



Research article

Analyzing who is relevant to engage in environmental decision-making processes by interests, influence and impact: The 3i framework

M.S. Reed^{a,*}, E.A. Jensen^{a,b}, S. Noles^{a,b}, D. Conneely^a, H. Kendall^{c,d}, M. Raley^c, A. Tarrant^e, N. Oakley^{a,d}, C. Hinson^f, V. Hoare^f, K. Marshall^g, L. Pugliese^h^a Thriving Natural Capital Challenge Centre, Department of Rural Economy, Environment and Society, Scotland's Rural College, West Mains Road, Kings Buildings, Peter Wilson Building, Edinburgh, EH9 3JG, UK^b Institute for Methods Innovation, 77 Lower Camden Street, Dublin, D02 XE80, Ireland^c Centre for Rural Economy, School of Natural and Environmental Science, Newcastle University, Newcastle Upon-Tyne, NE1 7RU, UK^d Natural England, Area 5A, Nobel House, 17 Smith Square, London, SW1P 3JR, UK^e School of Social and Political Sciences, University of Lincoln, Brayford Pool, Lincoln, LN6 7TS, UK^f Centre for Environmental Policy, Faculty of Natural Sciences, Imperial College London, UK^g Social, Economic and Geographical Sciences Department, The James Hutton Institute, Aberdeen, Scotland, AB15 8QH, UK^h Department of Agroecology, Aarhus University, Blichers Allé 20, Tjele, 8830, Denmark

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ABSTRACT

Outcomes in participatory environmental processes are strongly affected by choices about who is engaged. Inclusive engagement diversifies the range of interests and perspectives represented, including those from vulnerable and marginalized groups, ultimately contributing to more socially and environmentally sustainable and equitable outcomes. However, existing “stakeholder analysis” methods often bias participant identification away from disenfranchised groups with limited pre-existing interest or influence, instead favoring the most easily accessed and influential stakeholders. This paper draws on research impact theory and practice to propose a new, more inclusive approach, adding *impact* to the existing *interest* and *influence* criteria (which each begin with the letter “i”, hence the 3i framework) that are typically used to identify, categorize and prioritize those who are relevant to be included or excluded from engagement processes. As part of this proposed 3i analysis approach, we articulate a new typology of relevant parties to engage in environmental decision-making processes, including: uninterested; uninterested and impacted; uninterested influencers; disinterested, influential and impacted; only interested; interested and impacted; interested influencers; and interested, influential and impacted. Except for the first group, all types of relevant parties should be considered for engagement wherever possible, with participation strategies tailored to their specific 3i profile. The approach was developed and refined through a series of workshops before developing it into a survey instrument that was piloted to gather 3i data efficiently across several national contexts. Survey findings are presented for a case study identifying those relevant to wetland and peatland restoration in a Scottish catchment. If widely adopted, the 3i framework would be the most consequential change in stakeholder analysis methods since the introduction of interest-influence matrices in the 1980s.

1. Introduction

Engaging effectively with those affected by change is essential, as they typically represent varied, and often conflicting, positions, priorities and values (Reed, 2008; Reed et al., 2017). It is widely acknowledged that those affected by such challenges “*can and should*” (Prell et al., 2008) participate in decisions relating to those problems. The

focus of this paper is how to identify relevant parties for such decision-making. Although our case study focusses on environmental issues, the proposed methods may be applied across a range of decision-making contexts. The process of systematically analyzing who may be affected by an issue, intervention, project, process or decision has for decades been known as *stakeholder analysis*. This type of analysis is recognized as an essential precursor to effective engagement that can

* Corresponding author.

E-mail address: mark.reed@sruc.ac.uk (M.S. Reed).<https://doi.org/10.1016/j.jenvman.2024.123437>

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enhance the quality of decision-making (Colvin et al., 2020; Prell et al., 2009; Reed et al., 2009; Reed, 2018; Rowe and Frewer, 2000). By systematically ensuring the representation of relevant parties, a well-designed and theoretically-informed participatory process has potential to markedly improve outcomes and can mitigate the risks associated with tokenistic participation mechanisms (De Vente et al., 2016; Reed et al. 2009, 2018a; Rowe and Frewer, 2000). Studies in environmental governance show that co-production of knowledge and evidence can have long-lasting effects on relationships between different actors and implementation of policy outcomes (Armitage et al., 2015). On the other hand, failure to systematically identify and engage directly with those who are affected by a given issue at an early stage can inflame conflicts, resulting in alienation and distrust and the failure of well-meaning efforts to deliver social and environmental benefits (Chinseu et al., 2022; Reed et al., 2017; Prell et al., 2009). Without a systematic analysis of who is relevant to engage, there is a heightened risk that powerful groups and organisations dominate decision making, marginalising other groups and voices and potentially biasing outcomes (Reed et al., 2009; Reed and Rudman, 2022).

Despite their broad adoption and application to a variety of policy contexts, stakeholder analysis methods have seen limited conceptual development since their introduction 30 years ago. Traditional approaches have been criticized for oversimplifying the process by prioritizing stakeholders with high interest and influence (“key players”), using low interest and influence as a justification for the exclusion of marginalized groups (Reed et al., 2018a,b). This is widely acknowledged to reinforce existing power disparities (Dougill et al., 2006; Reed and Curzon, 2015; Prell et al., 2009; Colvin et al., 2020). Only 44% of the stakeholder analysis studies reviewed by Bendtsen et al. (2021) considered marginalized groups, a significant shortcoming given the need to incorporate the perspectives of disadvantaged and less powerful groups to avoid further marginalisation and protect the legitimacy of decisions (e.g. Bryson, 2004; Mushove and Vogel, 2005).

Considering Banerjee (2003) and Reed et al.’s (2024) call to decolonize language in research, we use the term *relevant parties*, drawing on Freeman’s (1984:52) original definition of stakeholders as “groups and individuals who can affect, or are affected by” an action or decision (in his case, he was referring to the mission of an organization). We use the word *parties* to refer to actors, people, groups, partners or rightsholders, to include non-human species and those who are not (yet) formally recognized as partners or rightsholders, but who may still be interested in, have influence over or be affected by an issue, intervention, project or decision. Freeman (1984) identified two essential characteristics: influence (the capacity to affect a decision) and impact (the capacity to be impacted by a decision, whether positively or negatively). However, stakeholder analysis has to date focused primarily on the relative interest and influence of different parties.

