International Journal of the Commons

Assessing Policy Issue Interdependencies in Environmental Governance

RESEARCH ARTICLE

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ABSTRACT

The ability to effectively resolve complex environmental problems hinges upon the capacity to address several different challenges in concert. These challenges, what we refer to as policy issues, often relate to one another – they interdepend. Policy issue interdependency has been extensively theorised in the literature, yet few methodological approaches and little empirical evidence exist to translate the concept of policy issue interdependency to the on-the-ground realities facing policy actors in specific cases and contexts. We build from previous studies to develop a methodological procedure that investigates policy issue interdependencies in ways that take into account what measures and possible solutions policy actors have at their disposal in specific cases for specific environmental problems. By applying our methodological procedure to a case of water governance in Sweden, four insights emerged. First, validation by stakeholders confirms that our procedure produces reliable results. Second, we find that many, but certainly not all, policy issues are interdependent. More specifically, different patterns of policy issue interdependencies are associated with the biophysical and the governance spheres, respectively. Third, our results suggest that policy issue interdependencies are most important to consider when the overall level of interdependency is moderate. Last, our study raises new questions about policy actors' perception of policy issue interdependencies. In particular, a key question for future research would be if reinforcing (win-win) or counteracting (trade-off) interdependencies are easier to comprehend and act on for policy actors.

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KEYWORDS:
policy issues; policy issue interdependencies; networks; policy issue networks; causal pathways

TO CITE THIS ARTICLE:
Hedlund, J., Bodin, Ö., & Nohrstedt, D. (2021). Assessing Policy Issue Interdependencies in Environmental Governance. *International Journal of the Commons*, 15(1), pp. 82–99. DOI: *https://doi.org/10.5334/ijc.1060*

1. INTRODUCTION

Many societal and environmental problems span geographical and juridical boundaries (DeFries & Nagendra, 2017; Edelenbos & Teisman, 2013; Heikkila, 2004). Thus, solving complex environmental problems often involves 'partitioning' problems into a set of challenges that are better aligned with existing governance procedures and division of responsibility (Brandenberger et al., 2020; Lubell, 2013; Simon, 1962). We define policy issues as a set of separable challenges associated with a broader environmental problem. This definition does not only encompass policy issues that are deliberately constructed by policy actors, it also embraces policy issues that emerge from the social- and biophysical contexts of the environmental problems at focus. Policy actors with responsibility for and/or stakes in environmental problems engage in policy issues to address the problems collectively or individually. They do so by addressing problems through different environmental targets defined by the policy issues at focus (Hedlund et al., 2021). In the process of developing new or implementing existing policies to reach such targets, actors must concentrate on certain step-wise actions to reach targets, and the possible biophysical- and/or societal consequences these actions can have. This definition does not prescribe what the actors need to do in each step, rather it relies on these steps defining a common, causal pathway from a policy issue (the challenge) to an environmental target (the desired outcome) through a series of intervening factors (***Figure 1***). We define *policy issue interdependency* as arising from any actions, or any consequences of these actions, associated with at least two different policy issues (ibid). For example, effectively reducing water pollution could involve devising rules against ditching since fewer ditches can decrease agricultural runoffs (policy issue one), but reducing ditching could also prevent the loss of wetlands (policy issue two). This example illustrates how one overall environmental problem (water pollution) is spanning two different policy issues, and that actions addressing one of these policy issues can have consequences for the other issue. Thus, these two policy issues are interdependent.

Policy issue interdependency has been extensively theorised in the literature (Feiock, 2013; Jordan & Lenschow, 2010; Lubell, 2013; McGinnis, 2011; Oberthür & Gehring, 2006), yet few methodological approaches and little empirical evidence exist to translate the concept of policy issue interdependency to the on-the-ground realities facing policy actors in specific cases and contexts. This is contrary to studies of interdependencies among high-level policy goals such as the UN Sustainable Development Goals (SDGs), which have been thoroughly addressed in recent research (Nilsson et al., 2018; Nilsson et al., 2016; Pham-Truffert et al., 2020; Weitz et al., 2017). The lack of effort to empirically study and evaluate policy issue interdependency in ways that align with how policies and planning processes play out in specific local and regional contexts thus constitutes a critical knowledge gap. A starting point in addressing this gap is to develop relevant methodologies as a tool to describe and analyse policy issue interdependencies. Such methodologies should consider the measures and possible solutions available to policy actors in managing specific environmental problem. This is different from identifying overarching interdependencies between ambitious and high-level policy goals, or from mainly assessing how systemic factors relate to one another (the latter often assessed using cognitive mapping, e.g. Hamilton et al. 2019; Özesmi & Özesmi, 2004). Hence, the question underlying this study is: 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 main ambition with this study is to elaborate a procedure to empirically assess policy issues and their interdependencies that, in any given context, comes close to capturing what local and regional actors are doing in their everyday work with policy and planning.

We combine and build from previous methodologies for identifying policy issues and their interdependencies, which we then apply in a case study of water governance in Mideast Sweden. Water-related environmental problems are useful study settings for policy issue interdependency since the flow of water makes such problems embedded

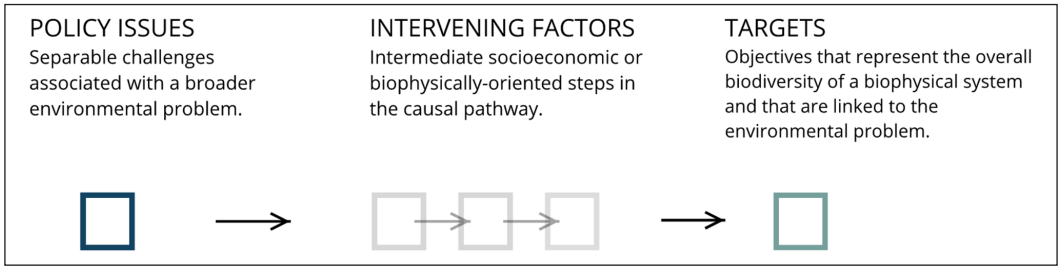

Figure 1 Causal pathway between policy issues and targets, mediated through a series of intervening factors.

in numerous scales and localities. Water governance therefore constitutes a relatively well-defined *policy subsystem* (Jenkins et al., 2017; Sabatier, 1988; Weible & Sabatier, 2009) with geographical (e.g. Mideast Sweden) and substantive (e.g. water-related policy) components. The high degree of interdependency in hydrological systems furthermore makes it non-trivial to distinguish causes and consequences deriving from different policy issues from each other, which makes water governance both suitable and challenging for probing the utility of our approach.

We draw from an established framework (Open Standards for the Practice of Conservation, OS) with an associated software tool (Miradi Open Standards, *www.miradi.org*). The OS framework and Miradi software have been widely implemented in over 115 conservation projects globally (Schwartz et al., 2012), yet the scientific literature on applications remains sparse (see however Carr et al., 2017; Margoluis et al., 2013; Salafsky, 2011). First developed as an aid for practitioners in conservation management, the framework details a procedure to unravel the processes by which actors organise (or ought to organise) actions to achieve certain targets by explicitly mapping causes and effects (***Figure 2a***). These processes, here referred to as *causal pathways*, comprise actions, defined as a series of different factors. This builds on the logic that certain contributing factors, direct threats and biophysical

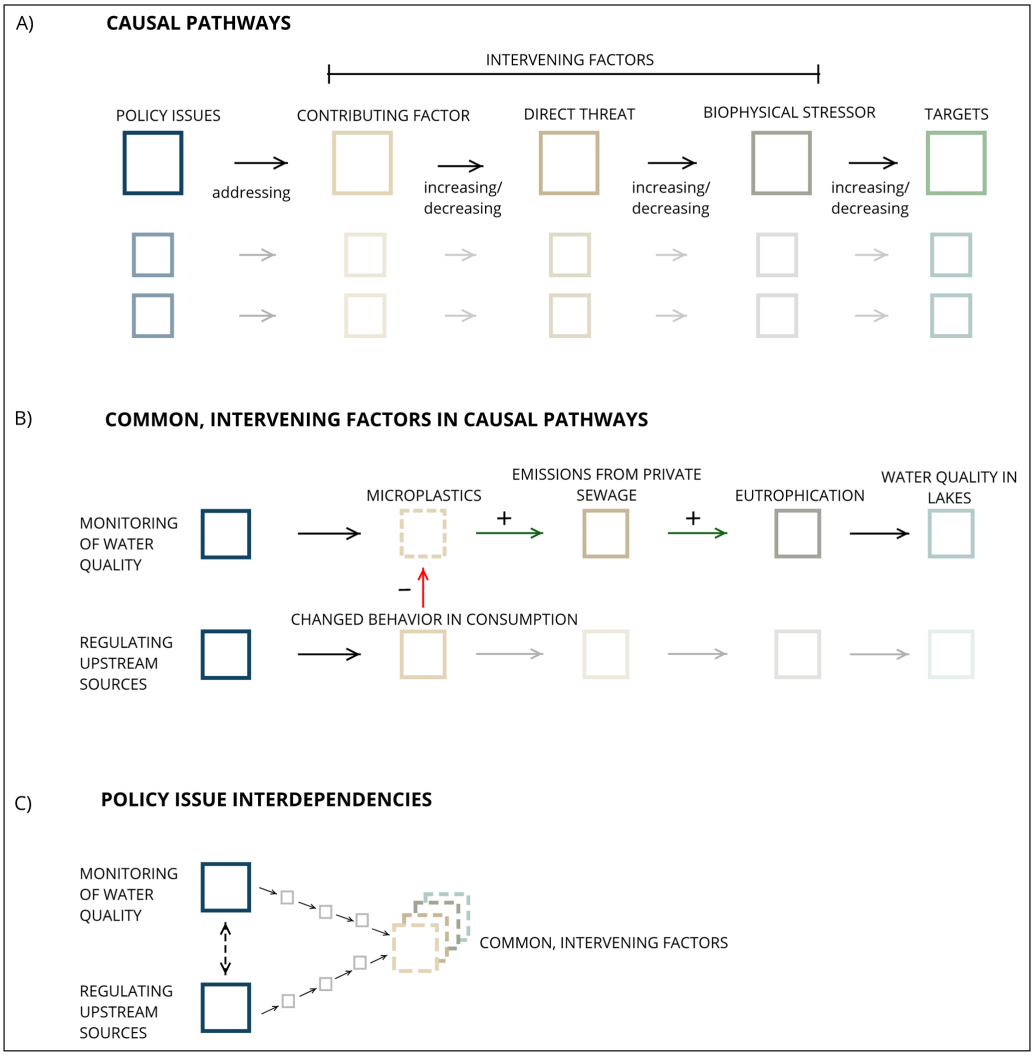

Figure 2 a) Conceptual illustration of a single causal pathway linking a policy issue to an environmental target by positive or negative causal steps (represented by arrows) and different intervening factors. **b)** Example of a common, intervening factor linking two causal pathways. Construction of wetlands and sustainable storm water management both increases water filtering and treatment, which could decrease leakage from land-based production, which commonly increases eutrophication, which ultimately impacts the water quality of lakes. The two policy issues become interdependent by both increasing water filtering and treatment as a common, intervening factor in their respective pathway towards improving water quality, which opts for their coordination. **c)** the emergence of policy issue interdependency through a common, intervening factor. The common, intervening factor can be of any type, and be preceded by a varying number of steps and other intervening factors. Policy issues can link directly to all types of intervening factors.

stressors intervene when actors try to reach targets. Mapping the factors involved in this process is useful for identifying actions that are associated with two or more policy issues, and thereby making them interdependent (***Figures 2b*** and ***2c***).

