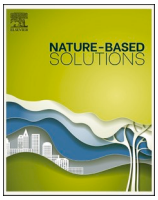
Nature-Based Solutions 4 (2023) 100096

Contents lists available at ScienceDirect

Nature-Based Solutions

journal homepage: www.elsevier.com/locate/nbsj



Nature-based solutions in flood risk management: Unlocking spatial, functional and policy perceptions amongst practitioners in South-West England

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ARTICLE INFO

Keywords:
Nature-based solutions
Flood risk governance
NFM
SuDS
Rural-urban links
Practitioner
Network governance

ABSTRACT

Nature-based solutions (NBS) to flood risk management include natural flood management (NFM) and sustainable drainage systems (SuDS). Still relatively untested in practice, their applications have been separated functionally and spatially. In this article, it is suggested that the emerging approach of managing flood risk holistically over whole catchments is hampered by the persistence of such binaries. Structural, organisational and policy contexts that entrench these divisions are explored through the experiences of flood risk practitioners working in south-west England. Interviews with 11 practitioners working in different aspects of flood risk management within the English Severn and Wye region are analysed. The key findings are grouped into two broad categories: (1) impediments faced by practitioners in implementing NBS, including different spatial NBS understandings, implementation and planning challenges and, monitoring and maintaining NBS; (2) the need for effective NBS governance focused around policy links and community involvement and incentivisation. The analysis draws out three formats of network governance in support of the expansion of cross-sectoral arrangements to plan, implement and monitor NBS flood interventions across extended river catchments in the longer term: regional administration, local lead flood organisation and participant-governed. The focus on the UK, rooted in national contexts, applies conceptually to flood risk governance scenarios in other countries.

Introduction

Nature-based solutions (NBS) are well established as an approach that responds to the needs of climate change [1], the threats of biodiversity loss [2] and broader issues such as urban regeneration [3]. Associated expectations emerge from definitions of NBS, which constitute *'actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits'* [4]. The focus of NBS is on 'win-win' solutions for tackling climate change, biodiversity loss and society, representing an eye-catching approach, but one with significant knowledge gaps [5,6] around effective indicators of success and systematic assessment.

In literature on flood risk management (FRM), debates have focused on the efficacy and multiple benefits of NBS both in contrast and complementary to conventional, engineered forms of flood interventions [7–12]. Less well-documented is how different FRM practitioners' attitudes extend to two forms of NBS: Natural Flood Management (NFM) and Sustainable Drainage Systems (SuDS). NFM is based upon the principle that, instead of locally defending floodplains from inundation, it is possible to manipulate river flow at the catchment-scale to reduce downstream inundation [13]. Therefore, the term NFM is used here to refer to the utilisation or restoration of 'natural' land cover and channel-floodplain features within catchments (i.e. actual interventions) to increase the time to peak and reduce the height of the flood wave downstream [14]. Whilst NFM aims to reduce runoff at the wider catchment-scale, SuDS focus on localised, typically urban runoff, to limit pluvial flood risk [15,16] through surface water drainage systems developed in line with ideals of sustainable development [17]. As designed features which mimic natural drainage, SuDS may be part of the agreed mitigation within the grey infrastructure responding to soil sealing and handling excess runoff water [18]. Both NFM and SuDS can

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https://doi.org/10.1016/j.nbsj.2023.100096
Received 29 March 2023; Received in revised form 29 September 2023; Accepted 23 October 2023
Available online 24 October 2023

be considered as sub-sets of NBS as they respond to increased threats presented by climate change, respond to biodiversity loss and meet societal needs.

Different functional and spatial applications are associated with NFM and SuDS respectively, resulting in their separation as tools of FRM rather than being parts of holistic catchment-based approaches [19,20]. Lashford et al. [21] highlighted this in relation to the series of challenges regarding the successful integration of SuDS and NFM at the wider catchment-scale, both in terms of policy and practical implementation. Their research recommended that more emphasis should be placed on FRM at multiple scales and suggested unification of the two using the phrase *'sustainable catchment-wide flood management'*. However, the success of such an integration in practise depends substantially on FRM practitioners, both individuals and networks, who are involved in implementing, managing and monitoring nature-based FRM solutions [22–24]. Practitioners have to implement policies and cope with the pressures of flood risk and the consequences flood impacts and, consequently, their views on NBS and the synthesis of NFM and SuDS should be understood.

In this study, we explore the views of local FRM practitioners, drawing out their experiences and perspectives of NFM and SuDS, and how these fit (and vary) within their own perceptions and definitions of NBS. Interviews were conducted within the administrative and fluvial catchment of the English Severn and Wye, one of 12 Regional Flood and Coastal Committee (RFCC) areas in England (Fig. 1). It comprises the local authority areas of Shropshire, Warwickshire, Telford & Wrekin, Dudley, Coventry, Hereford, Worcestershire, Gloucestershire.

