



Spatial relationships matter: How a spatial lens can illuminate barriers and motivators of natural flood management

Andrew David Tabas^{a,*}, Ian Pattison^a, Leo Peskett^a, Lindsay Beevers^b

^a School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, EH14 4AS, Scotland, United Kingdom

^b Institute of Infrastructure and Environment, School of Engineering, University of Edinburgh, EH9 3FG, Scotland, United Kingdom

ARTICLE INFO

Keywords:

Natural Flood Management
Nature-based solutions
Space
Place
Flood risk management

ABSTRACT

Flooding is a significant global risk that is being exacerbated by land use change and climate change. Natural Flood Management (NFM) is a group of practices that can help mitigate flood risk by slowing the flow, decreasing runoff rates, and storing water, and it can be effective at a variety of scales. NFM implementation is inherently spatial, as it requires upscaling as well as overcoming upstream-downstream spatial disconnections. However, existing literature on the barriers and motivators of NFM discusses the concept of space inconsistently. We review articles on the barriers and motivators of NFM implementation ($n = 30$) and find that the most common barriers are related to policies, knowledge, and funding; and the most common motivators are related to co-benefits, flood mitigation, and supportive policies. We use a spatial framework to analyse the barriers and motivators of NFM, finding that measuring NFM's effectiveness, encouraging upstream-downstream cooperation, and considering visual impact and sense of place are essential for NFM upscaling. More consistency is needed in spatial thinking to move from discussions of the barriers of NFM to successful catchment-scale implementation. A holistic spatial framework for NFM implementation, with links to existing implementation frameworks, is proposed to facilitate NFM upscaling.

1. Introduction

Flooding is a significant global risk that is being exacerbated by land use change and climate change (Abbott et al., 2019; IPCC 2023; Milly et al., 2008). A recent estimate found that over 1.8 billion people are at risk of flooding around the world (Rentschler et al., 2022), and according to the International Disaster Database (EM-DAT), worldwide riverine floods from 2000 to 2025 affected over 1.2 billion people and caused over \$377 billion in damages (EM-DAT 2025). Historically, grey infrastructure such as flood walls and embankments has been used to reduce flood risk. However, these solutions can be expensive and can have negative consequences for biodiversity and carbon emissions (Wingfield et al., 2019). Instead of focusing on grey infrastructure, a relatively new approach called Natural Flood Management (NFM) involves using natural features such as ponds and wetlands to slow and store water (Forbes et al., 2015; Smith et al., 2025). Natural Flood Management (NFM) aims to reduce flood risk through “the storage of water in the landscape, increasing water infiltration, slowing the flow of water and reducing hydrological connectivity within the landscape” (Pescott and Wentworth, 2011). Examples of NFM implementation can be found

globally with examples in the UK (Black et al., 2021), China (Martin et al., 2021), and Europe (Solheim et al., 2021). Related concepts include “Working with Natural Processes” (Pearson et al., 2025) and “Nature-Based Solutions” (NBS) (Cohen-Shacham et al., 2016). The change from traditional flood management to NFM requires a “paradigm shift” (Bark et al., 2021; Kuhn, 1962), similar to past paradigm shifts in how people think about conservation (Mace, 2014).

NFM implementation is affected by barriers and motivators. “Barriers” hinder a paradigm shift from current flood management practices to catchment-scale NFM (Bark et al., 2021; Wingfield et al., 2021; Castellar et al., 2024; Thorne et al., 2015). Examples of barriers include funding shortages, perceptions that favour traditional land uses or grey flood defences, knowledge gaps around NFM's effectiveness, unclear regulations, and mismatched timescales (Holstead et al., 2014; Sarabi et al., 2020). To counter these barriers, there are “motivators” which include drivers and enablers. Drivers are external: they include flood risk, climate change, and co-benefits (Sarabi et al., 2019). Enablers are internal: they include supportive policies, collaboration, and community involvement (Martin et al., 2021; Katsou et al., 2020).

Successful NFM implementation is inherently spatial, as it requires

* Correspondence to: Heriot-Watt University Edinburgh Campus, Edinburgh EH14 4AS, United Kingdom.

E-mail address: adt2001@hw.ac.uk (A.D. Tabas).

upscaling and improving upstream-downstream connections. Upscaling refers to implementing NFM across the catchment, defined as “the drainage area that contributes water to a particular point along a channel network (or a depression), based on its surface topography” (Wagener et al., 2007). Catchments vary in their form (their physical characteristics) and their function (how water moves through them) (Tarasova et al., 2024; Wagener et al., 2007). There is a growing body of evidence about the effectiveness of NFM at catchment scales (Dadson et al., 2017). The “spatial disconnection” between NFM implementers and beneficiaries refers to the fact that these two groups are often located in different areas (Serna-Chavez et al., 2014). There is a need for cooperation between the upstream areas where NFM is implemented and the downstream areas that benefit from NFM’s effects.

We aim to elucidate the barriers and motivators of NFM and to encourage policymakers to think about the various spatial aspects of NFM. To achieve this, we present the results of a scoping review of the barriers and motivators of NFM (n = 30). The review focused on articles related to catchment-scale NFM and fluvial flood risk. We found that articles on the barriers and motivators of NFM do not discuss space in a consistent way. To address this gap, we apply the framework of empirical, block, image, and place (Thrift, 2003). This framework can be paired with existing NFM implementation tools (e.g., Environment Agency, 2017) to upscale NFM implementation.

2. Conceptualisations of space

Conceptualisations of space have evolved over time from an understanding of space as a concrete and objective “neutral container” to an emphasis on space as subjective (Holloway et al., 2003; Hubbard and Kitchin, 2011). The latter view suggests that “space is always under construction” by people and groups (Massey, 2005). Space also intersects with the concept of power, which can influence people across large distances (Allen, 1997; Allen and Cochrane, 2010). The concept of place highlights the ways in which people interact with space and give it subjective “meaning” (Koops and Galić, 2017). The ways in which space and place are framed affect how people act (Massey, 2005).

NFM upscaling is challenging because it requires large-scale change to spaces and places. The “Spatial Flood Risk Management” approach describes that for each area of a catchment, NFM implementers must consider “environmental conditions,” “socio-political context,” and “stakeholders and interests” (Hartmann et al., 2022). “Ecosystem Services” (ES) literature frames flood risk reduction as an “offsite” environmental service, which upstream areas can provide to downstream

ones (Wunder, 2015). King and Bark (2024) describe four types of ES – “cultural,” “regulating,” “provisioning,” and “supporting” – and locate each of these within areas of an example catchment. Different types of ES have different types of spatial relationships. Thrift (2003) describes four types of space: empirical, block, image, and place.

While other frameworks such as Hartmann et al. (2022) and Wunder (2015) have been used to conceptualise space, we chose Thrift (2003) because it has the clearest presentation of both objective and subjective views of space. It also incorporates the concepts from the other frameworks effectively, as shown in Table 1. The Thrift (2003) framework has been used in a variety of disciplines to address challenges related to space, such as peace studies (Björkdahl and Buckley-Zistel, 2022), planning (Davoudi and Strange, 2008), and urban design (Donoff and Bridgman, 2017). For example, Donoff and Bridgman (2017) use Thrift’s ideas to discuss the ways in which intentionally designed urban spaces can shape the types of interactions that people have with them.

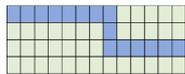
The first type of space, “empirical” space, incorporates the view of space as something physical that can be measured (Thrift, 2003). This view of space is similar to the “land as an object” approach (Hartmann et al., 2022), which focuses on measuring the impacts of NFM, as well as to early views of space as a “backdrop” (Hubbard and Kitchin, 2011). Empirical spatial thinking highlights land use decisions and their implications for flood risk.

The second type of space, block space, evokes questions around how space is organised. NFM occurs in catchments and sub-catchments, but also in urban and rural areas and across administrative boundaries. “Payments for Environmental Services” (PES) approaches divide catchments in this way, as upstream “providers” supply a service (flood risk reduction) to downstream “users” (Kosoy et al., 2007). The idea of “offsite” ecosystem services (Wunder, 2015) aligns with the concept of “spatial disconnections” (Serna-Chavez et al., 2014) in NFM. Blocks of space, however, can be challenging to define because space is something that things and people move through (Massey, 1993). For example, it is difficult to define the spatial extent of a region (Massey, 1993). Applying this thinking to flood risk management, it can be difficult to draw a clear line between upstream and downstream areas because flooding can affect different parts of catchments during different storms, people move throughout catchments, and flooding can close roads which affects access to spatially distant areas.

The third type of space, “image” space, incorporates questions around how space is represented in photographs and other visual media (Thrift, 2003). Images of flood damage and/or of well-maintained NFM, for example, could be used to motivate NFM implementation. On the

Table 1

Four types of space and their applications to flood risk management. This framework draws on Thrift’s (2003) concept of four types of space and incorporates ideas from Wunder (2015), Hartmann et al. (2022), Holstead et al. (2014), and Koops and Galić (2017).

Conceptualisations of Space				
Types of Space (Thrift, 2003)	1. Empirical	2: Block	3: Image	4: Place
				
Definitions	Space is measurable.	Space can be organised in bounded areas.	Space is represented by images.	Space has different meanings for different people.
Related concepts	"Land as an object" (Hartmann et al., 2022) Space as a “neutral container” (Hubbard and Kitchin, 2011)	Ecosystem service “providers” and “users” (Wunder, 2015) Upstream-downstream ecosystem services (King and Bark, 2024)	"Appearance" related issues (Holstead et al., 2014) Importance of visual changes (King and Bark, 2024)	"Land as a context" and "land as a process" (Hartmann et al., 2022) “Place” (Koops and Galić, 2017; Massey, 2005) “A progressive sense of place” (Massey, 1993)
Catchment examples and implications for flood risk management (hypothetical)	40 % of a catchment is farmland, 40 % is forest, and 20 % is urban. Increasing the amount of urban area would lead to more runoff.	The catchment can be divided into two main blocks: the rural upstream area and the downstream urban area. Land use decisions upstream can affect flooding downstream.	The catchment is known for its rolling, pastoral landscapes. Changing these landscapes (e.g., afforestation) will have a visual impact that could affect support for NFM schemes.	The town near the river is home to many people. Flood protection schemes (green or grey) could have implications for their daily lives.

other hand, concerns about “appearance” are a potential issue for NFM implementation (Holstead et al., 2014). The look and feel of existing landscapes is important, and people may be reluctant to support a change to how landscapes look (King and Bark, 2024).

The fourth type of space, “place,” highlights the subjective meaning that humans assign to places as they inhabit and act in them (Koops and Galić, 2017; Massey, 1993; Thrift, 2003). NFM schemes are located in places, which are associated with specific meanings, actions, and ways of life. The concepts of “land as a context” and “land as a process” (Hartmann et al., 2022) describe peoples’ interactions with places and the implications for NFM.

