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Towards *sustainable* policy instruments: assessing instrument selection among policy actors

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ABSTRACT
To address complex environmental problems we need *sustainable* policy solutions, which are often disregarded by policy actors in charge of addressing these problems. In this article, we study factors that promote or hinder policy actors' selection for *sustainable* policy instruments using the case of flood risk management in Switzerland. We evaluate flood risk management instruments based on three key sustainability dimensions and forgo conventional approaches to categorizing policy instruments. In a survey, we ask policy actors which policy instruments they prefer and thus evaluate which policy actors select *sustainable* policy instruments. Results indicate that problem perception is the key determinant influencing policy actors' selection of *sustainable* flood risk management instruments. Results also suggest that the tendency to select *sustainable* flood risk management instruments differs depending on actor type and actor level. These findings help us understand which settings promote the selection of *sustainable* policy solutions to tackle complex environmental problems.

KEYWORDS
Policy instruments, instrument selection, sustainability performance, problem perception, flood risk management

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1. Introduction

Complex environmental problems, such as loss of biodiversity, climate change or water scarcity challenge policy actors on environmental, economic and social dimensions simultaneously. Such problems call for innovative and integrative policy solutions (Kirschke *et al.* 2017). However, these policy solutions are often passed over by policy actors in charge of addressing the problem at hand. We investigate which factors bring a policy actor to support more innovative and integrative policy solutions (see e.g., Verlynde *et al.* 2019).

Rather than relying on conventional categorizations of policy instruments, we use the concept of sustainability to assess policy instruments and their potential to solve complex environmental problems. The sustainability concept encompasses different dimensions of environmental complexity, namely ecological protection, economic efficiency and social acceptance (Finnveden *et al.* 2013). That makes it ideal to assess policy instruments based on how innovative and integrative a solution they encompass. This is how we contribute, on the one hand side, to the discussion of policy instruments targeting a *sustainable* transition and, on the other hand side, to the literature investigating instrument selection and its determinants.

The most *sustainable* policy instruments to tackle complex environmental problems often cannot be implemented, because they do not pass political decision-making processes. One essential reason is the nature of complex environmental problems: they are often associated with high levels of uncertainty in terms of causes, impacts, and effects on human and ecological systems (Varone *et al.* 2013). Policy actors try to reduce uncertainty at the stage of instrument selection (Howlett 2005)by choosing policy instruments which do not cover all three dimensions of sustainability. It is therefore necessary to identify the conditions under which *sustainable* policy instruments have a chance to pass the decision-making process. We study determinants that drive policy actors to choose certain specific policy instruments over others. We therefore ask: **Which determinants influence policy actors in selecting *sustainable* policy instruments?**

By asking which determinants are crucial for the selection of *sustainable* policy in-

struments, we want to understand why *sustainable* policy instruments are not chosen, even if they address complex environmental problems on all relevant dimensions. We argue that two main determinants need to be considered: Policy actors' *perception* of a complex environmental problem and its consequences (see e.g., Lahat 2011) can influence their instrument selection to address the problem at hand. As policy actors are embedded in extensive policy networks that shape their perception (see e.g., Lubell and Fulton 2007), their *network partners' perception* of a complex environmental problem can equally affect policy actors' instrument selection.

We illustrate our theoretical arguments by taking the case of extreme flood events in Switzerland as an example of a complex environmental problem and focus on policy instruments related to flood risk management in three flood-prone Swiss sub-catchment areas. We conduct surveys with 206 policy actors. In the standardized questionnaire, we survey the policy actors on their preferred *sustainable* flood risk management instruments and determinants that may influence the selection of these *sustainable* flood risk management instruments. As the surveyed actors are not independent of each other, we use a network autocorrelation model (Leenders 2002) to analyze determinants influencing policy actors' selection of *sustainable* policy instruments. By understanding which determinants correlate with the selection of *sustainable* policy instruments, we highlight which aspects of the decision-making process should be strengthened to support *sustainable* solutions.

2. Theories on Policy Instruments and Sustainability

2.1. Linking Policy Instruments and Sustainability

2.1.1. The Nature of Policy Instruments

If policy actors[1] (henceforth actors) want to put a political idea into practice, they need to consider not only *what* to do, but also *how* to do it. Policy instruments (henceforth instruments) are the concrete tools or mechanisms for governments to implement a

[1]Policy actors are individuals or groups of individuals with direct or indirect government or non-government affiliations who seek to influence the outcome of a policy process. Policy actors can include representatives from government agencies, associations, interest groups, industry or scientific institutions (Weible and Ingold 2018).

planned policy (Howlett *et al.* 2009). However, instruments are not simple means of intervention, but have specific effects: they are control mechanisms to steer target groups' behaviour and actions towards a desired direction to achieve a previously defined political goal or to solve a previously identified societal problem (Bemelmans-Videc and Rist 1998). In practice, actors opt for several instruments and bundle them into a mix of instruments, rather than adopting an individual instrument (Howlett 2005). This article, however, identifies individual instruments and aims to study their sustainability performance, with the aim to bring *sustainable* instruments into sharper relief.

Instruments can be categorized into different instrument types. Some typologies of instruments focus on governments' actions and the resources available to governments (Hood 1983), while other taxonomies emphasize specific political goals that governments pursue (Schneider and Ingram 1990) or the degree of governments' intervention (Bemelmans-Videc and Rist 1998).

In line with Kaufmann-Hayoz *et al.* (2001), we argue that typologies of instruments are useful and can be adopted according to the purpose of categorization. While the above-mentioned typologies are valuable ways of distinguishing instruments, we deliberately distance ourselves from them. We claim that these typologies are focusing on the mode of action (i.e., the rationale of an instrument in terms of how to change behavior) or the mode of delivery (i.e., the way in which the state intervenes to lead to the desired behavioral change). In this research, we address a different level, namely the content of instruments and whether or not they cover different aspects of sustainability. It is however worth mentioning that a *sustainable* instrument can be either coercive, incentive-based or persuasive, meaning that different ways of assessing instruments are not mutually exclusive.

2.1.2. Criteria of Policy Instrument Selection

Literature identifies various criteria influencing actors' instrument selection. Whether an instrument stands a chance to survive the decision-making process, thus to pass from formulation to implementation and achieve the desired impact, depends in part on its political feasibility. Based on this criterion, one anticipates the likelihood of a

problem to be resolved by the proposed instrument (Webber 1986), based on actors' acceptance (Dermont *et al.* 2017) and policy support (Dietz *et al.* 2007). Both concepts are fundamental for an instrument to pass the decision-making process and to reach a policy's outcome. Thus, political feasibility reflects the process in which decisions are taken and is closely linked to involved actors' motivation, power, and resources.

