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Multi-level governance for effective natural flood management: Different roles at different scales

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Abstract
Natural Flood Management implementation is a wicked problem that involves difficult trade-offs, decisions by multiple stakeholders, and actions at multiple spatial scales. Governance of Natural Flood Management implementation is multi-level, with stakeholders connected through vertical, horizontal, and diagonal arrangements. We investigate the extent of multi-level governance of Natural Flood Management in two case studies in Scotland, United Kingdom to understand how decisions are currently made and how decision-making processes could be improved. We find that in vertical governance, national-level priorities dominate and constrain Local Authority and community decision-making. In horizontal governance, while there are many mechanisms for collaboration between Local Authorities such as the Local Flood Risk Management Plans, collaboration is in fact limited by funding and workload constraints. In diagonal governance, there are many ways to influence outcomes outside of traditional vertical and horizontal connections, especially through communities, Non-Governmental Organisations, and consulting firms. Improving cooperation and power-sharing across scales can lead to improved Natural Flood Management implementation and stronger resilience to flooding.

Keywords: flood risk management, natural flood management, governance, catchment, multi-level, Scotland

1. Introduction

Natural Flood Management (NFM) implementation is a wicked problem that involves difficult trade-offs and decisions by multiple stakeholders. NFM mimics natural processes to reduce flood risk downstream (Forbes et al., 2015). A "wicked problem" is a problem without a clear solution due to complexity (Wingfield et al., 2021; Rittel and Webber, 1973). NFM is one component of Flood Risk Management (FRM), which also includes flood warning systems and engineered flood defences. While NFM has not yet been widely implemented at large scales (defined by Dadson et al. (2017) as areas greater than 100 km^2), pilot projects have shown that NFM has the potential to reduce flood risk, especially in small storms and small catchments (areas less than 20 km^2) (Black et al., 2021; Dadson et al., 2017). Recent research highlights interest in upscaling NFM (increasing the amount of NFM to be used across entire catchments) along with the challenges that have made this goal difficult to achieve (Carter et al., 2024; King & Bark, 2024; Wingfield et al., 2021; Tabas et al., 2025).

The current FRM decision-making process has led to an underutilisation of NFM in many countries and contexts. For example, the literature describes NFM upscaling as "lacking" (Castellar et al., 2024), "sluggish" (Thorne et al., 2018), "slow" (Whilborg et al., 2019), and "messy" (Wingfield et al., 2021). In order to understand the causes of this lack of NFM, it is necessary to examine the governance systems involved in decision-making at the catchment scale (Waylen et al., 2023). Collaboration across governance scales is challenging because it is necessary to involve different groups, each with their own objectives, and to communicate with them effectively (Dieperink et al., 2016; Morrison et al., 2018; Koop & Van Leeuwen, 2017). FRM can be thought of as a "common pool resource," which means that it is shared by multiple users (Cowen & Delmotte, 2020; E. Ostrom, 1990). Innovative arrangements are necessary to manage flood risk effectively.

We investigate multi-level governance of NFM to understand how decision-making power is held at multiple governance levels, using two case studies from Scotland, United Kingdom (UK). In-depth analysis of individual perspectives at the local and national levels is an appropriate approach to answer these questions because it enables a stronger understanding of why policies were put in place, how those policies are implemented, and strategies to improve policies in the future. To achieve this, we use a comparative, "most similar" case study approach (Yin, 2003; Seawright and Gerring 2008). While existing research applies the concept of vertical and horizontal FRM governance (e.g. Vedeld et al., 2016; Dobravec et al., 2021; OECD, 2010; Pahl-Wostl & Knieper, 2023), we also consider diagonal governance arrangements. Understanding governance processes can lead to improved decision-making for other environmental wicked problems like climate change and pollution.

2. Multi-Level Governance Framework: Vertical, Horizontal, and Diagonal Governance

Governance is "the broad processes, institutions, policies, and relationships through which decisions are made and actions taken" (Morrison et al., 2018), and frameworks used to analyse governance include polycentric, networked, and multi-level governance. Polycentric governance describes situations with "many centres of decision making that are formally independent of each other" (V. Ostrom et al., 1961; E. Ostrom, 2010). "Network governance," meanwhile, focuses on the shape of the structures that connect these decision-makers (Waylen et al., 2023; Carlsson & Sandström, 2008). "Multi-level governance" examines "decision-making at various territorial levels," including "increased participation of non-state actors" (Bache & Flinders, 2004). Polycentric, networked, and multi-level governance can all include elements of collaborative governance, which is "the involvement of governmental and non-governmental actors in the processes and structures of decision making and management" (Waylen et al., 2023). We use multi-level governance as a framework because we are investigating how governments at different scales interact.

Multi-level governance can involve clear distinctions between roles or more "complex" overlaps between levels (Marks & Hooghe, 2004). The Multi-Level Governance Framework (OECD, 2015) identifies several

challenges in areas including policies and funding. Research on multi-level governance for FRM includes examples from Senegal (Vedeld et al., 2016); Italy (Vitale et al., 2022); Sweden (Nykvist et al., 2017); Bangladesh (Rahman et al., 2014); the Netherlands (van Herk et al., 2013); and Australia (Dare & Daniell, 2017). An analysis of multi-level governance of FRM in five countries highlighted the increased role of Non-Government Organisations (NGOs) in FRM (Plummer et al., 2018). We use Torfing et al. (2012)'s framework of vertical, horizontal, and diagonal governance to understand the relationships involved in multi-level governance, while clarifying the definitions.

