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REVIEW AND SYNTHESIS

Using natural capital and ecosystem services to facilitate participatory environmental decision making: Results from a systematic map

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Abstract

1. The rights all people have for involvement in environmental decision making has long been established yet collaborative resource management has had mixed success. Natural capital; the renewable and non-renewable natural assets that benefit societies, and the flow of ecosystem services these assets provide, are increasingly promoted as approaches that ensure consideration of the environment in decision making.
2. Natural capital and ecosystem services concepts can facilitate participation in decision making by explicitly describing the role of the environment in sustaining society. Increased promotion of these approaches requires consideration on how best to involve stakeholders, those involved and affected by a decision, in the process.
3. We conducted a systematic search to identify where stakeholders have participated in natural capital, ecosystem services and nature's contributions to people decision making, creating a systematic map of 56 case studies. While many papers discussing stakeholders and these concepts were found, few actively engaged stakeholders in a decision-making process that used the concepts and therefore were included in the map. Where stakeholders were involved, engagement methods included focus group discussion, stakeholder negotiation and scenario development, as well as ecosystem service ranking and mapping.
4. Ranking for prioritisation of ecosystem services was common, with a bias towards using services with a direct tangible economic benefit; food production and tourism, are both prominent examples. A limited number of case studies performed robust participatory methods evaluations, offering little indication of how best to use natural capital or ecosystem services in participatory approaches.

5. Therefore, the work highlights need for greater evaluation of participatory processes involving natural capital to ensure stakeholder engagement is efficient, productive and useful to all involved.

KEYWORDS
decision making, ecosystem services, natural capital, participation, stakeholders, systematic review

1 | INTRODUCTION

The importance of including public participation in environmental decision making has been long recognised at the international and local scale (Reed et al., 2009; UN, 1992; UNECE, 1998). This enables recognition of the rights of all people to have access to information and involvement in the decisions that affect them and promotes environmental justice (UN, 1992). Due to the interconnected nature of environmental systems, understanding the diverse range of impacts that could occur to is key to making fair and sustainable decisions (Gokhelashvili, 2015; Reed et al., 2009). Furthermore, it is argued that the quality, durability and success of decisions are likely to be greater when those who are affected by the decisions are included in the decision-making process (Beierle, 2002; Fisher et al., 2009; Reed et al., 2009), however, without robust evaluation of the impact of participation this is difficult to measure. Therefore, there is a need for active participation, to not only make individuals aware of the outcomes of their actions within a system, but also to facilitate the successful identification of appropriate management strategies (Jager et al., 2020; Pahl-Wostl & Hare, 2004) and to recognise the implicit connection between human and environmental rights (UNECE, 1998). Despite this, collaborative resource management and governance has had mixed successes (Benson et al., 2015; Ruiz-Villaverde & García-Rubio, 2017), requiring continued investigation of appropriate methods to involve stakeholders in environmental decision making.

Using natural capital; the stocks of renewable and non-renewable natural assets that benefit people both directly and indirectly, and the flow of ecosystem services these provide, as a method of understanding how the environment sustains society has been a well-established concept within academic literature for almost 30 years (Bateman & Mace, 2020; Constanza & Daly, 1992) with a significant debate on the application and use of the concepts (Chan & Satterfield, 2020; Spash & Hache, 2021). In addition, the concept of 'Nature's Contribution to People' has been a more recent addition to reflect wider understandings and definitions from non-Western and capitalist societies (IPBES, 2019). A number of studies have highlighted the importance of value elicitation in understanding and using ecosystem service concepts in decision making (Bateman et al., 2013; Chan et al., 2017; Gould et al., 2015; Klain et al., 2014); however, the role and methods for including this information within planning and management decision making are yet to be investigated.

Increasingly there is national and international attention on the concepts of natural capital in environmental policy (Dasgupta, 2021; Maes et al., 2020) as a means of providing more holistic information on the value of the environment and the impact that decision making can have. For example: the UK Government in their 25 Year Environmental Plan (DEFRA, 2018) promotes the natural capital approach to economic valuation of public goods to justify efficient resource management decision making. Comparably, the 8th European Environment Action Programme policy, in place until 2030, makes use of natural capital concepts to demonstrate the need for environmental protection for sustained citizen well-being (European Commission, 2020); the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) scheme has enabled national scale natural capital accounting for Brazil, China, India, Mexico and South Africa with the intension for it to be included in national environmental policy (UN, 2017); and the establishment of IPBES in 2012 to improve and strengthen science and policy collaboration for biodiversity and ecosystem services (IPBES, 2019).

By making the role the environment plays in sustaining society more explicit and articulating the impact that decisions could have on the natural stock and flow of goods and services (Bull et al., 2016), a natural capital and ecosystem services approach could facilitate participation by enabling stakeholders to understand these connections (Förster et al., 2015), therefore aiding plans for more sustainable futures and leading to innovation through opening new market opportunities and collaborations (Ruijs & van Egmond, 2017). However, use of natural capital and ecosystem service information or data within environmental planning and management decisions has lagged behind the promotion of the concept (Guerry et al., 2015). Ensuring participation and enabling the involvement of a diverse range of stakeholders could overcome the implementation gap by collaborating with decision makers to integrate ecosystems services in everyday decision making (Guerry et al., 2015). However, these concepts, in particular ecosystem services, have been dominated by numerical valuation without biophysical grounding resulting in limited applications to decision making (Chan & Satterfield, 2020). As ecosystem services and natural capital are increasingly used in environmental policy, there are moral, legal and practical needs to ensure the approaches incorporate successful stakeholder engagement and participatory decision making.

This paper aims to collate participatory methods that utilise concepts of natural capital and ecosystem services within environmental planning decision making. A systematic search method is applied to minimise bias in the retrieval of academic and non-peer reviewed articles (CEE, 2013;

Haddaway et al., 2015). Systematic map techniques (James et al., 2016) are then used to present the evidence. Specifically, this map assembles types of data and tools used to aid planning decision making, the prevalence and type of evaluation processes and the types of stakeholders that are involved. First, we present the methodology used, then the results of the search and then go on to synthesise the evidence to highlight common methods for participatory natural capital decision making.

2 | METHODS

A systematic approach to develop a search strategy, collate and screen literature and extract information to form a concise collection of articles related to the use of natural capital, ecosystem services and Nature's Contribution to People in participatory environmental decision making was undertaken following guidance on systematic principles (Collaboration for Environmental Evidence, 2018; Haddaway et al., 2015; James et al., 2016). Specifically, the map will collate examples of research with any stated application of ecosystem services, natural capital or Nature's Contribution to People in collaborative decision making that has an environmental planning or management outcome.

