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The transformative potential of experimentation as an environmental governance approach: The case of the Dutch peatlands

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Abstract

Governance of societal transformations toward sustainability is needed to address the fundamental system failures responsible for environmental problems. Possible transformation pathways range from radical shifts to more incremental change. Experimentation is seen as a form of incremental change, but its actual transformative potential is debated. The transformative potential of experimentation is especially questionable for environmental problems characterizing a "creeping crisis" because this problem type is not particularly a lever for social change. Our empirical research contributes to this debate by systemically evaluating the significance (degree of change) and sufficiency (reach of change) of experiments relating to an environmental problem characterizing a creeping crisis that appears to be predominantly governed through experimentation: land subsidence in Dutch peatlands. We found that experiments have indeed proved to be significant for local regime actors because most have tested technical innovations that kept the overall land use system intact. However, experimentation was less significant in terms of reflecting the complexity of environmental problems; that would require a more diverse set of technical, social, legal, and planning experiments from which the strategy most suitable for specific landscape contexts could be determined. We also found signs of accumulation of outcomes, but whether this eventually initiates transformative change or creates a technological lock-in can only be determined with longitudinal research. To enhance the transformative potential of experimentation, particularly as a governance approach for creeping crises, attention must be paid to actor and institutional features since they shape experiments. Hence, we conclude with design principles for transformative experimentation.

KEYWORDS
creeping crisis, environmental governance, experimentation, land subsidence, transformative potential, wicked problem

1 | INTRODUCTION

In times of environmental problems piling up rapidly and surprising societies worldwide, calls for governance of societal transformations toward sustainability have amplified concomitantly. Sustainability transformations are deemed necessary to address the system failures (e.g., values, mindsets, power structures, and institutions) in which environmental problems are rooted (Patterson et al., 2017; Visseren-Hamakers et al., 2021). Proposed governance approaches to transformations range from relatively rapid policy reform, to more incremental change (Patterson et al., 2017; Termeer & Dewulf, 2019). While many scholars argue that a combination of both is needed, the enduring challenge of adequate policymaking for wicked environmental problems (Crowley & Head, 2017; Head, 2019; Rittel & Webber, 1973; Van Bueren et al., 2003) and the widespread emergence of small, concrete actions using notions of creativity, learning and innovation (Bulkeley, 2021; Bulkeley & Castán Broto, 2013; Den Uyl & Munaretto, 2020; Evans et al., 2016; Huitema et al., 2018; Karvonen, 2018; McFadgen & Huitema, 2017; Torrens et al., 2019) suggest that the latter approach—also referred to as "experimentation"—is especially promising. Governance scholars in various fields, such as flood risk management (Buijs et al., 2018) and biodiversity (Visseren-Hamakers et al., 2021), have praised experimentation as an example of adaptive governance enabling "iterative learning, adjusting responses to uncertainty, social conflicts, and complexity over time" (Visseren-Hamakers et al., 2021, p. 23). It is therefore ostensibly an approach that can embrace the inherent wickedness (i.e., complexity, uncertainty, and norm plurality) of environmental problems (Van den Ende et al., 2023). One might expect particularly "exotic" ideas to be proposed for experimentation, because unlike structural policy, experiments provide a safe space in which the extent, duration, visibility, and intensity of potential failure are limited (Howlett, 2012). Experimentation is also appreciated in periods of chaos and crises, for the ability "to act despite uncertainties and gaps in knowledge" (Karvonen, 2018, p. 3) and for its "promise to introduce new conceptions and configurations to the evolution of (cities)" (Karvonen, 2018, p. 2).

The practical application of new ways of thinking or doing in the present mean that experiments can be seen as "seeds" of a desirable future (Bennett et al., 2016). However, the desirability of a certain future is above all a political matter. Hence, scholars are debating whether "experimental activities reinterpret and reframe the trajectories of contemporary (urban) development" (Evans et al., 2016, p. 2), or whether they merely reproduce existing systems, power structures, and institutions (Bulkeley, 2021; Evans et al., 2016; Karvonen, 2018; Patterson et al., 2017). Although we do not witness a complete knowledge gap around the role of experimentation in transformation processes, the literature has hitherto mainly focused on experimentation for climate governance in urban contexts (Bulkeley, 2021; Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013; Evans et al., 2016; Huitema et al., 2018; Karvonen, 2018; Torrens et al., 2019). Specifically lacking are studies evaluating the transformative potential of experimentation in relation to environmental problems that do *not* benefit from widespread political and societal urgency, also referred to as "creeping crises" (Boin et al., 2020). Creeping crises require special attention because they often lack structural policies and therefore rely on bottom-up approaches such as experimentation. The transformative potential is hereby questionable, because in contrast to regular crises, creeping crises are not typically levers for radical social change (Boin & Hart, 2022). In this paper, we intend to contribute to this knowledge gap with the following research question: "What is the transformative potential of experimentation as a governance approach to environmental problems characterizing a creeping crisis?". We developed an evaluation framework using two questions Bulkeley (2021, p. 273) posed for future research—the first concerning the significance of experimentation "(…) for whom and on what terms does experimentation matter?" and the second "most hotly debated" question concerning its sufficiency: "(…) where is experimentation leading?".

We applied the framework to the problem of land subsidence in Dutch peatlands. The peatlands are in the low-lying west of the Netherlands and comprise diverse landscapes such as thick peat layers (>3 m), thin peat layers (<1 m), strategic peatland zones near critical dams and dikes, buffer zones near nature areas, historical peatland, and peatland near urban areas (Wils et al., 2024). In the built environment, land subsidence is driven by the weight of buildings and infrastructure constructed on soft peat, causing costly damage. In agricultural areas, decades of draining land have led to low water levels and peat oxidation, resulting in greenhouse gas (GHG) emissions and land subsidence (Stouthamer et al., 2020). Land subsidence is one of many wicked environmental problems in the Dutch peatlands; some of which are labeled as a regular crisis (e.g., nitrogen pollution), while others simmer as a creeping crisis (e.g., biodiversity loss, freshwater shortage, zoonotic diseases, and relatedly, animal welfare).

