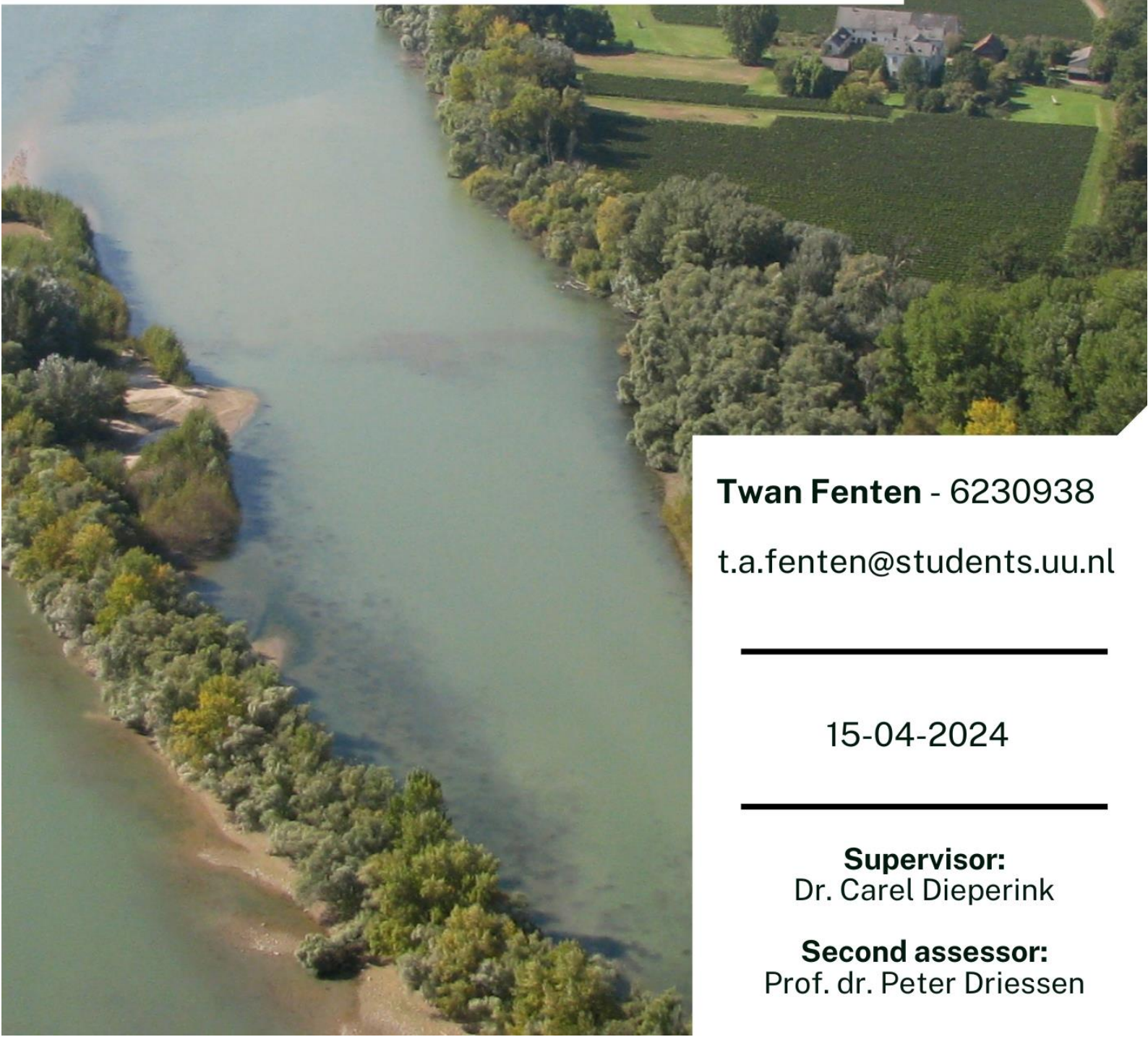


GOVERNANCE CONDITIONS FOR A SUCCESSFUL RESTORATION OF RIVERINE ECOSYSTEMS

LESSONS LEARNED FROM THE RHINE RIVER BASIN



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Landschap

'Die twee koeien staan helemaal alleen',
zei hij en een reiger-solist bleef kijken.
We reden samen kalm over de dijk en
zagen neer op de rivier waarop geen
mens te zien was. Gelukkig. De zon scheen
wel maar was geen oven. Geen vissenlijken
in een zuurstofarme poel. Zelfs niet één
dode eend met kraai om voor uit te wijken.

'Zo zou de nieuw aarde moeten zijn',
dacht ik hardop en mijn kleinzoon vertrok
geen spier onder zijn witte schipperspet.

Door de schutsluis – voor hem hemels terrein –
vroeg hij niet om noga, voor elk een brok.
Hij wist: je houdt je stil bij een gebed.

Lenze L. Bouwers

Colophon

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Front page: Pehlemann (2008)

Poem: Bouwers (2003)

Abstract

This research focuses on analysing the governance conditions for successful restoration of riverine ecosystems. To derive these conditions, firstly a scientific literature assessment is conducted to compile relevant governance conditions for ecosystem restoration into an analytical framework. This framework is then tested and refined by conducting a critical case study on the ecosystem restoration process of the Rhine River to bring back the Atlantic salmon, as coordinated by the International Commission for the Protection of the Rhine (ICPR). The case study on the ICPR governance structure is used to assess the presence or absence of governance conditions to facilitate successful ecosystem restoration of the Rhine. This case study is conducted by researching ICPR policy documents, scientific literature and by conducting expert interviews.

Despite ecosystem restoration efforts in the Rhine to reintroduce Atlantic salmon, a self-sustaining population has not yet been achieved. This indicates the need for improvement in restoration measures and suggests potential gaps in the presence of governance conditions. The analysis of the governance structure of the ICPR reveals strengths and weaknesses to facilitating ecosystem restoration. 14 out of 24 governance conditions are present in the governance structure of the ICPR and should advisable be retained to facilitate the process of ecosystem restoration of the Rhine. As 10 governance conditions are not or partially present, challenges persist, including slow decision-making, ambiguity in responsibilities within national politics and limited financial incentives. The ICPR's soft-law approach relies on public and political pressure for enforcement, lacking stringent measures. Financially, there's minimal support from riparian states, despite long-term economic benefits in avoided costs, which are harder to communicate and thus currently seldomly included in political or financial consideration. Policy recommendations are made, but transferring interdisciplinary insights to compartmentalized national politics is challenging. Additionally, the ICPR could benefit from involving political science experts or experienced individuals with a political background.

The drafted general framework for assessing governance conditions for ecosystem restoration structurally provided valuable insights into the governance structure, emphasizing the crucial role of governance in restoration efforts and the need to comprehend the interplay between governance structures and their focal areas. The framework was found to be applicable to riverine ecosystem restoration, as demonstrated by the Rhine case study. Based on the case study, an adjusted framework was presented, refining the initial draft with insights from the Rhine case study, which can be utilized for follow-up research on various case studies.

Key concepts: *Ecosystem restoration; Atlantic Salmon; Rhine; ICPR; Governance; Riverine*

Preface

This report is the result of my graduation research for the MSc Sustainable Development at Utrecht University. I take great pride in the work presented in this thesis, and I hope that everyone who reads it finds both enjoyment and value in its contents.

First of all, I would like to express my deepest gratitude to my supervisor, Dr. Carel Dieperink, for his invaluable guidance, unwavering support and insightful feedback throughout the entirety of this thesis. His expertise and encouragement have been instrumental in shaping my research and have guaranteed that I consistently found fulfillment in conducting this study.

I am also profoundly thankful to all the respondents who generously participated in the interviews for this study. Your willingness to share your experiences and perspectives has significantly enriched this research.

I extend my heartfelt appreciation to my family, my girlfriend and my friends for their unwavering encouragement, understanding and patience throughout this journey. Your support has been my rock and I am very grateful for your belief in me.

I'd like to thank Prof. Dr. Peter Driessen for taking the time to review both my proposal and Master's thesis as the second assessor, providing me with valued professional feedback.

I am indebted to the beauty and inspiration of nature. My passion for understanding and preserving the natural world has been a driving force behind this research and I am grateful for the opportunity to explore this passion within the context of my academic pursuits.

This thesis would not have been possible without the contributions and support of each and every one of you. Thank you from the bottom of my heart.

Twan Fenten

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1. Introduction

1.1. The necessity of ecosystem restoration

One of the largest challenges that humankind is facing is climate change. The stability of the Holocene that has enabled us to create our contemporary societies has been disrupted (Mayewski et al., 2004). At risk are coastal areas, vital ecosystems, our personal health and much more (IPCC, 2018). The Anthropocene has been inaugurated, as we as humans have become the main driver of climate change. Increasing greenhouse gas concentrations cause rising global temperatures, more extreme weather situations and an increased intensity and frequency of droughts, along with numerous other consequences (IPCC, 2018). Alongside global warming, increased land and sea use, pollution and the invasion of non-native species all threaten biodiversity on a global scale (IPBES, 2019). As a result, biodiversity loss is at an all-time high; If no fundamental steps are undertaken, the earth is heading off to the uninhabitable, as the climatically determined geographic range of both humans and other species diminishes. Climate change, diminishing ecosystems and biodiversity loss: these global transformations and their impact on our societies are putting pressure on governmental bodies to adapt to the changing world, while simultaneously mitigating the environmental impact of our societies. As approaches and potential solutions are countless, this research focusses on the implementation of one of them: ecosystem restoration.

Throughout the history of nature conservation, the concept of ecosystem restoration has known many definitions and implementations (Martin, 2017). This research adopts the definition as proposed by the International Union for Conservation of Nature (IUCN, n.d.), summarized by Lovat (2023) as: *"(...) the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed to reflect its intrinsic values and to provide goods and services that people value."* (Lovat, 2023). In this research, focus is put on riverine ecosystem restoration, thus sticking to a fluvial scale.

While for some riverine ecosystem restoration efforts have a more normative and ethical value, this conservation approach can be used to fight consequences of global warming and halt biodiversity loss (Attenborough, 2020). If ecosystem degradation is put to a halt, for example by reducing pollution and improving water quality, biodiversity loss can be counteracted and the species-richness can be preserved or expanded by ensuring the longevity of the natural area (Helmer et al., 2015; Palmer et al., 2005). Reversely, the (re-)introduction of certain species can both restore the functioning of a riverine ecosystem and evidently has a direct impact on the population size of said species. Additionally, ecosystem restoration of rivers can increase the resilience of the river ecosystem to external shocks, such as extreme weather events and increased rainfall, both prone to appear more frequently due to global warming (Palmer et al., 2005; Huber & Gullede, 2011; IPCC, 2018). In a more direct sense, rivers can mitigate the impact of global warming by functioning as a carbon sink, capturing carbon from the atmosphere (Zhu et al., 2022). As a prerequisite, a healthy, free-flowing river is required to accommodate carbon sequestration, thus underlining the importance of riverine ecosystem preservation and restoration.

1.2. The complexity of riverine ecosystem restoration

While the significance of maintaining healthy river ecosystems may appear evident, the restoration process poses significant challenges. As these ecosystems cover a large and far-stretched area, they are characterized by complex hydrological dynamics, meaning that a riverine ecosystem is highly sensitive to seasonal variations and the altering of water and sediment flows (Jain & Singh, 2020; Tealdi, Camporeale & Ridolfi, 2011). As riverine ecosystems span great distances, they rely on the interconnectedness and wellbeing of vastly different habitats, each with their respective biodiversity and ecological processes (Jansson, Nilsson & Malmqvist, 2007). These habitats are under pressure of human activities and land-use change, as urbanization and agriculture have reduced the habitat size

of various riverine ecosystem species and caused widespread deforestation of riverbanks in the last decades (Junior et al., 2015). Additionally, the riverine ecosystems suffer from the impact of human activities, which cause water pollution and the disturbance of peace and natural processes, such as water flow and sediment dynamics (Junior et al., 2015; Patil et al., 2018). As previously mentioned, riverine ecosystems are also increasingly impacted by climate change, which causes disturbance to precipitation patterns and water temperature, thus adding to the existing stressors to riverine ecosystem resilience (Pletterbauer et al., 2018; Palmer et al., 2005; Huber & Gullledge, 2011). To account for the complex functioning of riverine ecosystems and the impact of climate change amidst anthropogenic influences, the process of environmental conservation and restoration requires a sound scientific understanding of ecosystem processes and its internal and external stressors. Riverine ecosystem restoration thus involves in-depth research and extensive monitoring, while simultaneously demanding significant societal adaptation to safeguard habitat health and biodiversity (Bal et al., 2018).

1.3. Governance of ecosystem restoration

Globally, various countries have acknowledged the benefits of riverine ecosystem restoration efforts. From 2015 to 2022, a total of 85 countries actively participated in activities under the United Nations Water Convention (United Nations, 2022). Although the process of ecosystem restoration is demonstrably beneficial to halt global warming and biodiversity loss, it inevitably comes with large challenges for policy-makers (Pettorelli et al., 2018). For restoration to be successful, it requires a sizeable geographical area to be fully in line with the conservational vision. In case of riverine ecosystem restoration, rivers can even flow through the territory of multiple riparian states, thus requiring sound international collaboration to coordinate and achieve unidirectional restoration efforts. The implementation of ecosystem restoration efforts in a certain area requires a holistic integration of the project within the interplay of communities and economies that actively impact the same ecosystem (Jepson et al., 2018). For a society, this often means that a community needs to adapt their habits or livelihoods, as the quality of the natural world is increasingly prioritized over their current exploitation of the river. Therefore, the implementation of an ecosystem restoration project needs to be coordinated, as it always take place in a societal context of varying norms, values and stakes. Through governance, the complex societal context is navigated by crafting compromise-based policies and measures. In this study, governance is defined as the “(...) *interaction between public and/or private entities ultimately aiming at the realization of collective goals.*” (Lange et al., 2013, p. 406). Consequently, the success of ecological restoration is not just dependent on the efforts undertaken by conservation and restoration organisations, but also on certain governance conditions that facilitate this process or whose absence hampers the effectiveness of the restoration process. In this study, governance conditions are defined as elements or activities that are required for a governance approach to successfully realize riverine ecosystem restoration (Wuijts et al., 2022). As successful ecosystem restoration can be facilitated by successful governance, and reversely, ineffective governance might hamper successful ecosystem restoration, this study underlines the importance of assessing ecosystem restoration from a governance perspective.

1.4. Knowledge gap

Ecosystem restoration has been the focus of a considerable amount of studies, approached from various perspectives to explore its benefits, diverse restoration methodologies, cost evaluation and financing mechanisms, alongside research on ecological processes and their importance (Martin & Lyons, 2018; Aronson et al., 2020; Bodin et al. 2022; Prach et al. 2001). Compared to terrestrial ecosystem restoration, restoring riverine ecosystems has only recently received more scientific attention, despite its ecological and societal significance (Palmer et al. 2014). Moreover, the

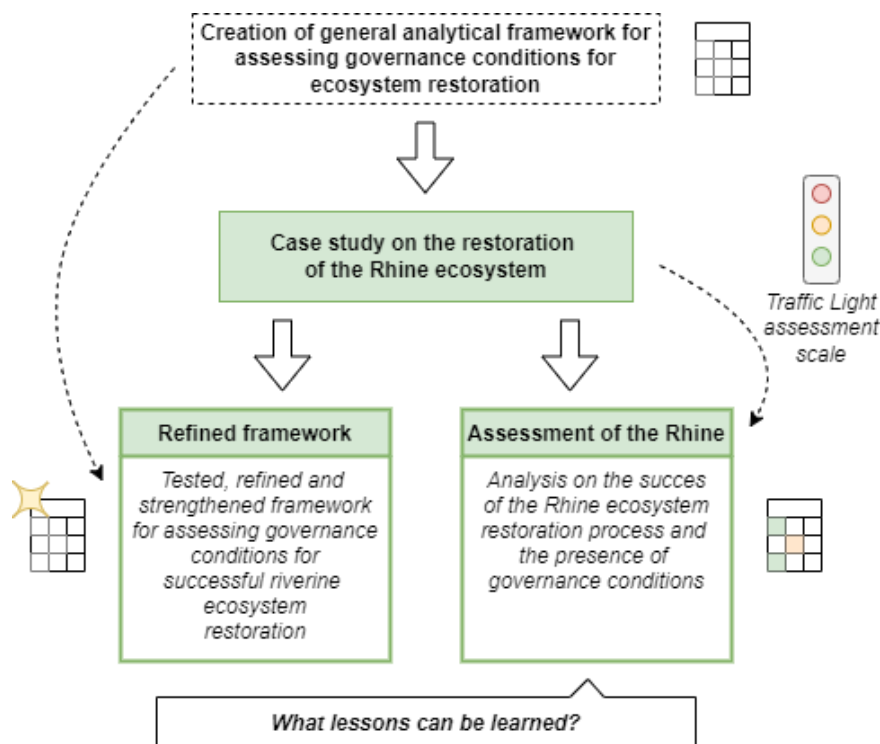
exploration of riverine ecosystem restoration through a governance lens is even more sparse, as only a few examples of descriptive studies were found, attempting to map out existing governance or management frameworks of complex ecological restoration projects (Cosens & Williams, 2012; Zingraff-Hamed et al., 2017; Adonis, 2021). The existing literature on the subject often confines itself to specific case studies that examine management approaches without providing a comprehensive and replicable framework for follow-up research or similar case studies. What is missing is a clear framework that is generally applicable to assess governance conditions for successful riverine ecosystem restoration. Additionally, there remains a significant gap in understanding how governance can influence the outcome of a restoration project. This gap in the literature highlights the need for establishing a universal framework for evaluating governance conditions in riverine ecosystem restoration projects. By addressing this gap, a better understanding is gained on the impact of governance on project success and a best practice governance structure can be identified for policy-makers as a guidance for future riverine ecosystem restoration efforts.

1.5. Research aim and questions

The aim of this research is to analyse the governance conditions for successful restoration of riverine ecosystems. This research seeks to identify key governance conditions that facilitate successful riverine ecosystem restoration projects, while simultaneously constructing a framework for this assessment that can be used in follow-up research. By doing so, it aims to expand the current knowledge on the relationship between governance and riverine ecosystem restoration projects, which in turn will help to increase the overall success of such projects. Figure 1 delineates the research structure that will be employed to realize the research aim.

Figure 1

Research structure of this report, visualizing how the analytical framework acts as a guideline for this research



To fathom governance conditions for successful riverine ecosystem restoration, firstly a literature review is conducted to explore studies on the governance of ecosystem restoration, deriving general governance conditions that have an impact on the success of ecosystem restoration. Secondly, a case study is conducted on the ecosystem restoration process of the Rhine river. By doing so, the applicability of the created framework to *riverine* ecosystem restoration is tested. By applying the created framework to this case study, the framework is refined and added to, as needed, in order to create a valid framework for assessing the governance conditions for successful riverine ecosystem restoration projects to be used in follow-up research. Through the conduction of the case study on the Rhine ecosystem restoration process, its current success is analysed, while simultaneously assessing the presence of governance conditions using the created framework. The presence of governance conditions is graded using a Traffic Light Assessment Scale, as visible in Figure 1. Ultimately, the framework can be used to explain the Rhine ecosystem restoration case study's current status by emphasising the governance conditions that facilitate the restoration process and, at the same time, highlighting the governance challenges associated with the Rhine ecosystem restoration through the absence of governance conditions. In the end, lessons are drawn from the Rhine river ecosystem restoration process, after which the refined framework and the carried out research will be reflected upon. This research is conducted to answer the following research question:

What governance conditions contribute to successful restoration of riverine ecosystems?

The above research question is answered using the following subquestions:

- *How can successful ecosystem restoration be defined?*
- *Which governance conditions that have an impact on ecosystem restoration can be found in scientific literature?*
- *What factors caused the decay of the Atlantic salmon population in the Rhine and what actions have been undertaken to restore the Rhine ecosystem?*
- *To what extent can the ecosystem restoration process of the Rhine river to bring back the Atlantic salmon be considered a success?*
- *What are enabling and restricting factors in the ecosystem restoration process of the Rhine river to bring back the Atlantic salmon?*
- *What lessons can be learned from the Rhine river ecosystem restoration process?*

In chapter 2 of this research, the concept of 'successful' ecosystem restoration and governance is demarcated, after which the general framework for assessing governance conditions for ecosystem restoration is presented. In chapter 3, a justification is given for the Rhine river ecosystem restoration case study, followed by the methods for data collection and analysis of this research. Chapter 4 describes the causes for the decay of the Rhine ecosystem and the Atlantic salmon population, added to by a historical overview of the restoration of the Rhine ecosystem. Chapter 5 presents the analysis of the current success of the ecosystem restoration process of the Rhine to bring back the Atlantic salmon, followed by the assessment of the presence of governance conditions in the process of the restoration of the Rhine river ecosystem. In chapter 6, the refined framework for assessing the governance conditions for riverine ecosystem restoration is presented. Additionally, the carried out research will be reflected upon and recommendations for follow-up research are given. Chapter 7 provides the conclusion of this research, in which the research findings are discussed and lessons are drawn from the Rhine case study, supported by recommendations to policy-makers.

2. Conceptualization of successful ecosystem restoration and related governance conditions

2.1. Introduction

In this chapter, the first two subquestions of this research are answered. Firstly, an important definition is given of what this research envisions to be 'successful ecosystem restoration' by answering the first subquestion: *How can successful ecosystem restoration be defined?* Secondly, a definition is given of 'successful governance' for ecosystem restoration, which leads to the first foundational research step of this report: the construction of a general framework for analyzing the governance structure of ecosystem restoration projects by focusing on governance conditions. This framework is constructed to answer the second subquestion of this research: *Which governance conditions that have an impact on ecosystem restoration can be found in scientific literature?* The created framework will act as a guideline for the subsequent research steps.

2.2. Demarcating 'successful' ecosystem restoration

Before focusing on the methodological execution of this research, it is important to demarcate the literary fundamentals of this research by defining the concept of 'successful' ecosystem restoration. The definition of 'successful' is important, as this is used as a benchmark to conduct the case study on the restoration of the Rhine ecosystem. At a first glance, ecosystem restoration might seem like an isolated ecological process. Summarized by Lovat (2023), ecosystem restoration is defined as: *"(...) the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed to reflect its intrinsic values and to provide goods and services that people value."* (Lovat, 2023). Derived from this definition, providing assistance for the recovery of an ecosystem can be approached from different angles. Carignan & Villard (2002) distinguish three different types of management approaches to ecosystem restoration: coarse-filter, fine-filter and ecosystem management. Whereas coarse-filter approaches focus on the protection of entire habitats to ensure vitality, fine-filter approaches take one or multiple indicator species, species whose wellbeing function as a reflection of the quality of an entire ecosystem and the status of restoration efforts. As the needs of indicators species can be expressed in proxies of ecosystem quality parameters, conservation and restoration efforts are provided with a clear goal to work towards (Bal et al., 2018). Ecosystem management approaches combine the two former approaches, intensifying the environmental conservation process. Due to its ability to reduce complexities of ecosystem needs, fine-filter approaches are frequently taken as a means to manage ecosystem conservation and restoration (Bal et al., 2018; Hunter et al., 1988; Carignan & Villard, 2002). For each approach, the definition of success however logically differs, as different benchmarks are used to monitor restoration progress (e.g. population size versus ecosystem parameter values).

Even so, 'successful' restoration is dependent on the adopted measurement approach. For ecosystem restoration, one might strive for the attainment of a set goal, which, fed back to the different approaches, might be a certain amount of population growth or the preservation of vital elements to see ecosystem quality advancement. To measure progress, one might adopt a historical ecology approach and compare the current state of an ecosystem to its past state, looking at factors such as species composition, habitat structure, and ecosystem function (Szabó, 2015). Alternatively, one could use a reference ecosystem approach, comparing the restored ecosystem to a similar, 'undisturbed' ecosystem to assess the level of recovery achieved and still required (Dey & Schweitzer, 2014). Both approaches provide valuable insights into the success of restoration efforts and help inform management decisions.

Ultimately, 'successful' ecosystem restoration is based on the perception of the involved actor or stakeholder and their answer to the question: 'What do we want to achieve?'. Besides the improvement of the ecological quality, some actors might value the provision of ecosystem services such as clean water and air. Additionally, social, cultural and economic aspects may be considered in defining the goals of restoration, such as preserving traditional practices or creating recreational opportunities for local communities and businesses.

In this research, a case study is conducted on the restoration of the ecosystem of the Rhine river, coordinated by the International Commission for the Protection of the Rhine (ICPR). For this specific case study, the question 'What do we want to achieve?' is answered to demarcate the definition of successful ecosystem restoration. The ICPR aims to restore the Rhine ecosystem to the extent that a self-sustaining Atlantic salmon population is able to thrive in its waters, thus using this fish species as an indicator species for assessing restoration progress (ICPR, 2001a; ICPR, 2020a). In this case, 'successful' ecosystem restoration would mean to achieve the goal of a thriving, self-sustaining Atlantic salmon population. In order to achieve this goal, it is important to focus ecosystem restoration efforts on resolving all challenges that currently hamper the Atlantic salmon population from thriving in the Rhine river. An overview of these challenges is given in section 4.2.1.

2.3. Demarcating 'successful' governance of ecosystem restoration

Overall, successful ecosystem restoration involves fostering a holistic approach that considers both ecological and human dimensions to achieve the stated objectives and ultimately the desired outcomes. The contextual societal demands, in addition to the ecological requirements for a revitalized ecosystem can be combined in the governance dimension by steering towards compromise and collaboration to achieve ecosystem restoration. Compromise may be necessary to balance conflicting interests and priorities among different stakeholders involved in the restoration process. Collaboration is crucial, as it allows for the pooling of knowledge, resources, and expertise from various sectors to achieve the stated objectives of ecosystem restoration. By addressing the contextual societal demands, ecosystem restoration can be more sustainable and successful in achieving its goals. Consequently, the likelihood of attaining desired results and long-term sustainability is greatly raised by ensuring successful and effective governance, since a greater number of people support the restoration strategy and goals. Successful governance of ecosystem restoration can be fostered by including various elements or activities in the governance structure that facilitate the process of achieving ecosystem restoration objectives, so-called governance conditions. Thus, assessing the presence of these governance conditions—enabling variables that make governance successful and effective in promoting ecosystem restoration—is the main emphasis of this research, as these conditions play a crucial role in determining the overall success of ecosystem restoration efforts. In the following section, an overview is given of the formulation of a framework to assess the governance of ecosystem restoration by focussing on the presence of all relevant governance conditions.

2.4. Creating an analytical framework for assessing governance conditions

As a first step of this research, an assembly was made of scientific articles that focused research on vital aspects of general ecosystem restoration from a governance perspective. The websites Scopus, WorldCat and Google Scholar were searched using a combination of the following search terms to obtain relevant articles that describe governance conditions for ecosystem restoration: *ecosystem, river basin, fluvial, riverine, restoration, governance (conditions), management, ecology*.

In total, ten relevant articles were conclusively assessed and stripped from their highlighted governance conditions. Each of the assessed studies presents a concise list of their collection of governance conditions or elements which they found to be vital to foster successful ecosystem

restoration. All these lists were inductively coded, ultimately categorizing governance conditions based on attributes and dimensions, as visible in Table 1. Attributes refer to the role of a governance condition in relation to the ecosystem restoration management structure, whereas dimensions refer to an overarching topic or aspect within the related attribute. *Fundamental* attributes are the building blocks that devise the general organizational structure of the governing body, in this case either through legislation or governance structure. *Strengthening* attributes entail proceedings that actively increase the strength of a governing body, which is expressed through dimensions of financing, information (gathering) and support (building). *Commanding* attributes refer to governance conditions that play a role in the controlling or governing of the ecosystem restoration management structure. Dimensions within this attribute relate to either leadership, which symbolizes a shared, strong and uniform vision, or discourse, giving attention to bottom-up governance input. Lastly, *Developing* attributes refer to the transformation of the ecosystem restoration management structure, which is expressed through adaptation and innovation. Governance conditions are explanatorily formulated; as the governance conditions themselves are lengthy, an additional column is added to the table, titled 'Keyword'. Each governance condition is summarized using a keyword, which captures the essence of a governance condition and which makes it easier to refer to a specific condition in the rest of the report.

All conditions that were coded with the same attribute and dimension were consequently compared and combined if conditions overlapped or showed strong similarities. Conclusively, the analytical framework of this research, as presented in Table 1, was created. All governance conditions are clustered and categorized, each paired with an explanation of the governance condition and the corresponding sources in which the condition is mentioned. All governance conditions which were only mentioned by one source were removed from the framework. Consequently, all governance conditions are proven to be vital for ecosystem restoration by at least two independent studies, which improves the validity of the framework. In Appendix A of this report, the sources of all governance conditions are presented in a table. In this appendix, for each governance condition the keyword is mentioned, followed by the scientific literature sources from which the governance condition was derived.