A steering group consisting of two academic advisors from Imperial College London (A.M.C., A.M.), and two practitioners from Thames21 (J.B., J.V.G.), a NGO who have interests in participation methods for river catchment partnership management, helped the reviewers (C.H., J.O.K.) refine the primary and secondary research questions (below), form categories for data extraction and identify sources of grey literature (Haddaway et al., 2015), following guidelines for stakeholder involvement in systematic reviews (Haddaway et al., 2017).

Primary Question:

What Natural Capital conceptual approaches have been used to facilitate participatory environmental decision making?

Secondary Questions:

1. *What types of project have applied a natural capital approach?*
2. *What information is used for the decision-making process?*
3. *Who are the stakeholders involved in the decision-making process?*
4. *How has the contribution of natural capital concepts to participatory decision making been evaluated?*

2.1 | Search strategy

We developed a search string (below) from the three key phrases of: 'natural capital', 'decision making' and 'participation' making use of Boolean operators and wildcards.

> *Search String: ("natural capital" OR "ecosystem service*" OR "ecosystem benefit*" OR "ecosystem approach*") AND ("decision mak*" OR "decision-mak*" OR decision* OR policy) AND (particip* OR collab* OR stake* OR codevelop* OR cocreat* OR actor*).*

This was applied to three academic databases: Web of Science, Scopus, Open Access Theses and Dissertations; and to Google Scholar. The string was tested and refined on Web of Science. No temporal or geographic restraints were applied. Grey literature was sourced through reviewer searching on 24 websites (Supporting Information) known for environmental project work, a list steered by the practitioners. The search was conducted on 4 May 2020, with an update completed on 15 March 2021 to capture relevant articles published during the time taken for screening and extraction. On 10 December 2021 an additional update was completed to include articles referring to 'Nature's Contribution to People' published before 15 March 2021.

2.2 | Article screening

Academic articles were screened at subsequent stages of title and abstract, against specific inclusion criteria: environmental management, concepts of natural capital and demonstration of a participatory decision-making approach (Table 1). Articles that did not meet the criteria at each stage were rejected (Figure 1). Article titles were required to meet at least one of the three criteria to pass the first stage assessment. To qualify for full text assessment eligibility and inclusion in the map, abstracts were required to meet all three criteria. This is an effective approach as it did not eliminate potentially relevant articles which did not include methodological detail in the title.

In addition, a two-stage text eligibility screen was performed to assess articles suitability, first assessing the methods section in isolation, followed by in conjunction with the full text. This ensured that all articles demonstrated participatory methods where multiple groups of stakeholders were actively involved in using natural capital to aid decision making in environmental management contexts. Screening was primarily conducted by one author (C.H.) with a random subset of 10% of articles after duplicate removal (360) checked by a second author (J.O.) for bias using a Cohen's Kappa test at the title and abstract levels. A benchmark Kappa Coefficient of 0.7 was used, with title screening achieving 0.7 without moderation and abstract screening achieving 0.85 after an iteration process to discuss differences.

Grey literature was assessed using the screening and text eligibility criteria simultaneously at a full text level. This was done because it was found that most of the relevant grey literature would be rejected despite displaying acceptable methods due to different naming practices applied to the titles of reports (Adams et al., 2017; Benzies et al., 2006).

2.3 | Data extraction and analysis

Studies that met the inclusion criteria were re-read at full text level and data were extracted in a variety of categories (Table 2, Supporting Information) relating to the methods and outcomes of the article. Where articles included more than one case study, these were included separately if the methods were reported individually. Data were extracted in the form of meta data, free text description

TABLE 1 Definitions of key concepts used for inclusion and exclusion criteria during screening

Key concept	Definition and criteria
Environmental decision making or policy design	Screening: • Any demonstration of planning or intervention or deliberate action to increase environmental resilience • Any change to minimise the impact of society on the environment • Any improvement to the function of the environment to benefit society • Any use of environment resources to provide benefits to society *Note: Method could include situations where decision making has a negative effect on the environment, however this would still be relevant if it used stakeholders and ecosystem services/natural capital* Text eligibility: • Explicit inclusion of explaining the decision-making process, for example, explanation of method, tool or process used
Concepts of natural capital	Screening: • Articles that actively use the concept of Natural Capital and/or Ecosystems Services for decision making and therefore: accounting for, describing or using the benefits of the environment to understand or inform the benefits of the environment for society • Other common terms may include environmental service or ecosystem benefits • Include mentions of financing or similar for the environment or accounting • Include implicit mentions of natural capital concepts, such as, but not limited to: biodiversity, natural assets, green space value etc Text eligibility: • Use of natural capital concepts during the decision-making process
Participatory	Screening: • Articles that include examples of project(s) that have consulted or considered more than one group of relevant stakeholders for decision making/policy design when referring to environmental management • Relevant stakeholders include, but is not limited to, local/regional/national/international authorities, residents, charities, funders, researchers • Decision making/policy design must actively include the stakeholders working in collaboration to make decisions within the scope of research *Note: Articles that do not refer to more than one stakeholder will be excluded* Text eligibility: • Clear collaboration between stakeholders during decision making • Clear reference to stakeholder inclusion throughout whole process *Note: Articles that only consult stakeholders for information gathering will be excluded. Articles that did not have enough detail on the participatory process to identify if they would meet the criteria will be excluded*

and coding. The categories were agreed with the review team in advance of data extraction, with further categories added during extraction to enable full representation of evidence. Some free text description fields were subsequently categorised for clarity during analysis once the scope of the results was realised, as detailed in Table 2. Each study was given a unique identification number to be referenced in the results, along with the citation. Where more than one case study was included in an article, sub-numbering was used for the reference number (e.g. 1.1, 1.2, 1.3 etc.) included with intext citation.

Analysis of the results was conducted by identifying frequencies and finding modal groups. The location of the studies was identified as coordinates and the open access tool EviAtlas was used to plot location maps (Haddaway et al., 2019). Main participatory methods and data examination processes were cross-tabulated to find clusters of methods. In addition, where ecosystem service mapping was included within the methods, but not used as the main data examination method it was noted as an additional method and compared with previously identified method clusters. Where a distinction between academic and grey literature could be identified in the results, it was analysed.