In contrast, policy effectiveness is related to the policy goal and its attainment. Effectiveness is an important criterion, because it explains the rationale according to which an instrument is supposed to work. A regulative instrument imposing a ban on a specific chemical compound is supposed to have an effect because target groups (e.g., industrial companies) want to avoid the penalties that go hand in hand with a violation of the ban (Kaufmann-Hayoz *et al.* 2001). The assessment of policy effectiveness is often criticized for being too goal-orientated and not taking the causes of the policy problem into consideration (Burger *et al.* 2015).

We share this criticism, particularly related to complex environmental problems, such as loss of biodiversity, climate change or water scarcity, which affect a broad spectrum of society, are cross-sectoral and involve a myriad of actors. Problems and solutions are intertwined and the selection of instruments might not only affect goal attainment, but also the causes of the problem. More integrative ways to capture and solve complex environmental problems are needed. Sustainability is one concept that facilitates a more integrative way of instrument selection. In line with Metz and Ingold (2014b), we argue that selected instruments have to guarantee *sustainable* environmental management. Within this research, we consider the nature of the problem as the single most important determinant for instrument selection. Complex environmental problems challenge policy actors along different dimensions; trade-offs between ecological preservation, economic growth, and social justice have to be balanced, and externalities have to be considered. However, the most feasible, accepted and effective solution might fail to balance the ecological, economic and social dimensions of the problem which contributes to perpetuating complexity rather than solving problems. This is why we propose to consider sustainability as a selection criterion when designing policies for complex environmental problems.

2.1.3. Sustainable *Policy Instruments*

The concept of sustainability consists of two integrative aspects: first, the balancing of environmental protection and economic growth, and second, guaranteeing environmental integrity to future generations (Brundtland 1987). In other words, instruments perform *sustainably* when they balance environmental and economic impacts and are socially accepted (Finnveden *et al.* 2013).

While a policy solution might contribute to better ecological outcomes (e.g., reduced risk of water contamination through the ban of certain chemicals), it might be disadvantageous for society (increased risk of crop loss leading to food shortages) and the economy (crop loss leading to less exportable goods). Therefore, reactive and fast-working solutions might not fit the complex environmental problem (Biesbroek *et al.* 2011). Instead, we claim that the interdependence of the ecological, economic and social dimensions of complex environmental problems (Jongman 2018) calls for integrative instruments—or in other words, instruments which perform well in promoting *sustainable* environmental management. It is thus actors' job to match the ecological, economic and social dimensions of a complex environmental problem to the instruments they have at their disposal to address these problems (Kundzewicz 2002).

2.2. Sustainable *Policy Instruments in Flood Risk Management*

Floods are ideal to study complex environmental problems and actors' instrument selection in case of their occurrence: they affect multiple policy sectors (e.g., water management, agriculture, and industry), decision-making levels (e.g., municipalities, cantons, and federal state), and territories (e.g., a whole catchment area, several regions or countries) simultaneously. Floods are cross-sectoral, multi-level, and trans-territorial in nature and call for *sustainable* flood risk management instruments encompassing these often disentangled dimensions (Persson and Klein 2009). Therefore, we identify *sustainable* flood risk management instruments which are capable of including all relevant dimensions of flood risks. Following the relevant flood risk management literature (see detailed Table 1 in the Supplementary Information (SI) Online), we assess the sustainability performance of nine different flood risk management instruments.

According to the sustainability definition used in this article, flood risk management instruments are evaluated to perform *sustainably*, when flood risks are addressed in an environmentally sound, economically feasible, and socially acceptable way (Takeuchi *et al.* 1998), for instance combining nature conservation, economic growth, and citizens' participation in the process simultaneously (Kundzewicz 1999).

Structural defences such as dams, river stabilization, and bank reinforcements perform less *sustainably* than non-structural instruments such as building codes and retention areas or ecological renaturation and river widening. This concerns mainly structural defences' ecological and economic characteristics, i.e., they cause high construction and maintenance costs and involve strong human intervention into various ecosystems. Non-structural instruments, in contrast, are ecologically sound and adapted to the natural regime, but can bear opportunity costs, which depending on their degree of restriction are not always accepted in the population.

This evaluation of flood risk management instruments' sustainability performance is in line with recent developments in European flood risk management: the less *sustainable* structural defences are in many European countries the most established instruments, while the more *sustainable* non-structural instruments are less frequently implemented (see e.g., Hegger *et al.* 2016). However, a shift from less *sustainable* instruments towards more *sustainable* alternatives is being discussed and sought (Jong and van den Brink 2017). Uncertain causes, impacts, and effects of climate change as well as higher environmental standards required by the European Commission's Water Framework Directive adopted in 2000 promote the drive for environmental enhancement and sustainability in flood risk management (Werritty 2006).

2.3. Determinants Influencing Instrument Selection

To understand the potential of *sustainable* instruments to be selected in decision-making processes, we investigate two main determinants—actors' individual problem perception and actors' network partners' problem perception—and some alternative determinants influencing actors' individual instrument selection processes.

2.3.1. Problem Perception as Main Determinant of Instrument Selection

When studying instrument selection in the context of complex environmental problems, one of the main drivers is how the public perceives risks and to what extent it is willing to internalise these risks into decision-making (Slovic 1997). Several studies have shown that the public's risk perception highly affects decision-making, including decisions on instruments to address a problem (see e.g., McGuire 2015). Risk or problem perception is defined as actors' judgement of a hazard's occurrence probability with the perceived severity of potential consequences. Simultaneously, it also includes an affective component, i.e., actors' awareness, emotions, and behavior related to the risk or problem at stake (Slovic *et al.* 2004).

For many climate-related issues, such as flooding, actors' perceived risk deviates from the actual risk, and actors hardly heed the potential consequences. In this situation, the public support for more *sustainable* instruments will be lacking, since actors come into conflict with the established less *sustainable* instruments (according to the concept of path dependency, see e.g., Peters *et al.* 2005). This mismatch is of particular importance for actors, since a potential shift from less towards more *sustainable* instruments is more likely to occur when actual and perceived risks are aligned and the public supports the selection of such *sustainable* instruments to reduce the risk (McGuire 2015). In addition, the selection of more *sustainable* instruments in general includes a significant change to actors' existing policy conditions and could thus cause losses of privileges for certain actor groups (Spangenberg 2004). We therefore argue that actors perceiving high risk of a complex environmental problem are less likely to support the selection of *sustainable* instruments and rather opt for the existing less *sustainable* instruments to be maintained (Howlett 2005).

Hypothesis 1. The more actors perceive the risk of a complex environmental problem, the less likely they are to select *sustainable* policy instruments.