Table 1

A general framework for analyzing governance of ecosystem restoration by assessing governance conditions

Attribute	Dimension	Governance condition	Keyword	
FUNDAMENTAL	<i>Legislation</i>	Ecosystem restoration is protected by and embedded in institutional arrangements and legislation.	<i>Nested</i>	
		The ecosystem restoration organization has the power to transform existing institutional restoration arrangements or institutionalize new restoration arrangements.	<i>Transformative power</i>	
		The ecosystem restoration organization has the will and power to legislatively enforce on the breaching of institutional restoration arrangements.	<i>Enforcement</i>	
	<i>Governance structure</i>	Ecosystem restoration management takes place at a cross-border, fluvial scale to ensure synergy between individual restoration measures	<i>Synergy</i>	
		Room is given to bottom-up, grassroots participation in the restoration process through designated communication platforms	<i>Participation</i>	
		There is a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process.	<i>Clear task division</i>	
		Employees of the ecosystem restoration organization are of multi-disciplinary backgrounds, thus accounting for the multi-dimensionality of the restoration area.	<i>Multi-disciplinary</i>	
		The ecosystem restoration organization has a concise strategy to resolve conflicts through consensus resolution.	<i>Conflict management</i>	
	STRENGTHENING	<i>Financing</i>	Contributions of actors to ecosystem restoration are financially rewarded.	<i>Financial incentive</i>
			Ecosystem restoration has economic benefits for partaking actors, besides possible direct reward structures (e.g. business development; protection of natural capital)	<i>Economic benefits</i>
Clear viable and long-term agreements are present to finance the ecosystem restoration project.			<i>Financial agreements</i>	
<i>Information</i>		There is a clear demarcated and designated role for scientists and research in the governance structure of the ecosystem restoration organization.	<i>Designated role for science</i>	
		The creation and implementation of restoration policies and measures is fundamentally supported through research and insights on the restoration area.	<i>Informed plan-making and execution</i>	

		Ecosystem restoration measures are weighed against alternative measures to assess the most favorable societal impact.	<i>Trade-off management</i>
		The ecosystem restoration process is actively supported by research to reduce and cope with uncertainties in the restoration process.	<i>Reducing uncertainty</i>
	<i>Support</i>	The ecosystem restoration project is supported by political will and adequate state support. This can be facilitated by active political brokering.	<i>Political support</i>
		The ecosystem restoration organization deploys an active capacity building process to increase the support base of the restoration project by including more actors and stakeholders.	<i>Capacity building</i>
COMMANDING	<i>Leadership</i>	Strong, inspiring leadership of individuals with experience and a relevant background.	<i>Individual leadership strength</i>
		Collaboration is coordinated by ensuring all partaking actors in the ecosystem restoration process share the same goals and vision for the project.	<i>Coordinated shared vision</i>
		Actors are held accountable for a timely implementation of restoration measures	<i>Efficient</i>
	<i>Discourse</i>	The ecosystem restoration organization has a platform to compromise on stakeholder discourses, thus accounting for different values and opinions for ecosystem restoration.	<i>Recognition of different perspectives</i>
DEVELOPING	<i>Adaptation</i>	The ecosystem restoration project has clear long-term goals, which are flexible to anticipate for future uncertainties.	<i>Long-term planning and anticipation</i>
		The ecosystem restoration organization continually improves its restoration policies and measures by evaluating the outcomes of existing policies and measures.	<i>Organizational adaptive management</i>
	<i>Innovation</i>	The ecosystem restoration organization has an organizational culture open for innovation, where experimental policies and measures are implemented to test new ideas.	<i>Open and innovative organizational culture</i>

2.5. Conclusion

After exploring the various definitions of ‘successful ecosystem restoration’, the chosen definition for this research is to accomplish the answer to the question: What do we want to achieve? For the case study on the Rhine river, which will be further elucidated in the next chapter, the set goal by the ICPR is the return of a self-sustaining Atlantic salmon population to the river. The importance of sound governance to foster successful ecosystem restoration is explained, as the governance structure can contain elements (governance conditions) which facilitate the process of successful riverine ecosystem restoration. Conclusively, governance conditions are derived from scientific literature to create a framework, which is used in the following steps of this study, as will be explained in the next chapter.

3. Methods

3.1. Introduction

In this chapter, firstly a justification is given for the conduction of a case study on the governance of the ecosystem restoration of the Rhine river. Then, the three distinct data collection methods of this research are explained, which use the created analytical framework from the previous chapter to extract information on the presence of governance conditions from the case study. Lastly, the data analysis methodology of this research is elucidated, which entails the digital coding of the data sources from each method using the governance conditions from the created framework.

3.2. The Rhine river ecosystem restoration as a case study

This research was conducted using a critical, single-case study design with a specified geographical focus area of the Rhine river basin (Gerring, 2004). By applying the created framework in Table 1 of this report to the critical case study, three vital insights were obtained. Firstly, enabling and restricting factors for the successful restoration of the Rhine ecosystem were underlined by assessing the presence of governance conditions. Secondly, the application of the framework to the Rhine case study offers case-specific 'solutions' that have been found to comply with the governance conditions, which can be used as insights for other restoration projects which struggle to comply with the same condition. Lastly, the case study indicated shortcomings of the analytical framework and brought to light new governance conditions which had previously not been derived from scientific literature. Using this last insight, the analytical framework was refined and added to if vital governance conditions were missing.

The focus of this research is on the governance of the restoration of the Rhine ecosystem, which is analysed from both an ecological and a governance perspective, but to the utmost extent at the interface of the two. The choice to conduct a critical case study was made to deepen the understanding of the government context of ecosystem restoration. As described by Sandelowski (1996), critical case studies are predominantly conducted to holistically and structurally assess complex phenomena, as more attention can be given to a single research focus point. As the governance conditions for riverine ecosystem restoration are seldomly researched, focus in this research was put on assessing these conditions for the Rhine river ecosystem restoration process using a case study approach. This way, a contextual and holistic analysis could be made of the whole river basin management structure, which ensured that all facets of the transboundary governance structure were investigated on its impact on the success of the Rhine ecosystem restoration process.

The governance of the restoration of the Rhine river ecosystem restoration perfectly lends itself to a critical case study due to its complex transboundary governance structure. It is estimated that 60 percent of the world's freshwater supply originates from transboundary rivers, which underlines the importance of understanding the challenges of transboundary fluvial management (Varis et al., 2008). From a governance perspective, transboundary rivers are the most interesting to analyse; for proper management of a transboundary river ecosystem, communication, coordination and cooperation are vital to ensure international co-benefits of restoration efforts (Mianabadi, Mostert & van de Giesen, 2015). As a result, the governance structure which manages transboundary rivers is hypothetically more extensive and thought-through, which makes these rivers more fit for a case study to analyse governance conditions. Various papers commend the international cooperation and management of the Rhine river basin by nine European nations. Its management structure is characterized by and praised for its strong transboundary institutions and adaptive management approaches (Zeitoun et al., 2013; Dieperink, 1998). Furthermore, the true ambitions of ecological restoration of the Rhine date back to as early as 1950, when the ICPR was founded (CCNR, 2023; ICPR, 2023). Consequently, the Rhine river basin management is frequently researched, which facilitated the process of deriving clear

governance conditions for riverine ecosystem restoration, as sufficient information on the management structure and its enabling and restricting factors could be defined. The governance context of the Rhine riverine ecosystem restoration process is thus suited for a critical case study on transboundary rivers, as there is a longstanding strong management structure present which is often exemplified by scientific literature (Bozkir et al., 2010; Schiff, 2017; Uehlinger et al., 2009).

3.3. Data collection

The critical case study on the Rhine was conducted through three distinct methods, namely a policy document assessment (PDA), a scientific literature assessment (SLA) and by interviewing experts on the case study. As a first step of this research, the PDA and the SLA were conducted. Using a combination of these data collection methods, the first analysis of the governance structure of the ecosystem restoration of the Rhine could be made. The creation of a first overview of the governance structure of the Rhine ecosystem restoration process enabled the shortening of the list of 24 governance conditions as a preparation for the expert interviews. The expert interviews were then employed as an extra research method to obtain a deeper understanding of uncertainties, which are the governance conditions for which a convincing answer regarding its presence in the governance structure could not be formulated. This way, the conducted interviews could be kept concise, allowing for a more results-oriented approach. In Table 2, each governance condition is displayed, followed by each respective case-specific source of information. In the following sections, a more in-depth description and justification is given on the details of each research method. In section 3.5, a justification is given for the selection of governance conditions that were operationalized for expert interviews.

Table 2

Overview of governance conditions and each respective source of information

Attribute	Dimension	Governance conditions	Data source
FUNDAMENTAL	<i>Legislation</i>	Nested	PDA, SLA
		Transformative power	PDA, SLA
		Enforcement	PDA, SLA
	<i>Governance structure</i>	Synergy	PDA, SLA
		Participation	PDA, SLA
		Clear task division	Expert interviews, PDA, SLA
		Multi-disciplinary	Expert interviews, PDA, SLA
		Conflict management	Expert interviews, PDA, SLA
	STRENGTHENING	<i>Financing</i>	Financial incentive
Economic benefits			Expert interviews, PDA, SLA
Financial agreements			PDA, SLA
<i>Information</i>		Designated role for science	PDA, SLA
		Informed plan-making and execution	PDA, SLA
		Trade-off management	Expert interviews, PDA, SLA
		Reducing uncertainty	PDA, SLA
<i>Support</i>		Political support	PDA, SLA
		Capacity building	PDA, SLA
COMMANDING	<i>Leadership</i>	Individual leadership strength	Expert interviews, PDA, SLA
		Coordinated shared vision	PDA, SLA
		Efficient	Expert interviews, PDA, SLA

	<i>Discourse</i>	Recognition of different perspectives	PDA, SLA
DEVELOPING	<i>Adaptation</i>	Long-term planning and anticipation	PDA, SLA
		Organizational adaptive management	PDA, SLA
	<i>Innovation</i>	Open and innovative organizational culture	PDA, SLA

Note. The abbreviations used in the table signify the methods used in this research. PDA: Policy document assessment. SLA: Scientific literature assessment.

3.3.1. Policy document assessment

To gain insight into the governance of ecosystem restoration in the Rhine river basin and its progress, a PDA was conducted. In these policy documents, restoration goals and their obstacles are underlined and supported by monitoring data. For the PDA, reports of the ICPR were analysed, as this organisation is the main responsible actor for the restoration process of the Rhine (ICPR, 2023). ICPR output is partially based on input from stakeholders that use or impact the quality of the Rhine and/or its ecosystem services. In Table 3, a list is given of the policy documents that were assessed for this research. These reports were selected for this research, as they contain an overview of the ICPR vision and activities during the last decades with regard to the ecosystem restoration of the Rhine. ‘Upstream Outcome of the Rhine Action Program’ evaluates the success of the Rhine Action Program from 1987, which is considered as the first official programme to improve the quality of the Rhine ecosystem (ICPR, 2003). ‘Rhine & Salmon 2020’, often shorted to ‘Salmon 2020’ entails the vision for the return of the Atlantic salmon and the required measures for the Rhine river from 2000 until 2020 (ICPR, 2001a). ‘Assessment Rhine 2020’ analyses the progress of the implementation of the ‘Rhine 2020’ programme, which was the leading vision for ecosystem restoration since 2001 until 2020, and included the ‘Salmon 2020’ vision (ICPR, 2020a; ICPR, 2001a; ICPR, 2001b). This report is the most recent ‘completed’ action programme for the Rhine ecosystem restoration. Lastly, ‘Rhine 2040’ is analysed, as this is the successor to ‘Rhine 2020’ (ICPR, 2020b). This new action programme entails the latest vision for the Rhine ecosystem restoration and the planned measures.

Table 3

Overview of reports for policy document assessment

Report title	Short explanation on report contents	Source
Rhine & Salmon 2020	This document summarizes the vision for the return of the Atlantic salmon from 2000 until 2020 and the required measures for further progress.	(ICPR, 2001a)
Upstream - Outcome of the Rhine Action Programme	This report from 2003 evaluates the success of the Rhine Action Programme from 1987, which is considered the first official programme to improve the quality of the Rhine ecosystem.	(ICPR, 2003)
Assessment Rhine 2020	This assessment analyses the progress of the implementation of the ‘Rhine 2020’ programme, which has been ongoing since 2001. This is the most recent ‘completed’ action programme for the Rhine ecosystem restoration.	(ICPR, 2020a)
Rhine 2040	In 2020, this new action programme was adopted as a successor to the ‘Rhine 2020’ action programme. This report	(ICPR, 2020b)

	entails the future vision for the Rhine ecosystem restoration with the planned measures.	
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Note. All policy documents and information on their contents are derived from the website of the ICPR (ICPR, 2023).

The progress of the Rhine river ecosystem restoration process to bring back the Atlantic salmon was evaluated using the latest available progress reports from the ICPR. As the drafted objectives in the 'Rhine 2020' report were used as a guideline for the ecosystem restoration efforts from 2001 until 2020, the progress report 'Assessment Rhine 2020' can be used to assess the success of Rhine ecosystem restoration efforts. From these reports, an assembly of objectives was made, focusing solely on targets that can be directly related to fostering the return of the Atlantic salmon. The following objectives were each assessed on the progress made, as reported on in 2020 (ICPR, 2001b; ICPR, 2020a):

1. *The reactivation of 160 km² of floodplains along the main stream of the Rhine*
2. *The connection of at least 100 oxbow lakes or lateral water bodies to the dynamics of the Rhine*
3. *Increasing the structural diversity of 800 km of riverbanks along the Rhine*
4. *The restoration of the ecological continuity of the Rhine to Basel and in the tributaries from the Migratory Fish Programme for upstream and downstream migrating fish*
5. *Achieving self-sustaining populations of Atlantic salmon*
6. *Making it possible to obtain drinking water using simple, near-natural treatment processes and ensuring that water constituents neither individually nor in their interaction have adverse effects on the biocoenoses of plants, animals and microorganisms*
 - 6a: *Significant reduction of nutrient concentration*
 - 6b: *Significant reduction of metals concentration*
 - 6c: *Significant reduction of pesticides concentration*
 - 6d: *Significant reduction of micropollutants concentration*

Each restoration objective's degree of accomplishment was assessed using a straightforward colour scheme, with green denoting goal achievement and red denoting goal failure. The results of this assessment are presented in Table 7 of this research.

3.3.2. Scientific literature assessment

To support the PDA, scientific literature on the ecosystem restoration process of the Rhine was assessed to retrieve additional insights on the governance process of the Rhine ecosystem restoration. In this scientific literature assessment (SLA), focus was put on articles in which research is conducted on the governance, management structure and policymaking process of the ecological restoration measures of the Rhine river. Articles on the governance of ecosystem restoration process of the Rhine were collected on Scopus, WorldCat and Google Scholar using (a combination of) the following search terms: *Rhine, river basin, governance (structure), (Atlantic) salmon, management (structure)*. Seemingly relevant articles were then assessed by reading the abstracts and by scanning the general content and structure of the study. As a precondition for the definitive selection of the article, a significant focus of the research needed to be on the analysis of the governance structure or -process of the restoration of the Rhine ecosystem. In Table 4, a list is presented of the scientific articles that were assessed in this research, which consists of seven different studies.

Table 4*Overview of articles for scientific literature assessment*

Title	Source
Integrated water management for the Rhine river basin, from pollution prevention to ecosystem improvement	(Wieriks & Schulte-Wülwer-Leidig, 1997)
International co-operation on Rhine water quality 1945–2008: An example to follow?	(Mostert, 2009)
Understanding ‘problem of fit’ between institutions and environment: lessons from the Rhine River Basin	(Myint, 2003)
There Must Be Something in the Water: An Exploration of the Rhine and Mississippi Rivers' Governing Differences and an Argument for Change	(Chase, 2011)
The link between polycentrism and adaptive capacity in river basin governance systems: insights from the river Rhine and the Zhujiang (Pearl river) basin	(Da Silveira & Richards, 2013)
The evolution of Rhine river governance: historical lessons for modern transboundary water management	(Schiff, 2017)
Environmental governance of western Europe and its enlightenment to China: in context to Rhine Basin and the Yangtze River Basin.	(Shi et al., 2021)

3.3.3. Expert interviews

Thirdly, semi-structured interviews were conducted with several actors related to restoration efforts of the Rhine ecosystem. The respondents were asked to be interviewed to gather additional insights to the case study, besides the gathered knowledge from the PDA and the SLA. After the conduction of these two research methods, some governance conditions were not mentioned enough in order come to a concise conclusion on the whether or not his condition was met. A justification and details on the selection of these underexposed governance conditions can be found in section 3.5., whereas the selection of these conditions is a successive step to the data analysis of the PDA and the SLA.

3.3.3.1. Semi-structured interviews

Semi-structured interviews were used as a method to collect information on the particular underexposed topics as outlined in the analytical framework. The collected data could then be compared to the responses provided by other respondents. At the same time, respondents retained the freedom to express themselves and to bring new or off-topic information to the table, for example about governance conditions which were not explicitly integrated in the interview outline. During or after the interviews, a snowball sampling technique was used to find more actors to interview through the networks of the interviewed respondents. As these actors or stakeholders had a good overview of all actors involved in ecological restoration efforts, the use of this technique opened up the possibility to contact additional relevant actors.

3.3.3.2. Respondents

All respondents were contacted to participate in this research via email. On the website of the ICPR (www.iksr.org), a list is presented of all authorities or organizations that are either a member or observer to the ICPR. Members of the ICPR are the national delegates that voluntarily cooperate based on the Convention on the Protection of the Rhine (ICPR, 2024a). Observers to the ICPR are states, intergovernmental organizations or non-governmental organizations that are related to or interested

in the work of the ICPR (ICPR, 2024b). As an observer, they are allowed to participate in the ICPR meetings, but they are not entitled to voting rights. Using this website, the contact information of possible respondents was retrieved and emails were sent to briefly explain the study and to request participation in this study. A total amount of seven respondents were interviewed for this research. A list with a description of the position of the respondents and their relation to the ICPR is presented in Table 5. The name of each respondent is anonymized to ensure the privacy and independence of the respondents in relation to the conclusion drawn in this research.

To facilitate the data analysis process, all interviewees were asked for consent to record the interview. This way, all conversations could be saved and replayed when conducting the data analysis. Additionally, respondents were informed that their name would not be used in this research, ensuring that the respondents felt at ease to freely answer all questions asked. The interviews with Respondent 1, 4, 5, 6 and 7 were conducted in Dutch and later translated to English with an online document translation program. Therefore, there can be small linguistic errors in the transcripts of these interviews, although the general narrative was checked for it to convey the same message.

Table 5

List of interview respondents with a description of their position their relation to the ICPR

Respondent	Description
Respondent 1	Head of the ICPR secretariat
Respondent 2	Executive secretary of the German Rhine River Basin Community, member of the German delegation in the Strategic Committee of the ICPR and member of several Expert- and Working Groups of the ICPR
Respondent 3	Employee of the Ministry of Environment of the German federal state Hessen and member of the Working Group Water Quality/Emissions of the ICPR
Respondent 4	Water Manager at Rijkswaterstaat ‘Water, Verkeer en Leefomgeving’ (WVL) and member of the Working Group Ecology of the ICPR
Respondent 5	Knowledge and Research Team Leader at Sportvisserij Nederland (<i>ICPR Observer</i>) and doctoral candidate at the University of Wageningen in Aquaculture, Fisheries and Marine Animal Ecology and member of the Expert Group Fish of the ICPR
Respondent 6	Director of RIWA Rhine (<i>ICPR Observer</i>) and member of the Working Group Water Quality/Emissions of the ICPR
Respondent 7	Coordinator at WWF Netherlands (<i>ICPR Observer</i>)

3.3.3.3. Operationalization

To create an interview outline for the expert interview research method, governance conditions had to be operationalized to interview questions to make them usable to retrieve the desired information. In Table 6, a list is presented of the governance conditions that were operationalized to interview questions for the interview outline, which was used during the semi-structured interviews. As will be further elucidated in section 3.5, only governance conditions that were ‘underexposed’ after the conduction of the first two research methods were operationalized for the interview outline.

Following the ‘Governance conditions’ section, four ‘Additional governance conditions’ are presented with their respective interview questions. These additional conditions were retrieved from the previously conducted PDA and SLA and represent topics that were frequently mentioned in the assessed sources to play a role in the facilitation of the ecosystem restoration process of the Rhine.

Below, a description is given of the context in which these topics are mentioned in the assessed policy documents and studies. These four topics were included in the operationalization and subsequently in the interview outline, in order to test how the respondents valued these aspect of the management of the ecosystem restoration of the Rhine. The aim of the inclusion of these additional governance conditions was to assess the importance of the role they have in the conducted case study, and subsequently the possibility of the inclusion of these topics as possible governance conditions in the final framework for riverine ecosystem restoration.

Table 6

List of governance conditions and related interview questions

Governance condition	Operationalization
Clear task-division	Is there a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process? If so, how is this organized?
Multi-disciplinary	Are the members of the ICPR of multi-disciplinary backgrounds? (Does this differ per ICPR working group?)
Conflict management	What does the strategy for resolving conflicts in the restoration process look like?
Financial incentive	Are contribution of actors to the ecosystem restoration process financially rewarded? If so, how? Can you give some examples?
Economic benefits	Are there economic benefits to partaking in the restoration process (besides possible direct reward systems)? (e.g. business development, protection of natural capital)
Trade-off management	Are ecosystem restoration measures weighed against alternative measures to assess the most favorable impact? If so, how? And by whom?
Individual leadership strength	Would you say that strong, inspiring leadership of specific individuals plays an important role in the success of the ICPR in taking recovery initiatives?
Efficient	Are actors held accountable for a timely implementation of restoration measures? How?
<i>Additional governance conditions</i>	
Flexibility	How important do you think it is to have flexibility in choosing fitting restoration measures to work towards the long-term goals for the restoration of the Rhine?
Transformative organizational structure	What do you think is the importance of the capacity of the ICPR to change its organizational structure, as it has historically has done?
Centrally coordinated monitoring	What do you think is the importance of the centrally coordinated monitoring system of the Rhine restoration process?
The use of an indicator species	What do you think is the importance of the Atlantic salmon as an indicator species for the restoration of the Rhine? Was this a good choice, or could this have been another indicator species as well? What do you think the ecological recovery process of the Rhine would look like if an indicator species had never been chosen to guide the process?

The first additional governance condition is 'Flexibility', which refers to the process of choosing restoration measures. In the assessed policy documents and scientific literature, it becomes clear that the implementation of restoration measures is the sole task of the riparian states of the Rhine (Chase,

2011; Mostert, 2009; Wieriks & Schulte-Wülwer-Leidig, 1997; Schiff, 2017) . In order to facilitate the process of finding compromises, implementing fitting restoration measures and finding optimal solutions to noted problems, the nation states retain freedom in choosing fitting restoration measures while working towards the same goals (ICPR, 2020a; Chase, 2011; Mostert, 2009; Wieriks & Schulte-Wülwer-Leidig, 1997; Schiff, 2017).

The second additional governance condition topic is 'Transformative organizational structure', which refers to the capacity of the ICPR to change its organizational structure, as it has historically done to streamline the functioning of the organization and its capacity to address newly arising issues. Examples of this are the decentralization of the working nature of the ICPR under the Rhine Action Program, the resultant establishment of new expert- and working groups and later the inclusion of a new political actor: the European Community (Myint, 2003; Schiff, 2017; Wieriks & Schulte-Wülwer-Leidig, 1997).

The third additional governance condition is 'Centrally coordinated monitoring', which refers to the role the ICPR has in the ecosystem restoration process of the Rhine. As an organization, the ICPR monitors the restoration of ecosystems in each of the individual riparian states, gathers data on the progress and compiles this data into comprehensive reports that reflect on the restoration advancements in the entire catchment area to coordinate international Rhine management (ICPR, 2020b; Da Silveira & Richards, 2013; Myint, 2003; Mostert, 2009).

The last additional governance condition is 'The use of an indicator species'. For the restoration of the Rhine ecosystem, the ICPR adopts a fine-filter approach, using the Atlantic salmon as an indicator species (Carignan & Villard, 2002; ICPR, 2001a; ICPR, 2020b). The wellbeing of the Atlantic salmon thus functions as a reflection of the quality of the Rhine ecosystem and the status of restoration efforts. As the needs of the Atlantic salmon can be expressed in proxies of ecosystem quality parameters, conservation and restoration efforts are provided with a clear goal to work towards (Bal et al., 2018). The restoration of the Rhine ecosystem and the implementation of new restoration measures, as coordinated by the ICPR, is ultimately done to obtain a self-sustaining Atlantic salmon population in the Rhine (ICPR, 2001a; ICPR, 2020a). To assess the importance of having an indicator species to guide the restoration process, respondents were asked about the importance of the Atlantic salmon as an indicator species for the restoration of the Rhine ecosystem. Additionally, the possible feasibility of a different indicator species was explored. Lastly, a speculative question was asked about the state of the ecosystem restoration of the Rhine if no indicator species had been chosen to guide the process.

3.3.3.4. Interview outline

In Appendix B and C, the interview outline which was used to conduct the semi-structured interviews is presented in both English and Dutch. Based on the topic of the conversation, the interviewer deviated from the order of the questions, as presented in Appendix B and C, to maintain the flow of the conversation. The outline consists of an introductory section, in which firstly a brief explanation was given to the respondent about the topic and aim of this research, after which two questions were asked about the position and background of the respondents to make acquaintance. After this introduction, the previously mentioned and operationalized (additional) governance conditions and their corresponding interview question were asked to the respondent. At the end of the interview, an evaluative section was created to evaluate the importance of the Atlantic salmon as an indicator species, assessing the fine-filter approach to ecosystem restoration as a possible governance condition for successful ecosystem restoration. In addition, an evaluative question was asked to the respondent, focused on deriving the perception of the respondent on the most important governance condition(s) that facilitates successful ecosystem restoration of the Rhine.

3.4. Data analysis

For all three of the research methods, data analysis and processing was conducted by coding the specific documents using the digital programme NVivo. Firstly, all relevant policy documents and scientific articles were imported into the programme to allow for digital coding. With consent of the respondents, all interviews were recorded to facilitate a similar data processing in this research. After the interviews were conducted, the recordings were transcribed to text, after which the transcripts were imported to NVivo. In this research, the coding process was conducted both inductively and deductively. Based on the created analytical framework, a code tree was inductively constructed to allow for a structural analysis of governance conditions in firstly the policy documents and scientific articles. Deductively, new insights earned from the policy documents and scientific literature, in the form of additional governance conditions, were added to the code tree, alongside codes related to questions to evaluate the importance of the governance conditions and the use of the Atlantic salmon as an indicator species. With this expanded code tree, which can be found in Appendix D of this research, the interview transcripts were coded.

As mentioned in section 3.4.3., only the 'underexposed' governance conditions after the conduction of the PDA and the SLA were operationalized to interview questions for the expert interviews. In Table 2, an overview is given of which governance conditions were included in the interview outline. As a selection criteria for these governance conditions, the total number of times a condition was coded was used. If a conditions was coded less than ten times, the conditions was included in the interview outline, in order to retrieve more information on this topic from experts.

As visible in Figure 1, the creation of a refined framework is one of the two outcomes of the critical case study. The second focus point of the critical case study is the analysis of the governance structure of the Rhine ecosystem restoration project. The compliance of the governance structure in focus with the formulated governance condition is presented in the form of a narrative, supported by a Traffic Light Assessment Scale. If a governance condition is mentioned in one of the assessed data sources, the section will be coded with the corresponding condition code. This way, an assembly can made of all mentions of a governance conditions, which is then used to formulate a narrative and to grade a governance condition using the Traffic Light Assessment Scale. The colour red indicates that a governance condition is absent from the current governance structure, orange indicates that a governance condition is partially present, and green indicates that a particular governance condition is fully fulfilled.

3.5. Conclusion

Conclusively, the case study of this research will be conducted using a PDA, a SLA and by conducting expert interviews. The policy documents, scientific literature and transcripts of the interviews will be coded based on the created framework to assess governance conditions for successful ecosystem restoration. The results of this case study will be presented in chapter 5 of this report. In the next chapter, the case study will firstly be elucidated by exploring the factors that contributed to the decline of the Atlantic salmon population, after which an historical overview is given of the decay of the Rhine ecosystem and restoration efforts that have been made to the present day.

4. The decay and restoration of the Atlantic salmon population and the Rhine ecosystem

4.1. Introduction

In this chapter, an answer to the following subquestion is formulated: *What factors caused the decay of the Atlantic salmon population in the Rhine and what actions have been undertaken to restore the Rhine ecosystem?* This question is answered by first explaining the contributing factors to the general decline of the Atlantic salmon population. Subsequently, a historical overview is given of the decay of the Rhine river ecosystem and the efforts that have been made by the riparian states to restore the ecosystem.

4.2. What caused the decline of the Atlantic salmon population?

Since the Atlantic salmon fish is a migratory or anadromous species, its habitat extends beyond the Rhine river basin (Koed et al., 2020). The Atlantic salmon's spawning sites are found upstream in coastal rivers that flow into the North Atlantic Ocean (Aas et al., 2010). The juvenile salmon hatch and begin their downstream migration towards the ocean, which will serve as this species' home. The adult salmon will eventually reproduce by returning to their original hatching habitats. The vast habitat of the Atlantic salmon makes population monitoring difficult (Nicola et al., 2018). Because of this, it is challenging to pinpoint the precise beginning of the global Atlantic salmon population drop in the Rhine River alone. While some sources identify 1970 as the starting point (Nicola et al., 2018; Almodóvar et al., 2019), other sources suggest the 1980s (Dadswell et al., 2022; Horreo et al., 2011), the early 1990s (Mills et al., 2013), or even the 18th century using historical data sources (Wolter, 2015). Besides disputes about the start of the population decline, reports on the decline underline varying causes that negatively impact the Atlantic salmon and its vast habitat. The following section aims to provide a general overview of factors contributing to the decline of the Atlantic salmon population in the Rhine. Due to the anadromous nature of the species, adverse effects on the Rhine Atlantic salmon population may also transcend the fluvial scale and derive from the larger scale of the North Atlantic Ocean, as this is their primary habitat for a significant portion of their lives.

4.2.1. Overexploitation

Fisheries are held responsible for the decline of the Atlantic salmon population and are often cited as one of the main causes for the steep population decline in the second half of the 20th century (Almodóvar et al., 2019; Dadswell et al., 2022; Horreo et al., 2011; Nicola et al., 2018; Wolter, 2015). As reported by Dadswell et al. (2022), high-seas fisheries have a high impact on the lifecycle of the Atlantic salmon, as adults are caught in the open ocean before they can return to their upstream hatching grounds, thus limiting reproduction numbers. Even so, local freshwater fisheries have made similarly large contributions to the diminishing salmon population due to overexploitation (Aas et al., 2010). Freshwater fisheries target both adult and juvenile salmon during their migration, which further hampers their ability to replenish the population. Efforts to regulate both local freshwater and high-seas fisheries are essential to the conservation and recovery of the Atlantic salmon population, but often hard to implement and enforce (Koed et al. 2020; Aas et al., 2010). Worldwide, attempts are being made or have been made to reduce fishing seasons, prohibit fishing in certain rivers, and impose limitations on the overall size of the catch (Stensland, Dugstad & Navrud, 2021). Besides intentional fishing for salmon, which is broadly regulated or even prohibited in some areas, the salmon population is stressed by unintentional bycatch (Aas et al., 2010; Dadswell et al., 2022). Additionally, illegal, unreported or unregulated (IUU) fishing plays a part in flatlining the abundance of adult salmon populations, but also undermines efforts to regulate and enforce sustainable fishing practices (Dadswell et al., 2022).