3 | RESULTS

3.1 | Number and type of article

The search of academic literature returned a total of 5,494 articles, of which 1,776 were duplicates leaving 3,718 articles for screening (Figure 1). Screening at title and abstract level further reduced the number of academic articles to 205 which were assessed at full text level. The search of grey literature found 123 articles, of which 4 were duplicates, leaving 119 to be assessed at full text (Figure 1). Among the reasons for exclusion at full text, the most common for academic literature was that papers only consulted stakeholders for information prior to the decision-making stage and therefore did not actively engage them in the decision-making process. A frequent reason for exclusion was where articles included concepts of natural

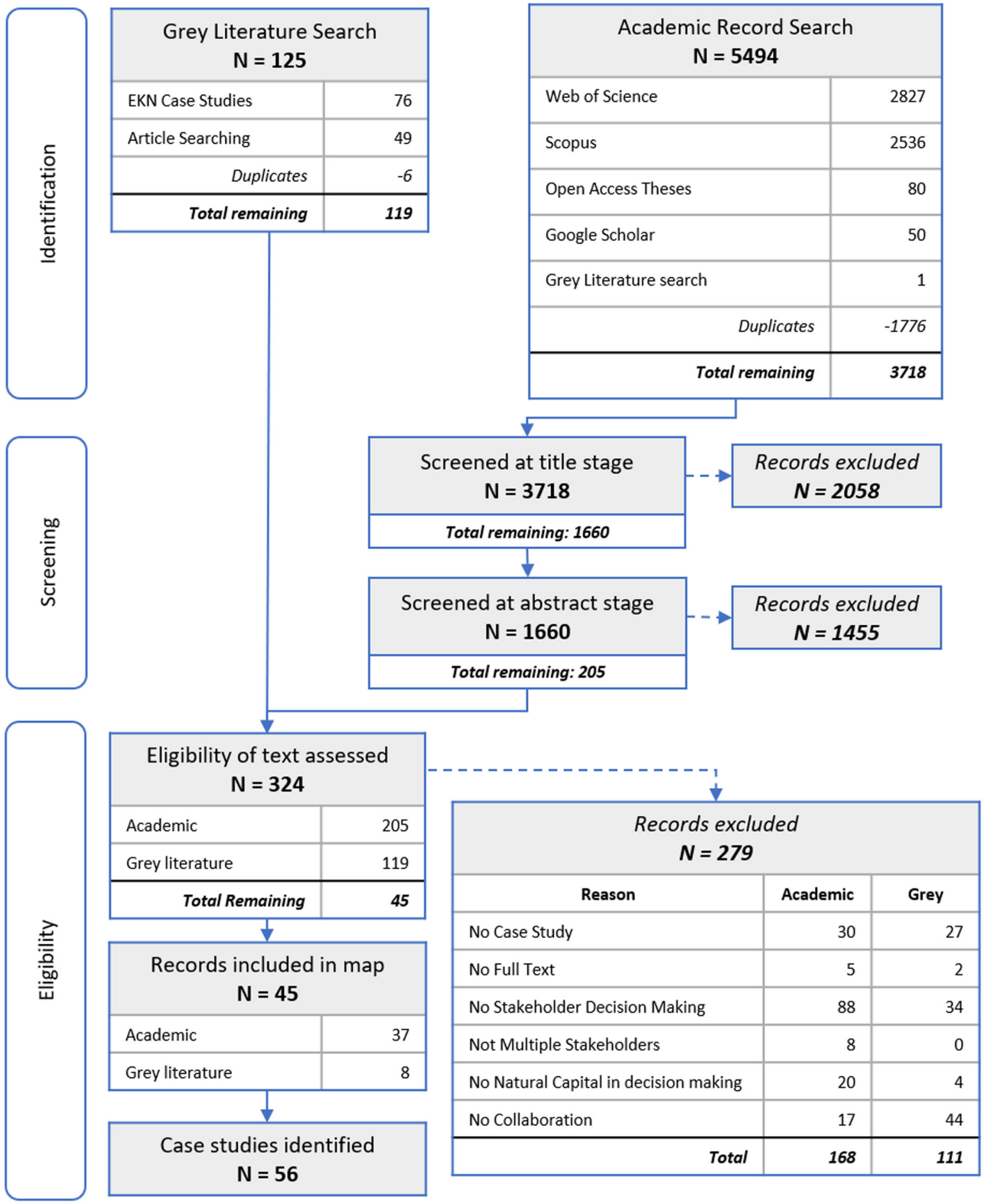

FIGURE 1 Flow chart indicating numbers of records processed during screening

capital and ecosystem services within the scope of the text, or introduction but not as an active component in the methods.

Within grey literature the most common reason for exclusion was the lack of evidence of collaboration between stakeholders in the decision-making process, despite the project including multiple groups of participants. Many academic and grey literature articles, were excluded for not including a case study, being review articles, protocols or new methodologies without a detailed case study. Of the 45 articles included, 56 case studies were identified and subjected to data extraction.

TABLE 2 Categories, detail and additional analytic breakdown of extracted information

Category	Detail	Subsequent categorisation
Bibliographic Information	Author names, publication information etc	
Case Study Information	*Location*, *primary environment type*, *Aim of Project* etc	Addition of *Case Study Title* for studies with multiple case studies; *Aim of Project* subcategorised; Coordinates of location found
Ecosystem Service and Natural Capital information	Use of Ecosystem Services, Natural Capital or both	Sub-categorisation of Ecosystem Services by Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) Identification of three most prominent Ecosystem Services Natural Capital concepts included if they meet criteria in Table 1
Stakeholder information	Numbers of stakeholders, stakeholder roles etc	
Participatory methods and processes	*Data Examination methods* (main process by which stakeholders interacted with ecosystem service data), *Decision-Making methods* (main process by which environmental outcomes and plans were chosen), *Tools*, *Evaluation processes*	*Ecosystem Service Mapping* methods identified if used in addition to other methods Data examination methods and decision-making methods categorised and cross tabulated to find methods clusters
Outcome of project	Output of the participatory approach	

Of the 56 case studies subjected to extraction all were published since 2005, with all but 8 papers since 2014. The articles were mostly European case studies ($n = 37$, 66%), with the remaining 19 case studies spanning the Americas ($n = 8$), Asia ($n = 4$), Pacific ($n = 3$) and Africa ($n = 2$). The geographic locations of the studies are show in Figure 2.

The case studies span a wide range of primary environment types. Categories may not be exclusive of each other as they reflect the primary environment type reported by the authors. Most common environment types were coastal ($n = 13$), inland water ($n = 9$) and urban environments ($n = 9$) (Figure 3). Only one example for marine and dryland environments was identified. Cultivated land ($n = 2$) is distinct from rural ($n = 3$), as some case studies that specifically refer to arable farm land.

