Public perceptions of nature-based coastal solutions in the UK

Seenath, A., Romeo Mahadeo, S. M. & Catterson, J.

DOI 10.1016/j.jenvman.2024.123413
ISSN 0301-4797

Publisher: Elsevier

Journal of Environmental Management 373 (2025) 123413

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Public perceptions of nature-based coastal solutions in the UK

Avidesh Seenath [a,*], Scott Mark Romeo Mahadeo [b], Jade Catterson [c]

[a] Environmental Change Institute, School of Geography and the Environment, University of Oxford, United Kingdom
[b] Portsmouth Business School, University of Portsmouth, United Kingdom
[c] School of Energy, Construction and Environment, Coventry University, United Kingdom

ARTICLE INFO

Handling Editor: Jason Michael Evans

Keywords:
Nature-based solutions
Coastal management
Public perceptions
Science communication

ABSTRACT

Coastal scientists are increasingly advocating for nature-based coastal solutions (NBCS) to ensure long-term coastal sustainability. Implementing NBCS will change coastal landscapes, necessitating consultation with the wider public as such changes directly affect the socio-cultural values of coastal zone residents and users. We, therefore, investigate public willingness to support, preferences for, and perceived effectiveness of coastal management solutions, nature-based and otherwise, focusing on the UK as a case study. We do this through an online survey of >500 UK residents, capturing their demographics, place of residence, and coastal management perceptions. We apply inductive coding, statistical, and geospatial techniques to analyse our survey data. While we find consensus on the need for coastal management, there are divergent coastal management preferences and perceptions: NBCS are most preferred while hard defences are considered most effective. We find that people with coastal management and/or engineering experience are more convinced by NBCS effectiveness, while coastal residents believe in hard defences. Although NBCS may have several environmental benefits (e.g., coastal protection, carbon sequestration, greater biodiversity), we find that public knowledge on their likely effectiveness is limited. Therefore, if NBCS is deemed to be the way forward for coastal sustainability, more local stakeholder engagement on NBCS will be needed, potentially through systems mapping, in order to facilitate more robust and inclusive coastal management policies.

1. Introduction

Nature-based coastal solutions (NBCS) are green initiatives and eco-engineering schemes for reducing the risks of climate-related coastal hazards, such as sea-level rise induced erosion and flooding (Dhyani et al., 2020; Unguendoli et al., 2023). Such solutions encompass a diverse range of initiatives, including living shorelines (Davis et al., 2015), engineered reefs (Chowdhury et al., 2021), and saltmarsh, mangrove, and dune restoration (Morris et al., 2018). NBCS have several *environmental* (e.g., carbon sequestration, water quality improvements, enhanced biodiversity, and habitat structures), *economic* (e.g., cost effectiveness and tourism), and *socio-cultural* (e.g., community resilience, livelihood support for coastal-dependent households, mental well-being, and coastal heritage preservation) benefits (Morris et al., 2018; Baustian et al., 2020; Dhyani et al., 2020; Dal Barco et al., 2024). As a result, the coastal science community (CSC) are increasingly advocating for NBCS to ensure the long-term sustainability of coastal environments (Morris et al., 2018; Forrester et al., 2024; Yasmeen et al., 2024). Historically, indigenous coastal communities relied on NBCS for protection against coastal hazards (Reed et al., 2022; Goreau, 2024). This reliance marks the early beginnings of the use of NBCS for coastal management. In the contemporary period, these solutions started gaining prevalence among the CSC in the early 21st century, coinciding with the increase in global pressures to address climate change by adopting greener initiatives in all spheres of human actions (Mackinnon et al., 2008; Seddon et al., 2020; Bianciardi et al., 2023). What is concerning, however, is that the longevity of NBCS over meso timescales (10^1–10^2 years) – timescales of interest to coastal managers and policymakers (French et al., 2016; Van Maanen et al., 2016; Reeve et al., 2019; Payo et al., 2020; Seenath and Dale, 2024) – is uncertain due to a lack of: (a) evidence-based studies and; (b) available data to fully understand how coastal systems would respond to these solutions over such long timescales (Morris et al., 2018; Seddon et al., 2020; Bueno-Pardo et al., 2024; Saunders et al., 2024). Nonetheless, the growing consensus among the CSC on NBCS being the way forward for sustainable coastal management need public support, as the adoption of such solutions (and any other form of coastal management) will affect the socio-cultural values of coastal communities and coastal zone users (Anderson et al., 2021;

* Corresponding author.
E-mail address: avidesh.seenath@eci.ox.ac.uk (A. Seenath).

https://doi.org/10.1016/j.jenvman.2024.123413
Received 16 July 2024; Received in revised form 24 October 2024; Accepted 16 November 2024
Available online 30 November 2024

Barra, 2024; Dario et al., 2024b).

In the UK, four types of coastal management approaches are implemented (Apine and Stojanovic, 2024):

(a) *Hold-the-line* approaches, such as seawalls, which are designed to maintain the shoreline position (preventing the shoreline from moving).
(b) *No active intervention*, to encourage a more natural coastline, usually adopted in areas perceived to be of low social or economic value.
(c) *Managed realignment*, where the shoreline is allowed to retreat in a controlled way to facilitate the creation of intertidal habitats that will act as the primary line of defence (Dale et al., 2018). In this approach, communities are relocated further inland, to facilitate the expansion of tidal habitats. Essentially, with managed realignment, there are multiple lines of defence – the shoreline, the intertidal habitats, and the use of hard defences landward of the new intertidal zone.
(d) *Advance-the-line* approaches, where hard defences are implemented further out in the sea, to enable the shoreline to move seaward (accrete to facilitate beach width expansion).

Each of these have their own strengths and limitations. For instance, while hold-the-line and advance-the-line approaches are effective for stabilising the shoreline at the local scale (within their immediate vicinity), these approaches essentially 'shift' the problem elsewhere through wave reflection, refraction and diffraction, amplifying erosion and habitat destruction elsewhere along the coast (Anfuso et al., 2011; Rangel-Buitrago et al., 2018). Additionally, they are costly, require frequent maintenance, and are, therefore, unsustainable and not (always) financially practical. Managed realignment, although effective in reducing flood risk and improving biodiversity, essentially relinquishes land to the sea (Schuerch et al., 2022) and requires the strategic relocation (displacement) of some people (Ajibade et al., 2022). No active intervention, while cost effective and allows the natural reworking of the coast (and creation of new landscapes) with new opportunities, also relinquishes land to the sea, often leading to lost economic opportunities. All of these approaches have the potential to alter the socio-cultural values (sense of belonging, heritage, identity) of coastal residents and coastal zone users (Döring and Ratter, 2017; Walsh and Döring, 2018). However, in the UK context, these approaches are engrained in cultural coastal management practices and heritage preservation (French, 2004; Apine and Stojanovic, 2024). As these approaches are known by the British public (Palmer et al., 1996), adopting an alternative form of management – NBCS – may be seen to compromise the protection of the 'known' coastal landscape, and this has potential implications for the socio-cultural values attached to the coast (Rendon et al., 2022).

Coastal environments hold significant socio-cultural values for both residents and users, including:

(a) *cultural and family heritage* (e.g., historical significance dating back to indigenous practices, fishing traditions, familial connections) (Khakzad et al., 2015).
(b) *social cohesion* in terms of community building (coastal zones are social hotspots) and intergenerational connections (coastal traditions being passed down through generations creating a sense of belonging) (Acott et al., 2022; Kjørholt et al., 2022).
(c) *identity* – coasts form an integral aspect of coastal residents' identity, and coastal symbols (e.g., light houses) often represent local coastal communities way of life (Magnani and Pistocchi, 2017).
(d) *recreational importance* – coastal tourism forms the economic backbone of many small island developing states, and coastal zones are popular destinations for unwinding and improving mental well-being (Forbes et al., 2013; Ghermandi, 2015; Acott et al., 2022).
(e) *environmental awareness* – coastal residents often develop a strong sense of environmental stewardship for protecting their homes and livelihoods from coastal hazards, and so too do end users that rely on the coast for recreation and work (Turnbull et al., 2020; Mcleod et al., 2024).
(f) *aesthetics and inspiration* – the beauty of the coast has historically been the source of inspiration for artists (e.g., Joseph Mallord William Turner), writers (e.g., Herman Melville), and musicians (e.g., Claude Debussy).

The overarching importance and value of the coast for residents and users inevitably mean that there is a strong societal desire to protect coastal landscapes globally (Arkema et al., 2017). Local societies may, hence, be wary of supporting coastal management strategies that are lesser known in terms of their effectiveness and, instead, may be willing to support strategies that are 'known' to work. Therefore, the growing call for NBCS by the CSC coupled with the limited implementation of these solutions on a global scale (Morris et al., 2018; Moraes et al., 2022) may mean that societal knowledge and acceptance of these solutions are limited (Josephs and Humphries, 2018; Rahman et al., 2023). Thus, we need to understand how people perceive NBCS relative to more traditional types of coastal management as public support is key for the successful implementation of any form of environmental management. Indeed, disregarding societal perceptions of NBCS (and other forms of new and alternative coastal management solutions) may be 'myopic', particularly as local societies (including coastal residents and coastal zone users) are often key coastal stakeholders, with adverse implications for the successful mitigation of coastal hazards and risks (Areia et al., 2023).

Recent studies have attempted to gauge support and preference for NBCS over hard defences through a range of empirical approaches. These include willingness-to-pay and discrete choice experiment surveys of coastal zone residents (e.g., Hagedoorn et al., 2021; Rendon et al., 2022; Dario et al., 2024b), Likert-based surveys of coastal management preferences and follow-up focus group discussions with a small number of people residing in areas at risk of hydrometeorological hazards (e.g., Anderson et al., 2022), interviews with a small number of various user-groups in coastal erosion zones (e.g., Josephs and Humphries, 2018), and interviews with coastal management practitioners and marine contractors (e.g., Dario et al., 2024a). While these studies provide critical insights on the support and preferences for NBCS from niche audiences and from a financial, governance, community, and broad environmental benefit lens, their survey instruments do not capture wider societal perceptions and broader willingness to support NBCS relative to alternative coastal management options. For example, they do not explicitly ask their participants to explain the reasons behind their coastal management preferences. Nor do they allow participants the opportunity to consider the various coastal management options without prompts (e.g., by not attributing a cost to fund a specific scheme). In this regard, a gap still exists regarding understandings of public perceptions and preferences for NBCS relative to alternative forms of coastal management.