Actors are embedded in a collaborative process (Kirschke *et al.* 2017) which can affect an actor's instrument selection. Whereas the wisdom of crowds has been demonstrated in collective decision-making (Becker *et al.* 2017; for a theoretical discussion, see Galton 1907), we examine whether fears of the crowd can shift an actor's instru-

ment selection towards more *sustainable* instruments. Two arguments support our hypotheses that being surrounded by actors who perceive floods as a risk, helps shift an actor's perspective and demand a more comprehensive approach to solving the current problem and avoiding the risks it brings with it: First, being exposed to different views, opinions, and problems faced by network partners might provide actors with a more holistic understanding of the problem situation (Koppenjan and Klijn 2004). Second, complex environmental problems are often associated with high levels of uncertainty. Through interaction with diverse network partners, actors' uncertainty might lower because they have access to more diverse political and technical information (Hamilton and Lubell 2018). This can help shift an actor's instrument selection towards *sustainable* instruments.

Hypothesis 2. The more actors' network partners perceive the risk of a complex environmental problem, the more likely actors are to select *sustainable* policy instruments.

2.3.2. Alternative Determinants of Instrument Selection

We indicate some further determinants deduced from the relevant literature, which are of importance for instrument selection processes.

First, actors' instrument selection can be influenced by their inclusion in the decision-making process (Wesselink *et al.* 2011). In particular, when actors judge this process to be fair and trust the involved policy makers (Mees *et al.* 2017), actors' satisfaction with the process functioning and with the selected instruments can be promoted. In addition, the allocation of financial resources to local governments—as the responsible scale in selecting instruments to address complex environmental problems (Coppola *et al.* 2015)—is crucial for actors' instrument selection. Local governments dealing with limited financial resources and many competing local problems may have other tendencies of instrument selection than actors without financial constraints (Suter *et al.* 2016). Furthermore, a problem's priority, i.e., the salience and urgency actors attribute to a problem, can decisively affect their instrument selection (Metz 2017). Depending on how pressing actors evaluate a problem in comparison to

others, they show different tendencies in selecting instruments (Nelson 2004). Last, actors' collaboration with a diverse set of other actors in a network may determine their instrument selection. In particular, diverse collaboration can lead to better outputs, foster trust (Metz and Ingold 2017), and enhance the chance for collective action (Henry and Vollan 2014), which may lead actors to select (or not) certain instruments.

3. Case selection, Data Gathering, and Method

3.1. Case selection: Flood risk management in Switzerland

Switzerland's geographic position at the source of several large European rivers and numerous national watercourses combined with its small size and dense settlement results in significant flood risks for the population (Ingold and Gavilano 2020). As in many European countries, the most widespread flood risk management instruments in Switzerland are structural defences (Zaugg Stern 2006). However, within the last 10 to 20 years, increasing discussions on sustainability principles and integrative approaches in Europe announced a more comprehensive, interlinked, and cross-sectoral approach, called integrated risk management (see e.g., Nordbeck *et al.* 2019). Swiss flood risk management proves an ideal example to learn from past experiences for today's design of *sustainable* flood risk management instruments.

We choose three Swiss sub-catchment areas in the basins of the Aare, Thur, and Kander rivers and study actors' instrument selection in regional flood risk management processes. Our case selection builds on hydrological and policy criteria: First, these three sub-catchment areas represent different topographic conditions (high- vs. lowland) and have all been repeatedly exposed to severe floods. Actors' flood exposure puts policy makers under pressure to act and to select adequate flood risk management instruments. Second, recent flood risk management projects in the three regions ease the identification of decision-making processes, actor groups and flood risk management instruments. Finally, the selected sub-catchment areas are embedded in a multi-level setting: they integrate different actor groups at all decision-making levels as well as from different sectors (for additional information on the three sub-catchments, see SI Online).

3.2. Data Gathering: Surveying Policy Actors

We gathered data using a mixed-mode postal survey with standardized questions and conducting semi-structured interviews. Our sample consists of federal, cantonal, and municipal decision-makers, as well as non-state actors such as interest groups, economic stakeholders, or research institutes. To identify these actors, we applied the commonly used decisional, positional, and reputational approaches, which evaluate key actors based on their central position in the process, their crucial impact on decisions, or their reputation in the process (Knoke 1993). Our resultant sample includes all actors involved in the policy processes of the flood risk management projects in the three sub-catchment areas ($N = 206$).

In total, we surveyed all 206 actors. The response rate of the survey was 72% (149 actors). Network studies demand unusually high response rates to ensure results are not biased due to missing observations (Costenbader and Valente 2003). We actively increased our response rate by contacting each of the addressed actors in person, asking for their participation.

3.3. Method: Network Autocorrelation Model

We run a network autocorrelation regression model to test whether actors' individual and network problem perception correlate with their selection of *sustainable* flood risk management instruments. Network autocorrelation regression models are comparable to conventional regression models with the difference that they account for dependencies among observations that result from a non-random population sample.

Since actors' instrument selection may depend on other actors' instrument selection, the network they are embedded in, or other external influence, no standard regression analysis with an intrinsic assumption of independence of observations can be used. Instead, a statistical model that models for the data generating process adequately is necessary to prevent faulty conclusions based on biased inference (Leifeld and Cranmer 2015). The network autocorrelation model is based on spatial lag models and incorporates weight matrices (also called lags or network lags) that can account for structural or network effects (Leenders 2002; for a theoretical discussion, see Doreian 1980). We

run a linear regression on instrument selection and control for network autocorrelation effects by including network lag terms that control for instrument selection of each actor's collaboration ties. These lag terms are calculated as follows: For each collaboration partner of an actor we evaluate their instrument selection index (see below) and use its average as a control variable in the regression. That way, we control for the lack of independence among observations and check whether actors have a tendency to choose similar instruments as their collaboration partners. We further test whether an actor's network position affects their instrument selection and present these models in the SI Online as the network position of an actor did not affect their instrument selection and the model.

3.4. Operationalization of Variables

We operationalize our **dependent variable** 'instrument selection' with a proxy of instrument policy preferences (Stead 2018). We surveyed actors' preferred flood risk management instruments in a statement battery contrasting different flood risk management instruments to each other (please refer to the SI Online for a list of surveyed instruments). Actors expressed their preferences for each instrument statement on a two-dimensional four-point Likert-scale ranging from full agreement for one instrument (e.g., dam) to full agreement for another instrument (e.g., river widening) (for an example survey item, see Figure 1). We construct an additive index of actors' tendency to select instruments that perform more or less *sustainably* (as evaluated in Section 2.2). The standardized index ranges from 0 to 1, with values close to 1 indicating actors' tendency to select more *sustainable* instruments, while index values close to 0 show actors' tendency to select less *sustainable* instruments.

