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Mainstreaming nature-based solutions: What role do Communities of Practice play in delivering a paradigm shift?

Phoebe King [a,b,*], Julia Martin-Ortega [a], Jennifer Armstrong [a], Marie Ferré [a,c,d], Rosalind H. Bark [b]

[a] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Woodhouse lane, LS2 9JT, UK
[b] School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, Norfolk NR4 7TJ, UK
[c] UMR Innovation, French Agricultural Research Centre for International Development (CIRAD), Montpellier, France
[d] University of Montpellier, Montpellier, France

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ABSTRACT

As the urgency to adapt to climate change intensifies, nature-based solutions (NBS) are receiving increasing attention. To mainstream NBS, a fundamental shift in environmental management is required. This study evaluates the role that Communities of Practice (CoP) can play as platforms to foster social learning to drive such a paradigm shift. A Natural Flood Management (NFM) CoP in Yorkshire, UK, was used as a case study. A unique research design combined opportunistic data collected prior to the inception of the CoP and purposive data collected during and after its formation. Opportunistic data captured information from stakeholders regarding NFM engagement and challenges around its instalment and delivery. Purposive data was used to examine the ability of a CoP to foster social learning, overcome the challenges identified prior to its establishment and evaluate the extent to which a CoP contributes to inducing a NBS paradigm shift, using a multi-loop social learning framework. Results demonstrate that the CoP was effective in delivering social learning and improving NFM instalment and delivery. While most evidence of social learning point to incremental rather than transformational changes, it did reveal abundant questioning of the current framing of flood management. Furthermore, the CoP seems to have encouraged some participants to re-think the current governance structures for NFM and the boundaries of current actor networks, raising promise that, if sustained in the longer term, the CoP could induce a paradigm shift. Further research should conduct longitudinal studies to examine the CoP's development overtime and its potential for overcoming current constraints.

1. Introduction

As the urgency to adapt to climate change intensifies, scholars are increasingly advocating the need to *work with nature* through the implementation of Nature-Based Solutions (NBS) (Lane, 2017; Zandersen et al., 2021). NBS consist of measures inspired and supported by nature that work to address socio-environmental challenges, aiming to provide benefits for both the environment and human wellbeing (European Commission, 2015). This approach is also gaining traction among policymakers internationally (Bridges et al., 2018), in the EU (Environment, 2015) and at national levels, such as in the UK (HM Government, 2020), as well as among non-governmental conservation groups (Cohen-Shacham et al., 2016).

In contrast to traditional forms of environmental management, which tend to involve technical experts and isolated engineered structures (Cook et al., 2016), the nature-based approach entails wholescape thinking, multidisciplinary working, and polycentric governance (Hartmann et al., 2019; Dushkova, Haase, 2020). Switching from civil engineering to NBS is not just a technical adjustment but it calls for a paradigm shift from *predict and control* to *adaptive management* (Moreau et al., 2022). This paradigm shift, in the Kuhnian sense (Kuhn, 1962), occurs when the routines and norms are replaced with a new set of standards and ways of thinking which integrate working with natural processes. Achieving a paradigm shift is notoriously difficult. To date, rhetorical support for NBS is often not matched by suitable policy or resources (Bark et al., 2021), suggesting NBS are being inserted into an existing paradigm where technical solutions and technocratic ways of working remain strongly embedded within governance and

* Corresponding author at: School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, Norfolk NR4 7TJ, UK.
E-mail address: phoebe.king@uea.ac.uk (P. King).

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organisations (Waylen et al., 2015; Cook et al., 2016; Bark et al., 2021).

NBS are multi-faceted, requiring diverse stakeholder coordination (Hartmann et al., 2019) and for whom a new paradigm can lead to uncomfortable discussions. For example, Waylen et al. (2015) noted the challenge of aligning the expertise and knowledge of flood risk management (FRM) engineers with new NBS ways of working. To facilitate discussions, align stakeholder values, and promote positive behavioural change that encourages the uptake of NBS, scholars are calling for the consideration of social learning models (Waylen et al., 2018; Moreau et al., 2022). Social learning enables collaboration between people from different areas of expertise, providing opportunities for knowledge sharing and co-creation (Pahl-Wostl, 2002, 2009; Johannessen and Hahn, 2013; Rodela, Gerger Swartling, 2019; Johannessen et al., 2019).

To date, NBS research has primarily focused on technical aspects, such as their effectiveness for adapting to environmental change (e.g., Calliari et al., 2019; Chausson et al., 2020; Seddon et al., 2020), enablers and challenges to implementation (e.g., Ershad Sarabi et al., 2019; Nelson et al., 2020), core principles linked to upscaling (e.g., Frantzeskaki et al., 2019; Cohen-Shacham et al., 2019) and potential for disaster risk reduction (Tyllianakis et al., 2022). The literature recognises that mainstreaming NBS will require a re-thinking of human-natural relations and multi-stakeholder collaboration (Nelson et al., 2020;Frantzeskaki et al., 2019) . For example, Moreau et al. (2022) conclude that social learning is required between risk managers and NBS practitioners to support an adaptive management approach where NBS are implemented at scale. Whilst some literature evaluates the role of social learning within NBS uptake (van der Jagt et al., 2019; Eastwood et al., 2022; Kiss et al., 2022), the extent to which social learning may facilitate a paradigm shift has yet to be explored.

A conducive environment for social learning and transformative change requires informal learning networks (Waylen et al., 2018; Marshall et al., 2019; Ngai et al., 2020). The present study examines a Community of Practice (CoP) to assess the role such informal structures can play in fostering social learning and evaluate to what extent this might facilitate a paradigm shift for NBS. A CoP refers to groups who 'share a concern, a set of problems, or a passion about a topic and who wish to deepen their knowledge and expertise in this area by interacting on an ongoing basis' (Wenger et al., 2002, p. 4). The concept of a CoP has been applied across multiple social science disciplines and professional fields since it was first introduced by Jean Lave, Wenger (1991) and Koliba and Gajda (2009). However, CoPs continue to be largely under-operationalised within the field of environmental management (Tran et al., 2018).