4.2.2. Damming

An extensive habitat is necessary for the anadromous Atlantic salmon to complete its reproductive cycle and maintain a vital population (Koed et al., 2020). This habitat spans the ocean itself as well as the upstream sources of rivers that flow into the North Atlantic (Aas et al., 2010). Longitudinal connectivity from the ocean to the source of the river basin is vital to Atlantic salmon, as obstructions prevent the fish from reaching their breeding grounds (Wolter, 2015). A significant hindrance to salmon populations is the installation of water dams, hydroelectric dams and power stations in river basins, which destroy juvenile habitats and impede the Atlantic salmon's upstream movement (Forseth et al., 2017; Dadswell et al., 2022). Hydroelectric dam turbines also contribute to an increased salmon mortality since the fish's relentless attempts to pass are lethal (Dadswell et al., 2022).

4.2.3. Pollution

Another cause of the impeding Atlantic salmon population is watershed pollution in freshwater rivers, which is almost entirely generated by human activities (Parrish et al., 1998). Water quality is negatively impacted by industrial pollution and pesticides from agricultural runoff (Dadswell et al., 2022). Pollutants can disrupt the balance of the natural environment, indirectly affecting the health of the Atlantic salmon. The buildup of toxins and pollutants in the salmon's habitat will eventually find its way into the body of the species, weakening their immune system and making them more susceptible to diseases and parasites (Arkoosh et al., 1998). Additionally, agricultural runoff can cause the bloom of algae and advance the process of eutrophication, which eventually makes the water anoxic and uninhabitable for all species (Forseth et al., 2017).

4.2.4. Non-endemic species

Another threat to the natural equilibrium in the habitat of the Atlantic salmon, is the introduction of non-endemic aquatic species (Dadswell et al., 2022; Forseth et al., 2017; Horreo et al., 2011). Non-endemic species, which from a natural origin do not exist in the habitat of the Atlantic salmon, are often introduced by humans. Accidental releases or intentional stocking are two major contributors to this problem, as more recently, reports also underline the impact of salmon aquaculture (Dadswell et al., 2022; Shephard & Gargan, 2017). The non-endemic aquatic species, often other fish species or predators with an overlapping diet, can outcompete the endemic Atlantic salmon in search of resources, thus altering the food chain (Thorstad et al., 2021). In addition, non-endemic species can carry exotic parasites and diseases with them, which they consequently introduce to the native species in their new habitat (Nicola et al., 2018; Dadswell et al., 2022). In case of the salmon aquaculture, genetic swamping of the salmon population can take place through stocking and accidental releases, as the non-endemic salmon species eventually breed with the native salmon. Genetic swamping, the mixture of native and non-endemic genes, inhibits local adaptation and negatively impacts the resilience of native salmon species. As non-endemic species produce offspring with native salmon, this may result in hybridization and additional genetic dilution of the salmon gene pool (Clifford et al., 1998). This may lead to the native salmon population losing distinctive genetic features and experiencing a decline in genetic diversity, increasing their susceptibility to environmental changes and lowering their capacity for long-term adaptation and survival.

4.2.5. Climate change

Inevitably, the health of the Atlantic salmon population is and will be significantly impacted by climate change. High atmospheric concentrations of greenhouse gases affect the temperature of the atmosphere and, in turn, the temperature of rivers and seas (Almodóvar et al., 2019). Oceans and rivers typically warm as a result of global warming, which affects the ecosystems that reside there

(Almodóvar et al., 2019; Nicola et al., 2018; Mills et al., 2013). The same greenhouse gases cause the acidification of oceanic and fluvial waters (Forseth et al.; 2017; Dadswell et al., 2022). Additionally, climate change generates more extreme weather conditions, of which fluctuations in rainfall have a strong impact on riverine ecosystems (Nicola et al., 2018). Variations in precipitation mean that droughts can occur more frequently and be longer in duration. They are also commonly followed by periods of intense rainfall. As a result of these more extreme weather conditions, rivers experience changes in flow variation, briefly explained as the amount of water that flows through the river (Almodóvar et al., 2019; Nicola et al., 2018). All these climate and physical conditions lead to changes in ecosystem characteristics, which are detrimental to the species that live there (Almodóvar et al., 2019; Dadswell et al., 2022; Mills et al., 2013; Nicola et al., 2018). The Atlantic salmon is particularly sensitive to environmental changes in temperature, flow variation and water quality, which means that climate change limits the survival of this species (Horreo et al., 2011; Nicola et al., 2018; Elliott & Elliott, 2010; Jonsson & Jonsson, 2017) In addition to posing a threat to the lives of Atlantic salmon, these shifting circumstances result in poor trophic conditions, which alter plankton ecosystems and lower the availability of prey, further disrupting the food chain vital for salmon (Mills et al., 2013; Dadswell et al., 2022; Almodóvar et al., 2019).

4.3. Historical overview of the Rhine ecosystem decay and restoration

Starting at the Swiss Alps and running all the way until the North Sea, the Rhine river basin was historically characterized by a winding river, surrounded by ecosystems varying from forests, wetlands to floodplains (Törnqvist, 1994). Through the ages, the Rhine river has been of tremendous value to the human population living next to it. From as much as 12.000 years ago, the river was used as a source of water, food, natural resources and as a means of transportation (Schiff, 2017). Later, from the Roman times on, transportation evolved into trading practices, adding more economic heft to the all-important river (Havinga, 2020). Additionally, the first efforts were made to control course and flow of the river by constructing the first weirs and dikes. During the medieval times, local impacts on the river grew by implementing agricultural practices, increased fishing and by using the river as a waste and sewage disposal (Winiwarter, 2016; Havinga, 2020).

4.3.1. Industrialization (1800-1900)

It was however not until the mid-19th century that the river started to get noticeably impacted by human activities under the effects of the Industrial Revolution (Schiff, 2017; Wilken, 2005; Uehlinger et al., 2009; De Groot, 2002). Rapid industrialization in continental Europe led to the construction industrial areas near the Rhine, using the river as a discharge for untreated waste (Uehlinger et al., 2009). This industrial waste water was contaminated with organic matter and pollutants, but also with heavy metals and chemicals. Especially polluting were chemical industry clusters which for example developed in Basel and Mannheim (Schiff, 2017). Alongside the industrial areas, a growth in riverside urbanization took place, increasing the sewage disposal flowing into the river, as waste water treatment systems were not yet present (Wilken, 2005; Uehlinger et al., 2009). Besides urban causes, agricultural intensification on river floodplains led to additional higher flooding risk and increased water pollution, as the use of chemical fertilizers and pesticides became more common (Uehlinger et al., 2009; Winiwarter, 2016). Although locally used, agricultural runoff caused the flow of these pollutants into the Rhine river basin, directly affecting riverine ecosystems. To make room for agricultural land, significant parts of the river's catchment area were deforested, which led to increased sediments and nutrients in the water of the river, as soil erosion took place (Wilken, 2005; Uehlinger et al., 2009; Winiwarter, 2016). As the industrial revolution led to more advancement in engineering capacity, hydroengineering projects also came to fruition, predominantly focused on

creating further economic growth through commerce. With the aim to control flooding of the Rhine during peak water and to facilitate trade and water navigation, projects were undertaken to straighten the river course of the Rhine through channelization (Figure 2) and by building additional dikes and weirs along the river banks (Wilken, 2005). These hydroengineering efforts were accompanied by the rise of new transportation methods, such as the introduction of the first steamships (Schiff, 2017; Wilken, 2005). These ships brought along occasional oil and fuel spills, besides other pollutant discharges (Andersson et al., 2016).

Despite the growing environmental impact of all the above mentioned causes, the decay of the Rhine did not lead to sensible international agreements to lessen the impact of human activity on the environment in the era of Industrial Revolution. It did however lead to the establishment of the Central Commission for the Navigation of the Rhine (CCNR) in 1815, which can be seen as the foundation of international cooperation on a fluvial scale (CCNR, 2023). The CCNR was primarily created to ensure freedom of navigation, centralizing individual toll levies for traversing the river to one Rhine toll, and to settle ensuing conflicts (Schiff, 2017; Wilken, 2005). Although true institutionalization of environmental protection of the Rhine only arrived decades later, the riparian states did acknowledge ecological degradation of the Rhine ecosystem, which they predominantly saw as a source of natural resources. This is where the vitality of the salmon population makes its first entrance in relation to the quality of the Rhine river. Due to overexploitation, the population saw a steep decline, which was noticed in reduced catch by downstream fisheries (Halbfaß, 1916). In response to the inevitably declining salmon population, riparian states signed the Salmon Treaty in 1885. In this treaty, riparian states agree to adapt fishing methods, to halt fishing in certain yearly periods, to stop fishing on Saturday and Sunday, to promote breeding of salmon in captivity and to enforce an allowed minimum fish size for fishing (Lachsvertrag, 1885).

4.3.2. The establishment of a new commission (1900-1950)

It was only until 1932 that the Dutch government decided to address the pollution of the Rhine on an international scale, as located downstream, the Netherlands were experiencing water quality issues of the river basin, which they intensively used for agriculture and as drinking water (ICPR, 2023). Still, the Dutch envoy was yet unable to convince the other riparian states to take decisive action. After the Second World War, the CCNR came together in 1946; during this meeting, the Dutch government again raised the issue of the pollution of the Rhine, but this time to more success (Dieperink, 1999). After years of research and consultation, the CCNR decided to establish a new commission in 1950, primarily focused on the environmental restoration and protection of the Rhine ecosystem: the International Commission for the Protection of the Rhine (ICPR) (CCNR, 2023; ICPR, 2023).

4.3.3. Chemical- and chloride pollution (1950-1986)

As prime concern, the ICPR firstly wanted to address the high concentration of (chemical) pollutants in the river basin (ICPR, 2023; Uehlinger et al., 2009). This resulted in the signing of the Convention

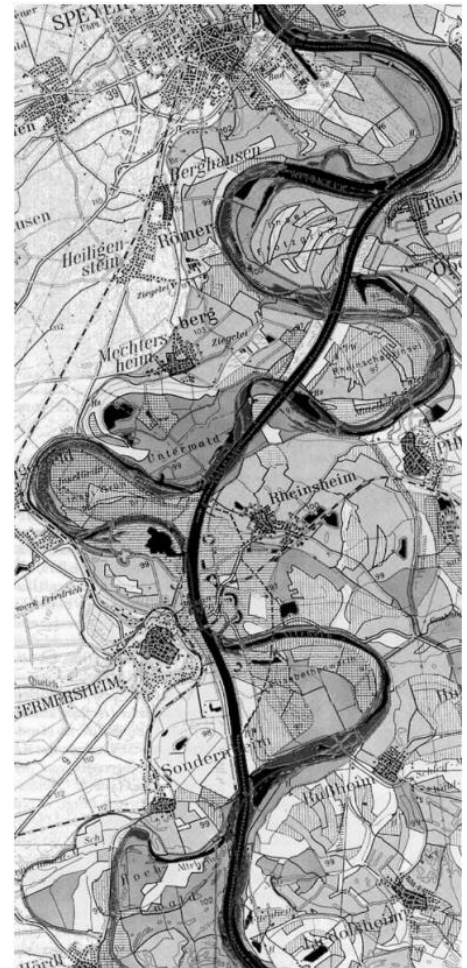


Figure 1 - Map of the 'old' Rhine river near Gernersheim, Germany, with the drawn correction (straight line) to channelize the river in 1817, from Wilken (2005).

on the Protection of the Rhine Against Pollution in 1963, which also gave the ICPR its official legal international status (Schiff, 2017). In order to be able to track progress, the riparian states successfully established a fluvial monitoring and analysis system for Rhine water quality parameters (ICPR, 2023). While cooperation appeared to be proceeding smoothly, the Rhine's pollution levels did not significantly decrease. In fact, as the industrial clusters along the Rhine river banks grew, so did the amount of pollutants entering the water. The pollution of the Rhine increased public awareness, and following a number of smaller incidents and a serious chemical accident in the Main tributary in 1969, political pressure increased to strengthen ongoing environmental restoration efforts (ICPR, 2023). This new political weight brought attention to the salination of the Rhine due to discharge from potassium mines in the Alsace, France (Malle, 1996). Although the issue had been noted decades ago, it was only in 1976 that the Convention on the Protection of the Rhine against Chloride Pollution (Chlorides Convention) took place, in which chloride discharge was limited to a significantly lower load than before (Schiff, 2017; ICPR, 2023; Malle, 1996). Alongside the Chlorides Convention, the Convention on the Protection of the Rhine against Chemical Pollution (Chemical Convention) was signed to reduce the instream of heavy metals from chemical industrial areas into the Rhine (Malle, 1996; ICPR, 2023). As a result, the first restoration measures were successfully implemented to improve the water quality of the Rhine river. Organic and chemical pollution was reportedly reduced for the first time in 1977 and the water quality continued to improve until 1986 (ICPR, 2023). Additionally, the ICPR acknowledged the impact of thermal pollution of the Rhine, mainly caused by power plants which discharged heated water directly into the river (Uehlinger et al., 2009). As a solution, cooling towers were introduced to decrease the temperature of discharge water before entering the Rhine.

4.3.4. A disastrous new beginning (1986-2000)

In 1986, a large fire broke out at the warehouse of Sandoz A.G. in Basel (Schiff, 2016). The warehouse contained large amount of chemicals and pesticides which, while extinguishing the fire, mixed with the firefighting water (Malle, 1996). The severely polluted run-off then flowed into the Rhine, which decimated water quality and aquatic life as far as hundreds of kilometers downstream from the accident. Reportedly, almost all living organisms from Basel to Koblenz (± 400 kilometer apart) were killed by the accident and washed up on the shores of the Rhine, whose water turned red due to the severe pollution (Schiff, 2017). In a span of weeks, three other chemical accidents took place at the burned-out warehouse and at a nearby chemical plant, further polluting the Rhine catchment area with severe chemical spills and a gas leakage (Schiff, 2016). As a result of this sequence of disasters, public pressure for adequate political action towards protection and restoration of the Rhine water quality and ecosystem rose to an all-time high. Subsequently, the ICPR signed off on the Rhine Action Program (RAP) in 1987 (ICPR, 1987a; ICPR, 2023). With the RAP, riparian states raised their ambitions for the Rhine restoration efforts. The ICPR strived to improve hydrological and biological riverine conditions by reducing the likelihood of (chemical) disasters, reducing water- and sediment pollution and consequently aiming for the return of native species, all to be achieved by the year 2000 (ICPR, 1987a). While drafting the RAP, the Dutch envoy alluded to the previously signed Salmon Treaty, which, as it was merely focused on limiting overexploitation, had not been as effective in fostering a vital salmon population in the degraded Rhine river. Nevertheless, the treaty was legally binding for all riparian states, which served as a sound foundation for international cooperation and action under the newly established RAP (Lachsvertrag, 1885). Thus, to guide the Rhine ecosystem restoration process, the ICPR specifically underlined the Atlantic salmon as an indicator species, focusing restoration efforts on meeting the habitat requirements of the fish species. This was the first time that the salmon was truly underlined as an indicator species to guide the Rhine ecosystem restoration process and to monitor the progress (Lachsvertrag, 1885; ICPR, 1987a). Part of the RAP was 'Salmon 2000', a specific

supplementary report focused on the improvements needed to revitalize ecosystem elements that were necessary for the salmon population to return to Rhine (ICPR, 1987b).

From 1987 onwards, the ICPR underwent an extensive development process to create a holistic approach to international water management of the Rhine river basin. In 1993, with the establishment of the European Union (EU), the objectives of the ICPR were formalized on a larger international scale (ICPR, 2023). Shook up by flooding incidents in 1993 and 1995, the commission also gave more attention to the creation of the Flood Action Plan and giving back land to free up the old course of the river (Disse & Engel, 2001; ICPR, 1995). The new water management approach accounted for all sectors and stakeholders that use and affect the water (quality) of the Rhine, from agriculture and drinking water production to industries and water transportation (ICPR, 2023). All details of this approach were integrated into the Convention on the Protection of the Rhine (Rhine Convention) in 1999 (ICPR, 1999). In 2000, the EU drew up the Water Framework Directive, a binding integrated water management approach for all water bodies of EU member states, which had a lot of similarities to the previously constructed management approach of the Rhine river (Uehlinger et al., 2009). The aim of the Water Framework Directive was to achieve a good state of all water bodies from member states of the EU by 2015, including member states within the Rhine catchment which were no official member of the ICPR (ICPR, 2023). By 2000, the Rhine restoration progress, led by the RAP objectives, was evaluated. When evaluating based on goal attainment, various positive results were achieved during the prior years: pollutant and nutrient concentrations had been significantly reduced, waste water treatment facilities had been constructed and noteworthy efforts were made to restore the ecosystem of the salmon, such as improving the accessibility of salmon spawning grounds (Dieperink, 1997).

4.3.5. 'Rhine 2020' and 'Rhine 2040' (2000-present)

From 2000 onwards, the ICPR continuously kept improving restoration measures by regularly evaluating existing policies and its difficulties and imperfections. With 'Rhine 2020', the ICPR extended its vision towards 2020 (ICPR, 2001b). Key points were the restoration of floodplains, reconnecting Rhine tributaries, increasing the riparian structural richness (biodiversity in various vertical layers of vegetation) of Rhine and its tributaries and lastly, improving the passability of the Rhine for migratory fish, ensuring an accessible river course connected from the sea to the upper reaches. The focus on the Atlantic salmon as an indicator species, tracing back to 'Salmon 2000', was expanded with a new supplementary report: 'Rhine & Salmon 2020', often shorted to 'Salmon 2020' (ICPR, 1987b; ICPR, 2001a). This report reflected on the current status of the salmon and its ecosystem, accompanied by specific measures needed to improve the quality of the Rhine as a habitat.

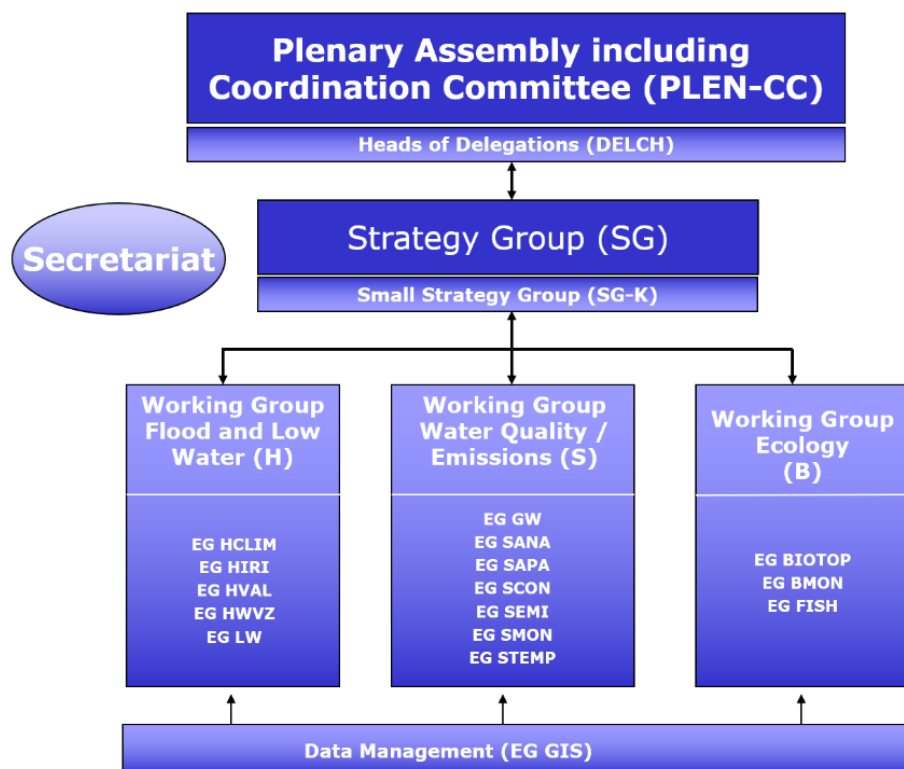
In 2020, the latest evaluation of restoration efforts has taken place when putting together 'Rhine 2040' (ICPR, 2020a; ICPR, 2020b). Prior to the construction of Rhine 2040, an overview was given of the Rhine 2020 objectives and the progress, compiled in the report 'Assessment "Rhine 2020"' (ICPR, 2020a). Based on the previously mentioned key points, varying success could be reported. The restoration of floodplains and the reconnection of tributaries turned out to be quite successful as all goals were obtained. The ecological restoration of riparian ecosystems and the return of structural richness turned out to be a bottleneck in restoration efforts, as approximately only 20 percent of the planned areas were restored by 2020. Although significant progress had been made on improving the passability of the Rhine by removing up to 600 migration barriers for anadromous species, only 28 percent of the historic habitat of the Atlantic salmon was readily accessible for the species. The species is showing signs of return as a couple hundred released juvenile salmon are able to reach and reproduce in Rhine tributaries. Nevertheless, the species is not yet self-sustaining and is still unable to reach spawning grounds in upstream Switzerland. Success on improving the Rhine water quality has been varying as well. Pollution by heavy metals has been reduced significantly, and the goal for the reduction of

nitrogen pollution has been achieved as well. The chemical and organic pollution of nutrients has however not been reduced compared to the year 2000, which can mainly be attributed to a stagnation in the sustainable development of agriculture and urban areas. Although not fully obtaining the planned results in water level reduction, the proposed Flood Action plans have successfully been implemented, making the Rhine catchment area more resilient to high water levels, which can occur more frequently as a result of climate change. Due to climate change, both high- and low-water level measures are further developed and/or implemented due to ensure a resilient, safe and vital Rhine during all climate conditions. Additionally, further research is conducted on the impact of climate change on the Rhine water balance, ecosystem and water quality, while simultaneously exploring additional required restoration and protection measures.

Rhine 2040 builds upon the highlighted bottlenecks from the Rhine 2020 evaluation and introduces additional goals and measures to be achieved by 2040 (ICPR, 2020b). Key points of Rhine 2040, which show large similarities with the above mentioned progress evaluation, include further increasing the passability of the Rhine, ecological restoration and protection of riparian ecosystems, further reconnecting Rhine tributaries and their ecosystems and further improving temperature and oxygen conditions. Additionally, the ICPR aims to further decrease nutrient pollution and to develop a sound monitoring system to track progress. Relatively new is the focus on decreasing (plastic) litter pollution in the Rhine and its sediment, which was briefly mentioned for the first time in Rhine 2020 (ICPR, 2001b). As the impact of climate change increases, the ICPR has developed more ambitious goals for low- and high-water situations. These goals include reducing flooding risk by implementing additional measures, increasing flood risk awareness of the population of the Rhine catchment area and lastly developing measures to prevent (negative consequences of) a low-water level (ICPR, 2020b).

Figure 3

Organization chart of the ICPR



Note. This organization chart was retrieved from the ICPR website (ICPR, 2024c).

Currently, the ICPR operates according to the organization chart depicted in Figure 3, which will be briefly explained in broad terms. At the bottom of the organization chart is an Expert Group Data Management, focusing on the creation of illustrative documents using available data to report on the progress of the restoration of the Rhine ecosystem (ICPR, 2024c). This Expert Group often works closely with all other Expert Groups, which each serve as dedicated platforms for sharing information and insights among scientific experts from all riparian states on various topics (ICPR, 2024c). The Expert Groups are organized in three Working Groups, representing the main issues in the restoration of the Rhine ecosystem: Flood and Low water, Water Quality and Emissions, and Ecology. Each Working Group has its own specific tasks and mandate for the (coordination of the) restoration of the Rhine, as described in the Rhine 2040 program, amongst coordinating the implementation of various EU Directives on a catchment area scale (ICPR, 2024c). Additionally, these Working Groups formulate scientific recommendations for the adjustment or expansion of ecosystem restoration measures. Above all Working Groups is the Strategy Group, tasked with nuancing the scientific recommendations to formulate policy recommendations, ensuring a possibly better political fit in search of common ground for the refinement or expansion of restoration measures (ICPR, 2024c). These recommendations are then submitted to Plenary Assembly, the annual meeting for discussion and negotiation by national delegations of all riparian states (ICPR, 2024c). Lastly, the secretariat oversees the organization of ICPR meetings, manages both internal and external communication, and facilitates language assistance among all riparian states (ICPR, 2024c).

4.4. Conclusion

In conclusion, various factors have contributed to the decline of the Atlantic salmon population, such as overexploitation, damming, pollution, the invasion of non-endemic species and climate change. The decay of the Rhine river can be traced back to the age of Industrialization in the mid-19th century, which led to pollution, waste discharge, agricultural intensification, deforestation, the construction of hydroengineering projects, channelization and new polluting transportation methods. In the following decades, unsuccessful efforts were made to restore the Rhine ecosystem. It was only until the establishment of the ICPR in 1950 that some progress was made on fostering international collaboration on ecosystem restoration. Nevertheless, progress was slow and almost nullified by the Sandoz disaster in 1986. It was only after the disaster that the foundation was laid for true riverine ecosystem restoration with the drafting of the Rhine Action Program and later the Convention on the Protection of the Rhine. From 2000 onwards, restoration of the Rhine ecosystem was backed by EU Directives, which added additional legitimacy to the international collaboration under the ICPR. The latest ICPR report 'Rhine 2040' encompasses the current ambitions for Rhine ecosystem restoration for the years to come. The next chapter looks at the success of the restoration of the Rhine ecosystem so far, with the main objective of reintroducing a self-sustaining Atlantic salmon population. Subsequently, the results of the case study on the Rhine will be presented.

5. Assessment of the governance of the Rhine basin ecosystem restoration

5.1. Introduction

In this chapter, firstly an answer is formulated to the question: *To what extent can the ecosystem restoration process of the Rhine river to bring back the Atlantic salmon be considered a success?* Subsequently, the results of the case study are presented to answer the subquestion: *What are enabling and restricting factors in the ecosystem restoration process of the Rhine river to bring back the Atlantic salmon?* Each governance condition is graded using the Traffic Light Assessment Scale on their presence in the Rhine case study, highlighting the factors that facilitate and hamper successful restoration of the Rhine river ecosystem. In addition, four additional governance conditions, as derived from the PDA and SLA, are assessed on their perceived importance by the interview respondents and thus on their possible inclusion in the refined framework. Lastly, the perceived importance of the governance condition by the interview respondents is elucidated.

5.2. The current status of the return of the Atlantic salmon to the Rhine river

The current status of the restoration of the Rhine ecosystem and the progress made on fostering the return of the Atlantic salmon to the waters of the Rhine can be derived from the latest reports of the ICPR. As the drafted objectives in the 'Rhine 2020' report were used as a guideline for the ecosystem restoration efforts from 2001 until 2020, the progress report 'Assessment Rhine 2020' can be used to assess the effectiveness of Rhine ecosystem restoration efforts. From these reports, an assembly of objectives was made, focusing solely on targets that can be directly related to fostering the return of the Atlantic salmon, as visible in Table 7. The objectives were each assessed on the progress made, as reported on in 2020 (ICPR, 2001b; ICPR, 2020a).

Table 7

Objectives from the ICPR to foster the return of the Atlantic salmon to the Rhine and the progress made

Objectives and progress	Achieved?
<p>1. <i>The reactivation of 160 km² of floodplains along the main stream of the Rhine</i></p> <p>The ICPR states that in 2018, 130 km² of floodplains had been reactivated. By 2020, an estimated 10 km² of extra reactivated floodplains were to be added to this total, which amounts to 140 km².</p>	
<p>2. <i>The connection of at least 100 oxbow lakes or lateral water bodies to the dynamics of the Rhine</i></p> <p>The ICPR states that in 2018, more than 120 oxbow lakes or lateral water bodies were re-connected to the dynamics of the Rhine. By 2020, more than 140 oxbow lakes or lateral water bodies were estimated to be re-connected.</p>	
<p>3. <i>Increasing the structural diversity of 800 km of riverbanks along the Rhine</i></p> <p>The ICPR states that in 2018, 166 km of riverbank measures were implemented to increase the structural diversity. By 2020, an estimated amount of 60 km riverbank measures were to be added to this total, which amounts to 196 km.</p>	
<p>4. <i>The restoration of the ecological continuity of the Rhine to Basel and in the tributaries from the Migratory Fish Programme for upstream and downstream migrating fish</i></p> <p>The ICPR states that approximately 600 fish migration obstacles were removed from the Rhine and its tributaries, or fish passages were constructed to restore the ecological continuity. However, the passability of the Rhine from the North Sea to Switzerland has not been achieved.</p>	
<p>5. <i>Achieving self-sustaining populations of Atlantic salmon</i></p>	

The ICPR states that the Atlantic salmon population in the Rhine is not yet self-sustaining and has to be supported by stocking measures.	
<i>6. Making it possible to obtain drinking water using simple, near-natural treatment processes and ensuring that water constituents neither individually nor in their interaction have adverse effects on the biocoenoses of plants, animals and microorganisms</i>	
<i>6a: Significant reduction of nutrient concentration.</i> The ICPR states that a significant reduction of phosphate and nitrogen concentrations was not achieved by 2020.	
<i>6b: Significant reduction of metals concentration.</i> The ICPR states that a significant reduction of metal concentrations was achieved by 2020.	
<i>6c: Significant reduction of pesticides concentration.</i> The ICPR states that a significant reduction of pesticide concentrations was not achieved by 2020.	
<i>6d: Significant reduction of micropollutants concentration.</i> The ICPR states that a significant reduction of micropollutant concentrations was not achieved by 2020.	

Source. 'Rhine 2020' and 'Assessment Rhine 2020' reports (ICPR, 2001b; ICPR, 2020a).

The overview created in Table 7 of the restoration progress of the Rhine ecosystem is not complete, as various objectives and their accompanied progress were not included, as they have a more indirect (or no) relation to the return of the Atlantic salmon to the Rhine. Additionally, some objectives were rather ambitious and still almost achieved, so the progress made should therefore not be trivialized. Nevertheless, the created overview in Table 7 is of importance to underline the value of this research. When referring back to the demarcated definition of 'successful ecosystem restoration', which is the achievement of the set goals for ecosystem restoration, this has not yet been achieved at the Rhine river case study, as no self-sustaining Atlantic salmon population has been established. As the stated objectives of ecosystem restoration by the ICPR are not yet met, this demonstrates the room for improvement of the ecosystem restoration measures and possibly indicates the absence of specific governance conditions to facilitate the ecosystem restoration process. In the next section, the case study results are elucidated, focusing on the presence of the various governance conditions. From these results, difficulties and challenges in the governance of the Rhine ecosystem restoration process are derived that hamper the achievement of the set objectives by the ICPR for the restoration of the Rhine ecosystem.

