Wicked problems and creeping crises: A framework for analyzing governance challenges to addressing environmental land-use problems

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A B S T R A C T

Human societies face significant difficulties in the governance of environmental land-use problems. The challenges involved must be thoroughly understood to develop effective and legitimate governance of these often inherently wicked problems. However, in environmental governance literature, governance challenges have been described rather generally, and the characteristic features of different types of problems have not been specified. Drawing on this literature, this paper presents an analytical framework for governance challenges typical of a "wicked problem" and a "creeping crisis". We empirically illustrate the combined framework by applying it to the environmental land-use problem of land subsidence in the Dutch peatlands. Land subsidence exemplifies a wicked problem because it is neither definable nor solvable. Due to the lack of effective governance, the problem has allowed threats with crisis potential to develop. However, land subsidence represents a "creeping" crisis because, despite the increasing risk of damage, there is little sense of urgency. The case study illustrates that governance challenges posed by such problems often originate from a lack of comprehensive sense-making of these problems' complexity and that responses, therefore, tend to be counterproductive. Hence, the paper empirically substantiates the need for governance approaches that help achieve the systemic change that is arguably needed to address environmental land-use problems adequately.

1. Introduction

From the long list of enduring environmental land-use related problems facing societies today such as climate change, biodiversity loss, and land subsidence, it can be concluded that their governance is far from simple. By governance, we mean "a process of — more or less institutionalized — interaction between public and/or private entities ultimately aiming at the realization of collective goals" (Lange et al., 2013, p.406). The environmental governance field specifically concerns "goals related to the management of the environment" (Driessen et al., 2012, p.144). Despite the growing body of literature on barriers to environmental governance, few studies have been explicit about the inherent reason environmental land-use problems are so challenging for governance. According to Ingold et al. and Termeer et al., the characteristics of environmental problems essential to consider for governance include "uncertainties, cause-effect mismatches and norm plurality" (Ingold et al., 2019, p.1821) and "an emerging policy domain, fragmentation, deep uncertainties, and a long-term horizon" (Termeer et al., 2017, p.5). Rittel and Webber (1973) would have argued that these

characteristics make environmental problems typical "wicked" problems. Environmental problems related to land use are likely even more wicked due to competing land-use claims on scarce soil. More recently, other scholars have argued that ineffective governance resulting in a long absence of adequate response strategies allows wicked problems to slumber, accumulating their crisis potential. Since societal urgency for the devastating damage potential often lacks for a long time, scholars call this type of problem a "creeping" crisis (Boin et al., 2020, 2021).

Since environmental land-use problems can be characterized by their wickedness and creeping nature, we argue for the need to consider governance challenges typical of both wicked and creeping crises. While several studies have been explicit about the link between the problem characteristics of wicked problems and governance challenges (e.g. Crowley and Head, 2017; Head, 2019; Ingold et al., 2019; Kirschke et al., 2019; Rittel and Webber, 1973; Termeer et al., 2015, 2017), challenges to governing creeping crises have not been explicitly taken into account by these studies. Furthermore, very few studies (among which Kirschke et al., 2019) provide empirical evidence for these linkages. We, therefore, set out to improve understanding and positioning of governance

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challenges to environmental land-use problems by developing a basis for an analytical framework with challenges derived from the bodies of literature on wicked problems and creeping crises. We applied the combined framework to an empirical case to illustrate and further unpack it.

This paper is structured as follows. Section 2 first conceptualizes environmental land-use problems as "wicked problems" and "creeping crises" before presenting eight governance challenges to these types of problems in a combined analytical framework. Section 3 contains the methodology. In Section 4, the governance challenges are illustrated and further unpacked with the case study. Section 5 presents the conclusions, reflections and recommendations.

2. Toward a combined analytical framework

2.1. The wickedness of environmental land-use problems

In the late 1960 s, planning scholar Horst Rittel noted a persistent misfit between the complex nature of public policy issues and simplistic ideas about how to solve them. As a counterpart to the "tame" problem that can be solved rationally, for instance, by engineers, Rittel introduced the socially complex type of "wicked problem", which he elaborated with Melvin Webber in their ground-breaking paper of 1973 (Crowley and Head, 2017). By stating that "there is no definitive formulation of a wicked problem", "every solution to a wicked problem is a one-shot operation", "wicked problems have no stopping rule", "solutions to wicked problems are not true-or-false, but good-or-bad", "every wicked problem is essentially unique", "every wicked problem can be considered to be a symptom of another problem", Rittel and Webber (1973, pp.161–165) mainly emphasized the *cognitive* uncertainty (resulting from the "lack of technical knowledge about the nature of the issues involved and their solutions") as a challenge to tackling wicked problems (Van Bueren et al., 2003, p.193). Over four decades later, the wicked type of problem has been denoted as "'messy' or 'intractable' or 'unstructured', or 'contested'" as well as "'recalcitrant', 'undisciplined', 'uncontrollable', and 'unmanageable'" (Crowley and Head, 2017, pp.542–543), a problem of "collective action" (Van Bueren et al., 2003, p.193) and even as "super wicked" (Levin et al., 2012, p.124). These terms reflect the enduring challenge of dealing not only with the inherent *cognitive* uncertainty but also with *strategic* uncertainty (resulting from the "variety of actors and strategies involved") and *institutional* uncertainty (as "decisions are made in different places, in different policy arenas in which actors from various policy networks participate") (Van Bueren et al., 2003, p.193). These uncertainties are also reflected in DeFries and Nagendra's (2017) definition of wicked problems in the field of ecosystem management: "wicked problems arise from one or a combination of multiple dimensions: complexity and interdependency of components, which create feedbacks and nonlinear responses to management interventions; uncertainty of risks and unintended consequences; divergence in values and decision-making power of multiple stakeholders; and mismatches in spatial and temporal scales of ecological and administrative processes" (p.266). Since environmental land-use problems generally have all features mentioned above, many have labelled them "wicked" (e.g. Balint et al., 2011; Ingold et al., 2019; Termeer et al., 2017; Van Bueren et al., 2003).

In this challenging governance context, stakeholders postpone dealing with environmental land-use problems because they do not dare, want to, or can intervene. Those who act may deliberately or subconsciously choose a less satisfactory solution (Rittel and Webber, 1973) or a minimal solution (i.e., window dressing). Either way, every form of (in)action is consequential; "it leaves 'traces' that cannot be undone" (Rittel and Webber, 1973, p.163), which may alleviate or aggravate the problem. Climate change is an example of an environmental land-use problem that has received insufficient action or inaction for decades (Levin et al., 2012; Moser, 2010). It is probably one of the most classic examples of how inadequate governance of a wicked

problem can, over time, fuel the development of a creeping crisis (Boin et al., 2020).

