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PAPER

Revitalizing Ethiopia's Amibara irrigation scheme: governance, institutions, and stakeholder engagement

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Abstract

This study aimed to assess irrigation practices, institutional arrangements, and stakeholder dynamics to inform the revitalization of irrigation schemes, using the Amibara irrigation scheme in Ethiopia as a case study. Specifically the study (i) examined water use and management practices, associated challenges, and their implications for revitalization, (ii) assessed institutional structures and key governance gaps in water access, use and management, (iii) identified and mapped stakeholders involved in revitalization based on their roles, interests and influence, (iv) analyzed the motivations of different stakeholder groups to engage in the revitalization process, (v) assessed the needs and capacities of stakeholders to influence revitalization; and (vi) proposed engagement strategies to enhance participation, collaboration and partnerships. The study used key informant interviews, group discussions and observations, with multi-stage stakeholder analysis. Qualitative data were analyzed using deductive content analysis, while stakeholder mapping tools assessed legitimate power and power resources, interests, and influence. Results showed that the use of irrigation water is dominated by individualized practices, causing water shortages, conflicts, and governance gaps threatening sustainability. The stakeholder analysis identified diverse groups interested in revitalizing the scheme, indicating the need for multisectoral collaboration. Most stakeholders had perceived high interest but low influence, while some had high interest and influence or low interest but high influence, requiring tailored engagement strategies. Stakeholder motivation stems from expected benefits and alignment with their goals. Participation can be increased through better access to data, technical and financial support, capacity building, and clear roles. Stakeholders could contribute expertise and resources. Barriers included unclear mandates, funding gaps, limited technical capacity, peace and security issues, and environmental risks like soil salinity and water scarcity. The findings emphasize that without strengthening institutional frameworks, promoting collective action, and establishing irrigation water user associations, infrastructure rehabilitation alone will not yield lasting benefits. It is also suggested that engagement approaches focusing on trust-building and collaboration, as well as integrated social and institutional reforms aligned with national and sub-regional policies, are crucial. Effective revitalization benefits from public-private partnerships and community-government collaboration. We recommend clarifying roles, formalizing partnerships, ensuring transparent communication, and establishing coordination mechanisms.

1. Introduction

In the face of climate change, irrigation is vital in stabilizing food production, enabling dry-season farming, and improving livelihoods in agrarian communities, especially in African and Asian countries (Fanadzo and Ncube 2018, Nalumu *et al* 2021). Irrigation schemes should be conceptualized as socio-technical systems involving hydro-social processes that integrate physical structures, human actors, and

social systems (Mollinga 2003, 2014, Veldwisch *et al* 2009), and typically encompass four interconnected systems: physical, cropping, economic, and social-organizational (Mwendera and Chilonda 2013). This perspective emphasizes that social factors such as water user organizations, institutional rules and norms, collective action, and conflict resolution mechanisms are as crucial as engineering and agronomic considerations for effective and sustainable irrigation management (Ostrom 1992, Dessalegn and Merrey 2015). However, the planning and management of irrigation projects have historically prioritized physical infrastructure and crop production, while often overlooking the social-organizational dimensions (Grobler 2023), contributing to the underperformance or failure of many irrigation projects globally (Fanadzo 2012, Bjornlund *et al* 2020). Failing to address these social dimensions can undermine water justice, equity, equality, and fairness; ultimately compromising the performance and benefits of irrigation systems (Collett and Henry 2014).

Bridging the theoretical understanding of irrigation as a socio-technical system into practice demands a shift from a narrow, infrastructure-centric approach in revitalization efforts toward integrated interventions that give equal weight to critical social and institutional dimensions (Mwendera and Chilonda 2013). However, many rehabilitation programs in developing countries have largely focused on physical repairs and upgrading while paying little attention to social and institutional reforms. As a result, they often fall into a repetitive 'build-neglect-rebuild' cycle that yields only short-term improvements (Lankford *et al* 2016). Evidence shows that such infrastructure-centric approaches rarely deliver sustainable outcomes when human capacity building and institutional strengthening are overlooked (Fanadzo and Ncube 2018, Azadi *et al* 2022). Despite growing recognition of these limitations, there remains a lack of empirically grounded analyses that integrate technical, institutional, and stakeholder dimensions in irrigation revitalization. Consequently, recent studies urge a shift in revitalization priorities to address the diverse needs and interests of stakeholders through tailored interventions and more inclusive engagement (Fanadzo and Ncube 2018, Ricart *et al* 2019). Achieving such an integrated approach requires genuine stakeholder consultation, participation, negotiation, and transparent communication (Collett and Henry 2014).

Sub-Saharan Africa (SSA), including Ethiopia, illustrates these challenges (Bjornlund *et al* 2020, Gedamu *et al* 2025). Many irrigation schemes in SSA have aging or poorly designed infrastructure and inadequate maintenance, leading to inefficient water use and low crop yields (Gedamu *et al* 2025). These technical problems are compounded by unclear governance structures, limited capacity of water user associations, and weak coordination among stakeholders (Aarnoudse *et al* 2018, Hailu and Tolossa 2020). Chronic financial constraints due to limited public investment and poor cost-recovery mechanisms further impede system maintenance and upgrades (Grimm and Richter 2006, Merrey and Lefore 2018). Weak farmer engagement and climate variability further compound these challenges (Rettberg *et al* 2017, Shitu and Almaw 2021).

