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ORIGINAL ARTICLE

Advancing stakeholder engagement in climate adaptation: a systematic review of structural barriers and operational enablers

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Abstract

Despite growing efforts to address climate change impacts, an adaptation implementation gap persists, where administrative, financial, cultural, and organizational challenges hinder the translation of climate change policies into action. As one of several approaches to bridge this gap, meaningful stakeholder engagement in adaptation is widely recognized as crucial for enhancing action effectiveness, acceptance, stakeholder empowerment, learning and social justice. Stakeholder engagement in climate adaptation has increased over the past decade, however it remains limited. To understand how to improve engagement, this paper reviews current practices and investigates key barriers and enablers in implementing citizens and stakeholders' engagement in climate adaptation action. It adopts a mixed-method approach that includes a systematic literature review ($n=123$ papers), interviews ($n=20$) and online surveys ($n=51$) with European adaptation practitioners. The findings reveal a critical disconnect: while operational enablers for engagement are widely recognized, their implementation is frequently undermined by persistent, often overlooked structural institutional and social barriers related to governance, resources, and capacity to engage. Consequently, the range of current engagement practices remains narrow, confined to specific solutions, socio-economic sectors, phases of the adaptation cycle and passive engagement approaches. Advancing engagement requires moving beyond operational guidelines to address these systemic constraints. Key enablers to promote change include strengthening local institutions' capacity and resources, embedding engagement mandates across sectors, diversifying methods, and meaningfully empowering citizens to engage. This can be achieved not only by raising awareness and disseminating knowledge, but also by building capacities, providing economic resources, and fostering trust.

Keywords Climate adaptation · Co-production · Stakeholder engagement · Barriers · Enablers

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Introduction

Adaptation to climate change (hereafter adaptation) is steadily advancing across the globe, with ever more countries, regions, and municipalities developing and implementing policies and actions (IPCC 2022). Despite progress, adaptation remains fragmented, incremental and insufficient, leaving a glaring implementation gap that requires accelerating and mainstreaming the implementation of adaptation solutions (De Roeck et al. 2018; Berrang-Ford et al. 2019; Haasnoot et al. 2020). Simultaneously, there is an increasing emphasis on the importance of engaging stakeholders, and particularly citizens, in the process. Broadly understood as involving those affected by or influencing adaptation decisions (Reed 2008), engagement is seen as essential to ensure that adaptation planning and actions are inclusive, equitable, and tailored to the local context (Conde et al. 2005; Araos et al. 2021; European Union 2024). Stakeholder and citizen engagement in climate adaptation is gaining traction in both policy and research agendas (Hügel and Davies 2020).

This claim has been repeatedly reinforced in international frameworks, including in the Rio Declaration *of* 1992, the Paris Agreement (2015), the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction (2015–2030), and in the IPCC 6th Assessment Report (AR6) Cycle (IPCC 2022). At the European level, the EU Mission on Adaptation to Climate Change reaffirmed the value of citizen and stakeholder engagement to support effective national planning and implementation (MI4ADAPT 2023; European Commission 2025).

This push for stakeholder engagement is driven by the expectation that it yields multiple and interconnected benefits. Yet, engagement is not a guarantee of success nor always appropriate. It represents one approach among others, such as top-down regulation or market-based incentives, which may be more efficient in contexts requiring urgent, standardized or large-scale infrastructural action (Lemos et al. 2018; Scheer et al. 2025). Moreover, it must operate alongside other critical catalysts for adaptation such as proactive leadership, sufficient resourcing, supportive legal frameworks or enhanced knowledge (IPCC 2022; Brullo et al. 2024).

Nevertheless, when strategically designed and effectively implemented, stakeholder engagement offers significant benefits, facilitating the successful implementation of climate related initiatives and enhancing their relevance and acceptance at the local level (Owen 2020; Cattino and Reckien 2021). Engagement can be key to manage the unique characteristics of climate adaptation such as the high levels of uncertainty, long temporal horizons, localized impacts, and the need to manage risks that may not yet be visible (Few et al. 2007; IPCC 2022). Research demonstrates that early and continuous stakeholder engagement offers several interconnected advantages (Kujala et al. 2022). It promotes inclusivity, and better representation of diverse perspectives and of marginalized voices, which in turn contribute to equitable outcomes, legitimacy, acceptance and ownership of decisions (Chambers et al. 2021; Wagner and Lima 2024). The process also improves transparency and accessibility in decision-making, overcoming technical and social barriers to allow for meaningful contributions (Doelle and Majekolagbe 2023). Furthermore, engagement facilitates mutual learning and knowledge integration, allowing decision-makers to incorporate both scientific expertise and lived experiences (Chambers et al. 2021; Newig et al. 2023). This enriched understanding strengthens the effectiveness of adaptation initiatives by enabling tailored solutions based on local knowledge. Ultimately, engagement provides a crucial platform for navigating complex trade-offs, addressing power dynamics, and resolving potential conflicts (Burton and Mustelin 2013).

Despite these benefits, the inherent complexity and challenges of stakeholder engagement have been widely acknowledged across multiple fields, to the extent that it is often described as a wicked problem (Few et al. 2007; Sprain 2016; Buhmann et al. 2024). These challenges can lead to poor quality engagement and even generate adverse effects that hamper the achievement of the benefits highlighted above (Lemos et al. 2018). For example, the effectiveness of stakeholder engagement in adaptation decision-making can be undermined by unclear objectives, inadequate facilitation, and the exclusion of marginalized voices, leading to tokenistic participation and weaker, contested outcomes (Lemos et al. 2018; Wamsler et al. 2020; Cattino and Reckien 2021). Indeed, achieving meaningful engagement remains challenging for local authorities and practitioners.

Key barriers include a lack of motivation, appropriate knowledge, and trust in governance bodies (Khatibi et al. 2021); and conflicting interests, power asymmetries, difficulties in sustaining meaningful participation as well as structural challenges that arise from inadequate organizational and governance structures (Wamsler et al. 2020; Scolobig and Gallagher 2020; Glaas et al. 2022). Moreover, participatory processes may be co-opted by specific interests, impacting the legitimacy of the outcomes (Newman et al. 2004; André et al. 2023). These failures are particularly concerning climate adaptation as they can reinforce existing power dynamics (Turnhout et al. 2020) or result in maladaptive outcomes that inadvertently increase the vulnerability of populations (Cattino and Reckien 2021). Thus, while the potential for engagement to be transformative exists (IPCC 2022), its actual contribution depends heavily on both the quality of the process and structural barriers that go beyond

simple procedural design (Lemos et al. 2018; Murunga 2022).

Given these challenges and potential pitfalls, engagement practices for adaptation remain fragmented and often limited to passive forms of participation, rather than being fully mainstreamed into policy and practice (Revez et al. 2022). To address this gap, it is crucial to provide greater support for adaptation practitioners to foster climate ambition and action (Owen 2020; Cattino and Reckien 2021). This requires developing targeted policies and practical recommendations better aligned with practitioners needs that acknowledge the conditions, challenges, and enabling factors associated with engagement practices implementation (Wamsler 2017).

Carried out as part of the EU-funded Adaptation AGORA project, this study aims to identify key challenges and priorities that can support practitioners and affected stakeholders in meaningfully engaging in adaptation actions. It builds upon both existing scientific knowledge and practitioner experience to understand the diverse contexts in which engagement processes occur and to identify transversal factors hindering or facilitating its implementation across a wide spectrum of adaptation initiatives, engagement approaches and contexts. To address these objectives, we combined a systematic review of scientific literature, an online survey and semi-structured interviews to gather the experience of adaptation practitioners. Specifically, this study investigates the following research questions: (1) How are stakeholder engagement processes currently operationalized in climate adaptation? (2) What are the main barriers and enablers influencing the implementation of stakeholder engagement processes? And (3) In what ways can adaptation practitioners and stakeholders be better supported to foster and sustain effective engagement practices? The following sections outline the conceptual framing, the methodology of the study, describes key findings, and discusses the scope of stakeholder engagement practices in adaptation, highlighting operational and structural gaps. The paper concludes by identifying policy and practice windows of opportunity to leverage stakeholder engagement for climate adaptation action.

Conceptual framing

To navigate the complex landscape of engagement in climate adaptation, we established a conceptual framing that guided our data collection and analysis. We structured our work around four core dimensions: the stakeholders, the process (levels of engagement), the context of the adaptation initiatives, and the influencing factors (barriers and enablers).