2.2. The creeping nature of environmental land-use problems

Four decades after scholarly acknowledgement of the complexity of wicked problems, signs of system collapse have emerged worldwide. For instance, climate change arrived on the public agenda in the 1980s and has slowly accumulated its damage potential ever since (Moser, 2010). However, a collective sense of urgency to tackling the problem has not grown concomitantly for reasons such as the "invisibility of causes, distant impacts, lack of immediacy and direct experience of the impacts, lack of gratification for taking mitigative actions, disbelief in human's [sic] global influence, complexity and uncertainty, inadequate signals indicating the need for change, perceptual limits and self-interests" (Moser, 2010, p.31). Boin et al. (2020) have therefore conceptualized climate change as a "creeping crisis". From an objective perspective, a creeping crisis can be seen as an empirical phenomenon with observable, potentially harmful threats that develop over a long period and exist independently of people's perceptions. However, such a "slow-burning crisis" or "crisis in slow motion" (Boin et al., 2020) differs from a regular crisis in subjective terms. There is an absence of societal consensus that it concerns "a threat to the core values of society and/or life-sustaining systems in that society that must be addressed urgently […]" (Rosenthal et al., 1989, in Boin et al., 2020, p.121). Manifestations of creeping crises (e.g. forest fires or floods in the case of climate change) can raise temporal attention, yet such "small bangs" are often long recognized as isolated events instead of symptoms of an underlying crisis. Although the creeping crisis can eventually be detected if disruptions happen more frequently, we only speak of a crisis if there is also a collective sense of urgency (Boin et al., 2020, 2021).

2.3. Challenges to governing wicked problems and creeping crises: a combined framework for analysis

Since the development and implementation of environmental land-use policy depend on interactions between multiple policy sectors at multiple levels of government and different stakeholders (Driessen et al., 2012), the very existence of problems reflects governance failure, with societies seemingly unprepared, unable, or unwilling to deal collectively with impending threats lingering in the background. For improved governance of environmental land-use problems, we believe better understanding and positioning of governance challenges to these problem types is needed. Therefore, as discussed in the previous sections, we developed an analytical framework (see Table 1) with governance challenges related to the cognitive, strategic and institutional uncertainty around wicked problems and the inconceivability of creeping crises. The framework is innovative as challenges from the vast body of literature on wicked problems (e.g. Crowley and Head, 2017; Rittel and Webber, 1973; Termeer et al., 2017; Van Bueren et al., 2003) are combined with insights from relatively novel literature on creeping crises (e.g. Boin et al., 2020, 2021; McConnell and 't Hart, 2019). Creeping crisis literature hereby explicitly accounts for the possibility that governance challenges to wicked problems lead to governance failure so that the problem can accumulate its damage potential. Hence, we argue that not every wicked problem is a creeping crisis (yet), but that creeping crises are wicked by nature.

Note that we aimed to develop a basis for a combined analytical framework. Hence the list and description of challenges are exemplary, not exhaustive. We mainly based it on a few key authors, including Termeer et al. (2017) and Boin et al. (2020) who have provided a comprehensive overview of research in the field. Also, note that there are two ways in which the table presents a sequence of challenges: 1) it starts with challenges related to wicked problems and then the challenge related to creeping crises, because we see the latter as a consequence of a lack of good governance of the former; 2) it starts with the challenge of

Table 1

Framework for analyzing challenges to governing environmental land-use problems.

Challenge to the governance of environmental land-use problems	Links to characteristics of problem type	Description of the challenge
Framing the problem	Wicked problem (cognitive uncertainty)	Framing environmental land-use problems is challenging because they are interrelated rather than single, separable problems (Termeer et al., 2017). Hence, "there is no definitive formulation" (Rittel and Webber, 1973, p.161). People with different values and interests can have conflicting perspectives on whether there is a problematic situation in the first place, its causes, and, accordingly, the response strategy (Crowley and Head, 2017; Head, 2019; Termeer et al., 2017).
The levels of action	Wicked problem (institutional uncertainty)	Finding a fit between the geographical levels at which impacts manifest and the corresponding levels of government is a challenge for cross-level environmental land-use problems. Activating action at different levels is another challenge as problems play out in a polycentric, fragmented governance system (Crowley and Head, 2017; Termeer et al., 2017; Van Bueren et al., 2003).
The timing of policies	Wicked problem (cognitive uncertainty)	The timing of environmental land-use policy is a challenge because "in spite of inherent long-term uncertainties, decisions about [adaptation] strategies need to be taken or prepared now" (Termeer et al., 2017, p.11). It is primarily a lack of scientific knowledge about "the nature of the issues involved and their solutions", their "causes and effects", and "causal relations" (Van Bueren et al., 2003, p.193) that leaves decision-makers with questions of "whether to act in a more precautionary manner or wait for more scientific evidence about the impacts […] or the projected harm" (Termeer et al., 2017, p.11).
The alignment across sectoral boundaries	Wicked problem (strategic and institutional uncertainty)	Aligning aspects of environmental land-use problems across sectoral boundaries is a challenge in a fragmented governance system; there are many policy sectors involved (e.g. "water management, environmental management, nature conservation, health, agriculture, or housing") (Termeer et al., 2017, p.12) that are not necessarily

Table 1 (*continued*)

Challenge to the governance of environmental land-use problems	Links to characteristics of problem type	Description of the challenge
		driven by environmental concerns. Decisions affecting the environment are often "only loosely coupled and sometimes not at all", which may result in "diverging and conflicting strategies" (Van Bueren et al., 2003, pp.193–194).
The selection of policy instruments	Wicked problem (cognitive, strategic and institutional uncertainty)	Selecting policy instruments "to influence the behavior of citizens or firms in a certain direction" (Termeer et al., 2017, p.13) that ideally meet the assessment criteria of accountability, effectiveness, efficiency, legitimacy, fairness, and legal certainty (Mees et al., 2014) is a challenge for environmental land-use problems due to inherent uncertainties, controversies, social complexities, and fragmentation (Head, 2019; Termeer et al., 2017; Van Bueren et al., 2003).
The organization of the science-policy interface	Wicked problem (cognitive uncertainty)	Organizing science-policy interfaces, defined by van den Hove (2007, p.807) as "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making" is another challenge to the governance of environmental land-use problems (Termeer et al., 2017; Hisschemöller et al., 2017). In particular, the discrepancy around wicked problems requires science to be about 'making sense together' rather than 'speaking truth to power' (Rittel and Webber, 1973; Termeer et al., 2017).
The appropriate forms of leadership	Wicked problem (strategic and institutional uncertainty)	Finding the appropriate forms of leadership for environmental land-use problems is a challenge because such 'complexity leadership' should fulfil more functions than the traditional notion of leadership in which positional leaders have sufficient means (e.g., knowledge, resources) to solve a problem (Termeer et al., 2017; Rittel and Webber, 1973). Positional leadership may work for tame problems that can be solved even if complicated, but positional leaders neither have all the resources to adequately address

