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REVIEW ARTICLE

On the necessity of connectivity: linking key characteristics of environmental problems with governance modes

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Environmental problems are often multi-faceted and complex by nature, consisting of diverse, intertwined dimensions. In this article, we argue that environmental problem characteristics have consequences for the selection of appropriate governance modes, and finally on policy effectiveness. We rely on an in-depth literature review to proceed in two steps. First, we outline three key environmental problem characteristics: uncertainties, cause–effect mismatches and norm plurality. We then outline six different governance modes capable of producing policies and solutions to tackle challenges arising from the three problem characteristics. Next, through empirical illustrations, we demonstrate the relevance of linking governance modes to these characteristics via the introduction and articulation of the concept of 'connectivity', i.e., linking actors, issues, sectors and scale levels towards realizing effective policy solutions for complex environmental problems.

Keywords: connectivity; effectiveness; environmental problems; governance modes; public policy

1. Introduction

There are many different frameworks and approaches linking the environment with the way in which it is – or should be – governed. Each of these, however, share a focus on interactions between nature and society, particularly how societal actors, and especially political systems, address problems arising from human–environmental interactions (see Termeer, Dewulf, and Breeman 2015; Lange *et al.* 2013; Driessen *et al.* 2012). These responses, however, have substantially changed over the past 40 years: new strategies have been developed in addition to traditional government interventions. These strategies were implemented to address persistent and emerging environmental problems, as well as to account for changes in the political, economic and societal landscape (Fiorino 2006; Holzinger, Knill, and Schäfer 2006).

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However, still today, the effectiveness of both traditional and new forms of environmental governance is often questioned or even criticised (Young 2011; Newig and Fritsch 2009; Knill and Liefferink 2007; Jordan, Wurzel, and Zito 2003; Lenschow 2002). Effectiveness is considered as one of the most important criteria in environmental policy and governance: It relates to the capacity of public policies, and of the actors introducing and implementing them, to tackle the problem and reach defined goals. We acknowledge that other criteria, such as efficiency, feasibility, accountability or legitimacy, are also important for an overall assessment of governance modes (see Newig and Kvarda 2012; Lieberherr, Klinke, and Finger 2012; Renn 2006; Smith 2003). However, we do not explicitly and systematically address them in this paper and rather focus on effectiveness. We thereby follow the argumentation in policy design that policies, and the arrangements in which they are produced (i.e. governance modes), should be selected that are able to reach defined targets (Howlett, Ramesh, and Perl 2009; Landry and Varone 2005). This target-oriented focus is relevant due to our particular interest in environmental problems urging for policy action (and less on stakeholder satisfaction or ethical norms; see Verschuren, Laird, and Cumming 2000). In policymaking processes, the solution of the environmental problem is articulated by ways of target formulation, and that is why target achievement and thus effectiveness becomes the key criterion. However, we do not conduct traditional policy evaluation (Clarke 1999) in terms of linking instruments to outcomes and back to problems. In this article, we aim at a procedural and structural assessment, focusing on actors, sectors, and institutions. It is thus the effectiveness of governance modes understood as policies, politics and polity that is at the core of our analysis (see Treib, Bähr, and Falkner 2007). Still, we fully acknowledge that procedural aspects of policymaking are strongly entangled with the more substantial elements of policy design (Driessen *et al.* 2012; Howlett 2009)

In this context, we contribute to the environmental governance literature by focusing on concrete environmental problem characteristics and systematically linking them to governance modes to identify ways to enhance the effectiveness of environmental governance. We explore the ideal-type modes of governance associated with specific environmental problem characteristics and the governance challenges they imply. We argue that a necessary precondition for addressing questions regarding effectiveness and ways to improve it is that environmental problems and their key characteristics should be clearly understood and governance modes adopted accordingly. This is in line with Peters and Hoornbeek (2005), who argued that the nature of policy problems should drive the choice of policy instruments. We go beyond this issue, as policy solutions and instruments are not our only area of interest. Indeed, we take a broader view of governance modes, including content-related aspects of policy (to which goals and instruments pertain), actors and interaction-related aspects (politics), and institutional elements (also known as "polity," i.e., the rules of the game; Lange *et al.* 2013).

In this article, we systematically outline the governance challenges of environmental problems such as water pollution, droughts or severe flood events. However, our goal is not to demonstrate the uniqueness of environmental problems but rather to highlight the governance challenges they pose once they are incorporated into the political agenda. Specifically, we address the following research questions:

1. Which specific governance challenges result from the characteristics of environmental problems?

2. Which ideal governance modes effectively address these governance challenges?

To address these questions, we introduce the concept of "enhancing connectivity" to analyse the links between problem characteristics, related governance challenges and governance modes. Enhancing connectivity means linking actors, issues, sectors and scale levels to realise effective policy solutions for complex environmental problems that also account for different values, interests and motivations.

The remainder of this paper unfolds as follows. In Section 2, we introduce the three problem characteristics underlying the proposed framework. We then outline how these characteristics create specific governance challenges as well as the types of challenges most appropriately addressed by different governance modes. More concretely, we introduce, step by step, different connectivity strategies and then illustrate them with case studies derived from the literature. Lastly, we discuss the benefits and potential shortcomings of addressing environmental problems and associated governance challenges through different dimensions of connectivity.

2. Typology of environmental problems

Environmental problems are often characterised through complex cause-and-effect relationships (Lubell and Edelenbos 2013), and are therefore categorised as wicked problems (e.g., Rittel and Webber 1973; see also Termeer, Dewulf, and Breeman 2015; Varone *et al.* 2013). We do not take an environmental problem's complexity or wickedness for granted; rather, we strongly suggest systematically disentangling the particular characteristics of environmental problems that challenge governance modes and impact policy (content), polity (institutions) or politics (actors and interaction processes), either separately or in unison.

Similar to Hoppe (1993, in Hisschemöller and Hoppe 1995) and Carter (2007), we define an environmental problem as a policy problem and concentrate on some of its crucial dimensions. In contrast to both authors, however, we focus strictly on the particular characteristics, at the moment the environmental problem arrives on the political agenda, and do not yet take characteristics into account, that arise once the policy-making process has started.[1] Put another way, we try to separate the two stages and highlight problem characteristics which, in turn, drive the selection of appropriate modes of governance.