First, regarding the stakeholders, the literature and practice refer to diverse and sometimes overlapping terminology to describe stakeholder engagement in climate governance, with terms such as public participation, co-creation, co-production, and transdisciplinarity often used interchangeably to describe deliberative decision-making processes (Alford 2014; Loeffler and Bovaird 2021; Kujala et al. 2022). These terms reflect different theoretical bases and normative assumptions, ranging from democratic theory emphasizing rights, equity, and empowerment (Arnstein 1969) to management and instrumental governance approaches prioritizing effectiveness, learning, and conflict resolution (Reed 2008). To navigate this complex linguistic landscape and to enable systematic analysis across heterogeneous practices, this paper adopts a deliberately broad and integrative understanding of stakeholder engagement. Consistent with the definition proposed by Reed (2008) in the context of environmental challenges, we refer to *stakeholder engagement* as a process through which individuals, groups, or organizations are involved to take an active role in making decisions that affect them or the related outcomes they can influence.

Although a distinction is frequently made in both research and practice between *citizen participation* and *stakeholder participation* — with tailored engagement processes designed for each group — in the context of adaptation, this distinction becomes increasingly problematic (Kahane et al. 2013; OECD 2022). Indeed, climate change affects all societal levels, blurring the boundary between the public and stakeholders (Reed et al. 2018), and effective adaptation depends on bridging technical and scientific expertise with experiential and place-based knowledge held by citizens and local communities (Reed et al. 2018; Murunga 2022). Accordingly, this study conceptualizes citizens as stakeholders, alongside the overall civil society with NGOs, organizations, and/or local communities, and professional actors such as government officials, managers, experts, businesses, investors, and media (Buhmann et al. 2024). Integrating these actors under a unified stakeholder engagement framing allows the identification of systemic barriers and enablers across adaptation processes.

Second, concerning the engagement process, we acknowledge that engagement takes many forms and exists on a spectrum of participation approaches. To categorize this continuum in our analysis, we draw upon the frameworks of Arnstein's Ladder (1969) and the IAP2 Spectrum (2018). We thus considered engagement processes ranging from passive or tokenistic approaches like informing and consultation, where stakeholders receive or provide input but lack decision-making power, to more active forms such as collaboration or empowerment where stakeholders share decision-making authority and co-produce outcomes (Arnstein 1969; IAP2 2018).

Third, regarding the context of adaptation, given that climate adaptation is often inherently cross-cutting, this study adopts a broad analytical scope to capture the diversity of adaptation efforts (Berrang-Ford et al. 2021). We therefore analyze initiatives across diverse sectors (e.g., agriculture, water, urban planning) and type of action. These include policymaking, planning processes, on-the-ground actions, climate services, knowledge co-production, and financial mechanisms.

Ultimately, to understand the influencing factors that shape engagement, we analyze barriers as factors that obstruct the implementation of stakeholder engagement process, whereas enablers are factors that facilitate it. We conceptually distinguish between operational factors, which relate to the internal design, facilitation, and management of the engagement process, and structural factors, which encompass the broader institutional, financial, and social context in which the engagement is embedded.

This non-restrictive conceptualization allows to analyze engagement practices across the entire landscape of adaptation efforts, rather than limiting our scope to a single approach or type of action.

Methodology

We employed both quantitative and qualitative methods to comprehensively understand the context in which stakeholder engagement occurs within adaptation processes, as well as the barriers and enablers to its implementation. To do so, the research combined a systematic literature review, online surveys and semi-structured interviews.

Systematic literature review

We first conducted a systematic review of the scientific literature in accordance with the *Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)* guidelines (Page et al. 2021) to identify relevant studies from the Web of Science database. To align with the scope of our research, five groups of keywords were selected (for more details on keywords selection, see ESM-S1). Initially, we narrowed our focus to the domain of climate change adaptation, recognizing that the literature on citizen and stakeholder engagement is extensive and spans various contexts. Subsequently, we identified studies that concurrently address adaptation initiatives, engagement processes, enablers and barriers, and the typology of involved actors. The search was restricted to peer-reviewed articles published in English prior to 19 June 2023, with the relevant keywords appearing in their title, abstract or keywords section. Despite our efforts to select a comprehensive set of keywords, we are conscious that the wide range of terminology used to describe engagement processes likely resulted in the omission of relevant studies.

The preliminary search of the Web of Science database yielded 1,340 records, from which 3 duplicates were removed (see Fig. 1). To assess the eligibility of each article we then screened their title and abstract. The eligibility criteria required articles to report on at least one stakeholder engagement process in an adaptation initiative, as well as on the barriers and/or enablers experienced during this process. A total of 1,190 papers were excluded for one or more of the following three reasons: (1) they did not address stakeholder engagement processes; (2) they lacked a description of enablers or barriers; or (3) they focused on enablers and barriers related to the implementation of adaptation

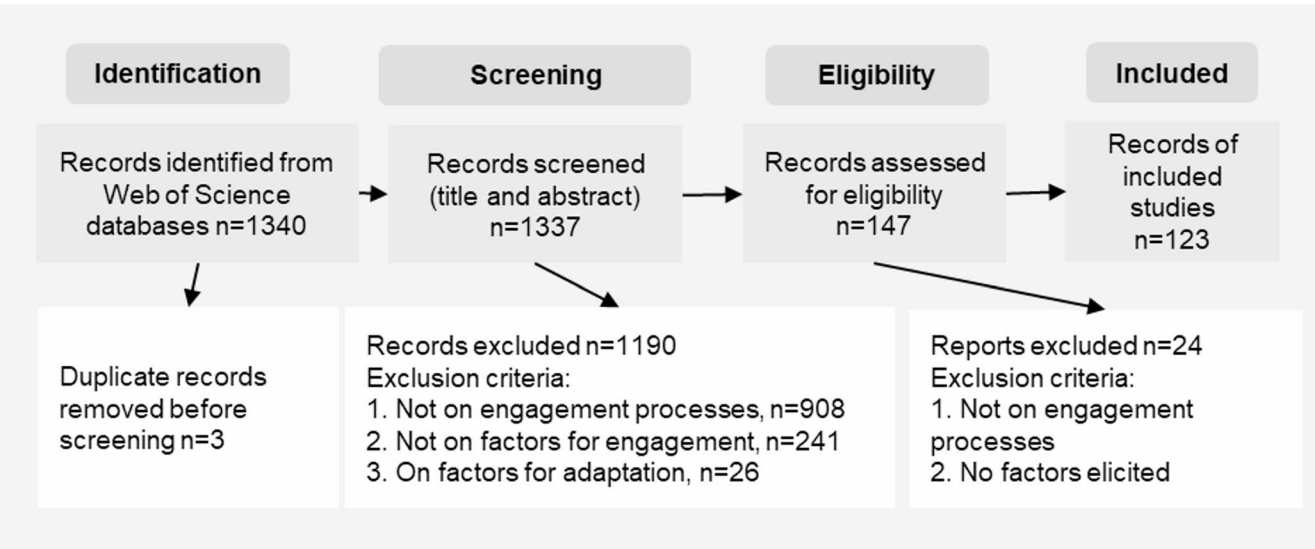

Fig. 1 PRISMA diagram reflecting systematic review process

solutions rather than on stakeholder engagement. By isolating the engagement process as our primary unit of analysis, we ensured that the extracted factors remained comparable across the heterogeneous range of adaptation initiatives and geographic contexts.

As a result, 147 articles were retrieved for content analysis, of which 24 were subsequently excluded for one of the above reasons following a thorough review. Thus, 123 articles were included in our analysis (the full list is available in ESM-S2).

Each article was examined by one co-author, with a second co-author reviewing the coding in case of uncertainties to ensure the robustness of the analysis. The coding framework was collaboratively developed based on research questions, associated hypotheses, and the collective expertise (see ESM-S3). The coding framework was divided into four main sections: (1) information about the paper (i.e., date, journal, authors, type of study, and methods for data collection); (2) the context of the adaptation initiatives (i.e., the adaptation solutions type, sectors, benefits, scale, and location); (3) the engagement processes (i.e., engagement definition provided, the type, outputs, and the methods used for stakeholders' engagement); and (4) factors influencing the engagement process, specifically each factor's name, description, broad category (e.g., institutional, financial, socio-cultural, relational), and influence (barriers or enablers). As these initial broad categories proved insufficient to capture the nuance of the 173 barriers and 471 enablers identified, we developed a refined categorization using inductive thematic analysis. Therefore, to ensure consistency and comparability, new specific categories were derived based on factors original terminology and underlying semantic meaning (e.g. merging "favorable institutional structure" and "government leadership" into "Institutional support"). To ensure distinct delimitation between categories, the specific scope of each category was explicitly defined (see detailed descriptions in ESM-S7) and subsequently used to recode the entire dataset. The raw dataset used for the literature review is available in an open repository at https://doi.org/10.5281/zenodo.14265645. A frequency analysis was then conducted to explore trends among the coded variables.