Table 1 (*continued*)

Challenge to the governance of environmental land-use problems	Links to characteristics of problem type	Description of the challenge
		wicked problems, nor are they able to connect the diversity of "actors, issues, sectors and scale levels to realize […] options that accommodate different values, interests, and motives" (Termeer et al., 2017, p.16).
Timely detection of the crisis potential	Creeping crisis (inconceivability)	Recognizing (moderate) manifestations or disruptions as symptoms of an underlying crisis rather than as relatively easily manageable, isolated events is a challenge to governing environmental land-use problems that have evolved into creeping crises. Whereas risk detection is generally easy for sudden crises, the "inch-by-inch dynamic of a 'creeping crisis'" usually prevents actors from timely recognition (Boin et al., 2021, p.22). In particular, the inconceivable nature of problems that "have not happened frequently enough to be familiar" (McConnell and 't Hart, 2019, p.652) causes indicators of escalation to evade detection by the "warning systems" of individuals, organizations, and even risk professionals (Boin et al., 2020).

'framing the problem', because all other governance challenges arise from different degrees of actors' acknowledgement of the wickedness of problems. The order in which the subsequent seven challenges are presented does, however, not reflect a logical sequence.

3. Methodology

3.1. Case study

We have opted for a single empirical case study to illustrate and further unpack the governance challenges listed in the framework. The selected case is the environmental land-use problem of land subsidence in the Netherlands, a country mostly below sea level, whose geology is characterized by unconsolidated sediment (peat, sand, clay) rather than hard rock. In built-up areas on peat soil, the weight of buildings and infrastructure has caused land subsidence and associated economic damage. Hitherto, measures to prevent subsided buildings from being flooded, such as drainage, have proven ineffective because of unintended effects (e.g., rot in wooden pile foundations). In rural areas on peat, subsidence mainly results from the traditional water management practice of lowering the water table for agricultural purposes. This causes peat to oxidize, which leads to a release of greenhouse gases (GHG) and degradation of natural resources (Den Uyl and Driessen, 2015; Stouthamer et al., 2020).

As with other wicked problems, there is much cognitive uncertainty about land subsidence due to limited technical knowledge about, among other things, the rate of subsidence, the effects and the effectiveness of measures. This makes land subsidence an ill-defined problem that relies

"upon elusive political judgment for resolution" (Rittel and Webber, 1973, p.160). The plurality of norms and perspectives of involved stakeholders (e.g. farmers, citizens, municipalities, waterboards, provinces, the national government) and their respective approaches to land subsidence causes strategic uncertainty. Institutional uncertainty shows from the fragmented institutional setting in which decisions on land subsidence are to be made (Van Bueren et al., 2003). Furthermore, it is competing land-use claims (e.g., agriculture, urbanization) in a densely populated area that characterizes land subsidence as a planning or land-use problem, hence a "wicked" problem. Together with other interconnected environmental land-use problems such as nitrogen pollution, biodiversity loss, flood risk, and water quality, land subsidence can be considered symptomatic of what Levin et al. (2012) would call the "super wicked problem" of unsustainable land use in the Netherlands. Land subsidence is also a creeping crisis, with a lack of adequate strategies (Stouthamer et al., 2020) reflecting the absence of a collective sense of urgency about its damage potential in terms of financial costs, national safety, and ecological degradation (Boin et al., 2020).

3.2. Data collection methods

We used a triangulation of data collection methods: semi-structured interviews, a document study, and stakeholder discussions. The interviews were held with 14 stakeholders (representatives of the national government, provinces, municipalities, water authorities, farmers) and independent experts. Each interview began by asking the open question of which governance challenges to addressing land subsidence the interviewee had hitherto experienced (see the interview guide in the Appendix). This way, the authors could check which of the challenges were mentioned. The interview process was relatively unstructured; only if it proved necessary to steer them back to the topic were interviewees asked open questions related to the governance challenges in the framework. The interviews took place from February 2021 until July 2021. They were online and lasted approximately one hour. The interviews were held in Dutch; the (anonymized) quotes presented in this paper are the authors' translations. All interviews were recorded and transcribed in NVivo. The eight governance challenges were used to code the transcripts. To improve the research's internal validity, the findings' accuracy has been checked based on publicly accessible policy reports (e.g. De Graeff et al., 2020; Hoendermis and Van den Brink, 2020; Van den Born et al., 2016) and informal discussions with stakeholders that are the consortium partners of the project this research is part of. These discussions took place on a consortium day and during a symposium.

4. Empirical illustration of the framework

In this section, we show and interpret the empirical manifestations of the eight challenges to governing environmental land-use problems as presented in the combined analytical framework.

4.1. Framing the problem

Land subsidence can be understood as a problem of, among other things, flood risk, climate change, infrastructure, housing, natural resource management, nature conservation, and intensive agriculture (Stouthamer et al., 2020). However, the Dutch have always framed land subsidence as a water management problem that, as "problem understanding and problem resolution are concomitant to each other" (Rittel and Webber, 1973, p.161), is solvable, repairable, or adaptable with water management techniques. These technological planning responses only address part of the problem, simplifying its wickedness.

Since the narrow "water" type of framing has traditionally informed Dutch institutions around land and water management, it is unsurprising that this challenge influences other governance challenges too. For

instance, the following quote by a farmer illustrates how a one-sided framing of the problem in societal debates has led to polarization, "tunnel vision and intractable controversies" (Termeer et al., 2017, p.9) and hence, to less action or leadership by the 'designated' problem-owners:

> "If people approach farmers negatively, saying 'you caused it, we have a problem now, you must solve it, and we put pressure on you to do that', I'll say that to me it's only a phenomenon and not a problem. If you see me as the culprit, I'll move less. [...] Many farmers feel they're society's scapegoats".

The interconnectedness between environmental land-use problems makes that one-sided debates on one problem can affect the governance of other problems, too, as shown by the following quote:

> "Conversations with the agricultural sector are very loaded because of everything related to nitrogen. That plays a role when we sit down with farmers. We are the government to them [...], and the moment you start talking, you notice a lot of bitterness. So, the nitrogen crisis does not help".

The case study also showed that dominant frames can change over time. For instance, the Dutch Climate Agreement recently reframed land subsidence as a climate mitigation problem. However, water management still seems to be the dominant frame for informing policy and instigating research.