In line with Peters and Hoornbeek (2005), we thus identified the following three environmental problem characteristics, which are not yet intertwined with, but nonetheless decisively impact, the design of governance modes (see also Metz and Ingold 2014).

2.1. Uncertainties

Most environmental problems that emerge on the political agenda are accompanied by a non-trivial degree of uncertainty (Newig and Fritsch 2009; Voss *et al.* 2007). Typical examples include climate change, nuclear waste and micropollutants in water. Problems such as these may raise uncertainties about their causes and effects (i.e., about *what* to govern), as well as appropriate response strategies (i.e., *how* to govern). Three types of uncertainty can be distinguished: unpredictability (unpredictable system behaviour), incomplete knowledge (lack of information; unreliable information) and

multiple knowledge frames (conflicting interpretations of human–environment relations; Raadgever *et al.* 2011; Brugnach *et al.* 2008). The main governance challenge is to develop policies and tactics to successfully cope with these types of uncertainties.

2.2. *Mismatches across sectors, levels, space and time*

An important characteristic of many environmental problems is a mismatch between those who create the problems and those forced to deal with the consequences. This mismatch can lead to uneven distributional effects across sectors, levels, space or time (Treml *et al.* 2015). First, *different sources and sectors* (such as agriculture, industry or transportation) might generate environmental problems, while their consequences might affect different sectors of society (e.g., children, communities, and neighbouring contaminated sites). The governance challenge is to compensate for negative effects among the involved parties and sectors. Second, environmental problems can have a *multi-level* and *spatial dimension* (Guerrero *et al.* 2015). While some arise on the local level (e.g., noise nuisance), others are transboundary in nature (e.g., water quality and safety) or have global dimensions (e.g., climate change). However, even when causes are local, their effects can be global, and vice versa. The governance challenge here consists of identifying the appropriate level and area to address the problem. Third, many environmental problems imply a *temporal dimension*. Some environmental problems occur after a substantial delay (e.g., climate change, biodiversity loss, and resource scarcity), demanding enduring solutions. Other problems are short-term (e.g., noise nuisance or extreme weather events) but more frequent, requiring preventive solutions or fast-response measures. One of the main challenges for environmental governance is coping with distributional inequalities resulting from temporal mismatches (see also Ebbeson 2010).

2.3 *Plurality of norms, values and interests*

Finally, environmental problems are characterised by different norms, values and interests within the network of involved public and/or private actors (Weible and Sabatier 2005). This refers to a fundamental belief system with different worldviews and value systems, varying perceptions of cause–effect relationships and different assessments of the effectiveness of policy instruments and regulations (Metz 2017; Jenkins-Smith *et al.* 2014). Moreover, it includes individuals' or organisations' personal interests and agendas, further influencing their definitions of environmental problems. This plurality of norms, values and interests challenges governance with a variety of often divergent preferences for different solutions to emerging environmental problems. The resultant value-laden discourses in terms of policy-making can be defined as ambivalent or compromising with respect to policy goals (Voss *et al.* 2007). Governance modes are required that can reconcile such views and interests.

3. Disentangling governance dimensions through "connectivity"

Very often, a structural perspective is assumed which defines governance as a configuration of actors, embracing both public and private entities, in contrast to a traditional government perspective in which public authorities are (almost) exclusively the focus (Hysing 2009; Kickert, Klijn, and Koopenjan 1997). A multi-level and network governance perspective highlights the interrelated and relational aspects of political

steering located between hierarchies and markets (Sørensen and Torfing 2009; Rhodes 1997; Marks and Hooghe 2001). Others have acknowledged different degrees of state intervention when conceptualising governance modes (Bolleyer and Börzel 2010). Besides these rather actor-centred and process-related approaches, which ask who is included or participating, others are more focused on the type of intervention and thus typically involve a variety of policy instruments to address cross-sectoral and multi-level challenges (Metz and Ingold 2014; Mees *et al.* 2014; Weber, Driessen, and Runhaar 2014; Sager 2009). Finally, institutional aspects are inherent to governance modes (Young 2011; Ostrom 2005): Fragmented or shared responsibilities, as well as overlapping or embedded jurisdictions, establish new rules, norms and values and thus a new social framework for addressing specific (environmental) problems.

In this article, we refer to environmental governance as the goals and measures by which societies interact with and manage the environment (Lemos and Agrawal 2006). Hence, we focus on societal responses or content that results from a certain type of actors' configuration within a specific institutional setting – also known as "modes of governance" – to address a problem resulting from human–environment interactions. As outlined by Treib, Bähr, and Falkner (2007) a broad variety of different phenomena is associated with governance modes. Based on existing literature, these authors classify the existing understandings according to the politics, the polity or the policy dimensions of governance respectively (ibid). We basically borrow from the underlying logic proposed by Driessen *et al.* (2012), to distinguish between five ideal-type modes of governance mapped on a continuum of state and non-state involvement. The authors identified modes where public actors are the main protagonist (subdivided into centralised and decentralised modes), modes of public–private interactions ("public–private governance" and "interactive governance") and modes primarily involving private actors ("self-governance"). Although we do not adopt these five ideal-types, and consequently do not include self-regulation in our analysis, we adopt the same underlying logic of governance modes, for example policies, politics and polity including actors, sectors, and institutions. Moreover, in addition to public actors we acknowledge for individuals and organisations from businesses and civil society who participate in the design and implementation of environmental policies as key elements of these modes.

