The environment knows no borders

Investigating the collective challenge of governing policy issue interdependencies

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Abstract
Many of today's most pressing environmental problems cross-cut jurisdictional, geographical, and administrative boundaries, creating interdependencies between different locations and between policy issues that no single actor can address alone. In practice, however, environmental policy is still often contained within the traditional responsibilities of the public sector and frequently judged ineffective, particularly in the European context. Whether and how interdependencies are actually associated with collaboration between policy actors has remained difficult to establish.

This cumulative thesis focuses on interdependent environmental challenges that policy actors need to manage. Specifically, this thesis describes and analyses policy issue interdependencies and how they align with the collaborations of policy actors. In addition, this thesis explores how policy issue interdependencies can be revealed, concretised, and analysed. Interdependencies are effectively represented by networks, both as conceptual models and as analytical methods. Therefore, the studies in this thesis use a multilevel network model to explore the structural alignment between interdependencies and collaboration through the perspective of institutional fit.

This thesis reports findings from two research projects. The first project focuses on policy issue interdependencies relating to regional water degradation. This project describes and analyses these interdependencies in relation to collaborative networks across administrative boundaries (Papers I–III). The second project focuses on climate change impacts that propagate through food trade dependencies. This project contributes insights into the effect of climate change on food trade networks that cross national borders, illustrating a need for global climate adaptation (Paper IV).

Paper I introduces a methodological procedure for assessing policy issue interdependencies and develops policy issue networks by identifying overlapping causal relationships between policy issues and their environmental targets. By applying the procedure empirically to water governance, the paper shows that policy issue interdependencies vary in degree and type. Paper II combines the policy issue networks from Paper I with collaborative networks of policy actors in a multilevel network to analyse the impact policy issue interdependencies have on who policy actors select for collaborative partners and to clarify if and how patterns of collaboration among actors are formed. Paper III differentiates reinforcing and counteracting policy issue interdependencies and studies how these impact the perceptions and collaborations of the actors. Paper IV, shifting the focus to the global level, analyses climate change impacts related to food trade dependencies across national borders. Specifically, Paper IV investigates the impact of climate change on the structure of global food trade networks and therefore contributes a baseline scenario analysis for future studies that investigate policy issue interdependencies and policy actor collaborations on the global level.

Keywords: policy issue interdependencies, collaborative governance, networks, environmental problems, policy issues, policy actors, boundary-spanning, water governance, cross-border climate impacts, food trade systems.

Stockholm 2021
http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-197272


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Johanna Hedlund
The earth to be spann’d, connected by network [. . .]

The oceans to be cross’d, the distant to be brought near,

The lands to be welded together.

“Passage to India”, Walt Whitman, 1872
Abstract

Many of today’s most pressing environmental problems cross-cut jurisdictional, geographical, and administrative boundaries, creating interdependencies between different locations and between policy issues that no single actor can address alone. Policy issue interdependencies can, for example, be illustrated by the mutually reinforcing effect that reforestation may have on carbon storage or the implications emerging when reforestation threatens regional water security. Therefore, there is a need for and an added value in simultaneously addressing interdependent policy issues related to environmental problems. In practice, however, environmental policy is still often contained within the traditional responsibilities of the public sector and frequently judged ineffective, particularly in the European context. Whether and how policy issue interdependencies are actually associated with collaboration between policy actors has remained difficult to establish.

This cumulative thesis focuses on interdependent environmental challenges that policy actors need to manage. Specifically, this thesis describes and analyses policy issue interdependencies and how they align with the collaborations of policy actors. In addition, this thesis explores how policy issue interdependencies can be revealed, concretised, and analysed. Interdependencies are effectively represented by networks, both as conceptual models and as analytical methods. Therefore, the studies in this thesis use a multilevel network model to explore the structural alignment between interdependencies and collaboration through the perspective of institutional fit.

This thesis reports findings from two research projects. The first project focuses on policy issue interdependencies relating to regional water degradation. This project describes and analyses these interdependencies in relation to collaborative networks across administrative boundaries (Papers I–III). The second project focuses on climate change impacts that propagate through food trade dependencies. This project contributes insights into the effect of climate change on food trade networks that cross national borders, illustrating a need for global climate adaptation (Paper IV).
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investigates the impact of climate change on the structure of global food trade
networks and therefore contributes a baseline scenario analysis for future studies
that investigate policy issue interdependencies and policy actor collaborations on
the global level.

This thesis argues that both theoretical and methodological advances are needed
for the understanding of policy issue interdependencies and for understanding
how policy issue interdependencies can be governed collaboratively. To this end,
the thesis makes three theoretical contributions. First, it shows that collaborative
networks may struggle to resolve interdependent policy issues. Second, it offers an
empirical examination of institutional fit as a base for problem-solving. Third, it
discusses how collaborative networks may better govern policy issue
interdependencies.

This thesis also makes three methodological contributions. First, it develops a
multilevel network model that frames the three types of networks studied. Second,
it illustrates how to methodologically disentangle relationships between global
network structures, micro-level processes, and individual policy actors. Third, it
highlights how detailed empirical studies of policy issue interdependencies can
contribute to a more coherent decision-making basis.

Keywords
policy issue interdependencies; collaborative governance; networks; environmental
problems; policy issues; policy actors; boundary-spanning; water governance;
cross-border climate impacts; food trade systems
Sammanfattning


Denna sammanläggning avhandlingen fokuserar på interdependenta miljötävlanings som policyaktörer måste hantera. Avhandlingen beskriver och analyserar specifikt interdependenser mellan policyfrågor och hur de formar policyaktörers samarbete. Vidare utforskar avhandlingen hur interdependens mellan policyfrågor kan synliggöras, beskrivas och analyseras. En effektiv representation av interdependens är nätverk, både som konceptuella modeller och som analytiska metoder. I delstudierna används därför en nätverksmodell i flera lager för att utforska sambandet mellan interdependenser och samarbeten genom perspektivet ”institutionell passform”.

Artikel I introducerar en metodologisk procedur för att utvärdera sammankopplingar mellan policyfrågor och utvecklar nätverk av policyfrågor genom att identifiera överlappande kausala länkar mellan policyfrågor och deras miljömål. Proceduren appliceras empiriskt på vattenförvaltning och artikeln visar att interdependens mellan policyfrågor varierar i grad och typ. Artikel II kombinerar policyfrågenätverken från Artikel I med samverkansnätverk av policyaktörer i ett nätverk i flera lager för att analysera hur interdependens mellan policyfrågor påverkar policyaktörers val av samverkanspartner, och för att utreda om och hur samverkansmönster mellan policyaktörer formas. Artikel III skiljer mellan policyfrågors förstärkande och motverkande interdependenser, och studerar hur dessa interdependenser påverkar policyaktörers perception och samverkan. Artikel IV skifter fokus till den globala nivån och analyserar nationellt gränsöverskridande klimateffekter relaterade till mat- och handelsinterdependenser. Mer specifikt studeras i Artikel IV klimateffekters påverkan på strukturen i mat- och handelsnätverk, och bidrar därmed med en grundläggande scenarioanalys för fortsatta studier av interdependens mellan policyfrågor och policyaktörers samverkan på den globala nivån.


Avhandlingen ger också tre metodologiska bidrag. För det första utvecklar den en nätverksmodell i flera lager som ramar in de tre typer av nätverk som studeras. För det andra illustrerar den hur relationen mellan globala nätverksstrukturer, processer på mikronivå och individuella policyaktörer kan utredas metodologiskt. Till sist synliggör den hur detaljerade, empiriska studier av interdependens mellan policyfrågor kan bidra till ett mer sammanhängande beslutsunderlag.

Nyckelord
interdependens; samverkan; nätverk; miljöproblem; policyfrågor; policyaktörer; gränsöverskridande; vattenförvaltning; transnationella klimateffekter; mat- och handelssystem
List of papers

Paper I

Paper II

Paper III

Paper IV
Hedlund, J., Carlsen, H, Croft, S., West, S. & Bodin, Ö. Cross-Border Climate Impacts in Global Food Trade Networks. [Manuscript].

Publications outside thesis


Contributions to papers

For **Paper I**, I co-developed the idea for the paper, collected qualitative data by triangulation (observation, text analysis, interviews, survey), and analysed it using thematic coding and mapping in Miradi Open Standards. I analysed the policy issue networks using descriptive network statistics. I led the development of the paper.

For **Paper II**, I co-developed the idea for the paper, led the design of the survey, and was responsible for and conducted all data gathering. I developed the Exponential Random Graph Models and led the development of the paper.

For **Paper III**, I developed the idea for the paper and performed and analysed interviews as well as designed the Exponential Random Graph Models. I led the development of the paper.

For **Paper IV**, I co-developed the idea for the paper and performed data collection, network community detection, network cartography, as well as visualisations. I produced the original draft and co-led the development of the paper.
Acknowledgements

Paper I-III of this dissertation was supported by the Swedish Research Council and the Swedish Research Council Formas through grants 2016-04263 and 2016-01137. Paper IV was supported by the Swedish Research Council Formas through grant 2017-01144.
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1 Introduction

There is mounting evidence that global sustainability is threatened by modern society’s pressure on environmental systems, which drives the emergence of environmental problems (Rockström et al., 2009; Steffen et al., 2015). Such environmental problems may result in complex interdependencies across jurisdictional, geographical, and administrative boundaries. For example, interdependencies can be illustrated by the effects of upstream emissions on downstream areas, consumption patterns with deteriorating effects on distant land use, and the outsourcing of pollution across administrative or national borders (Sterner et al., 2019). However, often policy actors do not engage directly with environmental problems but directly engage with policy issues, which may also be interdependent. Such policy issue interdependencies may be mutually reinforcing such as when the regulation of upstream sources and implementation of downstream wetlands both contribute to reducing water pollution, or when enhancing forest replantation and tree growth improve carbon storage (Stephenson et al., 2014). Efforts to address certain policy issues can also have detrimental implications for managing other issues. For example, replantation projects to address desertification may result in water shortages, counteracting efforts to ensure regional water security (Feng et al., 2016). Since interdependent policy issues cannot be solved independently, the challenge is twofold: understanding policy issue interdependencies and understanding how they can be governed collectively.