Despite these challenges, there have been some efforts to reverse the logic of traditional interest and influence frameworks and promote broader inclusivity. For example, Hart and Sharma’s (2004) concept of “radical transactiveness” acknowledges the knowledge, perspectives and potential to influence outcomes that are possessed by marginalized groups and supports the inclusion and empowerment of those on the “fringe”. This approach has been used to identify relevant marginalized groups to be empowered through the engagement process (Prell et al., 2009). Reed and Curzon (2015) proposed the use of “extendible matrices” to qualitatively characterize the nature of different interests and suggest reasons for the level of influence ascribed. This qualitative approach facilitated an exploration of relevant parties’ varying levels of influence in different contexts or at different times. In addition, the extendible matrix allowed for the consideration (and documentation) of additional factors that might influence existing social roles or relationships between groups, such as coalitions or conflicts between different parties that could affect engagement strategies. Consistent with radical transactiveness (Hart and Sharma, 2004), Reed et al. (2018a) proposed the inclusion of *benefit*, recognizing that interest does not necessarily

equate to benefit and not all stakeholders will benefit equally from the outcomes.

Building on this, we introduce *impact* as a third criterion in the “3i” framework that considers the relative ‘*interest*’, ‘*influence*’ and ‘*impact*’ of different parties. *Impact* can be either positive or negative, enabling the identification of both beneficiary groups and those likely to be negatively impacted. This is particularly pertinent for groups that have limited interest and influence, who would otherwise be overlooked by traditional interest-influence matrix approaches, who may already be marginalized, enabling more inclusive engagement.

The paper first details the conceptual development of the 3i approach, drawing on research impact theory and practice. It then describes how the approach was refined via a series of workshops, before developing and piloting a survey method for the efficient application of the approach. Finally, the approach is illustrated using a case study application of the survey method in a project to identify those relevant to wetland and peatland restoration in a Scottish catchment.

2. The 3i analytical framework

Here we present the 3i analytical framework as a tool for analyzing relevant parties’ *interest* in, *influence* over and experience or likely *impact* of issues, interventions, projects, processes and decisions. This approach helps to go beyond interest and influence to evaluate the likely impact of the issue both in terms of the likely benefits and potential risks. Table 1 shows how the analysis seeks to understand *interest*, *influence* and *impact* at two levels: primary and secondary. Such multi-level analysis builds more comprehensive understandings of relevant parties than traditional stakeholder analyses, aiming to uncover hidden dynamics that might be driving interactions and outcomes. Primary analysis seeks to provide metric style evaluations of relevant parties, aligned with traditional methods of stakeholder analysis. Secondary analysis questions assumptions and facilitates deeper discussions, fostering a more empathetic and effective engagement approach with relevant parties.

For *interest*, the primary level is consistent with traditional interest/influence matrices, and identifies their degree of interest from low to high via consideration of their stated interests and preferences. The secondary level of analysis considers a deeper articulation of (often implicit) underlying (transcendental) values, beliefs and norms that may underpin interests or drive disinterest (following the deliberative value formation model of Kenter et al. (2016) and their (2016b) conceptualization of “shared, plural and cultural values”).

The degree of *influence* that any party exerts, is explored along two dimensions defined from high to low and positive to negative. Influence here is framed by Berger’s (2005) definition of power and the first level is consistent with traditional interest-influence matrices in considering explicit, hierarchical ‘power-over’ forms of influence that are typically characterized by control, instrumentalism and self-interest, and driven by factors such as access to resources, organizational scale, property rights, and levels of authority and expertise. The secondary level of analysis probes deeper to consider the implicit or personal ‘power with’ forms of empowerment, characterized by dialogue, inclusion, networks, negotiation and shared power (Berger, 2005). For example, a landlord has ‘power over’ their tenant farmer due to the legally binding restrictions contained within a tenancy agreement, whereas, a farmers’

Table 1
The two levels for clarifying interest, influence and impact.

	Interest	Influence	Impact
Primary	Stated interest and preferences	Explicit, hierarchical “power over”	Immediate benefits or negative impacts
Secondary	Underpinning (transcendental) values beliefs and norms	Implicit, personal and transpersonal “power with”	Long-term benefits or negative impacts

union, which tries to guide or influence tenant farmers towards, say, adopting certain environmental practices has ‘power with’. In both cases, influence can act to facilitate or block change.

This inclusion of *impact* represents a novel third criterion for analysis that aims to understand who is likely to directly benefit or, equally as importantly, be negatively impacted from engaging with a given issue, intervention, project, process or decision. This broadens the benefit criteria proposed by Reed et al. (2018a), ensuring that disempowered groups are not further marginalized, whilst simultaneously identifying and mitigating the risk of negative unintended consequences for relevant parties. It seems paradoxical that groups or individuals expected to be impacted might be deemed not to be interested. Such a situation might arise from *inter alia* lacking information, social distance from decision-makers, being disconnected from issues or policy-making contexts, or being alienated by language or other power mechanisms. In common with the first two criteria, the impact criterion operates at two levels. The primary level is designed to consider the short-term impacts from engagement and identify both the benefits that might arise from engagement, for example, the formation of new networks, capacity, knowledge or skills, and the possible risks that may arise, such as inflaming conflict, or misunderstandings that could lead to disengagement. The secondary, deeper level of analysis considers the long-term putative benefits or possible risks that might arise from the engagement. This could include instrumental benefits, such as new policies, or economic, social, environmental, health or cultural benefits arising from the issue, intervention, project, process or decision as it plays out, or negative impacts that might arise as an unintended consequence.

The 3i framework in Tables 2 and 3 facilitates analytical classification of multiple parties and provides insights into the relationships between these parties and an issue, intervention, project, process or decision. The questions in Table 2 are designed to facilitate discussion (where the analysis is conducted via a workshop) or feed into a survey (where this method is preferred to conduct the analysis) at both the primary and secondary levels described in Table 1. Questions are posed in both positive and negative forms to capture those with and without interest and influence and those who may be negatively or positively impacted by the issue, intervention, project, process or decision. Table 3 provides a table that can be used to capture answers to these questions in workshops, and a survey instrument to operationalize the analysis can be found in Supplementary Material.

3. How to implement a 3i analysis: data collection

Stakeholder analyses can be undertaken with a range of social science methods. Other than the interest-influence matrices used in traditional stakeholder analyses (Reed et al., 2009), the most used data collection tools include qualitative interviews, mixed-method surveys, focus groups and participatory workshops. These tools can be used in concert to boost the reach and quality of an analysis (e.g., see Morgan, 2014). Here, we describe the workshop methods used to trial and refine our approach, followed by a new survey design that was created based on the 3i conceptual framework presented above.