Empirically, we investigate a series of actor-defined policy issues, and their interdependencies arising from common, intervening factors in the water governance system of the Norrström drainage basin in Sweden. From an actor-informed mapping of multiple causal pathways, we define and construct distinct *policy issue networks* where the policy issues are represented as nodes and the interdependencies as links. To our knowledge, no previous study has defined policy issue interdependencies as emerging indirectly through common, intervening factors between policy issues and targets.

Our methodological procedure is not hard-wired to any specific type of data or data collection. Instead, it embraces empirical triangulations and pluralism in methods, and the active involvement of policy actors. The results from our empirical analysis reveal that not all policy issues in Norrström are equally interdependent, but strongly vary in their degree of interdependency, and what intervening factors they have in common. One immediate implication of this work is that policy actors should pay close attention to the specific intervening factors that more strongly than others contribute to policy issue interdependencies, which we elaborate further in the discussion.

2. POLICY ISSUE INTERDEPENDENCY IN ENVIRONMENTAL GOVERNANCE

Interdependency reappears in different literatures as a central condition for collaboration (Barnes et al., 2016; Bodin et al., 2017; Folke et al., 2005; Koontz & Thomas, 2006; Scott, 2015). Research that focuses on purely ecological interdependencies in environmental governance is growing (Barnes et al., 2019; Bodin & Tengö, 2012; Pittman & Armitage, 2017). But in practice, policy actors often address ecologically derived entities and their interdependencies by framing them around specific policy issues. In the environmental governance literature, many empirical examples of interdependency focus on high-level goals. Studies of interacting SDG targets (Nilsson et al., 2016; Weitz et al. 2018) have generated multiple applications of the approach to specific empirical cases (Fuso Nerini et al., 2018; Jaramillo et al., 2019; McCollum, 2018). Similarly, Bergsten et al. (2019) identify governance gaps through a quantitative, empirical investigation of interdependencies between sustainability goals. 'Nexus' approaches commonly target linkages between multiple objectives pertaining to, for example, resources such as water, energy and land (Cremades et al., 2019). Moreover, analyses of interdependencies between policy objectives (Nilsson et al., 2012), policy preferences (Metz et al., 2019), and policy areas (Jiren et al., 2018; Mikulcak et al., 2013) add to findings of interdependency within the environmental policy sphere.

Much of this previous research does not, however, represent what actions policy actors practically undertake to accomplish problem-solving in settings where multiple policy issues exist and are interdependent. Our perspective of policy issues instead emphasises that goals or targets become realised when actors engage in policy issues and associated intervening factors. Policy issues thus signify what policy actors work on, from ambition to target, within a policy subsystem (Jenkins-Smith et al., 2017; Weible et al., 2012). At the regional and local level, a few studies have undertaken analysis on interdependencies that are closer to practice. Studies include Wang et al. (2014), who emphasise the interdependency of infrastructure tasks identified from Beijing flood emergency response plans, and Bodin and Nohrstedt (2016), who similarly describe interdependencies between wildfire response tasks and crisis response actors operating in Västmanland, Sweden. Angst (2019) provides a way of identifying interrelated issues in Swiss water governance. These previous studies do not, however, methodologically disentangle how to describe policy issues and targets in an actor-informed way to assess interdependencies, or account for how interdependency can vary in degree and type.

As recognised by Nilsson et al. (2018), systematically identifying and assessing interdependencies between policy issues is a methodological challenge. Literature review and cross-matrix evaluations (Weitz et al., 2017; Zhou & Moinuddin, 2017; Jaramillo et al., 2019) are some of the methods commonly applied in such assessments. Similarly, interdependencies are often based on content analysis of policy agreements and documents (Metz et al., 2020; Vladimirova & Le Blanc, 2016), or grounded in the expert judgment of case study authors (Oberthür & Gehring, 2006). Quantitative approaches that have been applied for comparing and integrating sustainability goals include, for example, multi-criteria decision analysis (Jayaraman et al., 2015). Identifying policy issue interdependency through mechanistic mappings of drivers and intervening biophysical, social, political, and economic factors provides a more process-oriented method (Dade et al., 2019; Hamilton et al., 2019; McGlashan et al., 2019). For example, mental models are cognitive maps that can produce representations of perceived causal relationships similar to Miradi mappings, but focus on depicting actors' perception of a system, and giving less description of what activities policy actors practically engage in (or could engage in).

Last, describing complex realities as networks of nodes and links (here, policy issues and their interdependencies), which can be further analysed using network analysis, is often employed to make these complex realities more tangible and tractable. Specifically, it has also proved efficient to discern variation in levels of interdependency (Bodin & Nohrstedt, 2016; McGlashan et al., 2019; Metz et al., 2020; Weitz et al., 2017). Different network measures can further demonstrate the impact on interdependencies as a result of changes in certain thresholds. Thereby, network analysis constitutes a powerful tool for investigating policy issue interdependencies.

3. METHODS

3.1 UNDERLYING CONSIDERATIONS FOR ASSESSING POLICY ISSUE INTERDEPENDENCIES

We have adopted existing methodological approaches to develop a procedure for assessing policy issue interdependencies that come close to the everyday reality for policy actors. The procedure was then applied to our empirical case. Three considerations underlined our assessment. First, we sought to facilitate transparency through the active involvement of policy actors in the research process. This ensures that the definition and interpretation of policy issues and their interdependencies are valid to the given context and directly relevant to the actors involved. Involving multiple policy actors also reduces subjectivity and arbitrariness. We utilised a mixed methods approach based on triangulation of data sources and the use of both quantitative and qualitative analyses to further reduce subjectivity and arbitrariness as elements of uncertainty. Kimmich (2013) has previously used triangulation of data sources to define interdependencies, but such approach is not consistently used in other similar assessments. In our view, a qualitative data triangulation process minimises the risk of biases from individual perception of policy issues among actors.

Second, we build on the established OS framework to help in assessing the causal relationships, here referred to as *causal pathways*, linking policy issues with environmental targets. These causal pathways consist of stepwise *intervening factors*, that affect the non-immediacy between a policy issue and a target. An intervening factor represents an intermediate socioeconomic or biophysically-oriented action (e.g. implementing a land use policy), and/or effect (e.g. increased stakeholder conflicts), in the causal pathway. Intervening factors can be common to two or more policy issues. In this way, policy issues become interdependent through common, intervening factors in their causal pathways. Hence, addressing one policy issue will have consequences for any interdependent policy issues.

To detail these relationships, we use the Miradi Open Standards tool to develop a network map representing the causal pathways between intervening factors (a directed acyclic graph), similar to previous approaches in Hamilton et al. (2019), McGlashan et al. (2019) and Boron et al. (2016). Miradi is advantageous since it is an established tool for detailing complex processes and casual relationships in close collaboration with stakeholders. Here, we describe causality through an assessment-based mapping from which we infer the direct effect on a factor as a result of a change in another particular factor. This focus on causation does, however, not prohibit also assessing relations between factors that are more associative, i.e. where the specific causal mechanisms are more diffuse, and/or potentially go in both directions. For simplicity, we nonetheless refer to all these relations as causal and directional.

We focus on interdependencies that emerge when two or more causal pathways have at least one intervening factor in common. This will connect the causal pathways. In this way, interdependencies emerge indirectly through common, intervening factor(s) of two or more policy issues. We thus consider all policy issue interdependencies as being bi-directional (the interdependencies go in both directions). In turn, we consider the type of interdependency between policy issues. If reinforcing, policy issues are in synergy with each other and strengthening one strengthens the other. In contrast, counteracting issues forestall or restrain each other in a trade-off situation. Following previous methods (Angst, 2019; Bodin & Nohrstedt, 2016; Metz et al., 2020; Weitz et al., 2017), we use a network-centric modelling approach to concretise varying degrees of interdependency, as well as reinforcing and counteracting interdependency type.

Third, we rely on validation of our mapped policy issues and policy issue interdependencies. Validation is suggested as part of creating a multiple evidence base to describe policy issues of concern (Tengö et al., 2014), and has recently been applied in assessments of interdependency (Kirschke et al., 2019). Here, we validate both causal pathways between intervening factors and policy issue interdependencies by engaging in close dialogue with key actors.