Given the preceding context, we aim to understand public perceptions of NBCS and more common forms of coastal management, with specific focus on the UK. We do this through an interdisciplinary approach, involving an online survey of >500 UK residents on their coastal management preferences and perceptions, statistical modelling, thematic analysis through inductive coding, and geospatial analysis. Our survey shares thematic similarities with those from related studies aforementioned in its focus on public perceptions and NBCS. However, our survey is distinct in its use of UK-specific coastal management preferences, its integration of inductive coding, and the use of spatial analysis linking geography to coastal management preferences. Our findings will, thus, have important policy implications for improving

stakeholder engagement in coastal management decision-making towards informing more inclusive and robust coastal management policies. The following sections outline our primary data collection and methods (Section 2), results and analysis (Section 3), discussion and wider implications (Section 4), and key conclusions (Section 5).

2. Data and methods

2.1. Primary data collection

We develop and disseminate a mixed open and closed-ended survey, to investigate public perceptions and perceived effectiveness of NBCS and the four common coastal management approaches in the UK in relation to flood risk mitigation. Our survey targets UK adult residents, regardless of nationality. We ask all participants to specify their age, highest level of educational attainment, and approximate monthly household income. We then ask them to specify the first part of their UK postcode (control question) in order to determine their eligibility for our survey. Next, we ask all participants to assume that they are living in an area with high coastal flood risk and, based on this assumption, specify their willingness to support the following five coastal management strategies using a standard Likert scale (very unwilling, unwilling, neutral, willing, very willing):

(a) Authorities install hard defences (e.g., groynes). To fund this, households will be required to pay higher council taxes.
(b) Authorities do nothing. Homeowners and renters invest in flood insurance for their property.
(c) Authorities, homeowners, and renters do nothing.
(d) Authorities move people away from flood risk areas following consultation with the public. Homeowners will be compensated for the loss of their land.
(e) Authorities introduce nature-based solutions (e.g., sand nourishment and salt marshes). To fund this, households will be required to pay higher council taxes.

Option (a) represents the hold-the-line and advance-the-line approaches that are commonly used for coastal management in the UK. Options (b) and (c) are variants of the do-nothing approach adopted in the UK for managing coastal zones of low social or economic value. Option (d) is partially equivalent to the managed realignment approach that has recently been implemented in the UK. Option (e) is NBCS, which are increasingly pushed as the way forward for coastal management globally. In our survey, we include a photo of groynes in Norfolk – the most common hard defence used for coastal management in the UK – and a photo of the Norfolk sandscaping scheme – a classic form of NBCS used in the UK. Both photos are accompanied by a link, which provide additional details of hard defences and NBCS in the UK. Additionally, we include saltmarshes as an example of NBCS in the wording of our coastal management questions, as these are a common form of such solutions in the UK. We provide this additional information, as we recognise that the lay person may not be familiar with standard coastal management terminologies. We acknowledge that there are other forms of NBCS, as outlined in Section 1, and we recognise that using a photo of a groyne and a sandscaping scheme to contextualise hard defences and NBCS, respectively, might skew the focus of participant responses towards groynes and sandscaping schemes rather than to hard defences and NBCS more broadly. However, we feel that it is more beneficial to use examples of both approaches that are familiar to the lay person in the UK – our study site. To minimise the potential implication of skewed responses towards groynes and sandscaping schemes, we pilot our survey to gauge whether participants interpret our questions in terms of hard defences and NBCS more broadly, as per the details further outlined below.

Additionally, we ask participants to consider the five coastal management options above for mitigating coastal flood risk and specify their most preferred and least preferred options. We also ask them to identify what they perceive to be the most effective option in the context of coastal flood risk mitigation, and to provide the reasons behind all of their selections (most preferred, least preferred, and most effective). Our two final survey questions ask all participants to declare whether they (a) currently, previously or never lived at the coast, and (b) have any coastal management and/or engineering experience. All of our survey questions, excluding the qualitative (open-ended) questions requiring participants to specify reasons for their selections of most preferred, least preferred, and perceived most effective coastal management strategy, are compulsory. However, despite not being compulsory, ~98% of our survey participants have completed the full survey, including the optional qualitative (open-ended) questions.

We first pilot our survey to ensure that our questions are clear and that associated responses enable us to address our research aim. We particularly use the pilot survey to gauge whether UK residents understand our questions in the context of coastal flood risk mitigation. The qualitative responses to our open-ended questions in the pilot survey confirm good understanding of the questions. For example, reasons quoted for "most preferred", "least preferred" and perceived "most effective" coastal management approaches to flood risk mitigation in our pilot study included issues of urgency and timescale (e.g., "hard defenses can be useful quickly and in a short time-scale"), efficacy (e.g., "Groynes have more historical data that they will work, not sure I have read anything about the effectiveness of the naturalistic method"), economic implications (e.g., "It is a nature-based solution which will have the least impact on tourism"), uncertainty (e.g., "Groynes do work but are ineffective against flooding. Salt marshes would be needed as well as development of flood plains for coastal inundation"), aesthetics (e.g., "nature-based solution is easier on the eyes, less ugly"), and wider environmental benefits (e.g., "[NBCS] Restores biodiversity and helps defend the people against the sea."). All of these emerging themes in our pilot study responses demonstrate good general understanding of coastal management challenges and benefits. Such themes also emerge in our main study responses, which we discuss further in our results section. Thus, our pilot study responses provide ample evidence that our survey design is clear for the intended purpose of understanding public perceptions of NBCS and more common forms of coastal management in the UK. We, therefore, include the pilot survey data in our final survey dataset, which underpin this study. Altogether, our pilot study includes responses from 13 individuals recruited via our wider networks in the UK (age = 32 to 54, gender = seven females and five males, education = secondary to tertiary, six homeowners and seven renters). We also ask our pilot survey participants to provide feedback on our survey design, all of whom acknowledge that our survey is clear for its intended purpose. A copy of our survey dataset (including qualitative responses) is available in our supplementary materials.

Following our pilot study, we disseminate our survey to the UK public online via survey-hosting platforms (commercial and non-commercial), social media, and mailing lists. We obtain 572 responses from 01-MAY-2023 to 31-JULY-2023, including 299 from Prolific (https://www.prolific.com/), 160 from SurveyCircle (https://www.surveycircle.com/en/), 20 from SurveySwap (https://surveyswap.io/), and 93 from other sources (social media and mailing lists). The Prolific survey platform has over 500,000 registered participants from the UK. Based on our available funding, we pay to recruit 300 participants from the UK in Prolific, but receive 299 responses as 1 response has been submitted prematurely. Unlike Prolific, SurveyCircle and SurveySwap are non-commercial survey platforms, meaning that participants in these platforms receive non-monetary compensation. Instead, these participants receive credit points based on their survey participation rates, which they can use to recruit participants for their own surveys. As SurveyCircle and SurveySwap are typically used for academic and market research, these platforms attract participants from various professional backgrounds. In both of these platforms, we simply list our survey for the period mentioned above, allowing eligible participants to

complete the survey of their own volition. To maximise the reach of our survey and ensure we are reaching a diverse population (e.g., non-professionals etc.), we share our survey link to UK community group pages on Facebook as well as to our wider networks via WhatsApp, Twitter, LinkedIn, Instagram, and email. Altogether, this ensures that our survey captures a good range of demographics across the wider UK public, evident from our survey data in our supplementary materials.

A challenge with any public survey, such as ours, is obtaining responses from demographics that directly align with the demographic breakdown of the wider population. While reweighting survey responses based on general population demographics is a common approach to address bias, we deliberately choose not to do this in our study. Reweighting can potentially amplify specific factors that might disproportionately influence perceptions of coastal management, especially when certain demographic groups are underrepresented in the survey sample. Instead, we analyse the influence of demographic subgroups (e.g., age, income, education) within the sample to understand their impact on coastal management perceptions, as outlined in Section 2.3. Doing so avoids over-adjusting the data while still enabling us to explore subgroup-specific trends.

We send no survey reminders via Prolific, SurveyCircle and SurveySwap, as this cannot be facilitated in these platforms. We do, however, re-share our survey link in the various social media platforms periodically, but responses received through these channels account for only a small percentage of our survey sample (16%). In this regard, the majority of our participants have been compensated for their time, which we believe reduced non-response bias and the likelihood of differential response patterns based on motivation or engagement that normally occurs in response to survey reminders.

Following data inspection for impaired and ineligible responses (e.g., not satisfying the survey eligibility criteria, such as an invalid UK postcode or not over the age of 17), we end up with 531 useable responses for this study. Our supplementary materials include a copy of the survey – which we develop using JISC Online Surveys (https://www.onlinesurveys.ac.uk/) – and our final dataset.

2.2. Quantitative data analysis

We use descriptive statistics to get an overview of public preferences and perceptions of the five coastal management strategies presented. Specifically, we tabulate and compare the count and percent of respondents very unwilling, unwilling, neither unwilling nor willing (neutral), willing, and very willing to support each coastal management strategy presented. We do the same for the data collected on least preferred, most preferred, and perceived most effective coastal management strategy.