3.1. Workshop methods

A five-stage workshop method was developed to assess the interest, influence and impact of relevant parties in relation to an issue, intervention, project, process or decision, consistent with recognized best practice engagement (see Rowe and Frewer, 2000; Reed, 2008). These methods were trialed and refined via a series of workshops in seven case study projects working across a range of environmental and health issues in Europe. Workshops were facilitated with groups of between 6 and 14 experts who had a strong, cross-cutting understanding of relevant parties. In successive workshops, different questions were used to elicit the second, deeper level of analysis in ways that could be easily

Table 2

Questions to identify relevant parties for engagement based on the dimensions of interest, influence and impact, including questions to facilitate analysis at both the primary and secondary levels described in Table 1.

Dimension	Primary level questions	Secondary level questions
Interest	<p>Which parties are already interested and what is the nature of their interest?</p> <ul style="list-style-type: none"> What is the scope of their interest? What aspects of an issue are they interested in? Who within the group or which part of the organization is most interested? <p>Who else do you think should be interested?</p> <ul style="list-style-type: none"> Why should they be interested? 	<ul style="list-style-type: none"> What values, beliefs, norms or assumptions might be influencing their <i>perception</i> of the issue, intervention, project, process or decision? What values, beliefs, norms or assumptions might be driving or inhibiting the <i>interest or disinterest</i> in the issue, intervention, project, process or decision?
Influence	<p>Which parties have the power to <i>facilitate</i> development of positive or negative impacts in relation to this issue, intervention, project, process or decision?</p> <ul style="list-style-type: none"> Do they have direct influence over impacts, for example via access to resources, organizational scale, property rights, or levels of authority and expertise that give them “power over” others? Which individuals with a group or groups within an organisation have most influence to facilitate impact and why? <p>Who has the power to <i>block</i> development of these impacts?</p> <ul style="list-style-type: none"> Do they have direct influence over impacts? Which individuals or groups have most influence to block impact and why? <p>Who or what can they influence and at what geographical, social or other scale?</p>	<ul style="list-style-type: none"> Who has indirect influence to facilitate or block impacts, for example via dialogue, inclusion, networks, negotiation and shared power that give them “power with” others? Which individuals or groups within organisations have most influence to facilitate or block impact in these ways? Who or what can they influence and at what geographical, social or other scale?
Impact	<p>Which parties might benefit most in the short-term from initial engagement with this issue, intervention, project, process or decision?</p> <ul style="list-style-type: none"> What types of benefits are likely to be gained for each of these parties, for example, the formation of new networks, capacity, knowledge or skills? <p>Which parties may be disadvantaged or harmed most in the short-term, from initial engagement with this issue, intervention, project, process or decision?</p> <ul style="list-style-type: none"> What risks are these parties likely to be exposed to or disadvantages might they suffer, such as inflaming conflict, or misunderstandings that could lead to disengagement? 	<p>Which parties might benefit most in the long-term as a result of the issue, intervention, project, process or decision as it plays out?</p> <ul style="list-style-type: none"> What types of benefits are likely to be gained for each of these parties, for example, new policies, or economic, social, environmental, health or cultural benefits? How significant and far-reaching are these impacts anticipated to be? <p>Which parties may be disadvantaged or harmed most in the long-term, as this issue, intervention, project, process or decision plays out?</p> <ul style="list-style-type: none"> What risks are these parties likely to be exposed to or disadvantages might they suffer, for example as a result of negative unintended consequences? How significant and far-reaching are these impacts anticipated to be?

Table 3
The 3i analytical framework.

Name of organization, group or individual	Interest				Influence (indirect)				Impact (direct)			Other context
Relevant Party 1 (named)	Scope of interest: Geographical or other relevant scope (Closed answer question: regional, national, multi-national)	Nature of interest (preferences): Which parties are <u>already</u> interested and what is the nature of their interest? Who do you think should be interested? (describe)	Nature of interest (values): What values, beliefs, norms or assumptions might be influencing their perception of or interest/disinterest in the issue, intervention, project, process or decision? (describe)	Level of interest in the work (Closed answer question: High, Medium or Low)	Nature of influence (direct power over): Which parties have direct influence or “power over” others to facilitate or block development of positive or negative impacts? Are there individuals or groups within organisations with more influence? (describe)	Nature of influence (indirect power with): Which parties have indirect influence or “power with” others to facilitate or block development of positive or negative impacts? Are there individuals or groups within organisations with more influence? (describe)	Reach of influence: who or what can they influence and at what geographical, social or other scale? (describe)	Level of influence: in the research (High/Medium/Low)	Nature of impact (short-term): Which parties might benefit or be disadvantaged most in the short-term from initial engagement with this issue, intervention, project, process or decision? (describe)	Nature of impact (long-term): Which parties might benefit or be disadvantaged most in the long-term as a result of the issue, intervention, project, process or decision as it plays out? (describe)	Level of impact: how significant and far-reaching are the identified impacts likely to be? (Closed answer question: high, medium or low)	For example: knowledge base, expertise, funding, political context etc. (describe)

understood by workshop participants, gradually expanding the scope of the analysis. However, as the scope expanded, so did the time required to complete the analysis, resulting in significant gaps in the analysis which were not always filled by participants after the workshop. The resulting analytical framework (in Table 3) attempts to strike a balance between depth and efficiency of analysis by integrating primary and secondary levels of analysis in as few questions as possible. The stages are summarized below and may be adapted by others for use in future work.

- **Stage 1 - Establishing the focus:** It is important to clearly define the issue, intervention, project, process or decision so that there is a clear boundary to the analysis and it is possible to identify what parties might be interested in, have influence over or be affected by the issue, intervention, project, process or decision. Stage 1 requires a facilitated discussion among key informants, which may for example, include the geographical or sectoral scope of the issue, intervention, project or decision. For example, in a local environmental issue or project, a decision would need to be made about the relevance of national organisations and government agencies working on the issue, and whether to extend the scope to international organisations and climate policy. These different geographical scales may then be used as prompts to remind the group not to forget national and international parties, or it may be decided that national and international parties so little interest in, influence over or impacts arising from such a local issue, that they should be scoped out of the analysis.
- **Stage 2 - Identifying relevant parties:** Identification of as many individuals, groups, or organisations as possible that may be interested, influential or affected by the issue, intervention, project, process or decision. This is done as an individual activity by separate key informants working in parallel with each other. Stage 2 of the analysis begins by identifying those with 'interest' in a given issue, intervention, project, process or decision. This analytic step is then extended by exploring each of the three analytical categories - *interest*, *influence* and *impact* - at two levels by following the prompts in Table 2. Where the interest, influence or impact differs within a group or organization, different sub-groups or teams may be analysed separately, or information about different teams may be captured in a single row for that organization, making multiple points relevant to each team. For example, the climate change team of a water utilities company might be the most interested in a decarbonization project. Still, ultimately, the power to implement the recommendations of the project might be determined by the delivery team or a director of finance. Stage 2 is relatively time-demanding, especially if there are many relevant parties to consider, so the method is flexible to allow key informants to gap-fill after the workshop if it is not possible to complete all stages of the analysis in the time available.
- **Stage 3 - Rate the relative interest, influence, and impact:** Participants use the analytical framework (see Table 3) to guide and capture the discussion, either using paper and sticky notes on walls or using a shared spreadsheet online. To train the key informants and ensure a consistent application of the approach, it is possible to first work as a group and then ask individual key informants to repeat the process for groups and organisations that they are familiar with. Key informants can then be asked to check the work of others, add information where they have additional knowledge or highlight any areas of disagreement, using additional sticky notes or online comments as necessary.
- **Stage 4 - Facilitate discussion:** Key informants should explore each others' contributions, discuss where there is disagreement about the parties identified, recognizing differences in perspectives and/or resolving this where possible. For example, one key informant may judge that an organisation has limited influence, based on their experience working with the organisation on a particular issue or in a