This paper is structured as follows. Section 2 first discusses the concept of transformative potential and then presents the evaluation framework. Section 3 contains the methodology. In Section 4, the findings with regards to the transformative potential of experimentation in relation to land subsidence are discussed. Section 5 presents the conclusion, reflections, and recommendations.

2 | CONCEPTUAL FRAMEWORK

2.1 | Transformative potential of environmental governance

Environmental governance, defined as "the ensemble of actors, institutions and content" with "all kinds of measure deliberately taken to prevent, reduce and/or mitigate harmful effects on the environment" (Driessen et al., 2012, p.144), is the key force of sustainability transformations. However, while there are ample examples of governance approaches that "actively trigger and steer" transformation pathways (Patterson et al., 2017, p. 4), they can also deviate from it (Du et al., 2022). Such differences in transformative potential show the importance of critical evaluations of environmental governance approaches.

Patterson et al.'s (2017) definition of sustainability transformations as "fundamental changes in structural, functional, relational, and cognitive aspects of socio-technical ecological systems that lead to new patterns of interactions and outcomes" (p. 2) provides two evaluation angles. The first angle focuses on the normative meaning (Jordan & Lenschow, 2010), "depth" (Termeer & Dewulf, 2019), or "degree" (Candel & Biesbroek, 2016) of change that governance approaches bring about. Broadly stated, governance approaches targeting "fit-and-conform" (Smith & Raven, 2012), "superficial", or "first-order" (Termeer et al., 2019) change "fix" or "repair" a problem *within* financial, technological, socio-cognitive, political and cultural structures, processes and practices. These system features are precisely the target of change of governance approaches initiating "stretch-and-transform" (Smith & Raven, 2012), "in-depth" or "second-order" change (Termeer & Dewulf, 2019). Persistent phenomena such as the "implementation gap" (Runhaar et al., 2018) raise the importance of also evaluating the implementation of conceptions of change articulated in, for example, policy plans (Reckien et al., 2018). Hence, the second evaluation angle concerns the "reach" or "impact" of change generated by environmental governance approaches (Jordan & Lenschow, 2010). It should be noted that although this conceptualization of transformative potential emphasizes the *content* or produce of governance approaches, this cannot be comprehensively understood without also considering *actors* and *institutions* (Driessen et al., 2012).

In the next paragraphs, we discuss the concept of transformative potential in the context of the governance approach of experimentation.

2.2 | The significance of experimentation: The degree of change at experiment level

Experimentation has been explored by scholars of environmental governance (Bulkeley & Castán Broto, 2013; McFadgen & Huitema, 2017), transition management (Loorbach et al., 2015; Sengers et al., 2019), and human geography (Evans et al., 2016; Torrens et al., 2019). Although there seems to be general agreement that experiments comprise a novelty practiced in a more or less controlled setting, the variety of denotations ranging from "policy experiments" (Den Uyl & Munaretto, 2020; McFadgen & Huitema, 2017), to "urban laboratories, innovation districts, demonstration projects, and testbeds" (Karvonen, 2018, p. 1), "niche experiments," "bounded socio-technical experiments," "transition experiments," "grassroots experiments," and "sustainability experiments" (Sengers et al., 2019, p. 160) suggests that experiments are not the same. In fact, experimentation for sustainability is not necessarily "an a priori beneficial endeavor" (Evans et al., 2016, p. 3) for the environment, although it may be in terms of, for instance, economic or social interests (Bulkeley, 2021; Jordan & Lenschow, 2010). Bulkeley's (2021, p. 273) question of "(…) for whom and on what terms does experimentation matter?" is therefore relevant, particularly for wicked environmental problems because of their indefinable nature, and for those characterizing a "creeping crisis" because of a lacking collective sense of urgency.

From a transformation perspective, experiments can be considered significant if they target the systemic root causes of environmental problems through "triple-loop learning": "redefining, relearning, and unlearning what we have all learnt before" (Gupta, 2016, p. 193). Experiments considered less significant are those testing very simplistic ideas about how to solve environmental problems, as if they were "tame" or structured by nature (Rittel & Webber, 1973). Such experiments perform "single-loop learning" by improving existing practices without questioning habits underpinned by assumptions, norms, and values. In the environmental governance literature, these experiments are commonly referred to as "quick wins," "low-hanging fruit," (Termeer & Dewulf, 2019) or "sustainability fixes" (Bulkeley, 2021). Moderately significant would then be experiments performing "double-loop learning," for instance in practices that redefine the assumptions underlying infinite economic growth, yet stick to the belief in eco-modernist notions such as "sustainable growth" (Gupta, 2016).

The wickedness of environmental problems means that people have different definitions of the problem and appropriate solutions. Hence, experiments receiving the label 'significant' are not necessarily also *perceived* as significant by stakeholders. For regime actors, transformative experiments may not be significant precisely *because* they challenge existing political, economic, and social system structures (Evans et al., 2016). Evaluations of the significance of experiments therefore require explicit consideration of actors and their problem framing.

2.3 | The sufficiency of experimentation: The reach of change at system level

Where significance represents the degree of change at the level of the experiment itself, we refer to sufficiency as the reach of change at the system level. Sufficient governance approaches are often referred to as "effective," "successful," or "viable" responses to "big" environmental challenges (Bulkeley, 2021). The question of "(…) where is experimentation leading?" (Bulkeley, 2021, p. 273) is particularly relevant given the small scale of experiments, which in the best case initiates incremental change toward sustainability. While the sufficiency of "incrementalism" for transformations is subject of ongoing scholarly debate (Patterson et al., 2017), in the optimistic camp views also differ on the way incremental change generated by experiments can matter at system level. Scholars of environmental planning and management often refer to the relatively manageable process of "upscaling," which assumes a more or less direct relation between the learning that happens in experiments and policy change (Karvonen, 2018; McFadgen & Huitema, 2017; Van Doren et al., 2018). Here, the renowned "pilot paradox" is invoked for cases where learning does not extend beyond the experiment level (Van Buuren et al., 2018). Evidence shows that the pilot paradox phenomenon particularly applies to experiments with transformative ideas (Den Uyl & Munaretto, 2020; McFadgen & Huitema, 2017; Meijerink, 2005; Stoker, 2010; Termeer & Dewulf, 2019). However, policy learning is only one way in which experimentation can generate enduring change. Experiments can also

impact the system in the absence of direct political commitment—for example, through more non-linear processes such as diffusion and embedding in different networks (Bulkeley, 2021). From this perspective, experiments are deemed sufficient if they "disrupt, reconfigure, and circulate through the more or less spatially extensive or socially-politically 'dense' networks of which they are already part, opening up cracks (in the urban milieu) that allow for other forms of possible (urban) futures to take hold" (Bulkeley, 2021, p. 275). Termeer and Dewulf (2019) have encapsulated this broader notion of the potential impact of experiments in the term "propelling mechanisms," defined as "chains of events that reinforce themselves through feedback loops with an amplifying effect on an initial small change so that it becomes larger and stronger, or intensifies and escalates its consequences" (p. 305).