3.2 APPLIED CASE – WATER POLICY ISSUES IN THE NORRSTRÖM BASIN

We demonstrate our methodological procedure in a case study setting characterised by a governance form that recognises and encourages stakeholder involvement, the existence of different political decision-making arenas, and the importance of accounting for biophysical interdependencies within a river basin unit, thereby representing a highly intertwined practical reality for the actors involved. The policy subsystem investigated here is

the Norrström drainage basin, located in Mideast Sweden (***Figure 3***). The catchment defines its territorial scope, and we regard water governance as the main policy topic that gathers actors operating within the policy subsystem. This also incorporates socioeconomic and managerial aspects, since water governance as a policy topic goes beyond strictly environmental concerns. The Norrström drainage basin is governed by one public organisation (called 'River Basin District Authority') and encapsulates a high number of water bodies including the lakes Mälaren and Hjälmaren, 62 municipalities populated by approximately 20% of the Swedish population (Jaramillo et al., 2013), and the capital of Stockholm. Its fragmented hydrological structure of interconnected water bodies gives rise to a multitude of different policy issues and interdependencies. Norrström thus constitutes a suitable case to empirically demonstrate our assessment. After the reform of the European Water Framework Directive (WFD) in 2000, the Swedish adoption has been dominated by administrative measures and ensuring participation in different collaborative venues. Most commonly, these collaborative venues have constituted subregional water councils. Within the Norrström basin, 21 collaborative water venues gather participants in the endeavour to implement the WFD. We focused our collection of interview data on five of these venues, namely Mälarens Vattenvårdsförbund (MVVF), Hjälmarens Vattenvårdsförbund (HVVF), Hjälmarens Vattenförbund, Oxunda Vattensamverkan, Sagåns vattenråd, as well as the River Basin District Authority. We included policy document data from MVVF and Sagåns vattenråd, the county administrative board of Västmanland, the River Basin District Authority of the Northern Baltic Sea, the EU project LIFE IP Rich Waters, the Ministry of Environment, Sweden, and the European Commission (Supplemental Material A2). The last two provided information on government directives under which the River Basin District Authority abide. We also surveyed meeting protocols from the venues obtained from their websites. Individual policy actors in the collaborative venues were represented by politicians with different party affiliations, civil servants, EU project coordinators, government representatives at the district, county and municipal scales, environmental NGO representatives, drinking water producers, industries and individual resource users often represented by landowners with interest in farming and hydropower. The chair positions of the collaborative councils were held by different types of public policy actors.

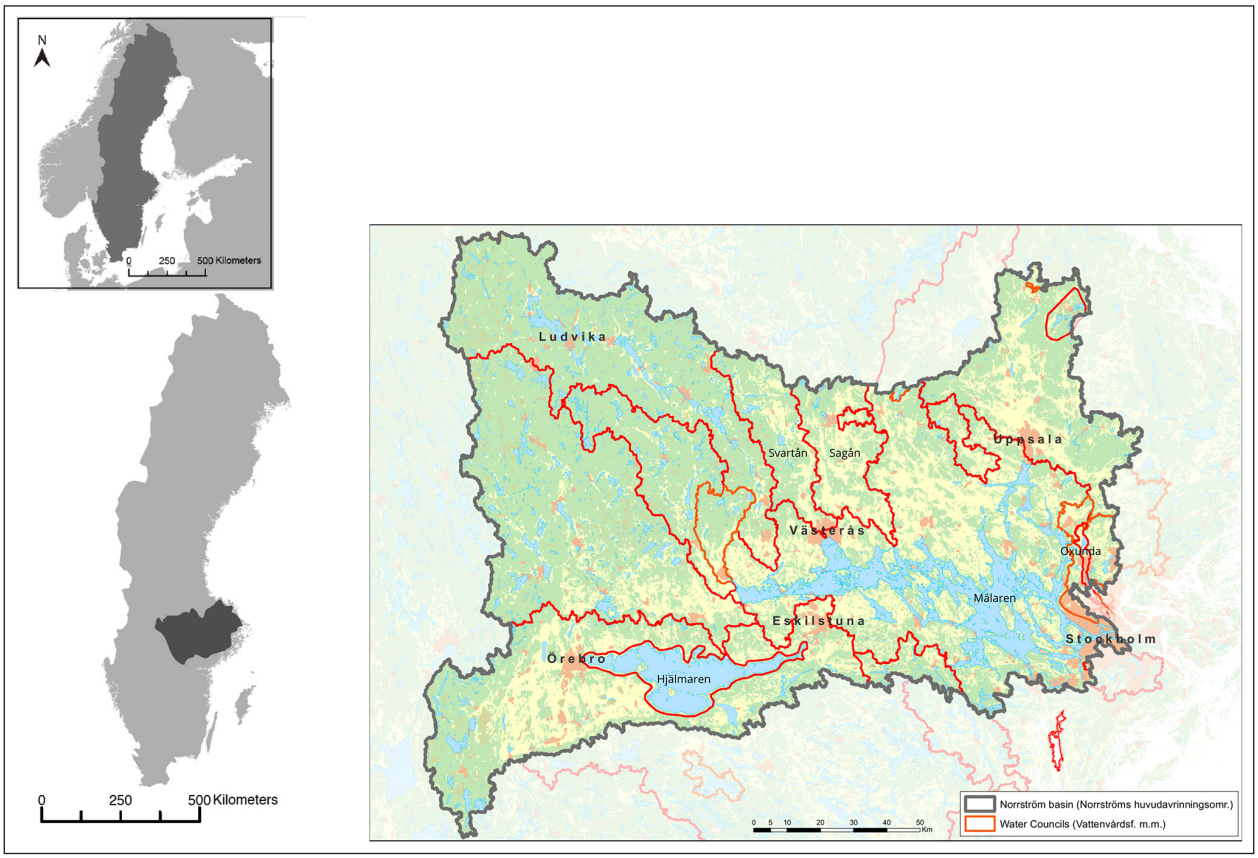

Figure 3 The Norrström basin, located in Mideast Sweden (Vattenmyndigheterna, Länsstyrelsen, SMHI, Lantmäteriet, 2020, reproduced from Hedlund et al., 2021). Names in bold refer to major cities, and names in regular font refer to catchment areas for the collaborative venues included in data collection.

3.3 A PROCEDURE FOR ASSESSING POLICY ISSUE INTERDEPENDENCIES

Our procedure for assessing policy issue interdependencies builds on the three considerations described above and consists of five steps (***Figure 4***): (i) policy issue identification and specification through an actor-centred approach supportive of data triangulation, (ii) detailed causal pathway mappings linking the different policy issues to environmental targets, followed by (iii) a network-centric modelling process teasing out indirect policy issue interdependencies deriving from linked causal pathways, (iv) determination of reinforcing or counteracting policy issue interdependencies by summarising positive and negative causal steps, and v) validation of policy issue interdependencies through interviews. Below we detail the five analytical steps.

Step 1 – Identifying policy issues and environmental targets

Our data collection aimed at identifying the main policy issues and environmental targets for the basin, and the causal pathways linking the policy issues with the targets. We identified issues and targets by gathering data on what issues actors were working on and what targets they were addressing by applying three different methods. Rather than selecting specific criteria for identifying policy issues and targets, we approached the identification in an exploratory manner by which we, with each method, narrowed down our definitions of policy issues and targets. First, we performed participant observation by partaking in two regional meetings within the Norrström district and one national conference on water governance. Second, we gathered policy documents

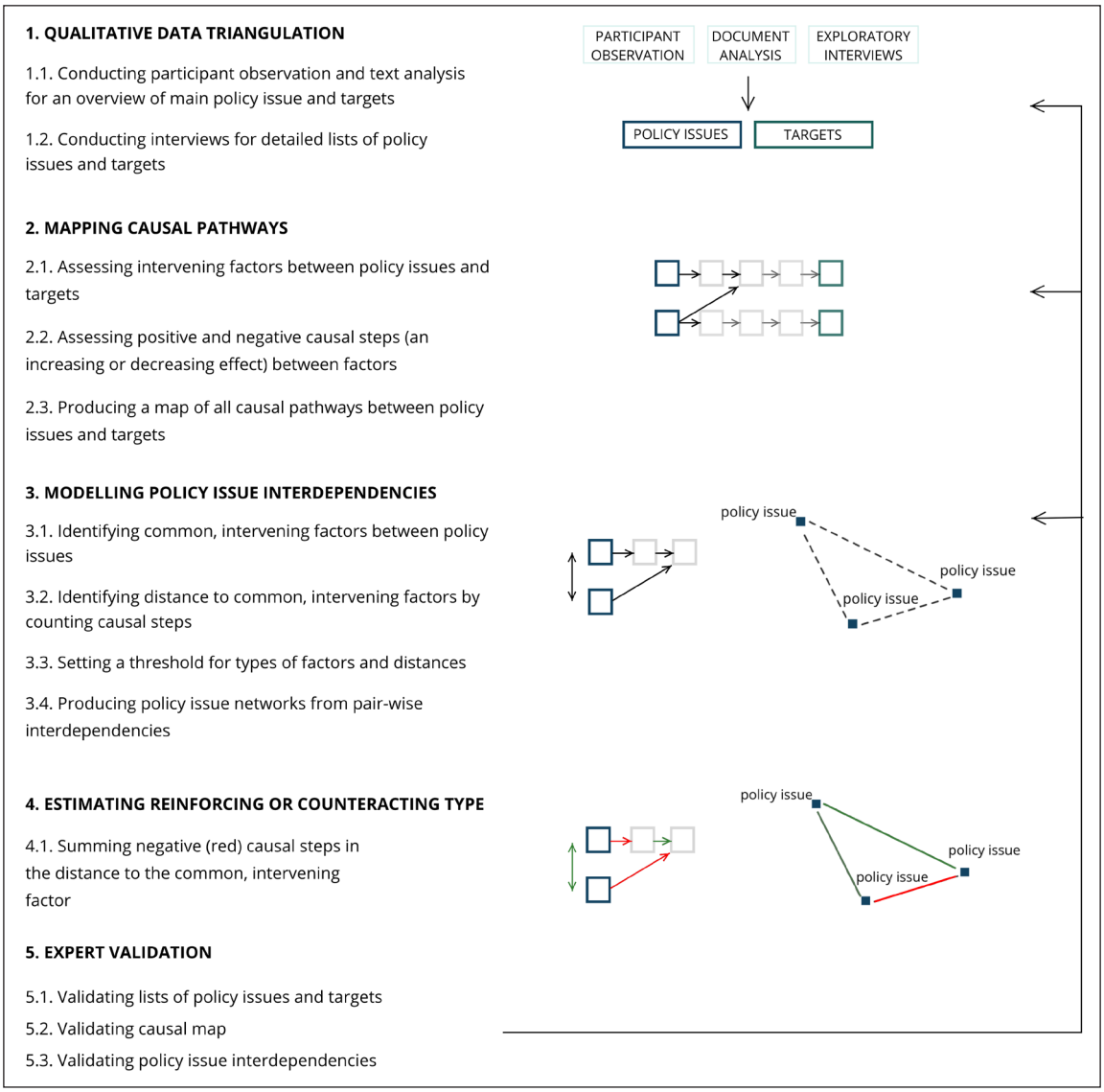

Figure 4 The methodological procedure for assessing policy issue interdependencies. The two policy issues in the figure together have three steps (illustrated by arrows) to their common, intervening factors.