We argue here that problem characteristics should drive the selection of appropriate modes of governance. Starting with the governance challenges identified above (see also second column in Table 1), we contend that each challenge can be addressed most effectively through specific connectivity strategies which bridge sectors, actors, institutions and levels (third column in Table 1). In line with the classification of governance modes by Treib, Bähr, and Falkner (2007), each of the connectivity strategies can be attributed to one or more dimensions: policy (content), politics (actors and interaction processes), or polity (institutions; see fourth column in Table 1). We subsequently introduce, justify and illustrate the different connectivity strategies by illustrating prominent examples from the literature that establish a link between specific environmental problems and selected governance modes. In doing so, we highlight the benefit of connectivity as a concept when thinking about governance modes and how to systematically link them to environmental problem characteristics. Subsequently, for each problem characteristic, the suggested connectivity strategies are outlined and supported by illustrations (see also columns three and five in Table 1).

Table 1. Problem characteristics, related governance challenges and connectivity strategies.

Environmental problem characteristics	Governance challenges	Connectivity strategies (suggested governance modes)	Dimension of governance modes	Illustrations
Uncertainty	Identifying and dealing with different types of uncertainties (about causes, effects and appropriate solutions)	Connecting science with politics	Politics (policy)	Bridging organizations in water management (Crona and Parker 2012); mining in the Dutch Wadden Sea (van Tatenhove 2017)
Mismatch across sectors, levels, space and time	To cope with uneven distributional effects, inequalities and missing accountability or legitimacy mechanisms	Connecting different sectors	Policy (polity)	Flood prevention in the Netherlands (Hegger *et al.* 2014); Climate Change Adaptation in Germany and the Netherlands (Bauer and Steurer 2015)
		Connecting different administrative levels	*Polity (politics; policy)*	*Cities for Climate protection programme (*Betsill and Bulkely 2006*); Swiss climate change adaptation (*Ingold 2014*)*
		Connecting jurisdictions and areas	Polity	Functional regulatory spaces (Varone *et al.* 2013; mountain initiatives (Balsiger and Nahrath 2015)
		Connecting long-term planning with short-term response	*Policy, politics polity*	*Climate risk perception (*Leiserowitz 2006), Interactive policymaking (Edelenbos, Klok, and Tatenhove 2009)
Plurality of norms, values and interests	Reconciliation of conflicting norms, values and interests	Connecting different problem frames	Policy, politics	Regional development and new policies (Driessen and Glasbergen 1995); network connections (Prell, Hubacek, and Reed 2009)

3.1 Uncertainties

Environmental problems are often accompanied by uncertainties about their causes, effects or solutions (Wardekker *et al.* 2008; Metz and Ingold 2017). Typically, the first generation of environmental problems, such as fish kills in the 1960s or forest dieback in the 1980s, emerged with no known cause, and this uncertainty persisted for a long time (Andrews 2006). In terms of policy design and governance of environmental problems, uncertainty can be problematic; conversely, because state action must be justified by evidence, identification of the appropriate problem might still cause problems. Citizens might become unsettled or even panic when confronted with certain policies aimed at raising their awareness about the problem (e.g., policies addressing environmental risks, such as floods or water quality). Furthermore, opponents of a policy can use uncertainties strategically to contest that policy (van Enst, Driessen, and Runhaar 2014; Wardekker *et al.* 2008).

Governance challenges typically arise from the multifarious nature of uncertainties (i.e., in terms of causes, effects and solutions), yet one prominent governance mode has been suggested that addresses all of them, by connecting science and politics.

3.1.1. Connecting science and politics

When problem properties, effects or solutions are not yet well known, political and administrative entities tend to call for evidence-based policy-making, involving scientific actors and experts at different stages of the policymaking processes (see Cairney 2016; Black 2001). But connecting (scientific) supply and (political process-related) demand appears to be challenging: Demands for additional and policy-relevant knowledge often fail to be met, not only because certain processes in the natural system are unpredictable (Brugnach *et al.* 2008), but also because scientific knowledge production is not based on policy needs per se (van Enst, Driessen, and Runhaar 2014; Sarewitz and Pielke Jr. 2007; Meadowcroft 2009). The two illustrations below show how science can be connected to politics, and vice-versa, to address uncertain and complex environmental phenomena.

Illustration 1: The role of "bridging organisations" in water management. *Crona and Parker* (2012) *analysed the metropolitan area of Phoenix in the southwestern US state of Arizona. They focused on water management, which is, in this arid zone, greatly challenged by climate change. Uncertainties exist about the exact degree, timing and water-related consequences sector of climate change effects. To address this problem, they presented a way to connect science to politics, through so-called "bridging organisations". According to Cash* et al. (2006)*, bridging organisations link science to decision-making across multiple levels.* Crona and Parker (2012) *investigated the degree of connection between science and decision-makers; namely, between academic and water governance groups. They studied the role of the "decision centre for a desert city" (DCDC) in Arizona as an example for such a bridging organisation. They concluded that uncertainties about environmental issues can best be reduced, and policies and solutions to the problem best produced, when different types of interactions among scientific experts, practitioners and decision-makers are investigated. They found that depoliticised arenas were the most promising "location" for different types of actors to exchange information and interact. In conclusion, their study confirmed the important*

role of bridging organisations as one form of science–politics connection when addressing uncertain environmental problems.

Illustration 2: Dealing with the uncertain effects of gas mining in the Dutch Wadden Sea. *Runhaar, van der Windt and van Tatenhove* (2017) *analysed the role of scientific studies on the ecological impacts of subsidence due to gas mining in the Dutch Wadden Sea. Due to subsidence (in combination with climate change-induced sea level rise), tidal basins may be submerged and no longer available as foraging areas for the many wading birds that depend on the Wadden Sea. Environmental impact assessments could not provide 100% certainty about these effects, and a governance challenge consequently arose in regard to the selection of the appropriate intervention: permitting activities and taking risks, or banning mining as a precautionary measure. Ultimately, gas mining was permitted, but under strict conditions: An arrangement was made by which gas mining would be continuously monitored and an independent scientific committee would review the quality of the monitoring. In the case of subsidence, gas mining would be stopped immediately – the "hand on the tap" principle (Runhaar, van der Windt, and van Tatenhove 2017). This example of science-based "adaptive management" shows how science and policy can be connected in uncertain situations and/or where traditional scientific (impact) assessment reaches its limits.*

3.2. Mismatches across sectors, levels, space and time

Cross-sectoral, multi-level, transboundary or temporal mismatches arise when problems are caused by activities in one sector, country, jurisdiction or period, but their effects are felt elsewhere, spatially or temporally.

