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ARTICLE

Policy experimentation within flood risk management: Transition pathways in Austria

Thomas Thaler[1,2] | **Edmund C. Penning-Rowsell**[3]

[1]Institute of Landscape Planning, University of Natural Resources and Life Sciences Vienna, Vienna, Austria

[2]Equity and Justice Research Group, Population and Just Societies Program, International Institute for Applied Systems Analysis, Laxenburg, Austria

[3]Flood Hazard Research Centre, Middlesex University, London, UK

Correspondence
Thomas Thaler, Institute of Landscape Planning, University of Natural Resources and Life Sciences Vienna, Vienna, Austria.
Email: thomas.thaler@boku.ac.at

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Abstract

Flood risk management (FRM) is facing various challenges, such as climate change and biodiversity losses. Traditional structural FRM measures are now not always feasible as responses to these challenges. One answer might be the use of policy experiments to promote innovation. This paper aims to assess and to explain why innovations in FRM are rarely implemented. We analysed seven innovative strategies across Austria that combine several different approaches. Each is concerned with risk reduction systems designed to save space, time and possible rising costs. The research used 76 qualitative standardised semi-structured interviews with key FRM experts conducted between 2012 and 2021 in order to examine transition pathways through time. The results show that there exist numerous drivers and barriers to debating, designing and implementing FRM innovations. The capture of transition pathways nevertheless shows the system shift from a more traditional understanding towards a transformative path, which created new understandings of the role of the different actors in FRM as well as new institutional settings. However, these policy experiments were still led by the relevant public administrations as they are the main funders, the principal actors in the planning and implementation phases in the realisation of many of these innovations.

KEYWORDS

Austria, bottom-up innovation, longitudinal qualitative research, policy entrepreneur, resilience, transition

1 | INTRODUCTION

Since it was established as the contemporary paradigm, flood risk management (FRM) has focused on reducing the risk of floods in terms of reducing the probability of flooding as well as the consequences of flooding (IPCC, 2022). By doing so, it addresses key societal challenges, as it is to be expected that climate change will lead to a higher frequency and magnitude of extreme events, incurring high current and higher future flood losses (Dottori et al., 2018; Hochrainer-Stigler et al., 2021; IPCC, 2021, 2022). In addition, new potential trade-offs are emerging or amplified, for instance between flood risk and drought risk management, representing a significant management challenge not just for infrastructure such as dams but also for decision- and policy-making processes in general. At the same time, new potential synergies can also be observed, such as when river restoration can help to reduce the flood peak and improve river biodiversity (Lane, 2017).

This situation has initiated a widespread debate on risk management strategies, many of them predominantly concerned with flood risk reduction (de Bruijn et al., 2022; Jongman et al., 2014; Thaler et al., 2019). FRM usually follows a 'classical' understanding and path on how to reduce current and future risks caused by flood events (Guerriero & Penning-Rowsell, 2020; Harris & Penning-Rowsell, 2011; Thaler et al., 2022). The main focus of this FRM approach concentrates on the implementation of structural (i.e., engineered) flood alleviation schemes as this is the common understanding of risk reduction by the relevant public administrations and their relevant professionals (Hanger-Kopp et al., 2022; Harris & Penning-Rowsell, 2011). The use of this approach is often the main strategy for several reasons: (1) knowledge and experiences about its efficiency and effectiveness in reducing risks; (2) routine knowledge (especially well known and well tested) about how to implement these types of measures; (3) experience to transfer them to other catchments from implementation successes; (4) high trust by local policymakers and citizens; (5) a minimum need for buying privately owned land for the implementation of these schemes; and (6) different actors are specialised in the required technical solutions (Hanger-Kopp et al., 2022; Seebauer et al., 2023). However, these measures are resource-intensive in terms of planning, implementation and maintenance (Penning-Rowsell, 2021). The costs of maintenance can be a particular challenge for public administrations, because such structural flood alleviation schemes are long-term solutions needing this type of funding for up to 80–100 years.

Besides the question of capital investment, engineered flood alleviation schemes are facing other current challenges. Today, FRM strategies need also to address other societal goals. This includes, among others, avoiding degrading water quality and biophysical degradation, loss of aquatic ecosystems and biodiversity, as well as a need to ensure the quality of human life, urban regeneration and long-term societal viability. For example, implementation of the European Water Framework Directive (European Commission, 2000) and the Floods Directive (European Commission, 2007) create different goals with some contradictory policy strategies and outcomes. Water bodies with poor ecological status are often in the floodplains, where the affected population seeks to implement solutions to reduce the flood risk that they face (Löschner et al., 2022; Nardini & Pavan, 2011; Wharton & Gilvear, 2007). At the same time, the societal debate about resilience has increased the question as to how flood risk management needs to be designed (Disse et al., 2020; Fekete et al., 2020). The main debates about resilience reflect the stronger discussion about who is responsible in flood risk management and how we can organise the share of tasks and duties between the government and citizens (Adger et al., 2013; Hutter et al., 2014). The outcome has been that citizens have come to have a more central role in flood risk management, taking over tasks from the government, which opened the debate about new concepts for reducing the potential losses of flood risks. Concepts gaining greater attention have included Natural Flood Risk Management (NFRM) (e.g., afforestation, wetlands, buffer strips, river restoration, upland water retention), sustainable drainage system (e.g., green roofs, parks, urban trees), planned population relocation, and individual adaptation strategies (e.g., property-level flood risk adaptation measures like dry and wet flood-proofing measures or barrier systems). All such ideas have become more prominent, seeking to respond to an increasing acknowledgement that our aspirations and the challenges societies are facing are multiple (Kuhlicke et al., 2020; Skrydstrup et al., 2022; Thaler et al., 2016, 2022).

These aspirations and challenges require a transformation process within current FRM systems and their governance. One reason for this is that 'traditional' FRM mainly focuses on quantitative risk reduction based on a quantified cost–benefit assessment, which can often overlook these further and broader societal goals. Innovations in FRM – often based on policy experiments – might overcome some of these limitations. Policy experiments can be understood as 'something new is being tried out – there is a conscious intervention that differs from the status quo' (Bernstein & Hoffmann, 2018, p. 192).

2 | INNOVATION AND OUR RESEARCH AIMS

We understand innovation in FRM to be where new ideas and technologies are developed at national, regional or local level to respond to its challenges (Guerriero & Penning-Rowsell, 2020; Seyfang & Smith, 2007; Thaler et al., 2022). As a result, the use of policy experiments has become more important to address different societal challenges and needs. However, innovations in FRM also require a shift of responsibility between public administrations and citizens as well as between different political levels (e.g., from national to local foci). Often innovations in FRM now have to be implemented and managed by house owners or local authorities, who can be opposed to these new 'solutions'.