Interdependencies across policy issues are increasingly recognised. The Agenda 2030 Sustainable Development Goals have been referred to as ‘intrinsically interdependent’ (UN, 2015), and the agenda calls for a translation of such interdependencies into policy action:

Sustainable development recognizes that eradicating poverty in all its forms and dimensions, combating inequality within and among countries, preserving the planet, creating sustained, inclusive and sustainable economic growth and fostering social inclusion are linked to each other and are interdependent (2015, p. 5).

Moreover, Peters emphasises how interdependence captures how policy problems ‘vary in the extent to which they are confined or confinable to a single policy domain’ (2005, p. 365). Problems that are less confinable (i.e., wicked problems) will most often cover interdependent issues that require collective action. Thus,
policy issue interdependency can be defined as instances where actions or events associate at least two policy issues, implying that actions that address one of these policy issues can have consequences for other policy issues (Hedlund et al., 2021a, 2021b).

Researchers agree that jurisdictional, geographical, and administrative boundaries increase the difficulties of managing policy issue interdependencies collectively (DeFries & Nagendra, 2017; Koppenjan & Klijn, 2004). Division of policy domains, sectors, and geographical jurisdictions may create fragmented ways of steering. This fragmentation may give rise to undesired effects. First, lack of coordination across different policy domains may lead to policy incoherence – i.e., separate policies often include ideas or objectives that do not harmonise (May et al., 2006). Second, fragmentation may create governance gaps when responsible actors fail to recognise how multiple issues and actors are interlinked (Bergsten et al., 2019). Third, the risk for spill over effects and institutional externalities may increase when positive interventions in one area result in negative spill over effects in other areas (Mewhirter & Lubell, 2018). Fourth, there is a risk of overexploitation of resources and duplication of actions (Ostrom, 1990). Finally, and as a result of the previous implications, independent efforts to address policy issue interdependencies may result in less effective solutions and insufficiently resolved environmental problems.

To combat these challenges, collaborative governance has often been seen as a remedy and a model for achieving policy integration on local, subnational, national, supranational, and global scales (Ansell, 2012; Ansell & Gash, 2008; Bodin, 2017; Emerson et al., 2012; Lubell, 2015; Marcussen & Torfing, 2007). Collaborative governance represents a way of organising interdependency between a wide range of policy actors across different levels of decision-making as ‘networked threats require a networked response’ (Slaughter, 2005, p. 2). This argument, emphasising the idea of institutional (or ‘social-ecological’) fit, presumes that an alignment between the properties of governance and the resources that are being governed enhances effectiveness of governance (Bergsten et al., 2019; Cox, 2012; Galaz et al., 2008; Ostrom, 1990; Young, 2002). This idea justifies why an integrated perspective on multiple interdependencies are important for achieving policy integration and why institutional misfit from divided policy domains is undesirable. A ‘networked response’, which may be enacted through collaborative governance, is presumed to better resolve interdependent policy issues than government-centric approaches as it can account for multiple dimensions of a given environmental problem (Roberts, 2000; van Bueren et al., 2003). Nevertheless, there is a broad need for more
empirical research on the premises of institutional fit as well as its usefulness for analysing how policy issue interdependencies may ultimately shape environmental problem-solving.

Today, distributed interaction constitutes a key element of environmental governance. Environmental governance research has been shaped by complementary contributions from political science, with its link to the state, and interdisciplinary sustainability science, which analyses environmental governance as part of social-ecological systems (Paavola et al., 2009). These contributions suggest that environmental governance has shifted from simple to more complex through ‘new modes of governance’ to better deal with complex environmental problems (Galaz, 2019; Gunningham, 2009). Such new modes build on, for example, the increased participation of non-state actors. These arguments also spurred a theoretical focus on appropriate governance models to manage policy issue interdependencies effectively. In practice, however, environmental policy is still often contained within the traditional responsibilities of the public sector and frequently judged ineffective, particularly in the European context (Jordan, 1999). More recently, public policy and environmental governance research has increasingly focused on how collective action can be accomplished to address policy issue interdependencies (Bodin, 2017; Koppenjan & Klijn, 2004; Lubell & Morrison, 2021). To navigate such empirical enquiry, there is a need to dismantle the components of complex social-ecological systems, systems characterised by many types of interdependencies.

Networks represent complex systems as nodes and links (Figure 1) (Borgatti et al., 2009). Networks function both as analytical objects and methodological tools. As analytical objects, networks focus on structural dimensions of network components and can be used to describe, among other things, interdependent policy actors, issues, or places. Network components form reoccurring micro-level network elements (motifs, such as dyads, triangles, or stars), which can represent processes by which nodes in a network affect each other. This thesis encompasses three interpretations of interdependency that can be exemplified through motifs. Motif A is used to study food trade dependencies across geographical localities. Motif B is used to study interdependency between policy actors as reciprocated collaboration. Motif C is used to study policy issue interdependencies by correlation as a way in which policy actors perceive them. As a methodological tool, network analysis can explain and test hypotheses about both micro-level processes and global network structures.
**Figure 1.** A network of nodes (circles) and relationships (links) that can be used to analyse different interpretations of interdependency. In this thesis, Motif A represents an observed interdependency, and B and C represent interdependencies as perceived by policy actors.

Despite these theoretical and methodological advances, it is still unclear how policy issue interdependencies influence collaboration. That is, current studies often separate their analyses of policy issue interdependencies and collaborative governance and may therefore underappreciate the influence of the former on the latter. Clearly, the promise of collaborative networks to resolve interdependent policy issues deserves closer scrutiny. Although the idea of institutional fit is taking hold in the collaborative governance literature, few studies have provided empirical evidence that show whether and how policy issue interdependencies affect collaboration (Bryson & Crosby, 2015).

This thesis focuses on environmental challenges that policy actors need to manage and that are strongly characterised by interdependency, and explores whether and how such challenges are met by collective action. Using networks as analytical representations and methodological tools (Barnes et al., 2019; Bodin et al., 2019; Bodin & Tengö, 2012), I analyse regional water degradation and global cross-border climate change. The first case study, a study of regional water degradation, focuses on the engagement of individual policy actors with interdependent water policy issues. The second case study, a study of the impacts of global cross-border climate change, focuses on how these impacts propagate through the food trade dependencies among countries. Using the idea of institutional fit as a springboard,
I use these case studies to describe and analyse global network structures, micro-level processes, and the perceptions of policy actors related to the challenges identified.

1.1 Research questions

The challenge of analysing policy issue interdependencies and their link to collaboration leads to the following research gaps that I address in this thesis.


Networks as forms of effective collaborative governance have received much attention in public policy as well as in environmental policy and governance literature (Ansell & Gash, 2008; Berardo et al., 2020; Emerson et al., 2012; Gunningham, 2009; Lubell, 2013; Newig et al., 2018). Although researchers in sustainability science have sometimes critiqued policy makers’ lack of focus on interdependencies (McCollum et al., 2011; Nilsson et al., 2016), they mainly focus on the implications of this lack of focus rather than how it emerges or can be mitigated. These literatures’ separate foci identify an important research gap. Therefore, it seems appropriate to integrate the two literatures and add the perspective of policy issue interdependencies, which may be abstracted as networks. Such approach has the potential to advance the understanding of what governance structures are more effective for resolving complex environmental problems and under what circumstances.

Research gap 2: Methodological approaches and empirical evidence that concretise policy issue interdependency in specific cases and contexts.

Policy integration literature often assumes that policy actors know what policy issues to integrate. Yet policy issue interdependencies are rarely explicitly defined or assessed with respect to the everyday practices of policy actors. As in the above, I argue that theoretical advancement needs to be supplemented by more concrete methodological approaches that help reveal and explore the nature of policy issue interdependencies. Advancing theory also requires empirical evidence from different cases and contingencies and should contribute to improved cross-sectional understanding.

To address these two research gaps, this thesis describes and analyses the collective challenge of governing interdependent policy issues. That is, this thesis
contributes insights into research on policy issue interdependencies collaboratively addressed by policy actors. More specifically, the thesis aims to find answers to the following questions:

1) How do collaborative networks structurally align with policy issue interdependencies?

2) How can policy issue interdependencies be revealed, concretised, and analysed?

I return to these challenges in each paper and at the close of this thesis. Papers II–III address RQ1 by analysing the collective challenge of governing policy issue interdependencies. Papers I and IV address RQ2 by revealing, concretising, and proving support for analysing policy issue interdependencies. The thesis relies on an interdisciplinary ground, combining terminology and knowledge from mainly the policy and complexity sciences with sustainability science. Table I lists the explicit definitions used in the thesis.
Collaborative governance and Environmental governance

Governance can be broadly defined as ‘interorganizational networks’ (Rhodes, 1996) and ‘the rules and forms that guide collective decision-making’ (Stoker, 2004, p. 3).

Collaborative governance can be defined as ‘A governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets’ (Ansell & Gash, 2008, p. 544).

Environmental governance can be understood as when ‘different actors work together to cope with and try solve environmental issues at different scales, including the design and creation of conditions for institutions, structures, and suitable decision making processes’ (Rodela & Gerger Swartling, 2019, p. 83).

In this thesis, I use environmental governance accordingly, yet focus specifically on its structures and processes and use collaborative governance and network governance interchangeably following (Ansell, 2012).

Environmental policy

Policy, defined broadly, is concerned with ‘who gets what, when, how’ (Lasswell, 1936). It can also be defined as ‘the setting of direction and broad intent; objectives’ (Cocklin & Moon, 2020, p. 227).

Environmental policy can broadly be defined as ‘any measure by a government or corporation or other public or private organization regarding the effects of human activities on the environment, particularly those measures that are designed to prevent or reduce harmful effects of human activities on ecosystems’ (Encyclopaedia Britannica, 2020).

In this thesis, I use environmental policy specifically to refer to if and how environmental policies are developed and the study of the environmental policies themselves.

Effectiveness

The extent to which arrangements contribute to solving or mitigating the problems that lead to their creation. (Young, 2011)

Institutional fit

The degree to which properties of governance match the resources that are being governed. (Young, 2002)

Interdependency

See exemplified motifs in Figure 1.