Several examples exist for such cause–effect mismatches: The contamination of water bodies and soil with persistent pharmaceutical pollutants, for example, not only involves the pharmaceutical industry, the water supply and wastewater management, but also affects fisheries, agriculture and/or public health (Brodin *et al.* 2013; Besse, Kausch-Barreto, and Garric 2008). The crucial point here is that the public authorities responsible for the management and regulation of resource uses are often organisationally separate from those tackling critical environmental problems. Institutionally speaking, they might be located in different departments or administrative entities. But the cross-sectoral nature of problems like the one just described demands not only institutional coherence and coordination, but also a policy design that can exploit synergies between different sectors, related actions and public policies (Persson and Klein 2009). Coordination efforts such as this might, however, be challenged by the fact that the goals, interests and priorities of the actors and sectors involved might differ substantially, resulting in potentially contradictory sectoral policies. This challenge could be addressed by connecting different sectors in terms of policy design and institutional arrangements. Accordingly, these governance modes are presented in more detail below (Section 3.2.1).

The abovementioned problem of pharmaceutical water and soil contamination is not just cross-sectoral, but is often also multi-level. Multi-national firms, as well as regional and local pharmaceutical consumers, all contribute to the problem; likewise, the prevailing political system and its characteristics (e.g., central vs. federalist state) might contribute to vertical fragmentation. Also, climate change represents an ideal-type of multi-level challenge, where global warming due to greenhouse gas emissions is discussed at a global level, but most climate change effects are felt at regional and

local levels (Ingold and Pflieger 2016; Ingold 2014). Accordingly, connecting these different levels can be viewed as a crucial determinant of the appropriate governance mode. Adopting an actor-centred approach, we illustrate two examples of connectivity at multiple levels among both public and private actors (Section 3.2.2).

The source of an environmental problem can be spatially separated from its consequences. For instance, river pollution affects downstream sites, acid rain may fall far away from power plants, and sulphur dioxide and CO_2 emissions cause global warming, resulting in, inter alia, rising sea levels that mostly affect low-lying coastal regions. As these examples show, environmental problems are not constrained by political borders. Thus, the governmental and administrative authorities in charge of addressing particular environmental problems may have no jurisdiction over the source of the problems. Put differently, a socioecological mismatch often exists between current politico-administrative jurisdictions and environmental problems (Bodin *et al.* 2014). Connecting different jurisdictions and environments, or even building new functional spaces, is thus a warranted connectivity strategy and governance mode, as presented in Section 3.2.3.

Lastly, a temporal mismatch, that is, a delay, might exist between the causes and effects of environmental problems. This could lead to intergenerational inequalities as well as legitimacy and accountability challenges: In recent decades, contaminated sites and old industrial facilities have deteriorated, requiring costly clean-up and rehabilitation. The owners or concessionaires of these sites, however, are often no longer alive or in control, making it difficult to determine accountability. Connecting long- and short-term planning and perspectives may be the appropriate governance mode needed to resolve this temporal issue, as discussed in Section 3.2.4.

3.2.1. Connecting different sectors in policy design and institutional arrangements

Policy design is the process whereby political actors work towards an agreement on similar goals in a specific context (Howlett and Lejano 2013). From a technocratic point of view, it involves the selection of instruments to reach defined political objectives (Howlett 2009). That said, finding the appropriate measures to address a societal, or socioecological, problem is never easy; and the process of policy design is further challenged in cross-sectoral situations.

Before a policy is introduced, some actors are classified as natural resource users who are the source of the problem (e.g., water pollution, overuse), whereas others are considered victims suffering from the negative actions of the former (Knoepfel 2007). An effective policy identifies both the sources and the victims of a problem. Ideally, the first become the target group, while the second represent the beneficiaries of a proposed environmental policy design (ibid.). This mechanism, however, does not work or is at least heavily challenged in a cross-sectoral setting. If a policy, even a greatly effective one, is introduced for a target group in sector A, it might still be ineffective for victims or additional target groups in sector B. To increase policy effectiveness and reduce negative distributional effects, we thus argue that a cross-sectoral policy design, which would address actors from different sectors, is necessary.

When designing cross-sectoral policies, several elements should be considered: First, instruments are seldom introduced in isolation from others. Their effectiveness heavily depends on other policy measures previously or simultaneously introduced in the same or different political fields (Weber, Driessen, and Runhaar 2014). Second, it is difficult to predict citizens' or target groups' reactions to new or altered instruments,

which could hinder their successful implementation. Third, a proposed instrument is seldom without alternatives. As a result, disagreements and opposing interests often lead to the selection of so-called "second-best options".

An environmental problem with cross-sectoral characteristics, and challenges in conceiving and designing cross-sectoral policies, are outlined in an illustrative example of Dutch flood prevention, presented below.

Illustration 1: Cross-sectoral flood prevention in the Netherlands. *Hegger* et al. (2014) *focused on the problem of climate change adaptation in general and flood prevention in particular. Besides the fact that flood events, primarily their frequency and extent, might be related to complex, interrelated geo-physical and climatic processes influenced by anthropogenically produced greenhouse gas emissions, floods result in cross-sectoral effects. They might affect land use and agriculture, housing or drinking water supply, and different types of reactions related to infrastructure, information systems or spatial planning. Designing flood prevention thus challenges various sectors, and Hegger* et al. (2014) *systematically outlined how the connection between different prevention strategies in diverse sectors and areas can overcome cross-sectoral fragmentation. They distinguished between five measures: flood defence, risk prevention, risk mitigation, flood preparation and flood recovery. In the case of Dordrecht Island, located at the prime west-coast urban agglomeration of the Netherlands, data were collected via in-depth document analysis as well as knowledge and experiences from other cases and programmes involving Dutch climate change adaptation or the Dutch Delta Programme. This case shows that flood recovery, and to some extent flood preparation measures, are typically designed to reduce risk in the event of natural disasters. Or, put differently, the major aim is to inform and protect the population during natural disasters, which does not require much cross-sectoral engagement. This is very different for flood mitigation or prevention: Here, the underlying assumption is that the mere risk of a flood can be reduced. In the case of Dordrecht, for instance, risk prevention measures include reducing urbanisation in the south of the island where flood governance is intimately connected to land use and spatial planning. Thus, to cope with cross-sectoral mismatches and prevent distributional inequalities between different sectors (e.g., prioritise urban areas over agricultural landscapes when designing so-called "flooding areas"), Hegger* et al. (2014) *emphasised a combination of different policy measures and responses.*