Figure 1.: Survey item for the selection of less versus more *sustainable* flood risk management instruments

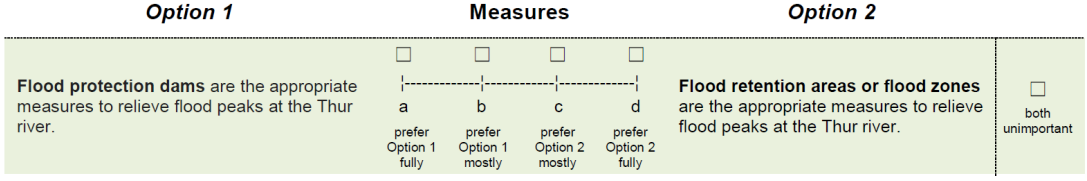


Table 1 shows the operationalization of our two **independent variables** 'individual problem perception' and 'network problem perception' as well as of our control variables. For additional information on the operationalization, summary statistics and sensitivity checks, see SI Online.

Table 1.: Operationalization of the dependent, independent and control variables

	Variables	**Operationalization**
DV	Instrument selection	Additive index measuring selection of less versus more *sustainable* instruments (normalized $[0, 1]$)
IV1	Individual problem perception	Additive index with items measuring perception of increasing number, extent, and damage of floods in the last 20 years, and of the risk for potential future flooding in the sub-catchment area (normalized $[0, 1]$)
IV2	Network problem perception	Average problem perception of each actor's network partners
CV1	Process inclusion	Additive index with items measuring general project support, satisfaction with process participation and satisfaction with representation of own interests (normalized $[0, 1]$)
CV2	Financial support	Additive index with items measuring perception of local governments about financial support from the national and cantonal governments being high enough (ranging from 1 to 4)
CV3	Problem priority	Priority of flood risk management in comparison to other environmental and water-related issues (ranging from 0 to 12)
CV4	Diverse network collaboration	Number of different actor types that are represented in each actor's collaboration network, i.e., the level of diversity in each actor's immediate network
CV5	Network instrument selection	Average instrument selection of each actor's network partners
CV6	Case	Sub-catchment areas at Aare, Kander, and Thur rivers
CV7	Actor level	Local, regional, cantonal, or national level (ranging from 1 to 4)

DV = dependent variable; IV = independent variable; CV = control variable.

4. Results & Discussion

4.1. Which Actors Really Select Sustainable *Policy Instruments?*

Our instrument selection index shows a lot of variance across the different actors (see Figure 2), indicating that these actors are driven by different motivations. Interest groups in the three sub-catchments show a high tendency to select more *sustainable*

instruments. This is an intuitive result, given that the majority of the surveyed interest groups are either environmental NGOs interested in maintaining or restoring the natural environment or leisure clubs such as fishery associations depending on a sound environment without much structural intervention. In contrast, municipalities are highly divided within and between sub-catchments and display a wide range of different tendencies for selecting instruments. This result can be explained partly by municipalities' different flood risk management strategies according to their unequal flood exposure, flood experience, and technical, financial, or political capacity to implement certain flood risk management instruments on their territories (Suter *et al.* 2016). Cantonal agencies position themselves in between and tend to choose instruments that perform in some aspects less and in others more *sustainably*. In all the three sub-catchments, one or several cantonal agencies are key actors in flood risk management projects. Often being the project leaders, cantonal agencies are interested to include as many actors as possible, guarantee the information flow between national and local agencies, and prevent conflicts ('gatekeeper role', see Ingold 2014), and thus select moderate instruments. Two further actor types—federal agencies and research institutes—lean towards the selection of more *sustainable* instruments. In Figure 2, we showcase three actors (marked points) to illustrate the different tendencies for instrument selection: the likelihood of selecting a less *sustainable* instrument (municipal actor in the Thur sub-catchment), a more *sustainable* instrument (interest group in the Aare sub-catchment) and an in-between instrument (cantonal agency in the Kander sub-catchment).

In Figure 3, we show the variance in the instrument selection index across actor levels. In the Aare and Thur sub-catchments actors hold high index values, and more *sustainable* flood risk management instruments have a high chance to be selected. The Kander values average out at lower levels. It is therefore important to consider the context of flood risk management at the Aare, Kander, and Thur rivers in order to understand our results.

In the **Thur sub-catchment**, the strong awareness of negative ecological consequences of less *sustainable* flood risk management instruments in the population seems to influence national, cantonal, and regional actors in their selection of more *sustain-*

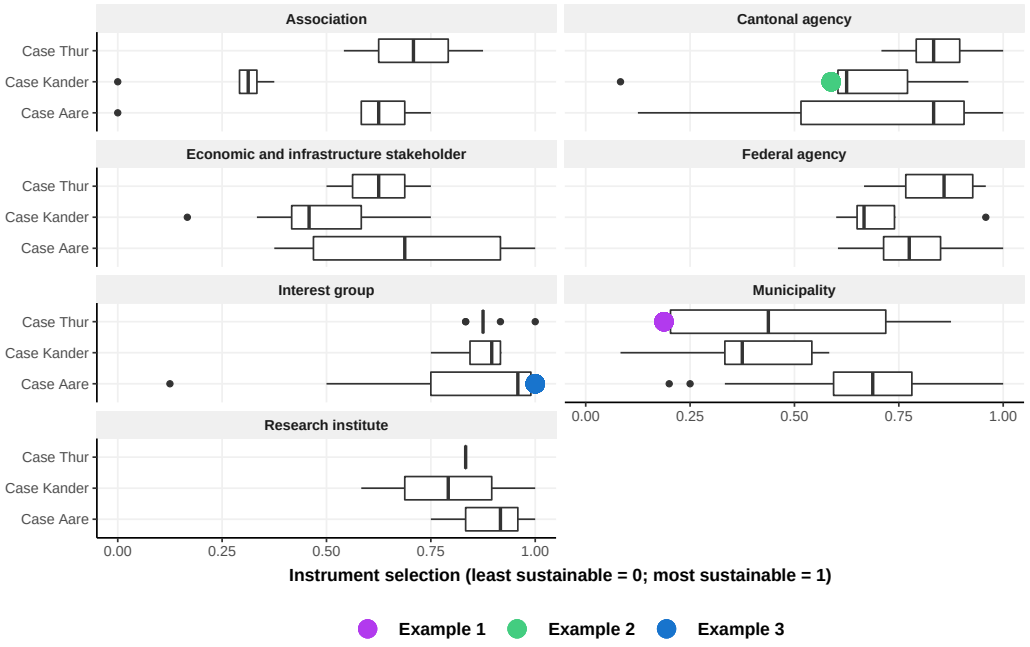


Figure 2.: Three examples of actors with different instrument selection tendencies and corresponding distribution of instrument selection for each actor type and by sub-catchment

able instruments. The sub-catchment includes the Thurauen region, one of the major wetlands in Switzerland, which affects discussions on flood risk management since the late 1970s. In the 1980s, two cantonal flood protection projects at the Thur had to be stopped because of missing acceptance of less *sustainable* instruments in the population and extensive pressure of environmental NGOs.