(listed in Supplemental Material A2) produced by the River Basin District Authority and the collaborative venues in the Norrström district. The observation and document analysis provided an overview of the main policy issues within Norrström. Third, we interviewed six expert practitioners to identify a detailed list of the main policy issues (see Supplementary Material A1 for further detail). In our case, the policy issue selection aimed to be comprehensive for the entire Norrström water district, and we therefore maximised the diversity of interviewed respondents to avoid biases in the selection of policy issues. The six individual respondents, representing different organisations and collaborative venues, were selected based on having a coordinating role in either a governmental organisation or a collaborative venue, but varied in their specific profession and the scale in which they were working. All interview data were analysed and coded thematically according to the categorisation provided by Miradi (see Step 2). We aimed at creating a similar list containing the environmental targets that the respondents considered as important for the conservation of the basin. These two lists were finalised based on qualitative triangulation. The triangulation process used different data gathering methods to empirically identify relevant issues and targets and narrowing down the lists through each method. The data further served as a base for the assessment of intervening factors (Step 2).

Step 2 - Mapping causal pathways

In the second step, we assessed the causal pathways linking policy issues with targets by specifying in-between intervening factors. We rely on Miradi's set categorisation of intervening factors. A causal pathway was thereby built from policy issues, targets, intervening factors, and the connecting causal steps between them.

Overall, the identification of causal pathways derived from our assessments, albeit relying on several data sources (see Step 1 and Supplemental Material A1), and was later verified through an expert interview (see Step 5). We began the mapping process with the *policy issue* and *target* lists from Step 1. Subsequently, intervening factors between policy issues and targets were mapped under the categories of *biophysical stressors* (factors that directly impair environmental targets), *direct threats* (human activities that immediately affect the biophysical stressors), and *indirect, contributing factors* (any other factors in-between the policy issue and the direct threats, typically being related to various socioeconomic and institutional characteristics of the study system, or human-induced actions and events[1]). All factors could also link directly to environmental targets, i.e. all types of intervening factors were not always necessary within a causal pathway. We approached the assessment of intervening factors between policy issues and targets from two directions, i.e. assessing causality from policy issues to intervening factors and reversely, targets to intervening factors (see Supplemental Appendix A3 for underlying assumptions). This was conducted independently for each of the identified policy issues and environmental targets (***Figure 2a***).

Step 3 - Modelling policy issue interdependencies by analysing linked causal pathways

If a causal pathway included an intervening factor also present in another pathway, the two causal pathways were linked (***Figure 2b***). Two linked pathways, originating at two policy issues, thus imply that the policy issues are (indirectly) interdependent, since one policy issue will have an impact on how the other issue can meet its environmental targets. All intervening factors that are part of more than one causal pathway are thus common to two or several policy issues. By going through all causal pathways from the preceding step, we identified all policy issues that were linked to common, intervening factors (***Figure 2c***). Two policy issues sharing at least one common, intervening factor were defined as interdependent. By considering all policy issues and their interdependencies simultaneously, a *policy issue network* was produced, where the nodes are the policy issues and the links represent their pair-wise interdependencies.

A causal pathway can be measured by its number of steps between intervening factors, or *path length* in network terminology. We use the term 'distance' to simply refer to the shortest possible path length to the common, intervening factor, i.e. the shortest number of causal steps linking two interdependent policy issues to their closest common, intervening factor. The shortest possible distance is by definition two (one for each issue to the common denominating factor). Our empirical mapping of causal pathways in the Norrström basin had a maximum shortest distance of eight. The distance is, in theory, irrelevant to determine if there is interdependency or not. Still, by defining certain thresholds for distance, and/or only considering intervening factors of certain types (***Figure 5***), different degrees and patterns of policy issue interdependencies emerge (and therefore, different policy issue networks). With a generous threshold, including all factor types and allowing for any distance to common, intervening factors, the policy issue network could end up being highly entangled with a large number of interdependencies between policy issues. A strict threshold could instead lead to a very sparse network, perhaps only outlining interdependency between very few policy issues.

We produced four policy issue networks, each corresponding to one or more of the four types of intervening factors. The networks were thereby building from a strict

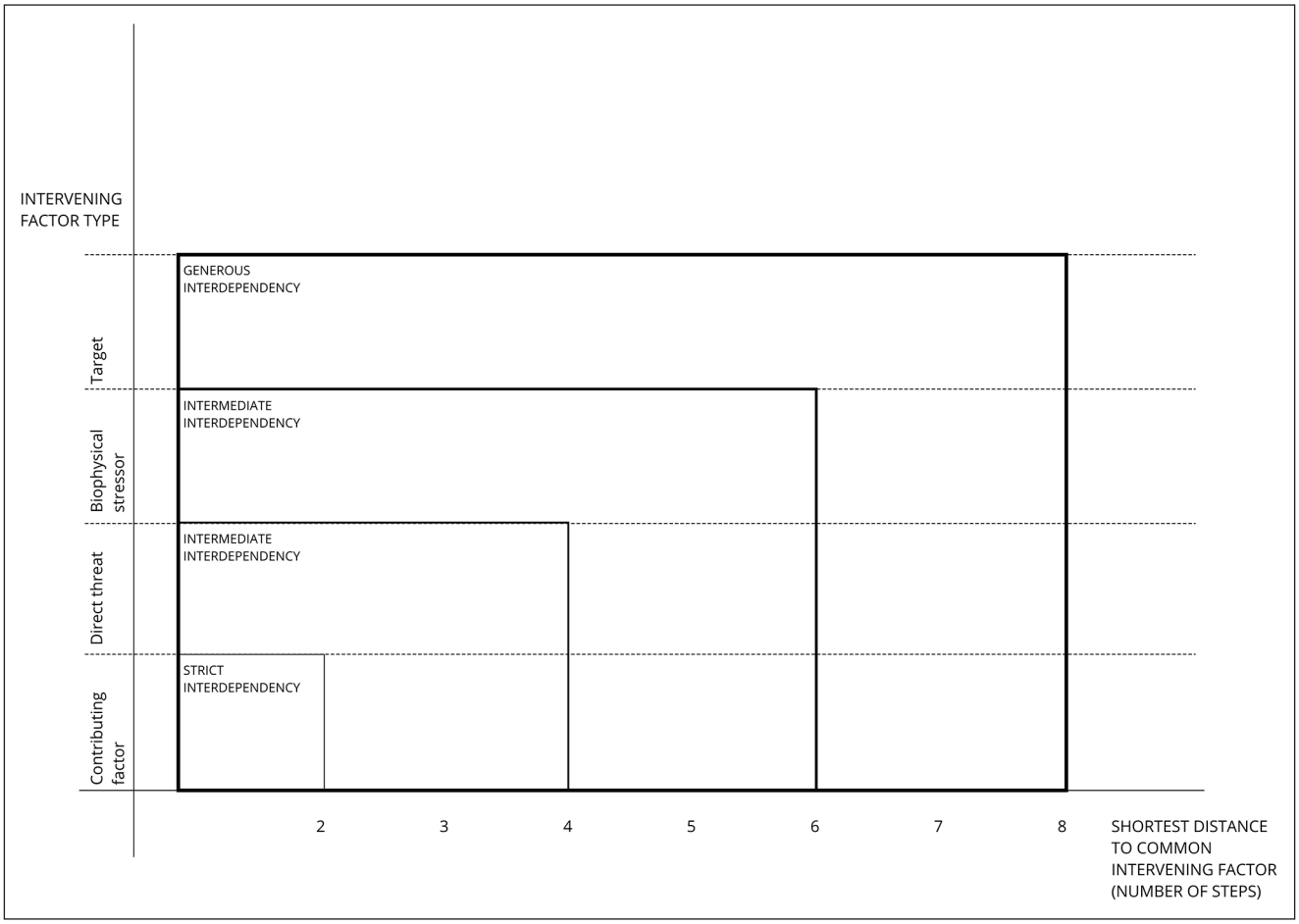

Figure 5 Interdependency by strict, intermediate, and generous thresholds as a selection of the network. All policy issue interdependency combinations fit within this diagram. The y axis categorises factor types included in causal pathways, while the x axis enumerates the number of steps included in each pathway linking the policy issues with the common, intervening factor.

threshold of one factor type only (contributing factors), to a generous threshold where the intervening factor could be of any type. All distances (from a minimum of two steps to a maximum of eight steps) were allowed for the four networks. We used network density, which measures the number of observed links in the network related to the maximally possible number of links, to capture the distinctive patterns of policy issue interdependency in the four networks (Henry & Vollan, 2014).

Step 4 – Estimation of reinforcing or counteracting type of policy issue interdependencies

The causal pathways consist of directed causal steps that link policy issues, intervening factors and targets by an increasing or a decreasing effect. We mapped these effects by assigning steps a positive or negative sign. A positive sign means that an increase of the intervening factor will lead to an increase in the affected factor, whereas a negative sign implies that an increase of the intervening factor leads to a decrease in the affected factor. We assumed that these increasing and decreasing steps between policy issues to common, intervening factors also affect *how* policy issues are interdependent. We expect that policy issues can reinforce or counteract each other, departing from the terminology developed in Nilsson et al. (2016). To estimate the type of interdependency, we summed the negative steps in the distance to the common, intervening factor. This method is consistent with how to calculate the nature of a feedback loop, whether it is reinforcing or balancing (Kirkwood, 1998). An even sum represented a reinforcing issue interdependency, while an uneven sum represented a counteracting issue interdependency. The basis for this is that an even number of negative signs, through multiplication, would turn into a positive sign (-1 multiplied with -1 equals 1). We applied this calculation to all policy issue interdependencies in the 'most inclusive' policy issue network, i.e. the network consisting of policy issue interdependencies where neither the type of intervening factors that created interdependency nor the distance was considered (the generous threshold in ***Figure 5***). In this way, all policy issue interdependencies were estimated as reinforcing or counteracting.

Step 5 – Validation of policy issue interdependencies

We performed two expert interviews to validate the list of policy issues, targets and our causality assessments (Steps 1 and 2). The interviews were conducted with an informed key actor with expert knowledge about the basin and the governance context. We focused the interviews on the produced material of causal pathway mappings (Step 3), and subsequently adjusted them based on the feedback from the respondent.