Another approach that enhances the connectivity of different policy sectors to environmental problems is Environmental Policy Integration (EPI). In general, EPI means that environmental objectives and instruments are included in all stages of policy-making in non-environmental sectors to either minimise conflicts with environmental policies or prioritise the former over the later (Lafferty and Hovden 2003). EPI thus aims to account for the borderless nature of environmental policy, which would otherwise be challenged by the decentralisation and functional specialisation of governments and administrations. To address this horizontal type of fragmentation, the EPI literature has suggested establishing organisational routines, such as working groups or interdepartmental committees, institutionalising procedures of information exchange or consultation, and implementing new instruments or reporting and monitoring practices (Runhaar, Driessen, and Uittenbroek 2014; Persson 2004; Jordan and Lenschow 2010).

Illustration 2: Cross-sectoral integration in climate change adaptation policy. *Bauer and Steurer* (2015) *analysed different approaches for integrating the*

governance of climate change adaptation with water and coastal management in Germany and the Netherlands. Due to its borderless nature (e.g., agriculture, water, tourism), policy integration has emerged as a key principle in climate change adaptation policy (e.g., Bauer, Feichtinger, and Steurer 2012). Moreover, due to varying local vulnerabilities and impacts, adaptation is also considered a cross-level issue. Although integration has been accepted as a principle in adaptation policy in both countries, their study reveals substantial differences in organisational and institutional arrangements: While Germany addressed adaptation for water and coastal management in a sweeping National Adaptation Strategy (NAS), the Netherlands chose a sectoral approach (the Dutch Delta Program) to integrate adaptation based on existing programmes in these two sectors. Bauer and Steurer (2015) showed that different approaches and contexts influenced the outcomes. While the German adaptation strategy lacks a binding character, the Dutch programme has a statutory role. Consequently, the Dutch programme involves strong financial backing and a long-term perspective. In contrast, no budget is allocated in Germany and adaption is mainly "business as usual". Moreover, due to the context of a unitary state, the Dutch programme is characterised by a top-down approach; meanwhile, the federal structure in Germany inhibits strong linkages to the provincial level. That said, the Dutch programme fails to integrate a broad range of sectors and exclusively focuses on water safety. The German NAS is more comprehensive, although this is no guarantee of successful implementation of adaptation policy. The study by Bauer and Steurer (2015) plainly demonstrated that policy integration has been adopted very differently across countries and that its effectiveness depends not only on the degree of cross-sectoral integration, but also the specificities of the political system in question.

3.2.2. Connecting different government and administrative levels

The concept of multi-level governance was explicitly developed to account for environmental policy (as well as other policy fields) becoming increasingly influenced by interactions between different governmental and administrative levels, instead of being the exclusive domain of the nation state (Hooghe and Marks 2003). In accordance with our framework (see Section 2), the enhanced need for multi-level interaction is due to the evolution of global and transnational environmental problems (Mitchell 2008). Furthermore, it is a reaction to the overall institutionalisation of environmental policies in international and supranational organisations, such as the European Union (Connelly *et al.* 2012; Jordan and Adelle 2012).

While multi-level governance was initially an analytical concept for describing and explaining current developments, it has recently been adopted by policymakers while gaining increased practical relevance in terms of establishing institutional, financial and collaborative links between levels, improving policy coherence to increase effectiveness, and shifting competences to subnational levels. Accordingly, local levels and initiatives have received increasing attention in the environmental governance literature, as the two illustrative examples below describe.

Illustration 1: Climate policy operating at and between different levels. Betsill and Bulkely (2006) *analysed the Cities for Climate Protection programme, demonstrating how this local initiative was embedded in (transnational) cooperation networks and established partnerships with businesses and non-governmental actors. Doing so involved traditional national government tasks, such as setting emissions*

standards or securing financial resources. This example shows how traditional state responsibilities can be reconfigured across levels and actors for the specific task of climate change mitigation. Moreover, where traditional divisions between governmental levels are insufficient, establishing new forms of authority can substantially enhance the effectiveness of environmental policy.

Illustration 2: The integration of local actors in Swiss climate adaptation policy. *Similar considerations to those illustrated in the example above have also been made in terms of adaptation to climate change. Ingold* (2014) *compared seven different climate change adaptation projects in two Swiss mountain areas. She was particularly interested in the inclusion of local actors in the design and implementation processes of flood prevention and land-use projects, as local communities and stakeholders are particularly affected by natural resource degradation in their areas. Local climate change impacts might typically be induced by global, or geographically distant, greenhouse gas emissions. In this complex, multi-level setting, the question arises as to what extent local (in contrast to regional or national) actors organise themselves in response to climate change adaptation. Data stemming from semi-structured surveys and the inclusion of local actors was assessed via social network analysis. The results indicated that local climate change adaptation initiatives in Switzerland are strongly characterised by interactions of local, regional and national actors. Regional actors seemed to play a crucial role as gatekeepers between the upper (national) and lower (local) levels; local actors, on the other hand, only managed to assume a leading role in such initiatives when they were the initiators of the project. Connecting different levels thus seems possible, but would mainly be shaped by intermediary (regional or subnational) and not local actors.*

3.2.3. Connecting different jurisdictions

The connection of different jurisdictions or geographically distant areas becomes crucial when the causes and effects of an environmental problem are spatially distant. So-called "functional regulatory spaces" (FRS) represent one concept for addressing spatial variability by connecting different areas (Holzinger 2000; Frey and Eichenberger 1999). Following Varone *et al.* (2013, 320), a functional space is "a regulatory space, which politically emerges in order to tackle, support or solve problems concerning several policy sectors in different institutional territories and at different levels of government […]. They are alternative regulatory spaces within which it becomes possible to tackle new types of problems that cut across various socioeconomic sectors, as well as institutional territories and government levels". This concept integrates approaches that demand enhanced coordination between sectors, institutions and levels. Moreover, it stipulates a rescaling process in terms of redefining the issue (problem definition), institutions (hierarchies and policy competences across government levels) and scales (spatial parameters of action).