To establish a relationship between participants' willingness to support alternative coastal management strategies, we use Pearson's product moment and Spearman's rank correlation measures. The latter is a non-parametric version of the former and they are commonly reported together for robustness complementarity (see, e.g., Mahadeo et al., 2019). Correlation analysis permits us to investigate the strength and direction of the relationship between respondents' willingness to support alternative coastal management strategies. If a given management strategy is positively (negatively) correlated with another, it implies that respondents have similar (diverging) views on those pair of strategies. Insights from these correlation coefficients allow us to gauge how respondents might perceive coastal management solutions both between and within more active (e.g., NBCS; hard defences) and passive (e.g., do-nothing) interventions.

To understand whether respondents' attributes influence their coastal management preferences and perceptions, we consider their age, education, income, coastal residency (currently/previously/never a coastal resident), and coastal management and/or engineering experience. As younger generations are reported to be more sensitive to nature and sustainability issues (see, e.g., Giachino et al., 2021), we define discrete categories for age using a k-means clustering algorithm based on Euclidean distance, which sorts respondents into relatively younger (18–39 years) and older ($\geq$40 years) adults. We determine subgroups for income (low, middle, high) and highest level of education attainment (undergraduate, postgraduate, other) based on our data distribution, to observe if perspectives change under discrete categories. Just over 30% of our respondents' monthly household income are <£2000; just under 50% are between £2000 and £4000; and the remaining 20% >£4000. About 40% of our sample have undergraduate education, another 40% have postgraduate education, and the remaining 20% have either secondary or further education (e.g., trade and college courses). We also consider whether the perspectives of a subgroup with coastal management and/or engineering experience align with those of the remaining participant pool. We also subgroup by coastal residency (currently, previously, never lived by the coast), as we recognise that the coastal management perspectives of coastal residents are likely to be different based on their coastal life experiences. For example, non-coastal residents may romanticise the quintessential idea of living by the coast, which has been commercially glamourised by advertising in the tourism and real estate sectors (see, e.g., Gillon and Gibbs, 2017), relative to coastal residents who may be faced with the realisation of coastal insurance. Comparisons between such subgroupings enable a more nuanced understanding of coastal management awareness among the different facets of the public, which can have important implications for coastal management decision-making policies. For each subgroup of respondents' attributes, we tabulate the total number and percentages of respondents selecting each coastal management strategy as their least preferred, most preferred, and perceived most effective option. We compare subgroup percentages data against the overall participant pool percentages data on coastal management preferences and perceptions, to evaluate whether specific individual attributes influence these preferences and perceptions.

2.3. Qualitative data analysis

We use thematic analysis to analyse our qualitative survey responses in order to identify the reasons for our survey respondents' most preferred, least preferred, and perceived most effective coastal management option. Our thematic analysis here involves several phases in the re-contextualisation and de-contextualisation of the data to reduce the subjectivity associated with this form of analysis (Starks and Trinidad, 2007; Nowell et al., 2017). Specifically, we use inductive coding to develop a conceptual discussion around respondents' insights and views on their coastal management preferences and perceived effectiveness, rather than creating codes based on pre-agreed philosophical angles. This allows us to prioritise respondents' coastal management preferences and perceptions, placing them at the centre of this discussion through a humanistic lens.

Our thematic analysis using inductive coding involves a series of phased stages, similar to those used by Braun and Clarke (2006) and Naeem et al. (2023). We first extract all qualitative survey responses and organise these into three spreadsheets, one each for the most preferred, least preferred, and perceived most effective coastal management strategy. We next comb through the data to identify emerging trends in order to establish preliminary codes based on the prevalence of phrases and words within our qualitative data. Here, the detail and emotions conveyed in this data shaped our overall code development. After establishing preliminary codes, we re-examine the data, rewording and reducing some of the preliminary codes to match standard terminology in related literature. We subsequently allocate responses to each code and quantify the number of responses per established codes, to understand the reasons behind respondents' coastal management preferences and perceptions. We complement our analysis here with a word cloud generator to visualise the frequency of responses for each most preferred, least preferred, and perceived most effective coastal management strategy, in order to obtain a visual overview of our

respondents' outlook on the strategies considered.

2.4. Geospatial analysis

To investigate whether place of residence and distance from the sea influence coastal management preferences and perceptions, we use ArcGIS Pro to map the most preferred and perceived most effective strategy by postcode in the UK. This enables us to see the spatial distribution in coastal management preferences and perceptions across the UK, in order to complement our quantitative analysis on coastal residency relative to such preferences and perceptions. Moreover, considering the spatial distribution in coastal management preferences and perceptions allows us to identify regional variations in these opinions. Such information has implications for improving coastal management policies in areas deemed to be most at risk of coastal hazards by indicating where more effective stakeholder engagements (e.g., communications between the CSC and local communities; education campaigns) are needed. More importantly, in the context of coastal management, understanding spatial perceptions of various intervention strategies can potentially reveal if certain coastal areas are more disproportionately affected by negative perceptions. Such an understanding has implications for ensuring all local coastal communities are engaged in coastal management decisions, to enable more inclusive, robust, and equitable coastal management policies.

3. Results and analysis

3.1. Perceptions of coastal management strategies

We first breakdown respondents' willingness to support each coastal management strategy presented, along with their level of preference and perceived effectiveness in Table 1.

We find most respondents are keen to support *NBCS* – 46.7 % (willing) and 36.53% (very willing) – with only a minority unwilling to support this form of coastal management (<9%). We find a consistent willingness to support (>75%) *hard defences* for coastal management, with only a minority (<10%) unwilling to support this form of management. Interestingly, both NBCS and hard defences are associated with higher council taxes, but this did not deter most respondents' willingness to support either of these strategies. Such findings imply that the public places a high value on effective coastal management, perhaps due to recognising that the benefits of these initiatives (hazard risk reduction) outweigh the financial burden of increased taxes, consistent with the findings of Kelly and Molina (2023). Kelly and Molina (2023), for example, show that property buyers are aware of the cost of flooding and the need to invest in suitable adaptation, even at the expense of higher property values. There may also be an underlying urgency regarding the need to respond to the threat of coastal hazards by investing in sound coastal management, hence the overall support for these initiatives (Jones et al., 2015).

Our reflexive arguments above are supported by the fact that the majority of our respondents are not keen to support a do-nothing approach. Specifically, we find that ~85% of respondents are unwilling to support the approach where authorities, homeowners, and renters do nothing. Such an approach is often based on the principle of '*let nature take its course*' and is usually adopted in coastal environments perceived to be of low social or economic value. Respondents' clear unwillingness to support this approach, further suggests that there is a strong public value placed on coastal environments. This is again evident from most respondents (~65%) also unwilling to support a coastal management initiative where authorities do nothing, but homeowners/renters invest in flood insurance. Taken together, most respondents are unwilling to invest in flood insurance where authorities do nothing but are in-fact willing to accept higher council taxes when authorities implement NBCS or hard defences. Public support for coastal management schemes, therefore, appear contingent on authorities willing to invest in coastal management, which might be related to issues of trust (in public institutions) and responsibility (where financing of coastal management is viewed as a national responsibility, and not just for those who may be directly affected by coastal hazards) (Jones et al., 2015). Also, the hesitancy to support flood insurance versus willingness to support higher taxes for NBCS and hard defences, may be dependent on perceived effectiveness of these strategies. For instance, community-wide solutions, such as NBCS and hard defences, may be seen as more effective (and proactive) and equitable (in terms of financial burden) than individual actions, such as investing in flood insurance. In fact, we find that

Table 1
Public perceptions of coastal management strategies. *Notes*: values in cells represent the number out of the 531 survey participants recorded for that item and the accompanying values in parentheses represent the corresponding percentages. The shaded box in each column corresponds to the most selected coastal management strategy under that column's category. We use a red (unwilling) to green (willing) colour grading palette to distinguish between the Likert categories under "Willingness to support" and adopt a red and green colour scheme to distinguish between least (red) and most (green) preferred coastal management strategy. Grey = neither willing nor unwilling to support a coastal management strategy. Blue = perceived most effective strategy.

	Willingness to support					Preference		Effectiveness
Coastal management strategy	Very unwilling	Unwilling	Neutral	Willing	Very willing	Least preferred	Most preferred	Most effective
Hard defences funded via higher council taxes.	16 (3.01%)	35 (6.59%)	74 (13.94%)	298 (56.12%)	108 (20.34%)	20 (3.77%)	132 (24.86%)	233 (43.88%)
Authorities **do nothing**. Homeowners/renters **invest in flood insurance**.	174 (32.77%)	178 (33.52%)	91 (17.14%)	78 (14.69%)	10 (1.88%)	83 (15.63%)	15 (2.82%)	10 (1.88%)
Authorities, homeowners, and renters **do nothing**.	370 (69.68%)	92 (17.33%)	45 (8.47%)	19 (3.58%)	5 (0.94%)	380 (71.56%)	5 (0.94%)	8 (1.51%)
Relocate residents away from flood risk zones. Homeowners compensated for land loss.	72 (13.56%)	126 (23.73%)	138 (25.99%)	153 (28.81%)	42 (7.91%)	40 (7.53%)	61 (11.49%)	69 (12.99%)
Nature-based solutions funded via higher council taxes.	8 (1.51%)	31 (5.84%)	50 (9.42%)	248 (46.70%)	194 (36.53%)	8 (1.51%)	318 (59.89%)	211 (39.74%)

hard defences (~44%) and NBCS (~40%) are strong contenders for the most perceived effective strategy, with a do-nothing approach (~87%) being perceived as least effective by most respondents.

Although most respondents perceive hard defences to be most effective, ~60% of respondents most prefer NBCS. This finding represents a nuanced viewpoint among our respondents, consistent with the findings of Anderson et al. (2021). Hard defences, for example, are the most common form of coastal management in the UK. This, therefore, means that most respondents would likely have a better understanding of how these defences work. NBCS are, however, a fairly new concept with little application in the UK, which likely diminishes the awareness of its effectiveness among the wider public. That said, NBCS may be perceived to be synonymous with a higher environmental aesthetic value, which may be skewing responses towards it being the most preferred option.