In this paper we ask: i) Is there a demand and role for CoPs in the development of NBS?; ii) Can a CoP foster social learning supporting the development of NBS?; and, ultimately, iii) can CoPs facilitate a NBS paradigm shift?

To address these questions, we use an example of a natural flood management (NFM) CoP in the UK to provide insights to NBS knowledge and practice, feeding into the environmental governance discussion on how we manage our relationship with nature in an increasingly changing and uncertain world.

2. Theoretical framework: multi-loop social learning

Social learning has been applied to help align stakeholder values and instigate change (Pahl-Wostl, 2009; Benson et al., 2016; Ngai et al., 2020). By understanding conducive conditions for social learning (e.g., within a CoP), a change in stakeholder mindset can be examined more closely. Pahl-Wostl (2006) argues that institutions, such as those involved in river basin management, will follow embedded rules, laws, customs, and norms that may constrain stakeholders' learning as new knowledge or actions may not fit into the existing mould of how 'things are done'. Moreover, embedded institutional values which are difficult to shift can constrain learning (Johannessen and Hahn, 2013; O'Donnell et al., 2018). Therefore, scholars have applied the theory of multi-loop social learning (MLSL) as a diagnostic tool to reference different levels of social learning within a group setting (e.g., Martin-Ortega et al., 2022; Brown et al., 2016; Benson et al., 2016; Johannessen and Hahn, 2013).

Despite the use of social learning to diagnose potential transformative change in FRM (den Boer et al., 2019) and water governance (Johannessen et al., 2019; Johannessen, Mostert, 2020), there is limited research on the ability of a CoP to foster this social learning and enable a paradigm shift. Maidl and Buchecker (2021) examine social learning within a CoP in the field of risk management, however, they do not apply a MLSL framework, and thus it is difficult to distinguish the level of social learning occurring within a CoP and its contribution to a paradigmatic change.

In the MLSL framework, the first loop (single-loop learning), may include incremental improvements or refinements to established actions to improve performance without altering underlying routines, norms or values (Hargrove, 2002). Double-loop learning involves incorporating new information which does not fit within existing patterns and schemes. The learner may question the rationale for taking a particular action (Huntjens et al., 2012), asking – 'Are we doing things right?' (Johannessen et al., 2019). Triple loop learning entails a paradigm shift within the whole system in which management practices and governance are based (Huntjens et al., 2012). This loop involves the restructuring of policies, rules and decision-making processes, addressing the question: 'How do we decide what is right?' (Medema et al., 2014). The elusive third loop(Martin-Ortega et al., 2022), is particularly relevant for understanding the extent to which social learning can facilitate regime transformation.

When applying this framework to empirical studies, fluidity between the loops has been evidenced (Fabricius and Cundill, 2014; Johannessen et al., 2019), suggesting that thoughts and behaviours may not distinctly be associated with a particular loop, rather they may merge across multiple loops. Considering this, the present study applies MLSL theory as a framework to analyse the value of social learning beyond the acquisition of new knowledge (e.g., 'surface-level learning' Reed et al., 2010), using the loops not as discreet categories but as reference points to evaluate the extent to which learning has altered participants' ways of thinking and acting, e.g., 'cognitive change' (Bos et al., 2013), and the extent to which they may be moving closer to more transformative change.

3. Materials and methodology

NBS are advocated to deal with complex and multi-faceted environmental issues, also referred to as 'wicked' problems (Rittel, Webber, 1973), that require new ways of thinking and the integration of disciplines and stakeholder engagement (Markowska et al., 2020; Duckett et al., 2016). Research designs must adapt to make use of different sources of data to fully understand these processes. This study follows an innovative and partially 'opportunistic' mixed methods approach whereby different sources of data are utilised as they emerge from an evolving NFM CoP.

3.1. Case study: the iCASP Yorkshire NFM CoP

A prominent example of NBS is NFM. NFM involves 'techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters' (SEPA, 2015, page 6), to attenuate or slow the flow of water (Lane, 2017; Wingfield et al., 2019). In contrast to traditional forms of FRM (engineering techniques, hard flood defences), the uptake of NFM requires a breakdown of dominant existing mentalities to *work with water* rather than *against it*. This has led to some resistance to integrate it into FRM strategies, principally due to uncertainty around effectiveness, particularly from those from flood engineering backgrounds (Waylen et al., 2018).

Since the early 2000s political support for NFM has grown in the UK.

In 2004, the Department for Environment, Food and Rural Affairs (DEFRA) launched a national strategy 'Making Space for Water' (DEFRA, 2004) and NFM features prominently in the 25-year Environmental Plan (DEFRA, 2018), which allocated £ 15 million to support 60 pilot NFM schemes across England (Environment Agency, 2017). Despite this funding, implementation of NFM continues to face challenges, including complex funding application processes, lack of standardised guidelines, incomplete data on the effectiveness of interventions, and inaccessible and/or complex modelling and monitoring tools (Ngai et al., 2020; Waylen et al., 2018; Dadson et al., 2017). In 2018, the Integrated Catchment Management Programme (iCASP),[1] began to provide support to the DEFRA NFM pilot projects in Yorkshire by creating, hosting and facilitating a NFM CoP to address challenges faced by NFM practitioners. A demand for a collaborative platform for networking, learning and disseminating NFM best practice arose, leading to the continued development and growth of the regional NFM CoP (hereafter the CoP).

Within the timeframe of this study (July 2018 - October 2020), the CoP grew from 30 to over 50 participants. A range of organisations actively participated (25 in total), including local authorities, statutory environmental organisations, water utilities, conservation organisations and academics. It hosted quarterly events with six meetings over the 27-month period. The participants co-designed the events schedule with events typically lasting a full day with a mix of site visit(s) and themed workshops (e.g., monitoring and modelling guidance, opportunity mapping for NFM, and funding opportunities).

This CoP is an ideal candidate to assess the impact of evolving social learning opportunities amongst stakeholders as well as its effect on NFM activity and practices more generally. Through evaluating the various levels and degrees of learning which occur among CoP participants, we analyse whether social learning can break down pre-existing assumptions and shift values, norms and routines of flood management stakeholders to consider the application of NBS and thus, encourage a paradigm shift.