To avoid oversimplification of the problem, controversies, and stakeholder exclusion, Rittel and Webber would argue for argumentative and collaborative governance approaches that welcome different perspectives and do not attempt to achieve consensus on the problem definition (Crowley and Head, 2017; Head, 2019).

4.2. The levels of action

Land subsidence manifests locally (e.g., damage to houses and infrastructure), regionally and nationally (e.g. increased flood risk), and internationally (e.g. GHG emissions). Hence it demands coordinated action by multiple levels of government (Termeer et al., 2017). However, the case study revealed that coordinated action by the national government was not a given:

> "It's a file with potentially enormous consequences, which is also the reason that the national government has kept its hands off hitherto. Remember the statement by the former minister: 'I don't want to become minister of pile rot' [...]. So that obviously plays a big role; there's also a threat behind it for everyone".

This quote suggests a tendency to avoid political blame for policy failures (Howlett, 2012), which is not surprising from the reasoning of Rittel and Webber (1973, p.167) that "planners are liable for the consequences of the actions they generate; the effects can matter a great deal to those people that are touched by those actions". A lack of political commitment by the national government, however, means that limited resources (e.g., staff, budgets, strategies) are available to guide and enable action by local governments (Uittenbroek et al., 2014), as illustrated by this quote:

> "Smaller municipalities are limited in their experts; people do a lot of different things, so [land subsidence] doesn't get that much attention at all"

Interestingly, the recent framing of land subsidence as a climate change issue has made it more of a problem of national interest, which has consequently attracted political support from previously uninvolved levels of government:

> "Since last year, the province has also joined in [national research on GHG emissions in peatlands]. I'm very happy with that".

> "The only reason the central government is actually doing it [funding research in peatlands] is because they've committed themselves [in the Climate Agreement] to reducing GHG emissions."

The quotes have shown that an arguable way to generate multi-level action on an environmental land-use problem is through regulation, facilitation or stimulation by the national government (Driessen et al., 2012). They also indicate that this first requires political acknowledgement of the wickedness of problems to change the culture of avoidance of political blame. In the meantime, small interventions to achieve sustainability that come with lower costs if they fail can help overcome governments' reluctance to act (Termeer and Dewulf, 2019). Another arguable way to stimulate multi-level action turns out by linking the environmental land-use problem to and integrating it with a policy issue higher on the political agenda (i.e. "mainstreaming") (Uittenbroek et al., 2014).

4.3. The timing of policies

Governmental interviewees indicated to struggle with decision-making on land subsidence policy in light of cognitive uncertainty about physical processes, such as current and future subsidence rates (e. g., influenced by climate change and human activity), the effectiveness of measures (e.g., wet crops, water drainage systems) and consequences for other problems (e.g., climate change and water quantity). Also, implementing bodies seem to want complete certainty before acting:

> "The managers responsible for the water system are holding back, saying: 'what are you doing, there's so much uncertainty!' when we try and test. Because if there's flooding because of a new system, then they will be the first to be blamed. So, they're very afraid that we're screwing it up".

This quote reflects another example of how cognitive uncertainty in a culture of "evidence-based policymaking" promotes blame avoidance for poor policy decisions (Howlett, 2012, p.550). The interviewees also mentioned institutional uncertainty influencing decision-making on land subsidence. For instance, they perceived a lack of policy guidance in terms of a long-term vision and clear goals. Hajer (2003, p.175) would call this lack of "generally accepted rules and norms according to which policy making and politics is to be conducted" an 'institutional void'.

Similarly in urban areas, very few municipalities have a spatial planning strategy that is "land subsidence proof" in the long term. Instead, they occasionally renovate buildings and repair infrastructure. However, the absence of land subsidence policy seems less due to cognitive uncertainty, as the interviewees indicated a lack of capacity (e. g., funds in larger municipalities and expertise in smaller municipalities) and competition from policy issues higher on the political agenda, as this quote illustrates:

> "Municipalities experience a dilemma: invest now so that management costs are low in the future, or, for example, due to the housing shortage quickly build houses and push the problem forward?".

Politicians' tendency to compromise on a creeping crisis in the long term to be able to address an acute crisis in the short term (De Gooyert and De Coninck, 2021) is also evident from a recent spatial planning decision to address the enormous housing shortage by building a new village in what is considered one of the worst land subsidence and flood-prone areas of the Netherlands (Stouthamer et al., 2020). Termeer and Dewulf (2019) could provide a way out here again, as they would suggest that one way to implement 'future-proof' decisions in the short term despite high uncertainties and without waiting for disturbances to create momentum and raise political attention is to choose moderately important measures, also referred to as "small wins".

4.4. The alignment across sectoral boundaries

Hitherto, land subsidence measures have not been adequately

implemented by relevant policy domains such as spatial planning, agriculture, housing, infrastructure, and safety (Van Hardeveld et al., 2019). The following quote indicates the importance of mainstreaming land subsidence across policy sectors to make progress:

"Land subsidence as a separate portfolio has too little power; it does nothing. While if you link it with other social problems, such as the climate crisis or housing issue, it does something. We need to search for ways to allow land subsidence piggyback on those sectors".

Recently, the Dutch Climate Agreement has been seized to address land subsidence under the auspices of climate mitigation:

"It's no longer just about uneven land subsidence and nature reserves that gradually become higher than surrounding agricultural land, but there's another argument added: GHGs. And that's a very important topic politically".

Although the climate crisis indeed raises the urgency for sustainable water management in some places with land subsidence, this does not necessarily apply to subsiding places with limited peat oxidation (e.g., thin layers of peat) or without peat oxidation (e.g., urban areas on peat) due to the limited or lack of GHG emissions.

The lack of more integral policy strategies also complicates the alignment of environmental land-use problems at the local level of implementation, as shown by Runhaar (2017) and illustrated by the following quotes:

"It all lands on the same farmer. You cannot come on Monday for subsidence, on Tuesday for nitrogen, on Wednesday for the energy transition, etc."

"There are so many different places the farmer can apply for subsidies for the services that he provides with sustainable farming – it's crazy. [...]. This should be facilitated more centrally, at the strategic level."

In urban areas, land subsidence is not yet mainstreamed in the policy domain of spatial development either. An important part of the challenge raised by interviewees concerns the change that such a new way of working implies, as illustrated by the following quote:

"At the top, you have to get politicians involved to make money available, so the entire organization with all its departments must be permeated. At the local level, you have the implementers, such as project managers, who must have the knowledge and the will to work in a different way. There's still much to do because there are conservative people who prefer to work with what they're used to because then they know what to expect".

Based on Wamsler and Pauleit (2016) and in line with Van den Ende et al. (2022), it can be argued that both top-down and bottom-up mainstreaming strategies are needed to align environmental land-use problems across policy domains effectively.