3. Methods

This paper uses a critical scoping review (Arksey and O’Malley, 2005; Paré and Kitsiou, 2017; Pham et al., 2014) to evaluate articles that discuss the barriers and motivators of NFM from a spatial angle. The research question is: *What are the barriers and motivators of NFM in the literature, and to what extent are they discussed in a spatial way?* The search was conducted using Scopus to find articles whose titles include “Natural Flood Management,” “Nature-Based Solutions,” or “Working With Natural Processes,” and “Barriers” or “Motivators” (all search terms, including synonyms, can be found in Appendix A). The search generated 295 results, and an additional six articles were added because they are relevant to the review topic (Blackwood and Renaud, 2022), resulting in 301 articles considered. Screening involved the following selection criteria: articles were included if the title focuses on the barriers and/or motivators of NFM; articles were excluded if they focused on marine NBS, urban NBS, NBS with a focus other than flooding (e.g., carbon sequestration), monitoring, modelling, and technical issues related to “barriers” as in “leaky barriers.”

The following information was gathered from each article ($n = 30$) using qualitative content analysis in NVivo (Bryman, 2004): barriers, motivators, references to space, and common themes. Codes were developed inductively and consolidated when possible. Several examples of consolidating codes include: the barrier *funding challenges* includes issues related to financing, money, and budget; the barrier *policy challenges* includes issues related to policies, government, and regulations; the barrier *knowledge challenges* includes issues related to lack of evidence and lack of education. Codes were developed iteratively. For example, in the first round of coding “lack of land or time” was considered one barrier because several articles early in the process listed this as one barrier. In later rounds of coding, this code was separated into “lack of land” and “lack of time” as two separate codes because some articles discussed only one of these issues. Once the barriers and motivators had been coded, the selected text was coded a second time for type of space to examine the extent to which each barrier was discussed spatially. Results are reported and discussed in the following sections.

4. Barriers, motivators, and spatial concepts

Across the articles reviewed ($n = 30$), the most frequently cited barriers were related to policies, funding, knowledge, and perceptions. The most frequently cited motivators were co-benefits and flood mitigation (drivers) and supportive policies and funding (enablers). *Collaboration, funding, knowledge, maintenance, perceptions, and policy* are categories for both barriers and motivators; Section 6.0 discusses these parallels. While the articles in this review did not discuss the barriers and motivators through a variety of spatial lenses, they do contain references to spatial concepts including “lack of land,” “lack of space,” and “catchment scale.”

4.1. Policies, funding, knowledge, and perceptions are top barriers to NFM

The barriers discussed in the highest number of the 30 papers are

policy challenges, funding challenges, knowledge challenges, and negative perceptions. Fig. 1 shows how many times each barrier to NFM implementation was discussed in the review.

Policy challenges were the most cited barrier across 25 of the articles included in the review. NFM occurs at the intersection of diverse government objectives, including flood risk management, food production, and placemaking. These objectives do not always align in the most efficient way for promoting NFM. Similarly, the benefits of NFM can be hard to measure, making it difficult to justify (Wells et al., 2020). Furthermore, unclear policies and regulations are an issue (Holstead et al., 2014). *Lack of time* (16 articles) can also be an issue for effective policies, as different processes take place on different timelines (Waylen et al., 2018). *Path dependence* (12 articles), which refers to inertia in policymaking, and *collaboration challenges* (18 articles) also prevent the coordinated policy change that would be necessary for NFM implementation. Policies need to be designed to account for potential *legal liability* (4 articles) when floods occur, to address *safety concerns* (2 articles), and to manage *unintended consequences* (5 articles). Seven articles stated that social barriers are more significant obstacles to NFM than technical barriers.

Funding challenges are another commonly cited barrier in 24 articles. In the public sector, funding challenges include restrictions on where or how money can be spent (Deely et al., 2020; Moreno et al., 2022) and the question of how to manage long-term maintenance costs (Han and Kuhlicke, 2021). Long-term *maintenance needs* (14 articles) require money, monitoring, and committed people (Crockford, 2022; Deely et al., 2020). In the private sector, landowners may be unwilling to implement NFM based on a reluctance to lose other sources of income from the land (Holstead et al., 2014). Private sector investors are limited by short timelines (Seddon et al., 2020) and uncertain returns. In addition, funding NFM is difficult because its benefits are uncertain (Wingfield et al., 2021) and spread across multiple beneficiaries (Seddon et al., 2020). Funding challenges, competing land uses, and landowner preferences can result in a *lack of land* (17 articles) for NFM.

Knowledge challenges such as a lack of knowledge or evidence was a common theme in 24 articles. This barrier has both technical and education and training components. On the technical side, there are uncertainties around how well NFM works, especially in the face of climate change (Deely et al., 2020; Seddon et al., 2020). On the knowledge side, there is “a lack of awareness or general knowledge” (Deely et al., 2020) and a need for more training and education (Wingfield et al., 2021). Wells et al. (2020) depict the lack of knowledge as part of a vicious cycle, which leads to less implementation and funding, which continues the dearth of evidence. However, the lack of evidence is not a primary concern for NFM upscaling according to Wingfield et al. (2021).

Negative perceptions about NFM are also an important barrier to NFM implementation, cited in 22 articles. The mindset of every person involved in the NFM implementation process – including landowners, engineers, policymakers and residents – matters for successful NFM implementation (Bark et al., 2021; Han and Kuhlicke, 2021). For landowners, NFM implementation represents a break from tradition and a potential source of criticism from neighbours (Holstead et al., 2014). Indeed, perceptions of perceptions is a barrier: some farmers are concerned that neighbours will deem them lazy (Holstead et al., 2014), and some flood risk managers think that residents prefer grey infrastructure to NFM (Waylen et al., 2018).

4.2. Flood mitigation, co-benefits, supportive policies, climate change, funding availability, and collaboration are the top motivators of NFM

The motivators discussed in the highest number of the 30 papers include three drivers and three enablers (Fig. 2). The drivers are *flood mitigation, co-benefits, and climate change*. The enablers are *supportive policies, funding availability, and collaboration*.

The drivers of NFM were *flood mitigation* (25 articles), mitigating and adapting to *climate change* (20 articles), and promoting NFM’s *co-benefits*

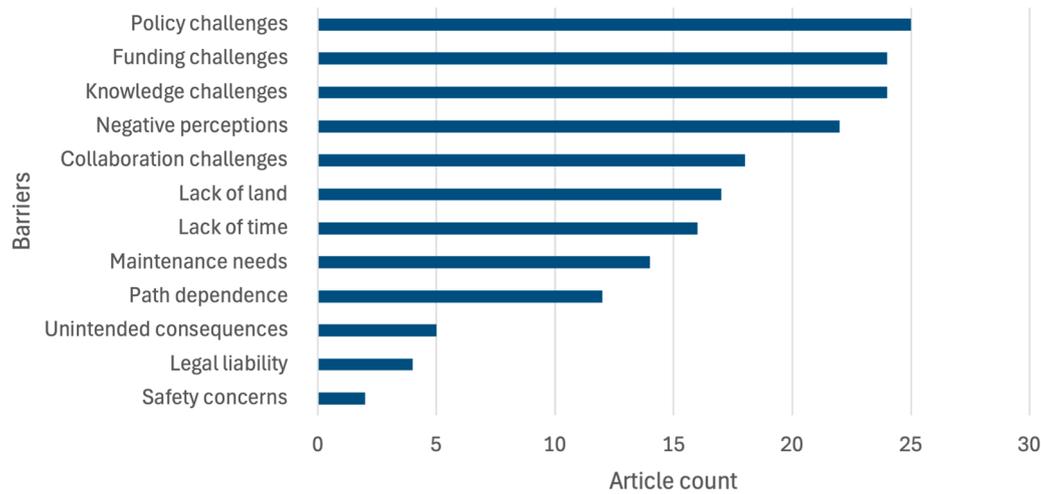


Fig. 1. Number of papers that cite each barrier (n = 30). Box size indicates the number of articles that discuss each barrier. Most papers include more than one barrier.

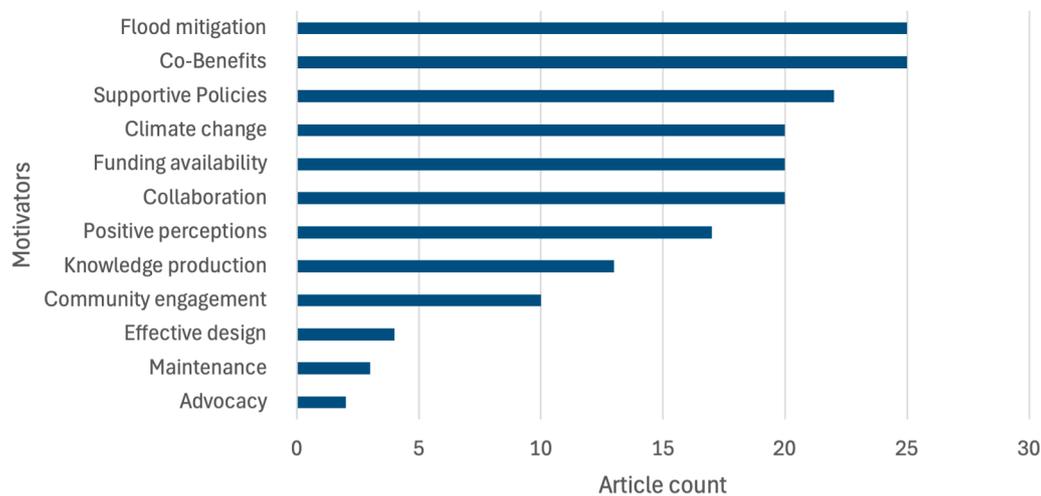


Fig. 2. Number of papers that cite each motivator (n = 30). Box size indicates the number of articles that discuss each motivator. Most papers include more than one motivator.

(25 articles). Central to NFM's appeal is its potential to mitigate flood impacts (Seddon et al., 2020; Bark et al., 2021). Flood events themselves can be drivers of policy change (Wingfield et al., 2021). Climate change is increasing the risk of flooding in many areas, which further motivates the use of NFM (20 articles). Co-benefits from NFM include carbon storage, water and air quality improvement, habitat creation for improved biodiversity, erosion control, and human mental and physical health improvement (Seddon et al., 2020; Wells et al., 2020; Bark, Martin-Ortega and Waylen, 2021; Morris and Tippett, 2023; Thaler et al., 2023; Christopher et al., 2024).

The most common enabler for NFM is *supportive policies* (22 articles). Governments have a significant role to play in supporting NFM implementation through policies like requiring new development to manage stormwater effectively, increasing communication between government departments, and providing funding for projects. Supportive governments are necessary at multiple scales, from local to national to international (Morris and Tippett, 2023; Waylen et al., 2018). Regulations that allow NFM to be built and technical standards that show how it should be designed are also important (O'Donnell et al., 2017).