In Ethiopia, the Amibara irrigation scheme, the focus of this case study, exemplifies these issues (Gebul 2021). Its physical infrastructure has deteriorated due to canal siltation, leakage, soil salinity, and outdated water conveyance systems, reducing irrigation efficiency and water delivery reliability (Abebe *et al* 2015, Kedir 2021). The scheme also faces significant socio-environmental pressures: invasive *Prosopis juliflora* encroaches on farmland, periodic flooding disrupts farming, and shifts in agricultural policy have reduced cultivated land and undermined local livelihoods (Bogale and Tolossa 2021, IWMI 2025). Despite these challenges, existing efforts have not sufficiently integrated infrastructure, institutional reform, and stakeholder engagement. More importantly, given the scheme's importance to local agriculture and its enduring problems, Amibara is a valuable case for examining how water management issues and stakeholder dynamics can be addressed through revitalization.

To address this gap, the present study focuses on the Amibara scheme with the following objectives: (i) examine current water-use practices and management challenges, including conflicts over water use, and assess their implications for revitalization; (ii) evaluate the scheme's existing institutional arrangements for water access and use, and identify major governance gaps hindering effective resource management; (iii) identify the key stakeholders involved in the scheme and map their roles, interests, and levels of influence in its management and revitalization; (iv) analyze the institutional, economic, and socio-political motivations driving different stakeholder groups' engagement in the scheme's revitalization; (v) assess each stakeholder group's needs and capacities and propose strategies to strengthen inclusive governance and sustainable revitalization.

These objectives are guided by the overarching research question of how institutional arrangements, governance processes, and stakeholder engagement shape water access, management, and revitalization outcomes in the Amibara irrigation scheme (see tables 2 and 3 for specific research questions). By integrating field-based analysis with systemic stakeholder assessment, this study provides a comprehensive perspective on revitalizing underperforming irrigation systems. Using the Amibara irrigation scheme in

Ethiopia as a case study, it identifies diverse stakeholders, spanning from formal and informal groups of male or female farmers, government agencies, non-governmental organizations (NGOs), international agencies, and multinational companies, and links technical and institutional challenges (e.g. water allocation conflicts, governance gaps, infrastructure deficiencies) with stakeholders roles, interests, motivations, and influence. Stakeholders are analytically differentiated by their authority, resource control, decision-making power, and implementation roles, providing insights into how each actor shapes management and governance outcomes. This integrated approach informs targeted engagement strategies that foster inclusive participation, collaborative management, and stronger governance structures for long-term sustainability. Ultimately, the findings offer practical insights for policymakers and practitioners seeking to improve underperforming irrigation schemes in Ethiopia and beyond, including those within the country's climate-resilient irrigation for sustainable production (CRISP) program, led by the Ministry of Irrigation and Lowlands (MILLs).

2. Materials and methods

2.1. Study area

The Amibara irrigation scheme is one of Ethiopia's largest and longest-running irrigation projects, covering about 15 000 hectares in the semi-arid Middle Awash valley of Afar region, about 250 km east of Addis Ababa (figure 1, Abebe *et al* 2015). Geographically, the scheme is situated between latitude 9.231N and 9.487N, and longitude 40.098E and 40.264E (figure 1). Annual rainfall is low (≈500–600 mm, bimodally distributed) and far outweighed by potential evaporation (∼3000 mm), making irrigation indispensable for agriculture in this hot and dry lowland region (Abebe *et al* 2015, Mamo *et al* 2019). Fed by diversions from the Awash River, the scheme's alluvial plain has historically produced cotton as the dominant crop, alongside maize, vegetables, and fruit; in the 2010s, sugarcane was introduced to align with evolving national agricultural priorities (IWMI 2025).

Established in the 1970s during a nationwide push for large-scale irrigated farming, Amibara was originally aimed at boosting cotton production and resettling semi-nomadic Afar pastoralists into commercial agriculture (World Bank 1977, Abebe *et al* 2015). Major donor-funded expansions in the late 1980s (including the construction of the Melka Sadi diversion weir and canal network) helped consolidate the scheme's command area and made Amibara one of the country's most advanced irrigation systems by the end of the 20th century (Abebe *et al* 2015). After decades of operation, however, the scheme faces challenges typical of aging irrigation projects, canal siltation, waterlogging and soil salinization, and declining water-delivery efficiency, despite intermittent rehabilitation efforts (Abebe *et al* 2015, Mamo 2025).

Nonetheless, Amibara remains vital for regional livelihoods: it supports thousands of people through a mix of state-run farms and smallholder plots (including many settled pastoralists) that depend on its water for crop production and local food security. Today, overall oversight of Amibara lies with Ethiopia's MILLs, in coordination with regional authorities and local water user associations. Recognizing its strategic importance and the need for integrated technical and institutional improvements, Amibara has recently been designated a priority site for revitalization under Ethiopia's CRISP program (IWMI 2025).