4.5. The selection of policy instruments

A first difficulty with regards to selecting policy instruments for land subsidence mentioned by interviewees concerns the question of accountability:

"Who owns the problem is a recurring issue. Should we put it on the farmers' plate, or is it something you, as a government, have to invest in heavily? Also, how should the use of environmental resources be managed? Is that something you leave to the market, or are you going to enforce [it]?"

Another difficulty is determining the effectiveness of policy instruments if uniform policy goals and targets are lacking. Inherent uncertainties make ex-ante assessments challenging as well. Efficient policy instruments promote flexible strategies in a context of uncertainty (Mees et al., 2014). According to one interviewee, this is generally not the case for Dutch spatial planning strategies:

"They now use a structural vision for 20 years that says how they should do what, while there are simply too many variables to plan that far ahead. Dealing with uncertainties [...] requires decision-makers to dare to change their choice if things turn out differently. [...] That requires a culture change".

Selecting legitimate policy in a context of controversy and social complexity (Mees et al., 2014) remains another issue, as illustrated in the following quote:

"Among farmers, there's a lack of trust in the government, leading to many doubts about measures"

Also, fairness in terms of an equal distribution of policy burdens is still challenging for wicked problems (Mees et al., 2014), as illustrated by these quotes by a farmer interviewee and an independent expert:

"Society wants less CO_2, and why do I have to suffer as a farmer – do you understand what I mean?"

"It's unfortunate for the farmers that everyone is against them, while in fact, the [farmers'] protests were mainly because of the pressure of large companies. That's where the big interests are. They [farmers] are under heavy pressure to produce at low costs."

The fairness of reactive policy instruments for land subsidence in urban areas may also become a topic of debate:

"I can imagine if those buildings subside another 30 cm in the next 100 years, you reach a point of saying 'we no longer find it responsible to pay from general resources to keep this one building dry'. That statement has never been made in the Netherlands, and I feel that we're heading toward it".

Finally, legal certainty in terms of a long-term perspective (Mees et al., 2014) is said to be generally lacking in Dutch land-use policy:

"There's a new government now, and all the rules change almost every week".

These quotes confirm again the arguable need for argumentative approaches (Crowley and Head, 2017) to enable multiple stakeholders, including non-governmental actors, to judge policy instruments in terms of "'good' or 'bad' or, more likely, as 'better or worse' or 'satisfying' or 'good enough'" (Rittel and Webber, 1973, p.163).

4.6. The organization of the science-policy interface

In the context of land subsidence, the role of science is mostly a traditional one of "speaking truth to power" (Termeer et al., 2017), which may work for engineering problems, but not for wicked problems that require more than technological knowledge (Rittel and Webber, 1973), as illustrates a policy advisor in this quote:

"I once thought in my naivety: if we have a group of [renowned research institutes] on board, we show that we don't engage any arbitrary consultancy but only the best of the best. Well, a city council isn't really impressed by that. Not at all. Because indeed, the man in the street who says, 'that's not true', is worth just as much as a statement by a professor in soil or foundation techniques. Really, that's not worth anything for decision making."

This would come as no surprise for Crowley and Head (2017, p.543), who argue that "environmental conflict is typically 'value-based' so that in many cases, not even the 'strongest possible evidence' can settle differences between stakeholders or avoid triggering major political conflicts". The quote also shows that in the absence of consensus on what is relevant science, decision-makers can strategically contest, deliberately ignore, and selectively use scientific knowledge (Van Enst et al., 2014). This indicates the "politicization of science" (Termeer et al., 2017, p.15). In the case of rural land subsidence, the politicization of science also applies to market parties:

"It's not only mistrust of government but also mistrust of science. They [farmers] rather trust the dairy or animal feed industry if it tells you to do something, while in the end, they also simply get their knowledge through science. But yes, it's a matter of trust – that's important."

Hence, there is an apparent need for an improved "science–policy–market" interface, in which science should be about "making sense together" (Termeer et al., 2017).

According to the interviewees, another aspect of the challenge is a perceived misfit between the nature of uncertain, wicked problems and the solution-oriented pressure from politics and society:

"There's a lot of expectation management you have to do. Politicians often think very simplistically about this: we do some research and then we know."

While some interviewees mentioned the importance of generating more scientific knowledge ("*It's extremely important for knowledge to be well-substantiated, clear and transparent for everyone, otherwise, you keep arguing about it"),* others mentioned the need for approaches to decision-making under uncertainty, which chimes more with the contention of Rittel and Webber (1973) that gathering, analyzing, and synthesizing information does not work for wicked problems. Experimentation can be a practical way of building a renewed relationship between science and policy, as it allows actors to "embrace ambiguity, uncertainty" and "welcome new understanding rather than tame wickedness" (Termeer and Dewulf, 2019, p.303).

4.7. Appropriate forms of leadership

The above challenges have shown that an important but generally lacking form of leadership for land subsidence is administrative leadership, to "create order within an organization, for example, by dividing tasks, allocating budgets, and monitoring task performance" (Termeer et al., 2017, p.16). The following quote illustrates how a tendency to avoid administrative responsibility (Van den Ende et al., 2022) complicates short-term action:

"The three levels of government seem to have the same long-term vision, but coming to a short-term approach is more difficult because then the question is who wants to do what?"

Adaptive leadership, another essential part of complexity leadership, is about developing "new ideas and practices" (Termeer et al., 2017, p.16). The extent of adaptive leadership for land subsidence seems limited, as new ideas and practices tested in pilot projects have mostly been technological. What is lacking, according to several interviewees, is social innovation in the context of public administration:

"Management of uncertainties […] requires a completely different way of steering: that you allow citizen participation and local initiatives to arise […], that you no longer govern centrally but orchestrate more – as a kind of orchestrator rather than a police officer."

Connective leadership is about connecting public and private stakeholders from multiple policy sectors and multiple levels of government (Termeer et al., 2017), which can also be improved for land subsidence. The following quote shows how crucial coalition forming is for environmental land-use problems with weakly defined responsibilities:

"If you don't feel the unity, it remains a problem of the other party."

Next, enabling leadership entails creating "the necessary conditions for innovation" (Termeer et al., 2017, p.16), which the interviewees mentioned missing when it comes to viable business models (e.g., for wet crops) or incentive schemes (e.g., for ecosystem services) (Runhaar, 2017). The following quotes show that farmers experienced limited innovation capacity due to path dependency but also policy vagueness, respectively:

"Many farmers say they want to, but they're not able to – not meaning that it's technically impossible, but they have to earn a certain income to pay off the debt. They're kind of trapped in their own system or the system we created together."

"What matters to them [farmers] is a sustainable future perspective […] the dot on the horizon […]. So, clarity that they know where they stand."