Network

A network consists of a set of nodes along with a set of ties of a specified type that link them. (Borgatti & Halgin, 2011)

Policy actor

Policy actors are defined as any individuals or groups that are directly or indirectly and formally or informally affiliated with or affected by the policy process at any stage and thereby ‘have some interest or ‘stake’ in the outcomes of decisions made in policy institutions and the resulting operational rules governing specific issues’ (Lubell, 2013).
In this thesis, I use policy actor to refer to individuals involved in implementing or developing policies.

<table>
<thead>
<tr>
<th>Policy domain</th>
<th>Policy domains are ‘more or less established areas of policy that give meaning to common problems and have integrative properties’ (May et al., 2006; see also Laumann &amp; Knoke, 1987).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy integration</td>
<td>An integrated policy is one where ‘the constituent elements are brought together and made subject to a single, unifying conception’ (Underdal, 1980, p. 159). Policy integration is also characterised by ‘the cooperation of actors from different policy domains’ (Tosun &amp; Lang, 2017), for example, unified water policy.</td>
</tr>
<tr>
<td>Policy issue</td>
<td>Policy issues are ‘a set of separable challenges that are associated with a broader environmental problem. Policy issues call for or incentivise actors with responsibility for and/or stakes in that broader environmental problem, and/or the specific challenges, to collectively or individually engage in addressing the challenge(s)’ (Hedlund et al., 2021a, 2021b). Policy issues, as defined here, are thus challenges that actors engage in to resolve environmental problems, a definition that lies close to specific measures and possible solutions. Policy issues may be, for example, upstream regulation by the source or implementing buffer zones.</td>
</tr>
<tr>
<td>Policy issue interdependency</td>
<td>Policy issue interdependency can be defined as instances where actions or events (intervening factors) associate at least two different policy issues, implying that actions to address one of these policy issues can have consequences for the other issue. (Hedlund et al., 2021a, 2021b)</td>
</tr>
<tr>
<td>Policy process</td>
<td>Policy process generally refers to ‘interactions that occur over time between public policies and surrounding actors, events, contexts, and outcomes’ (Weible &amp; Sabatier, 2017) with the purpose of addressing societal or environmental problems. In this thesis, I use the term policy process specifically to refer to the development of new or implementation of existing policies addressing the environmental targets defined by policy issues.</td>
</tr>
<tr>
<td>Policy subsystem</td>
<td>Policy subsystems define ‘[...] the substantive and geographic scope of the institutions that structure interaction’ (Sabatier &amp; Weible, 2007). ‘Policy subsystems consist of a large number of actors dealing with specific policy issues’ (Adam &amp; Kriesi, 2007).</td>
</tr>
<tr>
<td>Sustainable development</td>
<td>Sustainable development can be defined as ‘[...] the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Brundtland Commission, 1987).</td>
</tr>
</tbody>
</table>
2 Theory and key conceptualisations

2.1 Ensuring environmental policy integration

In 1987, the UN’s World Commission on Environment and Development (WCED) Brundtland report made the following observation:

Until recently, the planet was a large world in which human activities and their effects were neatly compartmentalized within nations, within sectors (energy, agriculture, trade), and within broad areas of concern (environment, economics, social). These compartments have begun to dissolve. (Brundtland Commission, 1987)

In this statement, the report explicitly supports the diffusion of complexity-informed approaches in the social, natural, and policy sciences (Byrne, 1998), making clear that linear equilibrium-centred representations in science do not fit the empirical evidence (Briassoulis, 2005). The Brundtland report, an important policy directive, acknowledges that most environmental problems are interdependent and therefore cannot be constrained to a single policy domain, a perspective that gave traction to the idea of policy integration. In the aftermath of the report, environmental policy integration (EPI) emerged as a key policy mechanism for ensuring sustainable development (Jordan & Lenschow, 2010). This objective relied on improving the institutional fit between the wider nature of environmental problems and compartmentalised policy domains, sectors, and nations (Briassoulis, 2005) by creating coordination, searching for synergies, and enabling reciprocity (Jordan & Lenschow, 2010).

A fundamental requirement for effective policy integration is collaboration among a diverse set of actors (Briassoulis, 2005). This requirement assumes that, in a pragmatic sense, collaboration can help resolve problems and, in a normative sense, that decision-making about a problem should involve affected actors. These aspects are often emphasised by the shift from ‘government to governance’ (Rhodes, 1996). This shift, albeit debated (Börzel, 2011), implies that environmental policies are increasingly developed by various levels of government (global, transnational, regional, and local) as well as by the private sector, nongovernmental actors, and civil society rather than strictly by the nation-state (Cocklin & Moon, 2020). Polycentrism, often mentioned in the sustainability literature, also emphasises how the interaction between multiple decision-making centres presumably enhances the ability to resolve collective action problems and to develop environmental policy. For example, climate policy and governance are
inherently networked and polycentric as states must act collectively on mitigation and adaptation (Morrison et al., 2017). Likewise, water policy and governance, particularly in the European context, have been characterised by policy principles such as increased participation and collaboration between different inter-sectoral interests and actors on a river basin scale (Jager et al., 2016) to generate policy integration (European Commission, 2000).

The broader nature of policy integration suggests that policy making should better fit the nature of problems (Briassoulis, 2005). Effective policy integration relies on structural alignment as captured by the idea of institutional fit and the problem-solving capacity of collaboration (Figure 2). Specialised policies, for example, may focus on parts of problems within a single policy domain and therefore risk counteracting each other unless governance acknowledges policy issue interdependencies and provide the means for integration. The degree to which properties of governance (e.g., institutions, collaboration) match the resources that are being governed, an idea rooted in institutional analysis (Ostrom, 1990), has been central to environmental governance (Young, 2002) and sustainability science (Galaz et al., 2008) literatures. Governance properties across contexts require developing a multilevel understanding that acknowledges how policy and governance align with specific conditions on-the-ground (Paavola et al., 2009). In this sense, institutional fit specifies how to manage complex problems using complex governance structures (Duit et al., 2010). In addition, institutional fit emphasises that structural alignment between different interdependencies can enhance the understanding of actors’ decision-making in environmental policymaking and improves problem-solving performance. Therefore, policy integration and the idea of fit implicitly question which governance components become connected by networked environmental systems.

**Figure 2.** Key conceptualisation of how an institutional fit between collaboration, policy and the environment enables enhanced governance effectiveness, improving the possibilities of reaching policy integration and therefore sustainable development.
2.2 Networked environmental systems

Network science, originally rooted in sociology and later mathematically developed in physics, can be used to describe and explain complex phenomena in the environment such as patterns of interdependency (Bascompte et al., 2003; Pilosof et al., 2017; Suweis et al., 2015). For example, Suweis et al. (2015) explore ecological networks as a set of species (nodes) and their interactions (competition, predation, parasitism, and mutualism) to explore how the architecture of such interactions reduce species susceptibility to perturbations and enhance the stability of species. In addition, river basins and streams can also be abstracted as networks by their ability to link seas, lakes, and landscapes. Kirkby (1976), for example, applies a network model to river basin hydrology to explore whether the structure of river basin networks influences the geomorphic processes of the river basin.

The network approach has also aided the analysis of complex systemic and social-ecological interactions. For example, a recent study investigating interactions among different physical, chemical, and biological processes showed that Earth system relationships intensify anthropogenic pressure on the environment and impact Earth’s capacity to support humanity (Lade et al., 2020). Another application concerns cross-scale interactions across regime shifts (Rocha et al., 2018) – i.e., large, abrupt, and persistent critical transitions that fundamentally change the structure and function of ecosystems. Abstracted as a network model, the authors showed that regime shift interactions can give rise to cascading effects. Finally, networks are increasingly being applied to study food trade dependencies (Heslin et al., 2020; Puma et al., 2015; Tu et al., 2019). For example, Tu et al. (2019) analysed structural network properties in global food and trade systems to explain the dynamics of increased or decreased resilience (as a function of such systems) of natural resources.

2.3 Networks as governance

Governance can also be understood as networks when there is coordination between multiple actors or decision-making units (Provan & Kenis, 2007; Rhodes, 1996; Sørensen & Torfing, 2007) abiding by rules and forms that guide their collective decision-making (Stoker, 2004). Typically, research focusing on networks as governance argues that collaboration in networks is a mechanism to overcome the negative aspects of fragmentation. This argument has been central in the different literatures on collaborative governance (Ansell & Gash, 2008), policy networks (Rhodes, 1996), polycentric governance (Lubell, 2015; Morrison et
al., 2017), network governance (Provan & Kenis, 2008), and multilevel governance (Thomann et al., 2019). These forms and terminologies all shed light on distributive interaction rather than central authority and are often said to represent horizontal rather than hierarchical forms of governance. Even if this perspective is a simplified dichotomy, networks as governance represent a way to structurally arrange collective action.

Networks as governance can also produce contradictory outcomes. On the one hand, they can represent democratic pluralism through increased participation, diversified representation, and focused deliberation (Klijn & Skelcher, 2007). In addition, scholars have claimed that distributed and diverse governance networks offer better flexibility and adaptability in mobilising resources to manage complex and dynamic problems (Carlsson & Sandström, 2008). These networks may do this by allowing for knowledge diffusion, commitment to common goals, and conflict resolution (Bodin & Crona, 2009). Because networks can produce larger gains than individual participants can produce, they offer a pathway to more effective governance. On the other hand, shifting regulated control of authorities to networked governance can also invite powerful actors with more resources to advocate for their opinions, skewing an equal consideration of interests. Networks have been called closed, undemocratic, selfinterested, and accommodating power centres without any mandate or accountability (Hay, 1998). Critics argue that governance networks resist change and democratic values, concerns often voiced in the policy network literature (Blanco et al., 2011). Although the governance network literature frames networks more positively, Klijn and Skelcher (2007) emphasise the lack of equal distribution: ‘[Governance networks] are based on interdependencies, but not necessarily equity, between public, private and civil society actors’.