2.2. Study approaches and data collection

The study was conducted through primary field research and stakeholder analysis. Primary field research was conducted using a qualitative research approach, employing interviews, group discussions, and observations. Research participants of the primary field research were identified from the different locations within the study sites: the upper part (around the canal head) of the Amibara irrigation scheme (Melka Sede, figure 1), the middle part of the irrigation scheme (Melika Werer), and the lower part (around the canal tail, Angelile) of the irrigation scheme. We conducted 18 key informant interviews and three focus group discussions with different community groups (table 1). Each focus group was composed of 6 people. We contacted 36 people in total during the primary field research.

In view of the study's case-specific and bounded scope, the limited sample size is justified by the clearly defined context of the Amibara irrigation scheme. This scheme encompasses a finite, identifiable set of stakeholders involved in its water management and revitalization, meaning that all relevant actors could be recognized and targeted. Participants were purposively selected to ensure representation of the diverse stakeholder spectrum, including individuals with distinct roles, interests, and levels of influence in the scheme's governance. Consequently, the study prioritizes analytical depth and comprehensive

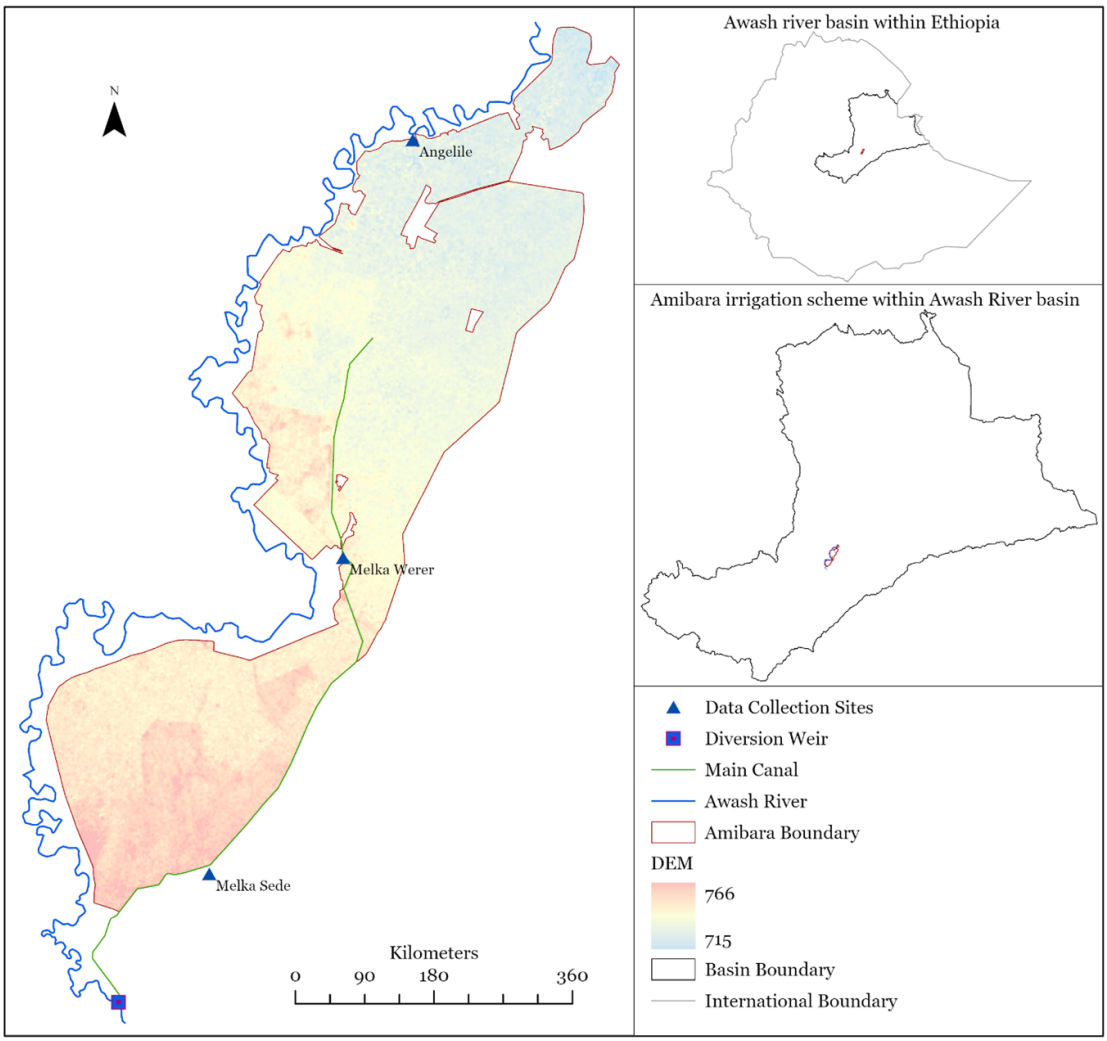

Figure 1. Location map of the Amibara irrigation scheme.

institutional coverage over sheer numerical breadth, aligning the sample size with the study's focused objectives and ensuring that the key perspectives within this setting are thoroughly represented.