specific sector, whereas another key informant may think they have significant influence on other issues or sectors. Both ratings (for example low versus high influence) and this would be discussed, either leading to a change in the rating and comments if it is agreed that one perspective has a stronger evidence-base, or both ratings and comments would be retained where disagreement cannot be resolved or both perspectives are deemed relevant.

- **Stage 5 - Identification and categorization of key parties:** Through group discussion, review the parties identified and look at ways in which they might be grouped and categorized. The resulting categorization will identify distinctly different groups which most commonly are differentiated by the nature of their interest in the issue. As a starting point, seek to condense the list by first identifying parties that are likely to have similar views, taking care to identify any parties with low influence that you do not want to marginalize in your work. It is important that these discussions are confidential, given that the opinions expressed by key informants about groups, organisations or individuals may be controversial. However, depending on the sensitivity of the issues, some of the identified parties may themselves be approached and encouraged to review categorizations. Case study teams were also recommended to review the identified parties and the subsequent categorizations after the workshop, giving key informants the time and space to re-consider the groupings and challenge/revise if necessary.

The outputs of this analysis may then be used to design and implement a targeted engagement plan adapted to the interests and needs of different groups of relevant parties. To effectively engage the identified and prioritized relevant parties, the engagement plan should include differentiated strategies for reaching out to different groups and methods for providing information and collecting feedback. The engagement plan should then be delivered, with regular monitoring and evaluation to ensure that it effectively reaches and engages relevant parties. Finally, there should be on-going refinement of 3i analysis and engagement plan. These processes should adapt to evolving needs and circumstances as new organisations become interested, increase or decrease in their level of influence, or start gaining benefits or being disadvantaged as the issue evolves or the intervention, project or decision progresses.

3.2. Survey methods



To efficiently generate data using the 3i approach, a survey was piloted and implemented across several countries to identify relevant parties for a multi-national research project focusing on wetlands restoration. The survey focuses on gathering insights about relevant parties from individuals who are identified by the researchers as knowledgeable about a given geographical area. That is, it is expected that the respondents will be identifying organisations that are relevant to a given project, as opposed to relevant individuals directly responding to the survey.

The survey instrument follows established good practices (e.g., Jensen and Laurie, 2016), including sticking to questions that the respondent could realistically answer about parties relevant to the topic being addressed (e.g., Tourangeau et al., 2000), using validated Likert-type scale anchors such as 'not at all' to 'extremely' (Vagias, 2006; Wagoner and Valsiner, 2005) and ensuring that survey response options are comprehensive and distinct (e.g., Jensen, 2014; Kennedy et al., 2022).

Here, we provide a step-by-step walkthrough of the survey design to show how the 3i framework can be operationalized in practice. We show the 3i-focused survey questions only, with a commentary explaining what each item is measuring and how it connects to the conceptual framework (Table 4). An additional 'impact planning' version of this survey, aimed at the relevant parties identified through the 3i analysis, is provided in the Supplementary Material.

Table 4
Survey questions operationalizing the 3i framework and commentary.

Question	Commentary
<p><i>[Respondents are provided with a description of the project.]</i></p> <p>Are you aware of any organisations or groups in [project area] that may be relevant to these topics in any way? [Radio box]</p> <p>Yes</p> <p>No</p> <p>Unsure</p>	<p>Following a description of the research project, the survey starts by asking respondents to assess their own awareness of organisations or groups that may be relevant to the planned work or aims of the project. This initiates the process of respondents reviewing their network in relation to the project, and defining specific relevant parties to answer subsequent 3i questions about.</p> <p>The inclusion of 'unsure' in addition to 'Yes' and 'No' ensures that all possible responses have been covered, in line with good practice (e.g., Jensen & Laurie, 2016).</p>
<p>At what level is this organization/group related to this project area? [Checkbox]</p> <p><i>(Tick all that apply)</i></p> <p>[Most familiar catchment areas]</p> <p>National</p> <p>International</p> <p>None of the above</p>	<p>Once a specific party has been named, the next question measures the level at which they are related to the research in terms of geographical scale, from the respondent's perspective. The analytical purpose of this question is to understand the scope of the relevant party's interest, and to indicate from which geographical angle their perspective is likely to be informed by.</p> <p>The inclusion of 'none of the above' as a response option ensures comprehensiveness in line with good practice (e.g., Jensen & Laurie, 2016).</p>
<p>How is this organization/group related to this project's work? [Checkbox]</p> <p><i>(Tick all that apply)</i></p> <p>Interest - They are likely to be interested in the project's work</p> <p>Influence - They are likely to have some power to block or facilitate the project's work</p> <p>Benefit - They might benefit from the project's work</p> <p>Negative impact - They might be negatively affected by the project's</p>	<p>This question directly measures which of the 3i concepts are perceived as relevant for the named party.</p> <p>The 'interest' checkbox constitutes a binary categorical variable measuring the respondent's perception of whether or not the relevant party is likely to want to pay attention to the project's work for any reason. It also serves as a screening question for follow up questions which dig deeper into the nature of their interest.</p> <p>The 'influence' checkbox also constitutes a binary categorical variable measuring the respondent's perception of whether the relevant party possesses any level of power that</p>