Through the application of the functional space concept, the two illustrations below show how jurisdictions and areas can be connected to tackle transboundary and cross-border environmental problems.

Illustration 1: (Un)successful examples of functional regulatory spaces in water and airspace politics. *Varone* et al. (2013) *put the concept of functional regulatory spaces (FRS) – and thus their spatial, institutional and political connections – forward to address so-called "wicked" problems. Wicked problems are those which affect*

a large part of the population, have severe consequences for humans and ecosystems, have complex causes, and require urgent solutions. Climate change, biodiversity loss or technological risks are examples of wicked problems, calling for new, more complex and innovative forms of governance, such as FRS. FRS are characterised through increased coordination among sectors, the building of new territorial jurisdictions, and the installation of multi-level institutions. Varone et al. (2013) *concluded that water policy within hydrological catchment areas, as outlined by the European Water Framework Directive, corresponded to an ideal type of functional space, whereas European airspace blocks do not. Both spaces manage to install cross-sectoral and transboundary governance modes, but the latter falls short in terms of multi-level coordination, as air traffic control is still maintained at national (not supranational) levels. This example shows how connecting jurisdictions is important for addressing spatial mismatches, but it also indicates that cross-sectoral and multi-level dimensions, as separately outlined under Sections 3.2.1 and 3.2.2, should also be taken into account.*

Illustration 2: Simultaneous transboundary coordination across sectors and jurisdictions. *While cross-sectoral and multi-level considerations are increasingly being adopted in policy-making (see also Sections 3.2.1 and 3.2.2), transterritorial coordination, which arises from the cross-border character of many mountain areas, must also be recognised. As the combination of these three coordination challenges basically follows the FRS approach, Balsiger and Nahrath* (2015) *evaluated the level of correspondence of seven mountain initiatives to the ideal type of FRS in terms of their degree of formalisation and institutionalisation. Regarding transterritoriality and multi-level governance arrangements, the authors revealed substantial differences between the seven initiatives, resulting from the overall but diverse impact of EU and UN frameworks and programmes in which they are embedded. Their findings suggest that an ideal-type FRS might be an effective – although due to substantial transaction costs, not necessarily the most efficient – approach to addressing wicked problems in terms of connecting jurisdictions and regions, but also sectors and levels.*

3.2.4. Connecting long term-planning to short-term action

Disasters such as flood events or nuclear power accidents demand immediate action by public authorities with appropriate emergency and action plans. But such disasters often also have long-term, environmental effects (e.g., on infrastructure or soil quality) as well as political ramifications (Nohrstedt and Weible 2010; Birkland 2006) via so-called "focusing events," which call into question current policy paradigms and policy-making (Cairney and Weible 2015). In the case of flood prevention, this could result in a shift away from purely technical and infrastructure-based solutions to more sustainable spatial planning options (Hegger *et al.* 2014); likewise, in the case of nuclear accidents, a shift in paradigm towards renewable or more efficient energy sources could result (Huenteler, Schmidt, and Kanie 2012). When environmental problems ask for both short- and long-term responses, their connectivity appears to become crucial, as emphasised in the following two examples.

Illustration 1: Climate change risk perception and related policy preferences. Leiserowitz (2006) *sought to bring risk perceptions of long-term phenomena in line with citizens' policy preferences. Therefore, relying on a household survey, he investigated how American citizens perceived climate risks, especially in relation to*

international and national actions to reduce greenhouse gas emissions. Climate change is a typical example of a temporal mismatch: The source of a problem might occur, for instance, in different sectors (such as industry, transportation, agriculture or forestry) and at different levels (global causes and local effects); but current anthropogenic greenhouse gas emissions might only demonstrate a significant effect on global climate many years or even decades from now. This temporal lag thus calls for inter-generational solidarity as outlined by the sustainability principle. Leiserowitz, back in 2006, concluded that despite a majority of the American public he surveyed being highly aware of climate risks, their concern about the effects of climate change was low. This might be one indicator of low inter-generational responsibility, one which has immediate impact on policy design: Options for the most effective, incentive-based instruments (energy price signals) were the most opposed. Thus, costly and immediate action for short- and long-term climate change mitigation was not accepted, even though awareness about the risks and effects was high.

Illustration 2: Institutional embedding of interactive environmental governance approaches. *Edelenbos, Klok and van Tatenhove* (2009) *investigated the institutional embeddedness of interactive policy-making in the Netherlands; or, in other words, how formal and informal forms of policy development and decision-making can be aligned. Based on a comparative case study of eight regional, sustainable development projects, the authors concluded that there are three forms of institutional embedding: the administrative-bureaucratic (i.e., the correspondence between the interactive process and bureaucracy of a government), the executive (i.e., the correspondence between the interactive process and the implementation side of decision-making) and representative-political (i.e., the correspondence between the interactive process and the democratic procedure for decision-making). When these three forms are present and well organised, there is a greater probability that the results of an interactive process will actually affect environmental policy-making, in the short- as well as long-term. This means that managers of such interactive projects play a key role in connecting informal means of environmental policy development with formal arenas of decision-making.*