We employed key informant interviews and focus group discussions using a set of semi-structured questions to pursue data and methodological triangulation and to comprehensively understand the research issues and answer the research questions (table 2). The thematic topics included in the checklists covered issues related to resource use and management, conflicts, competitions, institutional arrangements and governance (table 2). Data collection was conducted iteratively and continued until thematic saturation was reached, defined as the point at which additional interviews no longer yielded new insights, perspectives, or categories relevant to the study objectives. After 36 interviews across key stakeholder groups, responses became highly repetitive, with recurring patterns observed in institutional roles, governance challenges, stakeholder interests, and engagement dynamics.

Regarding stakeholder analysis, the study employed a multi-stage approach to map and analyze stakeholders. First, we clearly defined the problem to be addressed and the specific change objective for the Amibara irrigation scheme's revitalization. This initial step of our stakeholder analysis guided the identification of stakeholders and clarified the expected outputs (figure 2). Second, in consultation with MILLs (one of the key institutional stakeholders, as it currently oversees the scheme) and collaborating partners, which are leading the revitalization processes, we identified stakeholders, such as farmers, irrigation water user associations (IWUAs), local government authorities, water resources management agencies, NGOs, research institutions, universities, the private sector, community leaders, and financing institutions. MILL's involvement, together with that of other relevant collaborating partners, was essential to ensure an accurate understanding of the stakeholder landscape and to support the systematic identification of stakeholders in the study.

Table 1. Composition of participants of key informant interviews and focus group discussions.

Survey tool	Target institute	Number of participants	Remark/selection rationale
Key informant interviews	Amibara irrigation farm enterprise	2	Represents large-scale operations and scheme-level management influencing water allocation and overall performance.
	Local irrigation farmers (upper, middle, lower reaches)	9	Capture spatial differences in water access, equity, and on-farm irrigation performance along the canal system.
	Irrigation farm investors on rented plots	3	Provide a contrast between smallholders and private investors in management practices, efficiency, and resource use.
	Ministry of Irrigation and Lowlands office (MILLs)-local level	2	Offers governance and regulatory oversight perspectives on scheme planning, operation, and compliance.
	Melka Werer agricultural research center	1	Contributes technical expertise, research evidence, and insights on agronomic and irrigation performance.
	Local government administration office	1	Represent local coordination, scheme administration, and conflict resolution related to water use and access.
Focus group discussions	Focus group 1 (representatives of local irrigation farmers)	6	The rationale is given above. We did focus group discussions to complement and triangulate data gathered through key informant interviews.
	Focus group 2 (representatives of Amibara irrigation farm enterprise)	6	
	Focus group 3 (representatives of the local MILLs office)	6	

Table 2. Methods of data collection, types of data and issues, and linked objectives and research questions.

Method	Types of data gathered	Linked objectives	Linked research questions
Key informant interviews and focus group discussions	Water use and management practices; institutions related to irrigation water access, use and management; institutional structures for managing irrigation schemes; water use competition and conflict	Examine water use and management practices and major challenges, including conflicts and competitions over resource use, and the implications for revitalization processes. Assess institutional structures and prevailing institutional and governance gaps in guiding water access, use and management.	What are the major challenges in water use and management? What forms of conflict and competition exist within the irrigation scheme? What forms of institutions guide water access, use & management? What institutional and governance gaps exist for managing the irrigation scheme?
Field observations	Water use and management practices and challenges	Observing and understanding multidimensional water use and management challenges, including situations related to cooperation and conflicts over water use and attempts to solve tensions over water use.	What are the major challenges in water use and management within the irrigation scheme?

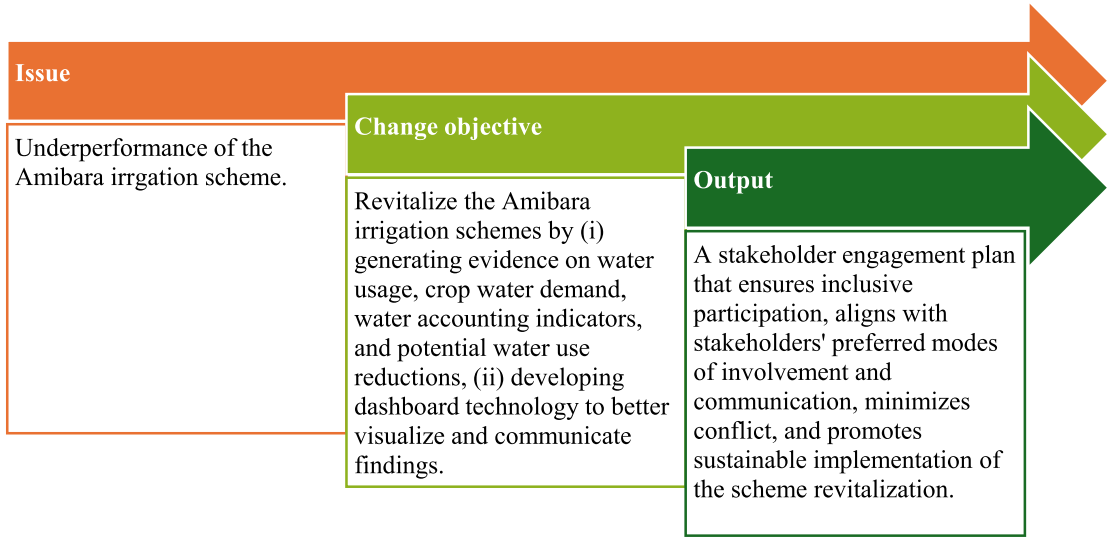

Figure 2. The issue and the planned change objective.