Vertical governance refers to connections from larger (e.g. national) to smaller (e.g. local) governments. "Vertical cooperation" (Sarabi et al., 2019) is essential for implementing national-level policies at a local level and can give local governments the opportunity to influence national policymaking. Scales (national, local, etc.) are not "static containers" – instead, they are constantly changing in terms of their extent and the power that each scale holds, due to political processes (Swyngedouw, 1997). While some might assume that giving more control to local organisations leads to better outcomes, Brown & Purcell (2005) caution against this view, which they call "the local trap." A study of flood governance in the UK finds that "power" is centralized while "responsibility [is] decentralized" (Penning-Rowsell & Johnson, 2015). Vertical governance arrangements are key where national and local governments have decision-making power on related or overlapping issues, such as the dynamics between national, state, and municipal governments in the U.S. (Ryan, 2016) and between the European Union, Germany, and individual lander in Germany (Demuth & Rademacher, 2016). Regional initiatives are one way to bridge local and national policymaking (Peskett et al., 2023).

Horizontal governance refers to arrangements between organisations at the same level (e.g. national to national; local to local), and it is especially important for managing transboundary natural resources (Sarabi et al., 2019). A key concept in river management is the catchment: the area that includes all of the land that, if rained on, would drain to the same downstream point (Wagener et al., 2007). Catchment-scale cooperation is necessary for NFM implementation and FRM (Carter et al., 2024; Johannessen & Granit, 2015; Waylen et al., 2023; Hartmann et al., 2022). While the cooperation may be "horizontal," one of the actors – the "hegemon" – may be more powerful than the other (Zeitoun & Warner, 2006). Managing water across political boundaries can lead to cooperation (De Stefano et al., 2010) or conflict (Gleick, 1993). Effective horizontal governance for FRM on transboundary rivers is a challenge around the world, including Canada-United States (Heinrich & Penning-Rowsell, 2022), Uganda-South Sudan (Canwat, 2023), India-Pakistan (Baseer & Iqbal, 2024), Ecuador-Peru (Oñate-Valdivieso & Oñate-Paladines, 2024), and Turkey-Bulgaria-Greece (Tuncok, 2015). Horizontal governance is also a factor between local governments within countries, such as between administrative regions in Indonesia (Rahayu et al., 2024).

Diagonal governance refers to the process of influencing decision-making outside of formal horizontal or vertical structures. Diagonal governance can occur within government, as when local officials and bureaucrats collaborate outside of official channels, and outside of government, through the influence of NGOs and private-sector organisations (Torfing et al., 2012). One way in which small-scale organisations can try to increase their power is through "scale jumping," which involves influencing decisions at other governance levels (Penning-Rowsell & Johnson, 2015; Smith, 1993; Swyngedouw, 1997). As explained by Torfing et al. (2012), NGOs can "move freely between the subnational, national, transnational, and sometimes even global levels of governance" (Torfing et al., 2012). Diagonal governance can also include bridging roles, such as NGOs taking the form of "trusted intermediaries" between local stakeholders and governments (Rouillard & Spray, 2017) and with academic researchers (Norström et al., 2020). Community involvement is an important but at times underutilized aspect of FRM (Johannessen & Granit, 2015; Lane et al., 2010). Furthermore, local actors are becoming more important in the process of "glocalisation", which involves the interaction of local and international actors (Sharma et al., 2023; Swyngedouw, 2004). Diagonal governance therefore involves the influence of these groups on decision-making at multiple levels of government.

3. Methods

We use a comparative case study approach (Yin, 2003) to understand NFM governance. The two case studies, the Allan Water and the (Lothian) River Esk, were selected using a "most similar" approach (Seawright & Gerring, 2008). They are similar in terms of catchment area, a downstream flood scheme under development, upstream rural areas, and location in the Forth catchment. After controlling for these similar elements, we aim to understand the influence of different NFM governance arrangements on perceived effectiveness of NFM implementation (Seawright and Gerring, 2008). From an FRM governance perspective, the two cases have similar FRM governance arrangements, but the flood scheme consultation processes have had different outcomes. From an NFM governance perspective, the Allan has had an ongoing NFM upscaling project since 2011 (Scottish Environment Protection Agency (SEPA), 2011) while NFM catchment-level coordination in the Esk is more recent. An additional difference between the cases is that Bridge of Allan (located in the Allan Water catchment) has had flood damage more recently in October 2023 (Stirling Council Flooding, 2026), while places in the Esk catchment have comparatively limited flood memory.

3.1 Research Design

We used a qualitative research strategy to investigate the following aim: analyse the effectiveness of multi-level governance of NFM (Bryman, 2004; Kabo et al., 2023). We used a constructionist lens, which focuses on how meaning is "produced" (Braun & Clarke, 2013) because the emphasis is on understanding stakeholders' subjective views of the governance of FRM. The three Research Questions (RQs) for this project, which were used to structure the data, are:

1. **Vertical governance**: In what ways do national-level policies, Local Authority (LA) decision-making, and community council planning interact to enable or constrain NFM implementation?
2. **Horizontal governance**: Why do Local Authorities collaborate with each other for NFM upscaling, why do they not collaborate with each other, and how could they build on current levels of collaboration?
3. **Diagonal governance**: To what extent do governments, communities, NGOs, consultants, and other groups influence NFM decision-making outside of vertical and horizontal connections, and to what extent do they affect outcomes?

Data were collected through 24 semi-structured interviews conducted from June 2023 – November 2024 in-person and on video call with people with national perspectives (e.g. Scottish Government, NatureScot, SEPA, Scottish Water) and expertise on the Allan Water and River Esk catchments (LA, NGO, private sector), as shown in Table 1. Interviews were, on average, one hour long. The interview guide included questions on the interviewee's role in NFM implementation, their connections to other organisations, and their views on NFM. Interviewees were identified based on a stakeholder mapping exercise and selected through purposive sampling. While purposive sampling methods may introduce bias, we aimed to include interviewees whose opinions would illuminate questions about governance and included a variety of perspectives (upstream and downstream; public and private sector) within the sample. In the Esk catchment, a new Esk Flood Forum community research group provided additional opportunities for interacting with stakeholders. Analysis of policy documents was also used. Ethical approval for this research was granted by Heriot-Watt University (approval numbers 2023-4979-7567; 2023-6305-8750) and consent was provided by all interviewees and workshop attendees. The primary researcher on this project is a university researcher from outside of the study catchments, which meant that it was necessary to take the time to learn the background of the study catchments and to make contacts in order to reduce the risk of inaccurate assumptions and to ensure that the interviewee sample was appropriate.

