement does indeed increase understanding of e-flows, can be used to accelerate e-flows implementation and will the decision to contribute to scientific knowledge on practical implementation in policy and practise instead of e-flows assessment motivate others to identify implementation possibilities in other world settings to help the concept further.

Chapter 6

Conclusions and recommendations

In this chapter, the main research question will be answered by providing challenges and opportunities for implementation of e-flows in Dutch water management.

6.1 Main conclusion

The main research question is *"What are the challenges and opportunities of implementing environmental flows in Dutch water management?"*. Through this research, several challenges are identified, answering the first part of the question. These challenges consist of a lack of a natural flow guide and land availability, a difficult trade-off between functions and benefits in an intensively used water system, low political feasibility and sectoral government administration. Opportunities are described to navigate these challenges and recommendations for further implementation of e-flows in Dutch water management are given in this research. These include creating a coherent e-flows narrative, developing better trade-off tools, change in administration, increasing discussion on land use, water use and lay-out of the water system and linking up environmental targets with other targets like flood safety or shipping.

6.2 Recommendations for further research

The first recommendation for future research is to research e-flows assessment in the Netherlands using the designer flow paradigm. In order to be able to create a coherent e-flows narrative in the Netherlands, a general method of e-flows assessment will be very useful.

Furthermore, the political feasibility of aquatic ecological restoration challenges can be researched further. In order to navigate the political climate of water management, it would be very interesting to know more about the decision making in national government, local government and water management organisation top management. The effects and possibilities of trans-boundary basin cooperation can also be investigated.

A further recommendation is to establish methods to implement an integral, adaptive bottom-up management approach in Dutch water management. Designing trade-off tools for a water system and devising smarter monitoring systems could also contribute to e-flows implementation.

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Appendix A
Interview guide

Table A.1: Interview guide

Category	Questions/Content	Goal
Introduction	Personal introduction interviewer	Introducing to research
	Informed consent and start recording	
	Research introduction	
E-flow definition	What do you understand as e-flows?	Create common ground
	Validation definition interviewer	
E-flow relation	What is the relation between e-flows and your work?	Understanding the expertise of interviewee
	What projects/plans are you familiar with that relate to e-flows?	
Goals/reasons	What are the reasons/goals behind the projects/plans?	Identifying motivation
	How high is the priority on ecological goals?	
Policy	What are the main policy drivers?	Identifying important policies
	(How) did the WFD influence?	
Methods	What specific actions were taken to reach the goals?	Characterizing actions
Factors	What are the main enabling factors?	Identifying challenges
	What are the main disabling factors?	
Future	(How) can the disabling factors/barriers be lifted?	Identifying opportunities
	Anything else	
Closing	Summary	
	Thanks	

Table A.2: Interview protocol (NL)

Categorie	Vragen/Inhoud	Doel
Introductie	Persoonlijke introductie interviewer	Introductie van onderzoek
	Officiele toestemming en start opname	
	Introduceren	
E-flow definitie	Wat verstaat u onder e-flows?	Gemeenschappelijke grond vinden
	Validatie definitie interviewer	
E-flow relatie	Wat is de relatie van e-flows met uw werk(zaamheden)?	Begrijpen van de expertise interviewee
	Welke projecten/plannen kent u die overlap hebben met e-flows?	
Doelen/redenen	Wat zijn de doelen of redenen achter deze projecten/plannen?	Identificeren motivatie
	Hoe hoog is de prioriteit van ecologische doelstellingen?	
Beleid	Wat zijn de bepalende wetten of beleidsplannen?	Identificeren belangrijke wetten en plannen
	Wat is de invloed van de KRW?	
Methodes	Welke specifieke acties zijn ondernomen om de doelen te halen?	Categoriseren van methodes
Factoren	Wat zijn belangrijke faciliterende factoren?	Identificeren uitdagingen
	Wat zijn belangrijke storende factoren?	
Toekomst	(Hoe) kunnen de storende factoren/barrieres opgelost worden?	Identificeren kansen
	Wvttk	
Afsluiten	Samenvatting	
	Dank	

Appendix B
Data analysis

Table B.1: Code occurrence in interviews

Code	Occurrence
WFD	29
Function trade-off	26
Agricultural land use	24
Legitimacy	24
Drought	20
Finance	15
Climate change	15
Natura 2000	15
Monitoring	14
Land acquiring	14
System approach	11
Stakeholder management	10
Sell the story	10
Change in mindset	10
Strict agreements	9
Compromise/polder model	9
Collaboration	9
Link up goals	9
Agricultural lobby	8
Designer flow	5