In the **Aare sub-catchment**, actors' rising awareness on the benefits of the removal or at least compensation of less *sustainable* instruments slowly dominates the disagreeing voices and seems to translate into national, cantonal, and regional actors' instrument selection tendencies. The high index values in this sub-catchment are embedded in long-lasting discussions about the renaturation of a strongly canalized section of the river. Despite the extensive negotiations with disagreeing actors who even blocked the process, several renaturation and restoration projects in the sub-catchment have been successfully implemented.

In contrast, in the narrow and steep **Kander sub-catchment**, more *sustainable* solutions develop slowly. The history of flood risk management in the last 100 years

in this sub-catchment shows that actors used to address flood risks with space-saving structural instruments, since there is little room for more *sustainable* instruments. For the national, cantonal, and regional actors involved in flood risk management processes at the Kander today, less *sustainable* instruments are therefore a simple, reliable, and effective way to address flood risks.

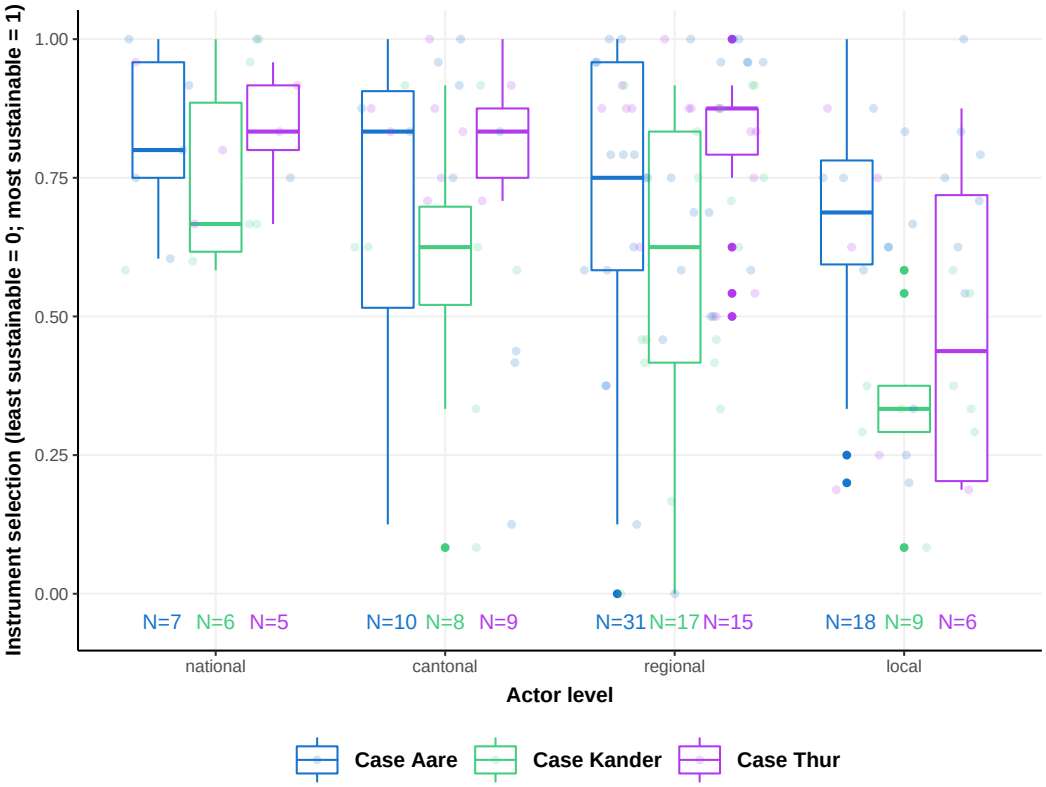


Figure 3.: Boxplot: Actors' instrument selection by actor level and sub-catchment

4.2. Problem Perception is Key

Table 2 shows the results of the linear regression on the dependent variable 'instrument selection'. We calculated two linear regression models: the first model includes the two independent variables 'individual problem perception' and 'network problem perception' and control variables for all actors. The second model includes municipal actors only and accounts for the control variable 'financial support'. We report sensitivity

	Model 1	Model 2 Municipalities only
Independent variables		
Individual problem perception (index, 0-1)	0.34 (0.15)*	0.23 (0.28)
Network problem perception	−0.45 (0.19)*	
Control variables		
Process inclusion (index, 0-1)	0.31 (0.19)$^{\cdot}$	
Financial support (index, 1-4)		0.19 (0.08)*
Problem priority (0-12)	−0.01 (0.01)	
Diverse network collaboration	−0.01 (0.01)	
Network instrument selection: Aare (baseline)	0.60 (0.21)**	0.36 (0.43)
Network instrument selection: Kander	0.14 (0.18)	−1.02 (0.59)
Network instrument selection: Thur	−0.40 (0.15)*	−1.10 (0.49)*
Case: Kander (Aare = baseline)	−0.08 (0.10)	0.16 (0.35)
Case: Thur (Aare = baseline)	0.28 (0.11)**	0.72 (0.38)$^{\cdot}$
Actor level (1 = local, 4 = national)	0.06 (0.02)**	
Intercept	0.08 (0.18)	−0.21 (0.43)
R^2	0.31	0.59
Num. obs.	141	29

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Table 2.: Linear regression on instrument selection

analyses for the independent and control variables in the SI Online.

Due to the fact that network autocorrelation terms are added to the linear regression as control variables, the interdependencies among observations are accounted for and the reported standard errors for each estimated parameter are unbiased and can be safely interpreted.

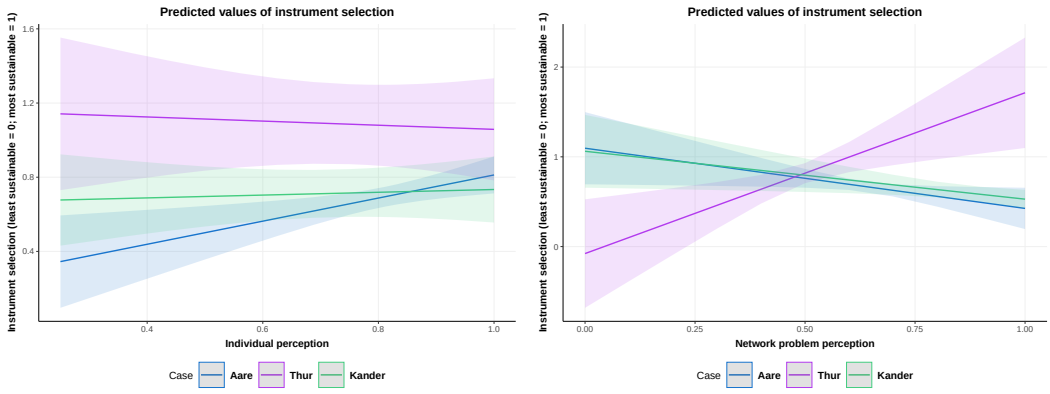
Results in model (1) indicate that actors with high **individual problem perception** of flood risks have a strong tendency to select *sustainable* instruments. This rejects our Hypothesis 1—saying the more actors perceive the risk of a complex environmental problem, the less likely they are to select *sustainable* policy instruments. The result supports the idea that actors who perceive an issue as a problem and are aware of the problem's potential negative consequences, tend to address the problem via the most *sustainable* instruments to reduce their burden to a minimum (see Metz and Ingold 2014a).