<p>work</p>	<p>may enable them to have influence on the project or its intended impacts or not. Selection of this checkbox triggers follow-up questions which dig deeper into the nature of their influence.</p> <p>The 'impact' assessment is split into two binary categorical variables - 'benefit' or 'negative impact', to immediately assess the respondent's perception of whether or not the relevant party could be positively or negatively affected by the project.</p> <p>The terminology used in this survey item is aimed at ensuring clarity and avoiding jargon, in line with good practice (e.g., Jensen & Laurie, 2016).</p>
<p><i>Shown if 'Interest - They are likely to be interested in the project's work' selected:</i></p> <p>How interested in the project's work do you think they are likely to be?</p> <p>Not at all 0 10 20 30 40 50 60 70 80 90 100 Extremely</p>  <p>Please explain [Text area]</p>	<p>This follow-up question measures the respondent's perception of the relevant party's level of interest in the project work. The 0-100 range response format provides ordinal data, and indicates the extent to which the relevant party is likely to want to pay attention to the project, learn about it and potentially engage with it. The survey item uses the scale anchors 'not at all' to 'extremely', which is drawn from a previously validated scale (Vagias, 2006).</p> <p>After this, the respondent is given an open text-box to explain the nature of the interest the relevant party has to the project. This provides the space for respondents to indicate which aspects of the work they are likely to be interested in, as well as what values, beliefs or assumptions that might drive this interest.</p>
<p><i>Shown if 'Influence - They are likely to have some power to block or facilitate the project's work' selected:</i></p> <p>How much power do you think they have to support the project to deliver its goals in [project area]?</p> <p>Not at all 0 10 20 30 40 50 60 70 80 90 100 Extremely</p> 	<p>This follow-up question measures the respondent's perception of the relevant party's level of power to support the project's work and its potential impacts. The 0-100 range response format provides ordinal data, and ultimately indicates how influential or useful the relevant party could be in supporting the project to achieve its aims.</p> <p>The subsequent text-box provides space for the respondent to explain their understanding of the nature of the relevant party's influence in terms of supporting the project to achieve its aims. Here, they can elaborate on the type of</p>

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The full survey design that was used in nine catchments for the EU-funded Wet Horizons project is available in Supplemental Material. This includes demographic and other questions. The survey design is available in English, Finnish, Danish, and Polish. The survey was also adapted as a semi-structured interview schedule for the same project. Informed consent was gained from all participants via a consent block in the online survey, and the survey design was approved by the SRUC Ethics Board. To identify participants for the survey, a call-out for participation was circulated within Wet Horizons researchers' networks, forming the

basis for a snowball sample. Participation was requested of those with knowledge of the groups or organisations with a stake or relation to wetlands restoration in each catchment. Where survey responses were low, additional requests for participation were made via social media (Twitter and LinkedIn). This first survey received $n = 94$ responses across the nine study catchments. Once data for each catchment had been collected, survey results were analysed to identify the nature and level of each relevant party's interest, influence and impact in relation to the Wet Horizons project. Each organisation was given an overall '3i

Table 5
Relevant party categories identified.

Relevant party category	Category description	Organisations	No. of organisations identified
National and regional level public bodies	National and regional public bodies with statutory powers responsible for nature conservation or public land management	<ul style="list-style-type: none"> ● Cairngorms National Park Authority ● Forestry & Land Scotland ● Peatland Action (NatureScot) 	3
Local authorities and community councils	Local level public bodies and voluntary organisations set up by statute by local authorities.	<ul style="list-style-type: none"> ● Ballater and Crathie Community Council 	1
Environmental charities, initiatives and partnerships	Non-governmental organisations, partnerships, networks and initiatives with conservation and restoration goals.	<ul style="list-style-type: none"> ● East Cairngorms Moorland Partnership ● Dee Catchment Partnership ● Dee District Salmon Fishery Board and River Dee Trust^a 	3
Landowners	Private estates, charitable estate owners, owner occupier farmers, and other institutional landowners.	<ul style="list-style-type: none"> ● Balmoral Estate ● Glenmuick Estate ● Invercauld Estate ● Mar Lodge Estate 	4

^a Dee District Salmon Fishery Board and River Dee Trust are legally separate entities that in many ways function as a separate organisation, with a shared website, office and staff team. The fisheries board is a statutory body, so could have been categorized differently here.

score', with higher scores indicating the more important organisations to engage in the project. The next section provides findings from one of the study catchments, located in Scotland, as a case study to illustrate the utility of the method.

4. Case study findings

The 3i analysis survey tool (see Supplementary Material) was used to identify parties relevant to wetland and peatland restoration within the River Dee catchment in Scotland, UK. A total of 11 organisations were identified with interests in, influence over and/or likely to be impacted positively or negatively by restoration effort. This information was provided by 9 survey respondents. Table 5 summarises the organisations identified in four categories and Table 6 shows the scores assigned for each organisation's interest, influence and impact. The full analysis of all organisations is provided in Supplementary Material. Results for two contrasting organisations are provided below, to allow comparison of the organisations with the highest versus lowest scores across the three criteria, interest, influence and impact. In some cases, respondents indicated there would be some level of interest, influence or impact for the organisation, but did not provide a score indicating the extent. In these cases, desk research and interpretation of open-ended responses were used to infer an appropriate level (low, medium or high).

4.1. Balmoral Estate

Balmoral Estate, covering an area over 20,000 ha, is well-known for Balmoral Castle - a residence of the British royal family. The estate was

bought by Prince Albert husband of Queen Victoria in 1852.¹ The estate falls within the Cairngorms National Park and partly within the Deeside and Lochnagar National Scenic Area, and contains several other designated protected areas. The estate contains extensive tracts of woodland, grouse moor and farmland, as well as large numbers of deer. The estate is also a major tourist destination with visitors coming to see the castle and grounds, access a range of guided walks, talks and 'land rover safaris', and pay to fish from the estate's rivers.²

The respondent commented that, 'Balmoral Estate probably owns the largest continuous area of peatland in the Dee catchment (south of Loch Muick), therefore their cooperation in progressing peatland restoration to help mitigate flood risk in this catchment is vital'.

4.1.1. Interest

Balmoral Estate was rated as likely to be highly interested (80%) in Wet Horizons and its outcomes. Though no further explanation was given, this is likely due to the estate containing significant areas of peatlands. Furthermore, Balmoral has been engaged in peatland restoration since 2015 with work to reprofile hags, install dams, and restore areas of bare peat.³ The estate was recently awarded further funding from Peatland Action to expand its restoration efforts.⁴ A number of monitoring studies are also being carried out on the estate in relation to peatland restoration, including one led by the James Hutton Institute which uses aerial mapping technology.⁵

4.1.2. Influence

Balmoral Estate was rated as likely to have a high level of influence (100%) to support Wet Horizons and its outcomes. This power to facilitate restoration relates firstly to control over what happens to peatlands contained on the estate itself. In addition, the respondent noted that 'if they take a lead in restoration, neighbouring estates that are managed in a similar way'. One forum where this type of influence may be exerted is the East Cairngorms Moorland Partnership, of which Balmoral is a partner, described below. Balmoral Estate was rated as likely to have a high level of influence (100%) to block Wet Horizons and its outcomes, with the respondent highlighting the control the estate has over what happens on its own land. Following the above, it is also evident that the estate's power to block restoration is likely to include its ability to shape the decision making of neighbouring estates.