Our first research aim therefore seeks to better understand what drives the development and use of policy experiments in seeking FRM solutions at the local/regional level; what are the barriers to implementing any new concepts? However, these experiments are facing various barriers to implementation, such as upscaling from local to mainstream solutions or downscaling from national policy (aspirations) to local levels for implementation. Our second aim therefore focuses on the role of selected innovations in FRM implemented in Austria within its different federal states. What is the actual transition pathway each innovation follows within the current socio-technical regime in Austrian FRM and what are the implications?

To answer our research questions, we use the conceptual framework of multi-level perspective (MLP; Geels, 2002). The MLP framework allows us to assess and to classify the socio-technical transition pathways of the selected innovations in Austrian FRM. Much research on FRM policy involves analysis at a particular single moment in time (e.g., Brody et al., 2009; Vitale & Meijerink, 2023; Woodruff et al., 2021). This inevitably can give only a partial picture so that, here, we look at how policy evolves through time, using a longitudinal method, in order to better understand the subtleties of the policy processes at work.

3 | RESEARCH FRAMEWORK

3.1 | Drivers and barriers to innovation

In the literature, we distinguish between several barriers that hinder the encouragement of innovations, such as the current political system, lack of resources (e.g., financial, time or personal) at different political levels (national, regional or local), cultural issues or lack of information and knowledge on how to use them (e.g., Biesbroek et al., 2013; Irshaid et al., 2021; Moser & Ekstrom, 2010; Thaler et al., 2019). In particular, the current institutional settings often hinder the development and use of innovations because establishing professional communities and legal requirements might discourage or forbid their use (Thaler et al., 2022).

On the other hand, we observe various opportunities, which encourage policy experiments. These opportunities can similarly be distinguished as being the result of political, technological, local capacities, information and cultural factors. Examples are the use of 'grey' zones in current legislations (Thaler et al., 2022), external shocks (e.g., flood events), the engagement of policy entrepreneurs and the lack of political presence or financial incentives at the local level (Thaler et al., 2019; Thaler & Levin-Keitel, 2016). Drivers and barriers do not only occur in the development of innovations, but also in their implementation, and operate by encouraging or hindering new transition pathways (Thaler et al., 2022).

3.2 | Transition pathways

FRM can be understood as a socio-technical regime. It focuses on technical innovations in terms of reducing the risks caused by flood events. Innovations are embedded and are a result of the actions of human actors (Geels, 2004). As individuals, we act within our institutional framework (Hogdson, 2006; North, 1990). Consequently, the institutional framework in which we operate shapes our norms as well as our moral and legal responsibilities, which strongly influence the possibility and interest in developing new innovations (Geels, 2004). Further, the institutional framework is constructed within a nested system (Geels, 2004; Geels & Schot, 2007). This is especially true for innovations within FRM that crucially depends on policies and practices at these multiple levels (Thaler et al., 2022).

Geels (2004, p. 915) distinguishes between three main nested levels: (1) technological niches (e.g., bottom-up radical solutions, which are mainly focused on a micro-level/single solution); (2) socio-technical regimes (e.g., local innovations are becoming routine concepts); and (3) landscape developments (e.g., shock caused by an extreme flood event or macro-political changes). The central question is how innovations evolve over time and include different pathways to change current systems. Geels and Schot (2007) use the concept of transition pathways, which they define 'as changes from one socio-technical regime to another' (p. 399). Transition pathways are based on the issue of timing (e.g., transition over months, years, decades) and their interactions in the relevant socio-technical regimes (Geels, 2004; Geels & Schot, 2007). For Geels et al. (2017, p. 896) this creates four different prototypes of transition pathway: (1) substitution, (2) transformation, (3) reconfiguration and (4) de-alignment and re-alignment. These we illustrate, taking examples from several non-FRM sectors at different times.

Substitution pathways focus on radical innovations with the aim to substitute current policies and solutions (Seyfang & Smith, 2007). These kinds of innovations are often locally based and include different new actors (e.g., citizens, grassroots organisations, communities) replacing the classical institutional actors. In terms of institutional setting and innovation, substitution pathways generally follow two main institutional changes: incremental adjustment and disruptive changes. Under incremental adjustment, innovations would fit under the current institutional rule system. Disruptive changes would require a more radical change within the rule system, as it has to adjust to the innovation (Geels et al., 2017). An example for a substitution pathway is the German low-carbon electricity transition at the beginning the 1990s. The German system was mainly characterised by the development of small-scale solutions, such as creation of photovoltaic options for individual householders, biogas or inshore windfarms. At the beginning, these innovations were mainly driven by citizens, local authorities or environmental activists under the umbrella of anti-nuclear or other environmental movements. At the later stage, large-scale business (from industrial and financial sectors) as well as the national government have encouraged the development of alternative energy systems in Germany (Geels et al., 2017).

Transformation usually can be separated into two main variants: (1) abrupt, resulting in a radical change and (2) incremental processes (Burch et al., 2014; Feola, 2015; Kates et al., 2012). A transformative pathway foresees a continuous incremental process with only a limited change within the current rule system as well as radical/substantial reorientation with an in-depth change of that system (Geels et al., 2017). An example is the British low-carbon electricity transition, where utilities, financial and industrial sectors encourage the process within economic interests in contrast to the first wave in Germany. Further, the British policy encourages incumbents to ensure their market position instead of opening it towards new actors and stakeholders (Geels et al., 2017).

Reconfiguration transitions foresee the combination of innovations and existing technologies with the goal of changing the current socio-technical system (Geels et al., 2017). Usually, such innovations are used as an add-on to already existing technologies (Geels et al., 2017; Hanger-Kopp et al., 2022). However, over time, the combination of different technologies, social learning processes and so-called 'knock-on effects' can provide a radical change to the current system (including the institutional rule system; Geels et al., 2017). Geels (2002) describe the evolutionary process within the global transport system as a reconfiguration transition. In particular, developments within the shipping industry (from sailing to steamships) were mainly driven by new innovations by different actors in various geographical areas, which triggered further development. Some of these innovations have been niche developments, but the adjustments and adaptations encourage a broader transformation process.