Practitioner views are considered through the lens of 'network governance'; this refers to both formal and informal institutions that guide activities to manage flood risk [25]. This perspective aids assessments of whether NFM and SuDS are treated differently within the FRM context and, in such a case, evaluates ways in which integrated approaches based on the NBS concept could prove meaningful for FRM practitioners who need to collaborate within river catchments. Research was constructed around three questions designed to solicit practitioners' responses about the functional and spatial divergence/integration of NFM and SuDS as NBS tools:

1 Seen from the perspective of FRM practitioners, what contexts separate and connect SuDS and NFM as NBS to flood management?
2 What challenges does the issue of separation present and how are these 'locked-in'?
3 What governance arrangements can help optimise an integrated catchment-based NBS, overcoming functional and spatial separations between SuDS and NFM. ?

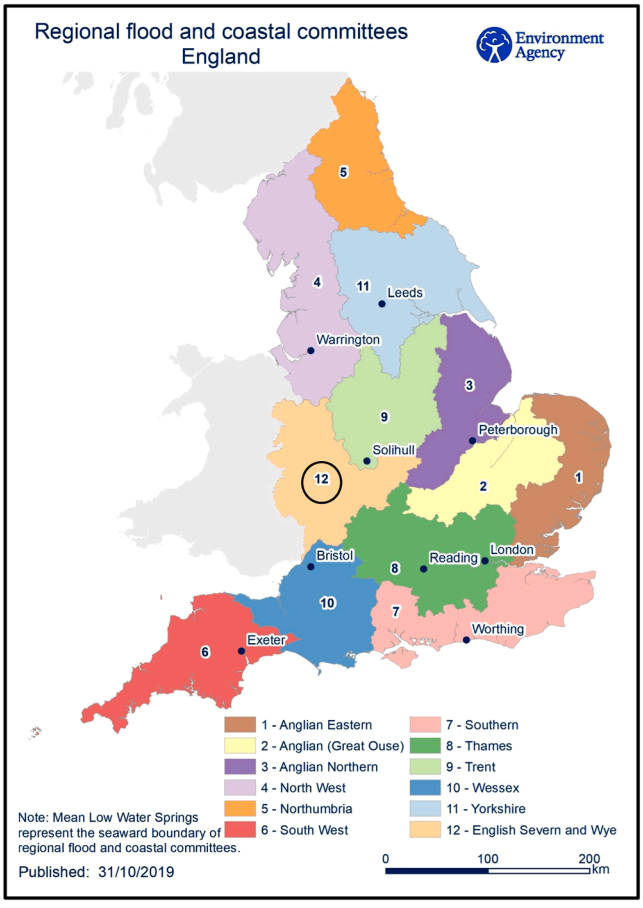

Fig. 1. Map of the 12 RFCC areas in England; the focus of this research is the English Severn and Wye (number 12, circled) (Source: Environment Agency).

Network governance – a route towards NBS integration?

Binary understandings of the merits of NFM and SuDS persist, despite arguments in favour of catchment thinking. Catchments present holistic systems within which upstream land use or riparian interventions affect downstream stability at different scales. It has been suggested that

'a prerequisite for sustainable resource management at a catchment-scale is understanding the water cycle and its fluctuations.' ([26]: 1)

It follows that individual FRM interventions along a catchment need to be understood in terms of their overall catchment impacts, if flood risk is to be reliably predicted and managed. This requirement becomes more urgent as interest in NBS grows. Clearly, NBS are linked to local contexts; yet, if catchments are the arenas over which NBS could be considered and assessed, the functions NBS offer are necessarily multiplied. An NFM intervention in the upper catchment may provide localised biodiversity gain and contribute to the finer-grained understanding of the water cycle overall, by aggregating localised interventions within the catchment system.

Attempts to foster collaboration and networking opportunities amongst FRM practitioners in England around NBS possibilities have emerged through collaborative structures such as catchment management partnerships [23,27] and the establishment of RFCCs. This must be considered in the complex institutional framework for FRM (Fig. 2), which delineates FRM strategic plans across national, river basin (catchment-scale) and local levels. Local planning tends to focus on urban areas and SuDS, whereas the river basin planning focuses on implementation of countryside management techniques including NFM. Additionally, the outcome measures (OM) upon which these plans are judged usually divide rural and urban spaces because of the types of hard and soft engineering and respective benefits they offer. The UK Department for Environment, Food and Rural Affairs (Defra) [28] defines four categories of OMs; of these, OM2 relates to interventions which reduce risk of damage to people and property (usually resulting in hard engineering to protect dense urban settlements), while OM4 focuses on statutory environmental obligations met through flood and coastal erosion risk management, which are usually linked to rural countryside management.

Organisational alliances linked to these plans contribute (in piecemeal ways) to cross-boundary collaborations. Beyond this, a systematic approach to catchment-based NBS lies in the adoption of network governance, increasingly applied as a problem-solving strategy for complex and systemic questions of sustainability and their integration across policy fields [30] and administrative boundaries. Network governance is:

'… [a] negotiated, multi-stakeholder process and a collaborative system of decision design and decision making, characterised by significant degrees of self-governing, with attendant resources commitments and shared power….' [31]