3.2. Research design

The research design selected combines a 'purposive' and 'opportunistic', mixed methods framework. Specifically, opportunistic data (OD) had been collected before the formalisation of the CoP, from participants who did and did not eventually form part of the CoP, and purposive data (PD) collected the views and experiences of CoP members to analyse social learning. Fig. 1 records the data collection timeline.

3.3. Data and analysis

The research design enabled the analysis of a learning network at different stages of development and the evolving mindsets of CoP members, as well as, gathering contextual input from outside the CoP. Table 1 provides detail on the data collection.

3.3.1. Opportunistic data (OD)

In July 2018, during the early stages of the iCASP NFM project, semi-structured interviews (OD1) were conducted with the NFM pilot scheme managers. Questions were designed to collect details of their interventions, level of knowledge and skills in NFM modelling and monitoring, engagement with landowners and local communities, and challenges relating to the delivery of NFM in their area. This data provided a baseline of the level of practitioners' knowledge, skills and information at the start of the NFM pilots, and an indication of interest in opportunities for more collaboration, such as a CoP. Analysis of OD1 qualitative responses involved thematic grouping and assessing the similarities and differences within themes and descriptive statistics were used for the quantitative data.

In October 2019, an online survey (OD2) was designed to understand community and individual perceptions of NFM and levels of engagement with NFM activities within Yorkshire. The survey was publicised and promoted utilising iCASP's extensive networks, including social media and website. This convenience sampling method could have introduced selection bias (Evans and Mathur, 2005), but this is considered positive in the context of this research which assesses people who consider themselves as part of the community. This survey contextualised the social learning process, by understanding how a range of catchment stakeholders perceive NFM and offered insights into the extent of acceptance it has across the community. Quantitative data was examined, and it was concluded that descriptive statistics were sufficient to capture an understanding of community perceptions and engagement in NFM.

3.3.2. Purposive data (PD)

To understand the role of social learning within a CoP and its value in supporting NFM delivery, PD1 and PD2 were collected from CoP members. In July 2020, eight in-depth semi-structured interviews (PD1) were completed with participants from diverse areas of employment (see Table 1). An interview script was designed to capture three themes: 1) learning experiences at CoP workshops, 2) degree of social learning (single-, double- or triple-loop), and 3) impacts of a CoP on NFM implementation and activity. The number of events that participants had attended ranged from 1 to 5, with the majority attending 4–5 events.

Interview transcripts were coded manually using Pahl-Wostl (2009) six domains to diagnose varied loops of learning and assess the extent to which a CoP can foster social learning between practitioners (Table 2). To capture the practical implications of a CoP for NBS, an open-code approach was taken, where actions taken by CoP members were grouped thematically. In the results section, quotes are provided in italics with the participant ID number and employment sector (e.g., P1/Government agency).

An online questionnaire (PD2) was designed to capture the CoP learning experience and individual actions occurring since attending CoP events. In October 2020, it was publicised at a virtual CoP meeting (53 attendees) and promoted until December 2020 via the aforementioned network. Six responses were collected from CoP members (see Table 1). Like with PD1, open-end responses were coded manually and compared to the pre-established codes provided by the multi-loop learning framework and descriptive statistics were calculated. Individual actions taken since the CoP were also extracted and combined with responses from PD1 to be analysed thematically.

There is a risk that external variables (e.g., other learning events) or internal variables (e.g., pre-existing cognitions, embedded personality traits) could have influenced participant responses. This was mitigated by asking participants to clarify whether changes were caused by the CoP workshops. Thus, examples of single, double, and triple-loop learning identified from PD1 And PD2 should be read with this in mind.

4. Results

4.1. Regional stakeholder engagement with NFM

More than half (N = 22) of the 39 participants who responded to the survey before the CoP formation (OD2), especially those from the public and environmental charity sectors, self-reported that they were highly familiar with the concept of NFM, whilst 3 respondents (all from the farming sector) had never heard of NFM. Among those familiar with NFM, those from private and environmental charity sectors perceived

[1] iCASP is a programme funded by the Natural Environment Research Council to translate existing environmental research into concrete "solutions" and tools, in order to overcome complex environmental challenges (Richardson et al., 2021). It funds regional initiatives designed through co-constructed processes by scientists from local universities and an array of land and water management stakeholders in the region. https://icasp.org.uk/

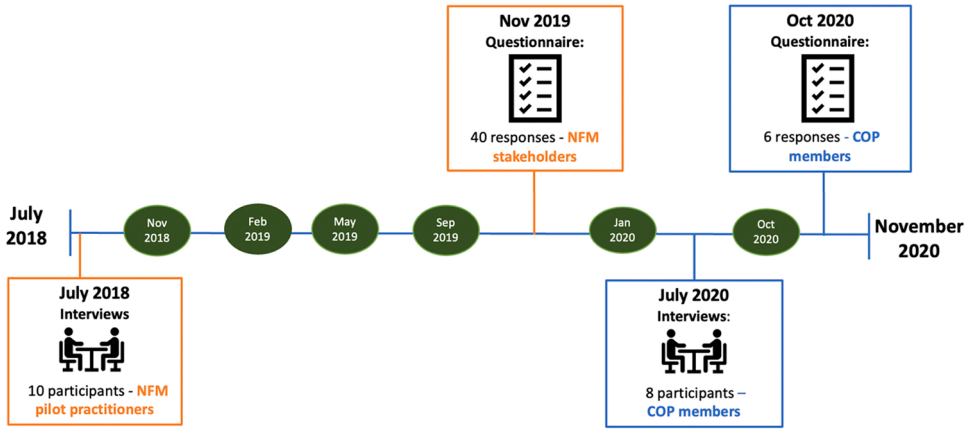

Fig. 1. Timeline: Primary data collection. Note: Green ovals are CoP events and orange/blue boxes indicate OD/PD, respectively.

Table 1
Chronological data collection summary information.