In sum, leadership at higher levels of government is needed to implement policy instruments that promote leadership by other governance actors in the sense of more environmentally friendly land use (Mees et al., 2014).

4.8. Timely detection of the crisis potential

The above challenges have hampered adequate governance of land subsidence for a long time. Because of this, the problem has been allowed to slumber and accumulate in terms of damage potential (e.g. financial costs, national safety, and ecological degradation) so that it would deserve the crisis label in objective terms. However, quite literally, the "inch-by-inch dynamic" of land subsidence seems to have prevented actors from recognizing manifestations as symptomatic of an underlying crisis (Boin et al., 2021), as illustrated by the following quote:

"I also notice that people say: 'we have to reduce and stop land subsidence now!' while it has already been going on for 1000 years!"

The inconceivability of an underlying crisis seems to have been maintained by an institutionalized, false sense of safety (McConnell and 't Hart, 2019) as a result of the technological "solutions" mastered by the Dutch to counter or adapt to land subsidence.

As discussed earlier, the recent detection of the high amount of GHG emissions from peat oxidation has allowed the problem of land subsidence to piggyback on the climate crisis. However, this mainstreaming attempt seems too limited to timely detect a creeping crisis relating to land subsidence because some symptoms, such as increased flood risk and damage to buildings and infrastructure, continue to be addressed as isolated events that are technologically solvable (Boin et al., 2020).

By understanding a creeping crisis as an escalated wicked problem, it is likely that more "argumentative, deliberative, collaborative, and network-based approaches" (Crowley and Head, 2017, p.545), as proposed by the wicked problem literature, likely enrich sense-making (i.e. "the root activity when people deal with an unknowable and unpredictable world" (Termeer and van den Brink, 2013, p.44)) of creeping crises as well, hence increasing the chance of early warning systems being activated (Boin et al., 2020).

5. Conclusions, reflections and recommendations

5.1. Conclusions

This paper started from the notion that environmental land-use problems often share characteristics of two types of problems: the wicked problem and the creeping crisis. Hitherto, some scholars have focused on one of them to explore governance challenges (e.g., Boin et al., 2020; Termeer et al., 2017) while underexposing their link: insufficiently addressed wicked problems eventually develop into creeping crises. Aiming to understand better and position governance challenges to environmental land-use problems, we developed ananalytical framework with a combination of governance challenges from the literature on wicked problems and creeping crises. We have illustrated the framework empirically by applying it to the problem of land subsidence in Dutch peatlands. The framework can be a useful analytical tool for governance scholars and a practical tool for self-reflection by societal stakeholders (e.g., decision-makers, practitioners), as its social science approach can broaden perspectives on what is considered "socially accepted, economically affordable, politically feasible, and technically

possible" when addressing environmental land-use problems, also referred to as "the solution space" or "room to manoeuvre" (Haasnoot et al., 2020, p.2). This is particularly relevant when public and political discourses on environmental land-use problems are often informed by knowledge on the natural system (Du et al., 2022).

The authors also identified several limitations. First, the list of challenges is based on a limited scope of papers from two bodies of literature. We invite other researchers to elaborate on the framework using more literature. Second, there are probably more interactions and a context-specific sequence of challenges that we cannot capture in this paper. Further research may provide more empirical evidence for such relations. The last limitation concerns the external validity of the findings. We use land subsidence to illustrate an environmental land-use problem while recognizing and acknowledging that these kinds of illustrations tend to be idiosyncratic as "every wicked problem is essentially unique" (Rittel and Webber, 1973). Although the manifestations of challenges may be different for each problem, the challenges themselves are generalizable for environmental land-use problems. Interpreting the challenges based on the wicked problem and creeping crisis literature further ensures generalisability. While the authors are most certain about the relevance of the framework for environmental land-use problems, its broader generalisability is unclear. We invite other authors to unpack the framework further using other environmental problems.

5.2. Reflections on the empirical case

The empirical application of the framework exposed three general counterproductive governance responses to dealing with environmental land-use problems. First, we found a tendency to simplify the complexity of problems, which is arguably part of a broader tendency also found in other policy domains such as climate change adaptation (Du et al., 2022). According to Termeer and Dewulf (2019, p.299), the simplified political belief that "wicked problems can actually be solved, implying a focus on one aspect or a single standpoint" typically leads to overestimation. In the case study, simplification is evident from the traditionally narrow framing of land subsidence as a water problem, and the consequently misplaced trust in technological water management fixes to "solve" the problem. Politicians tend to pursue a silver bullet from "the classical paradigm of science and engineering" (Rittel and Webber, 1973, p.160), while "solutions" for wicked problems are never effective and legitimate in an absolute sense. This miscalculated counterproductive governance response of simplification is precisely the fundamental mismatch between politics and wicked problems problematized by Rittel and Webber (1973). Simplified framing can be a deliberate attempt by politicians to not brand problems as crises if they do not "qualify as agreed-upon risk" in order to justify their lack of decisive interventions that can undermine their legitimacy (Boin et al., 2020, p.133). An explanation reflecting less deliberate intention is that "decision makers' pre-existing beliefs and assumptions about the phenomenon work against any substantial reappraisal of that phenomenon as a problem" (McConnell and 't Hart, 2019, p.652).

The latter explanation relates to the second counterproductive response, which is governmental actors' observed "silo mentality" (De Waal et al., 2019, p.2). The perceived neglect of the interconnectedness between environmental land-use problems has led not only to policy incoherence but also makes actors overlook possible feedback loops. For instance, the one-sided framing of the nitrogen crisis and the resulting polarized debate has also infected land subsidence discussions. At the same time, the policy goals set for climate change have raised attention to land subsidence. Furthermore, the dominant silo mentality behind developing and implementing technological water management fixes for land subsidence has greatly limited the solution space available for social change (Haasnoot et al., 2020).

A third counterproductive response to environmental land-use problems is paralysis, occurring when the wickedness seems overwhelming (Termeer and Dewulf, 2019). In the case study, a symptom of paralysis was the constant postponement of fundamental responses to land subsidence, which decision-makers often attributed to a knowledge gap, mentioning the need for more scientific research. Leaving aside whether these are attempts to postpone radical action, as some interviewees argued deliberatively, it is undeniable that the classical approach of collecting, analyzing, and synthesizing information will not yield an optimal solution for wicked problems (Van Bueren et al., 2003; Rittel and Webber, 1973). Additionally, the interconnected nature of environmental land-use problems seems to have aggravated decision-makers' paralysis. The challenge of organizing leadership reveals that paralyzed decision-makers also restrict the room to manoeuvre of other governance actors, such as innovative farmers, that could embrace the complexity of problems on a small scale.