To complement and compare the findings of the literature review, we designed an online survey and conducted semi-structured interviews to capture the experiences of practitioners in engaging stakeholders in climate change adaptation. Here, *practitioners* refers to actors responsible for designing or implementing adaptation policies or actions, which may include project leaders, public officials, civil servants, or researchers.

Practitioners survey

To empirically validate the findings from the literature review, the survey was structured into four sections (details on survey protocol are available in ESM-S4). The first section included a consent form that confirmed the respondents' legal age, ensured confidentiality, and obtained approval for the use of the collected information for research purposes. From then respondents were asked to reflect and report on a specific experience. The second part focused on collecting content about the adaptation initiatives (e.g., location, type, objectives, sectors) and the engagement process (e.g., respondent's role, engagement type, stakeholders involved, and outcomes achieved). The third part used *Likert scales* to assess the role of the barriers and enablers using the same categories identified in the systematic literature review.

The last section collected demographic and socio-economic data (e.g., age group, gender, education, residence, and sector of activity) to evaluate the inclusiveness of the sample. The survey was built using Microsoft Forms, conducted anonymously and aimed at European adaptation practitioners with experience in stakeholder engagement. Between December 2023 and June 2024 it was widely disseminated via various networks and media, such as adaptation projects and platforms newsletters, communities of practice, forums, social media, conferences, and personal emails. Identifying practitioners with dual expertise in stakeholder engagement and climate adaptation proved to be challenging.

Despite efforts to boost participation by incorporating practitioner feedback to enhance accessibility, specifically by shortening the survey and providing multilingual translations, the survey yielded a relatively small sample size of 51 responses. We quantitatively analysed the survey responses using a descriptive analysis approach, calculating each variable frequencies, and the *Likert scales* mean scores and standard deviations. The raw dataset of survey responses is available in an open repository at: https://doi.org/10.5281/zenodo.14265946.

Practitioners' interviews

To explore how public policies support stakeholder engagement in adaptation, we conducted twenty semi-structured interviews with municipal and regional practitioners that have experience in both policymaking and engagement (details on interview protocol and interviewee profile are available in ESM-S5). The interview pool included experts from climate mitigation, environmental management, water management, mobility, land planning, and urban sustainability, all of whom contribute to adaptation efforts. Interviewees were from the Adaptation AGORA project's four

pilot regions (5 interviews per region: Dresden, Malmö, Rome, and Zaragoza).

The interviews aimed to explore policy support for adaptation engagement, identifying contextual barriers and enablers. A co-designed protocol guided discussions through respondent roles/experience, local engagement examples, and perspectives on policy framework challenges and opportunities (funding, resources, support mechanisms). Interviews were carried out online or in-person in native languages during March and April 2024. Anonymized content was analysed using thematic content analysis (Braun and Clarke 2006) in *MAXQDA* which focused on engagement experiences, scales, objectives, policies, tools, barriers, and enablers. Further details on analysis codes are available in ESM-S6.

Results

By combining the outputs of the literature review, surveys, and interviews, this study provides a comprehensive description and analysis of the context in which stakeholder engagement for adaptation occurs, as well as key barriers and enablers shaping these processes.

Figure 2 shows that scientific interest in adaptation and engagement processes increased steadily between 2009 and 2023. Most of the reviewed papers are based on single case study (68%) or compilations of multiple cases (11%). Fewer papers focused on literature reviews (9%) or comparative studies (6%). Data collection predominantly involved mixed methods (41%), combining stakeholder elicitation, literature, and document analysis; or stakeholder-focused approaches (37%) such as workshops, interviews, or surveys. Papers based on scientific or grey literature (11% and 2% respectively) or authors' accumulated experience (7%) alone were relatively rare, indicating that most papers were grounded in engagement processes experienced or observed by the authors.

In the following sections, we describe the main findings by topic. We present the systematic literature review, practitioners surveys and interviews' results separately.

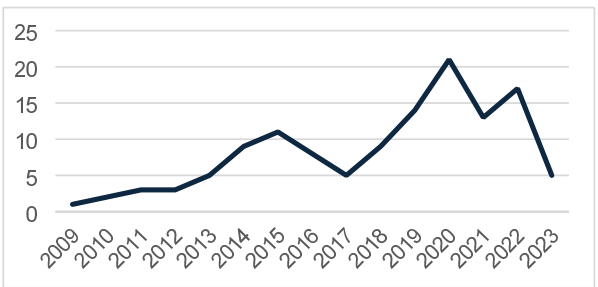

Fig. 2 Distribution of paper published by year from 1 January 2009–19 June 2023 ($n=123$)

Importantly, the interviews results are not available for all the selected topics (e.g. adaptation context or stakeholder engagement practices) because these issues were not the focus of the interviews with practitioners.

Adaptation context

Systematic literature review

To understand the nature and scope of the adaptation initiatives for which engagement processes were implemented, the analysis characterized the type of climate change adaptation measure, the sector to which it applied, and the implementation of location and scale. According to the literature review, stakeholders are primarily engaged in four main types of adaptation initiatives (Fig. 3a): (i) institutional solutions (24%), which focus on policies, regulations, and public strategies; (ii) social and behavioural solutions (17%), which aim to change practices, provide education, and support capacity building; (iii) research and innovation solutions (15%), which support knowledge co-production and service development; and (iv) on-the-ground solutions (14%), such as nature-based solutions. Technical and infrastructural solutions appear slightly less frequently (13%), whereas financial solutions are rarely identified (4%). Regarding the sector addressed by the adaptation initiatives (Fig. 3b), many of the reviewed papers (29%) do not explicitly refer to a specific sector. When cited, the sectors are mainly linked to natural areas management such as water (14%), agriculture and forestry (10%), and environment/biodiversity (9%), and to land management domains, including infrastructure/building (8%), disaster risk reduction (8%) and land use planning (5%). Adaptation solutions in business and industry, cultural, and financial sectors were the least reported (less than 3%). The most frequent location of the reported adaptation initiatives was Europe (30%) (Fig. 3c). However, adaptation initiatives were also identified in North and South America (18%), Africa (15%), Oceania (13%), and Asia (10%). Approximately half of the initiatives were implemented at the local scale (50%), followed by the regional (21%), national (18%) and international scales (less than 5%) (Fig. 3d).

Practitioners survey

The findings from the literature analysis broadly align with those for the practitioners' survey (Fig. 3). Regarding the type of adaptation initiatives, practitioners ($N=51$) most commonly reported initiatives related to research and innovation (26%), followed by institutional solutions (21%) and, to a lesser extent, to on-the-ground (18%) and social interventions (17%) (Fig. 3a). The predominant sectors related to