3.2 | Outcomes of project

Four categories of project aim were found from the free text entry. Most case studies ($n = 30$) aimed to form a management plan for the study area, by allowing for better allocation of resources, space for different activities or identifying possible planning trade-offs. In a further 19 case studies, the overall aim was for ecosystem service prioritisation. Here, planning and decision making was undertaken specifically using participants to choose which ecosystem services should be the focus of environmental management for the study area. The outcome often consisted of spatial prioritisation and the zoning of activities such as forestry, conservation and recreation. This often resulted in a balance between prioritising economic growth and ecosystem service provision. In addition, risk identification ($n = 4$) was a distinct project aim, where case studies approached management from the perspective of environmental pressures such as ecological redline areas (#2 Bai et al., 2018) meeting supply targets (#7 Borges et al., 2017; #15 Gonzalez-Redin et al., 2016) or risk of not meeting conservation targets (#13 Fletcher et al., 2014). In three of the cases, the aim of the project was to prioritise collaboration and agreement between participants. Case studies recognised the value of integrating local knowledge by demonstrating the link to management plans to the local community (#12 Delevaux et al., 2018; #20 Langemeyer et al., 2018) or increased communication between scientists and decision makers (#8.2 Brunet et al., 2018).

3.3 | Ecosystem service and natural capital concepts

Overall, there was a broad majority of studies using ecosystem services in decision making rather than natural capital or Nature's Contribution to People, either focusing on specific services or the general concept, ($n = 29$). Only one study (#12 Delevaux et al., 2018) was found to consider natural capital exclusive of other concepts. Only one study (Matuk et al., 2020) included Nature's Contribution to People. Of the 25 studies that considered both natural capital and ecosystem services, 12 reported biodiversity in their decision-making methods, sometimes including it as an ecosystem service. The remaining 13 studies that used both concepts used natural capital in ways not explicitly associated with biodiversity. Ecological land status, land or green space value and ecosystem socio-cultural value were common terms. In one case study, the indigenous Canadian Nuu-Chah-Nulth Principle of Hisukish Tsawalk of 'everything is one and all is interconnected' within the context of participatory environmental decision making demonstrates a systems approach considered comparable

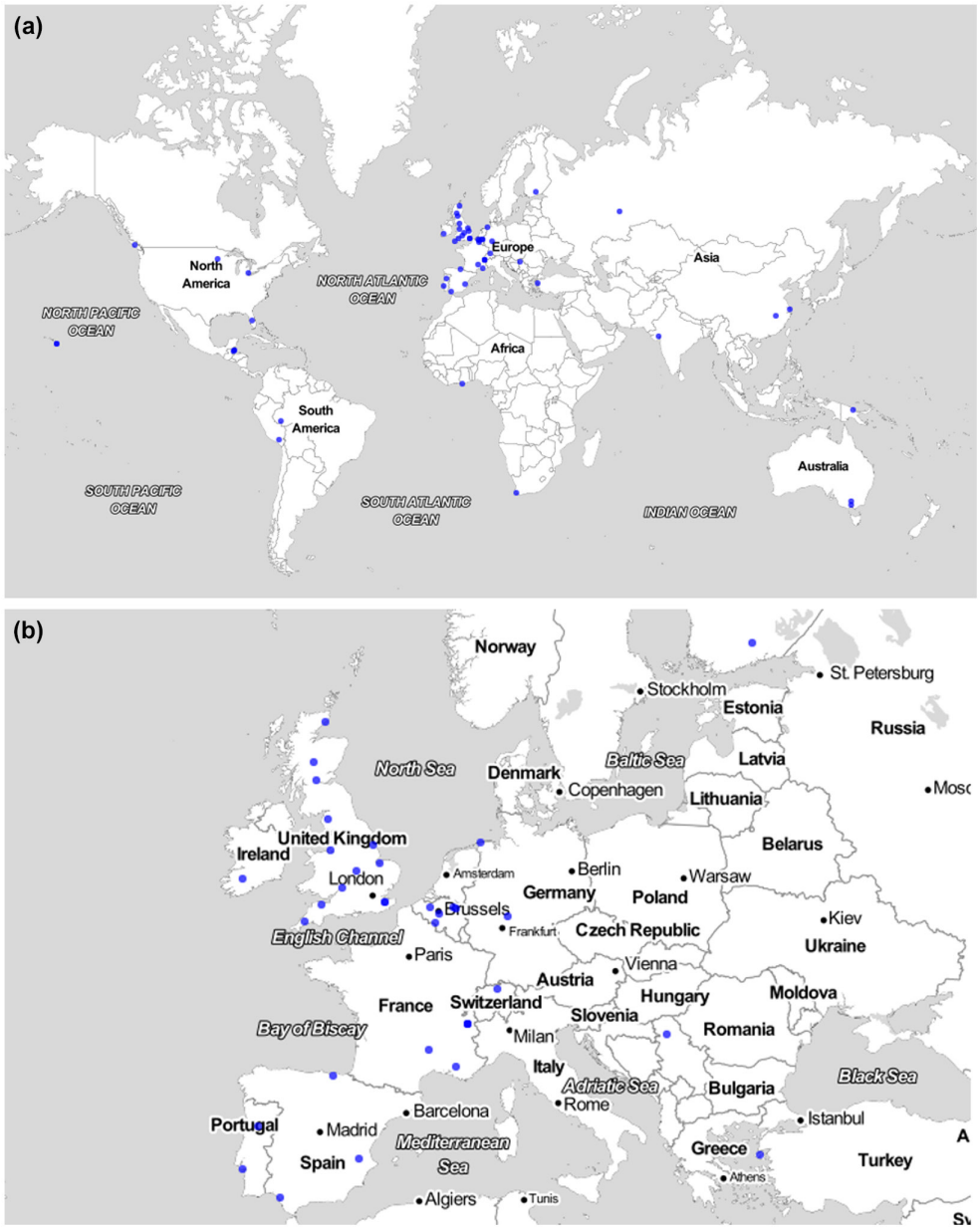

FIGURE 2 Geographical distribution of study location of included studies in (a) world; (b) Europe

with natural capital concepts (#23.3 McKenzie et al., 2014). In the map, reviewers identified where natural capital had been used implicitly, such as considering the habitats and the benefits they provide both as ecosystem services. For example; #41 (Sagoe et al., 2021) reported the value of fish nursery grounds within the context of ecosystem services, rather than using natural capital concepts.

Of the 55 case studies using ecosystem services, 9 give no detail of which services are used, instead using a general conceptual approach. Out of 46 cases that specify ecosystem services, 42 use provisioning, 39 cultural, 38 regulating and 28 supporting. Of the most commonly selected ecosystem services (Table 3), 55% have a tangible economic benefit to stakeholders: food, freshwater provision and regulation and tourism.