Interview transcripts were analysed by the primary researcher through qualitative thematic analysis (Braun & Clarke, 2021). Transcripts were developed for each interview with assistance from the Microsoft Word Online Transcribe tool, then the researcher listened to the interview and corrected errors. While listening, the researcher highlighted important sections and made notes of emerging themes. The researcher used

NVivo software to develop codes inductively and reviewed transcripts to standardize codes. An inductive approach was used because this is a qualitative study whose starting point is deep engagement with the two case studies. Bryman (2004) explains that inductive approaches are appropriate for analysing qualitative data. For example, the following studies on water governance used an inductive approach to coding interview data to generate findings: an investigation of stakeholders' views of water management in Scotland (Adams et al., 2022); an exploration of catchment partnerships (Waylen et al., 2023); and an analysis of views on NFM (King & Bark, 2024). Then, the RQs about vertical, horizontal, and diagonal cooperation were used to structure the data. Results were generated when themes occurred across multiple interviews. While there are limitations to the generalisability of qualitative case study research, this type of research enables an in-depth examination of multi-level governance in practice.

Table 1. Interviews conducted for this research. Interviewees included government, private sector, NGO, and other perspectives. Codes identify interviewees by catchment only to preserve anonymity.

Interviewee Category	**Number of Interviewees**
National perspectives	9 (codes: N1 – N9)
River Esk perspectives	9 (codes: E1 – E9)
Allan Water perspectives	6 (codes: A1 – A6)
Total	**24**

3.2 Case Studies

FRM in Scotland is managed at multiple levels. At the national level, Scottish Government writes laws and funds flood schemes; SEPA produces flood maps; Scottish Water manages the wastewater network; and NatureScot funds NFM projects. The Flood Risk Management (Scotland) Act 2009 requires a consideration of the potential for NFM (Scottish Parliament, 2009; Spray et al., 2010), as do more recent policies including National Planning Framework 4 (NPF4) (Scottish Government, 2023) and the Flood Resilience Strategy (Scottish Government, 2024). The next level is the 32 Local Authorities (LAs), which are responsible for protecting their residents and infrastructure from flooding and for developing flood schemes. LAs coordinate FRM through 14 Local Flood Risk Management Plans (LFRMPs) (Scottish Parliament, 2009). LAs' responsibilities also include biodiversity, environment, roads, education, and housing (Burn-Murdoch & Campbell, 2019). Local authorities interact horizontally with each other (for example, through shared LFRMPs); vertically with Scottish Government (for example, by applying for funding for flood schemes or NFM projects); and diagonally with community councils, residents, landowners, farmers, consultants, advocacy groups, and others as they make decisions about FRM and land use.

The first case study is the Allan Water, located in central Scotland. Its catchment, with an area of 225 km^2, begins in the Ochil Hills and ends at the River Forth (Figure 1). Land uses in the catchment include agriculture, forestry, and several small urban areas. The Allan Water catchment includes three LAs: Perth and Kinross upstream, Stirling downstream, and a small area of Clackmannanshire. According to the Forth Local Plan District FRMP, the Dunblane and Bridge of Allan Potentially Vulnerable Area (PVA) has 420 properties at risk of flooding (SEPA, 2021). Bridge of Allan suffered minor flood damage in October 2023 (Stirling Council Flooding, 2026). Sources of flood risk are river flooding and surface flooding. There is also a smaller PVA in the upstream town of Braco, where 30 properties are at risk. FRM projects in the catchment include an upstream NFM implementation project coordinated by Forth Rivers Trust (Forth Rivers Trust, n.d.) and the downstream Bridge of Allan flood protection scheme, scheduled to begin in 2026 (Project Scotland, 2024; Stirling Council Flooding, 2026).

The second case study is the (Lothian) River Esk, located in southern Scotland. The Esk catchment is 328 km^2, and it rises in the Pentland Hills and flows into the Firth of Forth (Figure 1). Land uses include agriculture, housing, large estates, and several towns. The Esk catchment includes four LAs: Midlothian Council upstream, East Lothian Council downstream, and small areas of Scottish Borders and City of Edinburgh. According to the Forth Estuary Local Plan District FRMP, the two PVAs in the catchment are Musselburgh (including northern Dalkeith) with 2,730 properties at risk to river, surface, and coastal flooding and Dalkeith, Lasswade,

and Newtongrange with 1,190 properties vulnerable to river and surface flooding (SEPA, 2021). Current projects in the Esk catchment include the Musselburgh Flood Protection Scheme (East Lothian Council, 2021), as well as small Nature-Based Solutions-type projects in the wider catchment, although NFM is not yet being implemented in a coordinated way. Regional groups including Climate Ready Southeast Scotland and the Esk River Improvement Group connect local authorities (Midlothian View, 2020; Sniffer, 2024).