Finally, the de-alignment and re-alignment pathway foresees those different external shocks highly disrupt (or destabilise) the current system. Consequently, the shocks create a wide range of innovations with the entry of a wide range of new actors. At the same time (independently), there is a decline in trust in the existing solutions. In terms of the rule system, within the de-alignment and re-alignment pathway, the existing institutional framework would be replaced after the shocks to the system (Geels et al., 2017). However, the shock could create a 'vacuum' directly afterwards, where the existing rule system would not work any longer and the new one is not yet created and implemented. This unstable period would subsequently be replaced with the introduction of a new socio-technical system (Geels et al., 2017). An example for de-alignment and re-alignment pathway can be seen in the British coal industry in the last three decades. Turnheim and Geels (2013) showed how various developments, such as change of industry strategies and global economic pressure, created a destabilisation of that whole industry with the consequential eventual virtual closure of this sector.

4 | METHODOLOGY AND CASE STUDY DESCRIPTION

4.1 | Study site description

This paper focuses on the Austrian FRM system. Austria is organised as a federal state with the consequence that there are a wide range of different actors, legal requirements and policy strategies at several levels (Leitner et al., 2020; Reiter et al., 2022; Schinko et al., 2017). Additionally (based on the type of flooding), we distinguish between four main institutional actors: (1) river flood risks at the main watercourse are managed by the Austrian Ministry for Infrastructure (BMVIT); (2) other river floods are managed by the Water Engineering Administration (BWW); (3) torrential flooding (mountains) is managed by the Austrian Service for Torrent and Avalanche Control (WLV); and (4) surface runoffs are managed by the local authorities.

The outcome is that the different actors have developed a wide range of different national policy strategies, funding strategies and legislation at the national and federal levels (Thaler et al., 2016). In particular, the federal state system allows the different regional authorities to act in some cases independently from each other. Nevertheless, the overall policy umbrella mainly reflects two key legal Acts: (1) the Water Act (1959) and (2) the Hydraulic Engineering Assistance Act (1986). The latter determines by which criteria flood alleviation schemes are funded by the national and regional authorities. The former embeds the implementation of the EU Floods Directive within national law as well as creating the general direction of the Austrian FRM system.

4.2 | Data collection and analysis

To assess the evidence for different transition pathways in Austrian FRM, we used a qualitative research methodology based on multiple case studies. Overall, we interviewed more than 76 people (experts, politicians, academics and citizens) from 2012 until 2021 (Supplementary information S1). The references here to the interviewees are presented in the format i1, i2, etc. The selection and recruiting of the sample were based on a snowballing technique. The interviews were conducted face-to-face until the COVID-19 pandemic. During the pandemic, the interviews were conducted using Zoom and Skype. In some cases, we conducted more than one interview with the same actor as they were responsible for more than one experiment or to understand better the historical evolution path of the relevant concepts.

The interviews lasted between 45 and 120 min (involving between 10 and 25 pages of transcription) and were conducted in German. The semi-structured interviews were based on a standardised questionnaire following key themes: the type of innovation; the motivation to develop the innovation; the challenges in the implementation process; multi-level interaction; funding streams; participation process with different stakeholders at local and regional level; upscaling processes; the influence of the institutional framework; changes in the institutional framework and the influence of shocks and other external developments (e.g., macro-political changes). The recorded interviews were transcribed and afterwards coded and analysed using MAXDQA software (MAXDQA, 2022), with the analysis based on systematic but broad content analysis. The codes were selected deductively from the literature on innovation and transition pathways described above.

5 | RESULTS

5.1 | Types of policy experiments in Austrian FRM

The current socio-technical regime of the Austrian FRM system largely focuses on technical engineered risk mitigation solutions, such as dams, reservoirs and check dams (e.g., i1, i5, i14, i60, i61). However, various experiments locally and nationally have been initiated since the 1990s, and we list seven such experiments (Table 1). Planned relocation has always been used in Austrian FRM policies. In particular, since 1991, this approach was used at several locations along the Danube river with the result that more than 500 homes were relocated (e.g., i60, i61). Since the Danube floods in 2002, property-level flood risk adaptation measures have become a more important strategy with the aim that individual householders adapt/prepare themselves against future events (e.g., i33, i35). Since the beginning of 2000, different Austrian communities have implemented various catchment-wide management approaches, from the construction of flood storage areas at the upper part of a catchment to protect downstream communities, or moving towards catchment-wide management concepts in terms of spatial planning and emergency management. The goal of these measures is to provide a more integrated FRM concept (e.g., i1, i2, i3, i7, i16, i17). The sixth measure includes multi-functional protection schemes. These measures combine different functions (e.g., a flood protection scheme plus a museum and other leisure activities) with the goal of reducing the flood risk as well as focusing on a more sustainable land use policy in Austria (e.g., i23, i25, i27). The latest strategy includes the implementation of NFRM in both urban and rural areas (e.g., i1, i2, i6, i27, i28).

Almost all policy experiments were driven by past events. Most started in the 2000s after the flood events in 2002 and 2005; both caused major flood damage across the country. Each policy experiment tried to provide a local response to these events. An exception was the innovation of catchment-wide spatial planning instruments/natural retention basins where a key trigger was the availability of European funding within the LIFE programme (L'Instrument Financier pour l'Environnement). The main actors in these experiments were generally the different regional water authorities, except in the case of planned relocation: that was mainly driven by the national water authority responsible for the Danube river. In terms of implementation, the experiments were successfully implemented at local scale, but did not achieve an upscaling of their ideas towards a broader mainstream FRM policy.

TABLE 1 Main characteristics of the selected experiments in Austria.

No.	Type of policy experiment	Starting date of the policy experiment in the selected case studies	Location of the case studies	Key political actors	Main reason for action	Main barriers for upscaling	Current status of implementation
1	Planned relocation	1991	Upper Austria	National and regional water authorities	Flood event	Acceptance of private house-owners	Some local examples, but no national strategy
2	Property-level flood risk adaptation measures	2005	Styria and Vorarlberg	House owners	Flood event	Acceptance of private house-owners	Some local examples; first attempt to develop a nation-wide strategy
3	Catchment-wide risk reduction measures	2002	Lower Austria, Upper Austria and Vorarlberg	Regional water authorities	Flood event	Acceptance of private land-owners and local authorities (upstream-downstream conflicts)	Some local examples; first attempt to develop a nation-wide strategy
4	Catchment-wide spatial planning instruments/natural retention basins	2000s	Carinthia	Regional water authorities	European project	Acceptance by the different regional and local authorities	Some local examples, but no national strategy
5	Catchment-wide disaster management concepts	2005	Lower Austria	Regional 'blue light' organisations	Flood event	No broader discussion in Austria	Some local examples, but no national strategy
6	Multi-functional protection schemes	1999	Carinthia and Tyrol	Regional water authorities and local authorities as well as citizens	Flood event	No broader discussion in Austria	Some local examples, but no national strategy
7	Natural flood risk management in rural and urban areas	2014	Styria	Regional and local authorities as well as citizens	Flood event	Acceptance of private house-owners and land-owners	Some local examples, first attempt to develop a nation-wide strategy