Funding availability is an important enabler that includes both public and private sector support for projects (20 articles). Public sector funding includes grants, NFM projects on public land, and agriculture

subsidies. Importantly, funding is a long-term concern: farmers need consistent income (Holstead et al., 2014) and many NFM projects have long-term maintenance needs. Private funding (Crockford, 2022) includes approaches such as environmental impact bonds (see Discussion). Ensuring that *maintenance* is performed effectively and on schedule (3 articles) and that implementers follow *effective designs* (4 articles) is essential.

There are many people involved in NFM implementation, including national and local governments, flood risk management engineers, environmental organizations, and residents. Enablers related to people include *collaboration* (20 articles), *community engagement* (10 articles), and *positive perceptions* of NFM (17 articles). Involving residents in the design process can improve public acceptance (Seddon et al., 2020; Solheim et al., 2021). Positive perceptions are essential for successful NFM implementation. In addition, *advocacy* is critical (2 articles): a "local champion" can play a significant role in promoting NFM projects (Martin et al., 2021). NFM also has the potential for *knowledge production* if its effects are monitored (13 articles).

Many of the barriers and motivators are related to each other: *collaboration*, *funding*, *knowledge*, *maintenance*, *perceptions*, and *policy* are categories for both barriers and motivators. Each of these categories can both encourage and discourage NFM. For example, in the discussion of

the *policy barrier*, Dorst et al. (2022) write that “limited collaborative governance” inhibits NFM upscaling. Mirroring that comment, in the discussion of the *policy motivator*, Ramírez-Agudelo et al. (2020) write that “regulations could link supra-national regulations to national, regional, or municipal initiatives.” Each of these areas can act as a barrier or motivator, depending on the context.

4.3. Articles about barriers and motivators consider space in diverse ways

The 30 articles included in this review do not explicitly discuss the barriers and motivators of NFM through a variety of spatial lenses. There are, however, diverse references to spatial concepts throughout the articles, especially the concept of upscaling. Fig. 3 shows how frequently several key spatial concepts were used in the literature. These concepts are diverse and overlapping and have been roughly matched to the four types of space (empirical, block, image, place) for clarity.

The most common spatial reference is a lack of land/space for NFM implementation (17 articles). Many articles highlight that NFM takes up more space than grey approaches to flood risk management (Carlone and Mannocchi, 2024). Other articles treat land use as a zero-sum game: more space for NFM means less space for housing, industry, or other land uses. Discussions of space include scale-related concepts such as the need for “multiple spatial scales” (13 articles), the existence of small-scale and large-scale NFM projects, and the need to “upscale” NFM (5 articles). Space is also discussed as a location: green space (13 articles), space on the floodplain (5 articles), and space for something (5 articles) are all ways of talking about what features occur on different areas of land. “Catchment scale” is a common framing for NFM projects (14 articles). To achieve this, it is necessary to link upstream and downstream areas (10 articles) to overcome spatial disconnections (6 articles). “Visual” impacts are mentioned in 8 articles in terms of the visual effects of NFM. “Place” or placemaking is mentioned in 7 articles, with discussions of meaningful places in King and Bark (2024) and Holstead et al. (2014). Space can be organised through “spatial planning” (3 articles), and space that achieves multiple goals is described as “multifunctional” (O’Donnell et al., 2017).

5. Applying spatial thinking to the barriers and motivators of NFM

While there are a variety of spatial terms used throughout the articles (Fig. 3), these terms are not used consistently. Of all the articles in this review, King and Bark (2024) has the clearest communication of four types of space and their implications for NFM but does not present a list of barriers and motivators. On the other hand, Wingfield et al. (2021) has a comprehensive list of the barriers of NFM with the goal of upscaling, but the article does not clearly communicate all four types of space. Therefore, there is a need for more consistent spatial thinking when discussing the barriers and motivators of NFM. A spatial framework can be used to organise and assess the barriers and motivators of NFM.

The framework of empirical, block, image, and place (Thrift, 2003) can be used to identify the spatial characteristics of the barriers and motivators of NFM. Some of the barriers and motivators, like the *lack of available land* to implement NFM (17 articles), are inherently spatial, and link well to the concept of empirical space. The barrier *collaboration challenges* (18 articles) is connected to political and geographic areas, so it links well to the concept of blocked space. The barrier of *negative perceptions* of NFM (22 articles) is linked to the concept of visual space: visual impacts matter for NFM implementation. *Policy challenges* (25 articles) can be linked to the concept of place, as policymakers strive to improve their places. Where articles discussed barriers and motivators in a spatial way, the quotes were analysed for the type of space implied in the quote (Table 2; Appendix C). Table 2 also shows where barriers and motivators are related to each other (for example, *funding challenges* is a barrier while *funding availability* is a motivator).

5.1. Empirical space and applications for barriers and motivators

An empirical view of space illuminates the barriers *lack of available land*, *lack of knowledge*, and *negative perceptions*. The articles discuss the need for “more intervention” (Bark et al., 2021; Wingfield et al., 2019) in the face of a “lack of available space” (Deely et al., 2020). With an empirical, zero-sum view of space, competition for space comes from housing, industrial and business sites, agriculture, roads, commercial forestry, and other land uses. The zero-sum view of space contrasts with a view of “multi-functional landscapes” which can support flood

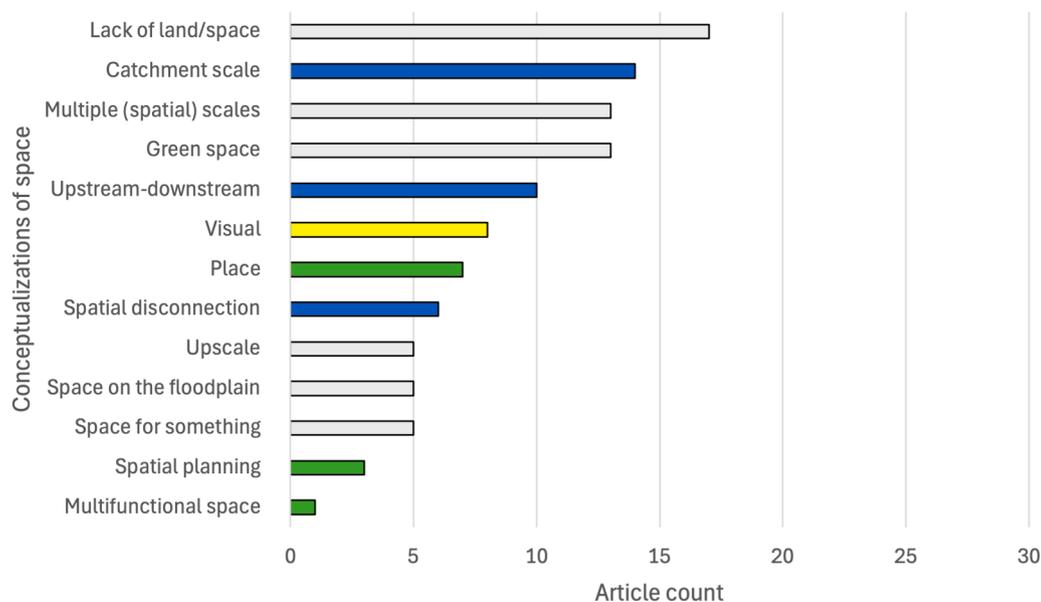


Fig. 3. Views of space in the articles on barriers and motivators reviewed in this paper (n = 30). The terms used in the articles are matched to the four types of space: empirical (grey), block (blue), image (yellow), and place (green).

Table 2

The articles discussed the barriers and motivators of NFM in a spatial way where indicated. Red cells refer to barriers and blue cells refer to motivators. Full quotes are in Appendix C.

Topics	Barriers and Motivators	Empirical	Block	Image	Place
Collaboration	There is not enough collaboration between stakeholders (Barrier)		x		x
	Collaboration can help to promote NFM implementation (Motivator)	x	x	x	x
Funding	There is not enough funding available for NFM implementation (Barrier)	x	x		
	Funding can help to promote NFM implementation (Motivator)		x		x
Knowledge	There is not enough knowledge or evidence about NFM (Barrier)	x			x
	NFM implementation and monitoring can generate new evidence (knowledge production) (Motivator)	x			
Maintenance	Maintenance challenges prevent NFM from functioning (Barrier)	x	x	x	
	Organising people around maintenance can drive NFM (Motivator)				x
Perceptions	Negative perceptions of NFM can limit uptake (Barrier)	x	x	x	x
	Positive perceptions of NFM can support NFM implementation (Motivator)	x		x	x
Policy	Policies and regulations that are not supportive of NFM can hinder NFM implementation (Barrier)	x	x		x
	Policies and regulations that promote NFM can help with its implementation (Motivator)		x		x
Other Barriers	There is not enough available land to implement NFM (Barrier)	x	x		x
	Time constraints make it difficult to implement NFM (Barrier)		x		
	NFM opens the door for legal liability in the event of a flood (Barrier)		x		
	Stakeholders can be locked in to repeating past decisions (path dependence) (Barrier)		x		
Other Motivators	There are potential safety concerns at NFM sites (Barrier)	x			
	NFM could bring unintended consequences (Barrier)				x
	Flood risk necessitates the use of NFM (Motivator)	x	x		

Table 2 (continued)

Topics	Barriers and Motivators	Empirical	Block	Image	Place
	Climate change brings risks that NFM can mitigate (Motivator)	x			
	NFM brings co-benefits for the environment, people, and the economy (Motivator)	x		x	x
	Community engagement can increase successful NFM projects (Motivator)				x
	Designing NFM well can make it more effective (Motivator)	x			
	Advocacy can increase NFM implementation (Motivator)				x

resilience and other goals simultaneously (Seddon et al., 2020). An empirical view of space is also used for considering the *lack of knowledge and evidence* for NFM (24 articles). The perceived lack of evidence about NFM’s effectiveness prevents implementation, forming a vicious cycle (Wells et al., 2020). The solution is to gather new data, and several articles in the review highlighted the importance of long-term monitoring for NFM projects. *Negative perceptions* can also be discussed through an empirical lens: more minds need to be changed so that more space can be used for NFM.

An empirical view of space is also used to discuss key motivators of NFM such as *flood risk* (25 articles), *climate change adaptation and mitigation* (20 articles), and *other co-benefits* of NFM (25 articles). To achieve large, “spatially extensive” NFM projects, it is necessary to measure NFM’s effects on flood risk, biodiversity, and other areas (Thaler et al., 2023). Similarly, Wingfield et al. (2021) write that “NFM delivery... transforms the scale at which flooding...is considered.” The article suggests using a measurable increase in NFM to achieve measurable benefits. In addition, “the intense pressures of rapid urbanization and climate change” motivate increased NFM implementation (Davies and Laforteza, 2019). Table 3 shows key quotes related to an empirical view of NFM.