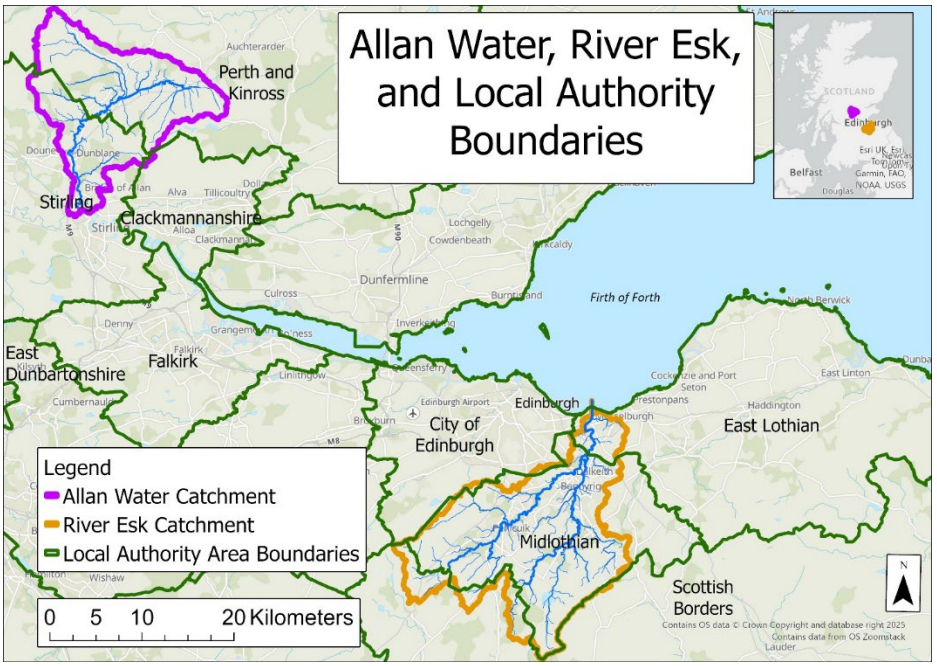

Figure 1. Map of the Allan Water (purple area in the north-west corner of the map) and River Esk (orange area in the southern part of the map) catchments and relevant Local Authority Areas in Scotland, UK.

4. Results

The Allan Water and River Esk cases show that cooperative vertical, horizontal, and diagonal governance are essential for FRM (Figure 2). In the vertical dimension, national policies impose constraints on LA decision-making. In the horizontal dimension, increased cooperation between LAs is necessary. In the diagonal dimension, there are multiple ways to influence events at multiple scales.

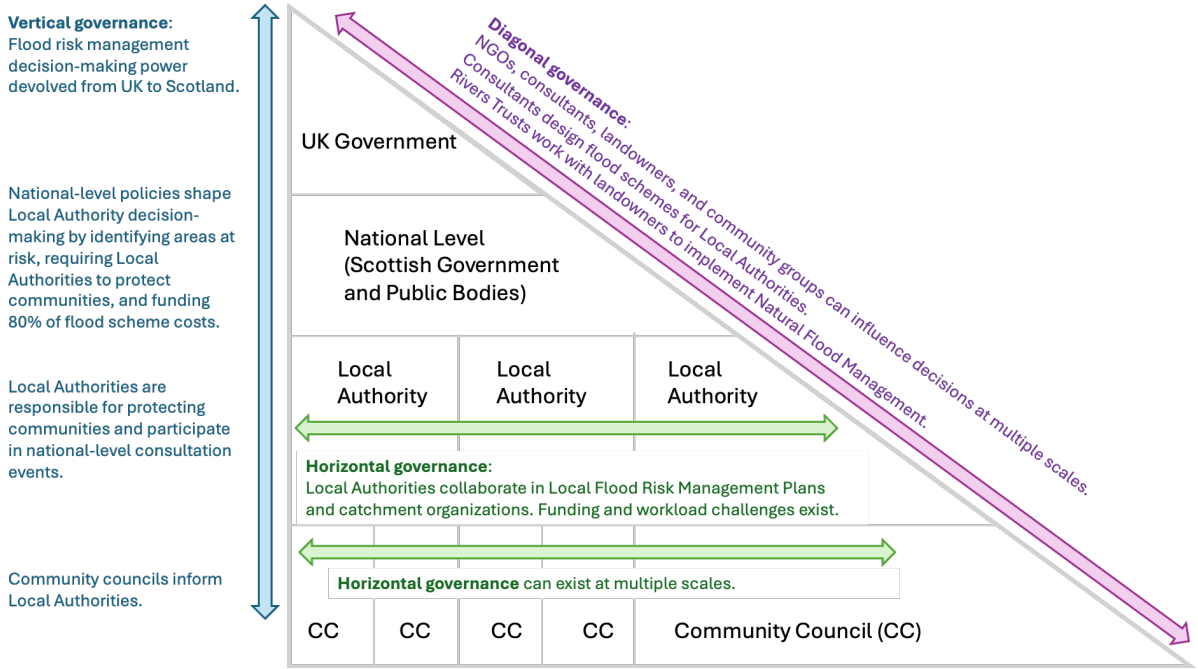

Figure 2. Overview of findings related to multi-level governance of Natural Flood Management (Figure source: The authors, building on the concept of vertical, horizontal, and diagonal governance from Torfing et al. 2012).

4.1 Vertical governance: National policies constrain and support NFM implementation by Local Authorities
From a vertical governance perspective, national government requires LAs to develop LFRMPs while LAs can influence the direction of national policy through consultation events. Similarly, there is two-way interaction between LAs and community councils. Areas of interaction between national and local perspectives are related to funding, the potential to account for NFM's co-benefits, and community planning processes (Table 2).

Table 2. Themes related to vertical governance.