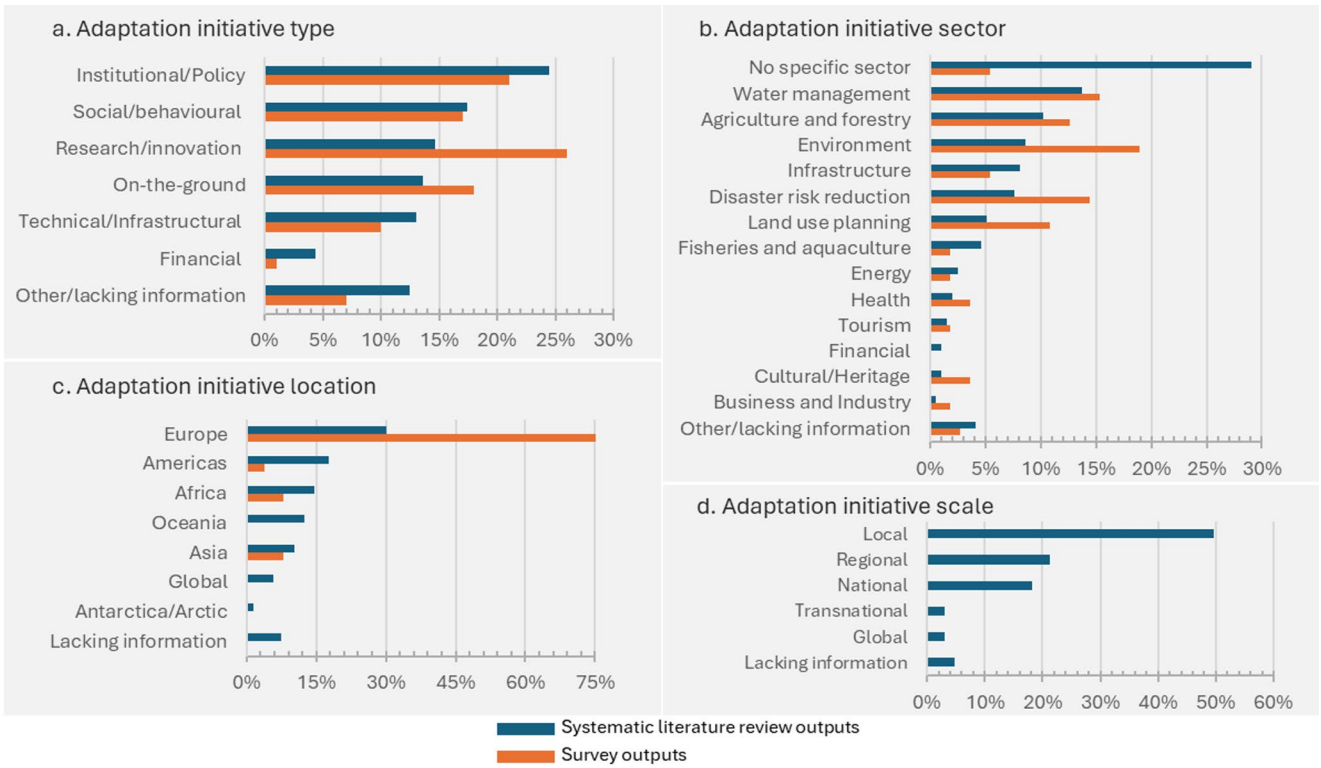

Fig. 3 Percentages of adaptation initiatives by type (**a**), sector (**b**), location (**c**) and scale (**d**) according to the literature review outputs (blue bars) and to the survey's outputs (orange bars). Note: Data on implementation scale (**d**) was only collected for literature review

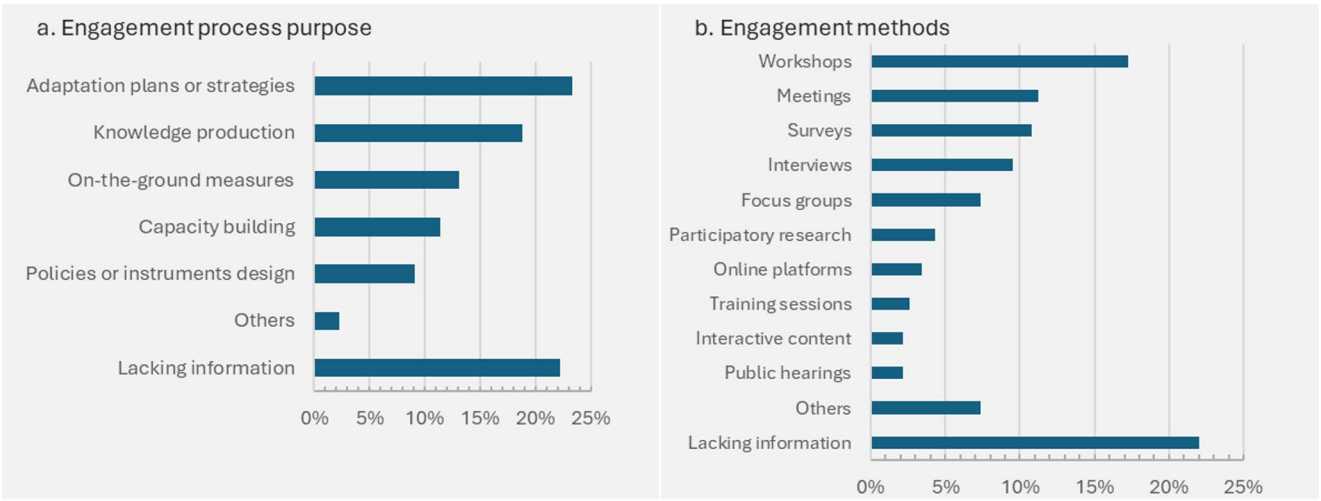

Fig. 4 Percentages of depicted engagement process's purpose (**a**) and methods used (**b**) according to the literature review outputs

natural areas and land management, including environment and biodiversity (19%), water management (15%), disaster risk reduction (14%), agriculture and forestry (13%) and land use planning (11%) (Fig. 3b). The vast majority of responses originated from Europe (80%), reflecting the fact that the survey was specifically targeted at European practitioners (Fig. 3c).

Stakeholder engagement practices

The characteristics of stakeholder engagement practices in relation to adaptation initiatives were examined. The literature review assessed engagement processes stated purpose, and the methods employed (Fig. 4). Complementing this overview, the survey assessed the purpose, approach, and origin of stakeholder engagement processes (Fig. 5).

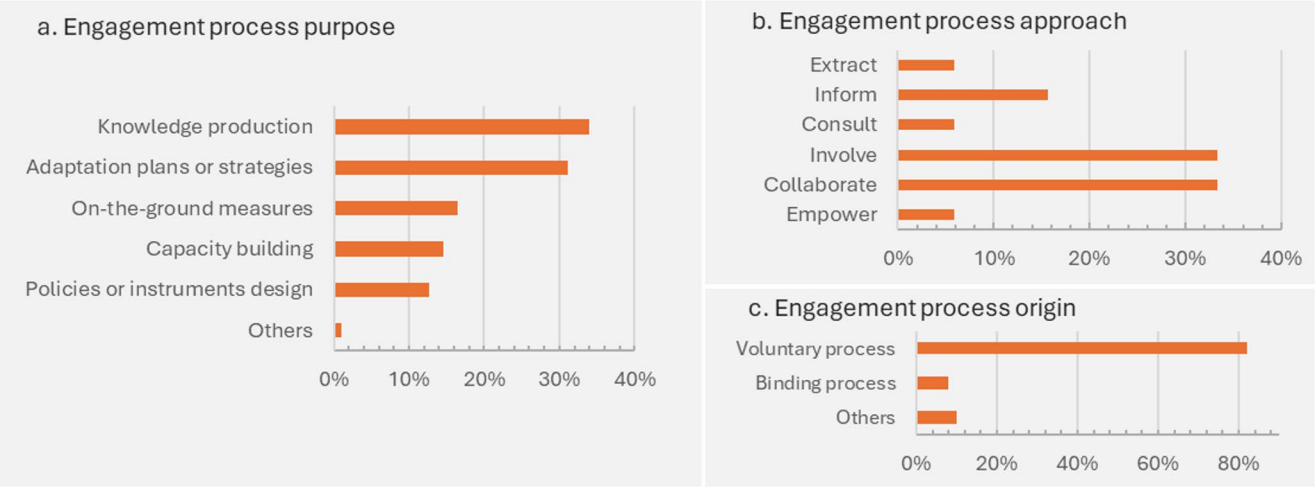

Fig. 5 Percentages of depicted engagement process's purpose (**a**), approach (**b**) and origin (**c**) according to the survey outputs

Systematic literature review

All of the articles reviewed linked stakeholder engagement to collaboration, inclusivity, iteration, and enabling diverse groups to engage in decision-making and problem-solving. However, these aspects were clustered under different concepts. These concepts included *co-production*, as described by Ostrom (1996), but also knowledge co-production; community-based adaptation; public participation; collaborative governance; and social learning.

The most common reason for stakeholder engagement was co-producing adaptations plans/strategies (23%) and adaptation knowledge (19%) (Fig. 4a). Other objectives included implementing on-the-ground initiatives (13%), capacity building (11%), and policy instrument design (9%). The articles documented a wide range of stakeholder engagement methods (Fig. 4b), with more conventional methods being most frequently employed, including workshops (17%), meetings (11%), surveys (11%), interviews (9%), and focus groups (7%). Importantly, 22% of the analysed papers did not provide details on either the specific objectives of engagement or on the methods used, underscoring the need for improved reporting about co-production processes.

Practitioners survey

The purpose of the engagement process is consistent between the literature review and the survey results (Fig. 5a). Indeed, survey respondents indicate that stakeholder engagement predominantly aimed at the co-production of knowledge (34%) and adaptation plans/strategies (31%), followed by on-the-ground initiatives implementation (17%). Two other variables depicting the engagement context were added to the survey, i.e. engagement process approach and origin. Survey results revealed that the two most frequent employed approaches relate to active stakeholder engagement (Fig. 5b) (IAP2 2018). These include to "collaborate" (33%), meaning to partner with stakeholders in each aspect of the decision, and to "involve" (33%), meaning to work directly with stakeholders throughout the process ensuring that their perspectives are included. Then, reported processes aimed to "inform" (16%), meaning to provide stakeholders with balanced and objective information to assist in understanding the problems and solutions. Of the last three options, two are among the least engaging forms, i.e. "extract" (6%) and "consult" (6%), and one is the strongest form of engagement, i.e. "empower" (6%). Finally, the origin of the engagement process was also examined (Fig. 5c). Most of the reported processes were developed on a voluntary basis (82%) rather than being linked to binding mechanisms or legal requirements (8%).