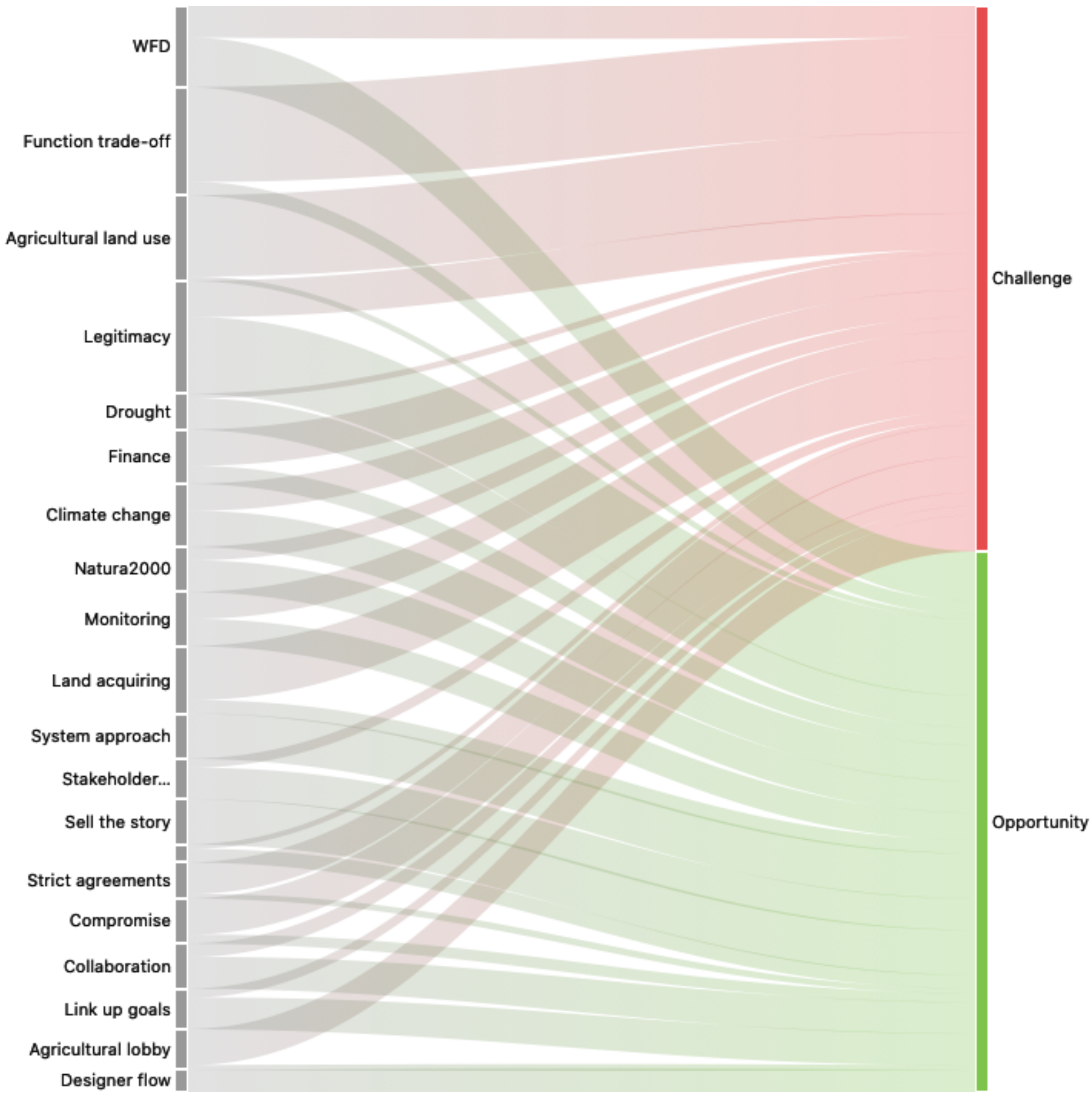

Figure B.1: Sankey figure representing challenges and opportunities of codes, ranked based on number of mentions

Table B.2: Co-occurrence WFD and N2000 in interviews

Code	WFD	Natura 2000
Strict agreements	5	5
Water quality	5	1
Legitimacy	4	0
Climate robustness	4	0
PAGW	3	0
Priorities	3	0
Climate change	2	1
Monitoring	2	0
Link up goals	1	1
Minimal effort	1	1
Land acquiring	0	1
Success based on outcome	1	0

Table B.3: Co-occurrence legitimacy in interviews

Code	Legitimacy
Climate change	8
WFD	4
Drought	4
Nitrogen crisis	4
Sell the story	2