Data	Aim of the data collection	Target sample	Area of employment/ type of organisation	Number of participants	Data collection method
OD1	Identify the types of learning needs and interactions pilot practitioners require to deliver NFM	NFM pilot practitioners	• Non-governmental organisation (NGO) (environment) • Public sector (environment) • Private sector (environment)	10	Interviews
OD2	Explore community perceptions towards and engagement in NFM	Regional NFM stakeholders (Yorkshire)	• Academia • Farming • NGO (environment & other) • Private sector (environment & other) • Public sector (environment & local government)	40	Online questionnaire
PD1	Explore the efficacy of a CoP to foster social learning and evaluate the impact of the CoP on NFM activity	CoP members	• Academia • NGO • Public sector (environment)	8	Interviews
PD2	Supplement the CoP interview data with a closed-questioned version of the interview script	CoP members	• Academia • NGO(environment) • Public (environment/local government)	6	Online questionnaire

NFM measures as rather effective, whereas academics and farmers exhibited a more nuanced perception of the effectiveness of NFM, one farming participant viewing NFM as completely ineffective for delivering flood risk reductions.

Furthermore, just over half of the participants (N = 20) had worked with NFM-related installations in the past 6 months and almost all (N = 36) reported a desire for more NFM to be implemented in their area. Among the various options reported as effective to facilitate NFM implementation, 'Receiving information on NFM effectiveness was rated the highest (N = 23), followed by 'Visiting sites where NFM has been implemented' (N = 17). Two-thirds of participants felt there had been limited opportunities to provide input into the design and delivery of NFM strategies to date.

4.2. Is there a demand for a CoP?

NFM practitioner interviews (OD1) emphasised several challenges to the instalment and delivery of NFM pilots. To overcome these challenges, support was cited to advance landowner collaboration, monitoring and modelling capabilities, resource exchange, coordination between practitioner groups and community engagement. These views demonstrate the demand and rationale for a CoP.

All practitioners felt that more could be done to engage with land managers. Suggestions included building a case for NFM based on a strong evidence base, improving coordination to avoid multiple practitioners bombarding the same land manager, improving links with the National Farmers Union, and more engagement events. These are suggestive of the relevance of a platform to deliver coordination, engagement opportunities, and consolidate resources.

Prior to the CoP, the majority of NFM practitioners neither utilised modelling to inform NFM design and implementation nor monitoring to evaluate their NFM projects. Key challenges around conducting both modelling and monitoring included lack of skill capability, lack of resources (time and funds), poor data availability, complex data logistics and difficulties accessing consultants. Practitioners stated the need for a freely available, easily accessible, and clear guidance from the inception of an NFM project through design, delivery, monitoring and evaluation. At the time of the interviews (July 2018), most practitioners were unaware of where they could access existing guidance or of platforms that they could engage with to facilitate resource exchange.

All practitioners were supportive of combining resources and data on the efficacy of different NFM interventions. Yet despite their willingness to share data, none had publicly shared data on the effectiveness of their NFM pilot project. In addition to reinforcing data exchange, practitioners highlighted the need to: learn from each other and previous mistakes, become more familiar with different interventions and practices, improve access to funds, and save resources by uniting monitoring and modelling efforts. Overall, participants showed a willingness to work collaboratively across the catchment and exchange resources and supported a suitable platform or forum to facilitate these activities.

Lastly, community engagement was recognised as an important aspect of delivery and one that needs attention. Suggestions to foster

Table 2
Key domains to diagnose single, double and triple-loop learning. Taken from Brown et al. (2016), modified from Pahl-Wostl (2009).

	Single-loop: incremental improvements of established routines	Double-loop: reframing of issues and challenging assumptions	Triple-loop: transformation of structures and regimes in place (learning from learning)
Norms	Established norms	Norms questioned	Actions based upon new norms
Actor networks	Same actor networks	Roles and identities questioned; new network considered	Change in networks, roles and power relations
Multi-level interactions	Established vertical patterns	Increased informal knowledge exchange between levels	Polycentric structures; formalised participation and knowledge exchange at different levels
Uncertainties	Risk-averse with limited adaptation and aim to 'reduce uncertainty'	Uncertainty used to identify different perspectives and frames	Uncertainty emphasises different levels and adaptive approaches
Institutions	Existing established institutions	Reinterpretation to encourage innovation beyond established groups	Institutional change or new institutions to enable new paradigms
Governance	No change in the dominant mode	New governance types become visible	New and diverse types of adaptive governance implemented

community engagement included site visits, community funds, informing schools and communities and publishing annual reports. The need for an NFM CoP involving both land managers and community members to enable relationship building, document sharing, idea input and mutual learning, was suggested. This willingness to engage in a CoP was coupled with an acknowledgement that they did not have the resources to start or run it.

4.3. Social learning within the CoP

In Table 3, evidence of social learning following participation in the CoP (PD1 and PD2) is classified according to MLSL diagnostic framework (Table 2).

In the sections that follow, further details of learning by loop are provided, illustrated by participant quotes.

4.3.1. Single-loop learning – incremental improvements to daily routines

Regarding 'norms', all participants reported that the CoP had increased their breadth of understanding of NFM. However, this had not led to major adjustments to their established norms or routines for NFM installation and delivery: '*it broadened my knowledge in terms of different techniques applied, different people involved…but I would say it's probably not that relevant to me*' (P7/Academia).

Some participants expressed that the current regional NFM 'actor network' was sufficient and that the individuals considered important to the delivery of NFM were present at the CoP: '*there are probably groups that we've not been talking to but…the breadth of the CoP is pretty good*' (P2/Environmental NGO). Similarly, top-down interactions established by the traditional FRM paradigm were reinforced for example, '*if we're doing NFM work on all our catchments, information needs to come from the Environment Agency*' (P5/Environmental NGO).

Common participant responses around the 'uncertainties' of NFM delivery and effectiveness, refer to managing expectations, validating impact, maintaining the interventions, and accessing funds. Managing public expectations was a concern for half the participants and ties together with the need for more evidence to ensure the NFM deliverables are not '*overegged*' (P1/Government agency). Others believed that a lack of evidence inhibits NFM profile-raising, '*I don't think we can necessarily see whole scale introduction of NFM as a technique before we can get the basics sorted*' (P5/Environmental NGO).