2.4 | Evaluation framework

We selected the small wins framework of Termeer and Dewulf (2019) to evaluate the transformative potential of the governance approach of experimentation in the Dutch peatlands (see Table 1). The main reason for choosing the small wins concept relates to the "evaluation paradox" of intractable and indefinable wicked problems, especially in combination with the small appearance of experiments. Ex-post evaluations using the small wins framework can help unraveling undesirable directions of incremental change induced by frequent counterproductive responses of paralysis and simplification, while ex-ante evaluations can help avoid such responses in the future.

The significance of experiments is captured by the notion of "small wins," defined as "concrete, completed, implemented outcomes of moderate importance" (Weick, 1984, p. 43). From this view, an experiment can be deemed significant if it tests radical new practices reflecting deep change (rather than "low-hanging fruit" reflecting superficial change), if it is an intermediate practice (rather than best practice), and if it is perceived by many stakeholders as an improvement or step forward to a shared ambition (rather than a small loss) (Termeer et al., 2019, p. 303). The indicator of 'concrete outcomes' was left out of the evaluation framework since experiments by definition test plans in practice. Small wins seem particularly appropriate for environmental problems characterizing wicked problems and creeping crises, because "Incremental steps can be made quickly because they are only incremental. They do not rock the boat, do not stir up the great antagonisms and paralyzing schisms, as do proposals for more drastic change." (Lindblom, 1979, in Termeer & Dewulf, 2019, p. 303).

The sufficiency of experiments is captured by the concept of "propelling mechanisms," which reflect the different ways experiments "accumulate and scale up, broaden or deepen" (Termeer et al., 2019, p. 305), namely through energizing stakeholders, stimulating iterative learning, attracting additional resources, inspiring others to do something similar, linking with other problem domains, and creating path dependency. By activating these mechanisms, an experiment diffuses its impact beyond its own level. We chose this concept to evaluate sufficiency because it goes beyond evaluation indicators such as "upscaling" (Kemp et al., 1998) that imply deliberate niche management strategies. Propelling mechanisms complement this view by also valuing the small improvements brought by experiments that "may not be taken up, and may never become institutionalized" (Termeer & Dewulf, 2019, p. 303)—something that would be labeled as the "pilot paradox" in policy sciences (Huitema et al., 2018; McFadgen & Huitema, 2017). An evaluation that appreciates such more non-linear ways of generating impact is especially important in the case of experiments for which policy uptake is most challenging, namely those targeting deep societal change (Den Uyl & Munaretto, 2020) and those addressing "creeping" crises (Boin et al., 2020). Similarities with political mechanisms of "normalization," "capacity building," and "coalition building" are a reminder that propelling mechanisms are not neutral processes either (Bernstein & Hoffmann, 2018).

TABLE 1 Analytical framework to evaluate the transformative potential of experiments inspired by the small wins framework (Termeer & Dewulf, 2019).

1) Significance (i.e., degree of change): is the experiment a small win?		
	Small win	Contra-indicator
Deep changes	Second- and third-order change	More of the same
	Radical new practices	Quick wins/low-hanging fruit
Moderate importance	Micro or local level	Large scale
	Intermediate	Best practice
Positive judgment	Improvement	Small loss for many actors
	Step forward	
	Related to shared ambition	
2) Sufficiency (i.e., reach of change): does the experiment activate propelling mechanisms?		
Energizing mechanism	Energy and enthusiasm	
	Empowerment	
Learning by doing mechanism	More than one experiment	
	Learning outcomes guide new experiments	
	Experimenting also continues after disappointing and unexpected outcomes	
Logic of attraction mechanism	Other communities know and value wins	
	Additional resources	
Bandwagon mechanism	Highlighting and celebrating wins	
Coupling mechanism	Connections with problems or aims from other policy domains	
	Connections across scales	
Robustness	Numerous experiments	
	Unstoppable	
	Internalized behavioral change	
	Examples of resisted opposition	

3 | METHODOLOGY

3.1 | Case study

We opted for a representative embedded single-case study: experimentation relating to land subsidence in the western peatlands of the Netherlands. Land subsidence was chosen as topical issue in relation to experimentation because it is a wicked problem with the "inch-by-inch" dynamic of a creeping crisis (Van den Ende et al., 2023). These problem characteristics pose several challenges for transformative governance (Van den Ende et al., 2023). First, as befits a wicked problem, land subsidence has no definite formulation. While it can be seen as a problem of safety, housing, climate adaptation, climate mitigation, water quality and biodiversity (Van den Ende et al., 2023), in practice the dominant framing of land subsidence is as a water management problem, and more recently as a climate problem. The wickedness of land subsidence also stems from its precarious position in the midst of competing land-use claims (e.g., housing, agriculture, urbanization) (Den Uyl & Munaretto, 2020). Furthermore, it faces persistent cognitive uncertainties (due to "limited technical knowledge about, among other things, the rate of subsidence, the effects and the effectiveness of measures"), strategic uncertainties (due to "the plurality of norms and perspectives of involved stakeholders (e.g., farmers, citizens, municipalities, water authorities, provinces, the national government) and their respective approaches (…)"), and institutional uncertainties (due to "the fragmented institutional setting in which decisions on land subsidence are made") (Van den Ende et al., 2023, p. 171). The governance challenge arising from the "creeping crisis" (Boin et al., 2020, 2021) nature of land subsidence, is that its slow pace has prevented significant societal and political urgency arising (Van den Ende et al., 2023). In this context, the lack of structural land subsidence policy (Stouthamer et al., 2020; Van den Ende et al., 2023) and the multiplicity of experiments (Den Uyl & Munaretto, 2020) suggest experimentation to be the dominant governance approach.