3.3.1 | Information sources used to assess ecosystem services and natural capital

Varied information sources were found to be used in the assessment of natural capital concepts, upon which the participation decisions are based. All studies used small groups within the methods, utilising stakeholder derived local/specialist knowledge of the specific environmental system or location to inform them. Eighteen studies used surveys or interviews to gather information, often to gain consensus of ecosystem service knowledge or preferences. Many case studies used expertise of a specialist (n = 21), such as an industry professional or scientist to conduct quantitative environmental assessments (n = 26) or GIS analysis (n = 26).

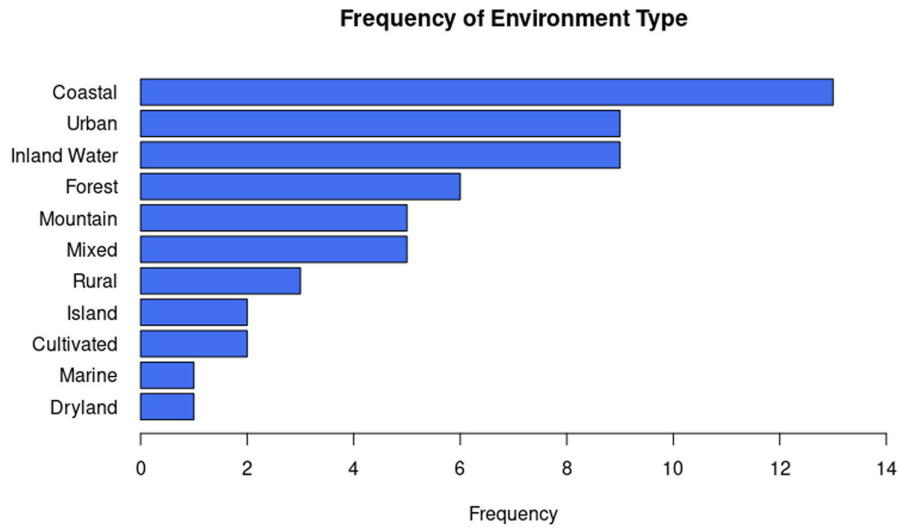

FIGURE 3 Frequency of primary environment type in case studies

TABLE 3 The commonly selected ES used in the case study based on the millennium ecosystem service definitions (note that some cases used multiple ES and so the total number is greater than case studies)

Provisioning		Regulating		Supporting		Cultural	
	N = 34		*N* = 34		*N* = 6		*N* = 27
Food	13	Water Regulation	15	Soil Formation	3	Recreation and Ecotourism	15
Fresh Water	12	Climate Regulation	14	Primary Production	3	Cultural Heritage	5
Fuelwood	5	Soil Quality	2	Nutrient Cycling	0	Aesthetic	4
Fibre	4	Pollination	2			Spiritual and Religious	3
Biochemicals	0	Disease Regulation	1			Inspirational	0
Genetic Resources	0					Educational	0
						Sense of place	0

3.4 | Types of stakeholder involved

The number of stakeholders involved in the study varied from between 1 and 10 to over 100, with most studies (n = 13) engaging with between 11 and 30 people. Eight projects operated on a large scale, involving over 100 individuals. These tended to be long term, large, team-led projects with the capacity to utilise additional resources to engage more people. Some case studies did not distinguish between participants involved in different stages of the project such as preparatory questionnaires or focus groups. In all reviewed cases which included large scale participatory involvement, stakeholders involved were split into small groups to fulfil the collaborative approach of decision making. Many (n = 25) case studies did not state the number of participants involved, despite reporting the use of small groups. Where the case study reported the methods of stakeholder identification, the majority (n = 12) involved researchers approaching stakeholders based on prior knowledge of the study area. Some case studies made use of partner organisations (n = 12), or local leaders (n = 5) to reach out to relevant stakeholders for participation. A small number used identification methods such as stakeholder mapping (n = 3) or snowball sampling (n = 2). Many (n = 22) case studies did not report how the stakeholders were identified, and 13 case studies reported neither the number or identification method.

All studies involved more than one type of stakeholder, with 83% of studies involving three or more categories (Table 4), and the most common number being four types. The most common stakeholder involved in decision making was local authorities (n = 49) such as councils, policy makers and park authorities. Non-Governmental Organisations were frequently involved (n = 37), such as environment or wildlife charities. Local residents (n = 25) and land managers (n = 21) were the next most commonly involved stakeholder. Scientists or academics were often included within the decision-making process (n = 24) and were also often involved in environmental assessments. Some studies used the academic stakeholder as a moderator, who both aided decision making and managed the decision-making process. Many case studies reported another stakeholder, such as business owners, investors, public agencies, youth groups and planning consultancies.

TABLE 4 Type of stakeholder involved in the case studies identified

Stakeholder	Frequency
Local Authorities	49
Other	44
Charity/NGO	37
Local Residents	25
Academic/Scientist	24
Land Manager	21

3.5 | Participation and decision-making methods

All the case studies involved small group work, including focus groups as methods of data collection, or group discussion where participants examined ecosystem service and natural capital information allowing for free discussion and decision making between participants. The latter was found to be the most common method of data examination, identified as group negotiation in Table 5 (n = 20). When ecosystem service data examination and decision-making methods (defined in Table 2) were compared (Table 5), four clusters of methods were identified: discussion methods (n = 10); ranking or scoring (n = 24); tool based (n = 11); game style (n = 4); and ecosystem service mapping (n = 7). In addition to the latter category, a further 20 studies utilised ecosystem service mapping methods as a secondary data examination processes to one of the clusters and were identified during subsequent categorisation (Table 2).

3.5.1 | Discussion-based methods

Discussion-based decision-making methods (Tables 5 and 6; n = 10) were defined as using group deliberation of various ecosystem service information to form consensus over management plans, such as from GIS data (#8.2 Brunet et al., 2018; #18 Jacobs et al., 2020), ecosystem assessment (#31 Xie et al., 2017) or a mixture of sources (#36 West Country Rivers Trust, 2016). There is also some use of scenario development, where participants divided management options to ease decision making (#27 Palacios-Agundez et al., 2014; #28 Reyers et al., 2015) or made use of artistic visualisations (#19 Karrasch et al., 2017) and narrative story development (#8.3 Brunet et al., 2018) for management scenarios.

3.5.2 | Tool-based methods

The case studies using tool-based methods (Tables 5 and 6; n = 11) combined either group discussion (n = 6) or scenario development (n = 5) with the use of a decision-making tool. Within this cluster, there was a mixture of participatory tool use, where participants were able to actively use tools, and presentation of data to participants.