Concerning 'institutions', established national-level agencies, e.g., the EA,[2] rather than bottom-up stakeholders relied on for NFM delivery, were considered suitable facilitators for the delivery of NFM based on their network and legislation framework. Whilst some participants questioned whether an organisation which historically dealt with technical flood management was suitable for delivering NFM, several participants commented that decision-making should remain with established institutions due to their vast experience in managing flood risk. For example: '*realistically,* [the EA] *are probably the only vehicle that can do* [NFM] *at the national scale…you're never going to get enough people involved outside of a government organisation*'. P2/Environmental NGO concurs, saying '*they* [EA & LAs] *should definitely be the decision-maker on these things because ultimately, it is about flood risk*' (P7/Academia).

4.3.2. Double-loop learning – a reframing of issues and challenging existing assumptions

Regarding 'norms', one participant did question the existing approach to NFM delivery, stating "*people take a narrow prism of what NFM actually is*' (P4/Government agency). This participant explained that '*…leaky dams are really sexy…and it's tangible…whereas, changing the soil, it takes times and doesn't happen overnight*', noting that '*this is about a behaviour change and re-education. I just think people are looking for quick wins*'.

Unlike some CoP participants who were content with the current 'actor network', others raised concern about the lack of network enlargement within the CoP: noting the presence of '*the same faces*' in the NFM community. Farmers and farmers' representatives, landowners and environmental organisations were cited as the actors who could be more engaged in the NFM network and also flood risk managers: '*if we've got people who don't necessarily work day-in, day-out, on NFM, whether it be* [flood] *scheme engineers…I think that would be really good to raise the profile*' (P8/Academia) and national agency personnel, '*we've had the opportunity to invite people from the national level EA*' (P7/Academia). This consideration of a new network, as well as reframing the roles that traditional actors, such as engineers, could play in a new era of FRM demonstrates that double-loop learning occurred during the CoP events.

Whilst some participants felt the uncertainty around NFM effectiveness was an inhibitor to delivery, others were more accepting. A respondent noted the over-reliance on models, believing they are time-consuming and single-focused, '*you need to take a bit of a risk…and get things done quicker…rather than the EA or local authorities doing 18 months of modelling*' (P2/Environmental NGO). Furthermore, over a quarter of participants noted that they feel more comfortable addressing NFM challenges following their participation in the CoP, demonstrating that uncertainty is being accepted and viewed as an opportunity for reframing current practices, another double-loop trait. Supporting this, participants believed that challenges did not have to be overcome before any real progress could be made, evidenced by comments such as: '*we'll crack on regardless*' (P2/Environmental NGO) and '*It's all going in the right direction…it's an upwards trajectory*' (R8/Academia).

A recognition that governance does not come from one organisation, but rather an inclusive governance approach was commonly suggested,

[2] The EA (Environment Agency) is a non-departmental public body which is sponsored by the UK's government's Department for Environment, Food and Rural Affairs. Its responsibilities relate to the protection and enhancement of the environment.

Table 3
Evidence of social learning following participation in the CoP classified according to MLSL diagnostic framework (Pahl-Wostl, 2009).

	Single-loop	Double-loop	Triple-loop
Norms	• Incremental improvements based on knowledge learnt, e.g., discussions with others have helped to inform decisions on NFM monitoring • A general increase in breadth of understanding but no subsequent action.	• Views that the NFM approach must be reframed – practices are too narrow and must be integrated more with soil and land management. • The assumption of who should raise the NFM profile should be expanded to members of the public, not just practitioners.	
Actor networks	• Improvement in access/recognition of new actors and their role in NFM (e.g., local MPs[a]) but the advice remains within the established network of NFM practitioners. • The profile of NFM does not need to be raised as the network already includes all necessary actors.	• Participatory roles emerge for farmers and landowners to help break down traditional drainage methods among farming communities. • Suggestions to expand network out to traditional flood risk manager engineers and landowners to help integrate NFM onto flood risk management agenda – connecting different networks.	• Changes in network boundary evidenced, e.g., collaborations outside of CoP.
Multi-level interactions	• Coordination of NFM activities must come from the top (e.g., the EA[b]) – vertical coordination remains.	• Informal information exchange via invitation to NFM demonstration sites and adaptable to meet different agendas, e.g., farmers, MPs.	
Uncertainties	• Concern for raising NFM profile before having solid science based on its impacts. • Fear of losing government support if cannot validate improvement.	• Learning from other NFM experiences has reframed views on addressing uncertainties, e.g., being less risk-averse and more ambitious. • Continued progress in NFM activities despite uncertainty.	
Institutions	• Current institutions are well placed to deliver NFM (e.g., EA, LAs[c]). No other facilitators were suggested.	• Established institutions (e.g., EA, local authorities) provide regulatory framework and guidance but are unsuitable facilitators for pushing NFM on the ground. • Alternative facilitators put forward (e.g. environmental charities, community organisations).	
Governance	• Decision-making must sit with flood risk authorities (EA, LAs). • Coordination of governance remains at a centralized hub.	• Believe informal networks can shape policy discourse. • Step change is needed to engage landowners and integrate them into established modes of governance.	• Demand for the change of current governance structures.

[a] Members of Parliament,
[b] Environment Agency,
[c] Local Authorities

such as the Catchment Based Approach (CaBA) model,[3] is further evidence of double-loop learning. Participants stated that ground-based facilitators are important for NFM delivery: '*What we've seen through the Community of Practice, the Rivers Trust, community organisations, grassroots organisations…are all really well placed to kind of push this forward*' (P2/Environmental NGO). The reinterpretation of NFM facilitators was supported by the realisation that established institutions are constrained by their regulatory frameworks and reputation: "*they are hindered by their issues with appearance and in-the-box thinking*" (P5/Environmental NGO) and "*you're trying to fit NFM within legislation that was developed to fit big, engineered schemes*" (P2/Environmental NGO). Nevertheless, half of the participants still relied on traditional forms of governance which might inhibit progression to double-loop learning: "*I think it* (NFM) *needs to be coordinated across organisations but obviously, there needs to be a centralized hub*" (P8/Academia).