An Internet search revealed an overview of existing land subsidence experiments. Specifically, we wanted to identify the *favorable* (Flyvbjerg, 2006) or *revelatory* (Yin, 2009) cases, assuming that "if the thesis could be proved false in the favorable case, then it would most likely be false for intermediate cases" (Flyvbjerg, 2006, p. 10). Hence, we opted for strategic sampling by conducting short interviews of 15–30 minutes (in Dutch) with five experts active in land subsidence issues in the Dutch context. The experts were strategically selected for their different backgrounds (research institutes, governments, NGO), on the premise that they complemented each other by having only a confined view of all the experiments. We asked the experts which experiments they perceived most significant for land subsidence. We left it to the experts to decide what being significant entailed. The only criteria were that the experiment had to: (1) involve collaboration between public and private parties (to capture governance interactions); (2) show a technical and social learning process (to avoid laboratory experiments); and (3) be ongoing or completed (to enable evaluation). From the experiments that the experts perceived most significant for land subsidence, we selected 10 for analysis (see Appendix A for an overview). While we tried to create variance, most experiments were similar in terms of "what" (technical innovations), "where" (agricultural area with a thick peat layer), "why" (to reduce land subsidence and GHG emissions while maintaining the existing land use function), "which knowledge" (scientific measurements and practical experience), and "who" (direct stakeholders: local/regional governments and farmers). They were also most similar in that they targeted land subsidence in the same socio-cultural, economic, and political context.

3.2 | Data collection

We used multiple methods of data collection, in addition to the exploratory interviews mentioned above. First, we studied the project plans, interim reports, and evaluation reports about the 10 experiments. Second, for each experiment, we formed a focus group of 3 to 5 key stakeholders. Focus group members were chosen for the richness of their experiences rather than their different perspectives. In all focus groups, local governments (e.g., municipality, water authority) and private actors (e.g., farmers, entrepreneurs) were represented. In total, 30 stakeholders participated in this research (participants are presented in bold in the overview of experiments in Appendix A).

The focus groups were semi-structured; two general questions were asked to set the subject for discussion, and the evaluation framework was used to check whether all aspects were covered during the conversation. If necessary, more questions were asked to cover the missing aspects. The focus groups met between July and October 2022. Meetings were held in Dutch. All participants gave formal permission to record the group discussion.

3.3 | Data analysis

We first transcribed the 10 focus group discussions and then used NVivo to analyze them using the categories of the evaluation framework presented in Section 2.4. The subcategories were used deductively as coding labels. We opted for deductive coding instead of inductive coding because the aim was to use it as a heuristic for evaluation. After the 10 transcriptions had been coded, the codes were analyzed along the subcategories. We used the results of the evaluation of significance (experiments generating deep changes with radical new practices versus experiments generating business-as-usual change with low-hanging fruit practices) to structure the evaluation of sufficiency.

4 | RESULTS

4.1 | Significance of experimentation

Eight out of 10 experiments focused on technical measures, of which one in combination with financial aspects (i.e., a financing instrument)

and two in combination with social/process innovation (i.e., a collaborative, local-led search for feasible options) (see Appendix A). Table 2 shows that the latter two experiments were positively judged by participants for their contribution to trust building. Although technical measures in the agricultural area were economically not beneficial (their effect was either neutral or entailed yield loss or investment costs) and the effects on the environment were not unanimously positive, farmers and governments appreciated them as intermediate solutions needing further development. It is not surprising that there is a relationship between the legitimization of technical measures by farmers and governments and the observation that these innovations failed to meet one aspect of the small wins' characterization: targeting deep changes. Resulting from a rather simplified framing of land subsidence as a problem of water management and climate change, the experiments entailed a "solution" to peat oxidation, which is only a symptom of an underlying, more complex systemic problem. Other framings of land subsidence (e.g., as a problem of public safety, economy, biodiversity, buildings, and infrastructure) as well as other environmental problems and (creeping) crises in the agricultural area (e.g., sea level rise, biodiversity loss, freshwater shortage, nitrogen pollution, sufficient housing, and animal welfare) thereby remained unaddressed. That the systemic root cause of the myriad of environmental problems in the Dutch peatlands, that is, unsustainable land use, was never intended to be fundamentally addressed shows from the shared ambition to find ways to addressing environmental problems without comprising the business-as-usual way of intensive dairy farming. Two experiments with paludiculture (i.e., a form of agroecology) in the agricultural area were more significant in this regard: farming in

TABLE 2 Overview of the significance of the 10 experiments.