In the wide literature on networks as governance, this thesis positions itself in the tradition of how to structure and manage networks to resolve complex environmental problems. Drawing on the idea of institutional fit, this focus centres on creating and adjusting network arrangements to ensure better coordination with the problem at hand. Following the previously mentioned development in networks as governance research, I move away from describing aspects of networks as an ultimate governance model or their institutional role to questioning what implications may emerge from attempting to steer collaborative networks in a certain direction to effectively resolve problems. Situating collaboration and networks as a problem-solving tool elevates the attention to and importance of problem characteristics (e.g., policy issue interdependencies) as
these characteristics materialise and morph into significant challenges for problem-solving in policy practice.

Therefore, it is relevant to ask what characteristics of collaborative networks make them effective for resolving policy issue interdependencies, or more generally, complex environmental problems. Their problem-solving approach may be an important factor. Lindblom describes a ‘rational-comprehensive’ (i.e., maximising targets) and a ‘successive-limited-comparison’ (i.e., achieving partial targets) approach to complex problem-solving (1959), arguing that resolving complex problems is impossible and irrelevant using ‘rational-comprehensive[ness]’ because this approach does not provide policy actors any information on how to prioritise. Furthermore, three other factors characterising collaborative networks may determine their ability to resolve complex environmental problems (Bodin, 2017). First, managing such problems ultimately depends on how the network can incentivise joint action without freeriding, which requires low transaction costs. Second, the effectiveness of a collaborative network varies by its levels of knowledge gaps. Third, the temporary or permanent nature of problems may impact the effectiveness of networks as governance. Third, according to a broader research stream, the nature of environmental and policy problems can significantly influence whether and how governance is undertaken (Ingold et al., 2018; Keohane & Victor, 2016; Pierre & Peters, 2005). However, few studies specifically describe how interdependent policy issues affect governance.

2.4 Networks of policy issues

The two perspectives described in 2.2 and 2.3 largely ignore how policy issues inform the way policy actors work in collaborative networks and how policy issues represent environmental problems in various policy processes. Policy issues (see Table 1 for full definition) are entry points for problem-solving by functioning as “the top of the primordial soup” and thus becomes well positioned to get public attention, the support of key actors, and potentially a policy solution’ (Brandenberger et al., 2020; see also Kingdon, 1984). In addition, policy issues become interdependent when seemingly unrelated policy issues both depend a common action or event to reach environmental targets (Hedlund et al., 2021a, 2021b; Lubell, 2013; Lubell et al., 2010). Apart from policy actors’ engagement with policy issues, other types of policy responses - e.g., decisions, implementation measures, management activities, actions, and regulations - can also be interdependent. For example, the concepts of ‘networked action situations’ (McGinnis, 2011) and ‘institutional externalities’ (Mewhirter et al., 2018) are used to analyse interaction across decisions and decision-making environments.
Moreover, previous research has described ‘issue linkage’ as ‘a framing strategy that involves combining multiple issues to change the perception of a policy problem in favour of action’ (Dellmuth et al., 2020; Roggero et al., 2019; Tosun & Varone, 2020). Policy issue interdependencies, however, define the opportunities that exist for policy action rather than a framing strategy intended to influence political agendas.

Policy issue interdependencies that are bidirectional often give rise to reinforcing or counteracting effects. These interdependencies are the basis for policy integration and coherence – e.g., the reinforcing relationship between enhancing tree growth and increasing carbon storage may be a reason to coordinate forest and carbon policy. Policy responses may also have unidirectional effects on each other. For example, recent research describes how climate adaptation strategies redistribute vulnerability and cause sustainability challenges elsewhere (Atteridge & Remling, 2018; Eriksen et al., 2021; Simpson et al., 2021). Despite this growing research area, interdependencies across policy issues or other policy responses are often ignored when analysing how collaboration can operate most effectively. Nevertheless, these interdependencies remain important areas of study if the goal is to reduce the risk of spill-over effects and unsuccessful policy integration.
3 Methodological approach

3.1 Conceptual frame – a multilevel network model

Inasmuch as the complexities of reality go beyond scientific representations, concretising complex phenomena remains important to enhance the understanding of today’s environmental problems and modern governance. Therefore, we require properly formulated models and methods that are flexible enough to apply to different study objects.

Most network studies have concentrated on studying networks of single nodes and links. In the last decade, network studies have tended to investigate multiple types of nodes and links in parallel, so-called multilevel networks. These networks have two types of nodes that connect to both the same and the other node type, and links are differentiated by the nodes they connect. Multilevel networks, derived by combining multilevel analysis and network analysis, connect ‘several interconnected systems of agency’ by joining parallel networks into different yet hierarchically nested levels (Lazega & Snijders, 2016). The ability of multilevel networks to combine systems is a clear advancement over single-level networks, which is evident in the many different areas where multilevel networks have been applied (for an overview, see Lazega et al., 2016). In addition, multilevel networks can capture mechanisms that derive from more than a single study group. One way of capturing such mechanisms is by defining motifs, or building blocks, which constitute subparts of a network. By imposing different assumptions on these smaller configurations of nodes and ties, motifs can be used to measure what processes dominate within a larger system.

A three-layered multilevel network model (MNM) (Figure 3) provides an illustration of the three types of networks studied in this thesis. The bottom layer illustrates interdependencies in environmental systems, for example, water flow or food trade (links) crossing geographical localities (nodes). The top layer illustrates a collaborative network, for example, information exchange (links) between policy actors or jurisdictional states (nodes). The middle network defines policy issues and their interdependencies, for example, reinforcing and counteracting relations between policy issues such as water regulation and creating fish connectivity or government responses such as export bans driving food subsidies elsewhere (nodes).
**Figure 3.** A multilevel network model (MNM) of nodes (circles) and relationships (links) as representation of different network components and their interdependencies. Note that all links could be either bidirectional or unidirectional. The MNM frames the papers of the thesis, which contribute to its different layers. As illustrated, the thesis separates the different parts of institutional fit to explore how the different layers can be described and analysed in the two case studies. A full line illustrates that the paper covers the full layer. A dashed line illustrates that the paper touches upon aspects of a layer.

### 3.2 Empirical cases

This thesis includes two case studies both characterised by structural interdependencies inherent in two environmental problems: the degradation of regional freshwater and the impact of global cross-border climate change.

Both case studies were selected because they exemplify challenges that policy actors need to manage related to environmental problems but where actors cannot themselves control all the factors to resolve the problem. Clearly, as interdependency affects both water and trade policy, these policy areas require collective action yet with diversity in approach, scale, and network boundaries. In addition, these two cases, although embedded in different contexts, were selected because previous research argues that institutional fit is relevant to combat these challenges.
The water case describes a state in which governance has moved from state-centred to a decentralised state where regional and local authorities take on different and sometimes overlapping responsibilities. Governing freshwater degradation in Norrström falls under the European Water Framework Directive, where a central element is an ecosystem approach that achieves spatial fit between governance structures and catchment scales (Hammer et al., 2011; Lebel et al., 2013). I analyse policy issue interdependencies by means of water policy issue networks and study their effect on collaborative networks of individual policy actors. The network boundaries, in this case, were the geographical area of the Norrström basin and the policy issues pertaining to the basin’s main environmental problems and collaborative venues influencing the water governance of the basin. This case can mainly be viewed as a representation of the actor and policy issue layers of the MNM. Therefore, this case study attempts to detail the characteristics of an environmental problem structure as obtained in the policy layer and whether these drive collaborations.

The climate case describes a state that seemingly needs to shift from a fragmented state (or unregulated state) to a state where international trade cooperation takes a more prominent role in climate adaptation. Until now, there has been a misfit between cross-border climate impacts and adaptation governance due to the framing of adaptation as a local territorial policy issue (Benzie & Persson, 2019; Persson & Dzebo, 2019). In this case study, I study cross-border climate change impacts that propagate through food trade dependencies in global food trade networks. Network boundaries are determined by the global trade of wheat, rice, and maize. As a physical or material flow dependent on land, this case mainly represents the environmental layer in the MNM. Therefore, this case study aims to review how cross-border climate change impacts propagate through food trade dependencies and ultimately force changes in the structure of the global food trade network, an outcome that might have consequences for global geopolitics and adaptation governance. In the following sections, I describe the cases in detail.

3.2.1 Basin-wide water governance

Today, the majority of European waters are in a degraded status (Kristensen et al., 2018). Water degradation arises ‘when the physical, chemical, or biological characteristics of water become harmful to the environment or organisms, including humans, by which the usefulness of the water resource is in some way reduced’ (Melesse & Scinto, 2015). That is, water degradation is an inherently complex environmental problem as it affects multiple interests and policy domains and arises from numerous pressures such as water pollution from toxins
and pesticides, declining biodiversity, physical modifications to water bodies, and water flow across a range of governance boundaries (Fischer & Ingold, 2020). Water governance has been a prominent area in the paradigm of sectoral, territorial, and organisational integration through the policy principle Integrated Water Resources Management (IWRM; Cook, 2014; Lubell & Edelenbos, 2013) and includes policy issues that cross agriculture, energy, spatial planning, and climate sectors. The level of hydrological and geographical interdependency in water bodies is high by definition as moving water connects water bodies and land across a basin and often crosses many administrative and jurisdictional boundaries (Blomquist & Schlager, 2005). Therefore, water degradation represents one of the most critical and complex challenges to modern environmental governance. In Europe, water governance falls under the regional umbrella of European environmental policy.

European environmental policy aims at an effective and sustainable provision of collective goods by reducing negative externalities (Héritier, 2009). Reconciling interest diversity is at the core of several European environmental directives. This reconciliation is particularly evident in the case of the European Water Framework Directive (WFD) (European Commission, 2000). Reformed in 2000, the WFD shifted from being a regulatory top-down policy to encouraging cross-sectoral collaboration as a means for reaching a ‘good ecological status’ (Newig et al., 2016). In this way, WFD operationalised non-binding policy integration principles of IWRM but is a legally-binding agreement (Quevauviller, 2010).