In subsequent sub-sections, we look more closely into the underlying quantitative and qualitative trends in our survey data to better explain our results discussed here.

3.1.1. Quantitative trends

The correlation matrix in Table 2 shows a relatively strong positive relationship between willingness to support hard defences and NBCS as coastal management strategies via higher council taxes, evident from Pearson and Spearman correlation coefficients of 0.34 and 0.36, respectively. This indicates that respondents who support one active strategy tend to support the other, and those who are unlikely to support one active strategy is unlikely to support the other. There is also a strong positive relationship between willingness to support passive strategies (do nothing approaches), implying that participants (un)supportive of one passive strategy are (un)likely to support the other, evident from Pearson and Spearman correlation coefficients of 0.38 and 0.40, respectively. Based on the relatively strongest negative relationships between willingness to support alternative coastal management strategies, we find that those partial to a form of management intervention, such as NBCS, are unwilling to support a do-nothing approach (authorities, homeowners, and renters do nothing), and vice-versa. This finding is supported by correlation coefficients of: (a) −0.25 (Pearson) and −0.28 (Spearman) between NBCS and the do-nothing approach, and (b) −0.27 (Pearson) and −0.32 (Spearman) between hard defences and the do-nothing approach.

3.1.2. Qualitative trends

Earlier, we show that 60% (318) of our respondents most prefer NBCS. Of these, ~40% (127) most prefer this option from an environmentally conscious lens (Table 3; Fig. 1), likening NBCS to being environmentally beneficial with minimal negative impact for biodiversity. A further 24% (77) of those that most prefer NBCS perceive these solutions as being an effective and sustainable approach for managing coastal hazards and risks, with an additional 11% (36) most preferring this option primarily for its aesthetic value. Interestingly, 48% (63) of those who most prefer hard defences perceive such defences as being effective and sustainable for managing coastal hazards and risks (Table 3; Fig. 1). These findings collectively suggest that 36% of our respondents most preferred choice of coastal management is based on *perceived effectiveness and sustainability of the intervention strategy*. This is also evident from 'effectiveness and sustainability' being the key deciding factors for most respondents (~44%) considering hard defences to be most effective.

Effectiveness and sustainability (longevity) are also the primary deciding factors for the majority of those who perceive NBCS to be most effective. However, what is noteworthy here is that the main reason for most people selecting NBCS (environmental consciousness) and hard defences (effectiveness and sustainability) as their most preferred coastal management strategy is fundamentally different. Specifically, we see clear distinctions in overall perceptions of effectiveness, with NBCS generally not perceived as effective compared to hard defences (Table 3; Fig. 1). Collectively, these findings suggest that most people are keen to support coastal management strategies that are (likely known to be) effective and sustainable, which is also evident from most respondents (~55%) least preferring a do-nothing approach, viewing such approaches as ineffective and unsustainable (Table 3; Fig. 1), consistent with Anderson et al. (2021). These findings point to considerable divergence in viewpoints between local residents (Table 3; Fig. 1) and the CSC on the effectiveness of NBCS (Section 1).

3.2. Determinants of coastal management perceptions

3.2.1. Demographic trends

Our demographic analysis reveals that income, coastal residency, and coastal management and/or engineering experience appear to influence overall coastal management preferences and perceptions, with education and age having a marginal influence (Table 4). Consequently, we focus on trends in coastal perspectives relative to income, coastal residency, and coastal management and/or engineering experience.

Income: relatively lower income subgroups have a higher propensity than other income subgroups to: (a) least prefer hard defences funded by higher council taxes; (b) most prefer authorities do nothing and

Table 2
Parametric and non-parametric correlation coefficients between willingness to support alternative coastal flood management strategies. *Notes*: correlation coefficients in the upper diagonal triangle are the parametric estimates from the linear Pearson's product moment method and correlation coefficients in the lower diagonal triangle are the non-parametric estimates from the Spearman's rank method. Darker (lighter) shades of green/red indicate relatively stronger (weaker) positive/negative relationships. The correlation coefficients are based on the level of willingness to support the various coastal management strategies, from a sample of 531 survey participants. For both correlation approaches, correlations values are bounded between −1 (a perfect negative relationship) and +1 (a perfect positive relationship) and values that tend towards 0 in either direction implies a weakening correlation, where 0 would indicate no correlation.

Coastal management strategy	**Hard defences** funded via higher council taxes.	Authorities **do nothing**. Homeowners/renters **invest in flood insurance**.	Authorities, homeowners, and renters **do nothing**.	**Relocate residents** away from flood risk zones. Homeowners compensated for land loss.	**Nature-based solutions** funded via higher council taxes.
Hard defences funded via higher local council tax.	1.00	-0.11	-0.27	-0.10	0.34
Authorities **do nothing**. Homeowners/renters **invest in flood insurance**.	-0.14	1.00	0.38	0.17	-0.20
Authorities, homeowners, and renters **do nothing**.	-0.32	0.40	1.00	0.19	-0.25
Relocate residents away from flood risk zones. Homeowners compensated for land loss.	-0.09	0.16	0.18	1.00	-0.10
Nature-based solutions funded via higher local council taxes.	0.36	-0.24	-0.28	-0.09	1.00

Table 3
Primary reasons behind the selection of most preferred, least preferred, and most effective coastal management strategy. **Option 1** = Hard defences funded via higher council taxes. **Option 2** = Authorities do nothing; Homeowners/renters invest in flood insurance. **Option 3** = Authorities, homeowners, and renters do nothing. **Option 4** = Relocate residents away from flood risk zones; homeowners compensated for land loss. **Option 5** = Nature-based solutions funded via higher council taxes.

	Primary reason for selection	Option 1	Option 2	Option 3	Option 4	Option 5
Reasons for selection of **MOST PREFRRED** coastal management options.	*Authorities' responsibility*	12	0	0	5	7
	Homeowner/occupant responsibility	0	6	0	5	4
	Combined responsibility	0	0	0	1	0
	Aesthetically pleasing	1	0	0	0	36
	Financial viability and cost effectiveness	14	1	0	18	21
	Environmentally conscious	9	2	0	18	127
	Least disruption/impact for community	8	0	0	3	6
	Effectiveness and sustainability of approach	63	0	0	9	77
	Familiarity and views on flood risk	8	2	2	0	3
	Preferable to other options provided	7	2	0	1	22
	No reason provided/unsure	10	2	3	1	15
	Total	132	15	5	61	**318**
Reasons for selection of **LEAST PREFERRED** coastal management options.	*Authorities' responsibility*	1	29	10	2	0
	Homeowner/occupant choice	0	3	9	0	0
	Combined responsibility	0	0	21	0	0
	Aesthetically displeasing	7	0	0	0	0
	Financial risk	6	14	33	6	3
	Environmental impact	3	1	16	1	0
	Disruption/impact for community	0	5	15	16	1
	Ineffective and unsustainable	0	26	264	6	2
	Familiarity and views on flood risk	1	1	2	0	0
	Preferable to other options provided	0	0	0	2	1
	No reason provided/unsure	2	4	10	7	1
	Total	20	83	**380**	40	8
Reasons for selection of **MOST EFFECTIVE** coastal management options	*Authorities' responsibility to do something*	4	0	0	0	3
	Homeowner/occupant choice to locate there	2	3	0	0	0
	Combined responsibility	3	0	0	2	0
	Effectiveness and sustainability	121	1	0	40	89
	Immediate impact/proactive	21	0	0	5	8
	Financial viability and cost effectiveness	5	2	4	4	7
	Environmentally conscious	3	0	0	3	51
	Least disruption/impact for community	4	1	0	2	7
	Familiarity and knowledge	31	0	0	0	11
	Preferable to other options provided	9	0	0	4	10
	No reason provided/unsure	24	2	3	9	21
	Other	6	1	1	0	4
	Total	**233**	10	8	69	211

homeowners/renters invest in flood insurance (i.e., control over their spending); (c) most prefer the relocation of residents away from flood risk zones with homeowners compensated for land loss, and; (d) perceive a do-nothing approach where authorities do nothing and homeowners/renters invest in flood insurance to be most effective (Table 4). A commonality in these findings is that lower income subgroups (understandably) have a stronger preference for coastal management approaches that are associated with minimal financial burdens, preferring the option of *choosing* to invest in an intervention strategy rather than being required to invest in strategies by authorities, similar to the findings of Dario et al. (2024b). This signals a desire for more autonomy in decision-making based on personal finances.