4.1.3. Impact

Balmoral Estate was rated as likely to receive a moderate level of benefit (50%) from Wet Horizons and its outcomes. The respondent noted here that there, 'could be significant potential benefits in terms of publicity for the estate, attracting paying visitors, if they can demonstrate green credentials ... peatland restoration could also enhance landscape quality, further attracting visitors'. Given that Balmoral Estate is already engaged in peatland restoration, it can also be assumed that the estate would benefit from any improvements in restoration practice as a result of the Wet Horizons project.

Conversely, Balmoral Estate was rated as likely to experience a high level of negative impact (80%) from Wet Horizons and its outcomes. The respondent explained that there is the, 'potential for incompatibilities between some of the estate's traditional commercial activities (e.g. hunting and shooting) that could be a barrier to restoration'. The

¹ <https://balmoralcastle.com/index.html>.

² <https://www.scottishlandandestates.co.uk/events/walk-talk-peatland-restoration-spittal-glenmuick-balmoral-estate>.

³ <https://www.theguardian.com/uk-news/2023/apr/20/royal-family-balmoral-estate-could-be-worth-80m>.

⁴ Aerial maps used to monitor peatland restoration on Balmoral Estate | The James Hutton Institute.

⁵ <https://www.heraldscotland.com/news/18270928.queen-urged-cull-deer-balmoral/>.

Table 6

Scores assigned to each of the organisations identified, in relation to their interest, ability to influence the achievement of restoration goals (positively or negatively), and the likely impacts (either positive or negative) arising from restoration for each organisation. Scores are based on an average of respondents' assessments of the identified relevant organisations in each category using a scale ranging from 0 (Not at all) to 100 (Extremely). Where no survey data was provided, interest/influence/impact levels were identified through desk research and/or interpretation of open-ended responses, are indicated by an asterisk (*), and are explained fully below.

Organisation	Interest	Influence (Positive)	Influence (Negative)	Impact (Positive)	Impact (Negative)	Total 3i score
Balmoral Estate	80	100	100	50	80	410
Invercauld Estate	80	90	80	50	80	380
Forestry and Land Scotland	100	76	70	79	N/A	325
Mar Lodge Estate (National Trust for Scotland)	90	80	30	70	N/A	270
East Cairngorms Moorland Partnership	50	80	80	40	N/A	250
Peatland Action (NatureScot)	70	100	80	N/A	N/A	250
Ballater and Crathie Community Council	90	50	20	80	NA	240
Dee Catchment Partnership	68.5	60	56.5	55	N/A	240
Glenmuick Estate	50	80	51	50	N/A	231
Cairngorms National Park Authority	70	69	30	60	N/A	229
Dee District Salmon Fishery Board and River Dee Trust	60	42.5	22	85	N/A	213

respondent highlighted the impact of high deer numbers in reducing the effectiveness of restoration, and it is notable that Balmoral Estate has previously been criticised for failing to reduce deer populations.⁶

4.1.4. Implications and recommendations

Here, we highlight any practical or strategic implications or inferences that can be drawn out based on the information presented about this organisation, both in terms of self-description and the perspective of the respondent(s). These recommendations focus on further engagement guidance, and outputs likely to be of interest for them.

- **Engaging through existing East Cairngorms Moorland Partnership and Cairngorms National Park Authority:** the estate is located within the Cairngorms National Park and is a member of the East Cairngorms Moorland Partnership. Engaging the estate through these and other existing forums may enhance its view of the credibility of the project.
- **Raising public awareness:** Balmoral Estate has a strong public presence as a residence of the British royal family and is a significant destination for tourists. Increasing the public's awareness of the value of restoration could there ensure the estate is more likely to engage with the project.
- **Sharing tools, best practice and lessons learned about restoration:** as the estate is already engaged in peatland restoration, it is likely to benefit from any practical outputs from the project.
- **Sharing ecosystem market outputs which support growth in revenue streams:** as the estate is privately owned and operates commercially, it is likely to be interested in any outputs that improve its ability to access natural capital markets.

4.2. Dee District Salmon Fishery Board and River Dee Trust

Dee District Salmon Fisheries Board (DDFSB) and River Dee Trust are separate legal entities working together as a single 'River Dee team', including through sharing a website, office and team.⁷ The organisations describe their shared roles as, 'two organisations who look after the UK's highest river and one of the best-known salmon fishing rivers worldwide ... working toward our vision of a thriving river supporting abundant biodiversity and binding strong the Deeside communities in Northeast Scotland'. The River Dee Trust is a community based charitable community set up to improve knowledge about the river's ecology and fish stocks and to carry out restoration activities. DDFSFB is a statutory body, 'tasked with protecting and enhancing stocks of salmon and sea trout

across the district'.⁸

One respondent commented here that, 'they work with local land-owners to restore habitat and natural geomorphic function to these watercourse. Restoring river habitats may include improving the channel-floodplain connectivity, which can have benefits for wetland environments on the floodplain. Therefore, there may be opportunities to tie in wetland restoration with some of the projects that they are working on'.

4.2.1. Interest

DDFSB and the River Dee Trust were rated as likely to have a moderate level of interest (60%) in Wet Horizons and its outcomes. One respondent commented here that the organisations, 'are regularly looking for opportunities to improve and restore the natural catchment function. This project may help to identify other potential areas for them to target. Following this, in its 'Management Plan 2020–25', DDFSFB states that it is planning to carry out peatland restoration in an effort reduce run-off during flooding and improve water quality. However, it also should be noted that no evidence that this work is on-gong was found during the research⁹.

4.2.2. Influence

DDFSB and the River Dee Trust were rated as likely to have moderate influence (45.5%) to support Wet Horizons and its outcomes. One respondent noted here that the organisations have, 'good connections with landowners across the Dee catchment, from previous and on-going work'. Such work includes a range of river restoration activities including removing dams, riparian woodland creation and tackling invasive species. A note of caution here is that activities to date appear to have mostly focused on the river and immediately adjacent lands, with less focus on restoration of peatlands or wetlands. Hence, the role of DDFSFB and the River Dee Trust in facilitating the Wet Horizons could be limited if the project is not seen as directly relevant their work. DDFSFB and the River Dee Trust were rated as likely to have a low level of influence (22%) to block Wet Horizons and its outcomes, with one respondent commenting here that 'it wouldn't be in their interest to do so, unless there was a specific risk to the Dee'.