5.3. Recommendations for workable governance approaches

Based on our findings and reflection, we believe the governance approaches of *responsibilization, mainstreaming* and *experimentation* to be more suitable for adequately addressing environmental land-use problems and thereby averting a crisis than the counterproductive responses to date.

The governance approach of *responsibilization* helps to bring "focus on collective solutions" (Brink and Wamsler, 2018, p.93) to "a collective action problem" (Crowley and Head, 2017, p.534). Although our findings show that responsibilization demands certain leadership from central governments (Mees et al., 2014), other one-sided debates about problem ownership should be avoided as much as possible because they provoke opposition and conflict. Instead, multiple framings of the given problem should be allowed and respected. Furthermore, careful consideration of compensation for actors bearing the burdens of policy (e.g., farmers in the case of land subsidence in rural areas) is deemed necessary (Mees et al., 2014). Hence, responsibilization would also support the selection of accountable policy instruments that stakeholders perceive as legitimate and fair (Termeer et al., 2017). Further research on how to responsibilize problems that typify both a wicked problem and a creeping crisis could build on the existing work of Termeer et al. (2017), Mees et al. (2014) and Brink and Wamsler (2018) about responsibilities for climate adaptation.

A governance approach adopted from the climate adaptation literature is *mainstreaming,* which requires less socio-political commitment to the problem than the governance approach of responsibilization (Uittenbroek et al., 2014; Van den Ende et al., 2022; Runhaar et al., 2018). The possibility of piggybacking on political commitment and exploiting resources available for other policy issues (e.g., the climate crisis) makes mainstreaming appropriate for problems structurally neglected by politicians (Termeer et al., 2017). The approach could address governance challenges such as the levels of action, the alignment across sectoral boundaries, and the selection of policy instruments. Concomitantly, mainstreaming requires strategic framing of environmental land-use problems to stimulate timely detection of anomalies in the system that "have not happened frequently enough to be familiar" (McConnell and 't Hart, 2019, p.652). In addition, little is known about mainstreaming transformative land-use policy that fundamentally differs from the status quo. Research is also needed on how to ensure said policymaking is mainstreamed in multiple policy domains and multiple levels of government simultaneously, as befits their cross-sectoral and cross-level nature (Wamsler and Pauleit, 2016).

Experimentation is a governance approach based on the notion of learning by doing, assuming that ultimately "experiments become embedded […] not through scaling and transfer but gradual replacement of existing modes of governance" (Karvonen, 2018, p.3). Since these small steps of change are less politically risky and can be implemented despite inherent uncertainties (Termeer and Dewulf, 2019), experimentation can help overcome challenges of the levels of action and the timing of policies. It also exemplifies a collaborative relationship

between science and policy (Termeer et al., 2017). Although experimentation can embrace the complexity of environmental land-use problems, there is the risk of labelling an intervention as a small win while it addresses only certain aspects of the problem, hence allowing it to persist. For instance, in the case of land subsidence, experiments have mainly targeted technological innovation while neglecting more social aspects. More research is needed to avoid the tendency of simplification in experimentation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The data that has been used is confidential.

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References

Balint, P.J., Stewart, R.E., Desai, A., Walters, L.C., 2011. Wicked Environmental Problems: Managing Uncertainty and Conflict. Island Press.

Boin, A., Ekengren, M., Rhinard, M., 2020. Hiding in plain sight: conceptualizing the creeping crisis. Risk Hazards Crisis Public Policy 11 (2), 116–138. https://doi.org/10.1002/rhc3.12193.

Boin, A., Mcconnell, A., 't Hart, P., 2021. Governing the Pandemic. The Politics of Navigating a Mega-Crisis. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-72680.

Brink, E., Wamsler, C., 2018. Collaborative governance for climate change adaptation: Mapping citizen-municipality interactions. Environ. Policy Gov. 28, 82–97. https://doi.org/10.1002/eet.1795.

Crowley, K., Head, B.W., 2017. The enduring challenge of 'wicked problems': revisiting Rittel and Webber. Policy Sci. 50, 539–547. https://doi.org/10.1007/s11077-017-9302-4.

De Gooyert, V., De Coninck, H., 2021. De dynamiek van sluipende crises: meekoppelen van klimaatbeleid met besluiten van vandaag. Bestuurskunde 30 (4), 31–40. https://doi.org/10.5553/Bk/092733872021030004004.

De Graeff, J.J., Demmers, M., Hooimeijer, P., Koeman, N.S.J., Kok, J., Nijhof, A.G., Peper, E., Poppe, K.J., Verdaas, J.C., & Van der Zande, A.N. (2020). Stop bodemdaling in veenweidegebieden: Het Groene Hart als voorbeeld.

De Waal, A., Weaver, M., Day, T., Van der Heijden, B., 2019. Silo-Busting: overcoming the greatest threat to organizational performance. Sustainability 11, 6680. https://doi.org/10.3390/su11236860.

DeFries, R., Nagendra, H., 2017. Ecosystem management as a wicked problem. Science 356 (6335), 265–270. https://doi.org/10.1126/science.aal1950.

Den Uyl, R.M., Driessen, P.P.J., 2015. Evaluating governance for sustainable development e Insights from experiences in the Dutch fen landscape. J. Environ. Manag. 163, 186–203. https://doi.org/10.1016/j.jenvman.2015.08.022.

Driessen, P., Dieperink, C., Van Laerhoven, F., Runhaar, H.A.C., Vermeulen, W.J.V., 2012. Towards a conceptual framework for the study of shifts in modes of environmental governance – experiences from The Netherlands. Environ. Policy Gov. 22, 143–160. https://doi.org/10.1002/eet.1580.

Du, H., Triyanti, A., Hegger, D.L.T., Gilissen, H.K., Driessen, P.P.J., van Rijswick, H.F.M.W., 2022. Enriching the concept of solution space for climate adaptation by unfolding legal and governance dimensions. Environ. Sci. Policy 127, 253–262. https://doi.org/10.1016/j.envsci.2021.10.021.

Haasnoot, M., Biesbroek, R., Lawrence, J., Muccione, V., Lempert, R., Glavovic, B., 2020. Defining the solution space to accelerate climate change adaptation. Reg. Environ. Change 20, 37. https://doi.org/10.1007/s10113-020-01623-8.

Hajer, M., 2003. Policy without polity? Policy analysis and the institutional void. Policy Sci. 36, 175–195. https://doi.org/10.1023/A.

Head, B.W., 2019. Forty years of wicked problems literature: forging closer links to policy studies. Policy Soc. 38 (2), 180–197. https://doi.org/10.1080/14494035.2018.1488797.