3.3. Plurality of norms, values and interests

A key challenge accompanying environmental problems is how they are framed or perceived. Frames are cognitive interpretations of complex phenomena that help us to understand them. When people label a phenomenon, they give meaning to some aspects while disregarding others as less important. Differences in problem frames are caused not only by different knowledge bases or even lack of knowledge, but also by differences in interests, beliefs or worldviews (Jenkins-Smith *et al.* 2014). Farmers, for instance, sometimes have different views of biodiversity protection than ecologists or government representatives. Of course, a plurality of ideas and views has its own merits. It can lead to confrontations, to discussions, to mutual learning, and ultimately, to common perspectives. However, in practice, it often leads to controversy and stalemate (Runhaar and van Nieuwaal 2010; van Eeten 1999). There are many examples where differing frames for environmental problems have caused conflicts between governments, businesses and social organisations, in instances such as airport expansion, the construction of onshore wind farms, the erection of dikes along rivers, urban developments and water quality measures in agricultural areas. Key questions arising from

such controversies are always who is causing the problem, who is responsible for the solution, what 'quality of environment' should we aim for, and at what price? Simply merging these different problem frames is not always easy, but prioritising one frame at the expense of others also generates difficulties. Thus, strategies which connect different frames are important new governance modes insofar as they address the concerns of various interests and worldviews that would otherwise likely result in policy conflict and/or stalemate.

3.3.1. Connecting different problem frames

Many scholars have contributed to developing ideas about how to cope with divergent policy frames in policy-making. Encouraging stakeholder participation and partnerships among multiple actors and across several policy levels, especially collaborative and deliberative governance arrangements, is considered promising (e.g., Lange *et al.* 2013; Voss *et al.* 2007; Driessen, Glasbergen, and Verdaas 2001). Yet, although cooperation and deliberation between stakeholders and governments are key issues in governance, the literature has also underscored how difficult it is to arrive at a common perspective between a multitude of actors with significantly different interests. In general, multiple definitions and views may be considered simultaneously, so long as all parties agree to do so.

Illustration 1: Creating room for different problem frames by broadening the scope of a project. Driessen and Glasbergen (1995) *investigated conflicts between agricultural development and nature conservation in the Netherlands. In some regions in the Netherlands, intensive livestock farming has increased sharply since the 1960s, as have the environmental problems associated with it (acidification of soil and air by ammonia release; contamination of ground water and surface water by phosphate and nitrate leaching; degradation of nature reserves). Twenty years ago, a new policy was developed. The question was no longer what regulations and associated compliance strategies are necessary to solve the environmental problems caused by the agricultural sector, but rather how can a regional development perspective be drawn such that it leads to a rapid reduction in the environmental load while offering promising options for sustainable socioeconomic development of the agricultural sector and the preservation of nature conservation areas? This new perspective created more room for all stakeholders to voice their own views and interests in the negotiation process. In fact, environmental goals were placed in a wider developmental perspective for each region, with equal attention paid to all stakes involved. In this way, environmental issues were well connected to socioeconomic problems.*

Collaborative network analysis is another approach for connecting different problem frames towards the resolution of conflicts stemming from different norms, values and interests. Collaborative network studies are also and often encouraged by so-called "stakeholder analysis," which can clearly be developed without any network component (as seen above), identifying relevant actors, organisations and individuals by first defining the issues each has a stake in (Prell, Hubacek, and Reed 2009; Ansell and Gash 2008). These studies typically focus on the daily management and (in)direct use of natural resources. Civil society and local communities depend on the natural resources, but so too do service deliverers (e.g., drinking water suppliers), policy implementers and street-level bureaucrats (e.g., forest rangers, local/regional regulators).

Regulating natural resources at the local level might be considered in the design of collaborative or participatory governance structures (Lubell and Edelenbos 2013).

Illustration 2: Connecting different frames through network connections. *Prell, Hubacek and Reed* (2009), *who studied Peak District National Park in the UK, effectively showed how intertwined stakes, different interests and diverse resource uses can lead to potential rivalries between environmental use and protection, tourism and agriculture. The authors thus provided not just an illustrative example of conflicting problem frames, values and interests, but also horizontal fragmentation in one specific, geographically delimitated area. Through stakeholder analysis, they first defined a number of so-called "issues" the different actors could have a stake in. They then derived eight different stakeholder groups for the area (water companies, recreational groups, agriculturalists, conservationists, grouse moor interests, tourist firms, foresters and statutory bodies). Members of these groups were defined as the nodes in the network. Via the detailed investigation of strong versus weak ties, the degree of each actor's inclusion was assessed. Centrality measures were then used to identify those actors with the most strategic ties in the network: those who controlled information flow and collaboration in the park. These results were then presented to stakeholders at a conference in order to develop strategies on how to further improve stakeholder representation and, most importantly, how to overcome different problem frames through participative methods of stakeholder and network analysis.*

4. Further governance challenges

The illustrations provided above demonstrate how the six presented connectivity strategies might support the design of efficient and effective governance modes towards solving environmental problems. But the illustrations also highlight other challenges which might arise from and intervene in environmental governance – challenges that are not directly related to, or derived from, the three characteristics of environmental problems (e.g., second column of Table 1). However, these governance challenges might enhance, as well as impede, the development of solutions to environmental problems. The most relevant challenges, as identified in the illustrations, are introduced and discussed below.

4.1. Democratic legitimacy

The examples pertaining to the connection between science and policy (Section 3.1) and different problem frames (Section 3.3; see Table 1 for an overview) explained that besides formal decision-makers, other types of actors, typically scientific experts or private organisations, can participate in the policy design and implementation process. These "new," private actors are not legitimized by democratic election; that is, they are included in political decision-making via science–policy interfaces and governance networks, yet are not accountable according to a liberal-democratic understanding policy-making processes (Benz and Papadopoulus 2006; Papadopoulos 2003; Pierre and Peters 2005). Therefore, citizens cannot vote them out of office should they disagree with their political performance. Moreover, these actors might diminish the influence of elected officials from traditional democratic institutions, such as parliaments. Indeed, citizens might even be unable to identify accountable agencies in the complex

and intricate context of public and private actors. However, while it has been argued that a lack of accountability can lead to performance problems, thus far "a model of political accountability in a governance perspective" has not been developed (Pierre and Peters 2005, 127).