Practitioners' interviews

Interviewees widely acknowledged the importance of citizen engagement in climate adaptation but noted that it is often treated as a procedural requirement with limited influence on decision-making. Voluntary forms of engagement were most common, and mandatory processes occurred either as part of an official responsibility, or as mandated by law. Engagement practices tended to rely on passive consultation methods rather than fostering genuine collaboration. Nonetheless, some active forms of engagement were reported, including collaborative municipal projects and grassroots initiatives led by NGOs. Digital platforms and tools are increasingly used to facilitate participation, though concerns were raised about digital exclusion due to varying levels of access and digital literacy among citizens.

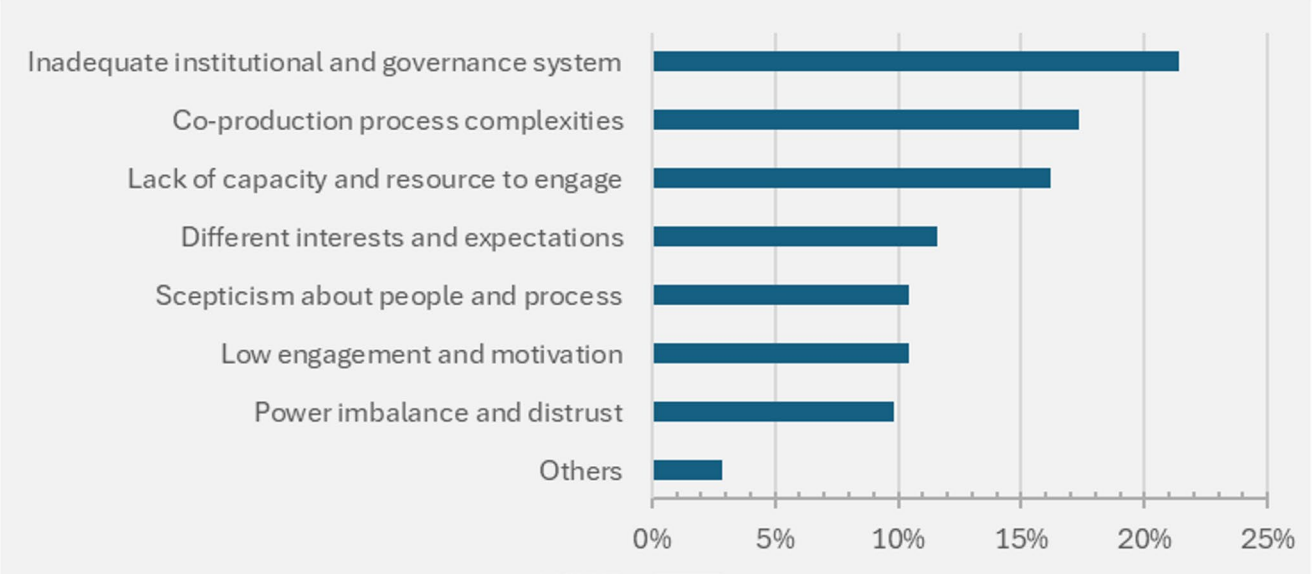

Fig. 6 Percentages of stakeholder engagement barriers identified in the literature review attributed to each category

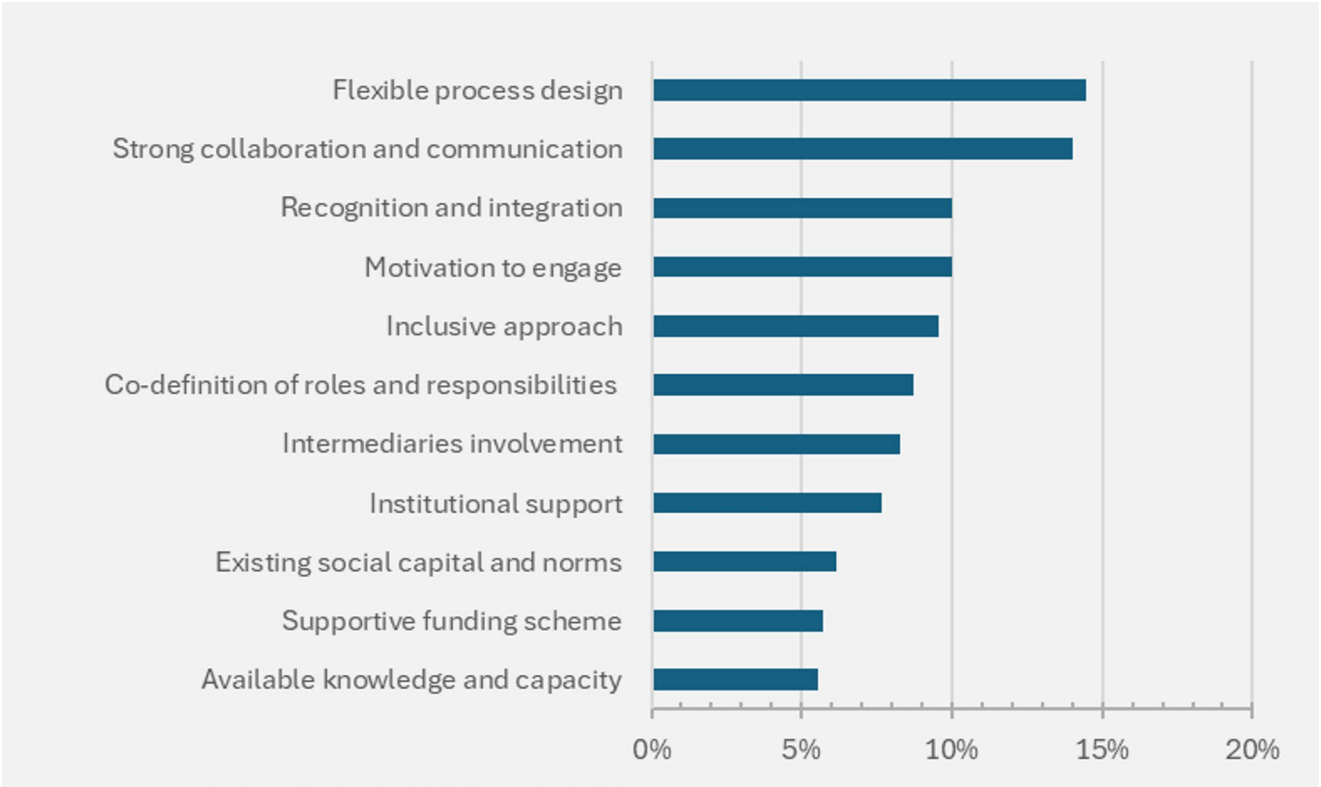

Fig. 7 Percentages of stakeholder engagement enablers identified in the literature review attributed to each category

Stakeholder engagement process barriers and enablers

Systematic literature review

The systematic literature review identified 173 barriers and 471 enablers to stakeholder engagement processes for adaptation, which were synthesized into thematic categories, seven for barriers (Fig. 6), and eleven for enablers (Fig. 7). A detailed description of these categories is provided in the ESM-S7.

Our analysis revealed that the most cited barrier category was *inadequate institutional and governance systems* (21% of identified barriers - Fig. 6). This category includes well documented institutional, structural, and cultural lock-ins, such as siloed thinking, poor internal coordination and collaboration, bureaucratic hurdles, frequent staff turnover, and insufficient human resources (e.g., in Regmi et al. 2016; Johannessen and Mostert 2020). Furthermore, external challenges were found to compound these internal issues, these included non-supportive political, legal and funding frameworks, constraints imposed by higher levels of governance, and a lack of clear mandates for climate adaptation (Dowsley 2009; Mackay et al. 2019; Piggott-Mckellar et al. 2020). The second-most-reported barrier category relates to the *engagement process internal complexity* (17%). This encompasses the dominance of technical or scientific language and concepts, discrepancies among working habits and professional practices, and a lack of engagement experience and training among organizers and facilitators (Castellanos et al. 2013; Baer et al. 2019; Carmen et al. 2022). Engaging stakeholders late in the process, fragmented approaches that lack continuity, and insufficient accountability and monitoring mechanisms were also found to limit the effectiveness of engagement processes (Ryan and Bustos 2019; Piggott-Mckellar et al. 2020). A third major barrier category identified was the *lack of capacities for people to engage* (16%). This category includes factors limiting individuals' access and ability to participate in adaptation such as limited financial resources, mobility constraints, educational gaps, and low self-confidence (Wood et al. 2018; Gladfelter 2018; (Akanksha) Patnaik 2021). Furthermore, the reported limited availability of reliable knowledge, data, and information on climate adaptation was identified as a factor restricting informed engagement and decision-making (Tudose et al. 2023; Areia et al. 2023).