4.2.3. Impact

DDFSB and the River Dee Trust were rated as likely to receive a high level of benefit (85%) from Wet Horizons and its outcomes. One respondent highlighted a potential benefit as, 'reduced runoff from degraded peatlands into the River Dee'. Following this, benefits could include improvements in restoration practice and tools leading to

⁶ <https://riverdee.org.uk/>.

⁷ <https://riverdee.org.uk/who-we-are/#board>.

⁸ <https://riverdee.org.uk/wp-content/uploads/2022/09/Dee-Fisheries-Management-Plan-2020-25.pdf>.

reductions in flood risk, enhancements in water quality and ultimately to improved fish stocks. Similarly, an increase in peatland restoration across the catchment could be beneficial for DDFS and the River Dee Trust, for example as a result of any improvements in modelling supporting further expansion of peatland natural capital markets. The respondents did not state whether DDFS and the River Dee Trust were likely to experience any negative impacts as a result of Wet Horizons and its outcomes, but this would appear to be unlikely.

5. Discussion

The central premise of the 3i approach is that, by the acquisition of a greater depth of knowledge regarding relevant parties and the nature of relationships between them, users are empowered to initiate effective and inclusive engagement. In doing so, the 3i approach acknowledges the importance of social context and the likelihood that, for any given issue, relevant parties may have had previous engagement experiences and therefore come with predispositions towards other participants or decision makers (Colvin et al., 2020). It is also important to emphasize that those who are interested, have influence or who are impacted by an issue, intervention, project, process or decision, are unlikely to be static and there is therefore a need to regularly revisit the analysis to capture new parties as they become relevant to the work, and to ensure that engagement remains targeted to dynamic needs and interests.

Using this framework, it is possible to propose a typology of relevant parties who should be engaged in issues, interventions, projects, processes or decisions, based on eight functional groups grounded in their levels of interest, influence, and relative impact (Table 7). Note that in traditional interest-influence matrices, those with low interest and low influence are termed “the crowd” and are often deprioritized or “crowded out” of subsequent engagement (Reed et al., 2009). However, this may exclude those who are not interested or influential, but who may be significantly impacted. Using the 3i approach, it is legitimate to deprioritize those who have limited interest, influence and impact, our “uninterested” category, only after ascertaining that they are low on all three criteria.

Critically, the 3i approach enhances levels of insight and inclusivity in “stakeholder analysis” through its integration of impact as a third criterion against which to identify and analyze relevant parties, alongside their relative levels of interest and influence. A number of alternative additional criteria have been discussed in the literature. For example, Hoare et al. (2023) found power, influence, legitimacy and urgency to be the most common criteria used in stakeholder analyses. First proposed by Mitchell et al. (1997), legitimacy is linked to both interest (i.e., those with legitimate interests in an issue, process or decision), and power (given that who is deemed to have a legitimate interest is typically decided by those in power), opening the analysis to bias and power imbalances, depending on how legitimacy is defined and by whom. As such, assessments of legitimacy will often combine the nature of a group’s interest as the basis for their legitimacy with information about the authority with which they lay claim to legitimacy. Nevertheless, legitimacy may be used to qualify the nature of a group’s interests. Indeed, the perceived level of legitimacy of different groups and their interests is often a source of conflict in engagement processes

(Birnbbaum et al., 2015). Like legitimacy, urgency may also be used to qualify the nature of an interest, and as such can be included in a 3i analysis to qualify the time-sensitivity and importance of any interest (Mitchell et al., 1997). The overlap and nuance of I remain the most used criteria in stakeholder analyses. Limiting the number of criteria in this way also increases the efficiency of the analysis. Given the additional time needed to analyze relevant parties in relation to each additional criterion, there needs to be a strong theoretical and/or normative argument for the inclusion of a third criterion. Given the key problem with existing stakeholder analysis methods being used to legitimize the exclusion of potentially important groups, the inclusion of impact has the potential to identify marginalized groups who have limited interest and influence, but who could nevertheless be significantly impacted (whether positively or negatively) by an issue, intervention, project, process or decision, to ensure that they are prioritized for engagement.

By including impact as a third criterion in the 3i analysis, two types of additional insight were gained from the environmental applications of the approach in the case study. First, additional depth of insight was facilitated by going beyond the exploration of interest as simple expressions of preferences (as is done in traditional stakeholder analyses), without considering the underpinning values and beliefs that drive those preferences. Second, the 3i approach facilitated greater inclusion of more diverse parties, including vulnerable groups with limited interest or influence, who stood to be significantly impacted (whether positively or negatively) by the issue or project (groups who are often “crowded out” in traditional stakeholder analyses). For example, the relatively narrow interests of the Dee District Salmon Fishery Board and River Dee Trust limited their interest in peatland restoration in the headwaters of the river (the main focus of the project), given that the benefits of restoration for water discoloration are more marginal for fish populations than the more significant issues of diffuse pollution in the catchment. Their specialist focus, limited capacity (as a poorly resourced public body and community-based charity) and focus on the lowland parts of the catchment may constrain their engagement with peatland restoration and so explain their relatively limited influence. While their position at the bottom of the score-based ranking in Table 6 could be used to justify engaging preferentially with other organisations, the insights into this organization arising from the analysis could also be used to create a tailored engagement strategy for this organization. For example, interest in potential benefits of peatland restoration for flooding and water quality could be further investigated, alongside the potential for landowners in their network to benefit from peatland carbon markets, as a way of engaging this organisation more actively in decisions about peatland restoration in their catchment. Although the case study focussed heavily on these two organisations, based on their ranking in the analysis, the findings also identified the Ballater and Crathie Community Council as a potentially marginalized group on the basis of the significant benefit they could derive (for example from community benefit funds arising from natural capital markets, which were being proposed by Scottish Government at the time of the research), compared to their very limited influence over restoration decisions (based on their scores for both positive and negative influence, this organisation ranked lowest out of those analysed). Community Councils in Scotland are often perceived to only be interested in issues in the towns and villages, as opposed to the rural areas in their jurisdiction, and so are often excluded from decision-making processes relating to environmental governance. The identification of this group as potentially marginalized could be used as a basis for more targeted engagement, based on the findings of the analysis, to better understand their needs and ensure their future engagement.

By employing the 3i analysis process systematically, organisations can identify a larger number of stakeholders than previously recognized by traditional approaches or by authorities. This can lead to a broader engagement. This in turn results in a shift from developing specific guidelines to establishing minimum requirements for existing entities operating in a particular space. Moreover, using a classification system

Table 7
Typology of relevant parties that should be included in engagement processes.