	Representative local perspective – Allan	**Representative local perspective – Esk**	**Representative national perspective**
Local and national stakeholders have conflicting views on how NFM should be funded	"We wouldn't see this [NFM] as a be-all, end-all solution at this stage. Because of the way the Scottish Government funding situation is outlined, they wouldn't fund nature-based solutions because it's meant to be a hard engineering solution or some sort of flood protection scheme, and that's how we come about funding." (A6)	"Local authorities don't get enough money from the Scottish Government and the also the local authorities keep getting asked to deliver...all these extra policy things...But you still have to deliver your skills and your social work and your personal care and stuff." (E9)	"I hope that there's a recognition within local authorities that [flood resilience] is not an additional thing to do....So the local authorities don't think, "oh, now we've got to do flood resilience." No. You're delivering flood resilience as part of delivering your biodiversity strategy or your adaptation strategy." (N7)
National emphasis on NFM's co-benefits could increase local NFM implementation	"I think their policies could be stronger and I and I think it's a little bit the same with NPF 4...I kind of wish they would say much more...you know, we're in a climate change emergency" (A1)	"So what I'm about to say in my opinion is potentially a game changer for nature-based solutions. So what I'm talking about here is NPF4...And biodiversity is flashing in big lights because there are now new obligations for all projects pertaining to biodiversity." (E4)	"We work with what we've got, and what we've got is arguably quite punchy. We've never been in as good a situation as we are at the moment, with so much opportunity. Particularly through NPF4. And I think it's just a question of us all being in a position to maximize that." (N5)
Community planning processes can improve vertical cooperation between LAs and communities for NFM implementation	"We are quite keen as a Community Council...to develop the local place plan for the area, because we recognize that we have quite a unique environment and we want to make sure that the community's views are taken into consideration when [the Local Authority makes] any planning decisions as part of that." (A2)	"So it is quite well established, the Community planning side of things and quite I find, you know, everyone's very, very passionate about what they do." (E7)	"The communities can write up their own plans. So it's like a placemaking plan that has to be taken account of in our local plans which are getting developed now. So there's definitely more opportunity for communities now than there has been in the past to shape what they want their future to be." (N6)

Funding decisions at the national level constrain LA options related to NFM by controlling what types of flood protection may be funded. As shown in the first row of Table 2, LAs perceive significant funding limitations for NFM, which contrasts with national-level confidence that NFM can be delivered through other strategies. In addition, the national Prioritisation process constrains what is possible for local authorities, project deadlines, and money spent planning for flood schemes. While local authorities and consultants are the ones to develop flood schemes, it is the national-level decision-makers who define areas at risk at the beginning of the process, rank the flood schemes, and ultimately decide which to fund. The Prioritisation process sets up competition between LAs: "If this scheme falls down, for example, the money...goes outwith the authority" (E8).

On the other hand, national policies related to biodiversity can open the door for increased use of NFM by local authorities. Six interviewees discussed the links between biodiversity and NFM, for example: "I think the benefits from NFM is not solely flooding and maybe there's too much weight put on the reduction in flood risks...and there's other benefits to be had" (E3). New national policies are aiming to correct that: interviewees called NPF4 "a game changer" (E4) and "punchy" (N5). This way, local authorities can "sell those positive benefits to the wider community so they become proud of it" (E2). Similarly, the Flood Resilience Strategy represents Scotland "moving away from fixing flooding problems to creating flood resilient places" (N4) as it "[sets] the tone as to how Scottish Government can...fund...in terms of flood risk management" (N3). While it can be difficult to upscale NFM based on its flood benefits alone, tallying its biodiversity and carbon storage benefits could make it more cost-effective.

Vertical cooperation extends to community-level planning as well. Three interviewees highlighted that communities have the ability to write plans that influence decisions at their Community Council and LA. One interviewee explained that "[The LA works] a lot with community councils or any community trusts [and is] quite often away meeting with the Community Council members and members of the public" (E5). These links between Community Councils and Local Authorities can help local priorities to be addressed. Vertical collaboration can improve overall capacity: the LA can be "a facilitatory hub that brings partners and sectors together" (E7) to achieve more than it could alone. Communities can also get involved in planting and maintenance of trees, rain gardens, and other NFM schemes. One potential challenge is managing expectations: "we're more dealing with a public that wants to see these measures going in" meaning that there is a need to "provide a sense of realism to what natural flood management measures can achieve in a river system" (N5).

In both study catchments and at the national level, interviewees emphasised that national policies determine local outcomes. This is especially apparent in the Esk catchment, where national timelines and requirements have been used to frame the scope of the flood scheme. Therefore, while flood scheme design is delegated to the LA level, significant power rests at the national level.

4.2 Horizontal governance: Local authorities need to dedicate more time and resources to catchment-level cooperation for NFM implementation

Horizontal cooperation is necessary for transboundary flood management. LFRMPs and catchment organisations are areas for collaboration, while workload and the challenge of justifying NFM limit the effectiveness of these catchment organisations (Table 3).

Horizontal cooperation is promoted through LFRMPs (SEPA, 2021), the Convention Of Scottish Local Authorities (COSLA), and the Scottish Collaboration of Transportation Specialists (SCOTS) flooding subgroup. The LFRMPs describe PVAs in the catchments and list actions that the LAs will take to reduce the level of risk. In cases of transboundary rivers, "the area in question may span different local authorities, in which case there is an obligation of working together" (E4). There are several additional groups in the Esk catchment: the Esk River Improvement Group and a new catchment organisation (E4).

Table 3. Themes related to horizontal governance.