This thesis uses the case study of water policy and governance of the Norrström basin, Sweden, which fall under the WFD. The Norrström basin was selected because it has a fragmented hydrological structure of interconnected water bodies that rise to a multitude of different policy issues and interdependencies, and also has a high level of administrative boundaries. The Norrström basin is a hydrologically complex system that includes more than 1300 lakes, accounting for 11% of its total area, and four outlets to the Baltic Sea (Jaramillo et al., 2013). It can be abstracted as a stream network (Åhlén et al., 2020) based on the ‘connecting capacity’ of water flow to link several water bodies. For example, its second largest lake, Lake Hjälmaren, drains into its largest lake, Lake Mälaren. As Norrström is also subject to several interests and activities, it provides a good platform for studying potential policy issue interdependencies. Moreover, the Swedish governance system for managing water resources is particularly complex, relying on a multitude of actors that collectively work to operationalise the WFD (Jager et al., 2016). Indirectly, the cross-boundary collaboration can be viewed as ‘externally-driven’ as WFD mandates the water authorities to involve affected
actors in its implementation (Emerson & Nabatchi, 2015). Therefore, the water authorities can be viewed as vertical intermediaries that operationalise EU policy at the local level (Ansell & Gash, 2018).

3.2.2 Cross-border climate impacts

Researchers predict climate change will cause severe effects across the globe. Similar to water degradation, the impacts of climate change are a cross-sectoral and cross-border problem. Due to modern patterns of globalisation, climate change impacts will not only hit locally but also cross national territories (Hedlund et al., 2018). Such cross-border climate change impacts may take place through interdependencies across governance boundaries, such as trade, migration, finance flows, and species movement. Individual adaptation actions of countries offer little preparation for cross-border climate change impacts. Rather, climate adaptation is a borderless public good that requires international cooperation (Hall & Persson, 2018).

Following the Paris Agreement in 2015, countries signed on to a ‘global goal on adaptation’ at the United Nations Framework Convention on Climate Change (UNFCCC) (Hall & Persson, 2018). Cross-border climate impacts constitute a significant adaptation challenge that require international cooperation. However, global adaptation governance remains weakly implemented and there have been claims of a ‘misfit’ between cross-border climate change impacts and current climate adaptation (Benzie & Persson, 2019), with subsequent calls for increased research and action (Jernbeck & Olsson, 2014). In turn, adaptation policy integration relies heavily on the collaboration with between different non-state and state policy actors and the mainstreaming across different issue areas (Dellmuth & Gustafsson, 2021).

Food trade dependencies constitute a salient example of where cross-border climate impacts will manifest (Puma et al., 2015). Climate change is predicted to significantly alter local production of key staple crops (Challinor et al., 2016). Countries that rely heavily on imports for food supply or on exports for financial stability may therefore face significant pressure. By affecting both production and trade, climate change impacts on the global food system will be both local and cascade transnationally.
3.3 Data and methods

This thesis, using a mixed methods approach, combines qualitative and quantitative empirical data and analyses (Table 2). **Paper I** relies heavily on the use of multiple sources of data and complementary methods. The paper triangulates observation notes, policy documents, interview transcripts from participation observations, document analyses, exploratory, and validation interviews combined with causal systems mapping (directed acyclic graphs, DAGs) and quantitative network analysis. **Paper II** explores survey data with statistical network analysis using Exponential Random Graph Models (ERGMs). **Paper III**, relying on the same models, extends and combines them with expert interviews for deeper insight into model results. In **Paper I-III**, the qualitative data serve both as input for modelling and validation of modelled outputs. **Paper IV** applies network methods in the form of community detection in food trade networks using available data from the Food and Agriculture Organization of the United Nations (FAOSTAT, http://faostat.fao.org).

This thesis relies on network modelling as a key analytical method. Network methods today provide an extensive methodological toolbox under constant development. They can be used qualitatively or quantitatively by assuming that a set of nodes (i.e., different entities) are connected through a set of links, representing the relationships between them. This approach generates the basic structure of networks (a graph), which most often assumes that a non-random dependence exists among the links (Lebacher, 2019). However, distinct selection processes determine how structural properties influence the way networks emerge, develop, and perform. That is, network models assume that these processes produce (statistically tractable) patterns of links. Networks can be analysed as either the dependent variable shaped by such processes or the independent variable giving rise to certain outcomes. This thesis mainly analyses networks as the former.

The thesis uses several network analysis tools to explore the structural features of the MNM. Since a model is always limited by the conditions of what it is trying to explain, I have integrated network modelling with qualitative methods. The qualitative methods were used iteratively with the network analysis as input and subsequently as a way to interpret the statistical results. **Papers I and III** contribute qualitative insights about the perceptions of policy actors and how policy actors work with complex environmental problems.
Table 2. Data, methods, and outputs for individual papers.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Case</th>
<th>Data</th>
<th>Method of data collection</th>
<th>Method of analysis</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Basin-wide water governance</td>
<td>Observation notes, policy documents interview transcripts from 6 exploratory interviews and 6 expert interviews respectively</td>
<td>Participant observation, web search, exploratory interviews, expert interviews (conducted October - December 2017)</td>
<td>Causal pathway mapping; network modelling</td>
<td>Policy issue networks</td>
</tr>
<tr>
<td>II</td>
<td>Basin-wide water governance</td>
<td>Survey data from 59 respondents in two collaborative venues</td>
<td>Survey (distributed October - November 2018)</td>
<td>Exponential Random Graph Models</td>
<td>1 multilevel network (policy actor-policy issue network)</td>
</tr>
<tr>
<td>III</td>
<td>Basin-wide water governance</td>
<td>Survey data from 35 respondents in one collaborative venue, interview transcripts from 6 validation interviews</td>
<td>Expert interviews (conducted January - March 2020)</td>
<td>Coding of interviews; Exponential Random Graph Models</td>
<td>2 multilevel networks (policy actor-reinforcing policy issue network and policy actor-counteracting policy issue network)</td>
</tr>
<tr>
<td>IV</td>
<td>Cross-border climate change impacts</td>
<td>Quantitative FAO bilateral food trade data of three crops (wheat, rice, maize)</td>
<td>Secondary data collection using FAOSTAT database (collected December 2020 - May 2021)</td>
<td>Network community detection, functional network cartography</td>
<td>Food trade network</td>
</tr>
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</table>
3.3.1 Qualitative data triangulation: participant observation, document analysis, and interviews

In Paper I, I triangulated qualitative data by combining observation notes, policy documents (for a detailed list of documents see supplementary material of Paper I), and interview transcripts from six exploratory interviews with chairs of different collaborative venues working on water governance across the Norrström basin. According to Tracy (2013), methodological triangulation is worthwhile because it is reliable, generalisable, and helps determine what “really” is happening. I used the material from this triangulation for several purposes. First, the material served to gain insight into the case study, mainly about what water resource problems dominated in the Norrström basin and how collaborative governance was operationalised. Second, the material was thematically coded and used as input to the identification of different causal factors and their relationships in causal pathway mapping. Third, the material was used to identify comprehensive lists of policy issues and their respective targets. Using this procedure, I identified 16 policy issues, 8 targets, several intervening causal factors and relationships, that supported the production of policy issue networks.

3.3.2 Causal pathway mapping (directed acyclic graphs)

Paper I uses causal pathway mapping to distinguish how policy issues link to different environmental targets through a series of intervening factors. This method is common in sustainability science and complex systems research (Kirkwood, 1998; Meadows, 2009) as it allows for the relational mapping of factors in such systems by indicating a direction (factors influencing each other by a reinforcing or counteracting effect) by which causal inference can be made based on observational data, but it does not allow for cyclic paths, where factors become their own drivers (Rohrer, 2018). To construct DAGs in Paper I, I used Miradi Open Standards (miradi.org), an established tool in conservation research and practice with a set categorisation of intervening factors relevant to environmental management (Schwartz et al., 2012). This tool creates a causal diagram, which was useful to map mediating intervening factors between policy issues and targets and their cause-effect relationships. Therefore, policy issues could be defined as interdependent when depending on a common intervening factor to reach environmental targets.
3.3.3 Survey

To collect network data on policy actor collaboration and their policy issue engagement for Papers II and III, an online survey was distributed to participating policy actors from two water councils in the Norrström basin. Surveys are an established method for gathering empirical network data (Robins, 2015) and useful when including predefined lists of network actors and issues. Respondents were identified through member lists gathered from their respective councils and represented a diversity of policy actors, spanning from politicians, government representatives at the county and municipal scales, NGOs and industry representatives to local landowners. In total, 59 respondents participated in the survey (67% and 74% response rate in the two councils, respectively).

3.3.4 Network modelling

Using a causal mapping diagram as input, Paper I applies network modelling to identify interdependent policy issues. This modelling approach reveals the degree and type of interdependency by accounting for the number of common intervening factors between policy issues as well as the path length (number of causal steps) between policy issues and factors, which enables the development of policy issue networks. The paper uses simple descriptive network statistics – i.e., network density (the number of connections) – to demonstrate the variability of policy issue networks by assigning thresholds to the intervening factors and paths.

Papers II and III use a central statistical model that allows for the analysis of dependence between links, ERGM (Robins et al., 2007). Although departing from a regression-like framework, ERGM differs from ordinary regression models as it accounts for within-network dependencies between independent variables (such as links). ERGMs can focus on the occurrences of certain reoccurring micro-level patterns such as dyads, triangles, or stars – so-called motifs or building blocks (Bodin & Tengö, 2012) – and can evaluate the relative frequency of each motif and compare it against what would be expected at random. As motifs represent different network processes, the under- or overrepresentation of motifs is thought to occur for a reason.

Paper IV uses network community detection to analyse how countries fall into trade blocs before and after modelling climate change impacts on the production of three food crops (wheat, rice, and maize). Network community detection constitutes a well-used network method for analysing the degree that nodes in a network form subgroups with many within-group links, so-called modules.
(Fortunato, 2010; Newman & Girvan, 2004; Radicchi et al., 2004). Therefore, this method is useful for understanding how countries’ food trade dependencies make them rely on foreign production and trade blocs to secure their food supply.