4.3.3. Triple-loop learning – a transformation of regimes

While identified changes remained mostly in the first and second loops, evidence was found on triple-loop learning with respect to the domains 'actor networks' and 'governance'. Analysis of PD2 revealed that half of the participants had enhanced their actor collaboration by sharing information, establishing a NFM project partnership and cooperating on a national NFM handbook. This is considered as triple-loop learning since it demonstrates actions (i.e. establishment of the new project partnership and handbook) which resulted as a direct consequence of the changes in network boundaries through the new connections made during the CoP. Collaborations also go beyond existing network boundaries: '*…as times gone by,* [the network] *has developed and…we've been invited along to different meetings. One of the nice things has been to start talking to people in South Yorkshire*' (P7/Academia).

One participant (P4/Government Agency) emphasises the importance of diversifying governance types in flood risk management and ensuring NFM is driven from a local perspective, suggesting that '*you set up a catchment committee for each river, so you have the focus, you have the people on the ground who know the catchment*'. They later add '*if we had that community of practice and we incorporated it into an Integrated Catchment Management Plan…you would have something that would be driven from the local perspective*' (P4/Government Agency). This narrative is associated with triple-loop learning as it demonstrates an implicit questioning of the current (predominantly top-down) established governance regime, with an explicit suggestion on new governance arrangements that place the focus on the local level as the crucial instigators for NFM delivery. This structural change would open up NFM governance to new actor groups, shifting power structures to those working on the ground.

4.4. Implications for NFM practice

The CoP was designed to provide a safe and open learning environment where practitioners share their experiences and knowledge and ask questions without concerns over their level of expertise/representation of their organisation. In Table 4, actions taken by participants following the CoP events are assessed against the challenges highlighted during interviews conducted before the CoP was formalized (OD1). There is evidence that the CoP facilitated changes in action and practice, increased awareness, skills and capacity building, information sharing and improved decision-making.

[3] The Catchment Based Approach (CaBA) is a civil society-led initiative that works in partnership with government, local authorities, businesses, water companies and more to collaboratively work at a river catchment scale to deliver integrated land and water management. https://catchmentbasedapproach.org/about/ 943

Table 4
Pre-CoP challenges and evidence of actions taken to address these since the formation of the CoP.

Pre-CoP challenges	Action required	Actions since CoP	Impact of actions	Evidence
Technical abilities required to implement NFM	Expansion of knowledge and skill-base	Learning from demonstrations during site visits → replication of interventions by practitioners.	Increased number of NFM measures.	*"We've definitely replicated stuff that they've done at Hardcastle Crags* (NFM site) *… those dry channels and catching the flow pathways, we've done that*" (P3/Environmental NGO).
		Discussions during the CoP → consideration of NFM co-benefits, particularly biodiversity improvements.	New information and awareness → co-benefits incorporated into NFM plans.	*"It doesn't particularly matter whereabouts we put the ponds and scrapes but actually, from a biodiversity point of view, where we locate them has made a massive difference"* (P2/ Environmental NGO)
		Improved understanding of which monitoring techniques are suitable for the various NFM measures.	Increased awareness and knowledge of monitoring methods and approaches.	"*I struggle to get very enthusiastic about monitoring. But it is very relevant, and it is something that I think a lot of us struggle with if we're not necessarily people from a hydrological background…So I think that was the most useful and relevant [workshop]"* (P5/ Environmental NGO)
		Use of opportunity mapping tools to assess areas of NFM priority.	Expansion of skill base → helps practitioners to implement NFM in optimal locations.	*"We have used it* (opportunity mapping) *to guide where to put stuff* (NFM interventions), *it has helped us with prioritization*" (P4/ Government agency)
Limited resource exchange	Knowledge exchange	Site visits → practitioners continued NFM site visits, sharing their experiences and lessons learnt.	Network building between Yorkshire practitioners → opportunities for NFM project promotion.	*"People have come up and asked if they can come and have a look at our demonstration sites"* (P5/Environmental NGO). "*I think* (the CoP) *did spark a lot of discussions and there's that platform for us to do that… you've got a range of practitioners there who you could discuss things with and learn from"* (P3/Environmental NGO)
	Resource exchange	Resources from the CoP, including funding information and examples of NFM measures, have been shared with colleagues and NFM networks, including project partners, sponsors, farmers and landowners.	Supporting those who have not attended the CoP events → wider impact beyond the CoP and improved NFM activity.	"*We've shared resources with our funders to help communicate the benefits of NFM*" (P3/Government agency).
		Use of the Defra GIS layer tool to upload NFM interventions → progress towards a nationwide NFM map.	Sharing locations and information on NFM interventions contributes to a national NFM evidence base.	*"The GIS Defra layer is recording what everyone's doing and so I learnt about that. That was really useful to see what other people are doing. I have looked at it to see the extent of NFM across the country and to get an idea for what to look out for in the catchment"* (P5/ Environmental NGO).
Obstructions to NFM decision-making	Stakeholder engagement	Use of opportunity mapping tools to influence NFM farm plans.	NFM farms plans support farmer decision-making and engagement. Combining opportunity mapping with farmer knowledge → identification of optimal NFM sites.	*"We've done some work on farm plans and that was communicated in the Community of Practice, at the Oughtershaw event"* (P3/ Environmental NGO)
	NFM network building	Networking opportunities at the CoP → practitioners expand their networks.	Expand NFM network → supports catchment collaboration and coordination.	"*For me…having the community of practice events, it allowed other people to come in which I wouldn't necessarily have the time to be involved with. So, it helped me massively"* (P3/ Environmental NGO)
		Relationships formed during an event based at a university led to a MSc student conducting monitoring analysis for an environmental charity.	MSc student gained knowledge and skills → contributing to the NFM evidence base and saving resources (time and money) for the charity.	"*Being able to have a master's student help us with that data collection and analysis, it's not only working on their experience, but it's helping us in terms of restrictions that we face for project delivery*" (P3/Environmental NGO)

5. Discussion

5.1. Is there a demand for CoP in the development of NBS?

High levels of pre-existing engagement of some stakeholders (mostly NGOs) were identified (OD2), however, farmers exhibited lower levels of engagement and revealed a lack of opportunity to voice their views on local NFM activity. These results fit earlier research where NGOs, such as the Rivers Trusts, are common NFM facilitators for developing, implementing, and managing projects (Ngai et al., 2020). Whereas farmers can feel isolated from decisions because many NFM practitioners do not understand the farming community challenges and cultural barriers (Huq and Stubbings, 2015; Wells et al., 2020; Bark et al., 2021).