	Representative local perspective – Allan	**Representative local perspective – Esk**	**Representative national perspective**
Horizontal cooperation is enabled by Local Plan Districts and other catchment approaches	"We're all in the same boat. We have all the same challenges. We have all the same issues, so we talk to each other frequently. We have deep, meaningful conversations, lighthearted conversations, and share experiences, positive and negative" (A4)	"A lot of parties...have all been having conversations with regards to the concept of trying to bring into existence such a new organisation, which would probably be a charity or an NGO, who could then coordinate those sort of positive changes in the Esk catchment" (E4)	"In terms of coordination for water bodies and catchments, I think it's fairly good ...because we have that structure that's in place under the Local Plan Districts and those Local Flood Risk Management Plans....There's not a I guess an admin boundary that's been created that makes it difficult." (N1)
Workload challenges inhibit horizontal cooperation	"Because of the catastrophic shortage of staff and resources, these [local authority planning] meetings are very, very few and far between" (A5)	"It depends loads on the personalities of the people in those jobs and also on how much time they have, what they've been told, like how stressed they are with their own workload...Do they have time to go and talk to [the other council]?" (E9)	*Not applicable - National stakeholders did not emphasise this point.*
Justifying NFM is a challenge for horizontal, catchment-scale cooperation	"You can't say we can guarantee a reduction of this...the uncertainty increases dramatically when you're talking about Nature-Based Solutions as opposed to hard engineered solutions and that's certainly a big barrier." (A6)	"We just don't have the evidence there yet." (E3)	"[The Council] have got a responsibility to reduce the flood risk in their area and they...probably don't think the natural flood management will guarantee them that and they have that statutory responsibility to protect their communities and to reduce flooding." (N4)

In practice, however, the high workload faced by the employees of local authorities is a challenge for NFM implementation. Interviewees highlighted that "most of these teams are not at full capacity" (A6) and that there is a "catastrophic shortage of staff and resources" (A5). Local authorities' budgets are limited, which can lead to staffing challenges (either a shortage of staff, or an already-full workload for existing staff). For example, one interviewee discussing community involvement said that "everyone is...trying to do an awful lot with very little resource" (E7). Furthermore, applying for funding is time-consuming: "even things [that] are 100% grant aided it's quite cumbersome now to administer and to apply" (E1). In one case, an interviewee described a LA without "any flooding team at all" (E7). This can make it difficult for other LAs to find the right person to contact. Often, local authorities rely on consultants to fill gaps in staffing, expertise, and access to

software. The longer-term challenge here is that the expertise sits outside of the council employees. To address these workload-related challenges, LAs would need to obtain more funding to hire more staff members.

Another challenge for catchment-level coordination is the evidence gaps – or perceived evidence gaps – related to upstream NFM implementation. Interviewees highlighted "uncertainty" (A6) related to NFM's effectiveness. As one interviewee explained, "it comes back to the NFM and having that empirical evidence to kind of quantify the benefit, I don't think it's there at the minute that would allow us to sanction money being spent outwith the area" (E3). The key point for horizontal cooperation is that NFM involves coordination between two LAs: the one with the flooding problem and the one with the upstream space to implement NFM. Upstream-downstream relationships are an important consideration for flood risk management, a point also highlighted by King and Bark (2024). One interviewee in the Allan Water catchment cautioned: "in principle, yes" it is possible to share funding, but "in practice, it's exceptionally difficult" (A4). On the other hand, three respondents in the Esk catchment explained that catchment-level NFM was being considered: "this is already [planned]...it's not something that can't be done, it's just, you know, just the logistics of it, it's just normal work to figure those things out" (E8). While workload and evidence gaps pose challenges to LA coordination, increased funding and data gathering could start to solve these issues.

4.3 Diagonal governance: Additional connections outside of vertical and horizontal governance affect NFM implementation

Diagonal governance enables various levels of government, communities, NGOs, environmental groups, consultants, landowners, residents, and others to affect decision-making outside of formal channels. Diagonal governance includes the role of NGOs and consultants, community attitudes towards flood schemes, and links between the international and the local that provide opportunities for diagonal cooperation (Table 4).

"Trusted intermediaries" (Rouillard & Spray, 2017) bridge the gap between national and local government, landowners, and communities. The Allan Water and River Esk are both tributaries of the Forth and are therefore eligible for FRT programmes. Three interviewees expressed the usefulness of having an NGO to coordinate stakeholder priorities, secure funding, and implement NFM projects. In the Allan Water catchment, FRT has been involved in working with landowners to install NFM through the Revive the Allan and MERLIN projects (Forth Rivers Trust, n.d.; Streater & Provan, 2022). Because one of the challenges for an NGO is long-term maintenance of sites, maintenance could be an area for communities or local authorities to participate. In the River Esk catchment, FRT's Citizen Esk program is aimed at public education and outreach. NGOs can also advocate at the LA, Scottish Government, and UK levels for improved environmental policies.

Flood schemes bring both tension and cooperation among communities, consultants, LAs, and Scottish Government, and they are rich areas for diagonal interactions. In Musselburgh, some community members protested the plans for the Flood Protection Scheme through public demonstrations, formal objections, and a petition to the Council. Community members contacted through the Esk Forum project critiqued the decision-making process of the scheme: "Asking [company] to decide whether we need a flood scheme is like asking a turkey farmer whether we should have Christmas." They also criticised the proposed design: "the openness [of the waterfront] is so positive for people's mental health and wellbeing and I think that will be destroyed." NFM was central to the debate about the flood scheme, as community members and consultants debated the level of risk and how effective upstream measures could be to reduce it (Kennedy, 2024). The petition to "pause" the flood scheme was treated as "misinformation" (Kennedy, 2024; East Lothian Council, 2023) for reasons including the fact that a pause would result in the scheme missing Scottish Government's funding deadline – an example of rules at different scales shaping outcomes. Other community members, however, supported the scheme: "Brechin [levels of flood damage] could have happened here. No one has convinced me that upstream management could solve the problem. Pro-wall." Protests were not seen related to the Bridge of Allan scheme (see Discussion).

Table 4. Themes related to diagonal governance.