Douglas [31] highlights a range of characteristics, including

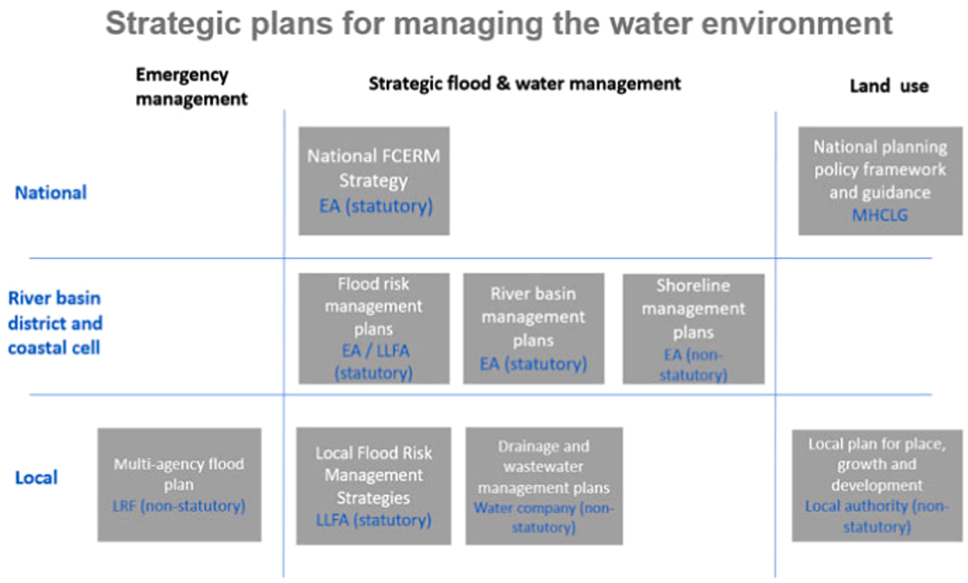

Fig. 2. Illustration of links between flood risk management (FRM) strategic plans across the National, River Basin and Local level in the England and the type of risk they are designed to manage, ranging from Emergency Planning, Strategic Flood and Water Management and Land Use [29]. Abbreviations: FCERM = Flood and Coastal Erosion Risk Management Strategy, EA = Environment Agency, MHCLG = UK Government Department for Housing Communities and Local Government, LLFA = Lead Local Flood Authorities, LRF = Local Resilience Forum.

autonomy, resources and multiple stakeholders, which distinguish governance from government. Governance implies a reallocation of power outwards from the central hierarchy of government [32]. These intrinsically collaborative distinctions and form variations need to be matched with the ability to make spatially contextualised change, otherwise the collaboration is simply a network [33]. This resonates in English catchment management challenges where territorially (or in this case, fluvially) organised networks seek to balance the urgency of addressing seasonal and climate induced flood severity with the introduction of NBS.

Provan and Kennis [34] suggest that governance networks, as multi-organisational governance arrangements, require three or more autonomous organisations that work together to achieve their own as well as collective goals. These can be classified in three ways: (i) those governed by their members (participant governed); (ii) those brokered by a lead organisation; and (iii) a network administrative organisation. An essential element in network governance which resonates here is trust. As networks increase in size and territorial scale, network structures must be able to facilitate trust amongst members to secure consensus around network operational goals.

In catchment-systems, FRM requires multi-stakeholder networks with decision-making powers in a territory, not least where the focus of such governance arrangements centre on NBS approaches to floods which, at best, are regarded as complementary interventions. This is partly because of the impact of floods on multiple sectors, including state flood management and emergency responses, commercial premises and interests, civil society networks that lobby for change and assist flooded citizens, and scientists who monitor and evaluate flood risk interventions. These requirements echo Woods et al. ([35]: 16), who offer a 5-point characterisation of network governance that can strengthen the governance of rural-urban links:

1 Groups from different sectors and scales are brought together in an ongoing partnership.
2 They negotiate with each other.
3 The partnership is formalised (i.e. a committee structure).
4 The partnership has autonomy to make decisions (subject to national regulatory and budget constraints).
5 There is a public purpose to the group's work.

Transitioning to a catchment-based NBS approach for FRM fits within this characterisation and applies to regional variations of catchment governance. Network governance reflects the shifting nature of government, away from central control towards the proliferation of governance partnerships through (brokered) quangos and/or the co-option of civil society networks as public service delivery agents. Some organisations evidently are founded upon network governance characteristics, including RFCCs which bring together water companies, local and regional authorities (lead local flood authorities – LLFAs), scientists and civil society groups to advise the Environment Agency on flood risk investment and intervention opportunities. In this respect RFCCs represent network administrative organisations, specifically established to govern the FRM network and its activities. LLFAs are represented on the RFCCs by local politicians and their democratic legitimacy represents a trust-building factor in the network. Alongside them technical competences are represented in the form of specialist but non-voting advisors. While the RFCC itself is a network administrative organisation, LLFAs can be regarded as lead organisation networks because they hold autonomous land use planning, FRM and statutory functions which are territorially and legally framed. In practice, however, this means that FRM policies in one county are created in and for that county. It is the RFCC which connects a county to its catchment, and the LLFA politicians within it.

In England, FRM networks, while locally contextualised by unique catchment geography and hydrology, conform to the loosening of government authority towards local decision-making. Network governance offers an opportunity to bolster the profile and evaluation of NBS interventions and, in time, their wider-scale adoption. This article now presents regional interview data. The assessment of network governance effectiveness outlined in this section later aids discussion of these two types of network governance, namely the RFCC and its constituent LLFAs.