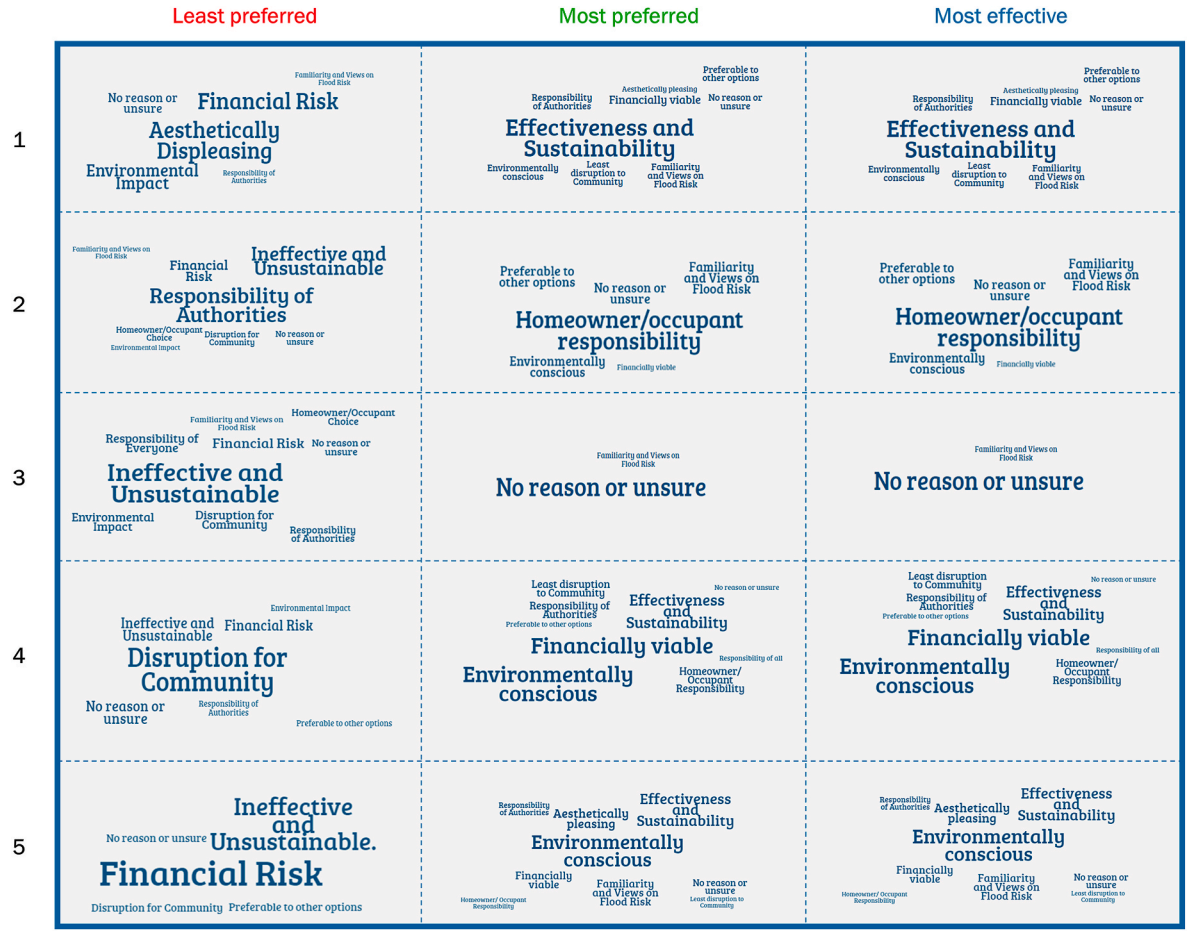

Fig. 1. Word cloud of most frequent cited reasons behind participants selection of their least preferred, most preferred and perceived most effective coastal management strategy. **1** = Hard defences funded via higher council taxes. **2** = Authorities do nothing; Homeowners/renters invest in flood insurance. **3** = Authorities, homeowners, and renters do nothing. **4** = Relocate residents away from flood risk zones; homeowners compensated for land loss. **5** = Nature-based solutions funded via higher council taxes.

Conversely, relatively higher income subgroups perceive hard defences funded by higher council taxes to be most effective for coastal management (Table 4). This finding indicates a larger appetite among higher income groups to invest in coastal management, likely because of less financial constraints relative to lower income groups, consistent with Liu and Wirtz (2010) findings.

Coastal residency: current coastal residents have a higher (lower) tendency than previous and non-coastal residents to most prefer hard defences (NBCS) (Table 4). Interestingly, previous coastal residents have a higher tendency than current and non-coastal residents to least prefer NBCS and a relocation option where homeowners are compensated for land loss (Table 4). These findings suggest that coastal residents (past and current) have a stronger preference for active coastal management schemes that have historically been used – hard defences – likely because of greater awareness of their effectiveness (Anderson et al., 2021). However, previous coastal residents have a lower tendency than current and non-coastal residents to least prefer a do-nothing approach (with no flood insurance investment). While this finding is complex to unpack, it seems to be related to previous coastal residents having more distributed responses across the five coastal management options presented under the least preferred management category relative to current and non-coastal residents. Such a finding may also be due to these residents (now inland residents) unwilling to pay (through taxes) for coastal management approaches that have a more tangible benefit for coastal residents than for them. This point on NIMBYism (Not In My Backyard-ism) may also be related to the purpose of these residents having to leave their coastal homes – which may have been to reduce their own taxes and, therefore, not wanting to pay for other people to have the life they once had. Our dataset, however, does not allow for definitive explanations here.

Coastal management and/or engineering experience: those with coastal management and/or engineering experience have a higher propensity than all other respondents to: (a) least prefer authorities do nothing, but homeowners invest in flood insurance; (b) most prefer authorities, homeowners, and renters do nothing, and; (c) perceive do-nothing approaches (with and without flood insurance investment) and NBCS to be most effective for coastal management (Table 4). Here, an important point to note is that only a tiny proportion (<4%) of the participant pool selected do-nothing approaches as their most preferred and most effective options. Conversely, those with coastal management and/or engineering experience have a lower tendency to perceive hard defences as the most effective approach for coastal management (Table 4). Overall, these results indicate that those with coastal management and/or engineering experience have a stronger preference for and belief in NBCS, consistent with the wider CSC in related literature.

Other demographics: a higher proportion of relatively younger (older) participants perceive hard defences (NBCS) to be most effective for coastal management (Table 4). This finding contradicts related literature where the opposite is documented (see, e.g., Giachino et al., 2021). However, it may suggest that younger people are more cautious (risk averse) in their long-term decision-making process – perhaps because of the current financial risks and greater challenges with accessing the property ladder – potentially favouring management approaches with a longer track record of visible success. These assertions align with Strain

Table 4
Preferences and perceived effectiveness of coastal management strategies by participants' characteristics.

Categorical sub-samples	Obs.	Preference										Perceived effectiveness				
		LEAST preferred (% of sub-sample)					MOST preferred (% of sub-sample)					Most EFFECTIVE (% of sub-sample)				
		Opt. 1	Opt. 2	Opt. 3	Opt. 4	Opt. 5	Opt. 1	Opt. 2	Opt. 3	Opt. 4	Opt. 5	Opt. 1	Opt. 2	Opt. 3	Opt. 4	Opt. 5
Full sample	531	3.77	15.63	71.56	7.53	1.51	24.86	2.82	0.94	11.49	59.89	43.88	1.88	1.51	12.99	39.74
Age																
18 ≤ years ≤39	352	3.69	18.75	70.17	6.25	1.14	25.57	2.84	1.14	13.35	57.10	**48.01**	2.27	1.70	13.92	34.09
≥40 years	179	3.91	9.50	74.30	10.06	2.23	23.46	2.79	0.56	7.82	65.36	35.75	1.12	1.12	11.17	**50.84**
Income*																
High	108	3.70	12.96	76.85	5.56	0.93	28.70	1.85	0.93	11.11	57.41	**54.63**	0.00	0.93	12.96	31.48
Medium	255	1.57	16.86	73.33	6.67	1.57	24.31	1.96	0.78	7.45	65.49	42.35	1.18	1.57	12.16	42.75
Low	166	**7.23**	15.66	65.66	9.64	1.81	22.89	**4.22**	1.20	**18.07**	53.61	39.16	**4.22**	1.81	14.46	40.36
Education																
Up to PG level	210	4.76	18.57	68.10	7.14	1.43	25.24	3.33	1.43	13.33	56.67	40.48	1.43	2.38	**15.71**	40.00
Up to UG level	209	3.35	13.40	72.73	8.61	1.91	23.92	2.39	0.96	9.09	63.64	48.33	2.87	0.96	11.00	36.84
Otherwise	112	2.68	14.29	75.89	6.25	0.89	25.89	2.68	0.00	12.50	58.93	41.96	0.89	0.89	11.61	44.64
Coastal resident																
Currently	94	5.32	12.77	74.47	6.38	1.06	**34.04**	2.13	1.06	12.77	**50.00**	46.81	1.06	1.06	11.70	39.36
Previous	120	6.67	15.00	**61.67**	**12.50**	**4.17**	24.17	3.33	1.67	9.17	61.67	40.83	2.50	2.50	14.17	40.00
Never	317	2.21	16.72	74.45	5.99	0.63	22.40	2.84	0.63	11.99	62.15	44.16	1.89	1.26	12.93	39.75
Coastal management and/or engineering experience																
Yes	35	5.71	**22.86**	62.86	5.71	2.86	20.00	2.86	**2.86**	11.43	62.86	**28.57**	**5.71**	**2.86**	5.71	**57.14**
No	496	3.63	15.12	72.18	7.66	1.41	25.20	2.82	0.81	11.49	59.68	44.96	1.61	1.41	13.51	38.51

Notes: percent values that are bolded are emphasised within the main text. *The income sample sub-sample groups sum to 529 (as opposed to 531), as two respondents did not disclose income information. The following abbreviations apply: Obs. = observation; **Opt. 1** = hard defences funded via higher council taxes; **Opt. 2** = authorities do nothing and homeowners/renters invest in flood insurance; **Opt. 3** = authorities, homeowners, and renters do nothing; **Opt. 4** = relocate residents away from flood risk zones and homeowners compensated for land loss; **Opt. 5** = nature-based solutions funded via higher council taxes; PG = postgraduate; UG = undergraduate.

et al. (2022) findings that older people are less likely to believe in and worry about climate change impacts relative to younger people. We also see that those with postgraduate education have a higher tendency to perceive a managed realignment type approach – relocation of people and compensation of land loss – to be most effective for coastal management. There is no clear theory to explain this finding, but it is an interesting avenue for further research into public decision-making processes.

3.2.2. *Geospatial trends*

Here, we focus explicitly on the geospatial trends on perceptions and perceived effectiveness of NBCS and hard defences, as these are the two most popular coastal management strategies among our respondents.

We do not find any explicit regional trends in preferences and perceptions of NBCS and hard defences, apart from the latter being evidently perceived to be most effective and the former most preferred by most respondents (Fig. 2). However, Fig. 2 shows that a wider spatial distribution of UK residents (not quantity), grouped by postcode, most prefer NBCS and consider such solutions to be most effective for coastal management. Yet, interestingly, we see that hard defences are perceived to be more effective than NBCS in postcodes along the UK's east and south coasts. This finding is plausibly linked to an over-heightened hazard risk perception (in the context of sea-level rise and coastal flooding), likely attributed to coastal residency or proximity, with hard defences viewed as a more proactive solution to such risks (Anderson et al., 2022). For both hard defences and NBCS, we see greater concentrations of people in landlocked postcode areas within the UK preferring these solutions and perceiving them to be most effective. We are mindful, however, that this observation might be indicative of an imbalanced spatially distributed sample across the UK.