TABLE 5 Cross tabulation of the data examination and decision-making methods to identify method clusters: Orange—discussion-based methods; yellow—Tool-based methods; blue—Ranking or scoring methods; green—Game style; Grey—Ecosystem service mapping

Main data examination process	Decision-making method: Group discussion alone	Group discussion based on tool	Ecosystem service scoring	Multi criteria decision making	Game style	Sum
Group negotiation	5	6	2	3	3	19
Scenario development	5	5	1	2		13
Individual ranking and group negotiation			4	5		9
Group criteria ranking			5	1		6
Ecosystem Service mapping	8	0			1	9
Sum	**18**	**11**	**12**	**11**	**4**	**56**

InVEST, an ecosystem service valuation tool (Sharp et al., 2020), was a popular choice for decision support ($n = 5$). It was used to determine the monetary contribution of priority ecosystem services, therefore supporting the participants to choose between management options (#2 Bai et al., 2018; #31 Verutes et al., 2017); or to enable justification for marine spatial planning (#32.1, 23.2, 23.3 McKenzie et al., 2014).

3.5.3 | Ranking or scoring methods

Methods of ranking or scoring features of the participatory process were common (Tables 5 and 6; $n = 23$) and appeared both as a process of examining the ecosystem service data and for decision making. A scoring process could apply to group assessment of priority ecosystem services or management actions. Often the process was done individually, followed by a group negotiation process, where individual scores were shared and subsequently altered. Scoring of scenarios, plans or ecosystem services was also a common decision-making method ($n = 12$) including the use of established ranking methods (#29 Srdjevic et al., 2019) and risk assessment (#1 Arkema et al., 2015). Many case studies applied multicriteria decision-making methods ($n = 11$), where different criteria, including ecosystem service provision are weighted to find what should be the most common answer. In one case study, a citizens' jury was set-up to disseminate ecosystem service information presented by expert witnesses and then apply multicriteria decision making (#10 Cork & Proctor, 2005).

3.5.4 | Game style

Another method identified was game style (Tables 5 and 6; $n = 4$), which was operated as a structured group discussion, often with negotiation where stakeholders were roleplaying alternative stakeholder perspectives in combination with ecosystem service mapping (#15 Gonzalez-Redin et al., 2016); identifying trade-offs (#8.1 Brunet et al., 2018; #25 Moreau et al., 2019) or modifying trading simulations for natural resource management (#14 Gissi & Garramone, 2018).

3.5.5 | Ecosystem service mapping

Ecosystem service mapping, a process where stakeholders geographically represent the supply of various ecosystem services on local maps, was a prevalent method for all the case studies. However, only nine case studies used it as the main method of participant ecosystem service data examination. These case studies developed environmental management plans that prioritise areas for ecosystem services provision, (#38 Fish et al., 2011; #37 GIFT-T!, 2015) and use the mapping method to communicate value of environmental services provided by a coastal zone or river catchment (#9.1;9.2;9.3;9.4 Burdon et al., 2019; #40 Waters et al., 2012).

The case studies that use mapping techniques as a secondary method ($n = 20$) are cross-examined with main data examination and decision-making methods in Table 7.

The studies included in Table 7, that is, those that use ecosystem service mapping as an additional examination method, are most

TABLE 6 References for each method cluster—With distinction on whether the case study uses ecosystem service mapping

		References	
Method cluster	***N***	**Non-ecosystem service mapping**	**Ecosystem service mapping as an additional method**
Discussion-based methods	10	#8.2 #8.3 Brunet et al., 2018; #44 Gottwald et al., 2020; #28 Reyers et al., 2015	#18 Jacobs et al., 2020; #19 Karrasch et al., 2017; #27 Palacios-Agundez et al., 2014; #31 Xie et al., 2017; #35 West Country Rivers Trust, 2012; #36 West Country Rivers Trust, 2016
Tool-based methods	11	#2 Bai et al., 2018; #3 Bartlett et al., 2017; #42 Campbell-Arvai & Lindquist, 2021; #24 Mongruel et al., 2010	#12 Delevaux et al., 2018; #23.1 #23.2 #23.3 McKenzie et al., 2014; #30 Verutes et al., 2017; #33 LUC and STAR, 2014; #34 Sheate et al., 2006
Ranking or Scoring Methods	23	#1 Arkema et al., 2015; #4 Bautista et al., 2017; #5 Blancas et al., 2018; #6.1 #6.3 #6.5 Boeraeve et al., 2018; #7 Borges et al., 2017; #43 Bush et al., 2021; #10 Cork & Proctor, 2005; #11 Corrigan & Nieuwenhuis, 2019; #13 Fletcher et al., 2014; #20 Langemeyer et al., 2018; #22 McInnes et al., 2016; #26 Oikonomou et al., 2011; ##29 Srdjevic et al., 2019	#6.2 #6.4 Boeraeve et al., 2018; #16 Hayek et al., 2012; #21 Lopes & Videira, 2019; #32 Burton et al., 2019; #40 Waters et al., 2012; #41 Sagoe et al., 2021
Game Style	4	#8.1 Brunet et al., 2018; #14 Gissi & Garramone, 2018; #25 Moreau et al., 2019	#15 Gonzalez-Redin et al., 2016
Ecosystem Service Mapping	9	#39 Austin et al., 2014; #9.1#9.2#9.3#9.4 Burdon et al., 2019; #38 Fish et al., 2011; #37 GIFT-T!, 2015; #56 Matuk et al., 2020	

associated with discussion methods for information examination and decision making (n = 13), with a few examples of ranking or scoring methods (n = 7). None of the studies that use ecosystem service mapping as an additional method came from the game style cluster as #15 Gonzalez-Redin et al. (2016) uses mapping as a main data examination method.

Ecosystem service mapping was used in all examples of grey literature identified (n = 8), either as a primary or supporting method. One grey literature case study used a matrix to identify how ecosystem services could be prioritised across different scenarios, as well as which scenarios fulfilled various partner objectives, such as meeting environmental directives (#40 Waters et al., 2012).

3.6 | Bespoke tools

Some case studies developed bespoke tools specific to the project, either the tool was provided to participants or the participants activity used or designed the tools during the project. Examples include land use change models coupled with scenarios (#2 Bai et al., 2018) or network analysis tools (#33 LUC and STAR, 2014; # 34 Sheate et al., 2006). A few case studies created decision support tools specific to the project purpose; such as simulating ecosystem service functions within given conditions of a river system (#24 Mongruel et al., 2010); combining a system dynamics model with environmental and ecosystem service indicators (#12 Delevaux et al., 2018) or creating a natural charter area (#3 Bartlett et al., 2017). In addition, bespoke ranking tools developed within the ranking cluster often represented a more complex study design such as: co-designed frameworks (#4 Bautista et al., 2017; #21 Lopes & Videira, 2019) and decision support tools (#7 Borges et al., 2017; #43 Bush et al., 2021; #16 Hayek et al., 2012).