Most stakeholders perceived NFM measures as effective and desired more measures to be implemented in the catchment while farmers expressed a more nuanced perception of NFM measures and their effectiveness (OD2). These results mirror those of Bark et al. (2021) who find some stakeholders believe working with NBS is a 'no-brainer', whilst farmers can hold more cautious views of NFM, particularly around effectiveness. Similarly, in examining farmer perspectives of NFM, Holstead et al. (2017) found a majority did not feel that they could personally contribute to flood reduction downstream and noted a lack of advice on implementing NFM on their land. This suggests the need for improved communication between the farming community and other NFM facilitators and an understanding that NFM measures are not designed to be implemented in isolation, rather collaboration between multiple farmers/landowners is required to collectively reduce flooding

downstream.

NFM practitioners remarked on the need for improved resource exchange and coordination and the opportunity to collaborate and learn from each other to improve the design and delivery of NFM interventions (OD1). Similarly, literature which evaluates NFM delivery challenges consistently advocates for different actors to come together and collaborate on ideas, experiences, and best practices around NFM (Short et al., 2019; Marshall et al., 2019; Wells et al., 2020; Wren et al., 2022). Ngai et al. (2020) suggest stakeholders share ideas and connect within an informal learning network or 'information hub'. Based on the literature and OD1/OD2 results, we can infer that a demand for a CoP exists among NFM stakeholders and practitioners who wish to engage more with NFM delivery, learn from each other and seek validation for their projects.

5.2. Can a NBS CoP foster social learning?

Consistent with Maidl and Buchecker (2021), we found a CoP can foster effective social learning in the context of NBS. The application of the MLSL framework highlighted various degrees of social learning among the CoP participants (PD1/PD2).

All participants revealed that they had acquired new knowledge following the CoP. This is common within social learning environments (Bos et al., 2013), with Muro and Jeffrey (2012) referring to this as personal 'cognitive change'. In a comparable study, Benson et al. (2016) found similar results, however, a notable limitation is that they were unable to distinguish whether this knowledge acquisition caused an attitudinal change. In this study, combining OD and PD allowed the analysis of challenges posed by NFM practitioners prior to the CoP and actions taken by practitioners following the CoP. From this analysis, we can infer that this new information is valuable and led to individual engagement in topics and adjustment to NFM routines. For example, Table 4 displays evidence of practitioners learning from CoP site visits which later led to them replicating NFM measures. Furthermore, networking opportunities during the CoP workshops allowed spontaneous relationships to develop after the events and led to practitioners arranging site visits with each other to share their NFM progress. This sustained social learning goes beyond the boundaries of the CoP and demonstrates that social learning environments provide more than 'facilitated stakeholder participation', as previously suggested by Reed et al. (2010).

There was a collective acknowledgement of the importance of sustained inter-organisational relationships, with the inclusion of participatory facilitators, such as farmers, landowners and environmental charities. In previous social learning studies, network expansion tends to mirror these findings, with actors forming relationships with similar organisations, known as horizontal network expansion (Benson et al., 2016). However, less prevalent in the literature, is the re-framing of vertical relationships and the roles traditional flood management actors could play in NFM delivery. In the present study, participants discussed the need to work with national government officials and technical flood scheme engineers and invite them into their NFM network. These results suggest that the CoP increased awareness among participants of the need to cooperate with each other and interact with those who are critical for the NBS co-design and co-implementation process. Actors who have historically been involved with technical flood management are often critical to encourage a paradigm shift (Pahl-Wostl, 2006). Technical experts have been found to struggle with the 'woolly' concept of NFM, which has led to resistance around the NBS concept (Johannessen and Hahn, 2013; Waylen et al., 2018). Therefore, this small indication of triple-loop learning evidenced by participants suggests that CoPs might contribute to a paradigm shift by educating traditional facilitators through alternative sources of knowledge thereby boosting acceptance of new concepts, such as NBS (Berkes and Folke, 2002; Newig et al., 2005; Wingfield et al., 2021).

Not only did the CoP provide some opportunities for transformational learning, it also encouraged some participants to rethink the current governance structures in place for NFM, with specific expressions of a desire for structural change in NFM governance, whereby CoPs are established into an Integrated Catchment Management plan at the local level. This would entail the creation of diverse actor groups, including those working on the ground and distribute decision-making power among those who understand different aspects of the catchment. Pahl-Wostl (2009) argues that this type of thinking and behaviour is strongly associated with triple-loop learning due to a demand for change within regulatory frameworks and practices in risk management. Despite this being relatively incipient in the conversation and not having yet been implemented, the presence of these thoughts in the discussion with participants (particularly when they include representatives of a government agency), raises certain promise of change.

It is important to note that whilst there is clear evidence of learning between individuals during and after the CoP, it is not possible to ascertain whether this learning was transmitted fully into the practitioners' organisations (organisational learning). It may be that the thoughts and behaviours associated with triple-loop learning are evident among those who are 'innovation champions' (Taylor, 2009) or 'change agents' (Wamsler, 2017) within their organisations, but not necessarily for their organisation/institution more broadly. Despite their presence within the CoP, the ability for champions to influence organisational learning in their own institutions may be hindered by various factors external to the CoP itself. For example, members of traditional FRM institutions may want to break 'agency culture' and encourage environment NGOs to take a lead on catchment-wide NFM, yet this a new concept in FRM policy and as they form part of the current 'establishment', these thoughts may not be shared to comply with the 'norm', as suggested by Martin-Ortega et al. (2022). In order to disentangle individual and organisational learning, longer-term analysis would be required to examine these possible institutional changes.