**Lastly, Paper IV** uses functional network cartography as developed by Guimerà and Amaral (2005) to identify countries’ roles according to their pattern of intra- and inter-module connections. This method can identify the degree that a country holds a specific network position, for example, as a central hub within trade blocs or a bridge across blocs, which may affect their vulnerability and ultimately their interest in engaging with specific collaborative partners.
4 Summary of papers

4.1 Paper I: Assessing Policy Issue Interdependencies in Environmental Governance

Paper I addresses the fact that policy issue interdependencies are rarely explicitly defined or assessed with respect to the everyday practices of policy actors. First, we defined a methodological procedure for assessing policy issue interdependencies and developed policy issue networks based on a mixed methods approach. Second, we empirically illustrated its use by identifying policy issue interdependencies in governance of the Norrström basin, Sweden. The paper uses a causal approach to identify interdependencies by mapping intervening factors between policy issues and environmental targets. Our approach also provides a unique methodological contribution by empirically constructing policy issue networks, and identifying the type of policy issue interdependency as reinforcing or counteracting.

Research question: How can we better assess policy issue interdependencies in ways that correspond with what measures and possible solutions policy actors have at their disposal in specific cases for specific environmental problems?

Our methodological procedure offers a way to assess policy issue interdependencies in real-world policy subsystems. Applying the procedure to the case of water governance in the Norrström basin shows that it can reveal empirical insights about how policy issue interdependencies may vary in degree and type. We find that policy actors in Norrström face many policy issues in order to reach set targets. By describing and analysing policy issue interdependencies, we demonstrate that even though many policy issues are interdependent, not all are and not to the same extent. This finding is contrary to the conception of complex or wicked problems (Head & Alford, 2015; Rittel & Webber, 1973), which simply describes interdependency as a general characteristic of such problems.

Different patterns of policy issue interdependencies are associated with specific types of intervening factors. Our results show that the type of intervening factors that create policy issue interdependencies is important and not all types of factors contribute equally to creating interdependencies. Finally, we found that the total number of counteracting interdependencies dominate over reinforcing, yet that reinforcing interdependencies dominate across policy issues directly linked to a common intervening factor (no other mediating factors).
4.2 Paper II: Policy Issue Interdependency and the Formation of Collaborative Networks

Although much research states that policy actors who address interdependent policy issues should collaborate, studies rarely focus on policy issue interdependencies as a drivers of collaboration, a limitation that motivates Paper II. Using the policy issue networks identified in Paper I, Paper II investigates the impact of policy issue networks on social tie formation in two collaborative networks in the Norrström basin, one collaborative network more centralised and the other more decentralised in structure. We differentiate between endogenous factors (i.e., factors associated with the actors and the collaborative network) and exogenous factors (i.e., factors associated with policy issues and their interdependencies). Applying a multilevel network modelling approach using ERGMs, we studied two collaborative venues of water governance and their engagement in policy issue interdependencies.

Research question: Is actor collaboration associated with policy issues and policy issue interdependencies and if so, how?

Collaborative networks of policy actors do not always align with policy issue interdependencies. In our case, the actors did not appear to be more active (i.e., have more social ties) based on their engagement with policy issues or their interdependencies. In one venue, actors’ choices of collaborative partners were associated with both endogenous factors, such as collaborating with a central chair and with actors in the same professional position as themselves (mainly politicians and civil servants), and exogenous factors, such as shared and single policy issues before interdependent issues, but not with policy issue interdependencies specifically. In the other venue, only actor and relational attributes, such as collaborating with a central chair and social transitivity, shaped social tie formation. These results suggest that policy actors appear to prioritise socio-political aspects of collaboration. While the tendency to collaborate with others working on the same policy issue corresponded to a better fit, results showed that how actors interact does not necessarily align with the policy issue interdependencies defined by the environmental problem they address. Thus, results indicated that institutional fit in the two collaborative venues was not optimal.
4.3 Paper III: Challenges for Environmental Governance: Policy Issue Interdependencies Might Not Lead to Collaboration

Here, we argue that it is problematic to assume that actors can successfully address interdependency in complex policy settings, where divergent problem perceptions often exist. This assumption stands in the way of understanding how interdependency relates to governance effectiveness in both theory and practice. We take our departure the empirical observations showing a lack of collaboration over policy issue interdependencies in the Norrström basin (Paper II). Next, we connect the networked structure of collaboration to policy actors’ awareness of and perceived feasibility of responding to policy issue interdependencies and differentiate between reinforcing and counteracting interdependencies. By combining statistical network analysis (ERGMs) and interviews with policy actors in the Norrström basin, we found that perceived feasibility of acting on policy issue interdependencies is low despite existing awareness of them. Surprisingly, we also found a lower tendency for collaboration related to reinforcing interdependencies.

Research question: Do different policy issue interdependencies affect policy actors’ perception and collaboration and if so, how?

We found that policy actors are aware of policy issue interdependencies, yet our analyses suggest actors might be less aware of counteracting interdependencies. However, responding to policy issue interdependencies is not always feasible for policy actors, due to barriers such as current working procedures and institutional structures and a lack of, among other things, knowledge of other issues, resources, and personal relations. These barriers point to a perceived uncertainty of gains and collaborative risk avoidance. In addition, the policy actors had different ways of responding to reinforcing and counteracting interdependencies. In our case, actors avoided collaborating over reinforcing interdependencies but ignored counteracting interdependencies as a basis for collaboration. Reinforcing interdependency thus appears to be a stronger explanation than counteracting interdependency to lack of collaboration. Managing reinforcing interdependencies appear to rely on voluntary and collaborative mechanisms, which often have a vague jurisdictional status and include risky choices as gains are often unknown. On the contrary, managing counteracting interdependencies rely on the formal process by which counteracting interdependencies are managed.
4.4 Paper IV: Cross-Border Climate Change Impacts in Global Food Trade Networks

Paper IV analyses interdependencies in another context and with a different type of data. Similar to the previous papers, however, Paper IV investigates the degree to which certain network structures are associated with and impacted by specific environmental problems. This paper takes institutional fit as its departure by addressing the current misfit between cross-border climate impacts and global adaptation governance (Benzie & Persson, 2019). To understand this misfit and advance research, this paper analyses food trade dependencies to develop a baseline scenario study of cross-border climate change impacts.

In this paper, we analyse the potential impact of climate change on the global food trade network. We study three key staple crops in the global food system (wheat, rice, and maize) and use network community detection to analyse how countries form trade blocs for these three crops before and after climate change impacts. We used FAO international trade data for 2018 to construct networks for each commodity coupled with projections in yield change gathered from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP, 2018). With these data, we explored how climate change might affect the structure of the global food trade system by analysing trade blocs before and after climate change impacts. In addition, we provided a functional cartography that assigns nodes different network roles based on their connectivity, such as hubs or peripheral roles. Lastly, we explored the distribution of change in production within blocs.

Research questions: 1) How will climate change impacts alter the structure of global food trade networks? 2) How will a change in production be distributed and possibly redistributed among countries in trade blocs?

To analyse food trade dependencies, we propose a simple network model. Although coarse, a simple network model allows for tractable analysis about the qualitative behaviour of food trade networks, such as potential disaggregation or consolidations in food trade network structures and the reorientation of major global producers across trade blocs.

According to our model, food trade networks of wheat, maize, and rice were largely divided into defined trade blocs pre and post climate change. Our results predict, however, that these networks will tend to restructure as a result of climate change impacts and become more disaggregated than today. Results suggest a trend towards increased distribution of trade connections across blocs among
countries that shift network role as a result of climate change impacts, that rather than a concentration of trade within blocs.

Furthermore, our model shows that there is also variability within trade blocs, as change in yield among countries is unevenly distributed. Thereby, our model identifies winners and losers that partly derives from the distribution of change within trade blocs and partly derives from who they are connected to. For maize, however, all trade blocs are estimated to face production loss. That is, maize does not have a refined trade structure that would allow most counties to maintain their current supply.

Our findings provide a baseline scenario analysis towards a knowledge base for identifying relevant climate adaptation responses for food trade systems. Hence, our findings may serve as a foundation for future research on policy issues and adaptation actions connected to impacts in the food trade system specifically.
5 Contributions

This thesis describes and analyses the collective challenge of governing policy issue interdependencies. Below, I discuss how this thesis contributes to advancing the two overarching research questions and to narrowing the research gaps.

5.1 Theoretical contributions

The following findings address the identified research gap concerning the lack of integrated study of collaborative networks with policy issue networks. They address the first question: How do collaborative networks structurally align with policy issue networks?

5.1.1 Networked responses to govern policy issue interdependencies

The results of this thesis contribute to the broader theoretical discussions on how collaboration can resolve interdependent policy issues by bringing collaborative governance research together with sustainability science. Findings indicate that interdependencies vary in degree and types and that collaborative networks could presumably enhance the effectiveness of resolving policy issue interdependencies by acknowledging their variations. Still, when selecting collaborative partners, policy actors prioritise socio-political aspects related to actor attributes and the collaborative network as well as shared and single policy issues before interdependent issues (Paper II). The reason that interdependent issues are not prioritised does not appear to be linked to the reinforcing or counteracting type of interdependencies, and for reinforcing interdependencies, does not derive from low awareness of them (Paper III). Rather, practical infeasibility rooted in a range of different institutional and individual barriers that increase transaction costs and uncertainty of gains are obstacles to action focused on policy issue interdependencies. These obstacles need to be better understood if the varying degrees and types of policy issue interdependencies are to play a role in shaping the conditions for collaboration.

The validity in Slaughter’s statement that ‘networked threats require networked responses’ (2005) remains true as policy issue interdependencies may not be effectively governed by single policy actors or domains. This thesis shows, however, that networked responses can also struggle to respond to networked threats. That is, despite the collaborative networks in place to manage policy issue interdependencies, institutional fit may be hard to achieve. Thus, Papers II and
III challenge the assumption that policy issue interdependences are a strong precondition for collaboration. Therefore, the overall desire among policy actors to enhance institutional fit might not be as strong as is sometimes presumed and as is needed to achieve policy integration. As noted by Keskitalo et al. (2016), ‘Given that complex governance is impacted not only by issue-specific aims, the existence of multiple aims within the systems will also inherently limit possibilities for alignment.’ Even when policy actors are aware of the potential for joint gains as the result of reinforcing interdependencies, their institutional choices strive to reduce risk, for example, by prioritising certain gains of collaborating on shared policy issues with similar others before uncertain costs of collaborating on interdependent policy issues (Paper III). These results suggest that the potential for joint gains may be a small incentive for collaboration in situations of institutional fragmentation and high risk.