5.2 | Actors in Austrian FRM

The Austrian FRM system is managed mainly by engineers from the public administration at national and regional level (e.g., i1, i8, i14, i23, i33, i49). This top-down approach is the backbone of the Austrian FRM system. The engineers in the public administration have been responsible for developing hazard maps, preparing planning documents for risk reduction measures and addressing the main financial sources for the implementation of these measures (e.g., i8, i9). Besides the national and regional actors, local authorities play an important role. Local authorities are responsible for various aspects, such as developing and implementing land use regulations to reduce the potentially exposed residential and non-residential buildings; concepts for emergency management; negotiation with private landowners to implement reservoirs or NFRM; or providing the financial payments for the maintenance costs of technical mitigation measures (e.g., i1, i5, i14, i15, i55, i58). This system was implemented after the Austrian Water Act in 1959 (i55). After the large natural hazards events in 1999, 2002 and 2005, the involvement of non-state actors (mainly citizens and NGOs) has become more common in different policy experiments, like planned relocation, encouragement of property-level flood risk adaptation measures, multi-functional protection schemes or NFRM (e.g., i70, i71, i74). The involvement of non-state actors has differed between the policy experiments as they have different responsibilities. The implementation of NFRM, for example, included a new collaboration and alliance between public administration and non-state actors as these measures are implemented on privately owned land as well as by private landowners who are responsible for maintenance tasks (i31, i32). Similar examples occurred in the development and implementation of multi-functional flood protection schemes. Here, citizens started the idea of using new technologies (e.g., i23, i29, i30).

5.3 | Institutional changes in Austrian FRM system

The interviewees showed that the concept of NFRM in rural areas was driven by the change of legal requirements. Especially, the ecological requirements for the implementation of the EU Water Framework played a crucial role (e.g., i14, i28). NFRM aims to reduce the risk of floods as well as to meet other societal needs, such as improving the current ecological status of water bodies and increasing biodiversity. As a result, the implementation of large NFRM measures over large parts of the catchment demanded new collaborations between the public administration and private landowners, as these measures were mainly implemented on privately owned land. Similar results can be observed with the implementation of the EU Floods Directive, where new legislation and administrative practices aim to implement catchment-wide management plans (e.g., i14, i60, i61, i70, i71). Further, the engagement of citizens also enforced changes in the institutional setting of the Austrian FRM system. Especially, the realisation of multi-functional flood protection schemes included a change in the planning process (e.g., i23 i24, i25, i26). The aim of the multi-functional protection schemes is to combine reducing the flood risk with leisure activities. The leisure activities have been planned by the citizens. An important change reflects the question about legal responsibility in terms of technical failures or potential losses caused by future events. Responsibility was transferred to the local authorities. Similarly, the additional costs for the realisation of the schemes have been paid by the citizens (i23).

5.4 | Drivers in the development and implementation of policy experiments

The first step here includes the question of what are the current drivers that enable or develop experiments as well as implementing them. Analysing the interviews, we observe various factors that encourage innovations. Assessing the empirical results from all examples, various drivers exist for local innovations, which encourage innovations in FRM. A key factor in all examples reflects a shock event or past flood events (e.g., i14, i23, i46, i47, i60). Based on the previous event, the different actors and stakeholders have realised that the current management system needs reconsideration to deal with future events.

Additionally, all of the seven implemented experiments in FRM were encouraged by policy entrepreneurs (e.g., i1, i14, i23, i29, i30, i33, i58, i70). These entrepreneurs played a crucial role in the development of new ideas and used different channels to influence the policy outcome, in our case the development and implementation of innovations in FRM. The policy entrepreneurs usually acted based on self-interest. The motivation was not to promote themselves but to develop new concepts that they favoured, to avoid similar flood damages in the future. Policy entrepreneurs came from the private sector (e.g., for multi-functional protection schemes), national political level (e.g., for planned relocation) or regional level (e.g., using catchment-wide management concepts like upstream-downstream technical mitigation measures, emergency management plans or common land use concepts). Based around the policy entrepreneurs, different actor coalitions were created to realise the experiments; the common pattern can be seen as a triangle between the policy entrepreneur, the mayor of the local authority and regional water engineers.

The question of funding had an important effect (e.g., i15, i24, i58, i72). This financial question was a key aspect in the development and realisation of innovations. All of these measures were able to get new financial sources rather than use the already existing funding sources. These new funding schemes allowed the different actors to enjoy more freedom in creating and implementing these measures. Besides the question of funding, a further central argument reflected the question of responsibility (e.g., i23, i28, i33). In Austrian FRM, the public administration at the national or regional level has been responsible in terms of planning, implementation and liability in the case of scheme or project failure. Our results highlighted that sharing the responsibility or even changing the focus of responsibility (such as the local authority taking the legal responsibility) played a crucial factor in enabling these innovations.

The final important factor was the incorporation of other societal needs in FRM, such as sustainable land use by improving the ecological status of water bodies or increasing wellbeing within the community. In particular, the multi-functional measures incorporated several societal goals with the end goal being seeking a high innovation acceptance rate by different actors, stakeholders and citizens (e.g., i23, i27, i28).

5.5 | Barriers to the development and implementation of policy experiments

Our data highlighted various barriers in the development, and especially the implementation, of these experiments. The first group of barriers can be observed at the national level. In particular, problems of downscaling were mainly seen in the use of NFRM (e.g., i1, i2, i3, i4, i5, i6, i7) and property-level flood risk adaptation measures (e.g., i31, i32, i33, i42, i47) or planned relocation (e.g., i14, i15, i16, i17). These concepts were developed at the national level without engagement with the local level, and without thinking of local constraints or knowing about the technical efficiency of these measures at a larger scale (e.g., i30, i65, i66, i73). Another key challenge reflects the question of legal restrictions (i5, i75, i76). All of these experiments need land, most of which is owned by private landowners. The government needs an agreement with the relevant citizens to implement these strategies. Most private landowners disagreed with what the public administration was proposing, which delayed or even halted implementation (e.g., i1, i14, i15, i16, i60, i61, i68, i69). Another key aspect reflects the question of who maintains the measures (e.g., i58, i59, i60, i68, i69). This is especially true for the implementation of NFRM, as these measures legally require that private landowners maintain these kinds of measures.