Even though actors provided information on policy issues, targets and the causal pathways in Step 1, they did not provide direct information on interdependencies. To validate our assessed policy issue interdependencies, we performed six expert interviews supported by examples of our modelled policy issue interdependencies (by which three experts also participated in the initial data collection on policy issues and environmental targets, see Step 1). This second round of interviews was conducted with six respondents between January and March 2020. The interviews were semi-structured, and occurred between 60 to 90 minutes. Prior to the interviews, the respondents received a preparatory e-mail listing the definitions of a policy issue, a reinforcing and a counteracting interdependency,[2] along with the list of the 16 identified issues and two diagrams exemplifying three reinforcing policy issues and three counteracting policy issues, derived from our previous mapping. For validation of interdependencies, we first asked whether the respondents agreed or disagreed about the depicted reinforcing or counteracting interdependency between the exemplified policy issues. Second, we asked if the respondents could provide other examples of reinforcing and counteracting interdependencies present in their work, to verify that these were also represented in the rest of our modelled interdependencies. The interviews were transcribed, coded and cross-analysed by comparing responses between interviewees.

4. RESULTS

4.1 VALIDATING PROCEDURE AND ASSESSED POLICY ISSUE INTERDEPENDENCIES

Our proposed methodological procedure supports the assessment of indirect policy issue interdependencies emerging through common, intervening factors. We applied the procedure to the case-study setting of water governance in the Norrström basin. Each step in our procedure produced a result that in itself provides knowledge about an empirical case. First, the initial qualitative triangulation identified 16 policy issues related to the water governance of Norrström (***Table 1***). This confirms that policy actors in Norrström have to address a high number of different issues to reach set targets. The second step resulted in a causal pathway diagram (Supplementary Figure A4). This mapping shows how all policy issues link to targets, and that some intervening factors are more frequently common to two or more policy issues. These factors can be seen as stronger drivers of policy issue interdependency compared to others. In Norrström, many policy issues were associated with *allocation of land* as a common, intervening factor on a short distance. Third, we identified 116 unique policy issue pairs that exhibited some forms of interdependency (using the most generous threshold). The patterns of policy issue interdependencies in our four modelled networks provided insights about whether policy issues were entangled, and if so, *how*. The policy issue networks revealed that most policy issues demonstrate interdependency to some other policy issue, but differ in how they interdepend through different types of intervening factors. Fourth, we could estimate which policy issue interdependencies were reinforcing and which were counteracting. This revealed that more counteracting interdependencies prevail between policy issues in Norrström. Last, our second interview round could account for the validity of our assessed policy issue interdependencies. Four of the six respondents, at first glance, perceived the three exemplified reinforcing policy issues as separate rather than interdependent. Yet, the respondents agreed on the intervening factors between the issues as a common denominator. The existence of

POLICY ISSUES
Environmental monitoring of **non-native species**
Regulation and distribution of **water flow**
Maintaining **fish connectivity**
Protection of **cultural heritage**
Ecological restoration of meandering watercourses
Climate change adaptation
Construction of wetlands
Sustainable storm water management
Implementation of **phosphorus dams**
Implementation of **buffer zones**
Implementation of **lime treatment**
Implementation of **private sewage**
Environmental monitoring of **water quality** and recipients
Upstream regulation by the source
Treatment of **benthic sediment**
Managing invasive species

Table 1 Policy issues in the Norrström basin (reproduced from Hedlund et al., 2021). Names in bold correspond to shortened names of policy issues in Figure 6.

an interdependency was in this way indirectly validated by the respondents. Their assertion of (some of the) the issues as separate may therefore have reflected how they deal with these issues in their practical work, i.e. as separate rather than as interdependent. Several respondents also exemplified other reinforcing interdependencies that were modelled in our data (albeit only visible using a more generous threshold). In turn, all respondents agreed on the existence of the exemplified counteracting interdependency. Thereby, they evidenced that overall, our procedure worked for assessing the existence of policy issue interdependencies, although not every respondent necessarily agreed on every detail in our aggregated assessments of policy issue interdependency (as expected since we assume that individual perceptions do have a role in defining if and to what extent any two policy issues are interdependent).

4.2 VARIATION OF INTERDEPENDENCY IN POLICY ISSUE NETWORKS

The graphs in ***Figure 6*** illustrate that the policy issue networks are sparser or denser based on what intervening factors and distances are considered. These thresholds are important to consider when using policy issue networks as

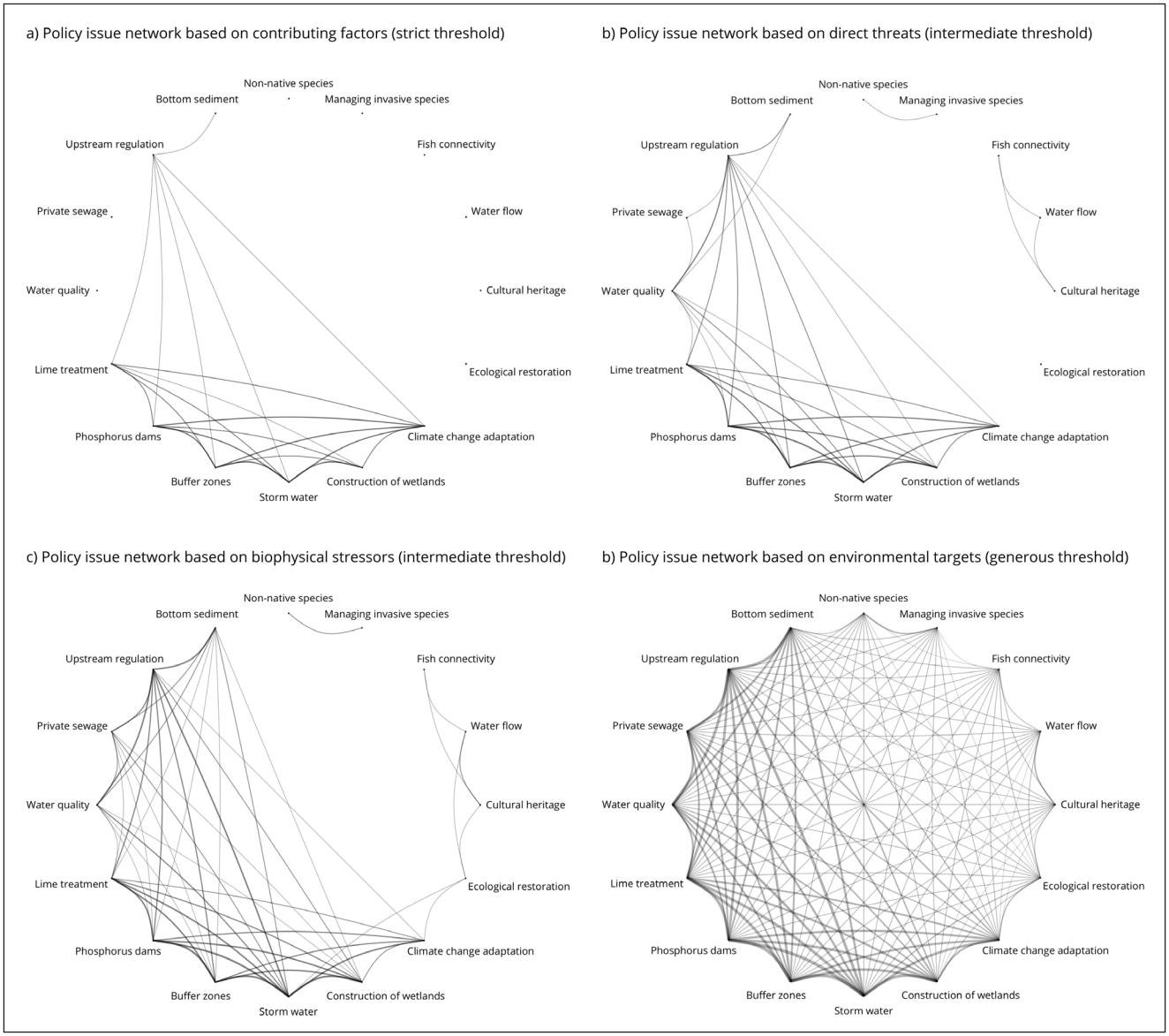

Figure 6 Policy issue networks based on factor types **a)** contributing factor (strict threshold producing a density of 0,175) **b)** direct threat (intermediate threshold producing a density of 0,292) **c)** biophysical stressor (intermediate threshold producing a density of 0,417) **d)** environmental target (generous threshold producing a density of 0,967). These results confirm an increase in network density the more intervening factors are included. Thicker ties illustrate that both issues are overall linked to many of the same factors, even though these can also be factors that connect the respective issues to other factors and not necessarily only to each other.

study objects in research. We see that applying the strictest threshold, i.e. producing interdependencies that derive from contributing factors only (***Figure 6a***), leads to the separation of seven isolate issues from a large cluster. An intermediate threshold spanning two factor types (contributing factors and direct threats) creates interdependency through one major cluster and two smaller separate ones (***Figure 6b***). Only two interdependent issues remain isolated from the main cluster when also including policy issue interdependencies deriving from biophysical stressors. It also reveals that one issue keeps the largest part of the cluster connected with a smaller cluster that otherwise would be disconnected (***Figure 6c***). The network based on the most generous threshold (***Figure 6d***) is highly inclusive and dense (116 links out of 120 possible), which is not unexpected given that targets are comprehensively formulated to apply to the improvement of the entire Norrström basin. In other words, it shows that virtually all issues are eventually interdependent through the environmental targets, but the other networks based on the stricter thresholds show that specific interdependency clusters are more distinguishable through other types of intervening factors. The variations across these networks illustrate the importance of considering the underlying criteria defining policy issue interdependency.