5.3. Presence of governance conditions

In this section, the results of the case study on the governance of the restoration of the Rhine ecosystem will be elucidated. In the form of a narrative, each governance condition is examined on their presence in the governance structure of the ICPR to restore the Rhine ecosystem. The section of each respective governance condition is titled with its keyword, directly followed by the full governance condition in cursive. Following the assessment of governance conditions, the additional governance conditions derived from the PDA and the SLA will be touched upon, assessing their perceived importance to fostering successful ecosystem restoration and thus their possible inclusion in the refined framework. Lastly, an evaluative section is presented in which the respondents of the expert interviews give their perception on the importance of the governance conditions in fostering successful riverine ecosystem restoration. In Table 8, the results of the grading of all governance conditions on the Traffic Light Assessment Scale is presented. The colour red indicates that a governance condition is absent from the current governance structure, orange indicates that a governance condition is partially present, and green indicates that a particular governance condition is fully fulfilled.

Table 8

Results of grading of each governance condition on the Traffic Light Assessment Scale

Attribute	Dimension	Governance condition	Keyword	
FUNDAMENTAL	<i>Legislation</i>	Ecosystem restoration is protected by and embedded in institutional arrangements and legislation.	Nested	
		The ecosystem restoration organization has the power to transform existing institutional restoration arrangements or institutionalize new restoration arrangements.	Transformative power	
		The ecosystem restoration organization has the will and power to legislatively enforce on the breaching of institutional restoration arrangements.	Enforcement	
	<i>Governance structure</i>	Ecosystem restoration management takes place at a cross-border, fluvial scale to ensure synergy between individual restoration measures	Synergy	
		Room is given to bottom-up, grassroots participation in the restoration process through designated communication platforms	Participation	
		There is a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process.	Clear task division	
		Employees of the ecosystem restoration organization are of multi-disciplinary backgrounds, thus accounting for the multi-dimensionality of the restoration area.	Multi-disciplinary	
		The ecosystem restoration organization has a concise strategy to resolve conflicts through consensus resolution.	Conflict management	
	STRENGTHENING	<i>Financing</i>	Contributions of actors to ecosystem restoration are financially rewarded.	Financial incentive
			Ecosystem restoration has economic benefits for partaking actors, besides possible direct reward structures (e.g. business development; protection of natural capital)	Economic benefits
Clear viable and long-term agreements are present to finance the ecosystem restoration project.			Financial agreements	
<i>Information</i>		There is a clear demarcated and designated role for scientists and research in the governance structure of the ecosystem restoration organization.	Designated role for science	
		The creation and implementation of restoration policies and measures is fundamentally supported through research and insights on the restoration area.	Informed plan-making and execution	
		Ecosystem restoration measures are weighed against alternative measures to assess the most favorable societal impact.	Trade-off management	

		The ecosystem restoration process is actively supported by research to reduce and cope with uncertainties in the restoration process.	Reducing uncertainty
	<i>Support</i>	The ecosystem restoration project is supported by political will and adequate state support. This can be facilitated by active political brokering.	Political support
		The ecosystem restoration organization deploys an active capacity building process to increase the support base of the restoration project by including more actors and stakeholders.	Capacity building
COMMANDING	<i>Leadership</i>	Strong, inspiring leadership of individuals with experience and a relevant background.	Individual leadership strength
		Collaboration is coordinated by ensuring all partaking actors in the ecosystem restoration process share the same goals and vision for the project.	Coordinated shared vision
		Actors are held accountable for a timely implementation of restoration measures	Efficient
	<i>Discourse</i>	The ecosystem restoration organization has a platform to compromise on stakeholder discourses, thus accounting for different values and opinions for ecosystem restoration.	Recognition of different perspectives
DEVELOPING	<i>Adaptation</i>	The ecosystem restoration project has clear long-term goals, which are flexible to anticipate for future uncertainties.	Long-term planning and anticipation
		The ecosystem restoration organization continually improves its restoration policies and measures by evaluating the outcomes of existing policies and measures.	Organizational adaptive management
	<i>Innovation</i>	The ecosystem restoration organization has an organizational culture open for innovation, where experimental policies and measures are implemented to test new ideas.	Open and innovative organizational culture

5.3.1. Nested

Ecosystem restoration is protected by and embedded in institutional arrangements and legislation

In conclusion, the ambitions for ecosystem restoration of the Rhine are deeply nested in institutional arrangements and legislation, which have evolved over decades of international cooperation. Historically, legal frameworks have provided a robust foundation for collaborative efforts. The inclusion of the European Community as a contracting party elevated restoration initiatives to a higher political level, guided by directives such as the Water Framework Directive and the Flood Risk Management Directive. These directives not only contribute significantly to the ICPR program but also provide enforcement through the European Court of Justice. Therefore, the governance condition 'Nested' is graded **GREEN on the Traffic Light Assessment Scale.**

The ICPR was brought to life on an informal basis in 1950 as an international agreement between the riparian states to work on the ecosystem restoration of the Rhine (Myint, 2003). In this year, the first Conference of Ministers was also held as a means to discuss problems and solutions surrounding the

pollution of the Rhine. It was only until 1963 that the riparian states agreed to officially establish the ICPR as a committee during the Bern Convention, while strengthening the organization with an official secretariat based in Koblenz (Chase, 2011; Myint, 2003; Schiff, 2017). At this convention, the official tasks of the ICPR and its organizational structure were agreed upon, which allowed the committee to draft official treaties for countries (as a contracting party) to sign, as a means to formalize negotiated agreements (Chase, 2011; Schiff, 2017; Wieriks & Schülte-Wulwer-Leidig; 1997). As a result, the ICPR drafted the Convention on the Protection of the Rhine against Chemical Pollution and the Convention on the Protection of the Rhine against Chloride Pollution in 1976, which is the same year in which the European Community joined the ICPR as a new contracting party (Mostert, 2009; Myint, 2003). After the accident at Sandoz, the ICPR established the Rhine Action Program in 1987, which institutionalized a nature rehabilitation program and working program with a flexible *modus operandi* for the riparian states to individually work towards the same agreed-upon goals on a national level (Da Silveira & Richards, 2013; Schiff, 2017). Consequently, national rules, legislation and working programs started to develop on the protection and restoration of species and habitats (ICPR, 2003; Respondent 6). Ultimately, in 1999, the Convention on the Protection of the Rhine was signed and adopted by all riparian states, replacing the earlier established international agreements on the management of the Rhine (ICPR, 2020a; ICPR, 1999; Schiff, 2017). The Convention on the Protection of the Rhine forms the legal basis for international cooperation on sustainable development and ecosystem restoration of the Rhine catchment area (ICPR, 1999). From this legal basis, new international working programs, such as 'Rhine 2020' and 'Rhine 2040', were formulated to report on restoration process and to set new goals for the future (ICPR, 2020a; ICPR, 2020b).

As mentioned by Da Silveira & Richards (2013), the inclusion of the European Community as a contracting party to the ICPR led to a shift of power to a higher political level. This created a new dynamic for the international cooperation, as ecosystem restoration is now structurally guided by EU directives, such as the Water Framework Directive, the Flood Risk Management Directive and the Habitats Directive (ICPR, 2020a; ICPR, 2020b; ICPR, 2003; ICPR, 2001a; Schiff, 2017; Respondent 1; Respondent 2; Respondent 4; Respondent 5). This is even mentioned in the 'Assessment Rhine 2020':

"The Water Framework Directive (WFD - Directive 2000/60/EC) and the Flood Risk Management Directive (FD - Directive 2007/60/EC) have contributed significantly to the implementation of the ICPR programme" (ICPR, 2020a)

These European directives protect ecosystem restoration on a higher institutional level, as the European Court of Justice has the power to enforce riparian states that defect from their agreements with fines (Schiff, 2017; Respondent 3). Respondent 4 even mentions the European Green Deal, which still needs to be voted upon, as an additional legal basis for ecosystem restoration:

"With now the entire Green Deal, which includes Free Flowing Rivers, and the nature restoration law that has just been passed. That really gives us extra support from Europe for why we have national legal goals and that they will continue to be maintained. Or may need to be tightened up." (Respondent 4)

5.3.2. Transformative power

The ecosystem restoration organization has the power to transform existing institutional restoration arrangements or institutionalize new restoration arrangements

This governance condition largely overlaps with the governance condition 'Nested'. In the previous section, the question was answered whether the ecosystem restoration process of the Rhine is embedded in institutional arrangements and legislation. In order to formulate a concise answer to

this question, a brief summary of the historical regime development of the ICPR was given, as a means to emphasize and elucidate the contemporary nested and protected restoration process of the ICPR. Simultaneously, by underlining the historical regime development, it becomes clear that the ICPR has transformed its own character and structure through institutional development or by institutionalizing new international arrangements. However, respondents criticize the lack of power of ecological values when confronted with economic interests in the formulation of new conservation or restoration agreements, which restrains the institutionalization of ecosystem restoration to limiting damage, instead of 'true' conservation and restoration. As there are still notable challenges in the institutionalization of ecosystem restoration as a means to prompt progress, the governance condition 'Transformative power' is graded **ORANGE** on the Traffic Light Assessment Scale.

From when the ICPR was officially established at the Bern convention in 1963, the organization exerted its transformative power by drafting various conventions, establishing the RAP, broadening its scope with the Flood Action Plans and guiding its restoration progress and ambitions with the Rhine 2020 and Rhine 2040 reports (ICPR, 2020a; ICPR, 2020b; Chase, 2011; Myint, 2003; Schiff, 2017; Mostert, 2009; Da Silveira & Richards, 2013). The development from a rather informal discussion platform on sustainable development to an international cooperation formalized through conventions and accompanied by (inter)national working programs reveals the political embeddedness of the ICPR and its ecosystem restoration mission.

Nevertheless, two respondents highlight two defects in the current coverage of the institutional embeddedness of the ecosystem restoration efforts. Respondent 7 emphasizes the shortcoming of institutional arrangements to truly constitute conservation and restoration process, as current arrangements are predominantly focused on solely limiting the damaging impact of actors:

"In fact, the only thing for them is that they have to meet most of the legal requirements, so they [actors whose activities have an impact on the Rhine ecosystem] do have to have a nature law permit, for example, but that is only aimed at not causing significant damage, there is no test for recovery and that is why we remain standing still." (Respondent 7)

Respondent 7 continues by criticizing the role of environmental impact analyses, which have a profound role in the decision-making process with regard to interventions that might harm the Rhine ecosystem:

"In this way, an objective picture is formed that we will never get further than just an impact analysis. And that is then added as an argument to the decision-making process for administrators or ministers. Then ecology gets a plus, this is also good. But that's just a really bad decision, disinformation. Actually there should just be a minus there." (Respondent 7)

Although the ICPR has shown to be able to develop and transform international institutional arrangements with regard to ecosystem restoration, Respondent 7 indicates that the value of ecology remains one of many in discussions with conflicting interests. A similar scenario is brought to light by Respondent 6 when discussing the legislation surrounding water quality of the Rhine:

"If you see what is happening now, for example around PFAS [per- and polyfluoroalkyl substances], there are also a number of large industrial dischargers along the Rhine, which we really have no control over. There is no legal or federally agreed standard for PFAS and for that reason we cannot set a limit value or limits on the discharge that takes place here. It is simply bizarre that after so many years of the Rhine Commission we still have to put these kinds of matters on the agenda." (Respondent 6)

Respondent 6 mentions additional lingering shortcomings in the current institutional arrangements surrounding the Rhine water quality improvement, regardless of the fact that the pollution of PFAS is acknowledged and has been repeatedly raised as an issue. Both critiques of Respondents 6 and 7 hint at a lack of power of ecological values when confronted with economic interests in the formulation of new conservation or restoration agreements, which is a recurring topic in this research. Although the organization itself is nested in sound international institutional arrangements, Respondents 6 and 7 highlight that ecosystem restoration at times comes to a standstill at 'just' conservation.

5.3.3. Enforcement

The ecosystem restoration organization has the will and power to legislatively enforce on the breaching of institutional restoration arrangements

Conclusively, the ICPR lacks the power to enforce on the breaching of institutional arrangements, although public naming and shaming plays a large and seemingly functional role on the compliance of actors with the made agreements. The drafted EU directives stray away from the soft law approach of the ICPR and give hard deadlines, which are legally binding and enforced by the European Court of Justice. Although the EU directives do not completely overlap with the working programmes of the ICPR, they are a profound addition to ensure compliance with environmental agreements within the EU. The combination of ICPR goals and ambitions, public pressure and legal enforcement mechanisms creates a more robust system for holding actors accountable for their actions. As these directives are relatively new additions, it will be important to monitor their effectiveness in achieving environmental goals and promoting sustainable practices within the EU. Additionally, ongoing collaboration between the ICPR and EU institutions will be crucial to ensure coherence and alignment in environmental policy implementation. For now, the governance condition 'Enforcement' is graded **ORANGE on the Traffic Light Assessment Scale.**

As briefly mentioned in section 4.3.1.1, the Convention on the Protection of the Rhine signed in 1999 serves as the legal basis for international cooperation with regard to the ecosystem restoration of the Rhine (ICPR, 2020a; ICPR, 1999; Schiff, 2017). Although this means that the restoration arrangements are institutionalized, this convention is not legally binding (ICPR, 1999). The ICPR takes a soft law approach with regards to the fulfillment of the agreements (Respondent 1; Respondent 2; Respondent 3; Myint, 2003). As an organization, it stays informed of all national progress made, which is reported to the secretariat and combined to get an image of the ecological state of the whole Rhine catchment area (Respondent 4; ICPR, 2020a). Combined with its own monitoring network, the ICPR is able to pinpoint sources of pollution to the polluter, after which the actor is informed or possibly included in the cooperative restoration process (ICPR, 2020a). On paper, there are no means of enforcement or imposition on the level of the ICPR (Respondent 1; Respondent 2; Respondent 6; Mostert, 2009; Schiff, 2017). However, the ICPR proceedings and reports are not confidential. NGO's can apply for an observer status, after which they can attend the ICPR meetings. At the same time, the ICPR reports and any involvement of NGO's is made publicly available, which ensures that the eyes of the public are always on the progress of ecosystem restoration (Respondent 2; Myint, 2003). Any actors who are unwilling to cooperate or who underperform based on their promises, are captured by the pressure from the public opinion, watch groups or stakeholders with conflicting interests (Myint, 2003). On a national level, the foundation for action is a political promise, which builds upon international agreements made by the Rhine ministers (Respondent 1). The ICPR can go as far as making recommendations for the proceedings of riparian states (Respondent 3; Myint, 2003; ICPR, 2003). This soft law approach is not always favored by the respondents of this research:

“On the one hand, there is a development of policy that pushes everyone in a certain direction and on the other hand, the realization of that policy is left to the member states, or to water boards or municipalities. There isn't a lot of pushing momentum yet.” (Respondent 5)

“Well, all the countries, they could do more. They could do more, because it's always recommendations of the Commission of the Rhine. It's a very soft control, and therefore also not enough pressure.” (Respondent 3)

Although progress is being made, it is perceived as slow, as Respondents 3 and 5 harkle the lack of pressure and enforcement from the ICPR. Nevertheless, the involvement of the EU has transformed the political playfield. Ecosystem restoration is now structurally guided by EU directives, such as the Water Framework Directive, the Flood Risk Management Directive and the Habitats Directive (ICPR, 2020a; ICPR, 2020b; ICPR, 2003; ICPR, 2001a; Schiff, 2017; Respondent 1; Respondent 2; Respondent 4; Respondent 5). In contrast to the ICPR action plans or working programs, these European directives are legally binding: the European Court of Justice has the power to enforce riparian states that defect from their agreements with fines (Mostert, 2009; Schiff, 2017; Respondent 3). Additionally, these directives give clear deadlines for restoration progress to be complied with, ensuring that ecosystem restoration is transposed into national law and legislation (Schiff, 2017). The involvement of the EU is perceived as positive to stimulate ecosystem restoration process (Respondent 2, Respondent 2, Respondent 4), which is best expressed by Respondent 3:

“If you compare it with the EU Commission. Then we have to do something for the nature, otherwise the EU Commission will punish us with money, which we would need to pay every day. We live in a very economical world, so monetary punishment does function better and we don't have it in the Commission of the Rhine.” (Respondent 3)

5.3.4. Synergy

Ecosystem restoration management takes place at a cross-border, fluvial scale to ensure synergy between individual restoration measures

The international collaboration through the ICPR is a textbook example of integrated river management on a catchment area scale, with a strong focus on information sharing. Besides ongoing efforts to harmonize national efforts on an international, cross-border scale, there is a stated purpose and desire to further develop intra-regional collaboration in the coming decades. Therefore, the governance condition ‘Synergy’ is graded **GREEN on the Traffic Light Assessment Scale.**

The restoration of the Rhine ecosystem is a process which is carried out on a national scale, but coordinated on an international scale (ICPR, 2020a; ICPR, 2020b; ICPR, 2001a; Chase, 2011; Myint, 2003; Wieriks & Schulte-Wülwer-Leidig; 1997). Riparian states are responsible for the implementation of restoration measures between their own state borders, but the Rhine ecosystem is considered an entity on a catchment area scale (ICPR, 2020a; ICPR, 2003; Myint, 2003). National efforts are coordinated internationally, as the ICPR acts as an exchange platform for information, knowledge and experiences (ICPR, 2020b; Myint, 2003). The results of scientific studies are shared through the ICPR to inform other riparian states of best practices (ICPR, 2020b). The international cooperation in the ICPR even transcends the level of the EU, as non-EU states such as Switzerland and Liechtenstein also participate (Mostert, 2009). The ICPR coordinates the process of harmonizing national restoration efforts, as focus is put on cross-border integrated approaches (ICPR, 2020a; ICPR, 2020b). These approaches aim to create a synergy between individual restoration measures, but also to combine diverse river management objectives, such as flood protection and nature conservation (ICPR, 2020b; Wieriks & Schulte-Wülwer-Leidig; 1997). One of the mentioned objectives in Rhine 2040 is to further

support the implementation and initiation of cross-border projects, with the aim to harmonize and streamline these efforts (ICPR, 2020b). Through the EU, the ICPR can even offer financial support focused specifically on intra-regional collaboration and projects, as the INTERREG subsidy scheme was brought into existence for this exact aim (ICPR, 2020b).

5.3.5. Participation

Room is given to bottom-up, grassroots participation in the restoration process through designated communication platforms

In this research, no clear defects or shortcomings were noted in the stakeholder participation strategies and methods of the ICPR. As noted by the ICPR in Rhine 2040, the scope of the stakeholder participation needs to be broadened to include more relevant stakeholders in the restoration process of the Rhine, with the aim to increase the effectiveness of restoration measures and to gain more public attention and support. Considering this expressed desire to continue developing stakeholder participation processes, the governance condition 'Participation' is graded GREEN on the Traffic Light Assessment Scale.

Myint (2003) describes how before the drafting of the RAP, stakeholder participation was almost non-existent. The success of the Chemical Convention in 1976 can be described as fairly limited because of the absence of participation of stakeholders during the negotiation and implementation of the convention, leading to a low impact and support for the restoration measures (Myint, 2003). This was recognized by the ICPR when drafting the RAP in 1987, and from then on local stakeholders and non-state actors were invited to join the ICPR Working Groups (Myint, 2003; Respondent 2). It was only until 1996 that the ICPR truly started to open up for stakeholder participation by inviting NGO's to attend the meetings of the ICPR (Mostert, 2003; Da Silveira & Richards, 2013). The participation activities to actively include more NGO's amongst other stakeholders in the decision-making process about restoration measures were formalized under the Convention on the Protection of the Rhine in 1999 (Mostert, 2003; ICPR, 1999).

The contemporary ICPR frequently organizes meetings and workshops with active users and stakeholders of the Rhine to draft shared visions and objectives for the restoration of the Rhine ecosystem (ICPR, 2020a; Respondent 2). Respondent 2 describes the inclusion of stakeholders as an "ongoing every day process", as regular meetings are held with NGO's ranging from "nature conservation to drinking water supplies, chemical industry and so on". When discussing the importance of stakeholders inclusion, Respondent 2 mentions:

"We will come together and talk for several hours and we just sit there and listen and ask them: What are your wishes? What do you think? Are we on the right way or how we should we change? Then we take all this information home and think about it and say, OK, they are right or they are wrong. And then we give them an answer to questions and so on. And this is everyday work. The other day we have emails to deal with that topic and so on. That's an ongoing process and these NGOs are also guests who are invited to participate in the discussion in the ICPR working groups. Especially on the strategic level, they play in very important role." (Respondent 2)

Respondent 4 mentions the participation of stakeholders from the private sector in the implementation of restoration measures. Excavation work to alter the flow of the river or to create more flooding areas is often outsourced to gravel or sand extractors (Respondent 4). The ICPR also mentions the large contribution of voluntary fisheries associations and nature protection association to the success of stocking measures for the salmon and other fish species in the Rhine catchment area (ICPR, 2001a). Additionally, as mentioned in section 4.3.1.3, public participation of NGO's and citizens

in debates or conflicts creates public pressure, which plays a large role in holding actors accountable to actively participate in the restoration process (Da Silveira & Richards, 2013; Respondent 2; Myint, 2003).

Rhine 2040 frequently mentions stakeholder participation as an active ongoing process which needs to be further developed in the coming years (ICPR, 2020b). The report mentions that “*cooperation with other intergovernmental and nongovernmental organizations (IGOs and NGOs) has intensified*” and that “*cooperation with recognised observers on the Rhine will be continued and further developed if necessary. Contact and cooperation with other stakeholders will be improved.*” (ICPR, 2020b, p. 25). As areas of improvement, the ICPR mentions that an intensification of cooperation with user interest groups is necessary to balance out the usage of water with the requirements for a healthy Rhine ecosystem (ICPR, 2020b). Additionally, a role needs to be developed for stakeholder participation in the cross-border collaboration projects, which requires more coordination than local efforts in a single riparian state (ICPR, 2020b). Stakeholder participation is finally mentioned as a distinct strategy to gain more public attention and support for the Rhine restoration process, whereas the ICPR wants to start up “*joint monitoring campaigns including citizen science projects (...) in coordination with the relevant NGOs and ICPR observers*” (ICPR, 2020b, p. 26).

5.3.6. Clear task division

There is a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process

In conclusion, the restoration process for the Rhine ecosystem involves a loosely defined task division among participating actors. The ICPR oversees the coordination of restoration efforts at a river catchment scale, setting international goals and objectives. However, the responsibility for implementing ecosystem restoration measures lies with the national governments, where each nation tailors restoration measures to address specific issues within its borders. The ICPR serves as a control system, ensuring that each riparian state is held responsible for implementing restoration measures. However, this approach faces criticism, with concerns raised about delays due to ambiguity in responsibilities and costs. In the Netherlands, for example, there's confusion over which authority is responsible for nature restoration along the Rhine. Thus, the governance condition ‘Clear task division’ is graded **ORANGE on the Traffic Light Assessment Scale.**

Although the Rhine ecosystem restoration process is coordinated at a river catchment scale by the ICPR, the responsibility for the implementation of ecosystem restoration measures is fixed at a national level (Mostert, 2009). The ICPR acts as a platform to establish international compromises in the form of goals and objectives, after which the riparian states are tasked with developing their own approach to ecosystem restoration (Chase, 2011). As Respondent 1 explains, the important decisions about goals and objectives within the ICPR are most often taken at the Ministerial Conferences. As a result, nation states have the option to tailor restoration measures to context-specific issues within the national borders (Chase, 2011; Mostert, 2009). Respondent 5 includes the European policies in his answer, which act as a fundamental support to the ICPR established goals and objectives, to briefly explain the task division in the restoration process:

“European policy guides what the member states do. (...) Governments, national and regional governments, are ultimately responsible for implementing policy.” (Respondent 5)

Within Germany, the decentralization of the implementation of restoration measures is even further divided, as explained by Respondent 2. Here, the eight federal states through which the Rhine flows need to coordinate their opinions and visions to eventually work united on ecosystem restoration in

the Rhine catchment area (Respondent 2). Chase (2011) even states that this flexible approach and task division is more effective to foster international cooperation than binding treaty with fixed measures would have been. Respondent 3 shares the statement of Chase (2011) and speaks out positively on the current organization of the attribution of tasks and responsibilities within the ICPR:

“It's the responsibility of the countries, of course, but in the end you have to give a report to the Commission and all the ministries have to state what they did to work towards the goals. So in the end, you don't want to have written in the report, the German delegation did not do anything. So it's our responsibility. It's our money and our human resources as well, but we have to produce results to fulfill the goals. And so it's very good that we have the Commission. The Commission will ask, what have you done? So it is like a control system, but I think it is OK!” (Respondent 3)

Respondent 3 refers to the ICPR as a control system to internationally coordinate the restoration progress and to ensure that each riparian state is held responsible for the timely implementation of restoration measures, while simultaneously alluding to the political and public pressure under which the riparian states operate. Respondent 2 shares a similar story and mentions that it is important *“that everybody knows what the others do, what the partners do. I think that the keyword is partnership”*. Respondent 6 describes the same control system of the ICPR as follows:

“In principle, the countries themselves are of course responsible for the measures in their area. And as I said, it mainly involves reporting to each other, this is what we have done. And that automatically puts the question on the table: what have you done? That's a bit of naming and shaming.” (Respondent 6)

The desirability and effectiveness of this control system and flexible approach to the attribution of tasks is not an opinion which is shared by everyone. The report ‘Assessment Rhine 2020’ even mentions the flaws of this strategy in the timely implementation of restoration measures (ICPR, 2020a):

“The transformation of the riverbank areas to a near-natural state is being prevented or at least delayed by the lack of clarity regarding responsibility for action and costs for large sections of the Rhine.” (ICPR, 2020a, p. 11)

An in-depth explanation of this very issue can be found in the interview with Respondent 7. Although the respondent explains that he solely speaks from his perspective and experience in the Netherlands, he states that this lack of clarity regarding the responsibility for action and costs is not necessarily an international issue, but a matter of internal national political ambiguity:

“In the Netherlands this is simply very poorly organized. Because to be very honest, no one actually knows who is in charge of nature restoration in the Rhine. Most people think Rijkswaterstaat, the I&W think differently about it, the LNV has doubts. They are sort of arguing with the provinces, and then there are also the water boards. But if you ask it face to face, no one actually has that formal obligation. And what you also see is that all kinds of things have been happening in the field for decades. Secondary channels are dug, land is purchased, which then takes on a natural function, but all often in the wrong place. Wrongly arranged, so that it looks natural, but does not benefit any species that you would want to do it for. The Natura 2000 and Water Framework Directive parameters also remain cheerfully in the red. So there really is a very big problem there at provincial level, so no one knows who is actually in charge.” (Respondent 7)

Respondent 7 addresses the lack of a clear task division on a national scale in the Netherlands, as multiple governance bodies and organisations feel partly but not fully responsible to take action and

bear the costs of the measures. In this research, no information was however found for a similar situation in the other riparian states. Respondent 4 does however give a direct point of criticism on the current flexible attribution of tasks and responsibilities, which is that the tasks at hand for the riparian states are not clearly defined:

“I am in the Working Group and above that you ultimately have the Strategy Group and above that the ministers and the ministerial conference. From my substantive working group, it always dilutes a bit into policy language and then it becomes a bit more abstract, which then has to be interpreted by a country.” (Respondent 4)

5.3.7. Multidisciplinary

Employees of the ecosystem restoration organization are of multi-disciplinary backgrounds, thus accounting for the multi-dimensionality of the restoration area.