3.7 | Evaluation

We identified 20 case studies that reported some form of process evaluation focusing on the participatory process, of those seven only provided brief comment in the text. Eight case studies conducted an evaluation through a feedback questionnaire at the end of the participatory engagement. In general, the evaluation results showed the success of using co-design processes within the case studies to develop management plans, especially when participants are aware of the benefits of co-design (#3 Bartlett et al., 2017; #19 Karrasch et al., 2017). In five case studies, surveys were used to facilitate participant feedback on the decision-making processes (#9 Burdon et al., 2019; #33 LUC and STAR, 2014).

Four case studies tracked the progress of the participation against specific objectives, either set by researchers or through a collaborative co-design process. These papers were able to demonstrate the impact of the engagement through this method, either by providing the satisfaction of the process and ecosystem service concepts with

TABLE 7 Cross tabulation of data examination and decision-making method for papers using ecosystem services as an additional method. Colour coding is the same as Table 5: Orange—Discussion based; yellow—Tool based; blue—Scoring or ranking based

Data examination method	Decision-making method: Group Discussion alone	Group Discussion based on tool	Ecosystem Service Ranking	Multicriteria Decision Making	Game Style	Sum
Group negotiation	4	3		2		9
Scenario Development	2	4				6
Individual ranking and group negotiation			1	1		2
Group criteria ranking			3			3
Sum	6	7	4	3	0	20

a criteria performance score (#20 Langemeyer et al., 2018) and by evaluating participant progress of the game style scenario role play (#14 Gissi & Garramone, 2018). Two examples took 'before and after scores' for statements, to show how participant opinion of certain ecosystem services or scenarios had changed after evidence was presented (#10 Cork & Proctor, 2005) or to track how the stakeholder engagement process enabled participants to converge on a specific management solution (#4 Bautista et al., 2017).

In addition to the case studies identified as including an evaluation process, #31 Xie et al. (2017) presented a comparison methodology where co-design was directly compared with computational spatial optimisation of land use and ecosystem service provision, concluding that although the results were similar, a hybrid approach is recommended to maximise the advantages of involving participants in the decision-making process.

Although this map included details of five case studies from #4 Boeraeve et al. (2018) exclusive of each other, the authors used reflexive evaluation techniques to examine their experiences of the case studies and score various successes and barriers identified against predetermined evaluation criteria (Blackstock et al., 2007). These criteria cover a range of concepts including social learning, quality of information used and opportunities for shared visions and influence.

4 | DISCUSSION

This systematic map demonstrates that while there is a large body of literature using ecosystem services and natural capital concepts within the context of participatory decision making, very few case studies (1.13%) met the strict methodological criteria, which required the active involvement of participants in environmental decision making. This indicates that despite the strong policy potential and high level attention on the concepts (UN, 1992, 2017; UNECE, 1998), peer reviewed literature more commonly reports on methods that elicit information and ecosystem service value from stakeholders rather than actively including them in a decision-making process (Figure 1). The growing number of academic studies investigating value elicitation was not reflected in our results, as the scope of the study is limited to planning decision making. In contrast, participatory processes found in the grey literature as part of this study are generally longer and more complex, with stakeholder led stages of planning, design and data examination methods. This could be explained by the different drivers for academic and grey literature work, with pressure leading academic studies to focus on publishable results over demonstrating long-term environmental improvements or the academic journal guidelines limiting what peer-reviewed articles include (Adams et al., 2017). This could also reflect an implementation gap in utilising more long-form participation methods, or a lack of clear evidence for their advantages and success. However, this result may be skewed by the length of reports, as academic articles are often shorter and therefore more discrete in content (Adams et al., 2017). We found very few articles considering Nature's Contribution to People and natural capital exclusive of ecosystem service concepts. This does not reflect the wide body of literature covering these topics, and therefore this disconnection could result from limited examples of practiced use of natural capital or Nature's Contribution to People, rather than limited theoretical work. It would be interesting to re-run our search in a few years' time to determine whether these concepts, which have been proposed relatively recently, are being more widely adopted within decision-making contexts.

There are distinct clusters of methods for participatory decision making (Table 5), likely suited to different situations; however, given the lack of evaluation of these methods, their effectiveness is difficult to determine. Small group discussions were prevalent in the map which may be used to provide a rich source of information for decision making demonstrating the value of qualitative information (SQ2). They are commonly accompanied with additional decision-making support, such as scenario development, decision-support tools, etc which add structure to aid the process. Ecosystem service assessments, mapping, scoring and ranking were also commonly found in the map and may be popular as they enable focussed interrogation of natural capital and ecosystem service concepts. Therefore, in response to our primary question these five clusters represent distinct approaches to participatory decision making.

The use of ecosystem service mapping improved understanding of the value of various land use types in terms of service delivery and was a common additional method. Such mapping approaches are used in all the grey literature case studies. Here, stakeholders are encouraged to locate ecosystems that provide services, outlining natural capital value and enabling a landscape scale approach to environmental management (#9 Burdon et al., 2019). Additional methods include the use of game style, where participants contribute to decision-making processes within simulated situations, either a hypothetical environment or role (#14 Gissi & Garramone, 2018; #15 Gonzalez-Redin et al., 2016). Such processes can encourage successful collaboration between stakeholders beyond the time-scale of the project, therefore promoting social learning (Jager et al., 2020), and long-term community engagement and ownership of projects (Mostert et al., 2008). The use and development of bespoke tools for data examination and decision making indicates that a range of additional support and skills can be utilised when working in collaboration with academic researchers (#43 Bush et al., 2021; #42 Campbell-Arvai & Lindquist, 2021; #12 Delevaux et al., 2018; #21 Lopes & Videira, 2019). However, in some cases, the development of elaborate tools that do not offer transferability could form some barriers to involvement for stakeholders.

Commonly the case studies make use of stakeholder knowledge to assess the applicability of policy scenarios to the local environment, possibly utilising local understanding of the specific characteristics of the study location (SQ1). This is supported through the range of stakeholder groups and personas included as participants, each providing different perspectives to the specific situation (SQ2 and 3). However, many go further, allowing the participants complete agency over the aim of the project, methods by which decisions

are made and the outcome of the management plan. These methods make use of stakeholder engagement beyond finding justification for environmental management projects through a consultation process meeting high level environmental goals of participation set out by the UN (UN, 1992; UNECE, 1998). Involving stakeholders in the design, application and evaluation of decision making promotes social learning (Jager et al., 2020; Pahl-Wostl & Hare, 2004), makes stakeholder engagement inherently more successful and yields beneficial outcomes (Mostert et al., 2008; Reed et al., 2018). While it is vital that stakeholders are consulted, this alone is not sustainable as it prevents bottom-up governance, stakeholder agency and social equity (Reed et al., 2009).