Experiment	Significant?
1.	The pilot concerned local initiative that was seen as an intermediate step (**intermediate practice, local level**); and while it did not bring direct economic benefits for farmers, many deemed investments in innovations necessary to be able to continue farming in the future (**related to shared ambition**). However, it did not target deep change as it represented a relatively easy option that allowed conventional dairy farming to continue (**low-hanging fruit**)
2.	The pilot was seen as a temporary financing instrument for a technical measure as part of a broader transition to agriculture with a higher groundwater level (**intermediate practice**); it was appreciated as a step toward a new business model for agriculture in the peatlands (**step forward**). However, although carbon certification can eventually become a financing instrument for stimulating radical new agricultural practices, these carbon credits were sold for a relatively easy and safe technical measure which allows conventional agriculture to continue (**low-hanging fruit**)
3.	The pilot embodied a local initiative that was seen as an intermediate step (**intermediate practice, local level**); and while it did not bring direct economic benefits for farmers, many deemed investments in innovations necessary to be able to continue farming in the future (**related to shared ambition**). However, it did not target deep change as it represented a relatively easy option that allowed conventional dairy farming to continue (**low-hanging fruit**)
4.	The company was a local initiative under development (**intermediate practice, local level**); it was appreciated by governments for its new business model and as an addition to the variety of local products in the peatlands (**improvement, related to shared ambition**); and it embodied a new way of agriculture that fitted the recently allocated land use of nature reserve (**second- and third-order change**)
5.	The pilot was a continuous learning process at the local level (**intermediate practice, local level**); it was appreciated for its participation process and the robust technique for adapting to land subsidence (**improvement**); and the collaborative and integral approach to spatial planning reflected a change in routines, beliefs, and values (**second- and third-order change**)
6.	The living lab was a continuous learning process at the local level (**intermediate practice, local level**). However, it also came with additional costs for the farmer (**small loss**) and while the measure improved existing water management, it represented a relatively easy option that allowed conventional dairy farming to continue (**low-hanging fruit**)
7.	The pilot embodied a local initiative that was seen as an intermediate step in a larger transition (**intermediate practice, local level**), and farmers perceived it as a win-win situation because it allowed them to continue to use the land for agriculture (**improvement, related to shared ambition**). However, it did not target deep change as it represented a relatively easy option that allowed conventional dairy farming to continue (**low-hanging fruit**)
8.	The pilot was seen as an intermediate step toward larger change (**intermediate practice**); it was appreciated by the local government and farmers for bringing the human dimension into addressing water system issues, a change that many were aware was necessary to enable farming to continue in the future (**improvement, related to shared ambition**), and the integral, collaborative, local-led search for solutions for water system issues represented a change in routines, beliefs, and values (**second- and third-order change**). However, it did not target deep change as the debated measures represented relatively easy options that allowed conventional dairy farming to continue (**low-hanging fruit**)
9.	The pilot was a local initiative under development (**intermediate practice, local level**); it was seen as a step toward a new business model for future-proof farming (**step forward, related to shared ambition**); and it embodied a radical new way of agriculture that fits with the announced sustainable water management policy in the peatland area (**second- and third-order change**)
10.	The pilot was seen as an innovation under development (**intermediate practice, local level**), and while it did not bring economic revenue or practical benefits for farmers, many recognized that investments in innovations are needed to be able to continue (extensive) farming in the future (**related to shared ambition**). However, the pilot did not represent deep change because the measure was a relatively easy option that allowed conventional dairy farming to continue (**low-hanging fruit**)

TABLE 3 Overview of the sufficiency of the 10 case study experiments.

	Ingredients of propelling mechanisms?					
Experiments	**Energizing**	**Learning by doing**	**Logic of attraction**	**Bandwagon**	**Coupling**	**Robustness**
Radical new practices (generating deep change)	It has reinforced the entrepreneur's enthusiasm for radically different forms of agriculture (4) It has empowered citizens in terms of co-deciding on spatial planning (5)	It has revealed possibilities (4, 5) and limitations (9) of radically different land use management (agroecology (4, 9) and spatial planning (5))		It has inspired others to do something similar (5, 9)	It reflected a broader, integral approach to more sustainable land use. In the built area, land subsidence was coupled with addressing spatial planning, and in the non-built area it was coupled with addressing climate change, biodiversity loss (4, 5, 9), the shortage of building materials, water quality, and the exploration of business models for a new system of agriculture (9)	
Low-hanging fruit (generating business-as-usual change)	It has enabled farmers to continue conventional farming in the future (1, 2, 7) It has empowered farmers because the measures came about as a result of a collaborative process instead of being hierarchically imposed (1, 3, 7, 8, 10)	It has contributed to initiatives to centralize knowledge in a regional partnership (1) It has contributed to a better understanding of the effectiveness and practical application of the measure (2, 6, 7, 8, 10)	It has contributed to the mobilization of new resources for upscaling similar experiments (3, 7)	It has inspired others to do something similar (1, 3, 7)	It was mostly coupled to enabling future of dairy farming (1, 2, 3, 6, 7, 8, 10), addressing climate change (1, 2, 3, 6, 7, 10), and to a lesser extent to biodiversity (6, 7) and nitrogen pollution (10)	It has increased legitimization of the technical measure (1, 3, 7) despite disappointing outcomes (1, 3)

collaboration with nature showcased a deep change in routines, beliefs, and values with regards to land use in the peatlands. These experiments were primarily appreciated by participating farmers, but less so by their colleagues due to social, economic, and institutional constraints.

Summarizing, the empirical case shows that experimentation in the Dutch peatlands mostly matters for incumbent stakeholders on the condition that it maintains the existing agricultural system. The result—a large majority of experiments testing technical "low-hanging fruit" options, does not reflect the complexity of land subsidence and other environmental problems in the Dutch peatlands. Hence, the governance approach is less significant from a transformation perspective.

4.2 | Sufficiency of experimentation

As at the time of writing many of the experiments were ongoing or had recently ended, it was impossible to assess their impact at system level. Nevertheless, we observed that all experiments contained important ingredients for activating propelling mechanisms (see Table 3). There are, however, differences: the two experiments showing signs of all propelling mechanisms were low-hanging fruit practices, while those experiments testing radical new practices showed signs of only half of the mechanisms.

Table 3 shows that all experiments with low-hanging fruit practices showed several signs of initiating an *energizing mechanism*. One is that farmers were becoming hopeful from committing to what they perceived as a win-win situation: addressing land subsidence while continuing conventional dairy farming. In addition, most of these experiments entailed horizontal collaboration, which contributed to farmers' sense of empowerment and to building trust between farmers and governments. Furthermore (perhaps unsurprisingly, as these are experiments), there is evidence for the *learning by doing mechanism*. The experiments with radical new practices have revealed opportunities but also obstacles, such as a lack of supply chain and institutional constraints. The technical experiments improved understanding of the effect and practical application of innovation. However, respondents also mentioned that the learning was rather ad hoc and occurred primarily within local and regional networks, with limited emphasis on communicating monitoring outcomes, collecting the lessons learned, and coordinating mutual learning. While respondents mentioned obstacles related to the transmission of results (e.g., lack of capacity in the form of a dedicated communication team), the discussions also hinted at obstacles on the recipients' side (e.g., lack of "organizational or political mandate for innovation") (Osborne & Brown, 2011, p. 1342).