Overall, the organizational structure of the ICPR considers the multi-dimensionality of ecosystem restoration, with working groups formed at strategic levels and focusing on specific points. The organization seeks individuals with specific scientific backgrounds to address a wide range of environmental issues. However, the political capacity of the ICPR is lacking when transferring policy goals and objectives to a national political playfield. As a result of the compartmentalization of policy and division of tasks among national ministries, they are unable to fully adopt the insights gained from the multidisciplinary information exchange on the level of the ICPR. The ICPR could improve its political strength to navigate the national political playfields of riparian states to ensure a better political fit for scientific knowledge and recommendations. A possible first step in this process could be to focus more on the inclusion of political sciences in the multidisciplinary scope of the ICPR. With this consideration in mind, this governance condition is graded **ORANGE on the Traffic Light Assessment Scale.**

For this specific governance condition, little to no information was found in the assessed policy documents and scientific literature. Although the role of experts is often mentioned in advising and supporting the political bodies with scientific knowledge, no clarification is given on the backgrounds and disciplines of these experts (ICPR, 2020a; ICPR 2020b; ICPR, 2003). Respondent 2 does however clarify how the multi-dimensionality of the ecosystem restoration process is taken into account in the ICPR organizational structure:

“It's a multidisciplinary issue, of course. And this is mirrored in how the working groups are formed. Especially on the strategic level, the high level above all these working group. The people we work here are on a high level in the ministries. Of course they have to think and to work multidisciplinary in the expert groups. On the other hand, you have real experts, which are very good in focusing on special points. And then, going up from experts, to working groups, to strategic groups, to a plenary session, step by step it gets more and more multidisciplinary and at the end you have to bring the ecological point of view and that of engineers and that of drinking water suppliers and of chemists and biologists together to then decide: What shall we do?” (Respondent 2)

Respondent 1, head of the ICPR secretariat, describes that multi-disciplinarity is taken into account when publishing new vacancies for the organization. As expected, a profile description is given for a new position at the ICPR, and when focusing on the scientific employees at the organization, people with a scientific background in natural sciences, biology, geography or chemistry are sought out (Respondent 1). This distinction is made per ICPR Working Group, in order to ensure that each team is well-rounded and diverse in their expertise, allowing for a comprehensive approach to research and problem-solving. By seeking individuals with specific scientific backgrounds, the ICPR can effectively

address a wide range of environmental issues and challenges. Respondent 1 was also asked about the interdisciplinarity of the organization, to see if the ICPR Working Groups work in a compartmentalized fashion, or if a mutual exchange of information is also formalized:

“We now also have a kind of informal steering group where the chairmen of the 3 groups ecology, water quality and chemistry and high and low water meet two or three times a year and ensure that they work closely with their groups, so it all becomes more interdisciplinary, including the collaboration between the groups.” (Respondent 1)

As Respondent 3 however underlines, this interdisciplinary collaboration between Working Groups is mostly focused on the exchange of information, whereas direct cooperation is less present on the ICPR agenda:

“Maybe we have to work together more, with all the working groups. So not just the biology or the ecology on its own, but more together, yeah. But the secretary tries to share the information from one group to the other. So it is starting to become a more combined working group. Yeah, maybe you're right, your idea of changing the structure may be a possibility in the future which is useful or necessary to act or to find solutions for the climate issues.” (Respondent 3)

At a first glance, the ICPR organizational structure ensures that the restoration of the Rhine ecosystem is studied and coordinated fairly multidisciplinary and interdisciplinary. Nevertheless, various respondents indicated that the scope of the ICPR needs to be broadened to include more scientific knowledge on underexposed topics. Respondent 4 underlines that the political capacity of the ICPR is lacking when transferring policy goals and objectives to a national political playfield. When asked about the multidisciplinary character of the ICPR, Respondent 4 answered:

“Yes, that can indeed be improved. As I said, there are also others on committees on the Rhine. There are several disciplines, but not everything, so it turns out to be very difficult to approach those different disciplines in a multidisciplinary or interdisciplinary manner. In the Netherlands, this is also due to the fact that we have divided it over different ministries and that the responsibilities within the ministries are also divided over different pillars. And shipping is in a different directorate than ecological water quality and nature is in LNV, so that's what you call the compartmentalization of policy. That really hinders multidisciplinary collaboration.” (Respondent 4)

The national compartmentalization of policy and division of tasks and responsibilities among national ministries hinders the multidisciplinary and interdisciplinary organizational structure of the ICPR, as policy recommendations are not directly applicable on a political playfield. This compartmentalization splits up the governance of topics relevant for the ecosystem restoration of the Rhine, whereas for example ecological water quality is under a different directorate than water freight transport. Respondent 1 acknowledges that the ICPR could ensure a better political fit by focusing more on the inclusion of political sciences in the multidisciplinary scope of the organization:

“I don't think we have anyone in the secretariat at the moment who has studied political science or something or is a political advisor. That could be something for the future, to better manage or understand processes. Yes, actually I could also imagine a head of the secretariat who has learned or studied something related to politics. But of course the secretariat must also be neutral. This is stated in our articles of association. But it could be.” (Respondent 1)

The potential for the ICPR to better navigate the international political playfield is best put into words by Respondent 4:

“At some point you have to make a decision: how does shipping or flood safety or drinking water supply relate to ecology? And how do you bring those functions together? So I see the role of the Rhine Commission mainly in maturing the minds of the different countries and supporting them with knowledge and ambitions. Providing a path, it could be, this is the path we should follow.” (Respondent 4).

5.3.8. Conflict management

The ecosystem restoration organization has a concise strategy to resolve conflicts through consensus resolution.

The ICPR's conflict management strategy, outlined in the Convention on the Protection of the Rhine, prioritizes negotiation and consensus-building among contracting parties. This approach reflects the absence of sanctions within the ICPR and emphasizes the necessity of negotiation due to the equal standing of all riparian states. If conflicts persist, the deployment of an arbitration strategy is an option, although it appears less frequently utilized. In conclusion, the governance condition ‘Conflict management’ is graded GREEN on the Traffic Light Assessment Scale, as two concise strategies are thought out by the ICPR.

The conflict management strategy of the ICPR is written down in the Convention on the Protection of the Rhine, as this document acts as the fundamental legal basis of the international cooperation with regard to ecosystem restoration. As elucidated in this document under Article 16:

“If a dispute arises between Contracting Parties regarding the interpretation or application of this Convention, the Parties concerned shall seek a solution through negotiation or any form of dispute settlement acceptable to them.” (ICPR, 1999, p. 4)

The ICPR thus seeks consensus resolution through negotiation and discussing, a given which is also confirmed by Respondent 1, 2, 3 and 6 (Da Silveira & Richards, 2013; Mostert, 2009; Schiff, 2017; Shi et al., 2021; Wieriks & Schulte-Wülwer-Leidig; 1997). Respondent 1, head of the ICPR secretariat, explains the conflict management strategy as follows:

“It's more about entering into discussions and looking for a compromise. Yes, that seems like a good formulation to me, because we have no sanctions. The entire collaboration is based on an international contract, an agreement. But when the countries decide something, for example in Amsterdam at a ministerial conference, they are actually political promises.” (Respondent 1)

Respondent 3 highlights that this is the only strategy that would function in the ICPR, as all riparian states are considered equal. Only through negotiation, compromises can be found for all countries to work on. Shi et al. (2021) underlines the importance of this strategy as well, as the ICPR can only give recommendations, after which the riparian states need to discuss a consensus on which they all agree. If a compromise cannot be found, the Convention on the Protection of the Rhine mentions the following strategy:

“If the dispute cannot be settled in this manner, it shall, unless the Parties to the dispute decide otherwise, be submitted, at the request of one of them, to arbitration in accordance with the provisions of the Annex to this Convention, which shall form an integral part thereof.” (ICPR, 1999)

This arbitration strategy to solve deadlocked conflicts was not mentioned by any of the respondent or the other assessed sources, which begs the question how often this strategy is employed. As Respondents 3 and 7 repine that the negotiation and discussing conflict resolution strategy often can

take a long time, this seems to hint at the fact that this strategy is retained for a long time before switching to arbitration.

5.3.9. Financial incentive

Contributions of actors to ecosystem restoration are financially rewarded.

In conclusion, the financial mechanisms governing the ICPR primarily support administrative functions, with minimal allocation towards actual restoration efforts. The responsibility for financing ecosystem restoration lies predominantly with the riparian states, driven by legal mandates such as the Water Framework Directive and other European laws and directives. Despite the absence of direct financial incentives on an international level, certain restoration projects may receive subsidies from the EU, although indirectly and without specific focus on the Rhine restoration. At the national level, the provision of subsidies for ecosystem restoration varies based on governmental strategies and approaches, indicating that it is not evident to promote ecosystem restoration with fixed financial incentives. Some respondents even advocate for more subsidies to stimulate and reward restoration efforts. Overall, this governance condition is graded **RED on the Traffic Light Assessment Scale.**

The only money that circulates in the ICPR is to finance the secretariat, the commission and as an exception, sometimes to carry out a small project (Respondent 6). As will be further elucidated in the next section, the riparian states are responsible for financing restoration efforts (Respondent 1; Respondent 3; Respondent 7). On an international level, countries do not receive financial incentives to contribute to the ecosystem restoration process (Respondent 1; Respondent 2; Respondent 3; Respondent 7). As explained by Respondent 1 and 2, the embeddedness of the restoration of the Rhine in European laws and directives explains the absence of direct reward systems for the riparian states:

“I: Are they financially rewarded in any form for their contribution?”

P: No, normally not, because ecological restoration is a legal mandate under the Water Framework Directive and also other legislation that is implemented at national or any level. And yes, it just has to be done.” (Respondent 1)

“P: No, no, there are no real incentives. Of course, nobody gets incentives to just follow the law.” (Respondent 2)

If restoration projects are in line with the objectives of these European Directives, sometimes context-specific projects can receive subsidies by the EU. An earlier mentioned example of this is the INTERREG subsidy scheme of the EU, which specifically focusses on promoting cross-border projects and collaboration networks (Da Silveira & Richards, 2013). This is however indirectly related to ecosystem restoration, as no specific subsidies are handed out for contributing to the Rhine restoration.

On the level of the riparian states, it depends on the strategy and approach of the national government whether or not ecosystem restoration contributions are directly rewarded through a subsidy scheme. This is explained by Respondent 1:

“There are of course subsidies and programs for which states can receive money, or states set up programs for other actors in their system, for municipalities, for provinces or so on, sometimes also for NGOs, which can then receive funding.” (Respondent 1)

These national subsidy schemes are not frequently set up, as stated by Respondent 5 and 7. Both respondents denounce the absence of subsidies to promote and reward ecosystem restoration contributions. Respondent 7 believes the economic benefits of ecosystem restoration are too indirect to stimulate monetary investments without subsidies, a belief which is shared by Respondent 5:

“Yes, that makes sense to me, right? If, as an organization or as a government or as an energy company, you work on the recovery of migratory fish and it is demonstrable that the salmon will return as a result of your work, then I believe that it should be able to be subsidized. So starting a farm, releasing salmon, ensuring that the pressure factors on the salmon are mitigated, for example by developing fish-friendly ship propellers, why shouldn't that be subsidized? That should be allowed by Europe if it helps the policy goals?” (Respondent 5)

5.3.10. Economic benefits

Ecosystem restoration has economic benefits for partaking actors, besides possible direct reward structures (e.g. business development; protection of natural capital)

The economic benefits of ecosystem restoration are underemphasized in motivating participation in ecosystem restoration, as respondents prioritize ethical values over economic gain, but acknowledge the challenge in communicating these moral beliefs. Economic benefits mentioned include improved water quality reducing purification costs, private sector involvement, public health benefits, increased economic value of natural environments, and tourism opportunities. However, these benefits are often indirect and long-term, with high upfront costs. Avoided costs, such as flood mitigation, are significant but not always considered in decision-making due to their indirect nature. Including cost-benefit analyses could leverage participation in restoration efforts, as well as focussing on the potential for innovative measures benefiting both economic sectors and the environment. As there are economic benefits to the ecosystem restoration process, but challenges remain for its communication and the inclusion of avoided costs, this governance conditions is graded **ORANGE on the Traffic Light Assessment Scale.**

In general, the economic benefits of ecosystem restoration do not have a central role in motivating or incentivizing participation to the restoration process. As economic benefits are only mentioned once, in the form of ecosystem services in the ‘Rhine 2040’ report, most insights for this governance condition are retrieved from the expert interviews (ICPR, 2020b). When respondents were asked about the economic benefits of the Rhine restoration process, respondents often were quick to mention that the benefits transcend economic gain. Respondent 2, 3, 4 and 7 mention the ethical values associated with ecosystem restoration as a motivation to participate: to protect the beauty of the natural world and to make it a better, more sustainable place than it is right now. At the same time, these respondents admitted that these ‘moral beliefs’ were harder to communicate to other stakeholders or the public than economic benefits. This notion is similarly mentioned by the ‘Rhine 2040’ report, which states that ‘(...) *the ecosystem services of the bodies of water must be better communicated not only to the general public, but also to stakeholders and at a political level.*’ (ICPR, 2020b, p. 25).

When purely focusing on economic benefits of the Rhine restoration process, a variety of benefits were mentioned by the respondents. Respondent 1 and 7 both mention the benefits of a better water quality for the drinking water production and the associated purification process. If the water quality of the Rhine is improved, the costs for the purification of drinking water will be lower than they are right now (Respondent 1; Respondent 7). Respondent 4 mentions the benefits of the participation of private stakeholders in the restoration process, as the physical interventions for restructuring the natural environment are often outsourced to private excavation sector. Respondent 7 mentions the

benefits for the health of the population to have healthy and clean natural environments. Respondent 6 mentions that the improvement of natural environments increases their economic value and that of surrounding public or private areas. Additionally, Respondent 6 mentions the opportunity for tourism development in these protected ecosystems.

A notable observation on the economic benefits of the Rhine restoration process, is that the economic benefits are generally fairly indirect and/or only achieved in the long-term, as mentioned by Respondent 3,4,6 and 7. Furthermore, Respondents 1, 3, and 6 claim that the costs associated with ecosystem restoration are high, so high that they might not even be profitable when weighed against the advantages of the recovery process. What complicates this matter, is the fact that a large sum of the economic benefits of ecosystem restoration are in the form of so-called 'avoided-costs' (Respondent 1; Respondent 4; Respondent 6). These avoided costs can be referred back to the mentioned purification costs for drinking water production, as mentioned by Respondent 1 and 7, but are mostly mentioned in relation to reducing the flooding risk of the Rhine:

“And also, for example, if you have a healthy Rhine with flood plains, etc., then you also get less flooding, which is also good for the countries and for the municipalities on an economic level, because there you can avoid costs.” (Respondent 1)

Respondent 4 also mentions the benefits of avoided costs, but directly mentions the associated problem of these costs in relation to the promotion of participation to the ecosystem restoration process:

“For business cases I always have to show that you can make money with it, but avoided costs are of course also good, but you cannot pay the bills with them, so they never count for such a business case.” (Respondent 4)

As avoided costs are not direct economic profits for stakeholders, these costs are frequently not included by public or private actors when making decisions surrounding sustainability measures. The inclusion of cost-benefit analyses could be a potential leverage point for the future of ecosystem restoration, as stated by Respondent 6:

“If you can indeed show that this measure, which cost so much, but we see that it yields so much in averted costs or averted risks. That might also help other countries to take the steps they are currently facing.” (Respondent 6)

Respondent 6 also states the importance of similar interests of the Rhine shipping industry and the Rhine ecosystem in relation to climate change. With the more frequent appearance of drought in the Rhine river, both the natural world and shipping is negatively impacted, as the living conditions for species turn suboptimal and water levels are too low for boats to navigate, which offers a possibility to promote and explore innovative measures that both industries and the environment.

5.3.11. Financial agreements

Clear viable and long-term agreements are present to finance the ecosystem restoration project.

In conclusion, the financing of ecosystem restoration of the Rhine River largely falls on the shoulders of individual riparian states, as no international funding structures are provided by the ICPR. Riparian states have committed to restoration under the Convention on the Protection of the Rhine and occasionally receive EU subsidies, but the primary financial burden rests on national budgets. The ICPR facilitates discussions on financing during annual meetings, aiming to encourage equitable distribution of responsibilities and costs among member countries. However, challenges remain at

the national level, as a lack of clarity about responsibilities hinders progress, and as there is an absence of clear implementation plans and financial accountability frameworks. As there are clear financial agreements on an international level, but notable challenges on the national scale of riparian states, this governance condition is graded **ORANGE on the Traffic Light Assessment Scale.**

The individual riparian states are responsible for financing their efforts towards ecosystem restoration, as the ICPR lacks independent financing structures for international restoration efforts. (Respondent 4; Respondent 6; Mostert, 2009; Shi et al., 2021). As the riparian states are contracting parties under the Convention on the Protection of the Rhine, they have pledged to individually participate in ecosystem restoration efforts between their borders (ICPR, 1999; Respondent 4; Respondent 6). Restoration measures are thus paid for with the government budget of a state. As the EU is also a contracting party to the ICPR, it participates and shares the costs of the Rhine restoration efforts (ICPR, 1999; Myint, 2003; Wieriks & Schulte-Wülwer-Leidig, 1997). For all riparian states, there are however additional options to receive support from the EU if restoration efforts align with the requirements of specific EU subsidy schemes (ICPR, 2020a; ICPR, 2020b; ICPR, 2001a; Wieriks & Schulte-Wülwer-Leidig, 1997). Additionally, sometimes specific restoration measures are co-financed by multiple riparian states based on political promises or due to the cross-border nature or location of the intervention (Respondent 5; Respondent 6; Mostert, 2009; Myint, 2003; ICPR, 2001a; ICPR, 2020b). The ICPR meets annually to discuss working programs for ecosystem restoration, but also to discuss the finances of the process (Wieriks & Schulte-Wülwer-Leidig, 1997; Chase, 2011). During these meetings, countries discuss and negotiate the individual efforts and financing of their taken measures, as the ICPR does not decide how much a state spends on ecosystem restoration efforts (Myint, 2003; Schiff, 2017). These meetings thus play an important role in leveraging ‘underperforming’ countries to increase their efforts in ecosystem restoration and contribute more financially to the process. This is explained by Respondent 6 in the following citation:

“For example, it is likely that at some point it will become increasingly public that France does not want to do A, B or C. Just like the Netherlands had with the Haringvliet lock. Perhaps that also played a role at one point, that the Netherlands invested 75 million euros to open up the Haringvliet by moving the intake point. Then of course you have a strong argument for hitting France. Why don't you invest 50 million in that fish ladder, while moving the drinking water intake point was even more expensive?” (Respondent 6)

By holding these meetings, the ICPR aims to create a more equitable distribution of responsibilities and costs among member countries. Some facets of the Rhine restoration are also financed by the private sector, such as the drinking water production industry, whose economic interest aligns with improving the water quality of the Rhine (Respondent 6).

Although internationally clear financial agreements are made for the financing of restoration measures, on a national scale these agreements seem to be less evident. The ‘Assessment Rhine 2020’ report mentions that *“the transformation of the riverbank areas to a near-natural state is being prevented or at least delayed by the lack of clarity regarding responsibility for action and costs for large sections of the Rhine.”* (ICPR, 2020a, p. 11). This statement is confirmed by Respondent 6 and 7. Respondent 6 states:

“Look, the fact is that we have set ourselves high goals, both with the Water Framework Directive or even with the Rhine Treaty. If you then look at what measures are required and what the costs are, things become difficult. And it also depends entirely on the financial position of the countries.” (Respondent 6)

On the Dutch national level, Respondent 7 notes that there is a lack of clarity with regard to the responsibility for the costs of implementing restoration measures:

“So there really is a very big problem there at provincial level, so no one knows who is actually in charge. And because they have been in that tension for so long, no one dares to agree to calculate those nature restoration goals in very concrete, quantitative terms. Because that is a bit of a sword of Damocles, they all feel hanging over their heads. As soon as it becomes very concrete and so many hectares of this ecotope or that ecotope, then a price tag will also be attached. And then we all run the risk of having that bill shoved in our pockets and so all those administrative bodies hold each other captive and in practice money is wasted, but very inefficiently.” (Respondent 7)

Respondent 6 notes that he has no clear solution to the problem of financial responsibility for restoration measures on a national scale. Respondent 7 underlines the need for clear and strict national implementation plan in the Netherlands, which clarifies which organization is responsible for the implementation of which restoration measures. He additionally notes that this ‘programmatic approach’ is long overdue and at a stalemate, as *“no one actually wants to be confronted with an additional financial claim”* (Respondent 7). Respondent 5 and 6 acknowledge that this stalemate exists in the political debate of other riparian states as well. All three respondents state that the underlying issue can often be attributed to the trade-off between economic and ecological values, as the overall costs of ecosystem restoration are significant and measures positive for the ecological state of the Rhine often directly hamper economic interests such as the shipping and fishing industry (Respondent 5; Respondent 6; Respondent 7).

5.3.12. Designated role for science

There is a clear demarcated and designated role for scientists and research in the governance structure of the ecosystem restoration organization.

Although there is a clear and demarcated role for science in the current governance of ecosystem restoration by the ICPR, predominantly focussing on drafting a scientific foundation for policy recommendations, critiques are expressed to increase the efficiency of gathering and utilizing scientific evidence to inform decision-making processes, possibly by adjusting the structure of the ICPR. The governance condition ‘Efficiency’ will be further elucidated in section 4.3.1.20. Solely focusing on the ecosystem restoration management of the ICPR to meet the governance condition of having a designated role for science, this governance condition is graded **GREEN on the Traffic Light Assessment Scale.**

Based on the role of the ICPR in relation to the riparian states, there is a clear need for a fundamental source of knowledge to direct the interests of the commission. As riparian states are themselves responsible for the implementation of individual restoration measures, the ICPR acts as a platform for international communication to report on progress and to discuss and coordinate the efforts of each state (Schiff, 2017; Myint, 2003; Mostert, 2009; Da Silveira & Richards, 2013). To guide and support this process, the ICPR drafts recommendations for policies or restoration measures in order to focus national restoration efforts on the needful or previously subordinated matters (Schiff, 2017; Myint, 2003; Respondent 1). These recommendations are supported by scientific research, which the ICPR conducts independently or in collaboration with other research institutes (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondent 1; Respondent 5). Scientific research is also conducted by NGO’s, research institutes and observers of the ICPR, which is then brought to the table, solicited or unsolicited, and discussed (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondent 5; Respondent 6; Respondent 7).

Input from Rhine stakeholders, such as industries, or occasionally consulting firms, is also included. (Myint, 2003).

The ICPR reports assessed for this research are packed with examples of conducted research or recommendations for follow-up research (ICPR, 2001a; ICPR, 2003; ICPR, 2020a; ICPR, 2020b). A small selection from these examples include:

- *“Information on the relevance of various micropollutants in the Rhine catchment area and on approaches to reducing water pollution.”* (ICPR, 2020a, p. 16)
- *“Investigation into the contamination of biota (fish) with pollutants in the Rhine catchment area”* (ICPR, 2020a, p. 23)
- *“Future potential changes in low water discharges due to climate change were also investigated”* (ICPR, 2020a, p. 33)
- *“The ICPR has commissioned a feasibility study on the restoration of the Upper Rhine river patency”* (ICPR, 2001a, p. 17)
- *“Between 1996 and 2000 the routes taken by migratory fish returning from the North Sea and travelling through the Rhine delta were subjected to telemetric research. To this end, sea trout and salmon were equipped with radio transmitters.”* (ICPR, 2001a, p. 23)
- *“Promotion of the improvement of research and knowledge on the effects of water temperatures on Rhine fish coenosis and with regard to the stabilisation of the oxygen balance”* (ICPR, 2020b, p. 14)

Besides research on new restoration measures, the success and effectiveness of existing measures is evaluated (Schiff, 2017; ICPR, 2001a). For this evaluation process, monitoring of the Rhine and ecosystem parameters is vital, as the impact of new measures can be directly measured (Mostert, 2009; ICPR, 2001a). Additionally, exact pollution sources in need of attention can be precisely tracked down, which induces the need for the refinement or expansion of restoration measures or the political requirement to include a polluting stakeholder in the Rhine restoration debate (Da Silveira & Richards, 2013; ICPR, 2001a).

The governance structure of the ICPR consists of various Working Groups or scientific Expert Groups on varying topics relevant to the restoration of the Rhine ecosystem (Chase, 2011; Respondent 6). These groups are made up of national scientific experts from all riparian states on these specific topics, and are each tasked with conducting research and adopting the results to coordinate policy recommendations, which are delivered to the Strategy Group above the working- and expert groups in the ICPR hierarchy (Mostert, 2009; Respondent 1; Respondent 3; Respondent 6). This Strategy Group is then tasked with nuancing scientific recommendations to ensure a possibly better political fit (Respondent 3; Respondent 5). By doing so, the ICPR navigates the individual national measures and the newfound scientific recommendations in search of common ground for the refinement or expansion of restoration measures. The riparian states then discuss the ICPR recommendations until a new international agreement is reached upon to further develop the Rhine ecosystem restoration strategy (Mostert, 2009; Myint, 2003; Shi et al., 2021). Scientific research thus acts as the foundation for international agreements (Mostert, 2009). This structure is however criticized by Shi et al. (2021) and Respondent 5. Shi et al. (2021) states that the ICPR work efficiency is low due to the extensive political negotiation process that bridges the gap from scientific recommendations to actual national restoration measure implementation. Respondent 5 expresses his concerns on the political nuances made by the ICPR Strategy Group:

“Yes, because they leave it to the member states and there is a strategic group on top that weighs everything up, how can they navigate through this? I think that when it comes to hydropower, they

just have to sound the alarm a little louder. There are people within the Rhine Commission, within the expert group, who are loudly sounding the alarm. That helps, I think that's good. But above that fish expert group there is a Strategy Group that will then provide nuance. I think that simply does a huge disservice to the expertise that is gathering and thinking along. So I actually think that the Strategy Group should realize that they occasionally put on the brakes and that this is not justified from a European policy perspective.” (Respondent 5)

Respondent 5 states that in forming political compromises and agreements, nuances are made that downplay the need for new, additional or refined restoration measures as demonstrated by scientific research and international experts. He continues by elucidating that before major political decisions are made, sufficient evidence is required to set the international discussion in motion. However, the time required to collect the baseline for what is said to be ‘sufficient’ evidence is taking his organisation five to ten years. This anecdote is thus in line with the critique by Shi et al. (2021) on a low work efficiency of the ICPR.

5.3.13. Informed plan-making and execution

The creation and implementation of restoration policies and measures is fundamentally supported through research and insights on the restoration area.

The role for science in the ICPR governance structure is predominantly to inform plan-making and execution, as scientific insights are used to draft policy recommendations to adjust or expand ecosystem restoration measures. However, as similarly stated in section 4.3.1.12, criticisms have been raised regarding the efficiency of the ICPR's decision-making process. The governance condition ‘Efficiency’ will be further elucidated in section 4.3.1.20. Solely focusing on the ecosystem restoration management of the ICPR to meet the governance condition of ‘Informed plan making and execution’, this governance condition is graded GREEN on the Traffic Light Assessment Scale.

This governance conditions partially overlaps or shows strong similarities to the condition to have a ‘Designated role for science’, which is elucidated in section 4.3.1.12. Using insights from both governance conditions, an explanation is given to the fulfillment of the governance condition of informed plan-making and execution in the management of the Rhine ecosystem restoration process.

The ICPR fulfills an important role in coordinating efforts among riparian states for the restoration and protection of the Rhine ecosystem (Schiff, 2017; Myint, 2003; Mostert, 2009; Da Silveira & Richards, 2013). The commission functions as a platform for international communication to exchange knowledge on the restoration process in the form of progress reports or by organizing meetings with the riparian states and other stakeholders (ICPR, 2020a; Schiff, 2017; Myint, 2003; Respondent 1). New insights on the Rhine ecosystem and the impact of restoration measures is gathered through scientific research, which is conducted both independently by the ICPR and in collaboration with various research institutes, NGOs, and observers, informs the commission's decisions and recommendations (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondent 1; Respondent 5). These research efforts span a wide range of topics, including water pollution, contaminant levels in biota, climate change impacts on water discharges, and the effectiveness of restoration measures such as fish migration studies and ecosystem monitoring (ICPR, 2001a; ICPR, 2003; ICPR, 2020a; ICPR, 2020b; Schiff, 2017). The ICPR's governance structure consists of specialized Working Groups and Expert Groups composed of national scientific experts from riparian states and stakeholders within the Rhine catchment area (Chase, 2011; Respondent 6). These groups conduct research, analyze results, and formulate policy recommendations, which are then refined by the Strategy Group to ensure political feasibility (Mostert, 2009; Respondent 1; Respondent 3; Respondent 6). Through this process, the ICPR aims to

find common ground among member states, using scientific evidence and insights to guide political decision-making and ultimately achieve international agreements on Rhine ecosystem restoration (Respondent 3; Respondent 5; Mostert, 2009; Myint, 2003; Shi et al., 2021). The mediating and informing role of the ICPR in the coordination of restoration measures among member states is thus underpinned by scientific research, which forms the cornerstone of the ICPR's recommendations to policy-making processes.

However, as similarly stated in section 4.3.1.12, criticisms have been raised regarding the efficiency of the ICPR's decision-making process, referring to the time-consuming nature of political discussions and negotiation (Shi et al., 2021). Respondent 5 also expresses concerns on the influence of nuances introduced by the Strategy Group to dilute scientific recommendations.

5.3.14. Trade-off management

Ecosystem restoration measures are weighed against alternative measures to assess the most favorable societal impact.

In conclusion, the strategy of 'Trade-off management' when choosing new restoration measures is not applied by the ICPR. This is partially because the organisation can only give policy recommendations, whereas the riparian states are themselves responsible for choosing and implementing restoration measures between their borders. The Rhine 2040 report, which contains the ICPR restoration measure selection strategy, emphasizes the importance of tailored ecosystem restoration measures, supported by scientific research and data analysis to assess effectiveness and inform decision-making. Monitoring reports and data analysis serve as crucial tools in evaluating the current state of the Rhine's ecosystem parameters and identifying areas requiring improvement. Scientific insights guide the selection of measures by focusing on substances with significant ecological impacts and establishing target values for ecological system health. Preferably, synergistic measures are chosen that simultaneously enhance ecosystem quality and provide flood protection. There is no indication as to which restoration measure selection strategy is superior in achieving successful ecosystem restoration. Purely focussing on the presence of the governance condition 'Trade-off management' in the current governance of the Rhine ecosystem restoration process, this governance condition is graded **RED on the Traffic Light Assessment Scale.**

In Rhine 2040, an insight is given in the selection of Rhine ecosystem restoration measures, which is briefly summarized as *'implementation of programmes of measures tailored to individual cases in the relevant nations using the variety of protection and water level-reducing measures'* (ICPR, 2020b, p. 21). As explained in the section about 'Designated role for science' and 'Informed plan-making and execution', scientific research is fundamental in assessing the required measures and the impact of measures already implemented. Monitoring reports and data analysis reflect the current state of the Rhine water quality and other ecosystem parameters, thus indicating the needs for new restoration measures for improvement. This is clearly explained by Respondent 3 when highlighting the assessment of the Rhine water quality:

"So you see, there are many substances. Normally you put the focus on these ones which are put in the water in enormous tons or something like this and then you will find out what the consequence is for the ecology. And so looked into the water and we looked at how many substances are sold. And for example this diclofenac is sold very much, in enormous tons, of which a lot ends up in the Rhine. So we looked for target values for which we can be sure that the ecological system will be okay. But it's normally not trial and error. Normally we have our measure programs, which we do every three years and at every evaluation, we try to find out which substances will make problems and we try to speak

with the industry to ask, do you have an idea of your substances which you put into the water?” (Respondent 3)

The same process is explained by Respondent 1, underlining the role of scientific research in formulating policy recommendations from the ICPR to the riparian states. As the ICPR can only give recommendations to achieve the internationally agreed-on restoration objectives, it is up to the riparian states to choose which measures to implement based on the available information:

“We often have reports and also interim reports where we publish interim results, not always for countries, but rather so that you can see the results from different measurement locations. Sometimes we also have sections of the Rhine, for example in the delta or between Basel and Mainz or something, and then you can also see where things are progressing at a good pace and where are there delays? But measures are the responsibility of the Member States. We often also have recommendations for measures. These are then developed together by international experts.” (Respondent 1)

Additionally, in the Rhine 2040 report, an underlying goal is described to focus on measures that both improve the ecosystem quality and provide protection against flooding (ICPR, 2020b). This focus on synergies between measures seems to play a growingly important role in the selection of new restoration measures, as this was not mentioned in the previous ICPR reports.

5.3.15. Reducing uncertainty

The ecosystem restoration process is actively supported by research to reduce and cope with uncertainties in the restoration process.