Other reported engagement barriers include: *different interests and expectations among* stakeholders (12%) arising from conflicting objectives, prioritization of self-interest, and uneven perceptions of the benefits of participation (Castellanos et al. 2013; Wamsler et al. 2020); *low motivation and engagement* (10%) attributed to co-production fatigue, time constraints, limited awareness about climate change adaptation, and a perceived lack of influence over outcomes (Wood et al. 2018; Singletary and Sterle 2020); *scepticism about the process or participants* (10%) that stems from the neglect of local knowledge, exclusion of community perspectives, and a narrow, instrumental view of participation (Fitton and Moncaster 2018; Putra et al. 2022); and finally, *power imbalances and distrust* (10%) originating from entrenched and invisible power structures, reluctance to share decision-making, and a lack of legitimacy and public ownership in adaptation processes (Myers et al. 2012; Wood et al. 2018).

Furthermore, the identified enablers (Fig. 7) can be distinguished according to whether they are operational or external to the engagement activities process. Operational enablers, more frequently reported, are largely influenced by process organisers and often relate to process design, in contrast, external enablers are less common and typically lie beyond the direct control of organisers.

The most common operational enablers category was *flexible process design* (14% of identified enablers). This category involves the creation of context-specific, adaptive, and reflexive processes that can accommodate uncertainty (Sherman and Ford 2014; Goodess et al. 2019). Such processes were described as promoting learning-by-doing, encouraging innovation, and supporting systemic thinking through the integration of both short- and long-term considerations (Wiseman et al. 2010; Simon et al. 2020). Additionally, the development of a conducive working environment and the provision of user-friendly tools were identified as playing a critical role in enhancing collaboration and sustaining engagement processes (Lemieux et al. 2014; Tudose et al. 2023).

The second most-common category was *strong collaboration and communication* (14%). This category emphasizes the creation of safe spaces for dialogue, trust-building, and mutual learning through transparent, iterative, and non-hierarchical interactions (Ryan and Bustos 2019; Zarei et al. 2020). Effective communication strategies were found to include co-developing shared, non-technical language and ensuring access to clear and continuous information tailored to diverse audiences (Murti et al. 2020; Buchori et al. 2022).

Other operational enablers categories were identified, operating in synergy to create inclusive, robust, and adaptive engagement processes that underpin successful climate adaptation efforts. The *recognition and integration* of participants' diversity (10%) involves embracing diverse knowledge systems, context, perspectives and worldviews and developing cross-sectoral collaboration (Hegger et al. 2014; Carmen et al. 2022). Building *inclusive approaches* (10%) entails the engagement of a broad range of stakeholders across gender, age, vulnerability, social roles, and sectoral

Table 1 Likert-scale mean scores based on survey responses ($n=51$) about the role, on a scale from 1 (none) to 5 (very important), played by each barrier and enabler categories during the stakeholder engagement process implementation measurement (Pimentel 2010)

	Likert means scores (ms)	Standard deviation (SD)
Barriers category		
Low engagement and motivation	3.20	1.3
Inadequate institutional and governance system*	3.01	1.4
Lack of capacity and resources to engage*	2.93	1.3
Co-production process complexities*	2.93	1.4
Different interests and expectations	2.60	1.3
Skepticism about people and process	2.57	1.3
Power imbalance and distrust	2.50	1.3
Enablers category		
Motivation to engage	4.42	0.8
Strong collaboration and communication	4.15	0.8
Recognition and integration	4.00	0.9
Flexible process design	3.89	0.9
Available knowledge and capacity*	3.83	1.1
Intermediaries involvement*	3.79	1.0
Existing social capital and norms	3.76	1.0
Co-definition of roles and responsibilities	3.71	1.0
Institutional support	3.60	1.2
Inclusive approach	3.27	1.2
Supportive funding scheme	3.15	1.4

(*) indicate combined factor categories, which merge previously separate categories to ensure analytical consistency

dimensions, while ensuring that participation platforms are accessible to all (Kythreotis et al. 2019; Masud-All-Kamal and Nursey-Bray 2022). The *co-definition of roles and responsibilities* (10%) underscores the importance to clarify participants' roles in process shared decision-making and governance, and to promote early and continuous engagement (Kolstad et al. 2019; Clarke et al. 2019). Finally, *intermediaries*' involvement (9%) relates to the engagement of boundary organizations, trained facilitators, local champions or leaders, and knowledge brokers to inspire and create commitment among participants and bridge science, policy, and local action (Sitas et al. 2016; Diep et al. 2022).

The most common external enabler category was people's *motivation to engage and act* for adaptation (10%). Motivation is reported to be driven by individuals' perception of vulnerability, awareness and lived experiences of climate impacts, and a range of intrinsic drivers including personal values, beliefs, sense of responsibility, and place attachment (Ford et al. 2016; Scholz and Methner 2020). Previous engagement experience was reported to encourage continued participation, and perceived benefits, such as learning opportunities, social innovation and incentives to sustain engagement (Doh et al. 2019; Wojewska et al. 2021). *Institutional support* (8%) emphasizes the importance of clear and coherent policies, guidelines, and mandates that prioritize adaptation and engagement across governance levels (Kythreotis et al. 2019), as well as local authorities' long-term commitment and inter-municipal cooperation (Stott and Huq 2014).

Other external enabler categories contribute to the broader context in which engagement processes unfold. Leveraging *existing social capital and norms* (6%) highlights the importance of leveraging existing community ties, trust networks, and culturally embedded practices to increase public ownership and promote grassroots initiatives (Ford et al. 2016; Doh et al. 2019). *Supportive funding schemes* (6%) includes the development of innovative incentives, dedicated funding streams, private sector involvement and accountability mechanisms to support engagement in adaptation (Biagini and Miller 2013; Hegger et al. 2014). Finally, the *knowledge and capacity to engage* category (6%) emphasizes the need for context-specific, clear, and reliable data and information on climate risks and adaptation options (Stein and Moser 2014), as well as capacity-building initiatives that improve access to information, foster digital and civic literacy (Areia et al. 2023).

Practitioners' survey

Barriers and enablers categories emerging from the systematic literature review were then evaluated by the surveyed practitioners using a 1–5 Likert scale to assess their importance during the engagement process implementation (Table 1). Regarding barriers, the results indicate a relatively lower perceived importance compared to enablers, yet with substantial variability between respondents. The highest-rated barrier categories were *low engagement and motivation* (mean score [ms]: 3.20) and *inadequate institutional system* (ms: 3.01). These were followed by *lack of capacity and resource* (ms: 2.93) and *co-production process complexities* (ms: 2.93). The remaining three barriers' categories - *different interests and expectations* (ms: 2.60), *scepticism about people and processes* (ms: 2.57) and *power imbalances and distrust* (ms: 2.50) - received lower mean scores. However, associated high standard deviation scores ($SD>1$; Table 1) indicates substantial variation between responses, reflecting a lack of consensus on these barriers' roles.

In contrast, enablers received consistently higher scores, with rather less variability within responses. The most prominent enabler was *motivation to engage* (ms:4.42), rated as having a very important role by 56% of respondents. This was followed closely by *strong collaboration and communication* (ms:4.15), *recognition and integration (ms*:4.10), and *flexible process design* (ms:3.89) - which were all highly rated with lower variability in responses

(SD < 1; Table 1). While most enablers scored highly, *building an inclusive approach* (ms:3.27) and *supportive funding schemes* (ms:3.15) received the lowest score among enablers associated with the highest variability (SD < 1.2).

Practitioners' interviews

Practitioners interviewed reinforced the understanding of barriers and enablers identified in the analyzed literature, offering significant insights on the challenges they face when implementing climate-related engagement activities.

Responses covered several key barriers. A key aspect was inadequate institutional and governance systems. These do not arise from a lack of regulations, but because policies lack specificity and operational guidance. Engagement is also often mandated without the necessary resources, incentives, or training for authorities, leading to fragmented efforts and bureaucratic delays. For instance, in Malmö, while the municipal budget includes citizen consultations, no resources are specifically allocated to adaptation engagement, leaving municipalities to decide how to structure these processes. This resource constraint was echoed by a practitioner in Spain who noted: "*I would like to have some funding, a team and more institutional support to advance more effectively in the process of collaborative adaptation […] We are trying, we are making some progress but much more slowly than I think would be necessary*" (INTSP2).