4.3 REINFORCING AND COUNTERACTING INTERDEPENDENCIES IN MOST INCLUSIVE POLICY ISSUE NETWORK

The most inclusive network (***Figure 6d***) was used to illustrate reinforcing or counteracting policy issue interdependencies (***Table 2***). To determine the type of interdependency, we counted positive (+1) and negative (-1) causal steps in the total causal pathway for each issue pair. A reinforcing or counteracting issue interdependency was calculated as the algebraic product of all negative ties for the distance to the common, intervening factor. Some policy issues had multiple shortest distances to the first intervening factor, e.g. policy issues had the same number of steps to both a contributing factor and a direct threat as the closest common, intervening factor. In cases where all pathways produced the same type of interdependency, i.e. either reinforcing or counteracting, the interdependency tie was then simply given that type in the most inclusive network (Supplementary Figure A5) and in ***Table 2***. Five pairs had both reinforcing and counteracting interdependencies, by having an equal amount of steps to two or more common, intervening factors, but where the number of negative signs revealed different types of interdependency. These policy issues might both reinforce and counteract each other in different ways, and were thus considered as neither reinforcing nor counteracting. In the most inclusive network (Supplementary Figure A5; ***Table 2***), results demonstrated that the number of counteracting interdependencies dominate over reinforcing, with 90 counteracting versus 71 reinforcing ties in total, and 61 counteracting versus 50 reinforcing if only accounting for unique policy issue interdependencies (i.e. multiple closest common, intervening factors can create multiple interdependencies between issues, hence unique interdependencies only allow for one link between issues). Even though a minimum distance (two steps) does not necessarily represent a stronger interdependency, it presents the shortest possible distance between the common, intervening factor that makes policy issues interdependent. In contrast, many intervening factors between issues and the common, intervening factor (i.e. a long distance) might make it more difficult for actors to perceive the policy issue interdependency. Among policy issue interdependencies with a distance close to a minimum, there was a clear

DISTANCE TO CLOSEST COMMON, INTERVENING FACTOR	NUMBER OF REINFORCING POLICY ISSUE PAIRS	NUMBER OF COUNTERACTING POLICY ISSUE PAIRS	REINFORCING AND COUNTERACTING POLICY ISSUE PAIRS
Minimum (2 steps)	13	5	–
3 steps	7	12	3
4 steps	11	15	–
5 steps	13	8	2
6 steps	6	15	–
7 steps	5	4	–
Maximum (8 steps)	–	7	–

Table 2 Count of reinforcing and counteracting policy issue pairs by their distance (number of steps) to their common, intervening factor. More reinforcing interdependencies have the shortest possible distance to the common, intervening factor, which means that no other intervening factors come between the policy issues and their factor. These interdependencies may therefore be easier to perceive for policy actors.

dominance of reinforcing interdependencies, with 13 reinforcing issue pairs over five counteracting (***Table 2***). However, among intermediate distances (three and four steps) to the common, intervening factor, counteracting interdependencies were dominant. Finally, no reinforcing interdependencies were represented among issues with a distance of eight.

5. DISCUSSION

5.1 PRACTICAL INSIGHTS FROM ASSESSING POLICY ISSUE INTERDEPENDENCIES

Policy issue interdependencies are rarely explicitly defined nor assessed close to the everyday practices of policy actors. Hence, knowledge on if and how policy issue interdependencies affect these actors and their activities are largely absent. In this paper, we elaborate a procedure for assessing policy issue interdependency that is aligned with the realities that confront policy actors in their everyday work. We apply our procedure empirically to demonstrate its validity. This work advances research of environmental governance in three important ways.

First, our methodological procedure offers a context-sensitive and innovative way to assess policy issue interdependencies in real-world policy subsystems. It specifies an approach embracing data triangulation by accommodating different sources such as direct involvement of policy actors and, for example, document analysis, which can ensure well-founded interpretations of policy issues and their interdependencies. It also offers a reproducible and systematic procedure to identify reinforcing and counteracting policy issue interdependencies emerging through linked causal pathways. The procedure is thus relevant for identifying policy issue interdependency in relation to any complex societal and environmental problem. Through validation with informed respondents, we demonstrate that this procedure can reveal policy issue interdependencies as perceived by policy actors.

Second, by empirically applying the procedure we show how each step of our assessment provides information that can be relevant for policy actors. Policy actors in Norrström face a high number of different policy issues in order to reach set targets. From describing and analysing their interdependencies, we demonstrate that even though many policy issues are interdependent, not all are, and not to the same extent. This is contrary to the conception of complex or 'wicked' problems (Head & Alford, 2015; Rittel & Webber, 1973), which have simply described interdependency as a general characteristic of such problems. Rather, different patterns of policy issue interdependencies are associated with specific types of intervening factors. This makes intervening factors important leverage points for action on environmental problems. Additionally, intervening factors can inform how actors may prioritise and engage in policy issue interdependencies. When actors focus more on biophysical measures, they could pay greater attention to policy issue interdependencies that derive from targets or biophysical stressors. Actors that perform more policy-oriented work could focus more on contributing factors and direct threats in addressing policy issue interdependencies. Our results show that the type of common, intervening factor that creates policy issue interdependencies is of importance, and not all types of factors contribute equally to creating interdependencies. From ***Figure 6a–d***, it is possible to estimate the extent to which the type of common, intervening factor that different actors associate more strongly with could affect their perception of policy issue interdependencies. Actors with a strict orientation towards only certain types of intervening factors, e.g. working strictly on microplastics (a contributing factor), may mainly perceive interdependencies that derive from that factor and therefore have more limited knowledge of other possible interdependencies. Conclusively, actors' perception of the extent to which certain policy issues are interdependent can differ depending on the role and position they hold, and what factors they are oriented towards, which may point their decision-making towards certain types of measures.

Polasky et al. (2020) recommend that policy actors follow pathways with fewer steps between a policy choice and an outcome. We however also want to caution only focusing on the very shortest distance, since our analysis (***Figure 6a–d***) shows that very many interdependencies are then likely disregarded. Some of these interdependencies could nonetheless be strong thus having a large effect on the policy outcomes. If policy actors follow the most direct pathway between policy issues and targets, acknowledging only few common, intervening factors, the level of interdependency will be low (***Figure 6a***) and may be experienced as of peripheral importance. In such case, it is reasonable to assume that the potentially increased effectiveness that actors perceived they can contribute with, by explicitly considering policy issue interdependencies in their governing and management activities, is rather limited since most policy issues can favourably be addressed separately. On the contrary, the policy issue network in ***Figure 6d*** is nearly fully connected. In such cases, most policy issues have at least one but potentially several common, intervening factors. The possible gains in effectiveness that could be derived by considering policy issue interdependencies are high by definition. However, a fully connected network means that every policy issue is connected to all other policy issues to the same extent. Hence, the potential benefits that could be gained from

considering policy issue interdependencies are uniformly distributed across all pairs of policy issues. In essence, an actor that intentionally wants to address synergies or trade-offs when working with any given policy issue would need to instigate coordinating activities towards all other policy issues. Such ambitious endeavours can, however, quickly exhaust limited resources, and the actor would in such case need to reduce his or her ambitions to better fit with given constraints. However, since everything is equally connected, the mapping of policy issue interdependencies would provide no guidance on how to maximise efforts given limited resources, and would therefore be of limited value. Furthermore, in cases where the number of policy issues abound, it seems plausible to assume that an actor risks being overwhelmed by the sheer number of interdependencies (this could be thought of as the 'dark side' of systemic thinking). As hypothesised by DeFries and Nagendra (2017), policy actors with a narrow or technical view on policy issue interdependencies may enact oversimplified solutions, while policy actors facing the highest levels of interdependency may be struck by inaction or 'uncertainty paralysis' (Polasky et al., 2020). A fruitful compromise might be to focus attention at the intermediate level of interdependency, opting to find a suitable balance between embracing complexity while maintaining manageability. Contrary to the cases of very low or very high levels of interdependencies - if the level of policy issue interdependency is moderate (as in ***Figure 6b–c***), the utility of explicating policy issue interdependency appears more significant both as a study object for researchers, but also for guiding actors in targeting activities across policy issues and incentivising them to work towards 'systemic solutions'. Here, policy issue interdependencies might be both discernible, which may not be true for a full network, and experienced as of higher importance than addressing issues separately, which may not be the case when few policy issues are interdependent. Actors' ability to perceive and act on interdependencies may therefore be highest at moderate levels of interdependency, and have a more significant effect on reaching targets.

Last, our assessment raises new questions about policy actors' perception of policy issue interdependencies. In this specific empirical case, our results revealed that more counteracting than reinforcing interdependencies are prevalent between policy issues when accounting for interdependency across all intervening factors and distance. A dominance of reinforcing character, however, prevails among issues that are interdependent by shorter distances to the common, intervening factor. Other studies have found a higher prevalence of reinforcing interdependencies between the SDG goals (Weitz et al., 2017) and in cases of institutional interaction (Oberthür & Gehring, 2006). Possibly, distance can matter for actors' perception of policy issue interdependency, and hence, reinforcing interdependencies may be easier to identify.

5.2 LIMITATIONS

Our study is not without caveats. First, although we did not attempt to assess the strength of overlap between two policy issues, we acknowledge it would most likely impact actors' perception of a given interdependency. Second, some elements of subjectivity exist in the selection of intervening factors in the causal pathway mapping, even though the triangulation of data sources will hopefully minimise this concern. Finally, our mapping represents an attempt to identify causal pathways that capture what most informed actors would agree on. However, we also acknowledge variation between actors in their perceptions of what policy issues and intervening factors are important, and what should be done to address policy issues. Hence, there is a balance between the desire to describe a complex reality in ways that capture something general about a case, and accommodating variability among individual actors. The qualitative differences between ***Figure 6a–d*** illustrate this (as did our interviews with the respondents). Although we stress that this variability is something we want to explore to assess how individual actors perceive their everyday challenges in addressing policy issues differently, it nonetheless involves differentiating what is a baseline, and what is deviating from the baseline. We encourage others to further elaborate this tension between the 'system' and the individual in assessing policy issue interdependencies.

5.3 FUTURE RESEARCH

Our results pose new questions for future research – particularly in relation to its practical relevance for policy actors. For example, does perception of policy issue interdependencies impact the selection of which issues actors engage with, and indirectly what intervening factors they choose to address more than others? And, if so, are counteracting interdependencies regarded as more important than reinforcing? Or, do actors perceive reinforcing interdependencies more easily? How many steps to the common, intervening factor are actors able to easily perceive? These questions represent important avenues for future research. Our assessment also calls into question how much precision we need for analysing policy issue interdependencies. We believe that precision is mainly linked to methodological choices. Low precision of policy issue interdependencies risks being less associated with the practical perspective. Still, data-heavy approaches are not always a preferred or feasible option. While this can be a drawback of our procedure, policy actors typically have existing awareness about policy issues,

targets and intervening factors which, if put in proper use, can shorten the procedure significantly if implemented in a policy setting. To ensure accuracy of assessed policy issue interdependencies in research, we advise that the identification of policy issues and targets stays actor-informed, even if using fewer data sources than we did here, and that the final assessments are validated.