The ICPR's governance approach integrates scientific research extensively, both independently and in collaboration with research institutes, NGOs, and observers. This collaborative effort ensures that knowledge gaps and uncertainties regarding the Rhine ecosystem are addressed comprehensively. Notably, ongoing monitoring and research initiatives are focused on understanding and mitigating the impacts of climate change, identifying pollutants, and assessing the effects of (micro)plastics on ecosystem health. Overall, this governance conditions is graded GREEN on the Traffic Light Assessment Scale.

Per established definition of this research, the Rhine restoration process must be actively supported by research to reduce and cope with uncertainties, in order to get graded GREEN on the Traffic Light Assessment Scale. Most insights to answer the question if the ICPR meets the governance condition of ‘reducing uncertainty’ can thus be found in section 4.3.1.12. (Designated role for science), where the question was answered if the ICPR governance of Rhine ecosystem restoration was supported by scientific research. By way of explanation, having a ‘designated role for science’ in the governance of ecosystem restoration can help to reduce uncertainties that arise during the governance, as scientific research can be conducted to gather additional information and new insights. The governance condition ‘Designated role for science’ was graded green, as the conduction of research and the analysis of results has a central role in the ICPR and the formulation of recommendations for the ecosystem restoration process of individual riparian states. Scientific research is carried out by the ICPR either independently or in cooperation with other research institutes in the event that there are knowledge gaps, missing information, or uncertainties regarding the functioning of the Rhine ecosystem that the ICPR and its contracting parties are aware of (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondent 1; Respondent 5). NGO's, research institutes, and ICPR observers also carry out scientific research, which is thereafter presented in ICPR meetings and discussed (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondents 5, 6, and 7). The ICPR thus acts as an important platform for the

exchange of information to address any gaps in knowledge and ensure a comprehensive understanding of the Rhine ecosystem (Wieriks & Schulte-Wülwer-Leidig, 1997). This is exemplified by Respondent 2:

“Yeah, but, an additional aspect we have to keep in mind, we learned that the success is not as good as we hoped. So a lot of money is spent to reintroduce the Salmon. Hundreds, thousands of young salmon are released into the river or the tributaries every year, and we still have not enough coming back as we hoped and we really don't know why this is the case. So now the ICPR is working on a big monitoring program or research program to find out what is the reason. And from this research we hope we will not only learn why the salmon did not come back, but to learn more about how our river functions, what the problems of the river are, which we may have neglected throughout the last decades. So even in that negative point of view, the salmon is a good indicator and a good symbol to work on restoration, because it forces us to learn more. To do more research on what is going on and what we've neglected for a long time.” (Respondent 2)

With a look at the future, the ICPR reports predominantly mention a focus on studying and monitoring the effects of climate change on the Rhine water regime, ecology and temperature, in order to further develop its climate change adaptation strategy (ICPR, 2020a; ICPR, 2020b). Previously drafted climate projections will be used to support this process, as well as the monitoring systems and measurement techniques (ICPR, 2020a). To deepen the understanding of the Rhine ecosystem and the effects of climate change, the ICPR mentions the further development of these monitoring and measurement systems (ICPR, 2020a; ICPR, 2020b). By doing so, the ICPR similarly aims to track down new possible pollutive substances that harmfully effect the Rhine ecosystem health (ICPR, 2020a). An additional focus mentioned by the ICPR in its most recent reports, is to reduce the knowledge gap about the impact of (micro)plastics on the Rhine ecosystem, while simultaneously studying best practices to reduce plastic pollution (ICPR, 2020a; ICPR, 2020b).

5.3.16. Political support

The ecosystem restoration project is supported by political will and adequate state support. This can be facilitated by active political brokering.

In summary, the ecosystem restoration project led by the ICPR derives significant benefits from the inclusion of the European community, the impact of European legislation and directives, (historical) enactment of new national legislation, involvement of high-level government officials as commissioners and coordinated lobbying efforts. Political support of the restoration of the Rhine ecosystem is visible through these varying indicators, some of which are very recent, meaning their full impact has yet to become clear in fostering significant environmental change within the Rhine catchment area. As it is clear that the ICPR is strongly embedded in political structures on a national and international level and as the political will to support the ICPR is visible, this governance condition is graded **GREEN on the Traffic Light Assessment Scale.**

The ecosystem restoration efforts of the Rhine river basin are coordinated by the ICPR on an international level. As the riparian states are themselves responsible for the implementation of restoration measures, the mandate of the ICPR is solely to give policy recommendations and to facilitate political discussions to create a shared vision for the future (ICPR, 2020b; Respondent 5). Politically, the ICPR serves as a platform for communication for all contracting parties, which are the riparian states of the Rhine. Since 1976, the international political position of the ICPR was strengthened with the involvement of the European Community as a contracting party (Wieriks & Schulte-Wülwer-Leidig, 1997; Chase, 2011; Da Silveira & Richards, 2013). As stated by Da Silveira & Richards (2013), the involvement of the European Community was mostly due to their initiation of

environmental regulations regarding water pollution. In the present time, the European Community, now known as the EU, has expanded her influence on the international collaboration constituted by the ICPR. Fundamental to strengthening the legitimacy and accountability of the ecosystem restoration of the Rhine are the directives and measures introduced by European legislation, most notably the Water Framework Directive and Flood Risk Management Directive (ICPR, 2020a; ICPR, 2020b; ICPR, 2003; Schiff, 2017; Mostert, 2009). These directives serve as cornerstones in shaping environmental policies within the Rhine basin by providing comprehensive guidelines and mandates for water management. The WFD, in particular, lays out an extensive framework for working towards sustainable resource utilization and ecosystem conservation and restoration (ICPR, 2003; Schiff, 2017). European directives protect ecosystem restoration on a higher institutional level, as the European Court of Justice has the power to enforce riparian states that defect from their agreements with fines (Da Silveira & Richards, 2013; Schiff, 2017; Respondent 3). The alignment of ICPR initiatives with Sustainable Development Goals (SDGs), notably SDG 6, highlights the power of the higher institutional level of the EU (ICPR, 2020b). By integrating SDGs into its agenda, the ICPR ensures that its actions are in harmony with broader global objectives, reinforcing the significance of its ecosystem restoration and placing trust in the EU to further develop and strengthen the accountability and legitimacy of the international collaboration as erected by the ICPR.

As progress on ecosystem restoration is entirely dependent on the restoration measures implemented by individual riparian states, each enactment of new national legislations within member states further strengthens the mandate of the ICPR (ICPR, 2020a; ICPR, 2003). Throughout the decades, new national legislations have been implemented to reduce water pollution and to restore the ecosystem of the Rhine (ICPR, 2020a; ICPR, 2003; Chase, 2011). Commissioners of the ICPR, comprising high-level government officials, thus play a vital role in implementing and enforcing these new legislations and measures after an international agreement is reached under the ICPR collaboration (Chase, 2011). Their involvement highlights the depth of state commitment to the ICPR, ensuring that national policies are effectively aligned with the goals of the commission. This collaboration between member states and the ICPR demonstrates a unified effort to restore the Rhine ecosystem.

Additionally, respondents frequently mention their lobby function as important in advocating for environmental policy reforms. Respondent 4, 5, 6 and 7 mention that the organization at which they work actively lobbies for implementing specific restoration measures based on the scientific findings retrieved by their organization. As mentioned by Respondent 4, 5, 6 and 7, lobbying is directed both at the ICPR and at national governments, as they are responsible for the actual implementation of restoration measures. Furthermore, political pressure can be exerted through the ICPR from one national government to another, in case of disputes or negligence (Myint, 2003; Mostert, 2009). No mention is made of lobbying strategies directed at national governments from the ICPR, the organisation focusses on coordinating the international political debate and supporting informed decision-making by making policy recommendations (ICPR, 2020b).

Lastly, sources mention the historic impact of natural disasters, notably the Sandoz chemical spill in 1986, in creating significant political pressure, leading to decisive action for Rhine ecosystem restoration (Wieriks & Schulte-Wülwer-Leidig, 1997). The catastrophe led to calls from the public and politicians to impose more strict regulations, which ultimately led to a quick response in the form of the drafting of the Rhine Action Program to address pollution and promote restoration efforts (Wieriks & Schulte-Wülwer-Leidig, 1997; Chase, 2011). When looking at disaster-response and its aftermath, the impact of political support can be regarded as significant to speed up the decision-making process with regard to ecosystem restoration (Wieriks & Schulte-Wülwer-Leidig, 1997; Myint, 2003).

5.3.17. Capacity building

The ecosystem restoration organization deploys an active capacity building process to increase the support base of the restoration project by including more actors and stakeholders.

In conclusion, the ICPR has made significant improvements in increasing stakeholder participation and cooperation in the management of the Rhine catchment area. Although initially limited, stakeholder participation increased with the drafting of the Rhine Action Program in 1987 and NGO involvement was later formalized under the Convention on the Protection of the Rhine in 1999. Today, the ICPR actively engages stakeholders through meetings, discussions and workshops. Moving forward, the ICPR aims to maintain or further develop partnerships and public participation, as outlined in the 'Rhine 2040' report. Based on this commitment and the historical development of the capacity building processes of the ICPR, this governance conditions is graded **GREEN on the Traffic Light Assessment Scale.**

As described in section 4.3.1.5, the current ICPR actively promotes participation and cooperates with stakeholders and actors in the Rhine catchment area, varying from NGO's to private cooperations. This process was fairly limited until the drafting of the RAP in 1987, for which local stakeholders, industries, NGO's and non-state actors were invited to participate (ICPR, 2003; Myint, 2003; Respondent 2; Wieriks & Schulte-Wülwer-Leidig, 1997). Afterwards, various stakeholders were invited to join the ICPR Working Groups (ICPR, 2003; Myint, 2003; Respondent 2). It was only until 1996 that the ICPR truly started to open up for stakeholder participation by inviting NGO's to attend the meetings of the ICPR (Mostert, 2003; Da Silveira & Richards, 2013; Chase, 2011). The participation activities to actively include more NGO's amongst other stakeholders in the decision-making process about restoration measures were formalized under the Convention on the Protection of the Rhine in 1999 (Mostert, 2003; ICPR, 1999; Chase, 2011). Article 14 of the Convention on the Protection of the Rhine states the following:

Article 14:

"1. The Commission shall cooperate with other intergovernmental organisations and may address recommendations to them.

(...)

3. The Commission shall exchange information with nongovernmental organisations insofar as their fields of interest or activities are relevant. The Commission shall in particular consult such organisations before discussing decisions liable to have an important impact on them and shall inform them as soon as such decisions have been taken.

(...)

5. The Commission may decide to consult specialists representing the recognised non-governmental organisations or other experts and invite them to its meetings." (ICPR, 1999, p.4)

The contemporary ICPR frequently organizes meetings, workshops and discussion groups with active users and stakeholders of the Rhine to encourage their participation and to draft shared visions and objectives for the restoration of the Rhine ecosystem (ICPR, 2020a; Mostert, 2009; Chase, 2011; Respondent 2). Stakeholders can apply for observer status at the ICPR (Chase, 2011). Observers to the ICPR are states, intergovernmental organizations or non-governmental organizations that are related to or interested in the work of the ICPR (ICPR, 2024b). As an observer, they are allowed to participate in the ICPR meetings, but they are not entitled to voting rights. The ICPR and riparian states also actively cooperate with organizations which they recognize as 'knowledge institutes', local actors with

significant relevant knowledge, in monitoring and data gathering processes (Respondent 5; ICPR, 2001a). As Respondent 7 also mentions, private parties that have a solution to a specific environmental problem or are able to participate, can be ‘plussed into national projects’, where they receive the funding and means for them to implement their solution. Public-private partnerships are thus also an active capacity building process which is deployed on a national scale of riparian states to work towards ecosystem restoration.

When looking at the present and future of the ICPR, the ‘Rhine 2040’ report mentions the plans and objectives with regard to the capacity building process surrounding ecosystem restoration. The report mentions that *“cooperation with recognised observers on the Rhine will be continued and further developed if necessary. Contact and cooperation with other stakeholders will be improved.”* (ICPR, 2020b, p. 25). In light of the relatively new focus on cross-border projects, the report states that ‘partnerships and regular rounds of talks’ with stakeholders will be part of the pilot project start-up (ICPR, 2020b). Lastly, the ICPR underlines its aim to further improve its public notoriety and public participation as part of its flood risk reduction strategy:

“Promotion of an intensive exchange of information, and the involvement of the public in the nations of the Rhine catchment area via the provision of information, advice, training, exercises, prevention in educational, civic and youth projects, round tables and the formation of municipal flood partnerships for the correct, damage-reducing handling of flood events.” (ICPR, 2020b, p. 22)

5.3.18. Individual leadership strength

Strong, inspiring leadership of individuals with experience and a relevant background.

Overall, the strong, inspiring leadership of individuals with experience and a relevant background is scarcely mentioned. Respondents mention a handful of individuals, but these are never mentioned more than once, which partially downplays their importance, or at least their notability. Furthermore, all the individuals mentioned have historical involvement in the ICPR, yet no currently active influential figures have been mentioned by either the evaluated sources or respondents. Thus, this governance condition is graded RED on the Traffic Light Assessment Scale.

The significance of individual leadership within the ecosystem restoration process was scarcely mentioned in the examined policy documents and scientific literature. Consequently, information on this governance condition is more reliant on the perspectives of respondents to gain an insight in the influence of specific individuals vital to the strength of the ICPR governance. Notably, Mostert (2009) highlights the importance of the role of former Dutch Minister for Water Management Neelie Smit-Kroes in transforming the political landscape of the ICPR. She played an important role in straying away from asserting strong legally binding command-and-control instruments towards international ecosystem restoration collaboration based on flexible, individual national efforts, which gave the progress of restoration efforts a boost. Nevertheless, respondents do not mention the impact of Neelie Smit-Kroes in their interviews. Every important individual mentioned in the answers of respondents is only mentioned once.

Respondent 4 underlines the contribution of Jan Pronk, former Dutch Minister for Foreign Trade and Development Cooperation, in allocating government funds for nature restoration in the Netherlands. Respondent 1 credits Cora van Nieuwenhuizen, former Minister of Water Management of the Netherlands, for mediating conflicts preceding the Rhine Ministerial Conference in 2020, attributing part of the conference's success to her efforts. He similarly mentions a former ICPR president, associated with the EU, respected by all riparian states for her robust leadership role. Respondent 6

expresses appreciation for a former president of the ICPR, without mentioning this individual by name, in building consensus surrounding a complex fish passage system at a large French hydropower project.

Respondent 2 mentions the general role of strong individuals in the governance of the ICPR, but describes this as follows:

“Of course, there are some strong mighty persons and the mightier they are, the more they are leaders, of course. But I think that the whole process does not depend on them. The whole process depends on the structures to function, not persons who are charismatic leaders. It's the structure itself, which brings the process forward and forward. Not special people. It's good to have sometimes one man or woman who is able to convince others. There are some people who are more able to convince others than others. But this is not necessary to bring the process forward.” (Respondent 2)

Respondent 2 thus states that the role of strong individuals in the ICPR governance is limited, and that the general structure of the ICPR is of much more importance. Respondent 7 goes a step further by stating that the current ICPR misses strong individuals to bring the restoration process further. This statement is indirectly underlined by all assessed sources and respondents, as only ‘historical’ strong individuals are mentioned to play an important role in the ICPR.

5.3.19. Coordinated shared vision

Collaboration is coordinated by ensuring all partaking actors in the ecosystem restoration process share the same goals and vision for the project.

Due to the role of the ICPR in the coordination of ecosystem restoration on a catchment area scale, the commission aligns varying opinions and interests of riparian states and stakeholders. By drafting recommendations for restoration measures, the ICPR translates political goals and scientific insights into actionable measures and fosters collaboration. In doing so, the ICPR creates a shared vision and objectives for the sustainable development of the Rhine alongside the restoration of its ecosystem. Thus, this governance condition is graded GREEN on the Traffic Light Assessment Scale.

The ICPR plays an important role in coordinating the ecosystem restoration of the Rhine catchment area by drafting shared visions and objectives among involved stakeholders (ICPR, 2020a; Chase, 2011; Shi et al., 2021; Respondent 1; Respondent 6). Examples of these goals and objectives are the removal of fish migration barriers, the restoration of floodplains, reducing the influx of micropollutants and (plastic waste), all elucidated with specific parameters, quantities and deadlines (ICPR, 2020b). The ICPR acts as a platform to facilitate discussions on restoration goals by gaining political consensus in the form of international agreements (ICPR, 2020a; Shi et al., 2021; Respondent 1). Through ministerial conferences and discussions of the ICPR Working Groups, Expert Groups and the Strategy Group, the ICPR fosters collaboration and knowledge exchange among member states, supporting them in the implementation of measures aimed at achieving shared objectives (Myint, 2003; Shi et al., 2021; Wieriks & Schulte-Wülwer-Leidig, 1997; Respondent 1; Respondent 3; Respondent 4). In addition, the ICPR frequently organizes meetings, workshops and discussion groups with active users and stakeholders of the Rhine to encourage their participation and to draft shared visions and objectives for the restoration of the Rhine ecosystem alongside the continuous development of the regions in the area (ICPR, 2020a; Mostert, 2009; Myint, 2003; Chase, 2011; Shi et al., 2021; Respondent 2). The international goals set by the ICPR are general to facilitate the reaching of compromises and eventually to allow for tailor-made contextual policies and measures by individual riparian states (Chase, 2011; Respondent 1; Respondent 4).

The ICPR provides a framework for assessing ongoing activities and progress through monitoring and data sharing, thus giving body to the agreed-on restoration goals by reporting on the progress made (Chase, 2011; Wieriks & Schulte-Wülwer-Leidig, 1997; Respondent 7). To support the collaboration, the ICPR also urges the riparian states to monitor progress and to share new insights, enhancing transparency and accountability across the basin (Wieriks & Schulte-Wülwer-Leidig, 1997; Respondent 4; Respondent 7). Additionally, stakeholders emphasize the ICPR's role in translating political aspirations into tangible measures and activities at the local level (Myint, 2003; Wieriks & Schulte-Wülwer-Leidig, 1997). While it does not have authority over member states, the ICPR acts as a guiding organization, offering policy recommendations for the different national governance bodies that manage ecosystem restoration efforts (Myint, 2003; Respondent 1; Respondent 2). Through the coordination of the ICPR, ecosystem restoration is coherent and unidirectional to adhere to the desired drafted vision for the future of the Rhine catchment area (ICPR, 2020a; ICPR, 2003). The encompassing vision for the future of the Rhine ecosystem is put into words in the ICPR action programs, which entail all goals and deadlines for the restoration efforts (ICPR, 2001a; ICPR, 2003; ICPR, 2020a; ICPR, 2020b).

5.3.20. Efficient

Actors are held accountable for a timely implementation of restoration measures

Although significant progress has been made in the last decades with regard to the restoration of the Rhine ecosystem, this cannot be said for all targets set by the ICPR. While the ICPR plays a vital role in setting goals and monitoring progress towards ecosystem restoration along the Rhine, its accountability mechanisms may require strengthening to ensure timely implementation of restoration measures by riparian states and partaking stakeholders. Addressing this issue can be crucial for a more efficient realization of the long-term environmental objectives set forth by the ICPR. This governance condition is graded **RED on the Traffic Light Assessment Scale.**

The ICPR navigates a complex international network of riparian states, NGO's and other stakeholders. To coordinate cooperation on a catchment area scale, the ICPR sets ambitious goals and objectives to guide individual ecosystem restoration efforts (Schiff, 2017; Respondent 2, Respondent 3). Pressure from stakeholders, including NGOs and the media, plays a significant role in holding actors accountable for their commitments (Respondent 1; Respondent 3; Respondent 4). When countries fail to fulfill their obligations, NGOs or other ICPR observers often publicize these shortcomings, highlighting the trailing of a riparian states in ecosystem restoration (Da Silveira & Richards, 2013; Respondent 2; Myint, 2003). As contracting parties, shortcomings of a riparian states might also lead to diplomatic tensions, as the political international cooperation functions on equal commitments to restore the Rhine ecosystem (Respondent 1). However, the absence of explicit enforcement measures at the ICPR level means that accountability relies largely on reputational risk and political pressure (Respondent 1; Respondent 2; Respondent 6; Mostert, 2009; Schiff, 2017). The role of the ICPR in monitoring progress strengthens accountability as it requires member states to report annually on their implementation efforts (Wieriks & Schulte-Wülwer-Leidig, 1997; Chase, 2011). These reports are also made public, fostering transparency and encouraging public participation in the decision-making process (Myint, 2003; Respondent 2). Additionally, the ICPR serves as a referee, intervening when member states fail to produce reports or make sufficient progress (Myint, 2003).

Nevertheless, various indications are given by respondents that the effectiveness of the accountability mechanisms of the ICPR for timely implementation of the restoration measures is lower than desired. While the transparency of the ICPR can lead to public and political pressure, there are no tangible consequences for non-compliance (Respondent 4). As a result, achieving timely implementation of

ecosystem restoration measures remains contingent on the goodwill and cooperation of member states. Respondent 3 highlights the impact of the absence of accountability measures on the functioning of the international collaboration on the Rhine ecosystem restoration:

“Well, all the countries, they could do more. They could do more, because it's always recommendations of the Commission of the Rhine. It's a very soft control, and therefore also not enough pressure. But for example, the European Commission has other rights and more power. But the Rhine Commission, some steps are very slowly, because the Member States and don't feel so much obliged. They won't do things as much as they do it for the European Commission. The Commission always talk about such or they do recommendations, but no one is obliged to do it. It functions on, how can you say, on like a promise. Yeah, all the states promise each other that they will do something for the goal. But you see, you can break the promise, which is not nice, but it can happen.” (Respondent 3)

Respondent 3 states that the soft control of the ICPR leads to a slow restoration process, as there is a lack of obligations for riparian states to implement restoration measures more efficiently. This is also highlighted by Respondent 6:

“If you look very specifically at the plans for 2000, 2020, it really said: we are going to create so many kilometers of Rhine bank, of course. And then in 2020 it is simply determined: we have not achieved that goal. Shame. There are no consequences whatsoever.” (Respondent 6)

Respondent 6 mentions that various restoration goals set by the ICPR are not achieved before the agreed-on deadline. Disparities between set targets and achievements can also be found throughout the assessed ICPR reports (ICPR, 2001a; ICPR, 2003; ICPR, 2020a; ICPR, 2020b). Exemplary is the statement in the ‘Assessment Rhine 2020’ report, noting that the goal for the ecological restoration of 800 kilometer of the Rhine river banks was only met by 25 percent in 2020, due to ‘the river’s intensive use as a shipping line’ (ICPR, 2020a). As with this particular restoration goal, shortcoming in the Rhine restoration process are often caused by a conflict between economic and ecological interests, as highlighted by Respondent 7:

“If a kind of political stalemate arises, this is often due to disinterest or by setting other priorities in politics. But that takes a very long time in nature, but you actually see that it is now actually becoming institutionalized. So when a new cabinet takes office, or a new Board of Provincial Executive, this is actually already included as a kind of fact in the official attitude and advice. And so it reinforces itself, it really becomes a self-fulfilling prophecy that becomes increasingly difficult to avoid.” (Respondent 7)

Respondent 7 contextualizes the inhibitory impact of financial matters, either when discussing the financing of restoration measures or when the ecological restoration process directly hampers economic gain or development. Respondent 4 points out another pitfall; as the ICPR functions on political compromises, individual restoration efforts of riparian states are dependent on the formulation of agreements and arrangements. This process takes a long time, as all riparian states must agree on the drafted compromises:

“That is a subtle interaction (...) It's actually about semantics, about words. How do you express things? Every now and then things get toned down. That actually happens with almost all European collaborations, they try to keep the slowest country involved.” (Respondent 4)

Shi et al. (2021) underline the judgement of Respondent 4, stating that the ICPR work efficiency is low due to the extensive political negotiation process that bridges the gap from scientific recommendations to actual national restoration measure implementation. Respondent 5 similarly criticizes the role of the Strategy Group of the ICPR to nuance scientific recommendations, as they tone

down the scientific call for more adequate restoration measures in the hopes of facilitating political agreements sooner.

As the enforcement mechanisms of the ICPR lack teeth, some sources express hope about the introduction of European Directives and, in case of negligence, the ability of the European Court of Justice to impose fines on riparian states (Da Silveira & Richards, 2013; Schiff, 2017; Respondent 3). Although this development suggests a shift towards greater oversight and accountability, Respondent 6 notes that the Directives do not yet encourage action:

“When it comes to the Water Framework Directive, if you don't achieve your goal, there are consequences, but even there. We get stressed about the fines, but not about the action.” (Respondent 6)

Since the deadlines for the goals of the Water Framework Directive are in 2027, it remains to be seen what the actual impact of these Directives will be.

5.3.21. Recognition of different perspectives

The ecosystem restoration organization has a platform to compromise on stakeholder discourses, thus accounting for different values and opinions for ecosystem restoration.

The ICPR serves as a platform for communication, information exchange and discussion by engaging with diverse stakeholders and recognizing their perspectives on ecosystem restoration within the Rhine basin. Through workshops, discussion groups and ongoing collaboration, the ICPR has demonstrated a commitment to integrating the voices of stakeholders from governmental, non-governmental, and local community sectors. Therefore, the governance condition ‘Recognition of different perspectives’ is graded GREEN on the Traffic Light Assessment Scale.

The ICPR recognizes the need for shared visions and objectives among all riparian states and stakeholders in the Rhine catchment area. As an organization, it frequently organizes workshops, discussion groups, conferences and negotiation forums that provide space for dialogue, information exchange and negotiation, with as aim to better understand the interests and concerns of all involved actors in the Rhine ecosystem restoration process (ICPR, 2020a; Wieriks & Schulte-Wülwer-Leidig, 1997; Schiff, 2017; Da Silveira & Richards, 2013). These participatory practices act as a form of capacity building to ultimately obtain more widely supported plan-making and execution (ICPR, 2020a; Chase, 2011). The ICPR does not solely focus on the protection and improvement of the Rhine ecosystem, but takes into account the needs of stakeholders for the continuous development of the Rhine catchment area and its economy (Shi et al., 2021; Myint, 2003). This is anecdotally explained by Myint (2003) when discussing the formulation of the Rhine Action Program in 1987:

“For instance, ICPR regime recognizes the fact that the implementation of reduction of chemical pollution in the Rhine requires participation and resources capacity of local industries and non-governmental organization in RAP. With this realization, local and non-state actors were encouraged to participate in various working groups of RAP. Therefore, in Rhine’s history, the RAP is the first of its regime type that begin to enhance the fit of regime to economic, political, and social contexts within which ICPR operates.” (Myint, 2003, p. 15)

Workshops conducted by the ICPR have emphasized the necessity of developing common goals and projects that involve local stakeholders (Shi et al., 2021). Moreover, the involvement of NGOs, intergovernmental organizations and states as observers in ICPR activities underscores a commitment to participation and transparency (ICPR, 2020a). Observers play a vital role in monitoring ICPR initiatives, providing critical feedback and sharing information to the public (ICPR, 2020a; Wieriks &

Schulte-Wülwer-Leidig, 1997; Myint, 2003). The engagement with local industries, NGOs, and other non-state actors in the formulation and implementation of restoration measures demonstrates a recognition of different perspectives through ICPR participation strategies.

The Rhine 2040 report states a future commitment to understanding and discussing different stakeholder perspectives and -needs in 'regular rounds of talks' (ICPR, 2020b). A focus point of communication the ICPR is to express the value of ecosystem services, as these are fragile when outweighed against economic interest (ICPR, 2020b). Additionally, the report mentions the need to coordinate water use to ensure an alignment of user interest with the needs for a more healthy Rhine ecosystem in the future (ICPR, 2020b). The following objective is stated:

"The ICPR's cooperation with water users such as those in shipping, industry, agriculture, power plant operators, drinking water production, interest groups, associations and environmental organisations etc. is to be further expanded in order to promote the sustainable management of waters in the Rhine catchment area." (ICPR, 2020b, p. 5)

5.3.22. Long-term planning and anticipation

The ecosystem restoration project has clear long-term goals, which are flexible to anticipate for future uncertainties.

In summary, the ICPR demonstrates a strong commitment to long-term planning and anticipation by setting ambitious goals, developing strategies to anticipate and mitigate the impact of climate change and flood risk and by evaluating and adjusting its restoration approach based on new scientific insights, regulations and arising challenges. Overall, this governance condition is graded GREEN on the Traffic Light Assessment Scale.

The ICPR incorporates long-term planning in its governance of the Rhine ecosystem restoration process by drafting long-term action programs to give direction to the international coordination and cooperation on a catchment area scale (Chase, 2011). These action programs set concrete targets for the improvement of ecosystem parameters to foster sustainable improvement of the Rhine ecosystem, thus underlining a forward-looking approach (ICPR, 2001a; ICPR, 2003; ICPR 2003; ICPR, 2020b; Respondent 4). The first of these action programs was the Rhine Action Program in 1987, followed up by Rhine 2020 and Rhine 2040 report, respectively setting targets for approximately 15 to 20 years in the future (ICPR, 2001a; ICPR 2003; ICPR, 2020b). An underlying long-term guideline for the Rhine restoration process since 1987 is the objective to achieve the return of an Atlantic salmon population in the Rhine and its tributaries (Myint, 2003; Wieriks & Schulte-Wülwer-Leidig, 1997; ICPR, 2003). Throughout the decades, this objective has evolved to now focus on establishing a self-sustaining population (ICPR, 2020b).