This lack of operational policies is particularly problematic in multilevel governance contexts and is further exacerbated by shifting political priorities, which hinder the institutionalization of engagement practices. Power imbalances and distrust between authorities and citizens further affect engagement processes, and – as a result – they are often dominated by organized or already engaged groups. An official from a national office dealing with public building regeneration revealed that participation tends to exclude younger and older populations, with a prevalence of middle-aged individuals with higher incomes. This highlights the need for more inclusive mechanisms such as random selection to ensure gender and generational balance. Moreover, interviewees suggested there is rarely sufficient pressure to incorporate the engagement processes of outcomes into formal decision-making, and little monitoring of whether public input is acted upon. Additionally, local political cultures also play a key role. For instance, in Sweden, a prevailing trust in elected representatives may reduce public demand for direct involvement, whereas in contexts marked by institutional distrust, like reported in Spain, citizens may be reluctant to engage. One interviewee explained: "*We have still built it on the idea that politicians should represent the people and the people's interests […] But other countries have a different approach to this. It doesn't come as naturally in Sweden to co-create with residents. […] It's just that culturally, the way our institutions are built, it's not as natural*" (INTSW1).

Interviewees frequently reported low motivation and engagement among citizens as a key challenge. They highlighted significant limitations in citizens' capacities to engage including limited access to clear and science-based knowledge to support informed participation and persistent structural exclusions with a lack of incentives for communities, already limited in capacity and tools. Interviewees also suggested that information about engagement opportunities was not always communicated effectively to the public, as specified in the case of Aragon, "*More than a problem of lack of tools, it is the social ignorance of their existence. The problem is that the information does not arrive […] Something bidirectional is needed, the administration must promote the information and citizens must be interested*" (INTSP3), pointing out this disconnect between institutions and the public, further compounded by citizens' distrust toward authorities. Finally, interviewees noted that engagement efforts often occur in isolated phases, lacking continuity and sustained follow-up, evaluation, or monitoring of the outcomes, which may further discourage engagement due to a low perceived influence over outcomes.

Interviewees provided fewer insights into enablers, though several recognized that institutional support is foundational to effective engagement. Despite many countries having legal frameworks and processes for engagement (such as Italy and Spain) stronger implementation, adaptability and continuity are needed to overcome political polarization and foster effective initiatives. Concrete strategies such as stakeholder pacts, mandatory participation mechanisms, and long-term planning tools, such as river contracts or territorial plans, can enhance these efforts. For instance, the institutional framework in Aragón was described as facilitating consistent and structured citizen engagement. Moreover, regarding existing social capital, interviewees pointed to the role of municipal, regional, and international networks in enhancing engagement.

For example, Malmö's role as a resilience hub in the UN's "Making Cities Resilient" initiative and its involvement in the EU Mission on Adaptation were cited as fostering knowledge sharing and active communities of practice (INTSW3). Additionally, access to supportive funding schemes through a well-resourced political-administrative system was emphasized as crucial. As illustrated in the Municipality of Rome, effective engagement can be supported through interdepartmental collaboration, such as between the Rome Climate Office department and the Participation and Communication departments with the support of a local company for citizen engagement to develop the City Adaptation Strategy.

Furthermore, interviewees emphasized that fostering a shared vision of long-term benefits and a sense of community among participants can strengthen collaboration and motivation. As specified by a respondent from Rome, "*There is a bad habit of not discussing the overall vision but rather focusing on daily problems. This causes citizens not to understand why certain choices were made. We need to have a vision! […] It remains a vague topic, and for this reason, citizens cannot verify what a municipality or administration is doing concretely*" (INTIT1). Meaningful participation was reported to be further supported by appointing staff dedicated to the inclusion of participants' inputs, which helps to build trust and reciprocity. As a practitioner from Dresden noted, this engagement is crucial because it "*increases the acceptance of measures, [which] can also be better designed… according to the demands and needs of the citizens*" (INTGE3).

Ensuring inclusivity, especially by incorporating marginalized and dissenting voices, was seen as crucial for equitable engagement, and raising awareness of climate risks was identified as a key step in motivating individuals, particularly in a context of growing disinformation.

Discussion

Our combined methodological approach provides a robust lens to critically discuss stakeholder engagement practices in climate adaptation. Our analysis reveals that while widely promoted operational enablers offer valuable guidelines for conducting stakeholder engagement in climate adaptation, their implementation is ultimately constrained by often-overlooked structural institutional and social barriers, resulting in the rather narrow scope of current engagement practices.

Operational enablers and structural gaps to stakeholder engagement

Scientific literature analysed tends to focus on leveraging operational enablers and surveyed practitioners widely acknowledge their importance in implementing engagement processes (Conde et al. 2005; Gerlak et al. 2023; Aili et al. 2024). These operational enablers commonly include effective communication, inclusive stakeholder representation, trust and accountability mechanisms, skilled facilitation, and co-defining the decision-making process and distribution of power (Gerlak et al. 2023). Such enablers, commonly used in engagement practices are particularly acknowledged to address critical barriers encountered in adaptation initiatives, such as uncertainty mitigation, conflict management, and power imbalances (Cattino and Reckien 2021), and are deemed essential for achieving locally relevant and context-sensitive adaptive responses (Few et al. 2007; Chambers et al. 2021). However, the findings suggest that these enablers are challenging to implement in real-world settings. Their application is constrained by the "no one size fits all" nature of engagement processes, and by deeper structural barriers, notably those related to governance arrangements, resource or capacity constraints (Glaas et al. 2022; Adams et al. 2024).

Although necessary, operational enablers on their own are insufficient to catalyse transformative engagement and adaptation, which fundamentally require systemic changes in institutional and governance structures (Termeer et al. 2017; Colloff et al. 2021). Despite well-documented institutional barriers and their acknowledged importance by practitioners, we find very few concrete enablers to overcome them. The findings indicate that, even where supportive policy frameworks exist, the primary impediment to meaningful and sustained engagement lies in the lack of associated resources and implementation-oriented policy guidance. Indeed, local public administrations, like municipalities, often lack the inherent capacity for effective stakeholder engagement and transformative adaptation (Wamsler 2017; Glaas et al. 2022). Thus, engagement is often impeded by diverging working habits and views, lack of cross-sectoral cooperation, limited knowledge on both engagement practices and climate adaptation, administrative burdens and financial and human resources scarcity (Glaas et al. 2022; Abas et al. 2023).

This resource scarcity is exacerbated by the specific temporal nature of climate adaptation. Adaptation requires sustaining engagement over time, yet current institutional structures, shaped by short-term political cycles, are not equipped to support the long-term horizons necessary for effective adaptation planning (Huitema et al. 2016). Interestingly, funding is often cited as a prominent barrier in the general discourse (UNEP 2024), however our findings suggest it may play a comparatively less critical role in the implementation of engagement processes.

While climate adaptation presents unique challenges, these operational enablers and structural barriers are remarkably consistent with the broader environmental governance literature (Reed et al. 2018). This suggests that adaptation practitioners face "universal" governance deficits (Termeer et al. 2017). However, these deficits are particularly detrimental in the adaptation context where delays lead to increased population vulnerabilities (Biesbroek et al. 2013). The solutions, therefore, may lie less in inventing new adaptation-specific engagement methods and more in resolving these structural barriers to allow for the rapid and flexible responses that climate adaptation requires. Given the pivotal role of local institutions in climate adaptation and

stakeholder inclusion, further research is required to better understand how public administrations should progress in this direction (Nordgren et al. 2016; Rogers et al. 2023).

Our combined analysis underscores the critical role of low engagement, motivation, and capacity, especially to citizens engagement, a finding consistently validated by practitioners in our survey and across various studies (Thaker et al. 2019; Khatibi et al. 2021). However, interpreting this primarily as a motivational issue risk oversimplifying the complex interconnection among multiple factors. First, at the individual level, a public knowledge and information deficit, compounded by limited trust in public authorities and institutional processes, can reduce the sense of urgency and willingness to engage (Lorenzoni et al. 2007). Second, even when knowledge is present, engagement may remain low, as the assumption that informed individuals will automatically translate knowledge into action through rational choices is unrealistic (Rask 2022).

Moreover, engagement is constrained by tangible capacity and resource limitations experienced by citizens. These encompass limited time, mobility, skills, viable options for action, self-confidence, financial means, or even basic material resources (Few et al. 2007). While adaptation practitioners often focus on improving engagement methods, capacity-building, and awareness initiatives, they frequently lack the mandates or resources to offer substantial material, social, or financial incentives that could genuinely empower citizen participation (Williams et al. 2020; André et al. 2023).

Consequently, greater emphasis should be placed on fostering citizens' agency to actively participate in adaptation efforts through robust engagement design processes (Bobbio 2019). This capacity gap is particularly pronounced in climate adaptation where stakeholders must navigate high scientific uncertainty, technically complex climate data, and abstract future scenarios. This raises the threshold for meaningful engagement and necessitates support from intermediaries, identified in our analysis as a key enabler, to translate scientific knowledge into local relevance (Lemos et al. 2018).