As for actors' **network problem perception**, we find a significant negative effect in model (1), rejecting our Hypothesis 2—saying the more actors' network partners perceive the risk of a complex environmental problem, the more likely actors are to select *sustainable* policy instruments. The negative effect indicates that if network partners' problem perception is high, the focal actors tend to select less *sustainable* instruments. Figure 4 reports marginal effects on models including an interaction effect of individual problem perception (left) and network problem perception (right) respectively and the three sub-catchments. The positive effect of actors' individual problem perception can be observed in all three sub-catchments (though weaker in the Thur sub-catchment). The negative average network problem perception effect is perpetrated in the Aare and Kander sub-catchments and contrary in the Thur sub-catchment.

The local residents of the Thur sub-catchment have long voiced demands for *sustainable* flood risk management and have been directly involved in the project process. As an interviewed local flood expert explained: "One aspect of success [*of the project*] is taking everyone seriously and listening to them." This is why the awareness among local communities in the Thur sub-catchment diverges historically from the ones in the other two sub-catchments. The overall negative effect, however, demonstrates that being surrounded by actors with high problem perception negatively affects actors' tendency to select more *sustainable* flood risk management instruments. Fears of the crowd are associated with a pull towards less *sustainable* instruments.

Individual and network problem perception effects contradict each other. It is possible that this discrepancy is specific for Swiss flood risk management and the surveyed sub-catchments. Swiss flood risk management is characterized by strong path dependency in terms of instruments (Metz and Glaus 2019): most regions developed stable flood risk management strategies over the last decades. These strategies have strong local roots, are adapted to local interests, and are accepted in the local population (Zaugg Stern 2006). Furthermore, the majority of the municipalities in Swiss flood risk management dispose of their individual flood risk management plans. As a result, they choose instruments in a solo effort rather than to collaborate with upstream and downstream neighbor municipalities and to select coordinated catchment-wide instru-

Figure 4.: Marginal effects of individual (left) and network (right) problem perception by sub-catchment



ments (Suter *et al.* 2016). Thus, even though individual surveyed actors indicate a tendency to select more *sustainable* instruments, many self-reinforcing mechanisms in the three sub-catchments (e.g., fixed sunk costs of structural instruments, institutional arrangements such as power asymmetries between actor groups, or social expectations of the public) impede actors from 'breaking' with path dependency and distancing themselves from existing less *sustainable* instruments (Parsons *et al.* 2019, Wiering *et al.* 2018). In future analyses, it would therefore be of interest to take a closer look at these opposing perception results and identify whether they are case specific or part of a general pattern of individual versus network problem perception. A first step to this end could be a complementary qualitative analysis, for instance by confronting the surveyed actors with these opposing results. More in-depth and context-specific research is needed to help us understand these findings.

The control variables show several significant effects on actors' instrument selection: In model (1), actors' process inclusion correlates marginally significantly positive with the index, indicating that the more inclusive a flood risk management process is designed, the more likely *sustainable* instruments are selected. Further, the Thur sub-catchment shows a significant positive correlation with the index, indicating that actors in the Thur sub-catchment have a slightly higher tendency to select *sustainable* instruments than actors in the Aare or Kander sub-catchments.[2] Last, the actor level also shows a marginal significant positive correlation with the index which con-

[2]We discuss sub-catchment differences further in the SI Online.

firms that national actors are more likely to select *sustainable* instruments than local actors. In model (2), local governments' financial support to address flood risks has a significant positive correlation with the index. This illustrates that the more local governments perceive to be financially supported by the national and cantonal governments to address flood risks, the more likely municipal actors are to select *sustainable* instruments.

5. Conclusion

Sustainable policy instruments balancing issues' intertwined ecological, economic, and social dimensions are most adequate to address complex environmental problems. However, these policy instruments often do not pass the political decision-making process because actors tend to select existing instruments with well-known functioning and outcomes (according to the concept of path dependency, see e.g., Peters *et al.* 2005). In this article, we studied determinants which promote or impede actors' selection of *sustainable* instruments in the case of flood risk management in Switzerland. Our results indicate that actors' instrument selection is positively influenced by their individual flood risk perception and negatively by their network partners' flood risk perception.

In a broader context, our results contribute to three bodies of literature: First, with our assessment of instruments' sustainability performance, we capture the content level of instruments and satisfy the literature requesting more focus on the nexus between problems and instrument selection (Ingold *et al.* 2019). This different way of characterizing instruments helps us identify instruments with an integrative *sustainable* approach to address flood risks and distinguish them from less *sustainable* instruments. In this article, we consider nature-based or ecological instruments to perform most *sustainably*, which is in line with recommendations of the European Union or the World Bank (European Commission 2011, World Bank 2017). We contribute to the discussion on instrument selection criteria by introducing an alternative way of evaluating instruments based on their sustainability performance.

Second, flood risk management is a sector, in which top-down policy making is

outdated, as a broad variety of actors participate in decision-making. It is therefore key to understand who is particularly inclined to promote more *sustainable* flood risk management instruments and who is not. This can contribute to actively promote an instrument shift from less *sustainable* towards alternative more *sustainable* policy solutions by strengthening these actor groups in the policy process ('change agent', see Wiering *et al.* 2018).

Third, raising public awareness of flood risks, for instance in form of information campaigns (see e.g., Maidl and Buchecker 2015), visualizing risks (see e.g., Larson and Edsall 2010) or game-based learning (see e.g., Meera *et al.* 2016), could lead each of the sub-catchments towards higher sustainability performance of selected instruments (Jänicke and Volkery 2001). Our analysis reveals that problem perception matters for actors' selection of *sustainable* instruments. To understand decision-making processes, and especially the phases of instrument selection, the way actors and their network perceive a certain problem is key. Considering regional flood risk management, our perception results are consistent with several other relevant studies (e.g., Buchecker *et al.* 2013, Bubeck *et al.* 2012).