The Rhine 2020 and Rhine 2040 reports show similarities in the main topics that are addressed to guide restoration efforts, as the newer report builds upon the progress made by riparian states (ICPR, 2020b). Additionally, scientific insights assess the impact of existing restoration measures and the need for refinement or additional measures to achieve the old or new objectives (ICPR, 2020a; Myint, 2003; Mostert, 2009; Respondent 1; Respondent 5). Rhine 2040 outlines specific goals and targets to be achieved by 2040 on the topic of ecosystem restoration and reducing pollution, such as reducing the influx of micropollutants, waste and plastic, removing fish migration obstacles and improving the sediment quality of the Rhine main stream (ICPR, 2020b). Furthermore, the Rhine 2040 report directly mentions the need and stated objective for long-term planning and anticipation:

“The orientation of the “Rhine 2040” programme and its implementation in the Rhine catchment area should be reviewed at regular intervals. If necessary and in the light of developments, for example at EU level, as well as new knowledge and experience gained, it should be adjusted and/or tightened. The assessment regarding the implementation of the “Rhine 2040” programme is carried out every 6 years or, depending on the development of ambitious political goals in all nations of the Rhine catchment area, more frequently, and finally in 2039.” (ICPR, 2020b, p. 6)

The ICPR thus anticipates the possible adjustment of the Rhine 2040 program in light of new insights, regulations and unforeseen future challenges. Since the drafting of Rhine 2020, the ICPR has worked on developing climate change adaptation strategies, analyzing the possible impact of different discharge scenarios on the Rhine ecosystem (ICPR, 2001a; ICPR, 2020a). The ICPR’s climate change adaptation strategy is stated to be ready by 2025 (ICPR, 2020b). Research on the impact of climate change is actively promoted and included in the recommendations of the ICPR to anticipate different scenarios in the near and distant future (ICPR, 2020a; ICPR, 2020b). This indicates a recognition of long-term environmental challenges and the need for adaptation measures. Climate change adaptation and anticipation strategies include the formulation of objectives with regard to reducing extreme flood levels and in addition reducing flood damage risk (ICPR, 2001a; ICPR, 2020a; ICPR, 2020b). Moreover, there's a focus on increasing flood awareness and improving flood announcement systems, proactively anticipating for the increased risk of environmental disasters (ICPR, 2001a; ICPR, 2020a; ICPR, 2020b).

5.3.23. Organizational adaptive management

The ecosystem restoration organization continually improves its restoration policies and measures by evaluating the outcomes of existing policies and measures.

Altogether, clear examples can be found of organizational adaptive management by the ICPR. In its reports, the monitoring of restoration progress and reviewing and adjusting restoration measures are frequently mentioned and seem to have a central role in the governance of the ICPR in relation to the restoration of the Rhine ecosystem. Conclusively, this governance condition is graded GREEN on the Traffic Light Assessment Scale.

One of the core tasks of the ICPR is the evaluation of the effectiveness of implemented restoration measures (ICPR, 1999; Schiff, 2017). At the Rhine Ministerial Conferences, the completed and ongoing restoration measures and the overall progress of Rhine ecosystem restoration is discussed and evaluated, after which new restoration objectives are formulated (Wieriks & Schulte-Wülwer-Leidig, 1997). The progress of restoration is elucidated in monitoring reports, based on which the ICPR gives recommendations to the riparian states to further improve their restoration efforts (Respondent 1). Similar information on restoration progress, combined with monitoring data, can be found in the assessed ICPR reports. ‘Rhine & Salmon 2020’ mentions the opening of the Haringvliet sluices in the Netherlands and the effect this has had on the population of different fish species (ICPR, 2001a). It also mentions the evaluation of this decision to possibly open the sluices further:

“The extent of opening depends on the discharge of the Rhine and will be monitored until 2012. After this period, a decision will be taken with respect to the question whether the sluices are to be opened more widely, thus also admitting tidal influence” (ICPR, 2001a, p. 15)

Similar examples of organizational adaptive management are found in the subsequent ICPR reports. In ‘Assessment Rhine 2020’, various restoration measures related to improving the Rhine passability, improving the Rhine retention capacity, reducing phosphorus and ammonium concentrations and reducing flood risk are mentioned to have been partially successful, after which revised additional

measures are mentioned to achieve the set goals (ICPR, 2020a). In order to increase the capacity of the ICPR to more precisely evaluate the impact of its own measures, the objective is also stated to further improve its own monitoring and evaluation systems (ICPR, 2020a). 'Rhine 2040' shares a similar vision as the previous report, as in the beginning of the report, the following quote is stated:

“The orientation of the “Rhine 2040” programme and its implementation in the Rhine catchment area should be reviewed at regular intervals. If necessary and in the light of developments, for example at EU level, as well as new knowledge and experience gained, it should be adjusted and/or tightened. The assessment regarding the implementation of the “Rhine 2040” programme is carried out every 6 years or, depending on the development of ambitious political goals in all nations of the Rhine catchment area, more frequently, and finally in 2039.” (ICPR, 2020b, p. 6)

This quote is a strong indication that 'organizational adaptive management' is actively pursued in the future by the ICPR to evaluate its own plans and implementation of Rhine ecosystem restoration measures. In the report, restoration measures are additionally repeatedly mentioned to be 'reviewed and, if necessary, adjusted' (ICPR, 2020b).

5.3.24. Open and innovative organizational culture

The ecosystem restoration organization has an organizational culture open for innovation, where experimental policies and measures are implemented to test new ideas.

The ICPR acknowledges the role of innovation in ecosystem restoration efforts, particularly in facilitating fish migration through innovative structures. Pilot projects serve as platforms for knowledge exchange and experimentation. Additionally, the ICPR adopts innovative monitoring methods like remote sensing and environmental DNA analysis to better understand the Rhine ecosystem. Overall, innovation plays a seemingly significant role in the ICPR's organizational culture in advancing restoration efforts. Therefore, the governance condition 'Open and innovative organizational culture' is graded GREEN on the Traffic Light Assessment Scale.

The ICPR describes its own organizational culture in the reports 'Assessment Rhine 2020' and 'Rhine 2040'. The focus on innovation in the Rhine ecosystem restoration process is most often mentioned in relation to fish ascent and descent structures. In the 'Assessment Rhine 2020' report, the ICPR mentions:

“In addition to the continuous improvement of fish migration upstream since the beginning of the 1990s, the ICPR has devoted itself intensively to the joint determination of innovative descending techniques for transverse structures.” (ICPR, 2020a, p. 13)

Chase (2011) also mentions that the Rhine 2020 report strongly advocated the use of innovative pilot projects to restore habitat in various location, using these experiments as a means to gather and share newly obtained knowledge. Focussing on the most recent objectives for ecosystem restoration for 2040, the stated aim to experiment with new fish ascent and descent structures at weirs and hydroengineering projects is re-included in the 'Rhine 2040' report, in order to reduce fish mortality and to improve the passability of the Rhine for migratory (fish) species, such as the Atlantic salmon:

“Continuation of the activities regarding innovative descent techniques on transverse structures that have been running since 2014, in order to reduce the loss of fish and damage to fish (e.g. salmon, eels) in turbines” (ICPR, 2020b, p.11)

“Regular testing, documentation and communication of the implementation and current state of research (best practice) for the restoration of fish ascent and descent at transverse structures” (ICPR, 2020b, p. 11)

Besides improving the passability, ‘Rhine 2040’ also re-includes the role of pilot projects to gain new insights in the ecosystem restoration process, while again mentioning the role of the ICPR as a platform for information exchange. New to this statement is the focus on cross-border projects, which is a repeatedly mentioned new objective of the ICPR, most-likely due to the availability of EU subsidies through the INTERREG subsidy scheme (Da Silveira & Richards, 2013):

“With the “Rhine 2040” programme, the ICPR wants to open up new paths for the development and implementation of innovative measures in water management. To this end, it should serve as a cross-border exchange platform and as a pioneer and initiator for cross-border and multilateral strategies.” (ICPR, 2020b, p. 6)

Lastly, the ICPR mentions innovation with regards to their monitoring methods and data collection on the progress of ecosystem restoration in the Rhine. New monitoring methods, such as the inclusion of remote sensing data and the analysis of environmental DNA are mentioned to be adopted and evaluated to gain a better understanding of the Rhine ecosystem and the effect of restoration measures (ICPR, 2020b).

5.4. Additional governance conditions

In the following section, the four additional governance conditions derived from the PDA and SLA are presented. For each governance condition, the perception of the interview respondents on the importance of this element to fostering successful riverine ecosystem restoration is explained. Based on the perceived importance, a decision is made on the possible inclusion of this additional governance condition to the refined framework, which contains all governance conditions for fostering successful riverine ecosystem restoration.

5.4.1. Centrally coordinated monitoring

Respondents were asked about their perception on the importance of the centrally coordinated monitoring role of the ICPR. In essence, the respondents recognize the importance of the role of centrally coordinated monitoring by the ICPR in assessing and addressing ecosystem restoration challenges in the Rhine basin. They underline the value of standardized monitoring techniques and the assessment reports for the whole river basin in gaining an understanding on the Rhine ecosystem, the impact of their restoration measures and in facilitating political discussions. Respondents do however express concerns that monitoring insights do not always result in further restoration action. As there is a consensus on the significance of centrally coordinated monitoring, this governance condition will be included in the adapted framework for analyzing governance conditions for successful ecosystem restoration.

Across all interviews, there's a consensus among respondents regarding the value of centrally coordinated monitoring in the restoration of the Rhine ecosystem. While individual countries monitor their respective ‘parts of the Rhine’ in line with European directives, such as the Water Framework Directive, and the agreements made within the ICPR, the ICPR's role lies in synthesizing these efforts (Respondent 1; Respondent 4). By drafting comprehensive reports on various aspects and parameters of the Rhine's ecosystem health, the commission facilitates a understanding of the entire river basin status. Moreover, it fosters collaboration and knowledge exchange among member states (Respondent 1; Respondent 4).

To facilitate the assessment of the entire Rhine catchment area, respondents mention the importance of the standardization of monitoring techniques as endorsed by the ICPR. The standardization of monitoring in all riparian states ensures consistency in the retrieved data, enabling easier comparisons and evaluation of ecosystem health for the whole river basin (Respondent 2; Respondent 3). However, as countries are not obliged to stick to the ICPR proposed monitoring techniques, challenges arise when countries deviate from these agreed-upon techniques, which hampers the comparability of data (Respondent 2; Respondent 3). Furthermore, respondents also highlight the importance of monitoring in creating an understanding on the Rhine ecosystem and the impact of restoration measures, opening up for the adaptation of restoration efforts if necessary (Respondent 2; Respondent 4; Respondent 5; Respondent 6; Respondent 7). This process of monitoring, learning, and adapting is frequently mentioned to be essential for refining restoration efforts over time (Respondent 2; Respondent 4; Respondent 5; Respondent 6; Respondent 7).

By centrally coordinating the monitoring of ecosystem restoration process within the Rhine catchment area, the ICPR also plays a crucial role in fostering accountability and collaboration among member states (Respondent 1; Respondent 2; Respondent 6). By ensuring that restoration efforts are not conducted in isolation of other riparian states, the commission encourages countries to fulfill their commitments on ecosystem restoration as agreed-upon within the ICPR (Respondent 2; Respondent 3; Respondent 6). With information on the status of the entire Rhine river, the ICPR serves as a platform for political negotiations and discussion in case of negligence of individual countries (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7).

Across interviews, there's a consensus among respondents regarding the significance of centrally coordinated monitoring in the ongoing process of restoring the Rhine ecosystem. While acknowledging the value of data collection and reporting, respondents emphasize the need of further translating the gained insights into tangible action. This is particularly mentioned in relation to restoration of the salmon population in the Rhine, as expressed by Respondent 2 and 5:

“So a lot of money is spent to reintroduce the Salmon. Hundreds, thousands of young salmon are released into the river or the tributaries every year, and we still have not enough coming back as we hoped and we really don't know why this is the case. So now the ICPR is working on a on a big monitoring program or research program to find out what is the reason. And from this research we hope we will not only learn why the salmon did not come back, but to learn more about how our river functions, what the problems of the river are, which we may have neglected throughout the last decades.” (Respondent 2)

“Let's talk about salmon for a moment, but there are 16 migratory fish in the Rhine, but when we talk about salmon, you see a huge decline in the reintroduction effects since 2010. And they worry. The fish expert group and the Rhine Commission commissioned Jörg Schneider to map this out. That's absolutely fine. The only question is, we've all seen it coming for 20 years. We know where the bottlenecks are, so you can collect data and continue reporting, but if you know what's going on there and you don't do anything about it, you keep reporting, then you won't make any progress.” (Respondent 5)

5.4.2. Flexibility

The respondents express a consensus that the flexibility granted to individual countries in choosing restoration measures is both a strength and a challenge. They acknowledge the diversity in restoration approaches among the riparian states, whereas each country has its own vision, preferences and contextual issues. Overall, the respondents emphasize the complexity of balancing

flexibility and imposition in restoration efforts. While flexibility allows for adaptation to local context, it can come at the expense of timely meeting agreed-upon restoration objectives. Therefore, this governance condition is not included in the refined framework for analyzing governance conditions for successful ecosystem restoration.

Although the ICPR facilitates political discussions and offers scientifically-sourced recommendations for restoration policies and measures, the ultimate decision in the implementation of measures lies with the riparian states themselves (Respondent 1; Respondent 2; Respondent 5). This decentralized approach allows countries to tailor solutions and restoration measures according to their specific needs and priorities (Respondent 6). However, it also creates challenges when different opinions and visions for restoration lead to conflicts (Respondent 2; Respondent 5). Exemplary is the situation mentioned by Respondent 5 in debates over hydropower and fish passage solutions:

“For example France, they have two huge hydroelectric power stations built in the middle of the Rhine. Then they talk about fish passages that have to start working. The energy company spends a lot of money on this, but the best thing is of course to just overhaul that hydropower and get rid of it. Why on earth? If on the one hand you want to have a migratory fish back that just needs to be able to swim to Switzerland, and on the other hand you have those turbines running. A lot of money is spent on research to see how you get those salmon past there, but those salmon are not crazy. Those turbines that create an enormous noise underwater, the salmon is forced into a narrow channel, but it just follows the main current, so it goes towards those turbines and that doesn't work. So from the point of view of the fish you should simply advise: you should not place that water power on the main stream of the Rhine, that is nonsense, that does not work. I can install hydropower high in the mountains where there is enormous decline. It is also not ideal for shipping to have a hydroelectric power station in the middle of the Rhine, so both ecologically and economically, we think that French hydroelectric power stations are not okay and not logical, but the French delegation in the Rhine Commission claims otherwise. Then we just have a conflict there, a difference of opinion.” (Respondent 5)

The respondents highlight the importance of international collaboration of scientific experts and knowledge exchange in drafting recommendations and consensus on best practices within the Rhine Commission (Respondent 1; Respondent 2). Nevertheless, various respondents state that scientific knowledge should remain in the form of recommendations, as they stress that decisions should not be imposed top-down, as national governments value their country's autonomy in decision-making (Respondent 2; Respondent 4). Respondent 1 also highlights that the flexibility is vital, as the ICPR does not have sufficient knowledge to strictly impose restoration measures:

“I am really convinced that we need this flexibility, because we really do not have the knowledge and competence to determine everything from the secretariat.” (Respondent 1)

Nevertheless, concerns are raised about the balance between flexibility and effectiveness. While flexibility allows for adaptation to local contexts and challenges, there's a recognition that flexibility frequently comes at the expense of timely achieving shared objectives, as flexibility leaves room for negligence or delay of restoration action (Respondent 3; Respondent 7). Various respondents advocate for clearer guidelines and stronger enforcement mechanisms to ensure compliance with agreed-upon restoration goals and objectives, as is the case with the European Directives (Respondent 3; Respondent 4; Respondent 5; Respondent 6; Respondent 7). Respondent 7 states the following:

“I: Do you think it would work better if there were stricter regulations in which really strict orders could be issued: you have to do this now in this time frame?”

P: Yes, please yes. You just have to have an implementation plan. That you know exactly what measures you need to take. Or at least first a roadmap of what steps you need to take to achieve this. But in the end you just have a list of measures and then agreements about who will do it and how it will be financed. But all that is missing.” (Respondent 7)

Finding the right balance between flexibility, imposition and timely collective action remains a key challenge in the restoration process of the Rhine ecosystem.

5.4.3. Transformative organizational structure

Based on the conducted interviews, it is evident that there are varied perceptions regarding the importance of having a transformative organizational structure within the ICPR to foster successful ecosystem restoration. While some respondents highlight the value of possible changes in the organizational structure of the ICPR to widen its scope and to adapt to new issues, others state that they are satisfied with the current organizational structure and its flexibility. Various respondents also highlight the importance of staying focussed on giving a voice to ecological values in political debates, expressing their worries about further development towards a more interdisciplinary organizational structure. Due to the varied perceptions with regard to the importance of a transformative organizational structure of the ICPR, this governance conditions is **not included in the refined framework for analyzing governance conditions for successful ecosystem restoration.**

Various respondents express contentment with the existing organizational structure, additionally highlighting its flexibility to adapt to new challenges and European directives without the need for significant structural organizational changes (Respondent 1; Respondent 2; Respondent 3; Respondent 6). At the same time, these respondents do however highlight the importance of the ability of the ICPR to form new expert groups and to broaden its scope in light of emerging issues like climate change and low water levels effectively (Respondent 1; Respondent 2; Respondent 3; Respondent 6). The underlying mindset seems to be that the general organizational structure of the ICPR works well, but that the flexibility of the organization to adapt to new issues is considered very important. Respondent 1 explains this flexibility as follows:

“But what has changed is that new tasks were added. For example, in the beginning it was just water quality and chemistry. Ecology was added in the 1980s and flooding in the 1990s. Now of course also low water and climate change, which also affects all other themes. It has become a bit interdisciplinary?” (Respondent 1)

The idea of more interdisciplinarity is supported by Respondent 3, who states her interest in the possibility of combining various Working Groups to create a more interdisciplinary focus within the ICPR. Respondent 6 has reservations about the interdisciplinary transformation of the ICPR, as he states that there are personnel issues within the riparian states, which has an impact on maintaining or expanding the current organisational structure of the ICPR. Because the government bodies of the riparian states are not adequately staffed, it takes longer to form new Working Groups or, for example, to find a new chair. Respondent 4 and 5 emphasize the importance of maintaining the focus of the ICPR on giving a voice to issues such as water quality and ecology. As a strength of the ICPR is to shed more light on the necessity of restoring and protecting the Rhine ecosystem, Respondent 4 states that the commission should not dilute this focus with the implementation of multidisciplinary approaches. Instead, he underlines the importance of the ICPR in providing an adequate discussion platform in balancing ecological concerns against economic interests within the commission's decision-making processes. Respondent 5 shares the same vision as Respondent 4, but stretches that the values of ecology should be voiced more loudly in consideration with economic interests:

“I think that the structure that is there now, that has emerged from that, is okay in itself. Fine. I do think that it is a bit of a discussion groups, meeting culture, reporting culture and that making direct decisions has been pushed into the background. This is also influenced by people who have started thinking very strategically. And that's not good for actually getting anything done. I think if you really want to get those salmon back, then some more stringent measures must be taken that are in line with the current policy. Because the policy is very clear, but the strategic considerations that are made; (...) You can see very clearly that economic interests and ecological interests are not entirely compatible. Together they cannot achieve what European policy dictates. And yes, that is mainly due to the meeting culture and the strategic consideration that is ultimately made by civil servants and policy makers. I think we need to give it a little more gas.” (Respondent 5)

5.4.4. The use of an indicator species

The use of the Atlantic salmon as an indicator species for guiding the restoration of the Rhine ecosystem is praised by various respondents, who underline the symbolic importance of the salmon to reflect the wellbeing of the Rhine ecosystem and whose demand for passability of the Rhine reflects the need for international collaboration. Additionally, the cultural and economic significance of the salmon within the Rhine catchment area further strengthens its role as a symbol for raising awareness and garnering support for restoration efforts. However, due to challenges in establishing a self-sustaining salmon population, concerns are raised with regard to the overreliance on the emotional appeal of the salmon, which possibly diverts attention from other crucial ecological factors within the Rhine ecosystem. Criticism also emerges regarding the suitability of the Atlantic salmon as a sole indicator species, with suggestions to explore alternative strategies or consider multiple indicator species to capture the complexity of the Rhine ecosystem dynamics. As respondents note both strengths and weaknesses to adopting a fine-filter approach to ecosystem restoration, this governance conditions is **not included in the refined framework for analyzing governance conditions for successful ecosystem restoration.**

The selection of Atlantic salmon as an indicator species to guide the restoration of the Rhine ecosystem is perceived to have significant added value, according to respondents who participated in expert interviews. Firstly, Respondents emphasized the salmon's role as a symbol of ecological health. Its presence or absence reflects the overall health of the ecosystem and therefore the progress made in the restoration of the Rhine (Respondent 1; Respondent 5). As the Atlantic salmon requires clean water, diverse riverine habitats and a passable Rhine from the sea to its source, the requirements of the salmon largely overlap with the restoration measures necessary to revive the entire Rhine ecosystem by resolving its most pressing issues (Respondent 1; Respondent 3; Respondent 4; Respondent 7). Respondent 7 even states that the salmon's demand for the passability of the whole Rhine directly hints to the connection and collaboration needed for successful international cooperation by all riparian states in the Rhine catchment area. Due to the high demands of the salmon, the species has facilitated the decision-making process by highlighting specific Rhine ecosystem restoration measures, such as the removal of barriers, such as dams, and the construction of fish passages to facilitate migration (Respondent 1; Respondent 2; Respondent 3; Respondent 4; Respondent 7). These measures benefit not only the salmon itself, but also the entire ecosystem (Respondent 1; Respondent 2; Respondent 3).

The salmon has a large cultural and historical economic significance within the Rhine catchment area as a source of food or income for fishermen (Respondent 2; Respondent 3; Respondent 4; Respondent 7). As the species is well-known, the call for its return resonates with the public, making it an effective symbol for raising awareness and to gain support for restoration efforts (Respondent 1; Respondent 2; Respondent 3; Respondent 6; Respondent 7). Respondents also mention the ‘cuddly appeal’ of the

salmon in comparison to other river species, underlining the role of the looks and familiarity of a species to function as a strong symbol for a restoration project (Respondent 2; Respondent 4; Respondent 6). In addition, respondents emphasise the importance of the salmon for attracting political attention and government funding to help with Rhine restoration (Respondent 4).

Furthermore, the effort to bring back the salmon is a learning process in itself, as the salmon is viewed as a facilitator to conducting more research and monitoring efforts by Respondent 2:

“We learned that the success is not as good as we hoped. So a lot of money is spent to reintroduce the Salmon. Hundreds, thousands of young salmons are released into the river or the tributaries every year, and we still have not enough coming back as we hoped and we really don't know why this is the case. So now the ICPR is working on a on a big monitoring program or research program to find out what is the reason. And from this research we hope we will not only learn why the salmon did not come back, but to learn more about how our river functions, what the problems of the river are, which we may have neglected throughout the last decades. So even in that negative point of view, the salmon is a good indicator and a good symbol to work on restoration, because it forces us to learn more. To do more research on what is going on and what we've neglected for a long time.” (Respondent 2)

The challenges in fostering a self-sustaining population in the Rhine river basin lead to the conduction of further research on the salmon and the Rhine ecosystem in general (Respondent 2). The focus on the Atlantic salmon thus stimulates informed plan-making and underlines the call for a better understanding of the broader ecological dynamics, as research aimed at elucidating the reasons behind the struggling salmon population contributes to a deeper understanding of ecosystem health and informs future restoration efforts (Respondent 2).

Despite the efforts to restore the Atlantic salmon population in the Rhine, the success achieved was not as great as initially hoped, as noted by Respondent 2. This raises the question of a potential risk as a result of relying too heavily on the emotional appeal of the salmon as a symbol for restoration. Although the salmon facilitated the process of political and public engagement and funding for conservation efforts, this may diminish if restoration efforts fail to meet the agreed-on long-term objectives (Respondent 4). Additionally, Respondent 4 mentions that without the salmon as an indicator species, the funding for restoration projects might have been directed elsewhere. This raises questions about whether the focus on the salmon as an indicator species has created negligence of other important ecological factors or species within the ecosystem.

A frequently mentioned criticism is the recognition of the migratory nature and the lifecycle of the Atlantic salmon, which spans vast distances from freshwater spawning grounds to saltwater habitats (Respondent 4; Respondent 5; Respondent 6). As the Atlantic salmon is an anadromous species, this complicates the use of salmon populations as indicator species solely for the ecosystem health of the Rhine river itself, as its habitat extends far beyond the river basin. As the habitat of the Atlantic salmon extends beyond the Rhine, challenges with regard to the return of a self-sustaining population could originate from areas outside the scope of the ICPR, creating challenges for the organization in fostering a successful holistic restoration strategy within the Rhine river basin (Respondent 4; Respondent 5; Respondent 6).

Criticism is also voiced by two respondents, who suggest that while using the Atlantic salmon as an indicator species has had an overall positive impact on promoting ecosystem restoration, there lies untapped potential in exploring alternative strategies. Respondent 7 reflects on the potential outcomes if a different species had been chosen as an indicator. He suggests that without a migratory fish species like salmon, restoration efforts might have focused more on underexposed aspects, such

as river bank restoration. Respondent 6 discusses nature restoration in tributaries of the Rhine and in areas outside dykes, suggesting nature restoration which can be more visible to the public than the current focus on a migratory fish species. He emphasizes the strength of an "indicator landscape" rather than solely focusing on a single indicator species, which can be given more public attention by constructing walking routes or by promoting other forms of recreation.

Respondent 3 and 5 acknowledge the importance of considering multiple indicator species beyond the Atlantic salmon. In order to ensure a comprehensive understanding of ecological health, Respondent 3 claims that a wider perspective on the overall health of the Rhine ecosystem could be obtained with multiple indicator species, including smaller organisms like mussels and flies. Respondent 5 similarly recognises the value of the salmon as a symbol, but advocates for an approach that uses multiple indicator species to capture the complexity of ecosystem dynamics. He underlines the potential of considering a broader range of migratory fish species, besides the salmon, as indicator species, as focusing solely on one species overlooks the significance of others. Given examples are the shad, sturgeon, houting, and barbel, which are vital for assessing the overall health of various parts of the Rhine river.

5.5. Perceived importance of governance conditions

In order to evaluate the significance of the different governance conditions, respondents were asked to identify the ones they considered to be the most crucial. The answers of the respondents varied widely, but there is some overlap in the considered importance of governance conditions.

Respondent 1, 2 and 7 state that the governance condition 'Nested' is one of the more important conditions to facilitate successful ecosystem restoration. Respondent 1 highlights the role of the drafted rules and regulations with regard to the functioning of the ICPR and the agreements made on the restoration of the Rhine river basin. As the international cooperation surrounding the Rhine ecosystem restoration is nested, the functioning of the ICPR as an organization is recorded in official documents, so that it continues to function for generations to come. Respondent 2 underlines the importance of having a fixed, nested governance structure, from which international collaboration can be discussed and negotiated:

"And good functioning structures. If you have good structures, if you have good teams which work together, then of course it is easier to go forwards, than if you have structures which are swimming or floating on a sort of ocean and don't have an anchor and don't have a harbor where they can be fixed."
(Respondent 2)

Respondent 7 additionally states the importance of the governance condition 'Nested', but derives his answer mostly from the newly adopted European laws, which give additional motivation and add a dimension of enforcement, another governance condition, to ecosystem restoration efforts by the riparian states:

"The nature restoration regulation adopted in the European Parliament. That a new idea arises: we all have laws and ambitions, but we are not making any progress, so an additional legal instrument must be added that encourages Member States to take action. Well, it has now been accepted. Then it is hoped that the Member States will still approve that this is possible, so that could be a kind of start to a change. By really just putting it higher on the priority list and actually just enforcing it with such a roadmap, an approach. I think that's good." (Respondent 7)

The perceived importance of 'Enforcement' is shared by Respondent 4, who similarly talks about the European Directives. With the Water Framework Directive, all riparian states are held more accountable for the actual implementation of ecosystem restoration measures. By having this legally

anchored goal, with the risk of financial punishment in case of negligence, Respondent 4 expresses her hopes about for the prioritization and acceleration of ecosystem restoration.

Both Respondent 2 and 6 underline the importance of having 'Financial agreements' for the implementation of restoration measures, as this is a difficult topic that slows down political debates and creates national disputes over responsibilities. According to them, a more concrete plan for financing the restoration of the Rhine would greatly benefit the overall process.

Conclusively, some governance conditions were only mentioned by a single respondent. Respondent 1 underlines the importance of having a 'Coordinated shared vision' as a foundation to guide international collaboration on the restoration of a cross-border river basin. Similarly, he mentions the importance of having a 'Conflict management' strategy in resolving possible conflicts that might arise. Respondent 3 values the role of the ICPR in 'Centrally coordinated monitoring', in order to be able to track the current progress of ecosystem restoration and to assess the impact of restoration measures. Lastly, Respondent 6 mentions 'Political support', calling the political will of the Rhine ministers to foster ecosystem restoration a decisive bottom-line in obtaining success.

5.6. Conclusion

Conclusively, the governance structure of the ICPR is fairly well structured to facilitate successful ecosystem restoration, as 14 out of 24 governance conditions are present, 6 are partially present and 4 are not present. From the 'Additional governance conditions', only 'Centrally coordinated monitoring' was generally perceived as vital to ensure successful restoration of riverine ecosystems. This governance condition will thus be included in the refined framework for successful riverine ecosystem restoration, which will be presented in the next chapter. Lastly, the respondents were asked to state their perceived importance of the various governance conditions. The conditions 'Nested', 'Enforcement' and 'Financial agreements' were perceived as important by most respondents. Other governance conditions mentioned to be important by individual respondents are 'Coordinated shared vision', 'Conflict management', 'Centrally coordinated monitoring' and 'Political support'.

6. Discussion

6.1. Introduction

In this chapter, the final subquestion of this research is answered, namely: *What lessons can be learned from the Rhine river ecosystem restoration process?* This question is answered in three steps. Firstly, the contribution of the conducted research to the current theoretical insights on the restoration of riverine ecosystems is reflected upon. Secondly, the limitations of the conducted research are discussed focussing on the research process and evaluating the choices made for the conducted research methods. Additionally, suggestions for follow-up research are presented. Thirdly, the refined framework for assessing governance conditions for successful restoration of riverine ecosystems is presented. The general framework, created in chapter 2 of this research, is refined and added to, in order create a framework applicable to riverine ecosystem restoration using insights from the Rhine case study. With the refinement of the framework, the validity and reliability of the framework is improved for possible follow-up research.