6. CONCLUSION

The methodological procedure elaborated here enables decision-making that acknowledges how policy issues influence each other, illustrating where attention to policy issues can potentially be most effective. The high interest in interdependencies proves why this is important (Díaz et al., 2020; Lade et al., 2020; Nilsson et al., 2016; Rocha et al., 2018), yet provide little guidance for policy actors who must face interdependencies at regional and local levels without being overwhelmed by 'uncertainty paralysis' in decision-making. Much research remains to further enhance our understanding of how policy issue interdependencies influence how actors act, individually and as a collective, and how effective they are in addressing environmental problems. To that end, our procedure invites scholars and practitioners to consider the ways in which policy issues are interdependent in different settings and how those relationships may shape collaboration.

NOTES

1 Defining and delimiting sets of *contributing factors* as the underlying drivers of environmental issues is generally challenging, since they could cover an infinite number of more or less remote phenomena (temporally, spatially, relationally). Miradi defines contributing factors as "indirect threats and opportunities (collectively contributing factors) are the economic, cultural, political, legal, social, and/or institutional factors that drive direct threats", and "a human-induced action or event that underlies or leads to one or more direct threats". In our data, an example of such a contributing factor was *allocation of land for water measures*. In some cases, we also conceptualised effects of various kinds as indirect factors, which could and likely should instigate action among the actors (e.g. increased yield from land production). Most contributing factors were represented by socioeconomic factors, but some biophysically-oriented events such as climate change also fit this category by being a human-induced event.

2 During interviews, we used the words *synergy* and *trade-off* for reinforcing and counteracting interdependencies as we thought these terms might be more familiar to the respondents.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Supplementary Material A1.** Qualitative Data Triangulation. DOI: *https://doi.org/10.5334/ijc.1060.s1*
- **Supplementary Material A2.** Table A2. DOI: *https://doi.org/10.5334/ijc.1060.s2*
- **Supplementary Material A3.** Underlying assumptions of causal pathways. DOI: *https://doi.org/10.5334/ijc.1060.s3*
- **Supplementary Figure A4.** Causal mapping. DOI: *https://doi.org/10.5334/ijc.1060.s4*
- **Supplementary Figure A5.** Most inclusive policy issue network. DOI: *https://doi.org/10.5334/ijc.1060.s5*

ACKNOWLEDGEMENTS

We wish to thank the informants for providing us with their insights during the interviews and by answering the surveys. We would also like to thank Emma Sundström and Mario Angst for their computational contribution. This work was supported by the Swedish Research Council and the Swedish Research Council Formas through grants 2016-04263 and 2016-01137.

COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

Angst, M. (2019). Networks of Swiss Water Governance Issues. Studying Fit between Media Attention and Organizational Activity. *Society & Natural Resources*, *32*(12), 1416–1432. DOI: *https://doi.org/10.1080/08941920.2018.1535102*

Barnes, M. L., Bodin, Ö., McClanahan, T. R., Kittinger, J. N., Hoey, A. S., Gaoue, O. G., & **Graham, N. A. J.** (2019). Social-Ecological Alignment and Ecological Conditions in Coral Reefs. *Nature Communications*, *10*(1). DOI: *https://doi.org/10.1038/s41467-019-09994-1*

Barnes, M. L., Lynham, J., Kalberg, K., & **Leung, P.** (2016). Social Networks and Environmental Outcomes. *PNAS*, *113*(23), 6466–6471. DOI: *https://doi.org/10.1073/pnas.1523245113*

Bergsten, A., Jiren, T. S., Leventon, J., Dorresteijn, I., & **Schultner, J.** (2019). Identifying Governance Gaps among Interlinked Sustainability Challenges. *Environmental*

Science and Policy, *91*, 27–38. DOI: *https://doi.org/10.1016/j.envsci.2018.10.007*

Bodin, Ö., & **Nohrstedt, D.** (2016). Formation and Performance of Collaborative Disaster Management Networks : Evidence from a Swedish Wildfire Response. *Global Environmental Change*, *41*, 183–194. DOI: *https://doi.org/10.1016/j.gloenvcha.2016.10.004*

Bodin, Ö., Sandström, A., & **Crona, B.** (2017). Collaborative Networks for Effective Ecosystem-Based Management: A Set of Working Hypotheses. *Policy Studies Journal*, *45*(2), 289–314. DOI: *https://doi.org/10.1111/psj.12146*

Bodin, Ö., & **Tengö, M.** (2012). Disentangling Intangible Social-Ecological Systems. *Global Environmental Change*, *22*(2), 430–439. DOI: *https://doi.org/10.1016/j.gloenvcha.2012.01.005*

Boron, V., Payán, E., MacMillan, D., & **Tzanopoulos, J.** (2016). Achieving Sustainable Development in Rural Areas in Colombia: Future Scenarios for Biodiversity Conservation under Land Use Change. *Land Use Policy*, *59*, 27–37. DOI: *https://doi.org/10.1016/j.landusepol.2016.08.017*

Brandenberger, L., Ingold, K., Fischer, M., Schläpfer, I., & **Leifeld, P.** (2020). Boundary Spanning Through Engagement of Policy Actors in Multiple Issues. *Policy Studies Journal*. DOI: *https://doi.org/10.1111/psj.12404*

Carr, B., Fitzsimons, J., Holland, N., Berkinshaw, T., Bradby, K., Cowell, S., … Weisenberger, F. (2017). CAPitalising on conservation knowledge: Using Conservation Action Planning, Healthy Country Planning and the Open Standards in Australia. *Ecological Management and Restoration*, *18*(3), 176–189. DOI: *https://doi.org/10.1111/emr.12267*

Cremades, R., Mitter, H., Tudose, N. C., Sanchez-Plaza, A., Graves, A., Broekman, A., … Marin, M. (2019). Ten Principles to Integrate the Water-Energy-Land Nexus with Climate Services for Co-producing Local and Regional Integrated Assessments. *Science of the Total Environment*, *693*, 133662. DOI: *https://doi.org/10.1016/j.scitotenv.2019.133662*

Dade, M. C., Mitchell, M. G. E., McAlpine, C. A., & **Rhodes, J. R.** (2019). Assessing Ecosystem Service Trade-Offs and Synergies: The Need for a more Mechanistic Approach. *Ambio*, *48*, 1116–1128. DOI: *https://doi.org/10.1007/s13280-018-1127-7*

DeFries, R., & **Nagendra, H.** (2017). Ecosystem Management as a Wicked Problem. *Science*, *356*, 265–270. DOI: *https://doi.org/10.1126/science.aal1950*

Díaz, S., Zafra-Calvo, N., Purvis, A., Verburg, P. H., Obura, D., Leadley, P., … Zanne, A. E. (2020). Set Ambitious Goals for Biodiversity and Sustainability. *Science*, *370*(6515), 411–413. DOI: *https://doi.org/10.1126/science.abe1530*

Edelenbos, J., & **Teisman, G.** (2013). Water Governance Capacity : The Art of Dealing with a Multiplicity of Levels, Sectors and Domains. *International Journal of Water Governance*, *1*, 89–108. DOI: *https://doi.org/10.7564/12-IJWG5*

Feiock, R. C. (2013). The Institutional Collective Action Framework. *Policy Studies Journal*, *41*(3), 397–425. DOI: *https://doi.org/10.1111/psj.12023*

Folke, C., Hahn, T., Olsson, P., & **Norberg, J.** (2005). Adaptive Governance of Social-Ecological Systems. *Annual Review of Environment and Resources*, *30*, 441–473. DOI: *https://doi.org/10.1146/annurev.energy.30.050504.144511*

Fuso Nerini, F., Tomei, J., To, L. S., Bisaga, I., Parikh, P., Black, M., … Mulugetta, Y. (2018). Mapping Synergies and Trade-offs between Energy and the Sustainable Development Goals. *Nature Energy*, *3*(1), 10–15. DOI: *https://doi.org/10.1038/s41560-017-0036-5*

Hamilton, M., Salerno, J., & **Fischer, A. P.** (2019). Cognition of Complexity and Trade-offs in a Wildfire-Prone Social-Ecological System. *Environmental Research Letters*, *14*(12), 125017. DOI: *https://doi.org/10.1088/1748-9326/ab59c1*

Head, B. W., & **Alford, J.** (2015). Wicked Problems. *Administration & Society*, *47*(6), 711–739. DOI: *https://doi.org/10.1177/0095399713481601*

Hedlund, J., Bodin, Ö., & **Nohrstedt, D.** (2021). Policy Issue Interdependency and the Formation of Collaborative Networks. *People and Nature*, *3*, 236–250. DOI: *https://doi.org/10.1002/pan3.10170*

Heikkila, T. (2004). Institutional Boundaries and Common-Pool Resource Management: A Comparative Analysis of Water Management Programs in California. *Journal of Policy Analysis and Management*, *23*(1), 97–117. DOI: *https://doi.org/10.1002/pam.10181*

Henry, A. D., & **Vollan, B.** (2014). Networks and the Challenge of Sustainable Development. *Annual Review of Environment and Resources*, *39*(1), 583–610. DOI: *https://doi.org/10.1146/annurev-environ-101813-013246*

Jaramillo, F., Desormeaux, A., Hedlund, J., Jawitz, J. W., Clerici, N., Piemontese, L., … Vigouroux, G. (2019). Priorities and Interactions of Sustainable Development Goals (SDGs) with Focus on Wetlands. *Water*, *11*(619). DOI: *https://doi.org/10.3390/w11030619*

Jaramillo, F., Prieto, C., Lyon, S. W., & **Destouni, G.** (2013). Multimethod Assessment of Evapotranspiration Shifts due to Non-irrigated Agricultural Development in Sweden. *Journal of Hydrology*, *484*, 55–62. DOI: *https://doi.org/10.1016/j.jhydrol.2013.01.010*

Jayaraman, R., Colapinto, C., La Torre, D., & **Malik, T.** (2015). Multi-Criteria Model for Sustainable Development using Goal Programming Applied to the United Arab Emirates. *Energy Policy*, *87*, 447–454. DOI: *https://doi.org/10.1016/j.enpol.2015.09.027*

Jiren, T. S., Bergsten, A., Dorresteijn, I., Collier, N. F., Leventon, J., & **Fischer, J.** (2018). Integrating Food Security and Biodiversity Governance: A Multi-Level Social Network Analysis in Ethiopia. *Land Use Policy*, *78*, 420–429. DOI: *https://doi.org/10.1016/j.landusepol.2018.07.014*

Jordan, A., & **Lenschow, A.** (2010). Environmental Policy Integration: a State of the Art Review. *Environmental Policy and Governance*, *20*, 147–158. DOI: *https://doi.org/10.1002/eet.539*

Kimmich, C. (2013). Linking Action Situations: Coordination, Conflicts, and Evolution in Electricity Provision for Irrigation in Andhra Pradesh, India. *Ecological Economics*, *90*, 150–158. DOI: *https://doi.org/10.1016/j.ecolecon.2013.03.017*

Kirkwood, C. W. (1998). *System Dynamics Methods: A Quick Introduction*. College of Business, Arizona State University.