Going beyond the case of flood risk management, our findings have the following implication. Addressing complex environmental problems calls for new ways of instrument selection. The focus on sustainability as a proposed instrument selection criterion, i.e., considering the content of a problem (Peters *et al.* 2005), including a thorough evaluation of the three dimensions for each instrument, paves a potential way to overcome path dependency. However, there are still many mechanisms of path dependency which prevent an institutional change from the conventional instrument selection criteria towards more content-based selection criteria such as sustainability. In contrast, ideas about new possible ways to select instruments cannot be prevented and are slowly gaining more weight and impact (Van Buuren *et al.* 2016). [3]

Future research on the selection of *sustainable* policy instruments and their determinants is necessary. Theoretically, we acknowledge that sustainability is only one of

[3]We are aware that *sustainable* instruments are not necessarily the instruments guaranteeing the most effective physical protection from complex environmental problems, one expectation about instruments often expressed in the population (Parsons *et al.* 2019). We therefore also calculated our regression models including an instrument selection index based on the effectiveness evaluation of instruments. There is no correlation between *sustainable* instrument choice and effective choice (see SI Online).

several potential instrument selection criteria. Including other criteria and comparing them with sustainability would be of interest. Furthermore, the performance of sustainability and other instrument selection criteria should be compared to the performance of conventional selection criteria such as instruments' feasibility or effectiveness. It remains an open question whether instruments based on sustainability or on conventional selection criteria perform better in the real world. Empirically, our analysis is based on the specific case of flood risk management in Switzerland which mainly generates contextual knowledge for *sustainable* flood risk management instruments. A comparison of our results to results in other regions, considering other complex environmental problems, or integrating even more determinants (e.g., of socio-psychological nature, see Dietz *et al.* 2007) is desirable. We are also interested in the selection of *sustainable* instruments and their determinants in other contexts, specifically in new complex policy sectors, where cross-sectoral and multi-level challenges are relevant. Furthermore, studying *sustainable* instruments in a policy sector where an issue is constantly urgent and salient (e.g., migration) would be of interest.

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References

Becker, J., Brackbill, D., and Centola, D., 2017. Network dynamics of social influence in the wisdom of crowds. *Proceedings of the national academy of sciences*, 114 (26), E5070–E5076.

Bemelmans-Videc, M.L. and Rist, R.C., 1998. *Carrots, Sticks & Sermons: Policy Instruments & Their Evaluation*. London: Transaction.

Biesbroek, R., *et al.*, 2011. Barriers to climate change adaptation in the netherlands. *Climate law*, 2 (2), 181–199.

Brundtland, G., 1987. *Our common future: Report of the 1987 World Commission on Environment and Development*. United Nations, Oslo.

Bubeck, P., Botzen, W., and Aerts, J., 2012. A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis*, 32 (9), 1481–1495.

Buchecker, M., *et al.*, 2013. The role of risk perception in making flood risk management more effective. *Natural Hazards and Earth System Sciences*, 13 (11), 3013–3030.

Burger, P., *et al.*, 2015. Advances in understanding energy consumption behavior and the governance of its change–outline of an integrated framework. *Frontiers in Energy Research*, 3, 29.

Coppola, D., *et al.*, 2015. *Living with climate change: How communities are surviving and thriving in a changing climate*. Auerbach Publications.

Costenbader, E. and Valente, T.W., 2003. The stability of centrality measures when networks are sampled. *Social Networks*, 25 (4), 283–307.

Dermont, C., *et al.*, 2017. Bringing the policy making perspective in: A political science approach to social acceptance. *Energy Policy*, 108, 359–368.

Dietz, T., Dan, A., and Shwom, R., 2007. Support for climate change policy: Social psychological and social structural influences. *Rural sociology*, 72 (2), 185–214.

Doreian, P., 1980. Linear models with spatially distributed data: Spatial disturbances or spatial effects? *Sociological Methods & Research*, 9 (1), 29–60.

European Commission, 2011. *Towards better environmental options for flood risk management*. European Union, Brussels.

Finnveden, G., *et al.*, 2013. Policy instruments towards a sustainable waste management. *Sustainability*, 5 (3), 841–881.

Galton, F., 1907. Vox populi (the wisdom of crowds). *Nature*, 75, 450–51.

Hamilton, M. and Lubell, M., 2018. Collaborative governance of climate change adaptation across spatial and institutional scales. *Policy Studies Journal*, 46 (2), 222–247.

Hegger, D.L., *et al.*, 2016. Toward more flood resilience: Is a diversification of flood risk management strategies the way forward? *Ecology and Society*, 21 (4).

Henry, A. and Vollan, B., 2014. Networks and the Challenge of Sustainable Development. *Annual Review of Environment and Resources*, 39, 583–610.

Hood, C., 1983. *The Tools of Government*. Springer.

Howlett, M., 2005. What is a Policy Instrument? Tools, Mixes, and Implementation Styles. *In*: F.P. Eliadis, M.M. Hill and M. Howlett, eds. *Designing government. From instruments to governance*. Montreal: McGill-Queen's University Press, 31–50.

Howlett, M., Ramesh, M., and Perl, A., 2009. *Studying public policy: Policy cycles and policy subsystems*. vol. 3. Oxford University Press Oxford.

Ingold, K., 2014. How involved are they really? A comparative network analysis of the institutional drivers of local actor inclusion. *Land Use Policy*, 39, 376–387.

Ingold, K., *et al.*, 2019. On the necessity of connectivity: linking key characteristics of environmental problems with governance modes. *Journal of Environmental Planning and Management*, 62 (11), 1821–1844.

Ingold, K. and Gavilano, A., 2020. Under what conditions does an extreme event deploy its focal power? *In*: F. Bynander and D. Nohrstedt, eds. *Collaborative crisis management: Inter-organizational approaches to extreme events*. Routledge, 132–147.

Jänicke, M. and Volkery, A., 2001. Persistente Probleme des Umweltschutzes. *Natur und Kultur*, 2 (2), 45–59.

Jong, P. and van den Brink, M., 2017. Between tradition and innovation: developing flood risk management plans in the Netherlands. *Journal of Flood Risk Management*, 10 (2), 155–163.

Jongman, B., 2018. Effective adaptation to rising flood risk. *Nature Communications*, 9 (1), 1986.

Kaufmann-Hayoz, R., *et al.*, 2001. A typology of tools for building sustainability strategies. *In*: *Changing things—moving people*. Springer, 33–107.

Kirschke, S., Borchardt, D., and Newig, J., 2017. Mapping Complexity in Environmental Governance: A Comparative Analysis of 37 Priority Issues in German Water Management. *Environmental Policy and Governance*, 27 (6), 534–559.