At the local level, the main constraints were sceptical reactions by citizens or local policymakers, especially in the case of planned relocation or implementing NFRM (e.g., i15, i16, i61, i62, i63). The implementation of catchment-wide solutions, for example, also often requires the acceptance by private landowners to implement the necessary measures. This acceptance was often not forthcoming, similar to attitudes at the local political level. Here, our results highlighted that local policymakers often act with strong antipathy. This lack of local support was also often driven by the creation of opposing local grassroots organisations, such as in the case of planned relocation or catchment-wide risk reduction measures (e.g., i23, i24, i25, i26, i70, i71, i72). These bottom-up initiatives often acted against experimentations. These groups have been very powerful in delaying the implementation process, going so far as stopping the use of these experiments as a strategy for reducing future risks. Another key barrier was political elections (e.g., i14, i33, i34, i58, i59). The implementation of experiments was often based on political change at the local or regional level. Therefore, innovations are often based on the political time framework; if it was the wrong time, in terms of the positions of office holders, no innovations took place.

A further key barrier to implement innovations in FRM also reflects the lack of a facility for upscaling the measures towards mainstream solutions. Here, the current Austrian federal state system hinders the implementation on a nation-wide scale (e.g., i1, i2, i5). This was often driven by lack of communication between the federal states or self-interest not to implement measures that were not accepted by other federal states. Another frequently mentioned reason was the lack of communication between the different federal states (i1, i26, i27, i28, i33). Many innovations are developed to create local solutions and these were not communicated between the different states, so often nobody elsewhere was aware of these concepts.

A final strong challenge was the lack of technical knowledge and experience: a further central barrier was therefore not appreciating the current institutional setting, such as the available financial resources or the relevant regulatory frameworks (e.g., i1, i2, i3, i4, i5, i75, i76). This problem was also exacerbated by the lack of local capacities and expertise.

6 | DISCUSSION AND CONCLUSION

Most research studies on FRM policy focus on a single timescale, but often overlook the time of implementation, evaluation and re-design after the definition of new policy strategies. This paper has discussed the challenge of using policy experiments in FRM with the example of Austria. Here FRM is largely managed in a 'traditional' way, which means a key focus on engineering solutions where the public administration is mainly funding the schemes as well as planning and implementing them (Schlögl et al., 2021; Thaler et al., 2022).

Nevertheless, in the past fifteen years, we observed various changes and developments within FRM systems here. The entrance of new actors, such as individual house owners or grassroots organisations similar to the Flood Action Groups in England (e.g., Thaler & Priest, 2014), new technologies such as multi-functional protection schemes (e.g., Thaler et al., 2019, 2022) and climate risk management (linking climate adaptation and risk management strategies; Schinko et al., 2017) have generated large shifts in FRM, adding to its complexity. Additionally, the past and current crises, such as financial crises since 2008, SARS-CoV-02 economic crises or the 2022/23 energy crisis, open again the debate about how to invest efficiently the limited public resources. An outcome has also been a shift in the 'classical' role distribution between state and private entities (Adger et al., 2013). The stronger engagement with citizens and stakeholders also needed a new institutional setting and rule system, which often caused large conflicts and an unclear distribution of power, responsibilities and resources (Rauter et al., 2020; Sayers et al., 2015; Thaler & Priest, 2014; Witte et al., 2021). We observed various consequential innovations in FRM, where experiments have been developed and implemented.

Our interview results showed that there exists a wide variety within the development and use of innovations in FRM, from technological solutions for a single building to large measures with impacts on a whole catchment. These measures have usually been developed as innovations with the aim of finding a response to the need for local solutions and not for the broad national-level societal application (Seher & Löschner, 2018; Seyfang & Smith, 2007; Thaler et al., 2022). Assessing the pilots we examined, we see that they have been successfully implemented within the local context. However, the local strategies lack the needed upscaling process to reach a broader transformative pathway in the Austrian FRM system. We can see that these policy experiments are usually based on individual interests and certain policy entrepreneurs at the local and regional levels. National authorities have had an important role in the realisation of the measures as they usually serve as doorkeepers; without their permission and encouragement, these new concepts would not be implemented. Here, the institutional setting played an important role, as the existing rule system did not forbid the use of innovative approaches in FRM. But the policy experiments often rarely overcome the status of a pilot. Here, the national policy framework would need a stronger role in promoting these concepts, as in other countries, such as England and Wales (Penning-Rowsell & Johnson, 2015; Wingfield et al., 2021).

Assessing the selected experiments based on the transition pathways concept (Geels, 2004; Geels et al., 2017; Geels & Schot, 2007) shows that there have not been radical solutions that also overthrow the contemporary public administration; also past flood events did not cause a collapse of the Austrian FRM system. Overall, we therefore see no substitution pathways in these examples. The experiments are acting within the current institutional setting and therefore within the current FRM strategies. Innovations in the examples are seen as a result of a hybrid solution (i.e., in combination with traditional flood alleviation schemes) and not as a radical single-solution-based idea. The interviewees stated that the selected experiments were seen as an additional risk reduction strategy, and the aim was not to substitute or replace existing technologies and strategies. Further, there are no de-alignment and re-alignment transition pathways. Our interviewees stated that past events, such as floods, or implementation of EU Floods Directive or past financial and economic crises, created new institutional frameworks with new stakeholders and regulations.

Reflecting on these empirical results, most of the selected experimental measures can be classified as on a transformation pathway (Table 2). The use of property-level flood risk adaptation measures and NFRM in urban areas (e.g., green roofs) involves a more gradual and incremental change to the current FRM system. Usually, the public actors start collaborations with non-state actors. However, we can only observe small adjustments within the public administration. The main point is that these measures need to be implemented voluntarily by private land owners with some support from the public administration in terms of informing or providing financial incentives. On the other hand, other innovative concepts create a more radical shift in the Austrian system. The use of planned relocation, for example, required a substantial change in the rule system. The government needed to introduce new legislation in terms of compensation or restrictions on the house owner in terms of the use of their property rights. This also included new collaboration between public administration and the citizens as well as new administration practices within the public administration.

Consequently, the results do not show radical institutional changes in Austria. Nevertheless, this does not mean that radical institutional changes can be ignored in the future. For example, our interviewees stated that Austria is at risk of

TABLE 2 Classification of the transition pathways of the selected experiments in Austria.