These findings signal that policy integration may be more difficult to achieve in practice than is often acknowledged. Integration rests on the capacity of collaborative networks to prioritise and succeed in managing policy issue interdependences. Therefore, a lack of policy integration may not always derive from a lack of political will. Rather, policy integration might be lacking due to policy actors’ perceived infeasibility of collaborating on policy issue interdependences. Evidently, raising awareness about reinforcing policy issue interdependencies is not enough nor is their inherent potential for joint gains. The results of Paper III make it relevant to question whether both policy integration literature and European policy practice overestimate the ability of individual policy actors to create coherent synergies.

This reasoning leads to a discussion of means and ends. Under the umbrella principles of policy integration and institutional fit and directives such as the WFD, collaboration is regarded as a means to achieve predefined environmental goals. These umbrella principles rely on collaboration as a problem-solving tool. Collaboration, however, often is used both as means and an end, although this does not fully comply with the normative perspective of the mentioned policy principles and directives. The water governance of the Norrström basin exemplifies this tension. On the one hand, collaboration here serves as an end in itself since several interview respondents note the importance of wide participation and healthy dialogue. The risk with operationalising collaboration as an end in itself may be that collaboration becomes overly cautious and ‘all talk and no action’ (Lubell, 2004), diminishing its ability to influence objectives. On the other hand, interviewed respondents also share frustration over the difficulty implementing physical measures and deciding who should bear responsibility and
costs. When collaborations are viewed as means, pluralistic and divergent interests often conflict with predefined normative goals, ultimately obstructing policy implementation. These arguments have been voiced in the larger debate about the potential incompatibility between democratic means and environmental ends (Eckersley, 2020; Klijn & Skelcher, 2007; Wong, 2015). Resolving such incompatibility, however, may be a question of sequencing network development (Imperial et al., 2016; Tang & Tang, 2014; Ulibarri et al., 2020), as policy actors may argue that a deliberative process is the only way to fulfil environmental objectives. Nevertheless, it is worth noting that collaborative networks may have limits to which they can respond to complexity, potentially rooted in the tension of collaboration being used as both a means and an end.

5.1.2 Empirically examining institutional fit

The findings of this thesis suggest that institutional fit is a useful way to reveal structural misalignment between different components of social-ecological systems and policy systems. Institutional fit is a perspective that relies on a normative outcome (Cox, 2012), often defined by environmental policy and governance literature as achieving effective governance and policy integration to ensure sustainable development. The findings of this thesis, however, suggest that misalignment cannot be entirely equated with or normatively judged as governance failure, but that collaboration is not only a problem-solving tool but also a socio-political process that is impacted by multiple governance levels. A misfit may not mean that collective measures towards managing policy issue interdependencies are entirely lacking. As mentioned earlier, policy actors often conflate policy issue interdependencies with socio-political aspects, which they also perceive as important. Rather, the findings confirm Mitchell’s argument (1990):

[There is never a perfect ‘fit’ among legitimisation instruments, functions and structures. As a result, use is made of various processes and mechanisms to overcome the problems which occur because of imperfect matches. It is often these processes and mechanisms, informal and formal, which facilitate co-ordination and integration. (Mitchell, 1990, p. 214)]

Following this reasoning, the insights from the water case open up new questions for the climate case. Cross-border climate change impacts introduce new problems of fit by linking often geographically distant areas and events. The MNM may be
applied to the global scale by combining the current analysis of food trade networks with actors such as jurisdictional nation states, foreign policy makers and climate adaptation planners engaging in transnational governance networks, and the adaptation-oriented policy issues these actors are engaging in. Collaboration may be different as problem-solving tool on the local, regional and global scales, yet socio-political aspects as drivers of collaboration may be important across all scales. As the global governance landscape is geopolitically driven, substituting trade relations, turning to global leaders or major producers, or allying with similar neighbours may be key for securing food supply. Vulnerability to cross-border climate change impacts may depend on how countries navigate these aspects in as part of geopolitical processes. As Paper IV predicts that climate change impacts may restructure food trade dependencies, policy actors will also need to dynamically re-arrange international cooperation and adaptation responses. Additionally, the question of equity in terms of distributing gains and costs may become intensified when countries are highly dependent on food staples from climate vulnerable countries. These patterns make the question of who engages with whom relevant on the local, regional, and global level.

5.1.3 How can collaborative networks better govern policy issue interdependencies?

Policy issue interdependencies blur the ways that problem-solving is best performed and how policy actors can provide effective policy responses. On the one hand, traditional policy solutions such as governmental regulation and legislation may be too narrow and linear to deal with policy issue interdependencies. On the other hand, alternative policy solutions such as collaborative networks are often comprehensive in scope yet formulated less concretely. From the institutional fit perspective, the results of this thesis point towards negative implications for problem-solving therefore, it is relevant to ask what the implications would be if policy actors do not acknowledge policy issue interdependencies.

One possible answer is that collaboration may become less tailored to the problems it intends to resolve. Without specific policy issues or interdependencies as a precondition, collaboration may be arranged inclusive of all interdependent policy issues, an arrangement that also risks becoming overinclusive of policy actors. As Lindblom argues (1959), such comprehensive arrangements may inhibit problem-solving. For example, targeting all interdependent issues may complicate the ability to reach agreement. In effect, comprehensive collaborative
arrangements may mainly achieve procedural outcomes such as social learning and become self-limiting. In such situations, collaboration may become an end rather than a means for problem-solving or a policy problem in itself.

The findings in this thesis, however, also show some positive implications for further investigation. Results suggest that the ability of collaborative networks to better resolve interdependent policy issues may depend on three aspects identified here. First, the thesis indicates that collaborative networks would benefit from acknowledging and specifying characteristics of problems, such as policy issue interdependencies, in specific cases and contexts. The prospect of well-functioning collaboration may increase if addressing limited yet strongly interdependent policy issues. Furthermore, the collaborative process may have to be designed differently for reinforcing and counteracting interdependencies. For example, processes focusing on reinforcing interdependencies may need to lower transactions costs and increase the perceived risk of collaborating while processes focusing on counteracting interdependencies may still need to increase awareness of interdependencies. Second, resolving policy issue interdependencies may depend on the purpose of the collaborative network and whether the network is a means or a precondition end more than the specific structure of the collaborative network. If collaboration is a means to a predefined end, collaborative arrangements may have to specifically identify relevant actors and explain why these actors should be included. However, collaboration can also intentionally be a sequential phase of knowledge-sharing and trust-building that precedes the implementation of solutions. Nevertheless, the findings of the thesis suggest that there are different ways to resolve policy issue interdependencies using different network structures. Paper II shows that collaboration was not associated with policy issue interdependencies regardless of the diverging structures of the studied collaborative networks – e.g., their different degree of centralisation. Turning this argument around implies that different types of network structures may operate well to govern interdependent policy issues. Complex system theorists refer to this principle as equifinality (von Bertalanffy, 1968) – i.e., many means can achieve the same end. This principle also strengthens the argument that both processes managing reinforcing and counteracting interdependencies can contribute to problem-solving. Yet since both types of processes are often complicated, policy actors may also need improved procedural instruments to work with interdependent policy issues.

One possible technique may be to use supporting documentation that illustrates what policy issues to integrate and what actors these issues connect. Such baseline assessments may help policy actors prioritise incremental change of critical policy issue interdependencies; however, this prioritisation must not result in policy-
making returning to a specialised focus on single policy issues. Rather, policy actors may need to prioritise sets of policy issues based on the level of their interdependency, which may minimise the effort needed for other policy issues in later stages. Such sets should ideally be based on moderate rather than comprehensive levels of interdependency (see Paper I). Therefore, collaboration could initially strive for limited agreement related to a smaller set of issues. For example, by comparing the policy issue network with the MVVF collaborative network in Paper II, Figure 4 shows that there may be reasons to create a specific coalition around seven highly interdependent policy issues and that currently the collaborative network is more dispersed as it lacks such a specific cluster of policy actors. Paper I identified that issues in this cluster are reinforcing—e.g., lime treatment, phosphorus dams, and storm water management:

Lime treatment is highly cost efficient, you remove phosphorus and nutrient salts instead of dealing with storm water management. As a politician, you are often faced with such prioritisations. (Policy actor in Norrström)

Therefore, there is abundant room for further progress in determining whether prioritising a limited set of interdependent policy issues improves the prospect of collaboration as a problem-solving tool. In that sense, collaboration between all policy actors with stakes in water governance may not mitigate the effect of hydropower on fish connectivity, and multilateral collaboration may not be optimal for managing food trade dependencies between a few countries. Instead, collaborative networks may be a more fruitful under a narrower reference frame, in particular, if aided by a prioritisation order of strongly interdependent policy issues and procedural policy instruments such as supporting documentation of policy issue interdependencies.
5.2 Methodological contributions

The following findings address the research gap in the need for methodological approaches and empirical evidence that concretise policy issue interdependency in specific cases and contexts. Specifically, these findings address the second research question: How can policy issue interdependencies be revealed, concretised, and analysed?

5.2.1 A multilayer network model (MNM) and its empirical applications

Complex structures require framings and methods that can move research from the conceptual and disintegrated to the informative and policy relevant. Therefore, this thesis is framed around an MNM and papers that empirically demonstrate its application. The model integrates interpretations and perspectives of interdependencies across locations, policy actors, and policy issues, which are often difficult to observe directly.

This thesis shows that the MNM is well equipped to study different types of interdependencies in different empirical cases. The model offers the possibility to reveal empirical details that may help develop more contextually-based knowledge about the nature of policy issue interdependencies and food trade dependencies.
and how they are associated with collaboration. Naturally, the two empirical cases portrayed in this thesis require highly different policy responses beyond the broader frame of policy integration, but apart from their contextual differences, both cases portray the use of a multilevel network framing as a common conceptual approach for empirically-revealing interdependencies across multiple network layers. Using the MNM as a frame offers the possibility to integrate the different layers and contribute to knowledge that is greater than studying the layers separately. Although the data and findings of applying the model are highly case-specific, MNM is generic and may be applied to other empirical problems and policy domains, such as health and finance. Empirical analyses could also extend the work performed in this thesis by analysing all three layers simultaneously. This presents an avenue for further methodological advancement, for example, by using three-layered motifs.