5.2. Spatial blocks and catchment-scale thinking

Spatial blocks are related to *collaboration challenges*, *funding challenges*, *policy challenges*, *maintenance needs*, and *lack of available land*. As explained by Wells et al. (2020), “hydrological catchments do not adhere to national...boundaries,” so it is necessary to consider potential spatial disconnections. Upstream-downstream connections are also linked to the barrier *funding challenges*: it may be difficult for governments to spend money outside of their administrative areas (Deely et al., 2020). The barrier *policy challenges* also plays a role, for example in cases with disconnects between national and local policies (Moreno et al., 2022). Similarly, *maintenance needs* are linked to administrative areas, which becomes a challenge when there are unclear maintenance responsibilities (Deely et al., 2020). The barrier *lack of available land* can be linked to specific parts of the catchment, such as “private owned land at the upper part of the catchment” (Thaler et al., 2023).

The motivators *flood risk*, *collaboration*, and *funding* are related to blocks of space. *Flood risk* is described based on its location, often “downstream” (Bark et al., 2021). *Collaboration* is a way to bridge downstream areas at risk of flooding with upstream areas that can implement solutions. “Catchment partnerships” can connect people from different areas (Bark et al., 2021; Wingfield et al., 2021), as spatial blocks are redrawn from local scales to catchment scales. Similarly, “polycentric governance arrangements” can improve the ways in which different stakeholders work together (Martin et al., 2021). Discussions of

Table 3

Key quotes that highlight the empirical considerations for NFM. Red cells refer to barriers and blue cells refer to motivators.

Barriers and Motivators through the “Empirical” Lens		
Barriers and Motivators	Key Quotes	Explanation
There is not enough knowledge or evidence about NFM (Barrier)	"There is a persisting lack of empirical data documenting the effectiveness and efficacy of NBS in FRM at various spatiotemporal scales" (Raska et al., 2022)	Empirical data on NFM is related to the measurable properties of space.
Negative perceptions of NFM can limit uptake (Barrier)	"More intervention will be required if all relevant stakeholders are to work together for the landscape transformations that NFM implies" (Bark et al., 2021)	More space – rather than any specific area – must be dedicated to NFM.
There is not enough available land to implement NFM (Barrier)	"Space – the interventions require a lot of space and the UK has a growing population." (Wingfield et al., 2021)	An empirical view of space describes NFM and housing as trade-offs.
Flood risk necessitates the use of NFM (Motivator)	"NFM delivery by its very nature transforms the scale at which flooding and flood generation processes are considered, from local to catchment." (Wingfield et al., 2021)	The description of the need for more NFM at a larger scale is an empirical concern. (However, "catchment" implies that there is a block around the area of interest.)
Climate change brings risks that NFM can mitigate (Motivator)	"A move from grey towards green infrastructure is considered a highly desirable prospect to address the intense pressures of rapid urbanisation and climate change." (Davies and Laforteza, 2019)	Climate change is an external driver that motivates the use of more NFM across a larger area.

funding as a motivator also consider blocks of space: “How can environmentalists get funders to care? By providing real valuation of the contribution that natural processes make to global society” (Crockford, 2022). NFM’s effects matter in different blocks, such as upstream, downstream, catchment, and global. Physical and political blocks provide a useful lens to understand the cooperation that can enable NFM implementation (Table 4).

5.3. Images of space influencing barriers and motivators

The primary barriers related to images are *negative perceptions* about NFM and *maintenance challenges*. In rural areas, NFM could involve visual changes such as replacing pastures with trees. In developed areas, NFM could involve replacing areas of neatly trimmed grass or asphalt with rain gardens. Concerns included reluctance to have an “unsightly” or “unkempt” appearance (Holstead et al., 2014); worries about secondary effects like “bird droppings” (Wamsler et al., 2020); and preexisting ideas about “how a landscape should look” (Wingfield et al., 2021). *Maintenance challenges* are linked to visuals as well: visually appealing NFM can motivate long-term maintenance, which in turn improves the visuals of the site.

Image-focused motivators include *positive perceptions*, *collaboration*, and *co-benefits*. For example, “the projects with more aesthetical selling points have received greater residential approval and developers’ interest” (Han and Kuhlicke, 2021). Attractive NFM designs can improve buy-in, increase collaboration, and motivate long-term maintenance. Stakeholder engagement during project design can improve visual impacts. For example, one project used “the inclusion of a golf course designer [to] manage the visual impact of the scheme” (Han and Kuhlicke, 2021; O’Donnell et al., 2017). NFM schemes have the potential to be viewed positively, as they can include parks with recreational

Table 4

Block space interpretations of the barriers and motivators of NFM highlight the differences between catchment boundaries and political boundaries. Red cells refer to barriers and blue cells refer to motivators.

Barriers and Motivators through the “Block” Lens		
Barriers and Motivators	Key Quotes	Explanation
There is not enough collaboration between stakeholders (Barrier)	"Challenges cited included data sharing across national boundaries, but also a lack of communication across administrative boundaries. As hydrological catchments do not adhere to national or administrative boundaries, communication needs to occur between stakeholders involved within the catchment rather than the political boundary" (Wells et al., 2020)	Defining space in terms of political or physical boundaries is an example of a block view of space.
Collaboration can help to promote NFM implementation (Motivator)	"Catchment partnerships were established in 2011 to deliver integrated water management by bringing together different sectors and organisations into a cooperative forum to facilitate greater integrated land and water management activities." (Wingfield et al., 2021)	Catchment partnerships define space in blocks. Within these blocks, there is an opportunity for cooperation.
Collaboration can help to promote NFM implementation (Motivator)	"The NBS vision shared by the national and local authorities can be viewed as an important driver of administrative innovation, spearheading the resulting polycentric governance arrangements that proved to be critically important in the realization of this ambitious NBS." (Martin et al., 2021)	Effective NFM implementation requires cooperation between spatial blocks at different scales.
There is not enough funding available for NFM implementation (Barrier)	"Funders may restrict the use of money to certain projects or certain areas... a restriction such as not being able to spend money on private land can impede the connectivity of BGI, making the project more expensive or infeasible" (Deely et al., 2020)	Limiting funding to specific blocks is a challenge for NFM upscaling.
Policies and regulations that are not supportive of NFM can hinder NFM implementation (Barrier)	"While some stakeholders mentioned that the legal and policy frameworks at the federal level are sometimes weak and incompatible with NBS adoption, others disagreed, arguing that they believe the legal backbone in the country is strong, especially regarding climate change. They indicated that the problem is that frameworks do not translate to the state or municipal level where there is usually a lack of resources, capacity, and training." (Moreno et al., 2022)	Policies are designed and applied to specific areas.
There is not enough available land to implement NFM (Barrier)	"NFM measures often cause land-use conflicts as well as upstream–downstream conflicts as they need to be implemented on private owned land at the upper part of the catchment usually used for farmland or forestry" (Thaler et al., 2023)	There are many types of blocks. These include public/private, upstream/downstream, and urban/rural.

opportunities, street trees that bring shade, and naturalised waterways with improved fishing. Deely et al. (2020) describe this benefit as “scenic value.” Furthermore, once people approve of an NFM scheme, they are more likely to participate in maintenance activities and take ownership of the project. Visual impacts of NFM are therefore an opportunity to involve people and find solutions that are acceptable in the long term (Table 5).

5.4. Concepts of place for barriers and motivators

Barriers of NFM related to place include *negative perceptions, unintended consequences, and collaboration challenges*. *Negative perceptions* of

Table 5

Image-related considerations highlight the visual implications of NFM. Red cells refer to barriers and blue cells refer to motivators.

Barriers and Motivators through the “Image” Lens		
Barriers and Motivators	Key Quotes	Explanation
Collaboration can help to promote NFM implementation (Motivator)	“Representatives...may have felt that their concerns were not being heard... However, interview respondents stated that the inclusion of a golf course designer helped manage the visual impact of the scheme and illustrated the potential benefits that could accrue to the golf course.” (O’Donnell et al., 2017)	Addressing visual concerns is an effective way to increase buy-in.
Negative perceptions of NFM can limit uptake (Barrier)	“Interviewees also noted the ‘unsightly’ visual appearance of NFM features. They sometimes described NFM as an ‘embarrassment’ because of its ‘unkempt’ appearance.” (Holstead et al., 2014)	The look of landscapes – in-person, in images, and in peoples’ mental perceptions – matters for upscaling NFM.
Positive perceptions of NFM can support NFM implementation (Motivator)	“In most cases, the projects with more aesthetical selling points have received greater residential approval and developers’ interest than projects that focus exclusively on ecological restoration, revealing the dilemma of public acceptance and ecosystem restoration.” (Han and Kuhlicke, 2021)	Incorporating visual considerations can make projects more likely to succeed.
NFM brings co-benefits for the environment, people, and the economy (Motivator)	“The benefits to society from a BGI are often nuanced and may require multiple valuation methods to be fully estimated. For example, a BGI may improve scenic value, water quality, offer flood protection and some amount of carbon sequestering all of which require different econometric analysis to estimate their value.” (Deely et al., 2020)	The visual effects of NFM can be a positive, which can in turn be a selling point for the projects. Visual benefits are important, but they can be difficult to quantify.
Maintenance challenges prevent NFM from functioning (Barrier)	“Stakeholder engagement remains paramount to the success of these measures, once they have been financed, with continuing maintenance and ownership still a consideration” (Crookford, 2022)	Building community ownership of NFM, where people care about keeping NFM looking good and functioning well, can help NFM to last in the long term.

NFM can be linked to sense of place: “community members may be wary...especially as their houses and neighbourhoods are in the line of damage if the hoped-for reduction in risk proves to be overestimated” (Morris and Tippett, 2023). Flood risk is not distributed evenly: it threatens specific places and the people who are connected to them. Similarly, people are concerned about potential *unintended consequences* of NFM, such as “eco-gentrification” (Han and Kuhlicke, 2021), in subjectively important places. Place is also linked to *collaboration challenges*, as it can be difficult to include all of the stakeholders who are connected to a place (Thaler et al., 2023). Stakeholder analysis frameworks such as “interest, influence, and impact” (Reed et al., 2025) can identify key people.

Co-benefits, funding, community engagement, and collaboration are linked to the concept of place. NFM projects “have multiple functions including producing food, providing cultural value and serving as public space” (Wolff et al., 2022). New areas of public parks, walking paths, or ponds can be considered new places. Co-designed NFM projects can enhance the sense of place, increase funding, and empower communities (Bark et al., 2021; Davies and Laforteza, 2019; Wolff et al., 2022). Place-based NFM can be supported by strong community engagement, including the involvement of “local champions” (O’Donnell et al., 2017) and “local actors” (Wickenberg et al., 2021). The ways in which NFM intersects with peoples’ sense of place is an essential consideration for NFM implementation, discussed directly in seven articles and relevant to barriers and motivators discussed in all articles (Table 6).