	Type of measure	Actors	Technologies	Institutions
Substitution pathway	None			
Transformation pathway	Property-level flood risk adaptation measures Nature-based solutions in urban areas, e.g., sponge city concept	Public administration gradually adjust their knowledge and action (in terms of routines and practice)	Incremental improvement of the used technologies	Limited change referring to the institutional rule system
	Planned relocation Upstream-downstream cooperations (technical mitigation, emergency management, spatial planning) Multi-functional technical mitigation measures	The public administration substantially change their own planning and implementation process to include the new technologies in their management strategy	Planned relocation included a new reorientation in the Austrian FRM; planned relocation included a full reorientation of the currently used of FRM technologies The FRM system foresee the use of new and old technologies (or partial reorientation of the use of technologies), such as technical flood storage solutions, with the aim to reduce the risk to downstream communities; or combination of mitigation measures with leisure activities	Substantial change of the current institutional rule system, such as influence of the current property rights system
Reconfiguration pathway	Nature-based solutions in rural areas	The implementation of nature-based solutions measures included a new collaboration and alliance between public administration and non-state actors	At the beginning, the new technologies were seen as an add-on to the already existing solutions; however, knock-on effects and new innovation caused a larger change of the FRM system	At the beginning, the institutional rule system was only partly re-designed, but after prolonged use of nature-based solutions in rural areas, there was the need to re-design the institutional setting
De-alignment and re-alignment pathway	None			

infringement proceedings in the case of implementing the EU Water Framework. The main reason is the creation of bad ecological status water bodies caused by the implementation of flood alleviation schemes. The Austrian public administration needs a radical reorientation of how to manage FRM, especially to be more open towards innovative solutions. We also observe much longer time frameworks in terms of developing and implementing the policy experiments, such as planned relocation needed in some areas for more than 20 years (from 1991 to 2013; Schindelegger, 2019; Seebauer & Winkler, 2020; Thaler et al., 2020).

As a response to these developments, the public administration needs to be more flexible within the design and implementation process. Policy experiments require new knowledge and techniques for the water engineers; negotiating, counselling and engaging with citizens become more important and create the need for further resources. This also requires new thinking regarding the time framework for implementing disaster risk reduction measures. So far, the Austrian FRM projects need to be implemented within an exact time period, without any possible extensions. This legal and administrative restriction creates conflicts between the public administration and citizens, which can result in implementation failure. Policy experiments need more time and decision-making to be more flexible to allow for the different interests in society.

Even with the introduction of new concepts, we still see a strong focus from the government, with weak grassroots or citizen engagement in Austrian FRM (Thaler & Seebauer, 2019). The policy experiments motivated different actors to engage in FRM but this engagement was driven by local actors, and the implementation was mainly managed by the public administration. The main reason is the lack of resources (financial, personal, knowledge) at the local level. In particular, the lack of engineering knowledge at the local level creates a key challenge and a power asymmetry between the public administration and citizens (Lindgren et al., 2019; Young & Tanner, 2022). The new measures suggested a re-orientation of the past FRM projects, but the main actors remained the same. A key reason is the responsibility sharing within FRM: Austrian FRM remains mainly driven by public administration, in terms of planning, funding and implementation (Rauter et al., 2020; Seebauer et al., 2023).

Nevertheless, the one key challenge inhibiting innovation involves the still dominant role of the national authorities in the Austrian FRM system. Currently, these national authorities provide the main funding source and have the necessary technical expertise and power to develop and implement FRM strategies. Therefore, engineering solutions remain the 'norm' in FRM (Harris & Penning-Rowsell, 2011). For a truly transformative process, there is still a need for a broader engagement of different actors, stakeholders and citizens in the decision-making process. In particular, sharing technical knowledge, providing new funding resources and a symmetric power distribution all need to be introduced and embedded before important new innovations can prosper.

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DATA AVAILABILITY STATEMENT

Data will be made available on request.

ORCID

Thomas Thaler https://orcid.org/0000-0003-3869-3722
Edmund C. Penning-Rowsell https://orcid.org/0000-0002-5333-8641

REFERENCES

Adger, N.W., Quinn, T., Lorenzoni, I., Murphy, C. & Sweeney, J. (2013) Changing social contracts in climate-change adaptation. *Nature Climate Change*, 3, 330–333. Available from: https://doi.org/10.1038/nclimate1751

Bernstein, S. & Hoffmann, M. (2018) The politics of decarbonization and the catalytic impact of subnational climate experiments. *Policy Sciences*, 51, 189–211. https://doi.org/10.1007/s11077-018-9314-8

Biesbroek, G.R., Klostermann, J.E.M., Termeer, C.J.A.M. & Kabat, P. (2013) On the nature of barriers to climate change adaptation. *Regional Environmental Change*, 13(5), 1119–1129. Available from: https://doi.org/10.1007/s10113-013-0421-y

Brody, S.D., Zahran, S., Highfield, W.E., Bernhardt, S. & Vadlitz, A. (2009) Policy learning for flood mitigation: A longitudinal assessment of the community rating system in Florida. *Risk Analysis*, 29(6), 912–929. Available from: https://doi.org/10.1111/j.1539-6924.2009.01210.x

Burch, S., Shaw, A., Dale, A. & Robinson, J. (2014) Triggering transformative change: A development path approach to climate change response in communities. *Climate Policy*, 14(4), 467–487. Available from: https://doi.org/10.1080/14693062.2014.876342 de Bruijn, K.M., Jafino, B.A., Merz, B., Doorn, N., Priest, S.J., Dahm, R.J. et al. (2022) Flood risk management through a resilience lens. *Communications Earth & Environment*, 3, 285. Available from: https://doi.org/10.1038/s43247-022-00613-4

Disse, M., Johnson, T.G., Leandor, J. & Hartmann, T. (2020) Exploring the relation between flood risk management and flood resilience. *Water Security*, 9, 100059. Available from: https://doi.org/10.1016/j.wasec.2020.100059

Dottori, F., Szewczyk, W., Ciscar, J.-C., Zhao, F., Alfieri, L., Hirabayashi, Y. et al. (2018) Increased human and economic losses from river flooding with anthropogenic warming. *Nature Climate Change*, 8, 781–786. Available from: https://doi.org/10.1038/s41558-018-0257-z

European Commission. (2000) *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060 [Accessed 19th May 2022].

European Commission. (2007) *Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060 [Accessed 19th May 2022].