5.3. Can a CoP facilitate a NBS paradigm shift?

Despite the CoPs ability to foster social learning, certain challenges and constraints exist which may affect the ability of a CoP to facilitate a NBS paradigm shift. The reluctance to raise the profile of NFM due to a limited evidence base around effectiveness is a notable discussion point. With 'Managing expectations' being a common theme, it suggests that NFM deliverables are being directly compared to traditional FRM schemes which can more easily achieve quantifiable measures of risk reduction. This also arose during discussions on suitable NFM facilitators, whereby some participants believed that the institutional framework which was designed for engineering schemes is too rigid for the NFM agenda. This could suggest that participants are open to breaking the *agency culture* which has historically existed in UK water governance (Benson et al., 2013; Van Buuren et al., 2015). However, most concluded that current institutions, which hold statutory responsibilities, are uniquely suitable to govern NFM as it is '*ultimately about flood risk*' (P7, Academia). Thus, several alternative facilitators who have the potential to deliver NFM at scale such as environmental NGOs or land managers, may not feel qualified for such a large responsibility because the traditional 'flood risk manager' role does not align with their identity or way of working. Therefore, this study illustrates that institutional inertia remains in the UK flood management agenda, as previously hypothesized (Harries and Penning-Rowsell, 2011; Van Buuren et al., 2015).

Dadson et al. (2017) note that NFM can be effective at a small scale, but catchment-scale initiatives hold more uncertainty. This could explain why some participants believe NFM measures are isolated, and practitioners are reluctant to raise their profile given associated risks and availability of funds to deliver large-scale NFM initiatives. The risk-averse culture demonstrated by some participants reinforces the maintenance of traditional flood management criteria that determines 'what flood management is', 'how it is practised' and 'how effectiveness is measured' (Cook et al., 2016). Nevertheless, a form of NFM is

emerging; it is grafted onto an existing paradigm where the quantitative nature of structural solutions is favoured (Werritty, 2006; Cook et al., 2016; Brillinger et al., 2020). Thus, despite the presence of double-loop and to a small extent, triple-loop learning, the CoP could not address the prevailing 'predict and control' mentality associated with the traditional risk management paradigm.

Much like previous empirical research on other environmental challenges (Martin-Ortega et al., 2022; Brown et al., 2016) changes in understanding and actions were predominantly associated with single- and double-loop learning. Despite the presence of some transformative actions, there was insufficient evidence to fully diagnose triple-loop learning. Rather, these 'triple-loop' like behaviours tended to be an extension of double-loop learning. A limitation of the MLSL framework is the expectation that a paradigm shift occurs only through a major change in underlying beliefs or assumptions at an individual and the collective level (Ackerman, 1997). Others view achieving a paradigm shift as a long-term process with incremental, step-by-step alterations (Medema et al., 2014; Martin-Ortega et al., 2022). Therefore, evidenced double-loop learning and the practical actions made by NFM practitioners to improve NFM delivery (Table 4) after five CoP events is encouraging and may indicate that CoPs can progress a NBS paradigm shift.

Although 'actor networks' and 'governance' represent the only domains where triple-loop learning was evident, they are arguably key for igniting transformative change among the other domains. It led practitioners to expand their networks as well as demand the need for a more diverse governance structure. These behaviours are key determinants for building resilient social-ecological systems in the face of global change (Grêt-Regamey et al., 2019). Thus, by bringing in farmers and engineers, alternative perspectives about NBS design and delivery can be shared and understood among CoP members, potentially increasing, with time, the opportunity for triple-loop learning among other domains and therefore, encouraging a paradigm shift.

6. Conclusion

The present study demonstrates the demand for CoPs and the positive role that they can play in supporting NBS delivery. The study shows cautious but promising indication that CoPs also have the potential for supporting the paradigm shift required for mainstreaming NBS. We can make this conclusion due to the unique opportunistic design of this research. Information collected prior to the formation of the Yorkshire NFM CoP outlined the need for information exchange, coordination, and collaboration to support practitioners in the design and delivery of NFM. The CoP has had practical implications for NFM implementation, as outlined in Table 4, which exhibits direct actions and changes made by practitioners following CoP workshops. Not only do these practical outcomes validate the CoPs role in improving the uptake of NBS, but it has also demonstrated its ability to foster social learning.

Prior to this study, it was uncertain to what extent social learning may occur within a CoP. The definition of what flood management is and the expectations that come with it confirmed an embedded, traditional flood management paradigm, where predictability and control were still favoured. NFM deliverables do not align with this 'predict and control' model, leading to resistance to its acceptance. However, findings depict that social learning did trigger a shift in practitioner mindsets with incremental changes and a re-framing of routines around NFM delivery (single, and double-loop learning). While these are not fundamentally transformational, they still indicate a certain direction of change, with a substantial amount of questioning of the current framing implicit in the double-loop learning. Such double-loop learning occurred after only five in-person workshops which took place within 18 months. Thus, by sustaining the CoP, social learning can arguably continue to progress toward triple-loop learning for a paradigm shift will become more salient. Furthermore, the indication of some triple-loop learning with respect to 'actor networks' and 'governance' raises promise that those revisited actor networks and reformed governance might have the potential of generating a "trailing" effect over the other domains.

Therefore, while mainstreaming NBS will be challenging if compared to the deliverables generated by traditional risk management, our result raises promise to the potentially transformative role that CoPs could play in delivering a paradigm shift in NBS implementation. Further research would benefit from a longitudinal study which periodically assesses whether changes to actions and relationships are sustained as the CoP develops. Finally, this research takes place within a NFM context, yet the application of CoPs must not be limited to a NBS alone and thus understanding the role of CoPs in addressing other wicked problems in environmental management would be beneficial.

CRediT authorship contribution statement

Phoebe King: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. **Julia Martin-Ortega:** Conceptualization, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing, Supervision. **Jennifer Armstrong:** Conceptualisation, Methodology, Resources, Writing – original draft, Writing – review & editing. **Marie Ferré:** Conceptualisation, Methodology, Resources, Investigation, Writing – original draft, Writing – review & editing. **Rosalind Bark**: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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