Third, we conducted mapping of the identified stakeholders to prioritize and tailor engagement efforts based on their interest, influence, and roles in revitalizing the Amibara irrigation schemes. The mapping of the stakeholders was done using a power-interest matrix, a tool that organizes stakeholders into quadrants based on their power and interest (Sarami-Foroushani *et al* 2024).

Fourth, we conducted stakeholder analysis using a combination of open-ended and targeted questions that provide insight into the stakeholders' motivations, interests, concerns, power and power resources, and capabilities. Fifth, we investigated the effectiveness of engagement strategies in place and used by the revitalization processes. We used three indicators: stakeholder satisfaction, participation levels, and knowledge uptake to monitor and evaluate the effectiveness of the engagement strategies.

Data for stakeholder analysis were gathered using consultation workshops. The study used combinations of open-ended and targeted questions during the consultation workshops that provide insight into stakeholders' motivation, needs, capacity, barriers and challenges, partnership and collaboration, stakeholders' satisfaction, participation level, and knowledge uptake. The workshop gathered more than 21 participants from a diverse range of institutions. This included representatives from national universities (6 participants) and research institutions (3), as well as key government bodies, namely the MILLs (6), the Ministry of Agriculture (2), and the Ministry of Water and Energy (2). In addition, development partners and other stakeholders were represented, including a donor organization (FAO, 1 participant) and the private sector (Amibara agricultural development PLC, 1 participant).

Tools used to facilitate discussion and data collection included a stakeholder mapping matrix and thematic group discussions. Specifically, the workshop used breakout sessions, dividing participants into four groups to identify stakeholders, map each identified stakeholder using a power-interest matrix, and conduct thematic discussions. The identification and mapping of stakeholders using the power-interest matrix enabled participants to evaluate stakeholders based on their level of influence and interest in the scheme's revitalization process. Each group presented its findings, which were then discussed collectively. The final stakeholder mapping was achieved through consensus among all participants, ensuring that the results reflected a shared understanding and agreement. The breakout sessions were also used to facilitate thematic discussions, collect data for stakeholder analysis and assess the engagement strategies in place from stakeholders' perspectives (table 3). These participatory and structured approaches provided a solid foundation for designing inclusive engagement strategies and promoting collaborative implementation of the revitalization process.

In summary, we deliberately prioritized qualitative methods because our case-specific research questions required in-depth, contextual insight into water management practices, institutional dynamics, and stakeholder perspectives that quantitative approaches could not adequately capture. Qualitative field research and stakeholder analysis were best suited to examine the complex processes, relationships, perceptions, and power dynamics involved in the Amibara irrigation scheme. For example, mapping diverse stakeholder roles, interests, and influences in local water governance requires rich narrative evidence

Table 3. Thematic areas and the aim of the key discussion questions of the stakeholder analysis.

Thematic areas	Aim of the discussion	Linked research questions
Stakeholder analysis		
Stakeholder mapping	Identify key stakeholders in the Amibara scheme, and assess how their interests, roles, and influence shape its governance and revitalization processes.	Who are the key stakeholders in the Amibara irrigation scheme, and what interests and roles do they hold? How does stakeholders' influence shape governance and revitalization processes in the scheme? What institutional factors motivate stakeholders' engagement in revitalizing the Amibara irrigation scheme? How do economic and socio-political motivations influence stakeholders' participation in the revitalization process?
Motivation	Understand the stakeholders' motivations to engage in the revitalization of the Amibara irrigation scheme.	
needs	Identify stakeholders' specific needs and the required external assistance to effectively engage the stakeholders in the revitalization process.	
Capacities	Assess stakeholders' existing skills, resources, organizational structures, past experiences, and partnerships, as well as their capacity-building needs to effectively contribute to and sustain the revitalization of the Amibara irrigation scheme.	
Barriers and challenges	Identify internal and external challenges or barriers that may hinder stakeholder participation, as well as assess the stakeholders' concerns about the long-term sustainability of the revitalization of the Amibara irrigation scheme.	
Collaboration and partnership	Explore stakeholders' perspectives on essential partners, effective forms of collaboration, and coordination strategies needed to ensure the successful revitalization of the Amibara irrigation scheme.	
Engagement strategy		
Stakeholder satisfaction	Assess stakeholder satisfaction with the revitalization of the Amibara irrigation scheme by evaluating their feedback, the responsiveness of support teams, willingness to remain engaged, and the strength of relationships established during the project.	Which stakeholder engagement and collaboration strategies can strengthen inclusive governance in the Amibara scheme? What partnership approaches can support the sustainable revitalization of the Amibara irrigation scheme?
Participation levels	Measure the level of stakeholder participation in the revitalization processes of the Amibara irrigation scheme by tracking attendance, active engagement in activities and decision-making, and the impact of technical support on their involvement.	
Knowledge uptake	Assess stakeholders' knowledge uptake by examining changes in their practices, adoption of new technologies, and their ability to understand and explain key concepts related to the revitalization of the Amibara irrigation scheme.	

rather than numerical data. This exclusive use of qualitative methods provided the nuanced understanding needed to address each objective (from identifying governance gaps to analyzing stakeholder motivations and capacities) and to formulate informed engagement strategies for the scheme's revitalization, without the need for a supplementary quantitative component.