The application of ecosystem service and natural capital concepts are wide ranging within the results. They cover management prioritisation of specific areas; are used to indicate and track project performance; and enable contribution to large scale environment issues such as mitigation of climate change, improvement to flood resilience and contribution to poverty alleviation. The case studies in this map demonstrate the applicability of the ecosystem service and natural capital concepts in use over various environmental management plans, across multiple and complex landscape types. Yet, when applying the methods reported in this map in future research, caution should be exercised to avoid assumptions on transferability between habitats (Leach et al., 2019). The results show a clear preference of ecosystem services within decision making, over natural capital or Nature's contribution to people. This could reflect ecosystem services being a more common place term within public knowledge and policy. It was also common for case studies to identify specific ecosystem services using the Millennium Ecosystem Assessment categories, determining the method of extraction (Table 2). This resulted in the focus and priority of specific individual services, often through participatory identification rather than a more general application of ecosystem services approaches in management. Biodiversity is often identified as an ecosystem service and ranked alongside other services, yet its complex relationship with ecosystem services encouraged it to be listed as a natural capital concept in the map results (Mace et al., 2012). Despite the apparent disconnection between natural capital and ecosystem service concepts identified throughout this review, natural capital is used implicitly throughout the case studies.

The method of using ecosystem services as indicators of environmental project delivery and impact is exemplified in the ranking methods cluster identification and in the case study aim category '*Ecosystem Service Prioritisation*'. In these cases, different services are compared, weighted for importance or relevance, or chosen to suit the environmental issue being addressed. This is followed by management practices designed to promote specific ecosystem services in isolation, rather than holistic environmental resilience. Isolation of ecosystem services can easily result from ranking and prioritisation methods. While these methods, especially when applied in the early stages of a project, can help focus planning and resource use, they must be used with caution if a systems perspective of the whole environmental system is not applied. These trade-offs between individual ecosystem services enable an over-simplification of the ecosystem services approach which may promote unsustainable management choices that do not account for continued delivery of all services to society (Gokhelashvili, 2015). Continued disregard of less 'attractive' ecosystem services, such as supporting, will lead to the overall depletion of natural assets that society relies upon (Bateman & Mace, 2020). The use of ecosystem services for sustainability is widespread, but it has been identified that when applied as a boundary object, where both interdisciplinary and normative perspectives are applied, transformative application for policy interventions, participation and management can be successful (Abson et al., 2014; Boeraeve et al., 2018). Yet, there remain few examples that use ecosystem service concepts to address policy using methods beyond monetary valuation (Chan & Satterfield, 2020). Trade-offs between individual ecosystem services should not be applied without solid understanding of the normative and systems perspectives (Abson et al., 2014; McShane et al., 2011; Van Wensem et al., 2017). This is due to the complexity of natural capital and ecosystem services as socio-ecological systems that require long-term management for sustainability.

In addition, a preference for tangible economic benefit in ecosystem service selection was found, where provisioning and regulating services are more prominent in the case studies identified in the map. While in the short term, it may make sense to promote directly beneficial ecosystem services like food production, long-term delivery is impossible without supporting services, such as pollination, soil formation and nutrient cycling. In the same way that economic development cannot be realised without substantial environmental resilience, ecosystem services with tangible economic benefit cannot be used as indicators of ecosystem service delivery unless the concept is applied as a system. Connected to the concept of 'wicked problems' solving complex, multi-dimensional environmental issues have no clear solutions (DeFries & Nagendra, 2017). However, using the systems perspective of natural capital, with the addition of successful and diverse participation and overall aim of increasing human well-being, could begin to address these issues (Bateman & Mace, 2020; DeFries & Nagendra, 2017; McShane et al., 2011).

Regardless of the intention or outcome behind the choice in methods of the case studies included in this map there is distinct lack of process evaluation providing no indication on success of using natural capital concepts in decision making (SQ4). Since there is a policy mandate for the process, especially in the United Kingdom, (Dasgupta, 2021; DEFRA, 2018; Maes et al., 2020), urgent research is required to ensure that public participation contributes to the decision-making process (Ferreira et al., 2020). This applies to both environmental management and improved stakeholder trust within decision-making partnerships and between the public and policy makers. Methodological planning is based on various factors, including researcher experience and stakeholder input, without the systematic evaluation of the contribution of those processes to the end goal. Since many case studies assessed in this review determine a management solution as the outcome, but the academic publishing timeframe does not necessary allow for results, the inclusion of environmental

outcome in method efficacy is challenging. This could reflect the lack of evaluating participation in environmental management more generally, and further increase the doubt many practitioners have when involving the public in decision-making process (Gokhelashvili, 2015).

5 | CONCLUSION

The wide range of applications of ecosystem service and natural capital concepts applied in the various case studies explored in the map demonstrate the potential for use in participatory decision-making methods. Common processes include small group discussion with varied stakeholders, scenario development, development and application of decision support tools, with ecosystem service mapping as a key supporting method (SQ2 and 3). Further research is required to understand which participatory decision-making methods would be best suited to different situations (SQ4). The benefits of co-design, promoting social learning and participant agency for environmental decision making should be recognised as equally important as environmental improvements. However, the results of this review also indicated that case studies often focus on trade-offs between ecosystem services, exemplified through using ranking methods to focus on certain services (SQ1). Further research should be cautious of applying the ecosystem service concept in this way, and instead make use of the systems perspective of natural capital.

Participatory natural capital decision making could be a useful and productive way of including the public and relevant stakeholders in environmental planning. However, without further research on evaluation processes to identify efficacy of participatory processes, the contribution of these techniques is not determinable. Ecosystem service and natural capital assessment have the potential to involve and empower stakeholders in environmental decision making, especially when social learning and community agency are recognised. This empowerment can be derived from involved stakeholders increasing their understanding of the system through a natural capital conceptual approach.

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AUTHORS' CONTRIBUTIONS

C.H. and A.M.C. conceived the ideas; All authors contributed to the methodology design; C.H. collected the data, conducted the analysis and led the writing of the manuscript; J.O.K. provided analytical support. All authors contributed critically to the draft and gave final approval for publication. There is no conflict of interest.

DATA AVAILABILITY STATEMENT

All data included in the article is from referenced secondary sources.

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