	Representative local perspective – Allan	**Representative local perspective – Esk**	**Representative national perspective**
NGOs can act as "trusted intermediaries" to connect stakeholders across governance scales	"It's certainly something we're kind of looking forward for the future, you know the likes of working with Forth Rivers Trust to kind of do joint venture projects and that's something we are we are really interested in." (A6)	"Sometimes we work with the Forth Rivers Trust doing clean ups...volunteers have done work on [site]." (E1)	"Basically, Forth Rivers Trust applied, came up with the project, they pretty much developed the whole idea." (N9)
Communities engage in diagonal cooperation and conflict around flood schemes and NFM	"There actually in these days was a flood group within the Community Council...There's a consultative process, it gets fed into the system. The Council then feeds it into what they have to do for the government, it's not funded and there's another cycle." (A3)	"I do think that the answer is not to try and collapse the scheme, but to try and compromise...What objections do you think we could actually reasonably meet within this scheme? What would make this scheme better for you?" (E9)	"How can we involve people more in improving our flood resilience?" (N4)
NFM links the international and the local in various ways	"Brexit has had the effect that...local food production has a more significant role to play...in the public consciousness, so contention for [NFM] at the expense of food production is...much more difficult to achieve." (A5)	"The professionals [determine] the best way forward on the basis of the evidence...and then [take] recommendations...to the elected representatives" (E4).	"The Flood Risk Management Scotland Act...included all the provisions in the EC Directive, plus some other things ... to tidy up how Flooding was managed in Scotland." (N4)

Diagonal relationships are also evident in the complex links between the international and the local in NFM implementation. While NFM involves large-scale land use changes that need to be implemented by local landowners, these landowners are supported by government subsidies: "We can't do [NFM] unless the people that own the land actually want to do it. So... it's much more about agriculture reform and the kind of payments that you would give" (E9). Agriculture subsidies were coordinated at the European Union (EU) level before the UK's exit from the EU. Since Brexit, Scotland's commitment to "dynamic alignment" with EU environmental regulations has continued to affect the conversation around flood management, NFM, and agriculture subsidies (Reid 2021). Coordination between Scotland and the EU is an example of scale jumping (see Discussion). In addition, consultants have significant influence on the decision-making process: "the Council that [is] addressing the flooding usually get [a] consultant because [the council does not] have the computer software to do all the stuff they do" (N6). Therefore, local public sector decision-making is influenced by consulting firms, which can operate at national and international scales.

5. Discussion

We analysed the effectiveness of multi-level governance of NFM and found that while vertical, horizontal, and diagonal cooperation exist in the two case study catchments, there are tensions in each area. In vertical governance, national-level flood policies constrain LA decision-making related to NFM while national-level biodiversity policies have the opposite effect. One of the reasons for this is the difficulty of measuring NFM's effectiveness for flood risk mitigation. In horizontal governance, there are formal structures in place for cooperation between LAs, but cooperation can be difficult in practice due to workload constraints. Horizontal cooperation exists at other levels as well (between community councils; between national governments) but the interviews conducted for this research – and therefore the findings – are focused on LA decision-making. Examples of diagonal governance include NGOs leading NFM projects, communities critiquing flood scheme designs outside of formal consultations, international consultants advising LAs, and Scottish Government finding links with EU policies.

5.1 Challenges of Sharing Power between Scales

The relative power of local and national scales is a key question in water governance research (Brown & Purcell, 2005; Swyngedouw, 1997). In Australia, for example, researchers investigated the extent to which powers had been delegated from national to local levels through the Murray-Darling Basin Plan and found that "localism provides a potential remedy for effective water governance by creating opportunities for multiple actors, especially at local or regional levels, to engage in water governance decision-making and implementation" (Dare & Daniell, 2017). The idea that local power will lead to improved outcomes is known as "subsidiarity" (Hukka & Katko, 2021). However, "the local trap" critiques the belief that local decision-making is always more effective (Brown & Purcell, 2005).

In Scotland, while existing literature emphasizes the power of Scottish LAs to make decisions (Rouillard et al., 2013; Penning-Rowsell & Johnson, 2015; Scottish Government, 2024), we find that LAs in Scotland are in fact significantly constrained by national-level policies. First, SEPA (a national-level group) defines the areas at risk of flooding through flood maps and PVAs. Second, local authorities are required to defend their residents against this flood risk. Third, the LAs submit these schemes back to Scottish Government to prioritize them and fund 80% of the cost. Grants to fund NFM also often originate at the national level. Therefore, because national-level organisations have the first and last word for flood scheme and NFM design and funding, LAs are actually very constrained in their decision-making process. This means that Penning-Rowsell and Johnson (2015)'s finding for the rest of the UK – that power rests at the national level – is true in Scotland as well. The Allan Water and River Esk case studies therefore provide a counter-example to the findings of Dare and Daniell (2017).

Giving power from the UK to Scotland, from Scotland to LAs, or from LAs to communities will not necessarily lead to better outcomes. The important thing, instead, is to "ensure clear responsibilities" (Rouillard et al., 2013) for cooperation between these various levels. For example, organisations have "slightly different views on who should be responsible" for surface flooding (N1), while "people need to know if they buy land that they're responsible for it" (A6). Clarifying responsibility, through policies like Scotland's Flood Resilience Strategy (Scottish Government, 2024), could improve outcomes.

5.2 Scale jumping

The extent to which "scale jumping" (Penning-Rowsell & Johnson, 2015; Smith, 1993; Swyngedouw, 1997) occurs is another key question in water governance literature. In Austria, for example, researchers found that "scale jumping and scalar re-organisations of local and private stakeholders mix up the established system of nested hierarchies in flood risk management" (Thaler et al., 2017).