Table 4. Definitions of selected terms used in data collection and analysis (adapted from Zimmermann and Claudia 2007, Matti 2009).

Words/terms/phrases	Definition in the context of the study
Stakeholder analysis	A systematic process of identifying and analyzing stakeholders and their interests in relation to a policy, program, or intervention.
Power	The level of resources and the ability of stakeholders to mobilize them in support of or against the revitalization of the irrigation scheme.
Power resources	The knowledge, expertise, capabilities, and resources that enable stakeholders to shape or affect the revitalization process.
Interest	The extent to which stakeholders support, oppose, or remain neutral toward the revitalization objective.
Influence	The extent to which stakeholders can influence the achievement of the revitalization objectives, ranging from key actors to passive participants.
Legitimacy	The formally or socially recognized rights, roles, or authority that justify stakeholder involvement in the revitalization process.

2.3. Data analysis

Qualitative data gathered through field research and the consultative workshop were analyzed using content analysis (Hsieh and Sannon 2005, Bernard 2006, Elo and Kyngas 2008). For qualitative analyses, we developed a coding scheme based on the main thematic areas summarized in table 2, and the thematic areas covered by field research, such as challenges in resource use and management, conflicts, competitions, institutional arrangements, and governance. These were coded manually by using codes such as the expected benefits, alignment with the stakeholders' goals, types of needs, existing skills and resources, internal and external challenges, type and levels of conflicts and competition over resource use, forms of coordination and collaboration, responsiveness, willingness to remain engaged, and change in practice. During the coding process, more codes were added when new issues emerged from the textual data (e.g. effects of conflict, types and levels of competition, seasonality of competition). In addition, codes were merged, removed, or modified to avoid repetition and to resolve disagreements between codes (Mekuria *et al* 2021, 2025).

We used the tools outlined by Zimmermann and Claudia (2007) to conduct stakeholder mapping and analyze their legitimate power and power resources, stakeholders' interests, and influence. Our previous studies (e.g. Mekuria *et al* 2021, 2025) were also used as a model for this study. In particular, in developing the interest-influence profile of each stakeholder, stakeholder interest was evaluated by examining the stakeholder's mandate, roles, and responsibilities in relation to the issue and the intended change objective. Stakeholder influence was determined by focusing on the stakeholder's legitimate power and various power resources, such as (i) power derived from information access, (ii) communication and negotiation capacities, (iii) specialist knowledge and expertise, (iv) practical relevance, (v) creativity, and (vi) social relations. The definition of some of the words, terms, or phrases used in data collection and analysis is summarized in table 4.

3. Results and discussion

3.1. Water use and management

Field research indicated that irrigation farms currently operating in the Amibara irrigation scheme fall into three types, identified by the scale of their farming enterprises and tenure arrangements. The predominant type is managed by a private irrigation enterprise, namely Amibara Middle Awash agricultural development. The second type consists of farms managed by private investors who rent irrigated plots from local landowners. The third type of irrigation farm is operated by small-scale individual local users who do the irrigation farm on their own plots. The two private irrigation farms differ clearly in landownership structures, levels of investment, and farming arrangements. The Amibara Middle Awash agricultural development operates on large, contiguous landholdings secured through formal, long-term arrangements, enabling high capital investment, mechanization, and centralized management. In contrast, investor-managed farms operate on leased irrigated plots, resulting in fragmented, shorter-term

tenure, lower investment intensity, and more localized plot-based farming. These differences in tenure and investment structures have important governance implications, as large-scale enterprises tend to operate with centralized control, while fragmented smallholder and leased systems lack coordinated management, making collective water governance more difficult.

Irrigation users and irrigation scheme-affiliated institutions indicated that irrigation farms have been expanding outside the original command area of the irrigation scheme. According to the local branch of the MILLs, the irrigation canal was originally designed to serve nearly 11 000 hectares. However, farmland has since extended beyond this boundary without a corresponding increase in water supply. Although the full extent of this expansion has not been fully assessed, partial assessment indicates that about 165 hectares of land have been cultivated outside the initial command area. This expansion beyond the planned command area reflects weak regulatory enforcement and the absence of mechanisms to control water abstraction, further intensifying competition among users.