Ultimately, our findings reveal a notable symmetry where many enablers (e.g. fostering inclusive approaches or strong communication) directly counteract specific barriers (e.g. power imbalance and distrust). However, structural barriers like institutional inertia and resource scarcity introduce a critical asymmetry. These factors are not simply the reciprocal of institutional support as they fundamentally constrain the effectiveness of operational enablers. While overcoming these structural barriers is an essential precondition, it is not sufficient on its own. Transformative adaptation thus demands a dual approach that resolves foundational structural constraints while strategically deploying operational enablers to foster meaningful and sustained engagement.

Narrow scope of stakeholder engagement practices in adaptation

Our results suggest that stakeholder engagement practice is as, if not more, fragmented than climate adaptation efforts. Significant operational and structural gaps identified previously provide key insights on this narrow scope of current stakeholder engagement practices.

First, if stakeholder engagement spans across the different types of adaptation responses, i.e. institutional, academic, behavioural and on-the-ground (Berrang-Ford et al. 2021), they are confined to the co-production of adaptation strategies and plans (Wamsler 2017), knowledge for research and innovation purpose (Gerlak et al. 2023), capacity building and nature-based solutions (Ferreira et al. 2020; Kiss et al. 2022). Engagement in higher-level policymaking and in the co-creation of financial mechanisms remains notably limited, despite the widely recognized potential of engagement to foster stakeholder ownership and long-term adaptation success (Burton and Mustelin 2013).

Additionally, despite the inherently cross-cutting nature of climate change impacts across all socio-economic sectors (Abbass et al. 2022), engagement practices for adaptation predominantly focus on the environmental sectors (water, agriculture, forestry, biodiversity) and disaster risk reduction (population and infrastructure protection). In contrast, fewer engagement practices are reported in sectors increasingly recognized as central to climate resilience such as economic, cultural, financial, health, and energy sectors (Rotter et al. 2012). This sectoral bias reflects the dominance of public-sector-led adaptation initiatives, where adaptation is often siloed within environmental and disaster management action, and the established but also limited scope of transdisciplinary research agendas (Klein et al. 2018; Chambers et al. 2021; Pachoud et al. 2023; Murunga et al. 2024). Although the absence of explicit private sector keywords in our systematic review search string (e.g., "corporate", "private sector") may have exacerbated their low visibility in our results, the persistent under-involvement of the private actors aligns with previous studies (Klein et al. 2018; Berrang-Ford et al. 2021; UNEP 2023).

Furthermore, as exemplified in our results, engagement practices are frequently concentrated in the early phases of the adaptation cycle, such as vulnerability assessments and planning, rather than the more complex and demanding phases of solution implementation, monitoring, and evaluation. This reduces further adaptation initiatives' ownership and legitimacy (Nordgren et al. 2016; Khatibi et al. 2021).

Another critical point lies in the lack of co-development of financial mechanisms supporting adaptation, which could otherwise promote a higher engagement of the private sector as our findings suggest. Given that financing is a major barrier to scaling adaptation, actively engaging private and financial sector stakeholders appear essential for sustained and comprehensive adaptation efforts across all sectors and phases of the adaptation cycle (UNEP 2024).

Finally, even if active stakeholder engagement is widely recognized as a cornerstone of effective climate adaptation outcomes (Few et al. 2007), persistent challenges in engagement format remains. Our survey indicated a trend towards active approaches like involving and collaborating, however, broader evidence reveals the continued prevalence of passive methods like informing and consulting (Khatibi et al. 2021; Kiss et al. 2022; Abas et al. 2023). This issue is further exacerbated by the dominance of the voluntary approach of engagement, with a few binding mechanisms generally linked to rather passive participation. However, if passive engagement can be relevant in certain context, it often falls short of delivering transformative outcomes (Owen 2020). Traditional methods of engagement such as surveys and workshops seem to prevail, though innovative approaches, especially digital tools for citizen engagement to foster democracy, are emerging (Lawrence et al. 2017; OECD 2022; MI4ADAPT 2023). Practitioners should be supported in adopting these innovations while mitigating the risks of digital exclusion (Murunga et al. 2024).

These discrepancies reinforce the importance of accessible operational tools and guidance to support practitioners in developing tailored, context-specific and active engagement mechanisms that effectively address both their needs and those of the participants (Murunga 2022). However, addressing the deeper structural, social and institutional barriers remains the paramount challenge. This aspect is essential to fully realize the transformative potential of stakeholder engagement for advancing climate adaptation.

Study limitations

Our findings should be interpreted considering certain methodological limitations regarding the scope and nature of the study. First, we acknowledge that the delineation of our systematic literature review introduces specific biases. The review was restricted to English-language peer-reviewed scientific literature. Given that valuable knowledge and lessons learned are often documented in local languages or grey literature (e.g., internal municipal reports, EU project reports), a broader scope might have revealed additional factors and operational nuances of these practices.

Second, our empirical data collection (survey and interviews) was targeted at European practitioners, particularly within the Adaptation AGORA project's pilot regions. The recruitment channels primarily reached public administrators and researchers rather than civil society or private sector representatives. Consequently, some of our results may be particularly reflective of the European public governance adaptation context. Further research should explore whether similar barriers and enablers persist in non-European contexts or within community-led initiatives, thus reinforcing the literature review findings.

Finally, regarding the analytical scope, this study aggregated a wide range of adaptation initiatives (from nature-based solutions to policy making) and engagement approaches (from information to full co-production) across diverse contexts. While this approach successfully highlights transversal patterns and systemic factors influencing the implementation of engagement processes, it necessarily limits the specificity of our findings. Statistical analysis of the systematic review data did not reveal specific correlations between contextual variables (adaptation initiatives or engagement process characteristics), and barriers and enablers. Therefore, we cannot claim that a specific enabler is more effective for a specific adaptation solution or a particular governance context, without conducting further disaggregated analysis.

However, our research, encompassing practitioner interviews and survey analyses as well, underscores that the perceived impact of the barriers and enablers depends on regional and local specificities, particularly on existing institutional frameworks, prevailing cultural practices, the degree of political commitment, and pre-existing participants' capacities. This context dependency highlights the limitations of universally applicable "one-size-fits-all" approaches. To build upon the data from our survey and interviews, which has limited generalizability, future comparative studies across a wider array of local and regional contexts would be valuable to develop more tailored and context-sensitive engagement recommendations.

Conclusion

Our analysis of stakeholder engagement practices in climate adaptation reveals a critical dichotomy: while operational enablers are readily identified and broadly supported, persistent structural gaps impede truly transformative engagement required to cope with the climate crisis. Our review highlights a multitude of operational enablers, acknowledged by practitioners as valuable for designing and implementing engagement processes thus addressing an important set of operational barriers. However, these often prove insufficient to overcome systemic challenges and navigate the complexity of adaptation.

Specifically, significant gaps remain in the broader context necessary to effectively support and scale up engagement efforts, particularly concerning the governance, financial, and social frameworks required for their meaningful and sustained implementation. These interlinked barriers suggest a reinforcing dynamic in which institutional weaknesses, top-down approaches, procedural shortcomings, and social inequalities act together to undermine the inclusiveness, effectiveness, and long-term sustainability of stakeholder engagement in adaptation and disproportionately discards vulnerable populations.

These findings offer valuable insights to support policy and practice in climate change adaptation and engagement practice. Firstly, policymakers should move beyond a primary focus on promoting operational engagement guidelines and prioritize addressing underlying structural barriers. This includes strengthening institutional capacity within local public administrations through dedicated resources, training, and inter-sectoral coordination mechanisms. Secondly, adaptation strategies and funding mechanisms should be expanded beyond traditional environmental sectors to encompass all socio-economic sectors and throughout all phases of the adaptation cycle, actively engaging the private sector. Thirdly, practitioners should critically evaluate and diversify their engagement formats, moving beyond passive methods towards more active and innovative approaches, including digital tools, and address digital literacy. Finally, efforts to enhance citizen engagement must go beyond awareness-raising and knowledge dissemination to genuinely empower citizens through capacity building, resource provision, and the fostering of agency and trust. A shift towards systemic and context-sensitive approaches is essential to unlock the full potential of stakeholder engagement for transformative climate adaptation.

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Author contributions EBr designed the research, contributed to data acquisition and analysis and wrote the paper. AS designed the research, contributed to data acquisition and revised the paper. ME, SP, ME, AV, EBa, DE and SB participated in research process design, contributed to data acquisition and revised the paper. SKA contributed to data acquisition and analysis. LM, JB; NNll and NK contributed to data acquisition and revised the paper. MM, MB and MS participated in research process design and revised the paper.

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Declarations

Conflict of interest The authors have no conflict of interest to declare that might have influenced the content of this article.

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