Fekete, A., Hartmann, T. & Jüpner, R. (2020) Resilience: On-going wave or subsiding trend in flood risk research and practice? *WIREs Water*, 7(1), e1397. Available from: https://doi.org/10.1002/wat2.1397

Feola, G. (2015) Societal transformation in response to global environmental change: A review of emerging concepts. *Ambio*, 44(5), 376–390. Available from: https://doi.org/10.1007/s13280-014-0582-z

Geels, F.W. (2002) Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, 31(8–9), 1257–1274. Available from: https://doi.org/10.1016/S0048-7333(02)00062-8

Geels, F.W. (2004) From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), 897–920. Available from: https://doi.org/10.1016/j.respol.2004.01.015

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J. et al. (2017) The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). *Research Policy*, 45(4), 896–913. Available from: https://doi.org/10.1016/j.respol.2016.01.015

Geels, F.W. & Schot, J. (2007) Typology of sociotechnical transition pathways. *Research Policy*, 36(3), 399–417. Available from: https://doi.org/10.1016/j.respol.2007.01.003

Guerriero, R. & Penning-Rowsell, E.C. (2020) Innovation in FRM: An 'avenues of innovation' analysis. *Journal of Flood Risk Management*, 14(1), e12677. Available from: https://doi.org/10.1111/jfr3.12677

Hanger-Kopp, S., Thaler, T., Seebauer, S., Schinko, T. & Clar, C. (2022) Defining and operationalizing path dependency for the development and monitoring of adaptation pathways. *Global Environmental Change*, 72, e102425. Available from: https://doi.org/10.1016/j.gloenvcha.2021.102425

Harris, T. & Penning-Rowsell, E.C. (2011) Victim pressure, institutional inertia and climate change adaptation: The case of flood risk. *Global Environmental Change*, 21, 188–197. Available from: https://doi.org/10.1016/j.gloenvcha.2010.09.002

Hochrainer-Stigler, S., Velev, S., Laurien, F., Campbell, K., Czajkowski, J., Keating, A. et al. (2021) Differences in the dynamics of community disaster resilience across the globe. *Scientific Reports*, 11, e17625. Available from: https://doi.org/10.1038/s41598-021-96763-0

Hogdson, G.M. (2006) What are institutions? *Journal of Economic Issues*, 40(1), 1–25. Available from: https://doi.org/10.1080/00213624.2006.11506879

Hutter, G., Leibenath, M. & Mattissek, A. (2014) Governing through resilience? Exploring flood protection in Dresden, Germany. *Social Science*, 3, 272–287. Available from: https://doi.org/10.3390/socsci3020272

IPCC. (2021) *Climate change 2021: The physical science basis*. Available from: https://www.ipcc.ch/report/ar6/wg1/ [Accessed 19th May 2022].

IPCC. (2022) *Climate change 2022: impacts, adaptation and vulnerability*. Available from: https://www.ipcc.ch/report/ar6/wg2/ [Accessed 19th May 2022].

Irshaid, J., Mochizuki, J. & Schinko, T. (2021) Challenges to local innovation and implementation of low-carbon energy-transition measures: A tale of two Austrian regions. *Energy Policy*, 156, 112432. Available from: https://doi.org/10.1016/j.enpol.2021.112432

Jongman, B., Hochrainer-Stigler, S., Feyen, L., Aerts, J.C.J.H., Mechler, R., Botzen, W.J.W. et al. (2014) Increasing stress on disaster-risk finance due to large floods. *Nature Climate Change*, 4, 264–268. Available from: https://doi.org/10.1038/nclimate2124

Kates, R.W., Travis, W.R. & Wilbanks, T.J. (2012) Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences of the United States of America*, 109(19), 7156–7161. Available from: https://doi.org/10.1073/pnas.1115521109

Kuhlicke, C., Seebauer, S., Hudson, P., Begg, C., Bubeck, P., Dittmer, C. et al. (2020) The behavioral turn in FRM, its assumptions and potential implications. *WIREs Water*, 7(3), e1418. Available from: https://doi.org/10.1002/wat2.1418

Lane, S. (2017) Natural flood management. *WIREs Water*, 4, e1211. Available from: https://doi.org/10.1002/wat2.1211

Leitner, M., Babcicky, P., Schinko, T. & Glas, N. (2020) The status of climate risk management in Austria. Assessing the governance landscape and proposing ways forward for comprehensively managing flood and drought risk. *Climate Risk Management*, 30, 100246. Available from: https://doi.org/10.1016/j.crm.2020.100246

Lindgren, I., Madson, C.O., Hofmann, S. & Melin, U. (2019) Close encounters of the digital kind: A research agenda for the digitalization of public services. *Government Information Quarterly*, 36(3), 427–436. Available from: https://doi.org/10.1016/j.giq.2019.03.002

Löschner, L., Eder, M., Herrnegger, M., Hogl, K., Nordbeck, R., Scherhaufer, P. et al. (2022) RegioFEM – Informing future-oriented FRM at the regional scale (part I). *Journal of Flood Risk Management*, 15(1), e12754. Available from: https://doi.org/10.1111/jfr3.12754

MAXDQA. (2022) *MAXDQA*. Available from: https://www.maxqda.com/de/ [Accessed 2nd March 2022].

Moser, S.C. & Ekstrom, J.A. (2010) A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences of the United States of America*, 107(51), 22026–22031. Available from: https://doi.org/10.1073/pnas.1007887107

Nardini, A. & Pavan, S. (2011) River restoration: Not only for the sake of nature but also for saving money while addressing flood risk. A decision-making framework applied to the Chiese River (Po basin, Italy). *Journal of Flood Risk Management*, 5(2), 111–133. Available from: https://doi.org/10.1111/j.1753-318X.2011.01132.x

North, D. (1990) *Institutions, institutional change and economic performance*. Cambridge, UK: Cambridge University Press.

Penning-Rowsell, E.C. (2021) Comparing the scale of modelled and recorded current flood risk: Results from England. *Journal of Flood Risk Management*, 14(1), e12685. Available from: https://doi.org/10.1111/jfr3.12685

Penning-Rowsell, E.C. & Johnson, C. (2015) The ebb and flow of power: British FRM and the politics of scale. *Geoforum*, 62, 131–142. Available from: https://doi.org/10.1016/j.geoforum.2015.03.019

Rauter, M., Kaufmann, M., Thaler, T. & Fuchs, S. (2020) FRM in Austria: Analysing the shift in responsibility-sharing between public and private actors from a public stakeholder's perspective. *Land Use Policy*, 99, 105017. Available from: https://doi.org/10.1016/j.landusepol.2020.105017

Reiter, K., Knittel, N., Bachner, G. & Hochrainer-Stigler, S. (2022) Barriers and ways forward to climate risk management against indirect effects of natural disasters: A case study on flood risk in Austria. *Climate Risk Management*, 36, 100431. Available from: https://doi.org/10.1016/j.crm.2022.100431

Sayers, P.B., Galloway, G., Penning-Rowsell, E.C., Shen, F., Wen, K., Chen, Y. et al. (2015) Strategic flood management: Ten 'golden rules' to guide a sound approach. *International Journal of River Basin Management*, 13(2), 137–151. Available from: https://doi.org/10.1080/15715124.2014.902378

Schindelegger, A. (2019) *Absiedlung als Planungsinstrument, Planerische Aspekte zu Siedlungsrückzug als Naturgefahrenprävention*. [relocations as a planning instrument: Managed retreat for natural hazard prevention from a planning perspective]. PhD thesis. Technical University of Vienna, Vienna.