4.2. Coping with traditional political power structures

Pioneers of environmental policy had enormous faith in the capabilities of governments to solve natural resource and pollution problems. Based on a government's superior hierarchical position, interventions tended to follow a command-and-control approach (Driessen and Glasbergen 2001). Yet, this form of steering and regulation was insufficient in addressing environmental problems caused in one location but affecting another. To address sectoral, multi-level and spatial mismatches, integrated and transboundary institutional arrangements and policy solutions emerged (Sections 3.2.1–3.2.3; see also Jordan and Lenschow 2010). Environmental Policy Integration (EPI) is one such approach insofar as it extends the influence of environmental departments. Previous research has shown, however, that EPI's influence over powerful economic departments remains weak (Carter 2007). Connecting different sectors, administrative levels and different jurisdictions might thus be impeded by traditional, prevailing power structures and competences (see also WCED 1987).

4.3. Institutions and policy styles matter

The negative effects of traditional structures are not limited to coping with cross-sectoral, multi-level or spatial mismatches. Mainly in governance systems of Type I (Hooghe and Marks 2003), the implementation of connectivity strategies might be more seamless than in traditional, centralised and top-down systems. Typical examples of Type I governance include the European Union or other federalist systems where most tasks are delegated to lower jurisdictional levels. Where coordination among levels is already established, or where local communities or subnational entities have expertise in independent policy design and implementation, a positive effect of the establishment of innovative governance modes can be expected. A positive effect has also been observed in institutional settings where internal coordination (such as "joined-up government" in the UK) is part of the political system (Russel and Jordan 2008).

4.4. Short-term side effects

The design of long-term, preventive policies is an important strategy for coping with inter-generational differences (Section 3.2.4), but research has shown that such policies may have short-term, potentially negative repercussions (Runhaar, Dieperink, and Driessen 2006). A well-known category of unintended effects is "rebound effects": indirect effects of policies contrary to their goals. An example of this is increased transport induced by lower operating costs due to higher fuel efficiency; here, the intended effect of reduced pollution per kilometre is partly offset by an increase in kilometres driven (Small and van Dender 2007).

Summarily, the illustrations outlined in Section 3 show that connectivity is an effective strategy for addressing governance challenges arising from complex or "wicked" environmental problems. However, future research is needed to address other, potentially

obstructive – or at least disruptive – governance challenges which occur simultaneous to their environmental counterparts when introducing new governance modes.

5. Conclusion

In this paper, we began with the assumption that addressing environmental problems effectively through public policies requires substantial knowledge about the nature, characteristics, causes and effects of the environmental problem in question. If surface-water contamination occurs in one country but affects another, then effective governance must include transboundary solutions. Likewise, if the source of increased flood events remains largely unknown, fostering greater cooperation and knowledge exchange between science and politics might accelerate the identification of the source. While these illustrations about water contamination or floods, and their respective governance solutions, might appear intuitive, we propose in this paper a systematic approach for objectively considering their problem characteristics and connecting them to appropriate governance modes. We therefore introduced the concept of "enhancing connectivity," showing how actors, issues, sectors and scale levels can be linked to determine effective policy solutions.

More concretely, we first identified three major characteristics of environmental problems: uncertainties; mismatches across sectors, levels, space, and time; and the plurality of norms, values and interests. We then identified the following six connectivity strategies to address these characteristics: connecting science with policy, connecting sectors, connecting levels, connecting jurisdictions or areas, connecting short- and long-term perspectives, and connecting different problem frames. Through illustrations and empirical case studies from the literature, we provided evidence for our core assumptions: (a) focusing on the nature of environmental problems when designing their solutions is an important precondition for effectiveness and (b) connectivity is an important concept for science and practice in resolving major governance challenges comprising a range of complex problems.

The proposed approach has several additional values: First, the complexity of an environmental problem is not taken for granted. Instead, we suggest systematically disentangling environmental problem characteristics, identifying related governance challenges, and addressing them through connectivity. This approach facilitates more in-depth knowledge about complex cases. As shown via the various empirical illustrations outlined above, understanding the nature of the problem and demonstrating how (or whether) governance solutions account for different elements in relation to it can help gauge the quality and effectiveness of the solutions.

In addition, abundant evidence exists that environmental complexity will further increase; consequently, the need for enhancing connectivity will also increase, especially in western countries where different processes of fragmentation can be observed. As societies and politics become more decentralised, formerly joint initiatives fracture and individualise, and responsibilities shift from governments to private actors and citizens. However, as the fragmented nature of environmental problems will persist, connecting different, newly decentralised and fractured units will become key.

As outlined in Table 1, we suggested a systematic approach of a combined analysis of a particular problem characteristic and the related governance challenge. We are, however, aware that complex, or wicked environmental problems typically involve diverse challenges and thus a combination of the problem characteristics outlined in

the first column of Table 1. Water pollution through emerging substances, or increased frequency of extreme weather events not only come with uncertainties related to their source, but also challenge different norms and values and act at different spatial and temporal scales. This concretely means that several governance challenges are present at a time and, in consequence, when following our framework, connectivity strategies would need to be combined. Subsequent research should further highlight how different governance modes – and thus the dimensions of politics, polity and policy – interact, can inform each other and be linked in order to create mutually beneficial synergies rather than creating additional dysfunctions.

As shown in our discussion (Section 4), further research is also needed to determine what additional difficulties and governance challenges might arise, through established power structures or unintended side effects, so they can be effectively addressed in governance modes via connectivity. Future research should thus focus on both governance challenges arising from complex environmental problems and those produced by other phenomena. Such socioecological interdependencies and their potential connectivity strategies should then be further highlighted with a particular focus on which work best in combination or in a disentangled way.

Disclosure statement

No potential conflict of interest was reported by the authors.

Note

1. Voss *et al.* (2007) defined different steering contexts for sustainability, therefore creating a typology taking ambivalence, uncertainty and the distribution of power into consideration; these, according to the authors, are inherent elements of sustainability contexts. If ambivalence and uncertainty can be classified as characteristics accompanying environmental problems (see uncertainties and mismatches in our classification), distribution of power is considered, in this paper, as an element inherent to governance modes.

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