3.3. *Overarching finding*

Collectively, a consistent finding across all our analyses is a discrepancy between public preferences and perceived effectiveness of NBCS and hard defences. As most people perceive hard defences to be most effective, a knowledge gap exists in public understanding of the likely effectiveness of NBCS despite the CSC considerable efforts to push such solutions for long-term coastal sustainability. This is indicative of a knowledge dissemination barrier between the CSC and local communities. Such a barrier may have adverse implications for effective coastal management policy-making (Palmer et al., 1996; Anderson et al., 2021).

4. Discussion

We find most people prefer NBCS but perceive hard defences to be more effective for coastal management (Table 1). The general public preference for NBCS reflects an overarching desire for sustainable and environmentally-friendly approaches for coastal management (Table 3). However, the perception that hard defences are most effective can be linked to five theoretical factors:

1. *Visible protection (awareness)* (Anderson et al., 2021, 2022). Relative to any other form of coastal management, hard defences have a clear visible and tangible impact on coastal flood and erosion risk reduction. Although these defences have knock-on effects by shifting the problem elsewhere through wave refraction, reflection and diffraction, they are successful in mitigating risks at the local scale within their immediate vicinity (Rangel-Buitrago et al., 2018). As a result, although hard defences are generally associated with lower aesthetic environmental values (Table 3; Blakemore et al., 2008), their implementation and visible effectiveness in mitigating coastal risks can comfort and reassure people concerned about coastal hazards (Bongarts Lebbe et al., 2021). For this reason, hard defences continue to be implemented for managing coastal hazards and risks by local coastal communities globally, particularly in small island states (Arnall, 2022).
2. *Historic use.* Globally, hard defences have been the most common strategy used over multi-decadal timescales for mitigating coastal risks (Palmer et al., 1996; Rangel-Buitrago et al., 2018; Arnall, 2022; Arkhurst et al., 2023). There is, therefore, well-documented evidence of their overarching effectiveness at reducing coastal risks at a local level. The historical reliance on hard defences is a difficult one to overturn, particularly, as such long-term reliance have inevitably

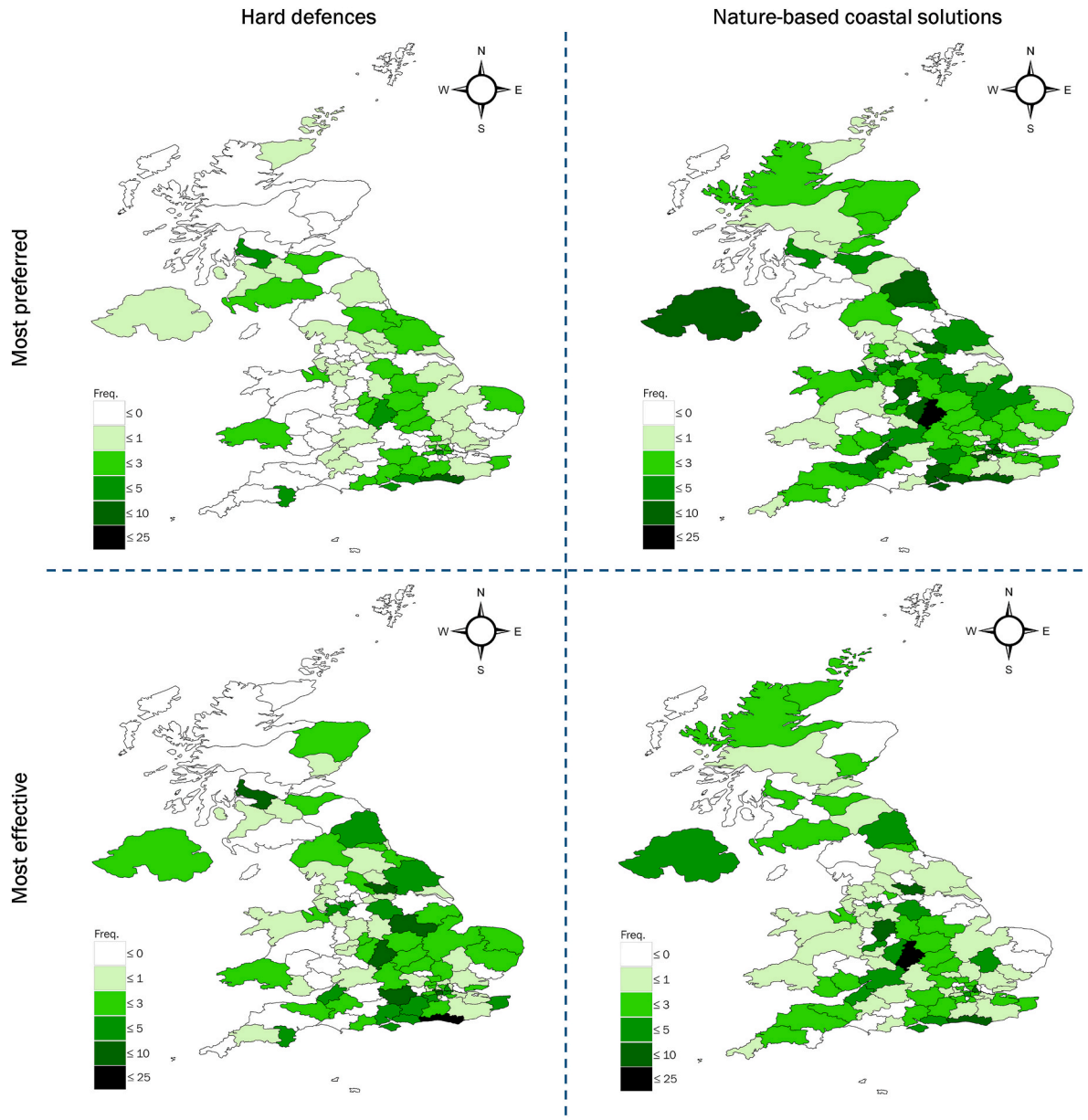

Fig. 2. Spatial distribution in preferences and perceived effectives for the two active coastal management strategies considered: hard defences and nature-based coastal solutions.

resulted in public trust in these defences, reinforcing the majority consensus that these defences are most effective (Anderson et al., 2022).

3. *Media coverage.* News coverage on flood events have often shed light on the effectiveness of grey management solutions, such as hard defences, for flood risk mitigation. These types of media coverage contribute to the evidence pool on the effectiveness of hard defences for coastal management, which, in turn, may be shaping overall public trust in these defences (Cologna et al., 2017).
4. *Risk aversion* (Anderson, 2023). People who live, work, and invest in vulnerable coastal regions (coastal residents) are known to believe and trust in coastal management schemes that provide immediate protection against coastal hazards (Gray et al., 2017). Although they might prefer NBCS for its aesthetics and environmentally friendly values, the effectiveness of such solutions is not immediately known, as coastal response to these solutions is generally slower than coastal response to hard defences (Anderson et al., 2021, 2022). NBCS may, therefore, not be seen as a proactive strategy for mitigating the risks of coastal hazards relative to hard defences.
5. *Trade-off between preferences and practical choices.* Building on the arguments above, coastal residents and coastal zone users may have a personal preference for NBCS due to the aesthetic and environmentally friendly benefits of these solutions. However, when faced with the realities of coastal hazards, these individuals may favour solutions that are known to provide a reliable form of defence (immediate protection) (Han et al., 2023). This highlights a trade-off between idealistic preferences (in this case, NBCS) and pragmatic choices (in this case, hard defences).

These theoretical factors converge well with our qualitative findings on the drivers behind our respondents' coastal management preferences and perceptions (Table 3). Specifically, we find that most people prefer NBCS from an environmentally conscious vantage but perceive hard defences as most effective because of its known effectiveness (and sustainability), familiarity and knowledge, and immediate impact/

proactiveness (Table 3). However, putting aside these explanatory theoretical factors, there are clear differences in perceptions of coastal management strategies between the CSC and wider public, with the former actively advocating for the use of NBCS (Bueno-Pardo et al., 2024) while the latter is more convinced by the use of hard defences (Anderson et al., 2021, 2022). This signals a breakdown in communication and dissemination of knowledge from the CSC to local communities, thus necessitating the need for more local stakeholder (local societies/general public) engagement in NBCS decision-making and implementation.

The design of coastal management plans in the UK have traditionally involved some form of local stakeholder engagement, which together with our findings above, may explain the greater perceived effectiveness of hard defences relative to NBCS, since these defences represent the most common form of coastal management in the UK (Defra, 2006). However, with increasing calls for greener (NBCS) or hybrid (grey and NBCS) coastal management solutions to address multi-environmental challenges related to biodiversity, net zero, and ecosystem services, more dialogue on NBCS needs to happen between all stakeholders at the decision-making level for coastal management in the UK (Defra, 2021). Such dialogue is particularly needed to address the communication and knowledge gap on NBCS between the CSC and wider society. A way forward to achieve this might be to adapt a systems mapping approach for coastal management decision-making.