Interestingly, all experiments showed signs of the *coupling mechanism*. However, while the radical new practices made connections with spatial planning in the broadest sense, most low-hanging fruit practices coupled it with the pending agricultural transition and the issue of climate change (the technical measures have the potential to also reduce GHG emissions). The (symbolic) acknowledgment of the climate crisis in the form of the National Climate Agreement has been helpful for policy learning of technical measures, since the goal to reduce GHG emissions in peatlands has initiated new learning programs, research networks, and local partnerships. The sudden increase in attention and resource mobilization for these experiments (a sign of the *logic of attraction mechanism*) could mark a point of no return, hence activating a *robustness mechanism*. However, the current geographic centering of technical experiments in agricultural areas with thick peat layers shows that locations with high potential for climate reasons are prioritized over those perhaps favorable for other considerations such as flood risk or economic damage (e.g., strategic peatland zones). The *logic of attraction* and *robustness mechanisms* activated by experiments that framed land subsidence as a climate problem, were not visibly activated by paludiculture experiments, probably because this practice can lead to significant emissions of another GHG: methane. Furthermore, many innovations inspired others (a sign of the *bandwagon effect mechanism*), which has led to some concrete adoptions. However, respondents mentioned various obstacles to upscaling, particularly when talking about the radical new practices. The obstacles indicated were lack of capacity (e.g., resources, time, manpower), and of supportive institutions and a viable business model; also indicated were cultural constraints (e.g., farmers wanted to continue dairy farming).

Summarizing, although it is too early to prove whether the experiments have activated certain propelling mechanisms needed for initiating larger processes of change, they—especially experiments with low-hanging fruit practices—certainly have ingredients that show they have potential to do so. The findings show that accumulation can also be stimulated by developments around other environmental problems—in this case, climate change. However, care must be taken to avoid the dominance of experiments investigating only one aspect of the problem, as that would again lead to simplification. From a transformation perspective, there is the risk that propelling mechanisms "normalizing the experiment in everyday practices" (Castán Broto & Bulkeley, 2013, p. 1938) eventually strengthen a technological path dependency or lock-in. The observed lack of institutions for sustainability transformations further reduces the chance of experiments with radical new practices impacting the direction of change.

5 | CONCLUSION, REFLECTIONS, AND RECOMMENDATIONS

5.1 | Conclusion

This article rests on the premise that the accumulation of environmental problems calls for governance approaches that can address their systemic root causes. We have argued that experimentation is an example of such a governance approach, that by exploring, trying out and learning from new practices can contribute to transformative change toward sustainability. However, the actual transformative potential of experimentation has been the subject of scholarly debate (see e.g., Bulkeley, 2021; Evans et al., 2016;

Patterson et al., 2017), reflecting doubts about both its degree of change, and its reach of change. In this paper we intended to answer the research question of "What is the transformative potential of experimentation as a governance approach to environmental problems characterizing a creeping crisis?", by evaluating the significance and sufficiency of 10 experiments relating to land subsidence in the Dutch peatlands. The focus on an environmental problem that characterizes a creeping crisis (Boin et al., 2020) was deliberate, as there is already substantial knowledge on experimentation relating to the more "eye-catching" issue of climate change (see e.g. Bulkeley, 2021; Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013; Evans et al., 2016; Karvonen, 2018; Torrens et al., 2019).

In the empirical case, experimentation was indeed significant for incumbent stakeholders, because technical innovations "fixing" land subsidence maintained the existing land use system. However, these experiments were less significant in terms of reflecting on the economic, institutional, and social aspects of the existing land use system in which land subsidence and other environmental problems in the peatlands are rooted. Only two out of ten experiments tested entirely new combinations of land use adapted to the specific landscape characteristics. In doing so, they introduced a new framing that better reflects the complexity of the problem of land subsidence. However, these experiments were judged negatively by many farmers due to social, institutional, and economic obstacles. With regard to sufficiency, we found several signs of accumulation of the progress made in experiments, most notably those by low-hanging fruit practices. It is possible that experimentation leads to path dependence of technical innovation, away from transformations. However—and this is linked to the limitations of our research—we recognize that an ex-ante evaluation of transformations is challenging, because transformative change is by definition messy, non-linear, and unfolds over the long-term (Patterson et al., 2017; Termeer & Dewulf, 2019). It would require longitudinal research to better capture the actual contribution of experiments to transformation pathways.

The evaluation framework, based on the concepts of small wins and propelling mechanisms, has proven useful to unraveling the transformative potential of experimentation as a governance approach. Policy actors can apply it to examine whether experimentation, influenced by actors and institutions, contributes to, or deviates from transformation pathways. This is relevant when it comes to wicked environmental problems because of their indefinable nature, and particularly those characterizing a "creeping crisis" because of a lacking sense of urgency. The ex-post focus of our empirical evaluation has limitations; in case of less transformative potential, the damage in the form of path dependencies or lock-ins has already been done. Hence, in the recommendations we provide some ex-ante design principles for transformative experimentation.