Irrigated agriculture in the Amibara irrigation scheme enables irrigation users to cultivate a variety of crops, including fiber crops, vegetables, fruits, and cereals. The main irrigated fiber crop is cotton. It is mainly cultivated for sale as a source of income. Irrigated vegetable crops include onion and tomato, which are also mainly produced for sale or for market, while they can also be used for household consumption. Watermelon, banana, and mango are the main fruit crops cultivated through irrigation. Farmers also mentioned that they have been able to produce cereal crops such as wheat. The different types of irrigation farms may not necessarily cultivate all crops during a farming season or cultivation year. The combination of crops cultivated by irrigation farmers depends on labor and water availability, and farmers' needs. Thus, different farming plots are not necessarily associated with different crop types. Instead, the inclusion of different crops depends on labor, water, financial and other resources availability, along with farmers' needs and seasonality. Nevertheless, irrigation users we interviewed in Amibara largely appreciated irrigation farming for enabling them to produce a variety of crops that can be used for market sales, largely, but also for household consumption.

However, current uses of irrigation water are uncoordinated and conflict-ridden. To get enough water in time for plants, there is always competition, and this involves conflicts. Across all interviews (18 KIIs and 3 FGDs), water conflict was consistently reported, with most respondents explicitly linking it to the absence of formal allocation rules, monitoring, and enforcement mechanisms. This indicates that the irrigation system operates as an uncoordinated resource use system, where users compete freely without institutional constraints.

Regarding collective action, there is a lack of practical social cooperation from user groups to maintain the irrigation infrastructure. For example, the overwhelming majority of key informants indicated that water canals have not been cleared for over five to ten years, creating an overaccumulation of siltation. Siltation has reached a level of immense problems by narrowing the waterway and limiting the flow of water. Besides, the invasive plant known as *Prosopis* has invaded the canals, even growing inside the canals. This has resulted in the closure or loss of conveyance capacity of the canal, and the water cannot flow properly. The narrowing of the canal due to siltation and its closure by the *Prosopis* tree have created water shortage and conflicts over water access and use. The lack of cooperative action to regularly maintain irrigation water canals and to collectively engage in a solution to overcome the problem afterwards is a deficiency of collective action. It is also interrelated with problems associated with the lack of appropriate institutions guiding water use and management, which will be discussed below. This breakdown of collective action reflects the absence of institutional arrangements that define responsibilities, enforce contributions, or sanction non-compliance. Without such mechanisms, individual users prioritize short-term gains over shared infrastructure maintenance.

The situation discussed above indicates that collective action breaks down when resource users are free to act and compete unrestricted (Rosokha *et al* 2024). Increasing social, economic, and power inequalities between heterogeneous resource user groups lead to the collapse of cooperation, thereby undermining successful collective action (Houle *et al* 2022). Thus, it is essential to understand how institutional, cultural, and biophysical contexts affect collective action situations (Ostrom 2000).

The findings have several important implications for the revitalization of the Amibara irrigation scheme and stakeholder engagement. The revitalization of the Amibara irrigation scheme requires urgent attention to infrastructure and water management challenges. The expansion of irrigated farmland beyond the original canal capacity has strained water distribution, while poor maintenance, especially siltation and invasion by *Prosopis*, has severely reduced canal efficiency, urging a comprehensive rehabilitation plan. This should include restoring canal infrastructure, controlling invasive species, and aligning water supply with current land use. This should be reinforced by a social justice approach to deal with issues related to water distribution and decision-making associated with water allocation (Collett and

Henry 2014). For this purpose, promoting collective action and cooperation among users is needed to address challenges related to infrastructure neglect and water use conflicts.

The results also suggest that stakeholder engagement should be inclusive and responsive to the diverse actors within the scheme, including large enterprises, private investors, and smallholder farmers. This is because irrigation scheme rehabilitation should consider justice and fairness by implementing genuine consultation, participation, negotiation, and dialogue among relevant stakeholders (Collett and Henry 2014). Effective engagement should focus on building trust and fostering collaboration through participatory platforms such as water user associations, as these platforms can facilitate joint decision-making, infrastructure maintenance, and conflict resolution (Chattopadhyay *et al* 2022).

3.2. Institutional and governance gaps

3.2.1. Institutional gaps

Analysis of irrigation use and management in Amibara revealed that there is a lack of a proper institutional and regulatory system and practice for allocating water for irrigation. Information obtained through field observations, as well as insights gathered from most key informant interviews and focus group discussions, clearly demonstrated this outcome. For example, water for irrigation is not released to farm plots based on any institutional arrangement of water use. Users simply compete with one another, without restriction, to divert water to their plots and irrigate their farms, creating water shortages and conflicts over water use, especially with users located at canal tails. Respondents indicated that this even involves taking control of irrigation valve openers on an individual basis, often involving conflicts with other users over access to water. Although the current unregulated, individual water usage and its potential risks to sustainable resource management may outwardly resemble the 'tragedy of the commons' concept (Hardin 1968), the underlying dynamics differ from that scenario. Instead, the situation in Amibara relates to the disappointing characteristics of major irrigation investments that narrowly focus on building dams, weirs and canals, while neglecting the essential need for ongoing institutional development involving users and suppliers of irrigation water (Ostrom 1992).