Hisschemöller, M., Hoppe, R., Dunn, W.N., Ravetz, J.R., 2017. Knowledge, power, and participation in environmental policy analysis. Taylor & Francis.

Hoendermis, M.J. & Van den Brink, I.M. (2020). Kennisagenda Slappe Bodem.

van den Hove, S., 2007. A rationale for science-policy interfaces. Futures 39 (7), 807–826. https://doi.org/10.1016/j.futures.2006.12.004.

Howlett, M., 2012. The lessons of failure: learning and blame avoidance in public policy-making. Int. Political Sci. Rev. 33 (5), 539–555. https://doi.org/10.1177/0192512112453603.

Ingold, K., Driessen, P.P.J., Runhaar, H.A.C., Widmer, A., 2019. On the necessity of connectivity: linking key characteristics of environmental problems with governance modes. J. Environ. Plan. Manag. 62 (11), 1821–1844. https://doi.org/10.1080/09640568.2018.1486700.

Karvonen, A., 2018. The city of permanent experiments? In: Turnheim, B., Kivimaa, P., Burkhout, F. (Eds.), Innovating Climate Governance: Moving Beyond Experiments. Cambridge University Press, pp. 201–215. https://doi.org/10.1017/9781108277679.014.

Kirschke, S., Franke, C., Newig, J., Borchardt, D., 2019. Clusters of water governance problems and their effects on policy delivery. Policy Soc. 38 (2), 255–277. https://doi.org/10.1080/14494035.2019.1586081.

Lange, P., Driessen, P.P.J., Sauer, A., Bornemann, B., Burger, P., 2013. Governing towards sustainability-conceptualizing modes of governance. J. Environ. Policy Plan. 15 (3), 403–425. https://doi.org/10.1080/1523908X.2013.769414.

Levin, K., Cashore, B., Bernstein, S., Auld, G., 2012. Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. Policy Sci. 45, 123–152. https://doi.org/10.1007/s11077-012-9151-0.

McConnell, A., 't Hart, P., 2019. Inaction and public policy: understanding why policymakers "do nothing". Policy Sci. 52, 645–661. https://doi.org/10.1007/s11077-019-09362-2.

Mees, H.L.P., Dijk, J., Van Soest, D., Driessen, P.P.J., Van Rijswick, H.F.M.W., Runhaar, H., 2014. A method for the deliberate and deliberative selection of policy instrument mixes for climate change adaptation. Ecol. Soc. 19 (2).

Moser, S.C., 2010. Communicating climate change: history, challenges, process and future directions. Wiley Interdiscip. Rev.: Clim. Change 1, 31–53. https://doi.org/10.1002/wcc.011.

Rittel, H.W.J., Webber, M.M., 1973. Dilemmas in a general theory of planning. Policy Sci. 4 (2), 155–169. https://doi.org/10.1007/BF01405730.

Runhaar, H., 2017. Governing the transformation towards 'nature-inclusive' agriculture: insights from the Netherlands. Int. J. Agric. Sustain. 15 (4), 340–349. https://doi.org/10.1080/14735903.2017.1312096.

Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C., Wamsler, C., 2018. Mainstreaming climate adaptation: taking stock about "what works" from empirical research worldwide. Reg. Environ. Change 18, 1201–1210. https://doi.org/10.1007/s10113-017-1259-5.

Stouthamer, E., Erkens, G., Cohen, K., Hegger, D., Driessen, P., PeterWeikard, H., Hefting, M., Hanssen, R., Fokker, P., Van Den Akker, J., Groothuijse, F., Van Rijswick, M., 2020. Dutch national scientific research program on land subsidence: living on soft soils subsidence and society. Proc. Int. Assoc. Hydrol. Sci. 382, 815–819. https://doi.org/10.5194/piahs-382-815-2020.

Termeer, C.J.A.M., van den Brink, M.A., 2013. Organizational conditions for dealing with the unknown unknown: illustrated by how a Dutch water management authority is preparing for climate change. Public Manag. Rev. 15 (1), 43–62. https://doi.org/10.1080/14719037.2012.664014.

Termeer, C.J.A.M., Dewulf, A., 2019. A small wins framework to overcome the evaluation paradox of governing wicked problems. Policy Soc. 38 (2), 298–314. https://doi.org/10.1080/14494035.2018.1497933.

Termeer, C.J.A.M., Dewulf, A., Breeman, G., Stiller, S.J., 2015. Governance capabilities for dealing wisely with wicked problems. Adm. Soc. Vol. 47 (Issue 6) https://doi.org/10.1177/0095399712469195.

Termeer, C.J.A.M., Van Buuren, A., Dewulf, A., Huitema, D., Mees, H., Meijerink, S., Van Rijswick, M., 2017. Governance arrangements for the adaptation to climate change. Clim. Sci. 1, 1–27. https://doi.org/10.1093/acrefore/9780190228620.013.600.

Uittenbroek, C.J., Janssen-Jansen, L.B., Spit, T.J.M., Willem, G.M., Runhaar, H.A.C., 2014. Political commitment in organising municipal responses to climate adaptation: the dedicated approach versus the mainstreaming approach. Environ. Polit. 23 (6), 1043–1063. https://doi.org/10.1080/09644016.2014.920563.

Van Bueren, E.M., Klijn, E.-H., Koppenjan, J.F.M., 2003. Dealing with wicked problems in networks: Analyzing an environmental debate from a network perspective. J. Public Adm. Res. Theory 13 (2), 193–212.

Van den Born, G.J., Kragt, F., Henkens, D., Rijken, B., Bemmel, B. van, Sluis, S.M. van der. (2016). Dalende bodems, stijgende kosten: mogelijke maatregelen tegen veenbodemdaling in het landelijk en stedelijk gebied.

Van den Ende, M.A., Mees, H.L.P., Hegger, D.L.T., Driessen, P.J., 2022. Mechanisms influencing mainstreaming of adaptation in spatial development: case studies in three Dutch municipalities. J. Environ. Plan. Manag.

Van Enst, W.I., Driessen, P.P.J., Runhaar, H.A.C., 2014. Towards productive science-policy interfaces: a research agenda. J. Environ. Assess. Policy Manag. 16 (1) https://doi.org/10.1142/S1464333214500070.

Van Hardeveld, H.A., Driessen, P.P.J., Schot, P.P., Wassen, M.J., 2019. How interactive simulations can improve the support of environmental management - lessons from the Dutch peatlands. Environ. Model. Softw. 119, 135–146. https://doi.org/10.1016/j.envsoft.2019.06.001.

Wamsler, C., Pauleit, S., 2016. Making headway in climate policy mainstreaming and ecosystem-based adaptation: two pioneering countries, different pathways, one goal. Clim. Change 137, 71–87. https://doi.org/10.1007/s10584-016-1660-y.