6. Implications

A holistic approach to NFM implementation – one that includes empirical, block, image, and place considerations – could contribute to overcoming the barriers to NFM. A common theme in the articles is that NFM upscaling would require a paradigm shift (13 articles). Achieving a paradigm shift is difficult because it involves going against usual practices, so a “revolution” in thinking and practice is necessary (Kuhn, 1962). A holistic approach to NFM can help to meet environmental, social, and economic goals (Brundtland, 1987; Jain and Mittal, 2024). Furthermore, views on flood risk management and conservation change over time. The current view of conservation, “people and nature,” describes the importance of approaches like NFM that bring multiple benefits (Mace, 2014). Empirical, block, visual, and place considerations can address the links between people and nature.

The barriers and motivators related to empirical views of space focused on managing risk: two of the empirically discussed motivators were *flood risk* and *climate change adaptation and mitigation* (Section 5.1). For example, Davies and Laforteza (2019) write that “a move from grey towards green infrastructure is considered a highly desirable prospect to address the intense pressures of rapid urbanisation and climate change.” Empirical discussions indicate a need for more evidence for NFM. As Carlone and Mannocchi (2024) explain, “stakeholders, accustomed to traditional grey solutions, express uncertainty about the effectiveness of NBSs due to its socio-technical novelty.” There is a need for more NFM implementation across larger areas to gather more evidence and to start to address these debates (Wingfield et al., 2019). NFM must be implemented in the right location to be effective (Pattison et al., 2014; Wilkinson et al., 2019). Furthermore, it is necessary to plan the locations of NFM projects strategically, rather than to implement them opportunistically. Knowledge about NFM relates to both barriers and motivators: *knowledge challenges* is a barrier, but *knowledge production* is a motivator.

The concept of spatial blocks frames barriers and motivators related to *collaboration, funding, policy, and maintenance* (Section 5.2). The difficulty of implementing NFM at catchment scales across political boundaries is a well-recognised issue (Wells et al., 2020; Morris and Tippett 2022). To manage this challenge, Wingfield et al. (2021) suggest the development of “catchment partnerships.” Research on catchment partnerships has found that they “both add to and help navigate the complexity of holistic and inclusive environmental management”

Table 6
Place-related considerations affect NFM’s success. Red cells refer to barriers and blue cells refer to motivators.

Barriers and Motivators through the “Place” Lens		
Barriers and Motivators	Key Quotes	Explanation
Collaboration can help to promote NFM implementation (Motivator)	"Co-design approaches in this context, allow multiple stakeholders to plan for uncertain future conditions by integrating local priorities and existing everyday challenges in the design of Nbs." (Wolff et al., 2022)	Peoples’ goals are based on their sense of place. Flood risk management must address peoples’ subjective realities, everyday actions, and sense of place.
Funding can help to promote NFM implementation (Motivator)	"The transition path we propose is based on simultaneous reforms in four areas: (i) education of existing and future infrastructure professionals; (ii) reform of institutions and their cultures; (iii) community-empowered placemaking combined with ‘ecosystem literacy’; and (iv) a new approach to public and private sector procurement" (Davies and Laforteza, 2019)	NFM can encourage people to contribute to the places around them.
Negative perceptions of NFM can limit uptake (Barrier)	"Community members may be wary of being at the front line of new policy experiments in flood risk, especially as their houses and neighbourhoods are in the line of damage if the hoped-for reduction in risk proves to be overestimated" (Morris and Tippett, 2023)	Peoples’ sense of place affects the level of risk that they are willing to take. People may be more cautious about their homes than they would be about public spaces, for example. Therefore, the threshold is higher for the evidence needed to support NFM schemes in peoples’ homes (bridging the <i>negative perceptions and lack of evidence</i> barriers).
NFM brings co-benefits for the environment, people, and the economy (Motivator)	"Ranging from raingardens to green roofs, tree planting or mangrove restoration initiatives, these projects have multiple functions including producing food, providing cultural value and serving as public space" (Wolff et al., 2022)	NFM has the potential to create new public green spaces. This could increase the local sense of place.
Community engagement can increase successful NFM projects (Motivator)	"Involvement of local actors boosted place identity." (Wickenberg et al., 2021)	The focus is on improving the sense of place through involvement in NFM projects.
Collaboration challenges (Barrier)	"The involvement of different stakeholders can be challenging and intensive because of the different backgrounds and interests involved" (Thaler et al., 2023).	Using the concept of place to organise and motivate stakeholder engagement could achieve greater collaboration and a common vision for the project.
Unintended consequences (Barrier)	"It raises increasing concerns about the unintended side-effects of upgrading exposed neighborhoods, which eventually leads to eco-gentrification processes due to focusing on the co-	While NFM can bring many benefits, it is also important to consider the unintended consequences for places.

Table 6 (continued)

Barriers and Motivators through the “Place” Lens		
Barriers and Motivators	Key Quotes	Explanation
Advocacy (Motivator)	benefits aspect of NBS" (Han and Kuhlicke, 2021) "Widescale stakeholder opposition to grey measures by interest or pressure groups and expert communities catalyzed the local decision-making processes for the NBS adoption." (Martin et al., 2021)	Local, place-based advocacy can make the case for NFM.

(Waylen et al., 2023). Collaboration challenges are a barrier to NFM, while increased collaboration can be a motivator. Another approach to managing catchment complexity is through Payments for Ecosystem Services schemes, in which downstream communities can negotiate payments to upstream communities for the “environmental service” of flood risk mitigation (King and Bark, 2024; Wunder, 2015). Sharing funding is a way to overcome the “spatial disconnection” problem in NFM implementation (Serna-Chavez et al., 2014). Private funding can support NFM implementation, although it has the potential risks of greenwashing and inequitable outcomes (Chausson et al., 2023). When coordinating at catchment scales, stakeholders must set clear goals and prioritise actions (Robins et al., 2025). Spatial blocks can be changed and updated over time, a process known as “unblocking space” (Thrift, 2003). Similarly, the decision-making power held by governments at different scales can change (Brown and Purcell, 2005).

Visual space is critical for gaining support for NFM projects and is reflected in the barriers *negative perceptions* and *maintenance challenges*, and in the motivators *positive perceptions*, *collaboration*, and *co-benefits*. Again, there are parallels between the barriers and motivators within this type of space. NFM could change the look of landscapes through more trees on hillsides, fewer grazing animals, increased foliage in the riparian zone, and wilder rivers that meander and change their course over time. Because NMF can look “unkempt,” public education is necessary to avoid negative perceptions (Holstead et al., 2014). While PES approaches like Wunder (2015) focus on the economic impacts of environmental programmes, the visual lens and findings by Holstead et al. (2014) and others suggest that visual impacts may be just as important. Visual impacts are key for urban greening projects as well (Kim and Arik, 2025). The key is to work with people to frame these visual changes in a positive way.

Place is also a key concept for NFM implementation as seen in the barriers *negative perceptions*, *unintended consequences*, and *collaboration challenges* and the drivers *co-benefits*, *funding*, *community engagement*, and *collaboration*. NFM schemes are located in places, which are associated with specific meanings, actions, and ways of life (Hartmann et al., 2022; Koops and Galič, 2017). For upstream communities, rural areas represent a way of life; they may be reluctant to change these places. For downstream communities, cities and towns are home; they may be reluctant to change or retreat from these areas. Heritage and sense of place can be integrated into conservation work (Willett, 2025). Wolff et al. (2022) advise that “co-design approaches...allow multiple stakeholders to plan for uncertain future conditions by integrating local priorities...in the design of NBS.” Considerations of place are also essential for involving stakeholders in NFM implementation and maintenance. However, there are also tensions involved in place-focused policies. For example, Massey (2005) highlights that “horror at local exclusivities sits uneasily against support for the vulnerable struggling to defend their patch.” In flood risk management, there are tensions between local preferences and national priorities. Debates include where to install NFM, when to use engineered defenses, and whether to implement managed retreat programmes. Each of these may have significant effects

on communities.

7. Towards a spatial framework for NFM upscaling

There are many existing frameworks that could be applied to NFM implementation: one study identified 29 such frameworks for NBS implementation (Berg et al., 2024). For example, the IUCN Global Standard for NBS explains that NBS must “address societal challenges” and be “informed by scale” (IUCN, 2020). Similarly, the NFM Toolbox presents seven steps for NFM implementation, from “define objectives” to “management and monitoring” (Environment Agency, 2017).

The following framework (Fig. 4) is designed to help catchment organizations to think through the challenges of NFM implementation to achieve the paradigm shift to upscaled NFM. To use the framework, a local government interested in implementing NFM would begin by assessing the empirical situation, including where there is significant flood risk and what the current land uses are. Then, they would consider which other governments (local and national) would need to be involved in the project, and how these governments’ boundaries intersect with catchment boundaries. The block space considerations may prompt conversations about potential PES approaches (Wunder et al., 2015). Third, they would consider the visual impacts of the project, seeking input from residents who would be affected by flooding and/or by the NFM project itself. Fourth, they would examine the sense of place in the area and consider how the project could affect it. In this way, the framework could help to prepare for an NFM project.

Building on the spatial framework linking types of space, barriers, and motivators (Fig. 4), Fig. 5 links the concept of four types of space (Thrift, 2003) with the Environment Agency (2017) implementation steps, highlighting key questions that could help implementers to overcome the barriers of NFM. Before NFM implementation, Environment Agency (2017) advises that implementers “define objectives,” “identify funding,” conduct “data collation,” “select NFM measures,”

and “design” the project. During these five steps, it is critical to consider the empirical level of flood risk, the positions of different actors (especially funders) in the catchment, the visual effects of the proposed design, and the effects on peoples’ actions and sense of place. Next, during EA (2017)’s “implementation” phase, it is necessary to consider the impacts of the construction processes through all four spatial lenses. Finally, after construction during the “management and monitoring” phase (Environment Agency, 2017), key spatial considerations relate to monitoring NFM’s effectiveness, exploring whether the project could be a model for upscaling in other areas, maintaining the functioning and appearance of the project, and assessing the impacts on place. NFM projects can protect existing places like buildings, towns, and parks. NFM projects can also create new places such as fishing ponds, gardens, and public footpaths. While Fig. 4 is primarily aimed at planning NFM, Fig. 5 considers space before, during, and after implementation. Environment Agency (2017) also recommends that throughout the implementation timeline, “stakeholder engagement” and “policy and legislation compliance” are considered. While many of the questions included in Fig. 5 are focused on flooding, similar questions across the four types of space could be used for the co-benefits of NFM such as habitat creation and carbon sequestration. Indeed, co-benefits are one of the main drivers of NFM as discussed in Section 4.2.