Materials & methods

Interviews were conducted with 11 individuals involved in the implementation, planning and monitoring of SuDS/NFM interventions from within the English Severn and Wye RFCC region (Table 1). Nine were held between March and July 2021, with two supplementary

Table 1
Role description of each FRM practitioner interviewed, and anonymised identifier.

Identifier	Description
LA1	Local authority flood risk official
LA2	Local authority flood risk official
GV1	Government agency regional official
GV2	Government agency regional official
GV3	Government agency official
CS1	Civil society network representative
WT1	Water company employee
WT2	Water company employee
DV1	Development consultant
NFM1	Local authority NFM expert
NFM2	Local authority NFM expert

interviews in March 2022 linked to institutional staff changes. They included key stakeholders involved in FRM governance (cf. Fig. 2), including local authority officers, national agency specialists, water company technicians and consultants who have advised developers on the implementation of SuDS features (Table 1). Local authority flood risk officials and NFM experts are distinct; the former hold LLFA status, whilst the latter are specialist and project-funded personnel who promote NFM opportunities in their areas, including amongst community or land management networks. Water company informants expressed interest in NBS as potentially cost effective and environmentally sensitive upstream interventions with multiple functions. The selection of interviewees was informed by authors' previous involvement in the Horizon project ROBUST (www.rural-urban.eu), which focused on the governance of rural-urban linkages in 11 locations, including Gloucestershire. Authors drew on contacts gleaned in ROBUST (methodology on project website) and requested further onward referral to include participants to capture responses from across the different roles within the FRM governance structure. Our cohort of interviewees was limited by research capacity and funding and could have benefitted from the inclusion of additional stakeholders such as representatives of internal drainage boards, the Highways Agency and land holders.

Semi-structured interviews were conducted online using Microsoft Teams and lasted between 35 and 70 min. Interviews were anonymised, to encourage openness and frankness. While several participants are public servants, it was felt important to glean opinions based on practice in relation to NBS implementation and planning, to complement official policy or institutional framings. Interview questions were arranged into three broad clusters: (1) definitional understandings of NBS and SuDS; (2) discussion about local NFM/SuDS practice including benefits, challenges and future opportunities; and (3) feedback on key actors in NFM/SuDS implementation in terms of practice and policymaking.

Interviews were transcribed by team members and manually thematically coded [36] to expose key discussion topics. Through internal discussions, these were refined into the main thematic clusters used to structure the next section.

Main findings and discussion

The key findings are grouped into two broad categories. The first outlines impediments which face LLFAs in implementing NBS in their area, sub-ordinated into three sub-categories: different spatial NBS understandings; implementation and planning challenges; and, monitoring and maintaining NBS. The second broad category highlights the need for effective NBS governance, sub-ordinated within policy links, and then community involvement and incentivisation. The objective throughout this section is to highlight the different perceptions of NFM and SuDS in praxis.

Impediments to implementing NBS

Different spatial NBS understandings

Interview data reveal wide interpretation of the specificities of NFM and SuDS, usually linked to spatial and functional divisions of interventions. Two quotations provide a representation of this within the cohort:

'They are both elements of working with natural processes, but they have slightly different focuses, priorities, locations… NFM's very much a flood risk management focus, and SuDS tend to be used generally to address sewer networks and new development sites.' (LA1)

'SuDS is usually used in the urban setting and NFM is usually used in the rural or upper catchment setting… all part of the toolkit to try and reduce flood risk for down-stream residents.' (NFM1)

Context specificities can reinforce functional and spatial divides; this is demonstrated in the context of the water company, with WT1 and WT2 stating that NFM measures are associated with rural amenities such as swales which can help mitigate pesticide run-off from farmland, whilst SuDS can help protect water company assets by holding back water from the sewer outflows.

The rural-urban distinction is further emphasised by associating urban areas with a downstream catchment position:

'I'm very definite that they are separate … NFM is a very naturalistic approach, it's best characterised by use in headwaters and small watercourses. Whereas SuDS is an engineered structure, which uses many characteristics of natural processes but has a distinctly different environment. It's lower down the system, it's in the urban environment…' (GV2)

A unified idea was also held, although the speaker emphasised that, in practice, the government agency confirms rural-urban divisions because it is asked to consult on planning applications (involving SuDS), distinctly from advising on flood risk environmental/habitat NFM projects:

'…absolutely, yes, [NFM and SuDS] can be used interchangeably… I don't see the benefit of specifying one term over another. I don't think it matters; it's about using the right tool in the right location.' (GV1)

Pragmatism also emerges, and debates apparently cause frustration:

'Ever since I've been doing it, people have been arguing … over what it is and what it isn't… I do get quite frustrated sometimes … it's fairly straightforward. To me, it's all about dealing with water as near to where it falls as possible, and that's it!' (LA2).

LA2 felt that NFM remains an unfamiliar concept at the community level which can lead to confusion:

'…the knowledge of NFM is only really just starting to find its feet within communities. SuDS is a little bit more widely known, particularly in urban areas. … [NFM] is a fairly new thing, and it's quite a hard thing for [people] to get [their] head around.' (CS1)

All the interviewees agreed that there are funding, implementation and structural procedures embedded within the FRM governance structure which necessitate the separation of NFM and SuDS on the basis of their function and location [19,20]. This view pervades the practical application of these interventions and prevents the holistic management of NBS at a wider catchment-scale [21,23].