Kirschke, S., Franke, C., Newig, J., & **Borchardt, D.** (2019). Clusters of Water Governance Problems and their Effects on Policy Delivery. *Policy and Society*, *38*(2), 255–277. DOI: *https://doi.org/10.1080/14494035.2019.1586081*

Koontz, T. M., & **Thomas, C. W.** (2006). What Do We Know and Need to Know about the Environmental Outcomes of Collaborative Management? *Public Administration Review*, *66*(1), 111–122. DOI: *https://doi.org/10.1111/j.1540-6210.2006.00671.x*

Lade, S. J., Steffen, W., de Vries, W., Carpenter, S. R., Donges, J. F., Gerten, D., … Rockström, J. (2020). Human Impacts on Planetary Boundaries Amplified by Earth System Interactions. *Nature Sustainability*, *3*(2), 119–128. DOI: *https://doi.org/10.1038/s41893-019-0454-4*

Lubell, M. (2013). Governing Institutional Complexity: The Ecology of Games Framework. *Policy Studies Journal*, *41*(3), 537–559. DOI: *https://doi.org/10.1111/psj.12028*

Margoluis, R., Stem, C., Swaminathan, V., Brown, M., Johnson, A., Placci, G., … Tilders, I. (2013). Results Chains: A Tool for Conservation Action Design, Management, and Evaluation. *Ecology and Society*, *18*(3). DOI: *https://doi.org/10.5751/ES-05610-180322*

McCollum, D. (2018). Connecting the Sustainable Development Goals by their Energy Interlinkages. *Environmental Research Letters*, *13*, 1–23. DOI: *https://doi.org/10.1088/1748-9326/aaafe3*

McGinnis, M. D. (2011). Networks of Adjacent Action Situations in Polycentric Governance. *Policy Studies Journal*, *39*(1), 51–79. DOI: *https://doi.org/10.1111/j.1541-0072.2010.00396.x*

McGlashan, J., Haye, K. De, Wang, P., & **Allender, S.** (2019). Collaboration in Complex Systems: Multilevel Network Analysis for Community-Based Obesity Prevention Interventions. *Scientific Reports*, *9*, 12599. DOI: *https://doi.org/10.1038/s41598-019-47759-4*

Metz, F., Angst, M., & **Fischer, M.** (2020). Policy Integration: Do Laws or Actors Integrate Issues Relevant to Flood Risk Management in Switzerland? *Global Environmental Change*, *61*, 101945. DOI: *https://doi.org/10.1016/j.gloenvcha.2019.101945*

Metz, F., Leifeld, P., & **Ingold, K.** (2019). Interdependent Policy Instrument Preferences: A Two-Mode Network Approach. *Journal of Public Policy*, *39*(4), 609–636. DOI: *https://doi.org/10.1017/S0143814X18000181*

Mikulcak, F., Newig, J., Milcu, A. I., Hartel, T., & **Fischer, J.** (2013). Integrating Rural Development and Biodiversity Conservation in Central Romania. *Environmental Conservation*, *40*(2), 129–137. DOI: *https://doi.org/10.1017/S0376892912000392*

Nilsson, M., Chisholm, E., Griggs, D., Howden-Chapman, P., McCollum, D., Messerli, P., … Stafford-Smith, M. (2018). Mapping Interactions between the Sustainable Development Goals: Lessons Learned and Ways Forward. *Sustainability Science*, *13*, 1489–1503. DOI: *https://doi.org/10.1007/s11625-018-0604-z*

Nilsson, M., Griggs, D., & **Visback, M.** (2016). Map the Interactions between Sustainable Development Goals. *Nature*, *534*, 320–322. DOI: *https://doi.org/10.1038/534320a*

Nilsson, M., Zamparutti, T., Petersen, J. E., Nykvist, B., Rudberg, P., & **McGuinn, J.** (2012). Understanding Policy Coherence: Analytical. *Environmental Policy and Governance*, *22*, 395–423. DOI: *https://doi.org/10.1002/eet.1589*

Oberthür, S., & **Gehring, T.** (2006). Comparative Empirical Analysis and Ideal Types of Institutional Interaction. In S. Oberthür & T. Gehring (red.) (Eds.), *Institutional Interaction in Global Environmental Governance* (pp. 307–371). Cambridge, MA: The MIT Press. DOI: *https://doi.org/10.7551/mitpress/3808.001.0001*

Özesmi, U., & **Özesmi, S. L.** (2004). Ecological Models Based on People's Knowledge: A Multi-Step Fuzzy Cognitive Mapping Approach. *Ecological Modelling*, *176*(1–2), 43–64. DOI: *https://doi.org/10.1016/j.ecolmodel.2003.10.027*

Pham-Truffert, M., Metz, F., Fischer, M., Rueff, H., & **Messerli, P.** (2020). Interactions among Sustainable Development Goals: Knowledge for Identifying Multipliers and Virtuous Cycles. *Sustainable Development*, *28*, 1236–1250. DOI: *https://doi.org/10.1002/sd.2073*

Pittman, J., & **Armitage, D.** (2017). How Does Network Governance Affect Social-ecological Fit across the Land–Sea Interface? An Empirical Assessment from the Lesser Antilles. *Ecology and Society*, *22*(4), 5. DOI: *https://doi.org/10.5751/ES-09593-220405*

Polasky, S., Crépin, A.-S., Biggs, R. (Oonsie), Carpenter, S. R., Folke, C., Peterson, G., … Xepapadeas, A. (2020). Corridors of Clarity: Four Principles to Overcome Uncertainty Paralysis in the Anthropocene. *BioScience*, *70*(12), 1139–1144. DOI: *https://doi.org/10.1093/biosci/biaa115*

Rittel, H. W. J., & **Webber, M. M.** (1973). Dilemmas in a General Theory of Planning*. *Policy Sciences*, *4*, 155–169. DOI: *https://doi.org/10.1007/BF01405730*

Rocha, J. C., Peterson, G., Bodin, Ö., & **Levin, S. A.** (2018). Cascading Regime Shifts within and across Scales. *Science*, *362*, 1379–1383. DOI: *https://doi.org/10.1101/364620*

Sabatier, P. A. (1988). An Advocacy Coalition Framework of Policy Change and the Role of Policy-Oriented Learning Therein. *Policy Sciences*, *21*(2–3), 129–168. DOI: *https://doi.org/10.1007/BF00136406*

Salafsky, N. (2011). Integrating Development with Conservation. A Means to a Conservation End, or a Mean End to

Conservation? *Biological Conservation*, *144*(3), 973–978. DOI: *https://doi.org/10.1016/j.biocon.2010.06.003*

Schwartz, M. W., Deiner, K., Forrester, T., Grof-Tisza, P., Muir, M. J., Santos, M. J., … Zylberberg, M. (2012). Perspectives on the Open Standards for the Practice of Conservation. *Biological Conservation*, *155*, 169–177. DOI: *https://doi.org/10.1016/j.biocon.2012.06.014*

Scott, T. (2015). Does Collaboration Make Any Difference? Linking Collaborative Governance to Environmental Outcomes. *Journal of Policy Analysis and Management*, *34*(3), 537–566. DOI: *https://doi.org/10.1002/pam.21836*

Simon, H. A. (1962). The Architecture of Complexity. *Proceedings of the American Philosophical Society*, *106*(6), 467–482. DOI: *https://doi.org/10.7551/mitpress/12107.003.0011*

Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., & **Spierenburg, M.** (2014). Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance : The Multiple Evidence Base Approach, *43*, 579–591. DOI: *https://doi.org/10.1007/s13280-014-0501-3*

Vattenmyndigheterna, Länsstyrelsen, Lantmäteriet, SMHI. (2020). The Norrström Basin. Registration number 106-2004/188. Retrieved from *https://www.vattenmyndigheterna.se/*

Vladimirova, K., & **Le Blanc, D.** (2016). Exploring Links Between Education and Sustainable Development Goals Through the Lens of UN Flagship Reports. *Sustainable Development*, *24*(4), 254–271. DOI: *https://doi.org/10.1002/sd.1626*

Weible, C. M., Heikkila, T., DeLeon, P., & **Sabatier, P. A.** (2012). Understanding and Influencing the Policy Process. *Policy Sciences*, *45*(1), 1–21. DOI: *https://doi.org/10.1007/s11077-011-9143-5*

Weible, C. M., & **Sabatier, P. A.** (2009). Coalitions, Science, and Belief Change: Comparing Adversarial and Collaborative Policy Subsystems. *Policy Studies Journal*, *37*(2), 195–212. DOI: *https://doi.org/10.1111/j.1541-0072.2009.00310.x*

Weitz, N., Carlsen, H., Nilsson, M., & **Skånberg, K.** (2017). Towards Systemic and Contextual Priority Setting for Implementing the 2030 Agenda. *Sustainability Science*, *13*(2), 531–548. DOI: *https://doi.org/10.1007/s11625-017-0470-0*

Zhou, X., & **Moinuddin, M.** (2017). *Sustainable Development Goals Interlinkages and Network Analysis: A practical tool for SDG integration and policy coherence*. IGES.

TO CITE THIS ARTICLE:
Hedlund, J., Bodin, Ö., & Nohrstedt, D. (2021). Assessing Policy Issue Interdependencies in Environmental Governance. *International Journal of the Commons*, 15(1), pp. 82–99. DOI: *https://doi.org/10.5334/ijc.1060*

Submitted: 30 June 2020 Accepted: 12 February 2021 Published: 01 April 2021