6.2. Theoretical implications

The aim of this research was to analyse the governance conditions for successful restoration of riverine ecosystems. Following an iterative process, governance conditions were derived from scientific literature, assembled to create an analytical framework and then tested in a critical case study. Ultimately, a better understanding of the Rhine ecosystem restoration process was gained, from which valuable recommendations for policymakers are formulated to improve the governance of the Rhine ecosystem restoration process. These recommendations are presented in the next chapter. While conducting the case study, a refined analytical framework for analyzing riverine ecosystem restoration was simultaneously constructed. The adoptability of this framework offers a valuable contribution to scientific literature, as similar case studies can be conducted to highlight limiting and enabling factors to a riverine ecosystem restoration project from a governance perspective. In addition, the success of ecosystem restoration projects can be better understood by taking into account its societal context, as the management of ecosystem restoration is significantly influenced by its overarching governance structure. This holistic approach is in line with the call for systems thinking in sustainability governance. Moving away from arbitrarily demarcating sustainability challenges, a contextual case study analysis as conducted in this research is able to better account for the complexity of fluvial management, particularly when focusing on cross-border governance. Hypothetically, the success of riverine ecosystem restoration projects can be improved and their value to fighting climate change and biodiversity loss can be underlined by conducting this research. As large steps need to be undertaken towards environmental restoration and conservation, it is important to gather scientific knowledge on the practical implementation of these efforts and on how to effectively streamline sustainability governance. This way, vital ecosystems and their ecosystem services can be preserved to support various facets of our society that are dependent on healthy, thriving river ecosystems. As limited research is conducted on assessing the best-practice governance structure for ecosystem restoration, let alone for riverine ecosystems, this research delivers a valuable contribution to narrowing this knowledge gap and gaining a better understanding.

6.3. Research limitations and recommendations for follow-up research

When looking at this research, there are some limitations to be noted, mainly when focussing on the research method and strategy. A conscious choice was made to conduct a critical case study on the riverine ecosystem restoration process of the Rhine. As the governance conditions for riverine ecosystem restoration are seldomly researched, focus in this research was put on assessing these conditions for the restoration of the Rhine for a contextual and holistic analysis of the whole river basin management structure, which ensures that all facets of the transboundary governance structure are

investigated. As the governance of the Rhine river basin is often positively exemplified in scientific literature, the conducted study can be valued as a critical case study from which valuable insights can be derived for other riverine ecosystem restoration projects. By constructing a transparent and clear framework for a case study analysis, the research design and strategy of this study can be easily replicated for other case studies on river basin management structures, thereby enhancing the reliability of findings and facilitating broader applicability across diverse geographical contexts. Nevertheless, this narrow research focus however left out the option to compare the Rhine restoration project with other restoration projects. This is partially due to the time available to conduct this research, and partially due to one of the conducted research methods. By choosing to conduct interviews instead of surveys, more in-depth information about the process of ecosystem restoration from a governance perspective could be extracted from experts, as this topic is complex and highly contextual. The usage of surveys could however largely improve the amount of possible respondents, as this method takes less time to carry out and has a broader reach. Additionally, more valuable insights could possibly be retrieved by expanding the respondent group for expert interviews, ultimately increasing the generalizability and validity of this research.

As a recommendation for follow-up research, the scope of this research could be expanded. This can be achieved by increasing the expert interview respondent group, or by changing the research method to surveys. Similarly, additional insights could be retrieved by comparing the governance structure of the Rhine case study to other riverine ecosystem restoration projects. A comparative study on various riverine ecosystem restoration projects will be able to underline similarities and differences in the governance structure of each project, while possibly highlighting 'solutions' for restoration projects who by exception might struggle with challenges for a certain governance condition. Such a comparative study will improve the generalizability of the research results, while simultaneously putting the created refined analytical framework for riverine ecosystem restoration to the test.

6.4. A refined framework for assessing governance conditions for successful riverine ecosystem restoration

By conducting a case study on the ecosystem restoration process of the Rhine, a refined framework for assessing governance conditions for successful riverine ecosystem restoration can be presented. The first draft of this framework was conducted by assembling governance conditions for ecosystem restoration in general. By applying this framework to the Rhine case study, the quality and completeness of the framework was put to the test, while simultaneously testing its usability for riverine ecosystem restoration projects. Ultimately, some adaptations are made to refine the framework for possible future or follow-up research. The refined framework is presented in Appendix E.

As a first revision, the governance condition 'Trade-off management' was removed from the framework. The assessment of the governance of ecosystem restoration by the ICPR revealed that there are varying strategies in choosing the best-practice restoration measures. The ICPR restoration measure selection strategy emphasizes the importance of tailored ecosystem restoration measures, supported by scientific research, monitoring and data analysis to assess effectiveness and inform decision-making. This strategy strongly differs from the selection of restoration measures through trade-off management, although no indication was found for the superiority of either one of these strategies. Conclusively, the governance condition 'Trade-off management' is removed from the framework, because it is not the only effective strategy for the selection of restoration measures, and therefore not vital in facilitating effective ecosystem restoration.

A second revision to the framework is the addition of the governance condition 'Centrally coordinated monitoring'. This governance condition was derived from the conducted PDA and SLA and presented to the respondents of the expert interviews. From these interviews, the perceived importance of this governance condition to facilitating successful ecosystem restoration was derived. In essence, the respondents recognize the importance of the role of centrally coordinated monitoring by the ICPR in assessing and addressing ecosystem restoration challenges in the Rhine basin. They underline the value of standardized monitoring techniques and the assessment reports for the whole river basin in gaining an understanding on the Rhine ecosystem, the impact of their restoration measures and in facilitating political discussions. Therefore, this governance condition is added to the refined framework.

As a third revision, the governance condition 'Multi-disciplinary' was refined to 'Multi- and interdisciplinary'. Various respondents of the expert interviews underline the importance of not solely the multi-disciplinary assessment of ecosystem restoration challenges, but additionally the collaboration and information exchange between scientific disciplines to gain a better holistic understanding of the functioning of the ecosystem. Therefore, the governance condition was expanded to now include the aspect of interdisciplinarity in its definition.

As a last revision to the framework, the governance conditions 'Designated role for science', 'Informed plan-making and execution' and 'Reducing uncertainty' were merged into one overlapping governance condition. During the assessment of these governance conditions for the Rhine case study, it became clear that the three governance conditions largely overlapped. The designated role for science in the ICPR governance structure is predominantly to inform plan-making and execution, as scientific insights are used to draft policy recommendations to adjust or expand ecosystem restoration measures and to reduce uncertainties in the restoration process. Due to the overlap of these governance conditions, all three conditions are combined under the condition 'Informed plan-making and execution', of which the definition was altered to include the important aspects of each condition.

6.5. Conclusion

Conclusively, various lessons can be learned from the conduction of a case study on the restoration of the Rhine ecosystem. Using insights from this case study, a refined framework for assessing governance conditions for successful restoration of riverine ecosystems is created, which can be used in follow-up research on similar restoration projects. Additionally, a contribution was made to reducing the knowledge gap on the impact of governance on the success of ecosystem restoration projects. Ultimately, the success of riverine ecosystem restoration projects can hypothetically be improved and their value to fighting climate change and biodiversity loss can be underlined. Based on the limitations of this study, recommendation for follow-up research are made to widen the research scope, possible by changing the research method, and by conducting a comparative research on different riverine ecosystem restoration projects. In the next chapter, the main research question of this study is answered, supported by recommendations for policymakers

7. Conclusion

7.1. Introduction

The aim of this research was to analyze governance conditions for successful restoration of riverine ecosystems using the following research question: *What governance conditions contribute to successful restoration of riverine ecosystems?* In order to formulate an answer to this research question, firstly a literature review was conducted to explore studies on the governance of ecosystem restoration, deriving general governance conditions that have an impact on the success of ecosystem restoration. Secondly, a case study was conducted on the governance of the ecosystem restoration process of the Rhine river, using a policy document assessment, scientific literature assessment and by conducting expert interviews. By doing so, the applicability of the created framework to *riverine* ecosystem restoration was tested, while simultaneously refining and adding to the framework. Subsequently, a refined framework was created for assessing the governance conditions for successful riverine ecosystem restoration projects to be used in follow-up research. Through the conduction of the case study on the Rhine ecosystem restoration process, its current success was analysed, while simultaneously assessing the presence of governance conditions using the created framework. Ultimately, the framework was used to explain the Rhine ecosystem restoration case study's current status by emphasising the governance conditions that facilitate the success of the restoration process, while additionally highlighting the governance challenges associated with the Rhine ecosystem restoration through the absence of governance conditions.

In this chapter, an answer is firstly formulated to the research question by presenting the governance conditions that contribute to successful restoration of the riverine ecosystems. Secondly, recommendations are given to the ICPR and other policymakers related to the restoration of the Rhine ecosystem, based on the results of the conducted case study and the presence of governance conditions in the governance structure of the restoration of the Rhine ecosystem.

7.2. Governance conditions for a successful restoration of riverine ecosystems

Reflecting on the constructed general framework for assessing governance conditions for ecosystem restoration, the tool was of significant added value to structurally assess the governance structure of the restoration of the Rhine ecosystem. From the drafted governance conditions, clear strengths and weaknesses of the governance structure could be extracted that both clearly facilitate or constrain the effectiveness of ecosystem restoration. This underlines the importance of understanding the role and impact of governance and assessing the complex interplay between governance structures and their subject of focus. After the inclusion of the refinements and additions based on insights from the case study, the refined framework in Appendix E is suitable to assess the governance structure of *riverine* ecosystem restoration efforts, of which the Rhine case study is exemplary.

Using the refined framework and insights from the case study on the governance of the restoration of the Rhine ecosystem, the following answer can be formulated to the main research question of this study by elucidating the governance conditions that contribute to successful restoration of riverine ecosystems.

The chances of successful riverine ecosystem restoration are greater if:

- Ecosystem restoration is protected by and embedded in institutional arrangements and legislation.
- The ecosystem restoration organization has the power to transform existing institutional restoration arrangements or institutionalize new restoration arrangements.

- The ecosystem restoration organization has the will and power to legislatively enforce on the breaching of institutional restoration arrangements.
- Ecosystem restoration management takes place at a cross-border, fluvial scale to ensure synergy between individual restoration measures
- Room is given to bottom-up, grassroots participation in the restoration process through designated communication platforms
- There is a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process.
- Employees of the ecosystem restoration organization are of multi-disciplinary backgrounds, thus accounting for the multi-dimensionality of the restoration area. The organization's multi-disciplinarity is effectively utilized through the inter-disciplinary assessment of ecosystem restoration challenges
- The ecosystem restoration organization has a concise strategy to resolve conflicts through consensus resolution.
- Contributions of actors to ecosystem restoration are financially rewarded.
- Ecosystem restoration has economic benefits for partaking actors, besides possible direct reward structures (e.g. business development; protection of natural capital)
- Clear viable and long-term agreements are present to finance the ecosystem restoration project.
- There is a clear demarcated and designated role for science in the creation and implementation of restoration policies and measures and in the reduction of uncertainties in the ecosystem restoration organization.
- The ecosystem restoration project is supported by political will and adequate state support. This can be facilitated by active political brokering.
- The ecosystem restoration organization deploys an active capacity building process to increase the support base of the restoration project by including more actors and stakeholders.
- There is notable strong, inspiring leadership of individuals with experience and a relevant background.
- Collaboration is coordinated by ensuring all partaking actors in the ecosystem restoration process share the same goals and vision for the project.
- Actors are held accountable for a timely implementation of restoration measures
- The ecosystem restoration organization centrally coordinates a monitoring program to assess the status of the ecosystem, the impact of restoration measures and the progress of restoration efforts.
- The ecosystem restoration organization has a platform to compromise on stakeholder discourses, thus accounting for different values and opinions for ecosystem restoration.
- The ecosystem restoration project has clear long-term goals, which are flexible to anticipate for future uncertainties.
- The ecosystem restoration organization continually improves its restoration policies and measures by evaluating the outcomes of existing policies and measures.
- The ecosystem restoration organization has an organizational culture open for innovation, where experimental policies and measures are implemented to test new ideas.

7.3. Recommendations for policymakers

By analyzing and comparing ten studies on the governance of ecosystem restoration, an analytical framework was created to assess the governance structure of ecosystem restoration projects by focusing on the presence of governance conditions, elements or activities that are required for a

governance approach to successfully realize ecosystem restoration. The created framework was then tested on its applicability on riverine ecosystem restoration projects through conducting a case study on the governance of the restoration of the Rhine ecosystem. By assessing four ICPR reports, seven studies on the ICPR and by conducting seven expert interviews, a foundational understanding was created of the governance of the restoration of the Rhine ecosystem and its challenges. In general, the governance structure of the ICPR is fairly well structured to facilitate successful ecosystem restoration, as 14 out of 24 governance conditions are fully present, 6 are partially present and 4 are not present. From the seven governance conditions mentioned as most important by the interview respondents, four conditions are fully present, two are partially present and one was included as additional governance condition in the refined framework, therefore not part of the initial Traffic Light assessment grading. Based on the grading of the conditions perceived as most important, the ICPR governance structure scores mainly favorable.

As a recommendation for the ICPR and other policymakers related to the restoration of the Rhine ecosystem, this study strongly advocates for maintaining the currently present governance conditions in the governance structure of the restoration of the Rhine, as they positively contribute to the success of the process. Additionally, addressing the following challenges identified by this research can be the suggested focal point of the ICPR in order to improve the governance of the Rhine ecosystem restoration process.

Although ecosystem restoration of the Rhine is nested in various international agreements, institutionalization is not seldomly restrained to solely limiting the anthropological damage to the Rhine, instead of formalizing true restoration and conservation agreements to improve the quality of the Rhine ecosystem. Criticism is directed towards the time-consuming procedures of discussion and negotiation within the ICPR and the ambiguity of responsibilities within national governmental organizations due to the attribution of tasks and responsibilities being loosely defined to each riparian state's national mandate. This is partially caused by the soft-law approach of the ICPR, which attributes its enforcement mechanisms largely to political or public pressure, although there lies potential in the more stringent enforcement measures from European Directives.

Financially, the governance of ecosystem restoration of the Rhine also has notable challenges, as there are minimal financial incentives for riparian states to support the funding of restoration measures using their own national budget. Although there are significant economic benefits to the restoration of the Rhine ecosystem, these benefits will be derived in the long-term. Part of these benefits are the avoided costs of potential disasters or the restoration of future damage to the ecosystem, which are indirect, therefore harder to communicate and thus currently seldomly included in political or financial considerations. Additionally, the same mentioned ambiguity within national governmental organizations plays a role in slowing down decision-making with regard to financing ecosystem restoration measures.

To coordinate the restoration of the Rhine ecosystem on a fluvial scale, the ICPR drafts policy recommendations for individual riparian states. Although the ICPR puts effort in weighing scientific knowledge from varying disciplines both multi- and interdisciplinary, some remarks are made on the challenges of transferring the multi- and interdisciplinary insights to the more compartmentalized national political playfields. From the perspective of the ICPR, a better political fit of policy recommendations can be sought out, possibly by including experts in political sciences in its Expert-, Working or Strategy Groups. As similarly the role of individual leadership strength is scarcely mentioned in the assessed sources to be of importance to the success of the ICPR, the involvement of individuals with relevant political experience at a national or international level could be of added value in order to raise awareness of the Rhine restoration process and to find better political alignment.

Based on the perception of the interview respondents, the conditions, 'Enforcement' and 'Financial agreements' were perceived as part of the most important governance conditions by more than individual. As the latter two governance conditions are endorsed as challenges to the current governance of the Rhine ecosystem restoration process, this study recommends to give priority to improving the current governance structure to meet these conditions first.

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Appendices

Appendix A – Sources of governance conditions

Keyword	Source
Nested	Bennett & Satterfield (2018); Ha et al. (2018); Mitchell et al. (2015); Van Oosten et al. (2021); Van Rijswick et al. (2014)
Transformative power	Bennett & Satterfield (2018); Ha et al. (2018); Mitchell et al. (2015); Van Oosten et al. (2021)
Enforcement	Ha et al. (2018); Van Rijswick et al. (2014)
Synergy	Angelopoulos et al. (2017); Ha et al. (2018); Van Rijswick et al. (2014)
Participation	Angelopoulos et al. (2017); Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); France (2016); Ha et al. (2018); Van Rijswick et al. (2014)
Clear task division	Bennett & Satterfield (2018); Ha et al. (2018); Hegger et al. (2012); Van Rijswick et al. (2014)
Multi-disciplinary	Angelopoulos et al. (2017); Ha et al. (2018); Van Oosten et al. (2021);
Conflict management	Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018); Van Oosten et al. (2021); Van Rijswick et al. (2014)
Financial incentive	Hegger et al. (2012); Mitchell et al. (2015)
Economic benefits	Angelopoulos et al. (2017); France (2016); Van Oosten et al. (2021); Palmer et al. (2005)
Financial agreements	Angelopoulos et al. (2017); Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018); Van Oosten et al. (2021); Van Rijswick et al. (2014)
Designated role for science	Buitenhuis & Dieperink (2019); Hegger et al. (2012)
Informed plan-making and execution	Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018); Mitchell et al. (2015); Van Oosten et al. (2021); Palmer et al. (2005); Van Rijswick et al. (2014)
Trade-off management	Van Oosten et al. (2021); Van Rijswick et al. (2014)
Reducing uncertainty	Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018)
Political support	Bennett & Satterfield (2018); Mitchell et al. (2015); Van Oosten et al. (2021)
Capacity building	Buitenhuis & Dieperink (2019); Hegger et al. (2012); Mitchell et al. (2015)
Individual leadership strength	Buitenhuis & Dieperink (2019); Van Oosten et al. (2021)
Coordinated shared vision	Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018); Hegger et al. (2012); Mitchell et al. (2015); Van Oosten et al. (2021); Palmer et al. (2005)
Efficient	Angelopoulos et al. (2017); Bennett & Satterfield (2018)
Recognition of different perspectives	Bennett & Satterfield (2018); France (2016); Hegger et al. (2012); Van Oosten et al. (2021); Van Rijswick et al. (2014)
Long-term planning and anticipation	Bennett & Satterfield (2018); Ha et al. (2018); Mitchell et al. (2015)

Organizational adaptive management	Angelopoulos et al. (2017); Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); France (2016); Ha et al. (2018); Mitchell et al. (2015); Palmer et al. (2005); Van Rijswick et al. (2014)
Open and innovative organizational culture	Bennett & Satterfield (2018); Buitenhuis & Dieperink (2019); Ha et al. (2018); Mitchell et al. (2015); Van Rijswick et al. (2014)

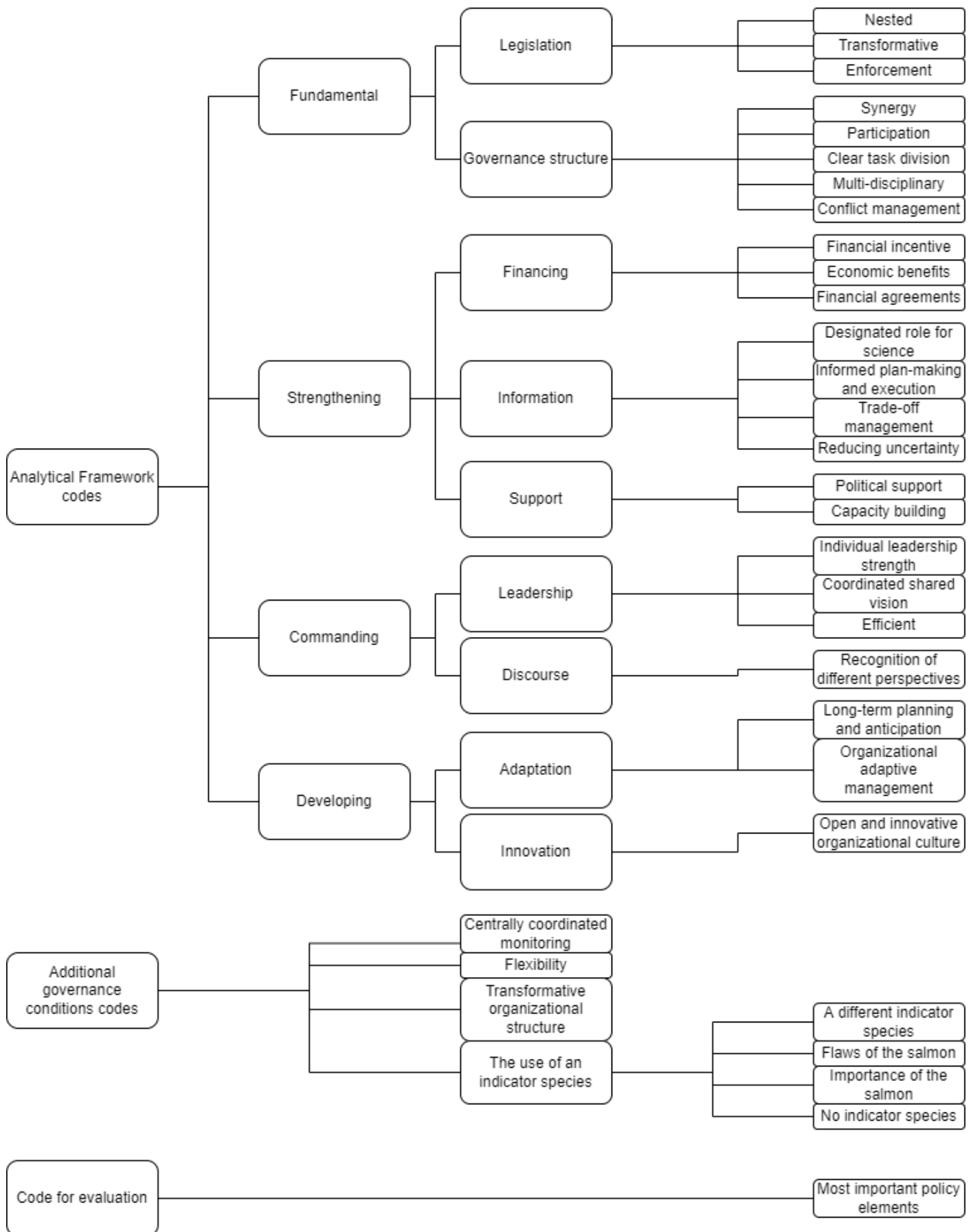
Appendix B – Interview outline (English)

Topic	Code	Question
Introduction and general questions		
Introduction		<i>Short explanation on the topic and aim of this research</i>
General questions		What is your function?
		What is your background?
Governance conditions		
Organization	<i>Trade-off management</i>	Are ecosystem restoration measures weighed against alternative measures to assess the most favorable impact? If so, how? And by whom?
	<i>Individual leadership strength</i>	Would you say that strong, inspiring leadership of specific individuals plays an important role in the success of the ICPR in taking recovery initiatives?
	<i>Multi-disciplinary</i>	Are the members of the ICPR of multi-disciplinary backgrounds? (Does this differ per ICPR working group?)
	<i>Transformative organizational structure</i>	What do you think is the importance of the capacity of the ICPR to change its organizational structure, as it has historically has done?
	<i>Centrally coordinated monitoring</i>	What do you think is the importance of the centrally coordinated monitoring system of the Rhine restoration process?
Finances	<i>Financial incentive</i>	Are contribution of actors to the ecosystem restoration process financially rewarded? If so, how? Can you give some examples?
	<i>Economic benefits</i>	Are there economic benefits to partaking in the restoration process (besides possible direct reward systems)? (e.g. business development, protection of natural capital)
Actors	<i>Clear task-division</i>	Is there a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process? If so, how is this organized?
	<i>Conflict management</i>	What does the strategy for resolving conflicts in the restoration process look like?
	<i>Efficient</i>	Are actors held accountable for a timely implementation of restoration measures? If so, how?
	<i>Flexibility</i>	How important do you think it is for actors to have flexibility in choosing fitting restoration measures to work towards the long-term goals for the restoration of the Rhine?
Evaluation		
Governance conditions		Which current policy elements do you think are most important to the success of the Rhine's ecological restoration?
Indicator species		What do you think is the importance of the Atlantic salmon as an indicator species for the restoration of the Rhine? Was this a good choice, or could this have been another indicator species as well?
		What do you think the ecological recovery process of the Rhine would look like if an indicator species had never been chosen to guide the process?

Appendix C – Interview outline (Dutch)

Topic	Code	Question
Introduction and general questions		
Introduction		<i>Short explanation on the topic and aim of this research</i>
General questions		Wat is uw functie?
		Wat is uw achtergrond?
Governance conditions		
Organization	<i>Trade-off management</i>	Worden maatregelen voor ecosysteemherstel afgewogen tegen alternatieve maatregelen om de meest gunstige impact te beoordelen? Zo ja, hoe? En door wie?
	<i>Individual leadership strength</i>	Zou je zeggen dat sterk, inspirerend leiderschap van specifieke individuen een belangrijke rol speelt in het succes van de ICBR bij het nemen van herstelmaatregelen?
	<i>Multi-disciplinary</i>	Hebben de leden van de ICBR een multidisciplinaire achtergrond? (Verschilt dit per ICBR-werkgroep?)
	<i>Transformative organizational structure</i>	Wat is volgens u het belang van het vermogen van de ICBR om haar organisatiestructuur te veranderen, zoals ze dat van oudsher heeft gedaan?
	<i>Centrally coordinated monitoring</i>	Wat is volgens u het belang van het centraal gecoördineerde monitoringsysteem van het Rijnherstelproces?
Finances	<i>Financial incentive</i>	Wordt het bijdragen van actoren aan het ecosysteemherstelproces financieel beloond? Zo ja, hoe? Kunt u enkele voorbeelden geven?
	<i>Economic benefits</i>	Zijn er economische voordelen verbonden aan deelname aan het herstelproces (naast mogelijke directe beloningssystemen)? (bijv. bedrijfsontwikkeling, bescherming van natuurlijk kapitaal)
Actors	<i>Clear task-division</i>	Is er een duidelijke toewijzing en verdeling van taken en verantwoordelijkheden voor alle deelnemende actoren aan het herstelproces? Zo ja, hoe is dit georganiseerd?
	<i>Conflict management</i>	Hoe ziet de strategie voor het oplossen van conflicten in het herstelproces eruit?
	<i>Efficient</i>	Worden actoren verantwoordelijk gehouden voor een tijdige uitvoering van herstelmaatregelen? Zo ja, hoe?
	<i>Flexibility</i>	Hoe belangrijk vindt u het dat de actoren flexibiliteit hebben bij het kiezen van passende herstelmaatregelen om de lange termijn doelstellingen voor het herstel van de Rijn te bereiken?
Evaluation		
Governance conditions		Welke actuele beleidselementen zijn volgens u het meest belangrijk voor het slagen van het ecologische herstel van de Rijn?
Indicator species		Wat is volgens u het belang van de Atlantische zalm als indicatorsoort voor het herstel van de Rijn? Was dit een goede keuze of had dit ook een andere indicatorsoort kunnen zijn?
		Hoe zou het ecologische herstelproces van de Rijn er volgens u uitzien als er nooit een indicatorsoort was gekozen om het proces te sturen?

Appendix D – Code tree



Appendix E – Refined framework for analyzing governance conditions for successful riverine ecosystem restoration

Attribute	Dimension	Governance condition	Keyword	
FUNDAMENTAL	<i>Legislation</i>	Ecosystem restoration is protected by and embedded in institutional arrangements and legislation.	<i>Nested</i>	
		The ecosystem restoration organization has the power to transform existing institutional restoration arrangements or institutionalize new restoration arrangements.	<i>Transformative power</i>	
		The ecosystem restoration organization has the will and power to legislatively enforce on the breaching of institutional restoration arrangements.	<i>Enforcement</i>	
	<i>Governance structure</i>	Ecosystem restoration management takes place at a cross-border, fluvial scale to ensure synergy between individual restoration measures	<i>Synergy</i>	
		Room is given to bottom-up, grassroots participation in the restoration process through designated communication platforms	<i>Participation</i>	
		There is a clear attribution and division of tasks and responsibilities for all partaking actors in the restoration process.	<i>Clear task division</i>	
		Employees of the ecosystem restoration organization are of multi-disciplinary backgrounds, thus accounting for the multi-dimensionality of the restoration area. The organization's multi-disciplinarity is effectively utilized through the inter-disciplinary assessment of ecosystem restoration challenges	<i>Multi- and interdisciplinary</i>	
		The ecosystem restoration organization has a concise strategy to resolve conflicts through consensus resolution.	<i>Conflict management</i>	
	STRENGTHENING	<i>Financing</i>	Contributions of actors to ecosystem restoration are financially rewarded.	<i>Financial incentive</i>
			Ecosystem restoration has economic benefits for partaking actors, besides possible direct reward structures (e.g. business development; protection of natural capital)	<i>Economic benefits</i>
Clear viable and long-term agreements are present to finance the ecosystem restoration project.			<i>Financial agreements</i>	
<i>Information</i>		There is a clear demarcated and designated role for science in the creation and implementation of restoration policies and measures and in the reduction of uncertainties in the ecosystem restoration organization.	<i>Informed plan-making and execution</i>	
<i>Support</i>		The ecosystem restoration project is supported by political will and adequate state support. This can be facilitated by active political brokering.	<i>Political support</i>	

		The ecosystem restoration organization deploys an active capacity building process to increase the support base of the restoration project by including more actors and stakeholders.	<i>Capacity building</i>
COMMANDING	<i>Leadership</i>	Strong, inspiring leadership of individuals with experience and a relevant background.	<i>Individual leadership strength</i>
		Collaboration is coordinated by ensuring all partaking actors in the ecosystem restoration process share the same goals and vision for the project.	<i>Coordinated shared vision</i>
		Actors are held accountable for a timely implementation of restoration measures	<i>Efficient</i>
		The ecosystem restoration organization centrally coordinates a monitoring program to assess the status of the ecosystem, the impact of restoration measures and the progress of restoration efforts.	<i>Centrally coordinated monitoring</i>
	<i>Discourse</i>	The ecosystem restoration organization has a platform to compromise on stakeholder discourses, thus accounting for different values and opinions for ecosystem restoration.	<i>Recognition of different perspectives</i>
DEVELOPING	<i>Adaptation</i>	The ecosystem restoration project has clear long-term goals, which are flexible to anticipate for future uncertainties.	<i>Long-term planning and anticipation</i>
		The ecosystem restoration organization continually improves its restoration policies and measures by evaluating the outcomes of existing policies and measures.	<i>Organizational adaptive management</i>
	<i>Innovation</i>	The ecosystem restoration organization has an organizational culture open for innovation, where experimental policies and measures are implemented to test new ideas.	<i>Open and innovative organizational culture</i>