Systems mapping is gaining traction for robust policy-making in various aspects of environmental management (Suno Wu et al., 2021; Penn et al., 2022). However, there is little uptake within the coastal management sphere. Evidence shows that such an approach enables an understanding of the various components, relationships, and dynamics within a system, primarily because it deconstructs the constituent parts of a system to understand the inter-relations within a system, fundamental for identifying inclusive and, potentially, more robust management approaches to ensure the sustainability of a system (Sedlacko et al., 2014; Lopes and Videira, 2017). Despite the limited uptake in the coastal management sphere, we see documented evidence of systems mapping being beneficial for integrated coastal zone management in Egypt (Sanò et al., 2014). The approach adopted there involved: (1) capturing mental models of individuals within each stakeholder group through causal loop diagrams, (2) building a conceptual model of the system by combining the contribution of all stakeholders, (3) identifying critical issues for the system, and (4) preparing a combined causal loop diagram for further discussion and system dynamics simulations. This four-stage process is certainly not a place-specific measure and has the potential for involving all stakeholders to ensure inclusive and (potentially) more effective coastal management decision-making on a local, regional, and global scale. Though not quite coastal management, we have seen elements of systems mapping leading to more refined flood risk communication strategies in the UK (Rollason et al., 2018). Therefore, such an approach is transferrable to the UK coastal management context, for improving coastal resiliency strategies.

5. Conclusions

In response to increasing advocacy for NBCS by the CSC, we investigate public preferences and perceived effectiveness of NBCS and other common forms of coastal management in the UK. We do this through an online survey of over 500 UK residents, followed by inductive coding and statistical and geospatial analyses of the survey data. Although our findings indicate general public preference for NBCS from an environmentally conscious lens, more people perceive hard defences to be most effective for coastal management for several reasons, primarily relating to overall awareness of the immediate impact and effectiveness of these approaches in hazard risk reduction. These findings signal a communication gap between the CSC, which advocates for NBCS, and the general public, who appear more convinced by the use of hard defences, necessitating the need for greater NBCS dialogue between all stakeholders at the decision-making level for coastal management. Such dialogue is needed given the increasing calls for greener (NBCS) and hybrid (grey and NBCS) initiatives to address multi-environmental challenges relating to biodiversity, net zero, and ecosystem services, which NBCS can help to facilitate. We recommend that discussions and decision-making around NBCS should adopt a systems mapping approach in order to enable inclusive and potentially more effective (and sustainable) coastal management policies. Such an approach will also help to address inequalities in the public's understanding of coastal management, with longer-term benefits for responding to coastal hazards and risks at both the local community and national levels.

CRediT authorship contribution statement

Avidesh Seenath: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Scott Mark Romeo Mahadeo:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jade Catterson:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation.

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.

Acknowledgements

We gratefully acknowledge Matthew Blackett (Coventry University) for collegial support with the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2024.123413.

Data availability

We have attached our survey, dataset, and results replication files.

References

Acott, T.G., Willis, C., Ranger, S., Cumming, G., Richardson, P., O'neill, R., Ford, A., 2022. Coastal transformations and connections: revealing values through the community voice method. People and Nature 5, 403–414.
Ajibade, I., Sullivan, M., Lower, C., Yarina, L., Reilly, A., 2022. Are managed retreat programs successful and just? A global mapping of success typologies, justice dimensions, and trade-offs. Global Environ. Change 76.
Anderson, C.C., Renaud, F.G., Hanscomb, S., Gonzalez-Ollauri, A., 2022. Green, hybrid, or grey disaster risk reduction measures: what shapes public preferences for nature-based solutions? J Environ Manage 310, 114727.
Anderson, C.C., Renaud, F.G., Hanscomb, S., Munro, K.E., Gonzalez-Ollauri, A., Thomson, C.S., Pouta, E., Soini, K., Loupis, M., Panga, D., Stefanopoulou, M., 2021. Public acceptance of nature-based solutions for natural hazard risk reduction: survey findings from three study sites in europe. Front. Environ. Sci. 9.
Anderson, R.B., 2023. Time, seawalls, and money. Environment and Society 14, 23–42.
Anfuso, G., Pranzini, E., Vitale, G., 2011. An integrated approach to coastal erosion problems in northern tuscany (Italy): littoral morphological evolution and cell distribution. Geomorphology 129, 204–214.
Apine, E., Stojanovic, T., 2024. Is the coastal future green, grey or hybrid? Diverse perspectives on coastal flood risk management and adaptation in the UK. Cambridge Prisms: Coastal Futures 2.
Areia, N.P., Tavares, A.O., Costa, P.J.M., 2023. Public perception and preferences for coastal risk management: evidence from a convergent parallel mixed-methods study. Sci. Total Environ. 882, 163440.
Arkema, K.K., Griffin, R., Maldonado, S., Silver, J., Suckale, J., Guerry, A.D., 2017. Linking social, ecological, and physical science to advance natural and nature-based protection for coastal communities. Ann. N. Y. Acad. Sci. 1399, 5–26.