Implementation and planning challenges

Despite flood risk benefits, NBS remain niche, supplementary interventions alongside 'hard' engineering [7]. This is because processes of implementation and management are flawed from the outset, it was claimed. In the case of SuDS, this can be linked to the way that developer-led maintenance companies are engaged to maintain features in the UK, as well as a lack of capacity in development control and flood risk teams:

'… developers are going their own way and it's [a challenge]! We've had a few developments … where the developer has not passed on the space and SuDS features to the local authority, and they've formed their own management company. Then, they [excessively charge] the

homeowners for a maintenance fee.' (LA2)

This is echoed in another LLFA:

'…particularly on small sites, [developers] set up limited companies of consortiums for the duration of the development site, and they fold them at the end of each development, and they walk away.' (LA1).

LLFA flood risk teams remain under-resourced and face increases in severe weather workloads:

'…we had six times as many internal floods last year as we did in the last five years put together… We offer to adopt SuDS on new development sites. We require 50-year commuted sums, which [means] operating at a 50-year loss because the standard design life of a new development should be 100 years. … we were not competitive with management companies.' (LA1)

On the other hand, administrative complexities can be frustrating or unclear for developers who have diverse responsibilities for completing highways and housing works, while future responsibility for maintenance is not clear. In one case:

'…the developer was saying "we're not going to do all these SuDS because [the water company] and [the council is] aren't going to adopt them".' (LA2)

Another problem is highlighted in the gap between the intention in the development plan and the reality after the development is completed:

'As a planning authority, [enforcement] is really quite hard. You can ensure it's being built in accordance with the plan. … The only time you know about it is when it doesn't work and then people jump up and down and demand we fix it.' (LA2)

Finally, despite development controls and policies which favour NBS, interviewees have implied that not all agreed measures materialise:

'… [with some major housing development schemes] you might have got a half-decent scheme at planning. Just look at how that's diminished and the difference that there is when it's implemented.' (DV1)

Monitoring and maintaining NBS

A challenge raised in relation to extending NBS implementation was the complexity of monitoring. This needs a longitudinal approach, can involve multiple parties, and the particularities of each intervention adds complications to monitoring designs and methodologies [19,24]. Comparison between different interventions in different places/times is difficult [23,24]. There is uncertainty about who, in multi-stakeholder NFM arrangements, is responsible for monitoring and maintenance:

'Where SuDS are on our land, we tend to inspect them quarterly… We have commuted sums [from developers] for maintaining them. When they're not our systems, no-one is monitoring them. No-one is even monitoring what is installed on some of the housing sites, particularly the medium-sized ones.' (LA1)

The difficulty of isolating the impacts of flood risk NBS is not simply about the diversity of structures and the organisation of maintenance. When installing flood risk measures:

'…there are certain legal obligations to adhere to and you've got to have revenue money, budgets in place each year to monitor and maintain these structures. Where there has been one [hard engineering] impairment that stores 100,000m^3 or whatever, you could have 50, 60, 100, 200 smaller [NFM] interventions. (GV1)

Co-ordinating multiple permissions and multiple partners can be challenging, involving multiple agencies, such as those responsible for roads, the environment, regulatory bodies, local and regional government as well as landowners [22]. Such complexity expands if interventions require the co-operation of and access permission from private stakeholders. This reflects the perception that NFM is a piecemeal, complementary approach, rather than something strategic [22]; by contrast, SuDS are linked to the regulated planning system (however imperfectly) making them organisationally more manageable [15,16]. Strategic approaches do not usually prioritise 'soft' measures, the benefits of which can be unclear at the project planning stage. For example, the prospect of marginally lower water bills for farmers compared to converting productive land for NFM may not be an adequate short-term incentive. It was suggested (by WT1 & WT2) that water company staff might be periodically seconded to LLFAs or EA to enhance partnership relations.

Questions remain about the lifetime of NFM features such as leaky dams, and their performance over time or during heavy flooding, especially as:

'…a lot of these schemes have gone in within the last 10 years, they haven't needed maintenance yet. Consequently, I think a lot of these solutions to these potential problems will be made as we go along … over time, you can assess how well these features are working.' (GV1).

NFM does not easily conform to Defra's grant-in-aid OM criteria [28], for example by reducing flood risk for the highest density of properties, or reducing the impacts of a serious flood event (less likely in a catchment headland):

'…monitoring these catchments through gauging will be vital to produce evidence for future schemes. … With some schemes, the modelling of some catchments costs more than the interventions themselves… The current funding regime is geared towards more traditional intervention techniques, engineering solutions. The consequence of that is that you have to retrofit the NFM schemes to funding criteria that was never designed to support NFM.' (GV1)

RFCC local levy funds and recent Defra NFM pilot projects [37] were effective ways to promote NFM experimental practice. Even so, excellent progress may be hampered by limited resources:

'Ensuring the projects have the right access to expensive equipment, for some of the smaller community projects that are really good at delivery but don't have the bigger budgets for monitoring. We've had great capital and support for project delivery and implementation, but our monitoring has come second to that … we don't have the resources to do the in-depth monitoring'. (NFM1)

Some water companies have trialled experimental SuDS monitoring, yet if this extends beyond the boundaries of 5-year funding cycles these organisations work to, innovation may be constrained (WT2). Notably, GV2 suggested NFM monitoring should extend up to 20 years and while water companies need to know the whole life cost of NBS interventions, many have not yet been in place for long.