While the spatial framework (Fig. 4) and integration with implementation steps (Fig. 5) are theoretical in nature, they can be used to encourage cooperation among diverse catchment stakeholders. For example, the questions in the framework could encourage traditional engineers who ordinarily prioritise grey infrastructure because its impact is easier to measure (Wingfield et al., 2021) to consider new approaches that center communities and sense of place (Lane et al., 2011). In addition, participants in catchment partnerships can discuss these questions to bring together upstream and downstream stakeholders to address “complexity” (Waylen et al., 2023). The questions in the framework could also encourage NFM implementers to evaluate the

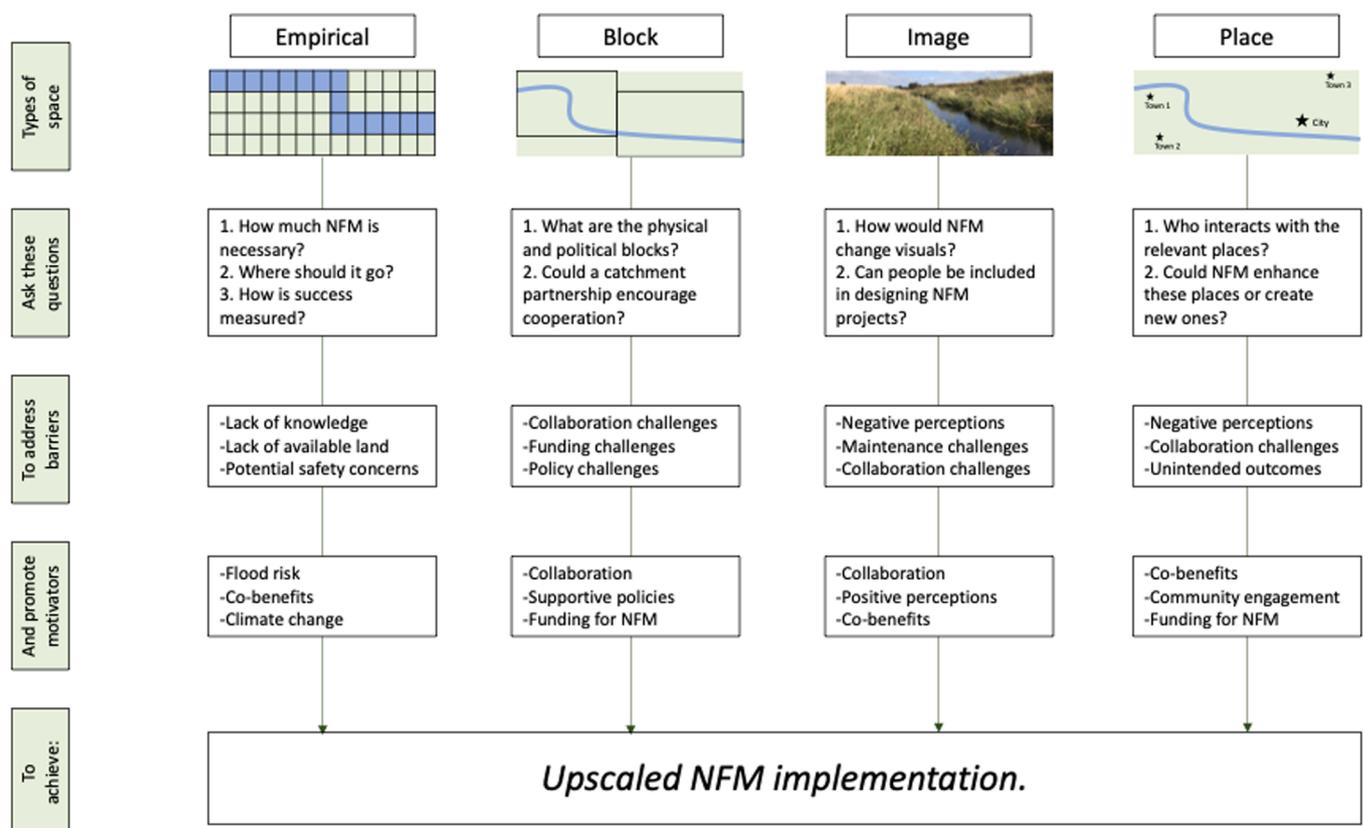


Fig. 4. This spatial framework can help NFM project implementers to think through the barriers and motivators of NFM.

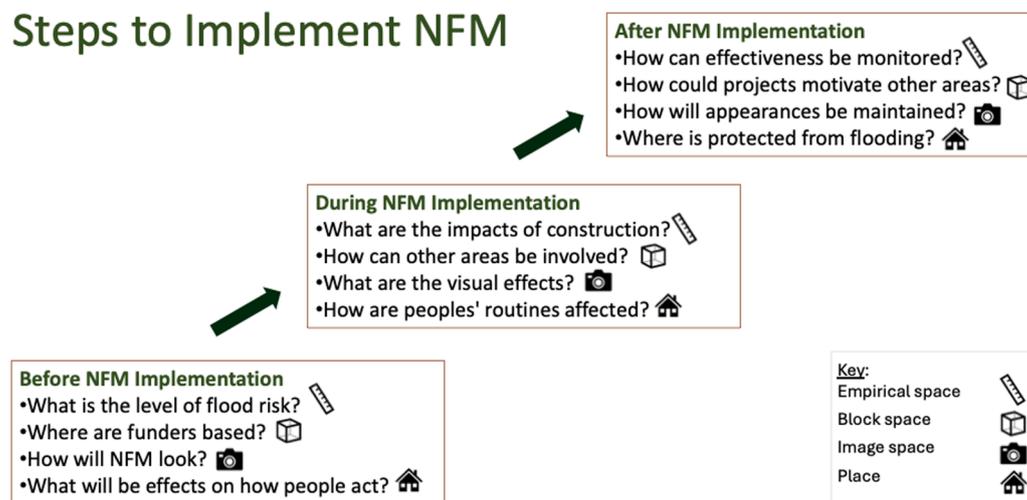


Fig. 5. Implications of the four types of space for the steps of NFM implementation, building on the steps described in [Environment Agency \(2017\)](#). The first box consolidates all of the steps before implementation: “define objectives,” “identify funding,” “data collection,” “select NFM measures,” and “design.” The second box is for the “implementation” step. The third box is for the “management and monitoring” step. The barriers and motivators of NFM are also incorporated in this diagram: funding, cooperation, perceptions, and other issues are included in these questions. Similar questions across the four types of space could be used to assess NFM’s co-benefits.

visual impacts of NFM ([Holstead et al., 2014](#)), as well as the effect of these changes on sense of place ([King and Bark 2024](#); [Massey, 2005](#)). Future research could involve investigating these questions in partnership with catchment stakeholders and studying whether the frameworks are useful for NFM upscaling.

8. Conclusion: A path forward for NFM research and practice

We conducted a scoping review of the barriers and motivators of NFM to answer the research question: *What are the barriers and motivators of NFM in the literature, and to what extent are they discussed in a spatial way?* Next, we used the framework of four types of space to analyse the barriers and motivators because it offers a holistic view of space that can incorporate other frameworks. Then, we developed a spatial framework ([Fig. 4](#)) and set of steps ([Fig. 5](#)) to encourage spatial thinking in NFM implementation.

The review found that the most frequently cited barriers were *policy challenges, funding challenges, knowledge challenges, and negative perceptions* ([Fig. 1](#)). It also found that the most frequently cited motivators were *flood mitigation, co-benefits, supportive policies, climate change, funding availability, and collaboration* ([Fig. 2](#)). Articles in the review discussed space using a variety of terms ([Fig. 3](#)). Barriers and motivators of NFM are related to different spatial concepts. For example, the barrier *lack of available land* is related to empirical spatial considerations, while the barrier *collaboration challenges* reflects the difficulty of working across spatial blocks.

The spatial framework for investigating the barriers and motivators of NFM ([Fig. 4](#)) indicates questions related to NFM upscaling. It can be linked to existing guidelines for NFM implementation ([Environment Agency, 2017](#)) ([Fig. 5](#)). These frameworks could be used by policy-makers and stakeholders to think more critically about the spatial implications of NFM upscaling.

Limitations of this study include that all the articles covered were written in English, and most have a focus on the Global North. The search was conducted in Scopus ($n = 30$), limiting the breadth of articles but allowing deeper reading of each. Research conducted with better linguistic and geographic diversity may uncover additional lessons about the barriers and drivers of NFM. While the number of articles is limited, the results provide a robust list of the barriers and motivators of NFM. An additional limitation of our work is our focus on NFM’s flooding benefits; an expanded framework could ask similar questions

for NFM’s other benefits.

Future research could involve collaborating with a catchment organisation to evaluate the effectiveness of the spatial framework in practice. Catchment partnerships ([Waylen et al., 2023](#)) could be a future venue for discussions around NFM upscaling, and various interactive tools (e.g., discussions, role-play simulations, and serious games) could be used to understand stakeholders’ priorities and considerations ([Garcia et al., 2022](#); [Khoury et al., 2018](#); [Mendler de Suarez et al., 2012](#)). Future research could then assess the impact of centering spatial thinking on NFM implementation.

CRediT authorship contribution statement

Andrew David Tabas: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Ian Pattison:** Writing – review & editing, Methodology, Conceptualization. **Leo Peskett:** Writing – review & editing, Methodology, Conceptualization. **Lindsay Beever:** Writing – review & editing, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Andrew Tabas reports financial support was provided by Scottish Government. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research is supported by The Hydro Nation Scholars Programme funded by the Scottish Government and managed by the Hydro Nation International Centre (Scottish Funding Council Project Code: H14002). Thank you to Forth Rivers Trust for being the external advisor on this project; to the two reviewers for their insightful comments; and to Professor Harry Smith, Dr. Sander van der Jagt, and Dorothy Heinrich for valuable input.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.envsci.2025.104259](https://doi.org/10.1016/j.envsci.2025.104259).

Data availability

No data was used for the research described in the article.