In the case studies, the first example of scale jumping occurs in the River Esk catchment, where community members went outside of established consultation processes to advocate for changes to the proposed flood scheme (section 5.3). Interestingly, opposition to the flood scheme did not occur in the Allan Water catchment. One potential explanation for this is that there was more recent flooding in Bridge of Allan than in Musselburgh: flood memory and attitudes towards risk are differences between the two cases. The second

example of scale jumping was Scotland's presence on the international stage through the Hydro Nation programme (Adams et al., 2022) and its commitment to follow EU environmental policies (Reid, 2021). Environmental policies are one of Scotland's devolved powers, and are therefore an opportunity for Scotland to develop its international presence. The third example of scale jumping is the role played by consulting companies in decision-making. By working on local issues in many local areas, international consultants could potentially have the effect of uniformising responses to flood risk. International yet local consulting firms therefore have "glocal" power (Swyngedouw, 2004; Sharma et al., 2023).

5.3 Implications for governance of NFM

Including NGOs, communities, consultants, landowners, and other stakeholders in NFM implementation – through vertical, horizontal, or diagonal governance arrangements – is a challenge around the world. Examples include Sweden, where "reliance on expert opinion needs to be complemented by strengthened stakeholder participation" (Johannessen & Granit, 2015); Senegal, where "there were limitations in how higher-level government and institutions supported the lower levels in vertical and horizontal coordination" (Vedeld et al., 2016); and the UK, where "catchment partnerships add to the complexity of environmental governance, yet offer a useful approach to navigating this complexity" (Waylen et al., 2023). In the Allan Water and River Esk catchments, local stakeholders can be included through community place plans and consultation events. There are many challenges to securing landowner and community buy-in for NFM implementation, especially because NFM requires changes on large areas of land. Community and landowner perspectives are a rich area for future research (e.g. Holstead et al., 2014).

While literature on transboundary water management often focuses on catchments that include multiple countries (e.g. Tuncok, 2015; Canwat, 2023; Baseer & Iqbal, 2024), the cases of the Allan Water and River Esk show that tension related to upstream land use and downstream flood risk can exist within one country as well. Indeed, interviewees discussed that an additional challenge for reducing flood risk using NFM is that increasing urbanisation in upstream areas poses the risk of undoing the benefits of NFM from a runoff generation perspective. Interviewees in the River Esk catchment discussed that Midlothian's population, especially, is growing, leading to increased impervious surface and increased runoff rates. A similar situation was found in Indonesia, where flood risk management was made more difficult due to within-country "transboundary challenges" (Rahayu et al., 2024). Tensions related to impervious surface development could be an opportunity for NGOs to bridge the gap between national and local priorities (Tabas & Callahan, 2022).

At larger scales, using the framework of horizontal, vertical, and diagonal collaboration to understand transboundary water management could lead to improved outcomes for people and the environment. For example, in the Great Lakes-St. Lawrence River Basin, horizontal cooperation between the U.S. and Canada could lead to improved flood risk management (Heinrich & Penning-Rowsell, 2022). There is also a need for vertical cooperation between the U.S. and the relevant states (e.g. Pennsylvania and New York); and between Canada and the relevant provinces (e.g. Ontario and Quebec). Diagonal cooperation in this context involves organisations such as the International Joint Commission and NGOs in each country. In this way, the story of the Allan Water and River Esk catchments can provide lessons for cooperative water governance around the world.

6. Conclusion

We investigated multi-level governance of NFM implementation to understand how decision-making power is held at multiple governance levels. The first RQ related to the connections between national-level policies, LA decision-making, and community council planning. We found that national-level priorities dominate and constrain LA and community decision-making. The second RQ related to horizontal cooperation between LAs. We found that, while there are many mechanisms for collaboration between LAs such as the LFRMPs, collaboration is in fact limited by funding and workload constraints. The third RQ investigated the occurrence of diagonal governance and scale jumping in the cases. We found that there are many ways to influence outcomes outside of traditional multi-level governance connections, especially through community activism, NGO-led projects, and the influence of consultants.

International literature on FRM highlights the importance of understanding multi-level governance. In Italy, for example, researchers found that "a better understanding of the power play between the actors involved in flood risk management may help to explain the poor coordination across the levels of government" (Vitale et al., 2022). Furthermore, Pahl-Wostl (2009) find that "more complex and diverse governance arrangements have a higher adaptive capacity." We aimed to understand how actors at multiple levels of governance make decisions in Scotland, using the vertical, horizontal, and diagonal framework (Torfing et al., 2012). While existing FRM literature discusses vertical and horizontal cooperation (e.g. Vedeld et al., 2016), the concept of diagonal cooperation is a useful way to discuss questions around scale jumping (Penning-Rowsell & Johnson, 2015; Smith, 1993; Swyngedouw, 1997). While case study research has limitations in terms of applicability to other areas, these cases were a useful way to begin to examine these questions.

Effective multi-level governance that includes vertical, horizontal, and diagonal cooperation is necessary to overcome a variety of environmental challenges. Increasing local government capacity could lead to improved FRM outcomes, especially for spatially dispersed solutions like NFM. Future research on multi-level governance and FRM could focus on NFM upscaling in other countries to understand the ways in which vertical, horizontal, and diagonal governance play out in these contexts. These discussions are relevant for other environmental challenges that cross jurisdictions such as carbon emissions, animal migrations, and plastic pollution. Future research could explore themes of space, place, and governance in order to find innovative solutions to these and other challenges.

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Contributor Statement

Andrew David Tabas: Conceptualization, Data curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Visualization, Writing – Original Draft, Writing – Review & Editing
Ian Pattison: Conceptualization, Funding Acquisition, Methodology, Supervision, Writing – Review & Editing
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Use of AI

During the preparation of this work, the authors used the Microsoft Word Online Transcribe tool in order to develop transcripts of interview recordings. After using this tool/service, the authors listened to all audio recordings in full and updated transcripts to correct errors and ensure that place names, etc. were spelled correctly. The authors take full responsibility for the quality of the interview transcripts and for the content of this publication.

Conflict of Interest

The researchers would like to note that Forth Rivers Trust is an external advisor on this project. There are no other conflicts of interest.

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