5.2 | Reflection on the findings

Our conclusions contain two starting points for discussing the transformative potential of experimentation. The first key observation is that experimentation was mainly significant in terms of stakeholders' perception. With local stakeholders operating along the notion of "making sense together" instead of "speaking truth to power" (Termeer et al., 2017), experiments are essentially a manifestation of an improved "science–policy–market interface" (Van den Ende et al., 2023) that can settle the power issues which often arise in centralized or decentralized modes of governance (Driessen et al., 2012). At the same time, experimentation was less significant in terms of deep change. This shows an interesting discrepancy compared with examples of local-led experimentation that display more transformative potential (Evans et al., 2016; Karvonen, 2018). A possible explanation is the varying threat perceptions associated with different problem types, and related to this, which groups of actors are represented in experimentation. By different problem types we mean environmental problems characterizing "creeping crises" versus those recognized as "regular crises" (Boin et al., 2020). To illustrate our point, it seems that public attention for climate change in the urban context has attracted a diverse group of societal actors to experimentation (Bennett et al., 2016; Evans et al., 2016; Karvonen, 2018; Torrens et al., 2019), resulting in a mixed bag of experiments bringing the discomfort, contradiction, contention, and disagreement that are deemed essential to question and challenge incumbent interests and visions of the future (Bulkeley, 2021; Chambers et al., 2022). This resonates with the notions of "stretch-and-transform" (Smith & Raven, 2012) or "Darwinian experimentalism"—a way of experimentation characterizing "high levels of diversity so that many diverging approaches are tried out" (Ansell & Bartenberger, 2016, in Huitema et al., 2018, p.146). In contrast, land subsidence in the Dutch peatlands is still a "creeping crisis" whose "inch-by-inch dynamic" (Boin et al., 2021) seems to have prevented the wider public from recognizing its huge damage potential (Van den Ende et al., 2023). As a result, only a select group of local regime actors directly confronted with the problem has been involved in the experimentation. Connected by their shared framing of land subsidence as a water management and climate problem, and their common interest in maintaining the existing land-use allocation, these regime actors formed "advocacy coalitions" (Meijerink, 2005) with the power to prioritize experiments with new (technical) ways of carrying on as usual over experiments with radical new ideas such as agroecology, cultivating salt-tolerant crops, natural water storage, or floating houses (Haasnoot et al., 2013). This observed "fit-and-conform" form of experimentation (Smith & Raven, 2012) resonates with the notion of "generative experimentation," which entails "trying out one specific innovation and constantly improving upon it on the basis of experience" (Ansell & Bartenberger, 2016, in Huitema et al., 2018, p. 146); a choice that can be eminently justified for problems that are 'only' a creeping crisis. Although seemingly apolitical in light of the Dutch legacy in combating water and the cultural identity of the Netherlands as a country of dairy farming, the one-sided framing of land subsidence is, in the words of Stirling (2008, p. 265), very much a "discursive (…) attachment to particular technological pathways" securing "a single course or a very small subset of possible courses of action (or technology commitments), which appear as preferable under the particular framing conditions privileged in appraisal. These conditioning assumptions and sensitivities will typically not be explored in detail."

Because the tendency of regime actors to experiment with sustainability fixes is usually supported by an institutional void around sustainability transformations, the introduction of fundamentally new ideas typically depends on the presence of committed individuals (Van den Ende et al., 2022).

A second point for discussion concerns the various signs of propelling mechanisms that suggest experimentation may eventually be sufficient on a larger scale, that is, the Dutch peatlands as a whole. Indeed, to a greater or lesser extent, experiments seem to have motivated local stakeholders, contributed to learning about what is possible, feasible, or preferable, and what is not, and some have inspired others. However, a dominant focus on technical experiments in learning networks and communities can lead to a technological path dependency in the process of experimentation, thereby reducing the available solution space and blocking alternative pathways (Du et al., 2022). At the same time, it could also be that the technological type of measure becomes appreciated as a specific "niche" that is deemed appropriate in certain contexts, or that such measures are deemed insufficient after several years of learning. The few radical innovations changing farming practices seem to have activated propelling mechanisms too, but Den Uyl and Munaretto (2020) found that in the absence of political support, the accumulation of more such experiments is challenging. While some propelling mechanisms reflect deliberate attempts at vertical upscaling (Van Doren et al., 2018)—also referred to as "mainstreaming" (Wamsler & Pauleit, 2016)—of technical experiments, these signs are absent in radical experiments. This can again be explained using the notion of technology commitments shaping the context in which experimentation on land subsidence takes place. To illustrate, while there seems to be some form of stimulation of technical experiments, there is no evidence for stimulation of more transformative directions, such as a shared vision of a sustainable future. In light of existing "'ontological' (Feenberg 2002, p. 3), discursive, institutional, economic, and infrastructural attachments to particular technological pathways" constituted by "policy attention, research funding, venture capital, training investments, regulatory standards, fiscal support, contractual risks, and legal liabilities" (Stirling, 2008, p. 265), it is unsurprising that more transformative experiments are at risk of the "pilot paradox" (Van Buuren et al., 2018). Although this is often the fate of more transformative experiments (Den Uyl & Munaretto, 2020), it is again even more true for experiments in relation to problems characterizing creeping crises, due to a lacking sense of urgency. Time will tell whether the current phase will be one of discovering diverse ways forward, or whether certain experiments eventually become institutionalized at a larger scale.

5.3 | Recommendations

It is important to note that we do not advocate the sole pursuit of radical experiments, as that would again simplify the wickedness of environmental problems (Van den Ende et al., 2023). More importantly, as a governance approach doing justice to the "diversity of actors, values, sense-making frames, scales and priorities involved" in environmental problems (Patterson et al., 2017, p. 11), experimentation should reflect the complexity of environmental problems by providing insights into the working of a great variety of measures—ranging from technological to social, legal, and market innovations—in order to accomplish sustainable land use in diverse contexts. But how can such "opening up" (Stirling, 2008) in the form of what Huitema et al. (2018) would call "Darwinian experimentalism" be stimulated to expand the available solution space (Du et al., 2022)?

According to Visseren-Hamakers et al. (2021) p. 22, increasing the transformative potential of the adaptive governance approach of experimentation would require a combination of inclusive governance ("in ways that empower those whose interests are currently not being met and represent values embodying transformative change for sustainability"), pluralist governance ("recognizing and incorporating different scientific and societal knowledge systems") and integrative governance ("to ensure local solutions also have sustainable impacts at other scales, on other issues, and in other places and sectors"). With regards to inclusive governance, our empirical study shows that visionary actors with transformative ideas do indeed participate in experimentation in the presence of certain enabling conditions, including financial capacity, human capacity, outlook for viable business models, trust building, and supportive institutions. Institutions could also help getting pluralist governance off of the ground. In the context of experimentation, this would entail promoting a broader notion of knowledge production, from the dominant technocratic focus on natural science-based learning, toward a learning approach that values a wide diversity of knowledge systems and world views, including those of underrepresented stakeholders such as citizens, future generations, and other-than-human actors.

Most of these enabling conditions require coordination by higher levels of government. Interestingly, this recommendation reflects the need for an approach that intentionally manages transformative change, such as strategic niche management (Kemp et al., 1998), to allow the noninterventionist small wins approach to transformative change thrive (Termeer & Dewulf, 2019). In the meantime, the increased political urgency for climate change which made actors take on responsibility for land subsidence as a climate problem illustrates the positive effect of a new policy discourse around a certain wicked problem (Bulkeley, 2021) on "opening up social appraisal" (Stirling, 2008) for experimentation around another wicked problem and creeping crisis. However, although the mainstreaming in climate mitigation policy has created new networks of responsible actors, the fact that land subsidence is also a problem of national safety and biodiversity is not apparent from the existing experiments. More research is required on the integration of not only of wicked problems, but, most importantly, of creeping crises, in order to embrace the wickedness of environmental land-use problems in experimentation.