Stakeholder type	Interest	Influence	Impact
Uninterested	Low	Low	Low
Uninterested and impacted	Low	Low	High
Uninterested influencers	Low	High	Low
Uninterested, influential and impacted	Low	High	High
Only interested	High	Low	Low
Interested and impacted	High	Low	High
Interested influencers	High	High	Low
Interested, influential and impacted	High	High	High

for stakeholders can help identify certain hard-to-reach groups that could be influential in generating impact if their interests are adequately addressed. Collaborative efforts with relevant parties can be particularly beneficial, as the insights gained from these partnerships have been used to strengthen existing alliances or forge new connections in various sectors. By employing a comprehensive framework, it is possible to identify essential categories of relevant parties that might otherwise be excluded from engagement in the research process. The analysis should also aim to achieve a high level of granularity to identify hard-to-reach and potentially vulnerable groups. This can include specific community groups, people affected by certain issues, or groups that might face negative consequences due to policy changes. While the large number of relevant parties identified using the 3i approach may be viewed as a challenge, the categorization step in the method enabled long lists of organisations to be organized into as few groups as possible, to help structure subsequent engagement. For example, organisations identified in the case study were categorized into national and regional public bodies, local authorities and community councils, environmental charities and partnerships, and landowners, providing a clear structure for understanding different types of relevant parties and their roles in restoration efforts. This sort of categorization makes it possible to ensure that at least one representative is engaged from each category in subsequent project work (or more than one individual/organization for large or diverse groups, which were sometimes divided into sub-groups to represent that diversity more systematically). There is now robust evidence that representation of relevant parties is the most significant factor influencing the outcomes of participatory processes in environmental governance (Newig and Fritsch, 2009; Newig et al., 2018). It is therefore essential that a systematic approach is followed, to choose who gets to “sit at the table”. Without this, a participatory process may be challenged and delegitimized by those who believe they were unfairly excluded from the process. Whilst being aware of a problem (e.g. the under-representation of minority groups) doesn’t inherently decrease its proclivity, these processes are designed to make the list of identified parties as comprehensive and representative as possible. In addition to this, developing the engagement process further to meet the needs of different types of relevant parties, could further increase impact of research (Reed and Rudman, 2022).

6. Conclusion

In this paper, we have presented a new method for identifying and analyzing those who should be engaged in issues, interventions, projects and decisions, including a detailed survey instrument that can be used to operationalize the method. We have proposed a five-stage process to inform the design of workshops and a short survey design to identify stakeholders and gain perceptions relevant to a 3i analysis from those who know the research context. The survey questions can also be formulated in a way to conduct direct measurement with stakeholders (see Supplemental Materials). Clear sections on interest, influence, negative impact and positive impact are used to collect both quantitative data through closed-ended scale items and qualitative data using open-ended ‘please explain’ text areas. Quantitative data enables comparison of levels of interest, influence and impact across stakeholders, while qualitative data allows for an in-depth understanding of stakeholder contexts and the layers of detail (see Table 3) underpinning their perspectives. Although more time-consuming, workshop experience, detailed in Supplemental Materials, demonstrates the flexibility of the proposed process, as it was adapted to a range of project contexts working across a different environmental and health issues.

The 3i framework, although applied in this paper to an environmental decision-making context, is broadly applicable. Results from a 3i analysis can be used to guide across a range of disciplinary and policy contexts, allowing practitioners to identify and understand those they should be engaging at a much deeper level than has previously been possible. The depth of knowledge generated by the 3i analysis can then

enable more targeted and empathic engagement (Reed and Rudman, 2022).

In addition to evidence that the representation of relevant parties engaging in participatory processes strongly influences outcomes (Newig and Fritsch, 2009; Newig et al., 2018), there is evidence that the breadth of information inputs enables participatory processes to generate impact (socially and environmentally beneficial and durable outcomes; de Vente et al., 2016). It is therefore imperative that engagement is inclusive, representing the fullest possible range of interests and perspectives, including those from vulnerable and marginalized groups, especially when they may be significantly impacted by an issue, intervention, project or decision. The insights gained from the case study underscore the importance of adapting engagement processes to the diverse needs and perspectives of different groups. By prioritizing the inclusion of marginalized and vulnerable groups, the 3i framework not only enhances the legitimacy and equity of environmental governance but also contributes to more sustainable and socially just outcomes.

Existing stakeholder analysis methods are part of the problem; they bias selection away from already disenfranchised groups with limited interest or influence on an issue, even though it is these very characteristics that make them vulnerable and marginalized (they have limited influence). This reifies marginalized groups’ positioning, for example, if they have limited interest in the issue or process because of the way it has been framed and communicated (or not communicated) up to that point. It is not possible to include everyone in a participatory process, due to constraints in resources or the process itself (e.g., if the goal is to facilitate deliberation), and it is legitimate to screen out those who have limited interest, influence and impact. However, the remaining seven types of stakeholders identified in our typology (uninterested and impacted; uninterested influencers; uninterested, influential and impacted; only interested; interested and impacted; interested influencers; and interested, influential and impacted; see Table 3) need to be engaged wherever possible, adapting the design of the participatory process to the needs of each group. To ensure inclusive and effective engagement, it is necessary to identify relevant parties from across this typology, and to do this, it is necessary to evaluate the relative interest, influence and impact arising from an issue, intervention, project or decision for each party identified. This is the kind of information that is needed to enable the kind of evidence-based approach to engagement called for by Jensen and Gerber (2020) and Jensen et al. (2021).

As environmental challenges become increasingly complex and interconnected, the need for robust and inclusive engagement frameworks is more critical than ever. The 3i framework offers a valuable tool for researchers, policymakers, and practitioners aiming to foster meaningful participation and collaboration in environmental decision-making. Its adoption could lead to more comprehensive and equitable engagement processes, ultimately improving the effectiveness of environmental policies and interventions. The potential for the 3i framework to transform stakeholder analysis methods and participatory practices is significant. By promoting broader inclusivity and deeper understanding of the impacts on all relevant parties, the 3i framework represents a crucial step towards more effective and just environmental governance.

CRedit authorship contribution statement

M.S. Reed: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **E.A. Jensen:** Writing – review & editing, Writing – original draft, Supervision, Software, Methodology, Conceptualization, Formal analysis. **S. Noles:** Writing – review & editing, Writing – original draft, Formal analysis. **D. Conneely:** Writing – review & editing. **H. Kendall:** Writing – original draft. **M. Raley:** Writing – original draft. **A. Tarrant:** Writing – original draft. **N. Oakley:** Writing – review & editing. **C. Hinson:** Writing – original draft. **V. Hoare:** Writing – original draft. **K. Marshall:**

Writing – review & editing. **L. Pugliese:** Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2024.123437>.

Data availability

Data will be made available on request.

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