Arkhurst, B.M., Poku-Boansi, M., Adarkwa, K.K., 2023. Indigenous knowledge in climate change adaptation: choice of indigenous adaptation responses to coastal erosion in Ghanaian communities. Environ. Sci. Pol. 147, 326–335.
Arnall, A., 2022. Where land meets sea: islands, erosion and the thing-power of hard coastal protection structures. Environ. Plann.: Nature and Space 6, 69–86.
Barra, M.P., 2024. Restoration otherwise: towards alternative coastal ecologies. Environ. Plann. Soc. Space 42, 147–165.
Baustian, M.M., Jung, H., Bienn, H.C., Barra, M., Hemmerling, S.A., Wang, Y., White, E., Meselhe, E., 2020. Engaging coastal community members about natural and nature-based solutions to assess their ecosystem function. Ecol. Eng. 143.
Bianciardi, A., Becattini, N., Cascini, G., 2023. How would nature design and implement nature-based solutions? Nature-Based Solutions 3.
Blakemore, F.B., Burrell, M., Jones, S.D.R., 2008. Beach users' aesthetic and economic evaluation of a "minor change" to the hard engineering coastal defences at wiseman's bridge, pembrokeshire, wales. Environmental Economics and Investment Assessment II 108, 115–125.
Bongarts Lebbe, T., Rey-Valette, H., Chaumillon, É., Camus, G., Almar, R., Cazenave, A., Claudet, J., Rocle, N., Meur-Férec, C., Viard, F., Mercier, D., Dupuy, C., Ménard, F., Rossel, B.A., Mullineaux, L., Sicre, M.-A., Zivian, A., Gaill, F., Euzen, A., 2021. Designing coastal adaptation strategies to tackle sea level rise. Front. Mar. Sci. 8.
Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3, 77–101.
Bueno-Pardo, J., Ruiz-Frau, A., Garcia, C., Ojea, E., 2024. Assessing the effectiveness of marine nature-based solutions with climate risk assessments. Glob Chang Biol 30, e17296.
Chowdhury, M.S.N., La Peyre, M., Coen, L.D., Morris, R.L., Luckenbach, M.W., Ysebaert, T., Walles, B., Smaal, A.C., 2021. Ecological engineering with oysters enhances coastal resilience efforts. Ecol. Eng. 169.
Cologna, V., Bark, R.H., Paavola, J., 2017. Flood risk perceptions and the UK media: moving beyond "once in a lifetime" to "Be prepared" reporting. Climate Risk Management 17, 1–10.
Dal Barco, M.K., Furlan, E., Pham, H.V., Torresan, S., Zachopoulos, K., Kokkos, N., Sylaios, G., Critto, A., 2024. Multi-scenario analysis in the apulia shoreline: a multi-tiers analytical framework for the combined evaluation and management of coastal erosion and water quality risks. Environ. Sci. Pol. 153.
Dale, J., Burgess, H.M., Nash, D.J., Cundy, A.B., 2018. Hydrodynamics and sedimentary processes in the main drainage channel of a large open coast managed realignment site. Estuar. Coast Shelf Sci. 215, 100–111.
Dario, C., Curley, C., Mach, K.J., 2024a. Shaping coastal nature-based solutions: perceptions and policy priorities of living shorelines. Nature-Based Solutions. https://doi.org/10.1016/j.nbsj.2024.100179.
Dario, C., Molina, R., Kelly, D.L., 2024b. Public preferences for coastal adaptation: economic evidence from a discrete choice experiment for hard structures and nature-based solutions in Miami, Florida. Mar. Pol. 165.
Davis, J.L., Currin, C.A., O'brien, C., Raffenburg, C., Davis, A., 2015. Living shorelines: coastal resilience with a blue carbon benefit. PLoS One 10, e0142595.
Defra, 2006. Shoreline Management Plan Guidance. Volume 1: Aims and Requirements. Department for Environment, Food and Rural Affairs, London.
Defra, 2021. Coastal Nature-Based Solutions: A Quick Scoping Review. Department for Environment, Food and Rural Affairs, London.
Dhyani, S., Karki, M., Gupta, A.K., 2020. Opportunities and advances to mainstream nature-based solutions in disaster risk management and climate strategy. In: Dhyani, S., Gupta, A.K., Karki, M. (Eds.), Nature-Based Solutions for Resilient Ecosystems and Societies. Springer Singapore, Singapore.
Döring, M., Ratter, B.M.W., 2017. Coastal landscapes: the relevance of researching coastscapes for managing coastal change in north frisia. Area 50, 169–176.
Forbes, D.L., James, T.S., Sutherland, M., Nichols, S.E., 2013. Physical basis of coastal adaptation on tropical small islands. Sustain. Sci. 8, 327–344.
Forrester, J., Leonardi, N., Cooper, J.R., Kumar, P., 2024. Seagrass as a nature-based solution for coastal protection. Ecol. Eng. 206.
French, J., Payo, A., Murray, B., Orford, J., Eliot, M., Cowell, P., 2016. Appropriate complexity for the prediction of coastal and estuarine geomorphic behaviour at decadal to centennial scales. Geomorphology 256, 3–16.
French, P.W., 2004. The changing nature of, and approaches to, UK coastal management at the start of the twenty-first century. Geogr. J. 170, 116–125.
Ghermandi, A., 2015. Benefits of coastal recreation in europe: identifying trade-offs and priority regions for sustainable management. J Environ Manage 152, 218–229.
Giachino, C., Pattanaro, G., Bertoldi, B., Bollani, L., Bonadonna, A., 2021. Nature-based solutions and their potential to attract the young generations. Land Use Pol. 101.
Gillon, C., Gibbs, L., 2017. Selling surf and turf: thrown togetherness and real estate advertising on the suburbanising east Australian coastline. Soc. Cult. Geogr. 1–22. https://doi.org/10.1080/14649365.2017.1328737.
Goreau, T.J.F., 2024. Indigenous/endogenous sea peoples: climate change adaptation and environmental regeneration prospects. In: Penteado, A., Chakrabarty, S.P., Shaikh, O.H. (Eds.), Traditional Knowledge and Climate Change: an Environmental Impact on Landscape and Communities. Springer Nature Singapore, Singapore.
Gray, J.D.E., O'neill, K., Qiu, Z., 2017. Coastal residents' perceptions of the function of and relationship between engineered and natural infrastructure for coastal hazard mitigation. Ocean Coast Manag. 146, 144–156.
Hagedoorn, L.C., Appeaning Addo, K., Koetse, M.J., Kinney, K., Van Beukering, P.J.H., 2021. Angry waves that eat the coast: an economic analysis of nature-based and engineering solutions to coastal erosion. Ocean Coast Manag. 214.
Han, S., Bubeck, P., Thieken, A., Kuhlicke, C., 2023. A place-based risk appraisal model for exploring residents' attitudes toward nature-based solutions to flood risks. Risk Anal. 43, 2562–2580.
Jones, N., Clark, J.R.A., Malesios, C., 2015. Social capital and willingness-to-pay for coastal defences in south-east england. Ecol. Econ. 119, 74–82.
Josephs, L.I., Humphries, A.T., 2018. Identifying social factors that undermine support for nature-based coastal management. J Environ Manage 212, 32–38.
Kelly, D.L., Molina, R., 2023. Adaptation infrastructure and its effects on property values in the face of climate risk. Journal of the Association of Environmental and Resource Economists 10, 1405–1438.
Khakzad, S., Pieters, M., Van Balen, K., 2015. Coastal cultural heritage: a resource to Be included in integrated coastal zone management. Ocean Coast Manag. 118, 110–128.
Kjørholt, A.T., Bessell, S., Devine, D., Gaini, F., Spyrou, S., 2022. Exploring coastal societies and knowledge in transition across generations. In: Kjørholt, A.T., Bessell, S., Devine, D., Gaini, F., Spyrou, S. (Eds.), Valuing the Past, Sustaining the Future? Exploring Coastal Societies, Childhood(S) and Local Knowledge in Times of Global Transition. Springer International Publishing, Cham.
Liu, X., Wirtz, K.W., 2010. Managing coastal area resources by stated choice experiments. Estuar. Coast Shelf Sci. 86, 512–517.
Lopes, R., Videira, N., 2017. Modelling feedback processes underpinning management of ecosystem services: the role of participatory systems mapping. Ecosyst. Serv. 28, 28–42.
Mackinnon, K., Sobrevila, C., Hickey, V., 2008. Biodiversity, Climate Change, and Adaptation: Nature-Based Solutions from the World Bank Portfolio. The World Bank.
Magnani, E., Pistocchi, F., 2017. The role of lighthouses in the construction of coastal identities. Almatourism - J. Tour. Cult. Territ. Dev. 8, 123–143.
Mahadeo, S.M.R., Heinlein, R., Legrenzi, G.D., 2019. Energy contagion analysis: a new perspective with application to a small petroleum economy. Energy Econ. 80, 890–903.
Mcleod, L.J., Kitson, J.C., Dorner, Z., Tassell-Matamua, N.A., Stahlmann-Brown, P., Milfont, T.L., Hine, D.W., 2024. Environmental stewardship: a systematic scoping review. PLoS One 19, e0284255.
Moraes, R.P.L., Reguero, B.G., Mazarrasa, I., Ricker, M., Juanes, J.A., 2022. Nature-based solutions in coastal and estuarine areas of europe. Front. Environ. Sci. 10.
Morris, R.L., Konlechner, T.M., Ghisalberti, M., Swearer, S.E., 2018. From grey to green: efficacy of eco-engineering solutions for nature-based coastal defence. Glob Chang Biol 24, 1827–1842.
Naeem, M., Ozuem, W., Howell, K., Ranfagni, S., 2023. A step-by-step process of thematic analysis to develop a conceptual model in qualitative research. Int. J. Qual. Methods 22, 16094069231205789.
Nowell, L.S., Norris, J.M., White, D.E., Moules, N.J., 2017. Thematic analysis: striving to meet the trustworthiness criteria. Int. J. Qual. Methods 16, 1609406917733847.
Palmer, R., Development, T.L., Consultants, E., 1996. History of coastal engineering in great britain. History and Heritage of Coastal Engineering, pp. 214–274.
Payo, A., French, J.R., Sutherland, J., Ellis, M.A., Walkden, M., 2020. Communicating simulation outputs of mesoscale coastal evolution to specialist and non-specialist audiences. J. Mar. Sci. Eng. 8, 235.
Penn, A.S., Bartington, S.E., Moller, S.J., Hamilton, I., Levine, J.G., Hatcher, K., Gilbert, N., 2022. Adopting a whole systems approach to transport decarbonisation, air quality and health: an online participatory systems mapping case study in the UK. Atmosphere 13.
Rahman, H.M.T., Manuel, P., Sherren, K., Rapaport, E., Van Proosdij, D., 2023. Characterizing social barriers to nature-based coastal adaptation approaches. Nature-Based Solutions 4.
Rangel-Buitrago, N., Williams, A., Anfuso, G., 2018. Hard protection structures as a principal coastal erosion management strategy along the caribbean coast of Colombia. A chronicle of pitfalls. Ocean Coast Manag. 156, 58–75.
Reed, G., Brunet, N.D., Mcgregor, D., Scurr, C., Sadik, T., Lavigne, J., Longboat, S., 2022. Toward indigenous visions of nature-based solutions: an exploration into Canadian federal climate policy. Clim. Pol. 22, 514–533.
Reeve, D.E., Horrillo-Caraballo, J., Karunarathna, H., Pan, S., 2019. A new perspective on meso-scale shoreline dynamics through data-driven analysis. Geomorphology 341, 169–191.
Rendon, O.R., Sandorf, E.D., Beaumont, N.J., 2022. Heterogeneity of values for coastal flood risk management with nature-based solutions. J Environ Manage 304, 114212.
Rollason, E., Bracken, L.J., Hardy, R.J., Large, A.R.G., 2018. Rethinking flood risk communication. Nat. Hazards 92, 1665–1686.
Sanò, M., Richards, R., Medina, R., 2014. A participatory approach for system conceptualization and analysis applied to coastal management in Egypt. Environ. Model. Software 54, 142–152.
Saunders, M.I., Cannard, T., Fischer, M., Sheppard, M., Twomey, A., Morris, R., Bishop, M.J., Mayer-Pinto, M., Malcolm, F., Vozzo, M., Steven, A., Swearer, S.E., Lovelock, C.E., Pomeroy, A.W.M., Mcleod, I., Waltham, N.J., 2024. A roadmap to coastal and marine ecological restoration in Australia. Environ. Sci. Pol. 159, 103808.
Schuerch, M., Mossman, H.L., Moore, H.E., Christie, E., Kiesel, J., 2022. Invited perspectives: managed realignment as a solution to mitigate coastal flood risks – optimizing success through knowledge Co-production. Nat. Hazards Earth Syst. Sci. 22, 2879–2890.
Seddon, N., Chausson, A., Berry, P., Girardin, C.a.J., Smith, A., Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philos. Trans. R. Soc. Lond. B Biol. Sci. 375, 20190120.
Sedlacko, M., Martinuzzi, A., Røpke, I., Videira, N., Antunes, P., 2014. Participatory systems mapping for sustainable consumption: discussion of a method promoting systemic insights. Ecol. Econ. 106, 33–43.
Seenath, A., Dale, J., 2024. On the bruun rule suitability for modelling shoreline change. Ocean Coast Manag. 255.

Starks, H., Trinidad, S.B., 2007. Choose your method: a comparison of phenomenology, discourse analysis, and grounded theory. Qual. Health Res. 17, 1372–1380.
Strain, E.M.A., Kompas, T., Boxshall, A., Kelvin, J., Swearer, S., Morris, R.L., 2022. Assessing the coastal protection services of natural mangrove forests and artificial rock revetments. Ecosyst. Serv. 55.
Suno Wu, J., Barbrook-Johnson, P., Font, X., 2021. Participatory complexity in tourism policy: understanding sustainability programmes with participatory systems mapping. Ann. Tourism Res. 90.
Turnbull, J.W., Johnston, E.L., Kajlich, L., Clark, G.F., 2020. Quantifying local coastal stewardship reveals motivations, models and engagement strategies. Biol. Conserv. 249.
Unguendoli, S., Biolchi, L.G., Aguzzi, M., Pillai, U.P.A., Alessandri, J., Valentini, A., 2023. A modeling application of integrated nature based solutions (nbs) for coastal erosion and flooding mitigation in the emilia-romagna coastline (northeast Italy). Sci. Total Environ. 867, 161357.
Van Maanen, B., Nicholls, R.J., French, J.R., Barkwith, A., Bonaldo, D., Burningham, H., Brad Murray, A., Payo, A., Sutherland, J., Thornhill, G., Townend, I.H., Van Der Wegen, M., Walkden, M.J.A., 2016. Simulating mesoscale coastal evolution for decadal coastal management: a new framework integrating multiple, complementary modelling approaches. Geomorphology 256, 68–80.
Walsh, C., Döring, M., 2018. Cultural geographies of coastal change. Area 50, 146–149.
Yasmeen, A., Pumijumnong, N., Arunrat, N., Punwong, P., Sereenonchai, S., Chareonwong, U., 2024. Nature-based solutions for coastal erosion protection in a changing climate: a cutting-edge analysis of contexts and prospects of the muddy coasts. Estuar. Coast Shelf Sci. 298.