Both water company interviewees highlighted a prevailing 'culture of hard engineering', which is easier to quantify than NBS in terms of costs, benefits, and maintenance needs. Furthermore, community benefits of 'soft' interventions are not always considered the direct responsibility of the utility companies, who are risk/liability averse in cases where NBS interventions are publicly accessible.

Risk aversion is not universal. NFM1 described a project where annual monitoring of NFM installations by parish volunteers and land holders *'…is enough to check on structures to make sure that they are still functional and providing NFM benefit'*. However, as the project has grown to include over 600 interventions along the catchment, it has become necessary to *'bring a greater formality to that [monitoring] process'*, including a Memorandum of Understanding for partners:

'…we also have a monitoring partnership with interested parties. These include some of the … NGOs. [The local university] has a number of specific research interests linked to NFM. The Environment Agency and local authorities are more interested in monitoring the flood alleviation benefits and the functionality and the maintenance of the individual structures and the risk. These parties all form a monitoring partnership. We come together to share learning between us all.' (NFM1).

Interviewees called for research on whole-life cost of interventions, plus national-scale and long-term monitoring so that experiences can reach beyond localised case studies. Others advocated research into householder knowledge of the benefits of NBS and ways to extend household incentives more systematically. Broadcasting pioneering experiences from continental Europe and the USA were highlighted to routinise knowledge of NBS practices, and to move past continuing

debates about efficacy:

'… if you look worldwide, these things work… I'd like to have research that said: let's accept that these methods do work, so how do we make them work better in the longer term? How do we improve what we know …? How do we integrate them more thoroughly in the day-to-day?' (DV1)

'We know it works, but does it actually make a measurable difference to people's experience of flooding? Our profession is full of people who want a number [that connects cause and effect]. And sometimes you don't know… ' (LA2)

The need for effective NBS governance

Policy links

There was limited consensus that the UK-EU Withdrawal (Brexit) [38] in this context is an opportunity to re-think land management via new funding mechanisms. Initial proposals emerged from Defra's [39] document, where the idea of a new Environmental Land Management scheme (ELMs) focusing on 'actions' rather than 'support', using the phrase 'public money for public goods'. There was initially wide-spread support for this approach and applications for NBS were foreseen, underpinned by the UK Governments' Agriculture Act 2021, which shifted soil management from a 'private' benefit to a 'public' one. This means resources can be prioritised for actions that result in increasing soil function. However, the development of ELMs has been slow, including retaining the 'income foregone' payment system, which presents a challenge to NBS as benefits do not fit a conventional cost-benefit analysis.

Other concerns with ELMs centre around the potential for local intervention strategies that do not include NBS but focus on 'priority' or 'vulnerable' areas, when NFM options such as soil and land management are most effective if widely adopted across a catchment-scale. This is important in relation to aligning farming and environmental/conservation interests:

'It's important that flood risk measures are planned in the context of the wider catchment management … not just in isolation. That's why we have a multi-partner approach [here]. … The catchment-based approach requires a join-up between all these policies to ensure they're delivering NFM appropriately' (NFM1).

As SuDS implementation expands, new regulatory frameworks have also been mandated; from 2015 installation of SuDS are required for most developments of more than 10 homes in England [40], and in Wales since 2019 SuDS are required for all new developments of more than one house or where the construction area is 100m^2 or more [41]. However, the process for delivery was critiqued in a review [42], both in terms of the initial decision and subsequent inspections. Changes to the current system have been proposed and are undergoing consultation, with results planned for introduction in 2024. This is something LLFAs are keenly aware of:

'No-one is managing the implementation and construction, and if it's not a big, visible site, or if it's a buried SuDS system, who knows… If Schedule 3 of the Flood and Water Management Act [40] had been enacted, we'd have SuDS approval bodies, and there would be mechanisms to fund the regulation and on-going management and maintenance of those features.' (LA1)

Defra [42] found that existing planning provisions are sufficient. Indeed:

'…our Local Plan has been updated and the [person] who does the consenting and consults on the planning applications, he's worked with the planning team to ensure we include more support for SuDS and NFM. In addition, the [regional council] is revising its 10-year FRM Strategy by 2024 and that will include provisions for NFM. Similarly, the [local] Climate Change Strategy also includes NFM…' (NFM1)

Flood and biodiversity policy objectives can both be met through NFM and SuDS interventions:

'…in terms of climate policies … SuDS are quite important. Urban areas are phenomenally diverse habitats and these days, actually, most of the wildlife is in urban areas, not in the countryside, which is often highly monocultural. SuDS really do make a significant difference because they provide that rich [habitat] fabric and connectivity within urban areas because they allow species to move around and multiply' (LA2).

However, there was a sense among interviewees that policy remains both disjointed and prolific. For example:

'We have a local FRM strategy, every LLFA's got their own strategy. It's a little bit of a nightmare between drainage and wastewater management plans and local FRM strategies and catchment-based approach plans, and currently the Environment Agency is rewriting the pumps risk management plans for the catchment… you could spend days trying to get a handle on all the various different plans' (LA1).