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APPENDIX A

Description of the 10 case study experiments (actors are labeled, and participants of the group interviews are presented in bold)[1].

[1]a = government or other public entity, b = private actor, c = non-governmental organization/research institute.

Experiment	What?	Where?	Why?	Which knowledge?	Who?	When?
1. Pilot Toekomstbestendige Polder Lange Weide (translated: Pilot "Future-Proof Lange Weide Polder")	Technical measure (submerged drainage subsurface irrigation (SDSI) in combination with a dynamic ditch water level) to raise the groundwater level	Agricultural area with a thick peat layer	To mitigate land subsidence and GHG emissions as an attempt to future-proof the polder (by responding to climate change, reducing water management costs, offering a future perspective for dairy farming, and creating an attractive environment to live in)	About the effects on groundwater level, land subsidence, water balance, water quality and ecology, GHG emissions (*measurements*) and on farming practices and water management (*practical experience*)	Rijn & Gouwe Wiericke Foundation [c]; **water authority [a]**, municipality [a], province [a], landowners (including **farmers**) [b], national research program (NOBV, since 2021) [c]	2017–2022
2. Pilot Carbon Credits	A concept whereby carbon farming finances a technical measure	Agricultural area with thick and thin peat layers	To contribute to further upscaling of the measure and to increase the economic resilience of dairy farms	About financing a technical measure that mitigates land subsidence and GHG emissions with carbon credits (*practical experience*)	Network collaboration Groene Cirkel Kaas en Bodemdaling (translated: Green Circle Cheese and Land Subsidence): **water authority [a]**, **province [a],** national bank [b], dairy company [b], dairy cooperative [b], research institute (Wageningen University & Research (WUR)) [c]	2020–2022
3. Bedrijvenproef Spengen: Sturen met grondwater (translated: Spengen Trial: "Controlling groundwater")	Technical measure (pressurized SDSI) to raise the groundwater level	Agricultural area with a thick peat layer	To mitigate land subsidence	About the effects on groundwater level, land subsidence, water quantity, soil (condition, moisture content, carrying capacity) and energy consumption (*measurements*) and on farming practices (*practical experience*)	**Water authority [a], farmers [b], province [a]**	2017–2021
4. The Cranberry Company	Paludiculture	Buffer zone near nature area	To develop and demonstrate a financially viable, agroecological company as an alternative to dairy farming in nature areas	About the working of paludiculture (*practical experience*) and the effects on GHG emissions, water quality, and biodiversity (*measurements*)	**Entrepreneur [b], municipality [a], province [a],** research institutes (among which NOBV) [c]	2016-present
5. Pilot Zettingsvrij: Reconstructie Kanis (translated: Pilot reconstruction of Kanis)	Technical measure (lightweight material to raise the street) and social/process innovation (a more participatory, integral, and long-term reconstruction approach)	Built environment	To collaboratively identify a sustainable solution for the consequences of land subsidence in the built environment and to substantiate sustainable choices in the future	About the effectiveness of the measure (*measurements)* and the working of a more participatory, integral, and long-term reconstruction approach (*practical experience)*	**Municipality [a], citizens [b],** research institute (Deltares) [c]	2014–2022

(Continues)

Experiment	What?	Where?	Why?	Which knowledge?	Who?	When?
6. Living Lab Boeren bij Hoog Water (translated: Living Lab "Farming with a shallower water level")	Alternative form of dairy farming with a high groundwater level	Agricultural area with a thick peat layer	To develop a new economically viable business model for dairy farming on peatlands with minimal climate impact	About the effects of a high groundwater level on land subsidence, GHG emissions, and biodiversity (*measurements)* and on farming practices (*practical experience)*	Water authorities [a], provinces [a], agrarian collective [b], national government [a], research institutes (NOBV, KTC Zegveld, WUR, Louis Bolk Institute, **consultancy company, peat meadow Innovation Center (VIC)) [c]**	2020–2024
7. Pilot Klei in Veen (translated: Pilot "Clay in peat")	Technical measure (spreading clay over peat)	Agricultural area with a thick peat layer	To mitigate land subsidence and GHG emissions as an attempt to provide good prospects for dairy farming on the peat meadows	About the effects on organic matter in peat (and therefore on GHG emissions and land subsidence) (*measurements)* and on farming practices (*practical experience)*	**Municipality [a], farmers [b], research institute (Louis Bolk Institute) [c]**	2018–2022
8. Pilot Polderkennis op Peil (translated: Pilot "Polder knowledge on the level")	Social/process innovation (a polder network collaboration)	Agricultural area with a thick peat layer	To raise awareness about mitigating land subsidence and stimulate action as an attempt to reduce the negative effects of dairy farming on the water system	About the level of awareness and commitment of farmers (*practical experience)*	Participants in the polder network (representatives of the **water authority [a], farmers [b], agrarian collectives [b]**), province [a], **consultancy company [c]**	2017–2021
9. Pilot Natte teelten (translated: Pilot with cattail cultivation)	Paludiculture	Buffer zone near nature area	To demonstrate paludiculture as an alternative source of income for farmers that mitigates land subsidence and GHG emissions	About the effects of paludiculture on GHG emissions, land subsidence, water quality, groundwater level (*measurements)* and on farming practices (*practical experience)*	**Water authority [a], farmer [b]**, research institute (NOBV) [c]	2019-present
10. Pilot Drukdrainage (translated: Pilot on pressurized SDSI)	Technical measure (pressurized SDSI)	Agricultural area with mineral cover (clay)	To mitigate land subsidence in a way that is feasible for dairy farming	About the effects on land subsidence, water quality, water quantity, soil, and biodiversity (*measurements)* and on farming practices (*practical experience)*	**Blauwzaam Foundation [c], farmers [b],** provinces [a], **research institutes** (**KnowH20**, KTC Zegveld) [c]	2020-present