References

- Abbott, B.W., Bishop, K., Zarnetske, J.P., Minaudo, C., Chapin, F.S., Krause, S., Hannah, D.M., Conner, L., Ellison, D., Godsey, S.E., Plont, S., Marçais, J., Kolbe, T., Huebner, A., Frei, R.J., Hampton, T., Gu, S., Buhman, M., Sara Sayedi, S., Pinay, G., 2019. Human domination of the global water cycle absent from depictions and perceptions. *Nat. Geosci.* 12 (7). <https://doi.org/10.1038/s41561-019-0374-y>.
- Allen, J., 1997. *Economies of power and space*. In: Lee, In.R., Wills, J. (Eds.), *Geographies of Economies*. Arnold.
- Allen, J., Cochrane, A., 2010. Assemblages of state power: topological shifts in the organization of government and politics. *Antipode* 42 (5), 1071–1089. <https://doi.org/10.1111/j.1467-8330.2010.00794.x>.
- Arksey, H., O'Malley, L., 2005. Scoping studies: towards a methodological framework. *Int. J. Soc. Res. Methodol.* 8 (1), 19–32. <https://doi.org/10.1080/1364557032000119616>.
- Bark, R., Martin-Ortega, J., Waylen, K., 2021. Stakeholders' views on natural flood management: implications for the nature-based solutions paradigm shift? *Environ. Sci. POLICY* 115, 91–98. <https://doi.org/10.1016/j.envsci.2020.10.018>.
- Berg, M., Spray, C.J., Blom, A., Slinger, J.H., Stancanelli, L.M., Snoek, Y., Schielen, R.M. J., 2024. Assessing the IUCN global standard as a framework for nature-based solutions in river flood management applications. *Sci. Total Environ.* 950, 175269. <https://doi.org/10.1016/j.scitotenv.2024.175269>.
- Björkdahl, A., Buckley-Zistel, S., 2022. Space for Peace: a research agenda. *J. Interv. State* 16 (5), 659–676. <https://doi.org/10.1080/17502977.2022.2131194>.
- Black, A., Peskett, L., MacDonald, A., Young, A., Spray, C., Ball, T., Thomas, H., Werritty, A., 2021. Natural flood management, lag time and catchment scale: results from an empirical nested catchment study. *J. Flood Risk Manag.* 14 (3), e12717. <https://doi.org/10.1111/jfr3.12717>.
- Blackwood, L., Renaud, F.G., 2022. Barriers and tools for implementing Nature-based solutions for rail climate change adaptation. *Transp. Res. Part D Transp. Environ.* 113, 103529. <https://doi.org/10.1016/j.trd.2022.103529>.
- Brown, J.C., Purcell, M., 2005. There's nothing inherent about scale: political ecology, the local trap, and the politics of development in the Brazilian Amazon. In: *Geoforum*, 36. Scopus, pp. 607–624. <https://doi.org/10.1016/j.geoforum.2004.09.001>.
- Brundtland, G. (1987). Report of the World Commission on Environment and Development: Our Common Future. (<https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf>).
- Bryman, A. (2004). *Social Research Methods* (Second Edition). Oxford University Press.
- Carlone, T., Mannocci, M., 2024. Overcoming barriers and fostering adoption: evaluating the institutional mainstreaming of nature-based solutions in the Emilia-Romagna Region's Socio-Ecological system. *Land* 13 (8), 1175. <https://doi.org/10.3390/land13081175>.
- Castellar, J.A.C., Popartan, L.A., Pucher, B., Pineda-Martos, R., Hecht, K., Katsou, E., Nika, C.E., Junge, R., Langergraber, G., Atanasova, N., Comas, J., Monclús, H., Pueyo-Ros, J., 2024. What does it take to renature cities? An expert-based analysis of barriers and strategies for the implementation of nature-based solutions. In: *Journal of Environmental Management*, 354. Scopus. <https://doi.org/10.1016/j.jenvman.2024.120385>.
- Chausson, A., Welden, E.A., Melanidis, M.S., Gray, E., Hiron, M., Seddon, N., 2023. Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures. *PLOS Clim.* 2 (4), e0000169. <https://doi.org/10.1371/journal.pclm.0000169>.
- Christopher, N., Vachette, A., Horne, A., Kosovac, A., 2024. Enhancing river floodplain management with nature-based solutions: overcoming barriers and harnessing enablers. In: *Wiley Interdisciplinary Reviews: Water*, 11. Scopus. <https://doi.org/10.1002/wat2.1723>.
- Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (Eds.). (2016). *Nature-based solutions to address global societal challenges*. IUCN International Union for Conservation of Nature. <https://doi.org/10.2305/IUCN.CH.2016.13.en>.
- Crockford, L., 2022. Achieving cleaner water for UN sustainable development goal 6 with natural processes: challenges and the future. *Front. Environ. Sci.* 10. (<https://www.frontiersin.org/articles/10.3389/fenvs.2022.976687>).
- Dadson, S.J., Hall, J.W., Murgatroyd, A., Acreman, M., Bates, P., Beven, K., Heathwaite, L., Holden, J., Holman, I.P., Lane, S.N., O'Connell, E., Penning-Rowell, E., Reynard, N., Sear, D., Thorne, C., Wilby, R., 2017. A restatement of the natural science evidence concerning catchment-based 'natural' flood management in the UK. *Proc. R. Soc. A Math. Phys. Eng. Sci.* 473 (2199), 20160706. <https://doi.org/10.1098/rspa.2016.0706>.
- Davies, C., Laforzezza, R., 2019. Transitional path to the adoption of nature-based solutions. *Land Use Policy* 80, 406–409. <https://doi.org/10.1016/j.landusepol.2018.09.020>.
- Davoudi, S., & Strange, I. (Eds.). (2008). *Conceptions of Space and Place in Strategic Spatial Planning* (0 ed.). Routledge. <https://doi.org/10.4324/9780203886502>.
- Deely, J., Hynes, S., Barquín, J., Burgess, D., Finney, G., Silió, A., Álvarez-Martínez, J.M., Bailly, D., Ballé-Béganton, J., 2020. Barrier identification framework for the implementation of blue and Green infrastructures. *Land Use Policy* 99, 105108. <https://doi.org/10.1016/j.landusepol.2020.105108>.
- Donoff, G., Bridgman, R., 2017. The playful city: constructing a typology for urban design interventions. *Int. J. Play* 6 (3), 294–307. <https://doi.org/10.1080/21594937.2017.1382995>.
- Dorst, H., van der Jagt, A., Toxopeus, H., Tozer, L., Raven, R., Runhaar, H., 2022. What's behind the barriers? Uncovering structural conditions working against urban nature-based solutions. *Landsc. Urban Plan.* 220. <https://doi.org/10.1016/j.landurbplan.2021.104335>.
- EM-DAT (2025). UCLouvain / CRED, Brussels, Belgium, accessed on 22-07-2025, (<https://public.emdat.be/>).
- Environment Agency. (2017). *Natural Flood Management Toolbox: Guidance for working with natural processes in flood management schemes*.
- Forbes, H., Ball, K., & McLay, F. (2015). *Natural Flood Management Handbook*. Scottish Environment Protection Agency. (<https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf>).
- García, C.A., Savilaakso, S., Verburg, R.W., Stoudmann, N., Fernbach, P., Sloman, S.A., Peterson, G.D., Araújo, M.B., Bastin, J.-F., Blaser, J., Boutinot, L., Crowther, T.W., Dessard, H., Dray, A., Francisco, S., Ghazoul, J., Feintrenie, L., Hainzlin, E., Kleinschroth, F., Waeber, P.O., 2022. Strategy games to improve environmental policymaking. *Article 6. Nat. Sustain.* 5 (6). <https://doi.org/10.1038/s41893-022-00881-0>.
- Han, S., Kuhllicke, C., 2021. Barriers and drivers for mainstreaming Nature-Based solutions for flood risks: the case of South Korea. *Int. J. Disaster Risk Sci.* 12 (5), 661–672. <https://doi.org/10.1007/s13753-021-00372-4>.
- Hartmann, T., Slavíková, L., Wilkinson, M., 2022. Spatial flood risk management: implementing Catchment-based retention and resilience on private land. In *Spatial Flood Risk Management*. Edward Elgar Publishing. (<https://www.elgaronline.com/view/edcoll/9781800379527/9781800379527.xml>).
- Holloway, S.L., Rice, S.P., & Valentine, G. (Eds.). (2003). *Key Concepts in Geography*. SAGE Publications Ltd.
- Holstead, K. I., Kenyon, W., Rouillard, J. J., Hopkins, J., Galán-Díaz, C., 2014. Natural flood management from the farmer's perspective: criteria that affect uptake. *J. Flood Risk Manag.* 10 (2), 205–218. <https://doi.org/10.1111/jfr3.12129>.
- Hubbard, P., & Kitchin, R. (2011). *Key Thinkers on Space and Place* (2nd ed.). SAGE.
- IPCC, 2023. Sections. In: *Climate Change 2023: Synthesis Report*. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team. IPCC, Geneva, Switzerland, pp. 35–115. <https://doi.org/10.59327/IPCC/AR6-9789291691647>].
- IUCN. (2020). *IUCN Global Standard for Nature-based Solutions*.
- Jain, V., & Mittal, A. (2024). *Management for Sustainable Development: Integrating Social, Economic, and Environmental Goals*. CRC Press.
- Katsou, E., Nika, C.E., Buehler, D., Marić, B., Megyesi, B., Mino, E., Babí Almenar, J., Bas, B., Bećirović, D., Bokal, S., Dolčić, M., Elginöz, N., Kalnis, G., Mateo, M.-C.G., Miloussi, M., Mousavi, A., Rincić, I., Rizzo, A., Rodríguez-Roda, I., Atanasova, N., 2020. Transformation tools enabling the implementation of nature-based solutions for creating a resourceful circular city. *BlueGreen. Syst.* 2 (1), 188–213. <https://doi.org/10.2166/bgs.2020.929>.
- Khoury, M., Gibson, M.J., Savic, D., Chen, A.S., Vamvakeridou-Lyroudia, L., Langford, H., Wigley, S., 2018. A serious game designed to explore and understand the complexities of flood mitigation options in Urban-Rural catchments. In: *Water (Switzerland)*, 10. Scopus. <https://doi.org/10.3390/w10121885>.
- Kim, C., Arik, A.D., 2025. Greening streets, gaining insights: unpacking resident perceptions of urban greening. *Urban For. Urban Green.* 107, 128775. <https://doi.org/10.1016/j.ufug.2025.128775>.
- King, P., & Bark, R. (2024). From local solutions to catchment-wide management: An investigation of upstream-downstream trade-offs when scaling out nature-based flood risk management. *Ecosystems and People*. (<https://www.tandfonline.com/doi/full/10.1080/26395916.2024.2426716#abstract>).
- Koops, B.-J., & Galić, M. (2017). Conceptualising Space and Place: Lessons from Geography for the Debate on Privacy in Public (SSRN Scholarly Paper 3260690). (<https://papers.ssrn.com/abstract=3260690>).
- Kosoy, N., Martínez-Tuna, M., Muradian, R., Martínez-Alier, J., 2007. Payments for environmental services in watersheds: insights from a comparative study of three cases in Central America. *Ecol. Econ.* 61 (2), 446–455. <https://doi.org/10.1016/j.ecolecon.2006.03.016>.
- Kuhn, T. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
- Lane, S.N., Odoni, N., Landström, C., Whatmore, S.J., Ward, N., Bradley, S., 2011. Doing flood risk science differently: An experiment in radical scientific method. *Transactions of the Institute of British Geographers* 36. <https://www.jstor.org/stable/23020839>.
- Mace, G.M., 2014. Whose conservation? *Science* 345 (6204), 1558–1560. <https://doi.org/10.1126/science.1254704>.
- Martin, J.G.C., Scolobig, A., Linnerooth-Bayer, J., Liu, W., Balsiger, J., 2021. Catalyzing innovation: governance enablers of nature-based solutions. In: *Sustainability (Switzerland)*, 13. Scopus, pp. 1–28. <https://doi.org/10.3390/su13041971>.
- Massey, D., 1993. *Power-Geometry and a progressive sense of place*. In: Bird, In.J., Curtis, B., Putnam, T., Robertson, G., Tickler, L. (Eds.), *Mapping the Futures: Local Cultures, Global Change*. Routledge, pp. 59–69.
- Massey, D. (2005). *For Space*. SAGE Publications Ltd.
- Mendler de Suarez, J., Suarez, P., Bachofen, C., Fortugno, N., Goentzel, J., Gonçalves, P., Grist, N., Macklin, C., Pfeifer, K., Schweizer, S., van Aalst, M., & Virji, H. (2012). *Games for a New Climate: Experiencing the Complexity of Future Risks*. Pardee Center Task Force Report.