The common factor in these assertions is the impact of climate change and connecting issues such as flooding with health and well-being. For example, the National Flood and Coastal Risk Management Strategy [41,43] includes holistic objectives relating to health and well-being, which inform local level actions which LLFAs are well-placed to implement. In addition, signs of design innovation are evident, such as SuDS adoption by water companies as FRM for 1-in-100 years events [44].

'Having an authority who can do that, that is responsible and has an income, is a massive step forward…' (LA1)

'Communities' and how to incentivise them

Diversity understandings of NFM/SuDS also applies to 'communities'. Interviewees (LA2, CV1, WT1 and WT2) applied this description to residents and businesses in the case of SuDS, because FRM prioritises the protection of people and property. When discussing NFM measures, interviewees (GV1, GV2, NFM1) regarded the community as local landholders/contractors and the local residents who are involved in monitoring activities.

Community involvement was presented as a vital part of SuDS and NFM that aligns with the principles of NBS [3,5]. Private homeowners need to be involved in SuDS maintenance contracts and the implementation of NFM measures require the arrangement of permissions, access and works. Further, WT2 described the community amenity potentials (and associated liabilities) of some urban SuDS, such as ponds. Ominously, the need to manage community expectations is emphasised, because at the *'…next big flood…a lot of the measures we put in with NFM probably won't hold'*. (GV1)

A different narrative emerges where communities are essential to embracing the atomised approach to SuDS/NFM:

'…a stronger community voice is needed, especially as a [policy] aim is climate resilient communities… they need to feel more empowered in having that voice with all agencies… Often they feel like SuDS/NFM is something that's being done to them, not something that's done for them or with them'. (LA1)

The National Flood Forum, an organisation in the UK that supports citizens affected by flooding, plugs an important gap, in this respect, linked to the limitations of official capacity:

'The community are experts in their own area. … I think we're terrible at that community side of things, we're used to having professionals and organisations'. (LA1)

Interviewees (CS1, WT2) stressed that micro-scale domestic measures should be promoted, such as installing water butts, raising wall sockets and installing stone floors where possible. Industry and commercial actors are also part of a community of responsibility:

'…we want… this to transcend sectors. We don't want this just to be a water-environment issue… it has to be a societal thing that everybody does… there needs to be a financial motivation for them to come to the table'. (GV1)

Here, rural-urban divides remain evident through the concept of community. The SuDS challenges outlined contrast to a sense of community agency and empowerment in relation to NFM. In one scheme,

the community proactively approached flood risk agencies after severe floods and campaigned for better flood protection, which ultimately resulted the implementation of an NFM scheme of interventions across the catchment funded through the RFCC local levy:

'One of the key drivers of the project is the good relations with the landowners. It's one of the main bottlenecks and key influencers on whether we are successful in our project delivery. It's essential that we have good relations with our landowners in order to implement good NFM schemes. We take a co-design approach, [via] NFM. It may not always be the best NFM feature for flood attenuation or alleviation benefit… . It fits in with the landscape but also works for the landowner on a working farm'. (NFM1)

Positive community engagement can help mitigate some of the post-development maintenance challenges of SuDS, outlined earlier:

'…we'd done a community engagement [process] so they fully understood this was a drainage system. They chose the plants, we gave them colour pallets to choose from… They could choose the shape they wanted and where it was located so … they got the ownership.' (DV1)

The application of network governance to NBS

Reflecting on network governance effectiveness [34,35], three governance formats of the English Severn and Wye are shown in Table 2. Two were introduced in Section 'Network governance – a route towards NBS integration?', namely the RFCC and its constituent LLFAs, with a third format, participant-governed networks arising from our empirical data (Section 'Monitoring and maintaining NBS') in the shape of monitoring networks. These were presented in a formal iteration with network structured through a memorandum of understanding between its members and the project co-ordinator, and an informal network of local people and landowners who, as regular countryside users and managers, inspect the condition of NBS features.

A challenge for NBS management in the network administrative format is that the 12 RFCCs have a variable approach to the implementation of nature-based FRM. Furthermore, although elected councillors connect LLFAs in any RFCC region, LLFAs still tend to operate substantially within the constraints and contexts of their own democratic and administrative territories, especially when it comes to responding to flood risk mitigations linked to urban development. Data reveal how individual LLFAs struggle to implement or regulate some NBS practices, while the RFCC is able, as a network governance format, to harness and combine individual LLFA support around NBS in the catchment. Finally, participant-governed networks offer flexibility and complementarity to the other two network governance formats and clearly hold potential in urban settings, for example to help monitor publicly accessible SuDS.

Finally, we reflect on the three research questions. First, the perspective of FRM managers and practitioners reveal different spatial NBS understandings, planning challenges and maintenance issues that reinforce the separation between SuDS and NFM. Second, the challenges that this separation presents are manifested in parallel governance systems, policies, and practitioner culture for both NFM and SuDS, impacting the decision making process. Third, Table 2 presents effective network governance arrangements that can help optimise an integrated catchment-based NBS, overcoming functional and spatial separations between SuDS and NFM.