Schinko, T., Mechler, R. & Hochrainer-Stigler, S. (2017) A methodological framework to operationalize climate risk management: Managing sovereign climate-related extreme event risk in Austria. *Mitigation and Adaptation Strategies and Global Change*, 22(7), 1063–1986. Available from: https://doi.org/10.1007/s11027-016-9713-0

Schlögl, M., Fuchs, S., Scheidl, C. & Heiser, M. (2021) Trends in torrential flooding in the Austrian Alps: A combination of climate change, exposure dynamics, and mitigation measures. *Climate Risk Management*, 32, 100294. Available from: https://doi.org/10.1016/j.crm.2021.100294

Seebauer, S., Thaler, T., Hanger-Kopp, S. & Schinko, T. (2023) How path dependency manifests in flood risk management: Observations from four decades in the Ennstal and Aist catchments in Austria. *Regional Environmental Change*, 23, 31. Available from: https://doi.org/10.1007/s10113-023-02029-y

Seebauer, S. & Winkler, C. (2020) Should I stay or should I go? Factors in household decisions for or against relocation from a flood risk area. *Global Environmental Change*, 60, 102018. https://doi.org/10.1016/j.gloenvcha.2019.102018

Seher, W. & Löschner, L. (2018) Balancing upstream–downstream interests in flood risk management: Experiences from a catchment-based approach in Austria. *Journal of Flood Risk Management*, 11(1), 56–65. Available from: https://doi.org/10.1111/jfr3.12266

Seyfang, G. & Smith, A. (2007) Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, 16(4), 584–603. Available from: https://doi.org/10.1080/09644010701419121

Skrydstrup, J., Löwe, R., Bülow-Gregersen, I., Koetse, M., Aerts, J.C.J.H., de Ruiter, M. et al. (2022) Assessing the recreational value of small-scale nature-based solutions when planning urban flood adaptation. *Journal of Environmental Management*, 320, 115724. Available from: https://doi.org/10.1016/j.jenvman.2022.115724

Thaler, T., Attems, M.-S., Bonnefond, M., Clarke, D., Gatien-Tournat, A., Gralepois, M. et al. (2019) Drivers and barriers of adaptation initiatives – How societal transformation affects natural hazard management and risk mitigation in Europe. *Science of the Total Environment*, 650(1), 1073–1082. Available from: https://doi.org/10.1016/j.scitotenv.2018.08.306

Thaler, T., Attems, M.-S. & Fuchs, S. (2022) Bottom-up innovations in natural hazard risk management in Austria. *International Journal of Disaster Risk Reduction*, 67, 102689. Available from: https://doi.org/10.1016/j.ijdrr.2021.102689

Thaler, T. & Levin-Keitel, M. (2016) Multi-level stakeholder engagement in FRM—A question of roles and power: Lessons from England. *Environmental Science & Policy*, 55(2), 292–301. Available from: https://doi.org/10.1016/j.envsci.2015.04.007

Thaler, T. & Priest, S.J. (2014) Partnership funding in FRM: New localism debate and policy in England. *Area*, 46(4), 418–425. Available from: https://doi.org/10.1111/area.12135

Thaler, T., Priest, S.J. & Fuchs, S. (2016) Evolving inter-regional co-operation in FRM: Distances and types of partnership approaches in Austria. *Regional Environmental Change*, 16, 841–853. Available from: https://doi.org/10.1007/s10113-015-0796-z

Thaler, T. & Seebauer, S. (2019) Bottom-up citizen initiatives in natural hazard management: Why they appear and what they can do? *Environmental Science & Policy*, 94, 101–111. Available from: https://doi.org/10.1016/j.envsci.2018.12.012

Thaler, T., Seebauer, S. & Schindelegger, A. (2020) Patience, persistence and pre-signals: Policy dynamics of planned relocation in Austria. *Global Environmental Change*, 63, 102122. Available from: https://doi.org/10.1016/j.gloenvcha.2020.102122

Turnheim, B. & Geels, F.W. (2013) The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). *Research Policy*, 42(10), 1749–1767. Available from: https://doi.org/10.1016/j.respol.2013.04.009

Vitale, C. & Meijerink, S. (2023) Flood risk policies in Italy: A longitudinal institutional analysis of continuity and change. *International Journal of Water Resources Development*, 39(2), 211–235. Available from: https://doi.org/10.1080/07900627.2021.1985972

Wharton, G. & Gilvear, D.J. (2007) River restoration in the UK: Meeting the dual needs of the European union water framework directive and flood defence? *International Journal of River Basin Management*, 5(2), 143–154. Available from: https://doi.org/10.1080/15715124.2007.9635314

Wingfield, T., Macdonald, N., Peters, K. & Spees, J. (2021) Barriers to mainstream adoption of catchment-wide natural flood management: A transdisciplinary problem-framing study of delivery practice. *Hydrological Earth and System Sciences*, 25, 6239–6259. Available from: https://doi.org/10.5194/hess-25-6239-2021

Witte, P.A., Snel, K.A. & Geertman, S.C.M. (2021) Less is more? Evaluating technical aspects and user experiences of smart flood risk assessment tools. *Urban Planning*, 6(3), 283–294. Available from: https://doi.org/10.17645/up.v6i3.4257

Woodruff, S., Meerow, S., Gilbertson, P., Hannibal, B., Matos, M., Roy, M. et al. (2021) Is flood resilience planning improving? A longitudinal analysis of networks of plans in Boston and Fort Lauderdale. *Climate Risk Management*, 34, 100354. Available from: https://doi.org/10.1016/j.crm.2021.100354

Young, S.L. & Tanner, J. (2022) *Citizen participation matters. Bureaucratic discretion matters more*. Public Administration. Available from: https://doi.org/10.1111/padm.12867

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