Knoke, D., 1993. Networks of elite structure and decision making. *Sociological Methods & Research*, 22 (1), 23–45.

Koppenjan, J. and Klijn, E.H., 2004. *Managing uncertainties in networks: Public private controversies*. Routledge.

Kundzewicz, Z.W., 1999. Flood protection—sustainability issues. *Hydrological Sciences Journal*, 44 (4), 559–571.

Kundzewicz, Z.W., 2002. Non-structural flood protection and sustainability. *Water International*, 27 (1), 3–13.

Lahat, L., 2011. How Can Leaders' Perceptions Guide Policy Analysis in an Era of Governance? *Policy Sciences*, 44 (2), 135–155.

Larson, K.L. and Edsall, R.M., 2010. The impact of visual information on perceptions of water resource problems and management alternatives. *Journal of Environmental Planning and Management*, 53 (3), 335–352.

Leenders, R., 2002. Modeling social influence through network autocorrelation: constructing the weight matrix. *Social Networks*, 24 (1), 21–47.

Leifeld, P. and Cranmer, S., 2015. The temporal network autocorrelation model. *Working paper and package vignette*.

Lubell, M. and Fulton, A., 2007. Local Policy Networks and Agricultural Watershed Management. *Journal of Public Administration Research and Theory*, 18 (4), 673–696.

Maidl, E. and Buchecker, M., 2015. Raising risk preparedness by flood risk communication. *Natural Hazards & Earth System Sciences*, 15 (7).

McGuire, C.J., 2015. The role of risk perception in building sustainable policy instruments: a case study of public coastal flood insurance in the USA. *Interdisciplinary Environmental Review*, 16 (2-4), 232–252.

Meera, P., *et al.*, 2016. Serious game on flood risk management. *In*: *Emerging research in computing, information, communication and applications*. Springer, 197–206.

Mees, H., Crabbé, A., and Driessen, P.P., 2017. Conditions for citizen co-production in a resilient, efficient and legitimate flood risk governance arrangement. a tentative framework. *Journal of Environmental Policy & Planning*, 19 (6), 827–842.

Metz, F., 2017. *From Network Structure to Policy Design in Water Protection: A Comparative Perspective on Micropollutants in the Rhine River Riparian Countries*. Springer.

Metz, F. and Glaus, A., 2019. Integrated water resources management and policy integration: Lessons from 169 years of flood policies in Switzerland. *Water*, 11 (6), 1173.

Metz, F. and Ingold, K., 2014a. Policy instrument selection under uncertainty: The case of micropollution regulation. *Annual Meeting of the Swiss Political Science Association*. Bern, Switzerland, 30.-31.01.2014.

Metz, F. and Ingold, K., 2014b. Sustainable wastewater management: Is it possible to regulate

micropollution in the future by learning from the past? A policy analysis. *Sustainability*, 6 (4), 1992–2012.

Metz, F. and Ingold, K., 2017. Politics of the Precautionary Principle: Assessing Actors' Preferences in Water Protection Policy. *Policy Sciences*, 50 (4), 1–23.

Nelson, T., 2004. Policy goals, public rhetoric, and political attitudes. *The Journal of Politics*, 66 (2), 581–605.

Nordbeck, R., Steurer, R., and Löschner, L., 2019. The future orientation of Austria's flood policies: from flood control to anticipatory flood risk management. *Journal of Environmental Planning and Management*, 62 (11), 1864–1885.

Parsons, M., *et al.*, 2019. Disrupting path dependency: Making room for indigenous knowledge in river management. *Global Environmental Change*, 56, 95–113.

Persson, Å. and Klein, R.J., 2009. Mainstreaming adaptation to climate change in official development assistance: challenges to foreign policy integration. *In*: *Climate change and foreign policy*. Routledge, 180–195.

Peters, B.G., Pierre, J., and King, D., 2005. The politics of path dependency: Political conflict in historical institutionalism. *The Journal of Politics*, 67 (4), 1275–1300.

Schneider, A. and Ingram, H., 1990. Behavioral assumptions of policy tools. *The Journal of Politics*, 52 (2), 510–529.

Slovic, P., 1997. Public perceptions of risk. *Journal of Environmental Health*, 59 (9), 22–23.

Slovic, P., *et al.*, 2004. Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis: An International Journal*, 24 (2), 311–322.

Spangenberg, J.H., 2004. Reconciling sustainability and growth: criteria, indicators, policies. *Sustainable development*, 12 (2), 74–86.

Stead, D., 2018. Policy preferences and the diversity of instrument choice for mitigating climate change impacts in the transport sector. *Journal of Environmental Planning and Management*, 61 (14), 2445–2467.

Suter, H., *et al.*, 2016. Was macht Hochwasserschutzprojekte erfolgreich? Eine Evaluation von Projektablauf und Risiko basierend auf den Perspektiven von Schweizer Gemeinden. *13th Congress Interpraevent 2016*. Lucerne, Switzerland, 30.05.-02.06.2016.

Takeuchi, K., *et al.*, 1998. *Sustainable reservoir development and management*. No. 251. Wallingford, UK: International Association of Hydrological Sciences Press.

Van Buuren, A., Ellen, G.J., and Warner, J.F., 2016. Path-dependency and policy learning in the Dutch delta: toward more resilient flood risk management in the Netherlands? *Ecology*

and Society, 21 (4).

Varone, F., *et al.*, 2013. Functional regulatory spaces. *Policy Sciences*, 46 (4), 311–333.

Verlynde, N., Voltaire, L., and Chagnon, P., 2019. Exploring the link between flood risk perception and public support for funding on flood mitigation policies. *Journal of Environmental Planning and Management*, 62 (13), 2330–2351.

Webber, D.J., 1986. Analyzing political feasibility: political scientists' unique contribution to policy analysis. *Policy Studies Journal*, 14 (4), 545–553.

Weible, C. and Ingold, K., 2018. Why advocacy coalitions matter and practical insights about them. *Policy & Politics*, 46 (2), 325–343.

Werritty, A., 2006. Sustainable flood management: oxymoron or new paradigm? *Area*, 38 (1), 16–23.

Wesselink, A., *et al.*, 2011. Rationales for public participation in environmental policy and governance: practitioners' perspectives. *Environment and Planning A*, 43 (11), 2688–2704.

Wiering, M., Liefferink, D., and Crabbé, A., 2018. Stability and change in flood risk governance: on path dependencies and change agents. *Journal of Flood Risk Management*, 11 (3), 230–238.

World Bank, 2017. *Implementing nature-based flood protection: Principles and implementation guidance*. World Bank, Washington DC.

Zaugg Stern, M., 2006. *Philosophiewandel im Schweizerischen Wasserbau*. Zürich: Schriftenreihe Humangeographie.