Summary

Past NBS discussion in the UK has concerned the efficacy of NFM and SuDS [7–12] with less attention to the challenges that practitioners face in advocating for and implementing these techniques [22]. These challenges represent persistent barriers to effective catchment-scale NBS operations. This article reveals such barriers to NBS expansion due to binary spatial and functional thinking, implementation and planning challenges and limited monitoring capacity. Data supports assertions that SuDS and NFM should be regarded as integrated tools in the mission to enhance NBS to flood risk within catchments [5,7,8,19,23], thereby overcoming rural-urban divides. Divides are rooted in territorially delineated governance arrangements for FRM that, until recently, have changed at the county boundary; or have suffered from governance formats that struggle to integrate land use and fluvial management. This is partially linked to the complexity of FRM policy and implementation over different scales (local, regional, national). Spatial and functional separations limit the potential of NBS techniques, most particularly in development but also in practitioners' room for manoeuvre when advocating catchment approaches to FRM.

Agreement exists that SuDS and NFM interventions are effective but must be monitored and evaluated longitudinally to assess whole life costs. Who is responsible for long-term maintenance and monitoring of interventions is unclear, and focus has primarily been on academic assessments of NFM. SuDS monitoring remains limited. Such assertions indicate the need for clearer policy guidance in the UK. Meanwhile, central government has entrusted regional FRM governance to networks

Table 2
Network governance effectiveness within the English Severn and Wye RFCC region arising from this research (categories drawn from [34]).

Governance form	Trust	No. Of participants	Goal consensus	Network level competences
Administrative (RFCC)	Moderate: high 'density' and reciprocal trust linked to combination of top-down network structure with flexibility to embrace local contexts. Democratic decision-making via LLFA politicians.	Moderate: one elected representative from each of the eight LLFAs.	High: ability to directly inform public funding allocation for local NBS implementation. Commitment to achieving collaborative catchment-scale NBS through the establishment of a dedicated sub-group chaired by RFCC non-political member.	High: based on dedicated administrative and secretariat support offered by the national Environment Agency.
Lead organisation (LLFAs)	Low: NBS prioritisation may depend on political support, e.g. in response to need for FRM to be seen to be solid, not experimental.	Low: related functions including development control, emergency planning, FRM, are led by the local authority but NBS officers perceive NBS struggles to resonate.	Low-moderate: room for manoeuvre is constrained by the planning system and the local authorities' ability to regulate development conditions, despite the emergence of national guidance.	Low-moderate: NBS staff capacity is limited as is horizontal integration across departments.
Participant-governed	Moderate- high: trust is invested to contribute to specific NBS monitoring functions. Levels of contact, e.g. land manager peer group, land manager– community, university- community etc., may build and enhance local trust networks as an outcome of network governance arrangements.	High: in some cases, hundreds of individuals are involved. Membership can change over time as long as initial instructions are available and are followed.	High: FRM is a shared concern for the monitoring networks.	Low-moderate: regular reporting is adequate in some cases, while the potential for training a large number of individuals to take technical readings and report these depends on the availability of technical equipment; essential specialist knowledge can be easily learned.

which themselves must foster and secure internal trust commensurate with the size of the network and the scope of the catchment.

Lock-ins in NFM/SUDs separations reveal limited municipal capacity despite increased flood incidents facing local authorities, and challenges in monitoring huge numbers of NBS interventions. For the latter, ways to empower and place trust in community members for delegated and funded maintenance offer potential through existing planning tools. To foster such innovations, network governance is essential, helping to convert complex, numerous and multiple scale policy contexts into local opportunities, and in sharing and multiplying good practice from the margins into meaningful multi-actor alliances with real decision-making power.

In this article, three network governance formats have been used to study the region of the English Severn and Wye RFCC region and their effectiveness evaluated in relation to empirical research findings. Clearly, the UK context is very specific; but the introduction of network governance seems highly necessary in the transition from local municipal (rural/urban) FRM to cross-sectoral catchment partnerships which elevate and integrate the role of NBS beyond the margins of carbon-costly hard engineering. As is the case here, a combination of network governance formats may be necessary, with network administrative organisations helping to unify governance and dissemination arrangements, participant governed networks empowered as monitoring nodes, leaving lead organisation formats to act as local action enablers including, importantly, forging much stronger links between internal regulatory functions to better connect statutory climate, planning and flood responsibilities. In short, the optimisation of catchment-scale NBS requires the proliferation of new network governance arrangements, some of which may need to be as experimental as the NBS interventions trialled. The cross-sectoral challenges of handling flood risk, in experiences here, seem viable in the face of shared interest to create change.

Ethical declaration

This research conforms to regulations set out by the University of Gloucestershire's Ethics Committee pertaining to the School of Natural, Social & Sports Sciences at the time the research was carried out. Interviewees were provided with *Participation Information Sheets* and *Debrief Forms.* These documents set out the University's responsibilities as a data controller and set out how interview data is stored and ultimately deleted. They indicate the right of interviewees to withdraw their data at any time. Interviewees signed an *Informed Consent Form* before participating in the interview.

Declaration of Competing Interest

None.

Data availability

The data that has been used is confidential.

Acknowledgements

The authors acknowledge funding via the University of Gloucestershire's QR Policy Support Fund . Sincere thanks are extended to the interviewees, who were so generous with their time and support. The authors also thank the anonymous reviewers for their insightful, helpful and constructive comments.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.nbsj.2023.100096.

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