- Milly, P.C.D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., Stouffer, R.J., 2008. Stationarity is dead: whither water management? *Science* 319 (5863), 573–574. <https://doi.org/10.1126/science.1151915>.
- Moreno, C.S., Roman-Cuesta, R.M., Canty, S.W.J., Herrera, J., Teutli, C., Muñoz-Castillo, A.I., McField, M., Soto, M., do Amaral, C., Paton, S., González-Trujillo, J.D., Poulter, B., Schumacher, M., Durán-Díaz, P., 2022. Stakeholders' perceptions of Nature-Based solutions for hurricane risk reduction policies in the Mexican Caribbean. *Article 10. Land 11* (10). <https://doi.org/10.3390/land11101701>.
- Morris, S., & Tippett, J. (2023). Perceptions and practice in Natural Flood Management: Unpacking differences in community and practitioner perspectives. *JOURNAL OF ENVIRONMENTAL PLANNING AND MANAGEMENT*. <https://doi.org/10.1080/09640568.2023.2192861>.
- O'Donnell, Lamond, J.E., & Thorne, C.R. (2017). Recognising barriers to implementation of Blue-Green Infrastructure: A Newcastle case study. (<https://www.tandfonline.com/doi/full/10.1080/1573062X.2017.1279190>).
- Paré, G., & Kitsiou, S. (2017). Chapter 9 Methods for Literature Reviews. In *Handbook of eHealth Evaluation: An Evidence-based Approach [Internet]*. University of Victoria. (<https://www.ncbi.nlm.nih.gov/books/NBK481583/>).
- Pattison, I., Lane, S.N., Hardy, R.J., Reaney, S.M., 2014. The role of tributary relative timing and sequencing in controlling large floods. *Water Resour. Res.* 50 (7), 5444–5458. <https://doi.org/10.1002/2013WR014067>.
- Pearson, E., Baldwin, M., Bard, H., Bromley, T., Broomby, J., Burgess, T., Burgess-Gamble, L., Champion, H., Evans, H., Hankin, B., Hastewell, L., Hemsworth, M., Humphries, A., Langler, G., Maslen, S., Prtak, E., Rees, C., & Rose, S. (2025). Working with natural processes: Evidence directory update. Environment Agency.
- Pescott, O., & Wentworth, J. (2011). Natural flood management. *POST Note* 396.
- Pham, M.T., Rajić, A., Greig, J.D., Sargeant, J.M., Papadopoulos, A., McEwen, S.A., 2014. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Res. Synth. Methods* 5 (4), 371–385. <https://doi.org/10.1002/jrsm.1123>.
- Ramírez-Agudelo, N., Anento, R.P., Villares, M., Roca, E., 2020. Nature-based solutions for water management in peri-urban areas: Barriers and lessons learned from implementation experiences. *Sustainability* 12. <https://doi.org/10.3390/su12239799>.
- Raska, P., Bezak, N., Ferreira, C.S.S., Kalantari, Z., Banasik, K., Bertola, M., Bourke, M., Cerda, A., Davids, P., de Brito, M.M., Evans, R., Finger, D.C., Halbac-Cotoara-Zamfir, R., Housh, M., Hysa, A., Jakubinsky, J., Solomun, M.K., Kaufmann, M., Keesstra, S., Hartmann, T., 2022. Identifying barriers for nature-based solutions in flood risk management: an interdisciplinary overview using expert community approach. *J. Environ. Manag.* 310, 114725. <https://doi.org/10.1016/j.jenvman.2022.114725>.
- Reed, M.S., Jensen, E.A., Noles, S., Conneely, D., Kendall, H., Raley, M., Tarrant, A., Oakley, N., Hinson, C., Hoare, V., Marshall, K., Pugliese, L., 2025. Analyzing who is relevant to engage in environmental decision-making processes by interests, influence and impact: the 3i framework. *J. Environ. Manag.* 373, 123437. <https://doi.org/10.1016/j.jenvman.2024.123437>.
- Rentschler, J., Salhab, M., Jafino, B.A., 2022. Flood exposure and poverty in 188 countries. *Nat. Commun.* 13 (1), 3527. <https://doi.org/10.1038/s41467-022-30727-4>.
- Robins, J.E., Naura, M., Austin, S., Bryden, A., Cullis, J., Prady, J., Shi, F., Treves, R., 2025. A new framework for river restoration planning at catchment scale in the UK. *River Res. Appl.* 41 (1), 82–107. <https://doi.org/10.1002/rra.4408>.
- Sarabi, S.E., Han, Q., Romme, A.G.L., de Vries, B., Wendling, L., 2019. Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: a review. In: *Resources*. Scopus. <https://doi.org/10.3390/resources8030121>.
- Sarabi, S., Han, Q., Romme, A.G.L., de Vries, B., Valkenburg, R., den Ouden, E., 2020. Uptake and implementation of Nature-Based solutions: an analysis of barriers using interpretive structural modeling. In: *Journal of Environmental Management*, 270. Scopus. <https://doi.org/10.1016/j.jenvman.2020.110749>.
- Seddon, N., Chausson, A., Berry, P., Girardin, C.A.J., Smith, A., Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philos. Trans. R. Soc. B Biol. Sci.* 375 (1794), 20190120. <https://doi.org/10.1098/rstb.2019.0120>.
- Serna-Chavez, H.M., Schulp, C.J.E., van Bodegom, P.M., Bouten, W., Verburg, P.H., Davidson, M.D., 2014. A quantitative framework for assessing spatial flows of ecosystem services. *Ecol. Indic.* 39, 24–33. <https://doi.org/10.1016/j.ecolind.2013.11.024>.
- Smith, M., Gammie, G., Song, J., Atwell, B., Shemie, D., Bennett, M., Adriaola, J.C., Juliet Joubert, I., & Tanguy, P. (2025). Doubling Down on Nature: State of Investment in Nature-based Solutions for Water Security. (<https://www.nature.org/en-us/what-we-do/our-insights/perspectives/investments-in-nature-based-solutions-for-watershed-security/>).
- Solheim, A., Capobianco, V., Oen, A., Kalsnes, B., Wulff-Knutson, T., Olsen, M., Del Seppia, N., Arauzo, I., Garcia Balaguer, E., Strout, J.M., 2021. Implementing Nature-Based solutions in rural landscapes: barriers experienced in the PHUSICOS project. *Article 3. Sustainability* 13 (3). <https://doi.org/10.3390/su13031461>.
- Tarasova, L., Gnann, S., Yang, S., Hartmann, A., Wagener, T., 2024. Catchment characterization: current descriptors, knowledge gaps and future opportunities. *Earth Sci. Rev.* 252, 104739. <https://doi.org/10.1016/j.earscirev.2024.104739>.
- Thaler, T., Hudson, P., Viavattene, C., Green, C., 2023. Natural flood management: opportunities to implement nature-based solutions on privately owned land. In: *Wiley Interdisciplinary Reviews: Water*, 10. Scopus. <https://doi.org/10.1002/wat2.1637>.
- Thorne, C.R., Lawson, E.C., Ozawa, C., Hamlin, S.I., Smith, L.A., 2015. Overcoming uncertainty and barriers to adoption of Blue-Green infrastructure for urban flood risk management. *J. Flood Risk Manag.* 11 (S2), S960–S972. <https://doi.org/10.1111/jfr3.12218>.
- Thrift, N., 2003. Space: the fundamental stuff of geography. In *Key Concepts in Geography*. SAGE, pp. 95–107.
- Wagener, T., Sivapalan, M., Troch, P., Woods, R., 2007. Catchment classification and hydrologic similarity. *Geogr. Compass* 1 (4), 901–931. <https://doi.org/10.1111/j.1749-8198.2007.00039.x>.
- Wamsler, C., Wickenberg, B., Hanson, H., Alkan Olsson, J., Stålhammar, S., Björn, H., Falck, H., Gerell, D., Oskarsson, T., Simonsson, E., Torffvit, F., Zelterlow, F., 2020. Environmental and climate policy integration: targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. In: *Journal of Cleaner Production*, 247. Scopus. <https://doi.org/10.1016/j.jclepro.2019.119154>.
- Waylen, K.A., Blackstock, K.L., Marshall, K., Juarez-Bourke, A., 2023. Navigating or adding to complexity? Exploring the role of catchment partnerships in collaborative governance. In: *Sustainability Science*, 18. Scopus, pp. 2533–2548. <https://doi.org/10.1007/s11625-023-01387-0>.
- Waylen, K.A., Holstead, K.L., Colley, K., Hopkins, J., 2018. Challenges to enabling and implementing natural flood management in Scotland. In: *Journal of Flood Risk Management*, 11. Scopus, pp. S1078–S1089. <https://doi.org/10.1111/jfr3.12301>.
- Wells, J., Labadz, J.C., Smith, A., Islam, Md.M., 2020. Barriers to the uptake and implementation of natural flood management: a social-ecological analysis. *J. Flood Risk Manag.* 13 (S1), e12561. <https://doi.org/10.1111/jfr3.12561>.
- Wickenburg, B., McCormick, K., Olsson, J.A., 2021. Advancing the implementation of nature-based solutions in cities: a review of frameworks. *Environ. Sci. Policy* 125, 44–53. <https://doi.org/10.1016/j.envsci.2021.08.016>.
- Wilkinson, M.E., Addy, S., Quinn, P.F., Stutter, M., 2019. Natural flood management: Small-scale progress and larger-scale challenges. *Scott. Geogr. J.* 135 (1–2), 23–32. <https://doi.org/10.1080/14702541.2019.1610571>.
- Willett, E., 2025. Leading the way: working towards Heritage-Led nature recovery in natural England. *Hist. Environ. Policy Pract.* 16 (1), 63–79. <https://doi.org/10.1080/17567505.2024.2442654>.
- Wingfield, T., Macdonald, N., Peters, K., Spees, J., Potter, K., 2019. Natural flood management: beyond the evidence debate. *AREA* 51 (4), 743–751. <https://doi.org/10.1111/area.12535>.
- 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. In: *Hydrology and Earth System Sciences*, 25. Scopus, pp. 6239–6259. <https://doi.org/10.5194/hess-25-6239-2021>.
- Wolff, E., Rauf, H.A., Diep, L., Natakun, B., Kelly, K., Hamel, P., 2022. Implementing participatory nature-based solutions in the global south. *Front. Sustain. Cities* 4. (<https://www.frontiersin.org/articles/10.3389/frsc.2022.956534>).
- Wunder, S., 2015. Revisiting the concept of payments for environmental services. *Ecol. Econ.* 117, 234–243. <https://doi.org/10.1016/j.ecolecon.2014.08.016>.