5.2.2 Methodological disentanglement of the relationship between global network structure, micro-level process, and individual policy actor

Analysing networks and the preferences of policy actors simultaneously can disentangle complexity and make it traceable for policy actors. In the water case (Papers I–III), the reiteration between qualitative methods and network modelling enables methodological pluralism that provides depth to the relationship between the networked structure and the individual policy actor. On the one hand, Paper II explores the drivers of collaborative network formation and shows how the preferences of policy actors shape the collaborate network structure. On the other hand, Paper III uses policy issue network structures as a starting point to understand how policy actors perceive and engage network structures. Therefore, the papers offer approaches to integrate a structural and actor-based perspective. The findings from the water case study contribute to methodological individualism – i.e., how structure conditions the way policy actors exert agency (Giddens, 1979). The findings reinforce the notion that collaborative structures shape the policy actors’ agency in the way that the collaborative network, more than the policy issue network, shapes how the actors select collaborative partners. The policy issue network, however, shapes the choices of policy actors through their avoidance of collaboration based on policy issue interdependencies. Finally, institutional structures affect how policy actors perceive the feasibility of acting on policy issue interdependencies as well as their willingness to take risks. Overall, these findings illustrate the methodological disentanglement of the relationship between global network structure, micro-level process, and individual policy actor.
5.2.3 Detailed studies of policy issue interdependencies as a coherent decision-making basis

Moving between descriptive and inferential methods can extrapolate the meaning of particular properties of data and therefore adds to the practical relevance of research. In this way, detailed analyses of policy issue interdependencies can have significant value as this type of supporting information can improve governance and policy intervention. Hidden interdependencies may constitute gaps of effectiveness in governance, and policy actors in the studied water case have asked for supporting information on policy issue interdependencies to improve environmental policy integration in Sweden and the European Union.

The network mappings produced in Papers I and IV may be the first steps towards providing such supporting information. These mappings may subsequently contribute to forming more intentionally designed collaborative efforts grounded in the given problem. The contextually close procedure developed in Paper I can be used to make detailed maps of policy issue interdependencies that could be useful to decision-makers. Paper IV unpacks food trade dependencies that shape the global food trade network structure, information that can be used to better estimate how cross-border climate change impacts may manifest and affect international collective action and future adaptation needs. Its predictions about where and how cross-border climate impacts may occur are relevant for defining baseline scenarios and providing refined risk assessments.

Finally, detailed studies of policy issue and food trade dependencies give environmental problems more “agency” in analyses of the formation, evolution, and performance of networks as governance. This agency contrasts with the common description that environmental problems are wicked objects that should be governed as it shows that environmental problems hold characteristics that can fundamentally change the way governance is enacted and environmental policies are developed.

5.3 Limitations

Major debates are on-going about how to best represent complex phenomena scientifically (Rathkopf, 2018). This section discusses a few limitations of this thesis.
First, there is a methodological trade-off between representing overall complex phenomena and representing individual perspectives. For example, analysing policy issue networks requires a comprehensive list of the main policy issues, yet policy issues are embedded in different contexts and regulations, and perceptions of policy actors remain subjective and diverse. In Papers I–III, the lists of policy issues and environmental targets aim to represent water governance across the entire basin, but the list ignores nuances that could explain differences between policy issues. In our identification of policy issues and subsequent analysis of policy issue interdependencies, we did not separate policy issues according to their legal compliances or their framings in the policy process. Adding such lenses could have refined our data, but this addition would have lessened the comprehensive scope of the policy issues.

Second, this research explains dynamic changes using static snapshots of networks. Although desirable, longitudinal or time series analyses would have required extensive data collection on policy issues and actor networks in Papers I–III, efforts beyond the scope and resources of these studies. In addition, in Paper IV, using longitudinal data and correcting the data for re-exports as the algorithm of the re-exports could potentially shuffle the yearly data. These navigations reveal how methodological and practical choices must be weighed against how best to represent reality.

Third, as this thesis relies on an interdisciplinary research approach, deeper disciplinary discussions were omitted. Because the research of this thesis spans policy studies to hydrology to social psychology, many dimensions of related fields were not investigated in depth. This is an interdisciplinary limitation that derives from investigating the fit in different types of cases. The multi-dimensionality of the research, however, illustrates the number of ways that this study could be extended.

Fourth, this thesis does not contribute to the ability to document and explain outcomes, a goal collaborative governance literature often identifies. Nonetheless, this thesis touches on output as Paper III uses a four-cycle motif as a dependent variable to represent collaborating policy actors who engage in interdependent policy issues.

Finally, this thesis has some limitations related to generalisation. First, a case selection based on diversity in approach, scale, and network boundaries complicates generalisation as even the most common elements may depend on institutional and socio-political contexts. However, a transferrable insight of the
two studied cases may be that the barriers of using institutional fit as a reference frame for problem-solving on the subnational scale may be even greater on the global scale. Second, the lack of policy actors’ consideration of policy issue interdependencies is specific to the Norrström basin, but there may be other cases of environmental governance where policy issue interdependencies are collaboratively considered. However, a general insight is that collaborative networks may still struggle to resolve interdependent policy issues in cases with substantial institutional fragmentation and high transaction costs for collaboration. Although specific policy issue interdependencies are highly context-dependent, the MNM and Paper I’s procedure for identifying and assessing these can be used to investigate problems other than freshwater degradation and cross-border climate impacts.
6 Conclusion

The environment knows no borders, but governance does. Many environmental problems interact with or spill over to other areas, introducing policy issue interdependencies that cannot be governed by single policy actors or states. Against this backdrop, this thesis has described and analysed the challenge of collaboratively resolving policy issue interdependencies.

Related to the first research question, this thesis found that policy issue interdependencies are not always associated with collaboration. Collaborative networks also struggle to respond to networked threats, so this thesis challenges the assumption that collaborative networks will in themselves resolve interdependent policy issues, even when there is potential for joint gains. From the institutional fit perspective, the results of this thesis thus point towards negative implications for problem-solving. Going beyond this frame suggests, however, that collaboration is not only a problem-solving tool but also a socio-political process that may potentially be aided by targeting more limited sets of interdependent issues.

Related to the second research question, this thesis found that policy issue interdependencies can be concretised by applying multilevel network framing and developing empirical applications on different case studies. As a result of this approach, this thesis suggests that environmental problems have characteristics that can fundamentally change the way governance is enacted and environmental policies are developed. This thesis demonstrates that the relationship between global network structure, micro-level process, and the individual policy actor can be disentangled to reveal a multidimensional understanding of how to resolve interdependent policy issues.
7 Science-policy interface

During the 2021 Stockholm University Sustainability Forum, Helena Lindberg, the Swedish National Audit Office Auditor General, was asked how to balance fragmentation between policy domains with the inability of all domains to engage in all policy issues and their interdependencies. She responded by calling for a more coherent decision strategy. She expressed concern that the lack of coordination around supporting evidence leads to government agencies using different scenarios, resulting in different assumptions that lead to incoherent decisions. In such cases, demand for coordination and collaboration to create policy integration may arrive woefully late.

This reply shows that the question of how collaborative networks can better deal with policy issue interdependencies is important for enhancing the prospect of achieving policy integration and calls for more supporting evidence. This thesis suggests that detailed studies of interdependencies can contribute to identifying integration gaps between relevant policy issues and policy actors. Mappings help encourage inter-organisational dialogue that focuses on integrating policy issues and may identify explicit areas in particular need of coordination across policy domains and geographical territories. Although the division of domains, sectors, and territories make administration tangible, detailed mappings can identify where and how structural gaps exist in policy integration in different empirical contexts rather than transforming governance systems entirely. This tool can be used to forge and assess participation and collaboration in partnerships for integrated policy-making.

Network studies are in and moving towards an even more profound interventionist tradition. This thesis offers some insights for policy actors that aim to implement, for example, the European Water Framework Directive or the European Adaptation Strategy. The Swedish WFD implementation has currently only vaguely defined requirements for collaboration, lacking detailed instructions on which actors and authorities to include. Potentially, mappings identifying integration gaps could support such recommendations. Under the LIFE programme, the EU recently launched so-called ‘Integrated projects’, which aim to integrate environmental and climate policies in other sectoral policies and should rely on co-financing. These projects may be a promising avenue for policy integration. The potential risk with these projects, however, is that they become highly comprehensive in terms of the policy actors and policy issues included. Although the findings of this thesis are not necessarily representative or extrapolated across all European countries, detailed mappings of policy issue
interdependencies may support policy intervention by contributing to more coherent decision-making basis and by identifying who to include in projects and co-finance initiatives for policy integration.
8 Looking ahead

Science is fulfilling its purpose if we can leave better defined problems to the next generation than those we inherited. One aim has continuously guided this thesis: to describe interdependencies across sustainability challenges that are more hidden than obvious. Concretising such interdependencies has offered a unique opportunity to make an important contribution to both science and practice.

We are transitioning from a time of target-setting to a time of accountability (Karlsson-Vinkhuyzen et al., 2018). That is, it is increasingly important to translate sustainability targets into policy interventions. Attention to the ways in which policy issue interdependencies are perceived and acted upon by policy actors is therefore increasingly important. This thesis has shown that today we need more coherent evidence to understand interdependent policy issues that can better support collaborative networks as a means for problem-solving.

Looking ahead, many lessons from the thesis warrant further research. For example, this thesis opens up new questions when bringing insights across the two case studies, from the local and regional to the global. In particular, as complexity rises with scale, how can policy integration and the mainstreaming of climate adaptation across national borders be accomplished? What conditions make the consideration of interdependent policy issues feasible on this scale? A new pursuit would be to complete a three-layered MNM for the climate case by relating actor and policy layers to the analysis of food trade dependencies.

The results also suggest that more research is needed to understand the tools and instruments that exist for collaborative networks – e.g., how do we incorporate and design planning and policy instruments for collaborative networks that are flexible enough to deal with dynamic change and to aid the implementation of defined environmental targets? And how can policy instruments enhance the accountability of collaborative networks to respond to interdependencies? These are issues to follow closely.
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