Furthermore, individual users pump water using motor pumps from the main canal. These activities happen in the absence of any institutional apparatus to guide collective water use and management. This includes the absence of formal water allocation rules, user associations, and enforcement mechanisms. As a result, individual users extract water independently, often through motor pumps, without coordination or accountability. The local MILLs office attributed the lack of capacity, resources and system to their inability to control such misuses. The individualization of water use, along with competition for water, is so intense that owners of big irrigation farms hire guards who can divert the flow of water to their farms. However, when several such farm owners attempt to do so, they engage in conflicts, turning the field of irrigation into a field of conflict. Observing this situation, a small-holder irrigation farmer expressed his frustration regarding the sustainability of the irrigation scheme by saying, 'After this year, only those who have "force" will be able to use the water.' Conversely, certain private investors who voiced concerns regarding water shortages indicated their dissatisfaction with the competitive dynamics involving small-holder farmers. Although challenges in accessing irrigation water impact all users, disparities arise due to varying resource capacities. For instance, private investors managing large-scale farms may employ personnel to monitor and control water outlets, thereby exerting more influence on water access.

The shortage of water created by uncoordinated water use and damaged canals forced some irrigation users to resort to motor-pumping water outside the irrigation scheme. They use fuel-reliant motor pumps to extract water from the river passing through the area. This is happening in addition to the situation where individuals are already bringing motor pumps to work within the irrigation scheme. This illustrates a scenario in which individual resource users may prioritize their personal interests rather than collaborating toward a common objective within a shared irrigation scheme.

What has been stated above has crucial implications for irrigation scheme revitalization and institutional development. The current lack of institutional oversight is not merely a descriptive gap but a fundamental barrier to revitalizing the Amibara irrigation scheme. Without formal coordination mechanisms, the current chaotic, every-user-for-themselves water grabbing and unchecked canal use will continue to wreak damage, leading to infrastructure breakdown, exacerbated inequality among irrigators, and ultimately undermining the scheme's sustainability. These outcomes matter profoundly for the scheme's future: physical rehabilitation alone will be futile if unregulated competition and conflict persist, as the scheme would degrade environmentally and fail to secure local livelihoods. This calls for appropriate institutional development. Theory and experience show that effective irrigation management hinges on institutions that can coordinate water acquisition, fair allocation and distribution, resource mobilization, infrastructure maintenance, and conflict resolution among diverse user

groups (Sakthivadivel *et al* 2004, Wang *et al* 2021). Thus, our findings signal that true revitalization demands coupling canal repairs with creating capable irrigation management institutions. This integrated approach aligns with lessons from similar rehabilitation efforts (e.g. India), where merely fixing physical infrastructure did not improve performance without simultaneous institutional reform (Sakthivadivel *et al* 2004).

3.2.2. Governance gaps

For the past 12 years, the Amibara irrigation scheme has confronted persistent governance challenges at the institutional level, beyond the direct control of local water users. Multiple irrigation users noted that these problems have worsened over that period, coinciding with a major reorganization of water-management authorities. Historically, the irrigation scheme was administered by the Awash basin authority, but a subsequent restructuring nominally placed it under the local MILLs office. The Awash Basin authority, together with other river basin authorities, was established to facilitate effective water resources management by enabling sustainable, coordinated management of basin water resources among stakeholders (FDRE 2007). Information accessed from the MILLs website indicates that the MILLs was established to develop efficient and sustainable irrigation systems, aiming to transform agriculture in Ethiopia's lowland regions by utilizing local land, water, animal, and human resources for national development (MILLs 2026). However, local MILL's officials report that control of the scheme's canal was never formally transferred to their office, leaving them struggling to manage it effectively under this ambiguous arrangement. This incomplete transfer of authority, combined with overlapping mandates between the Basin authority and MILLs, has created a governance vacuum in which no single institution has clear responsibility or sufficient authority to enforce water allocation, coordinate maintenance, or resolve conflicts, thereby undermining effective management of the scheme.

In practice, the local MILLS office has been stepping in formally to mediate water use problems on the ground. During fieldwork, we observed irrigation users coming to this office to complain about water shortages, with staff attempting to address their concerns. One local MILLs representative explained that staff are doing their best to resolve issues, even though canal management has not been formally handed over to them.

Local MILL officials further highlighted significant resources and capacity shortfalls hindering effective scheme management. They noted severe shortages of personnel, technical expertise, funding, and equipment needed to operate and maintain the system—a situation exacerbated by the institutional restructuring. For example, some staff with critical irrigation expertise remained under the Ministry of Water and Energy instead of moving to the MILLS office, leaving the local team without the necessary technical support. Previously, the scheme had dedicated guards to protect canal gates and staff to oversee water distribution, but those roles are no longer in place, and essential machinery is not under the local office's control. Other interviewed water users from private irrigation schemes, as well as small-scale irrigation plots also expressed that, following the reshuffling of the previous organizational structure, the irrigation scheme has faced management challenges.

Respondents across different groups emphasized the severity of this governance vacuum. One key informant emphatically stated, 'Now nobody knows under whose control the scheme is. It is not under the Awash Basin authority, nor is it under MILLS. Now users can simply cut canals and use water. Now it is open.' These situations demonstrate that the management of the Amibara irrigation scheme requires revitalization. This process should encompass both institutional and infrastructural revitalization, as well as the formulation of resource management systems designed to promote ownership, accountability, and trust.

The governance vacuum arises from fragmented and overlapping institutional mandates, where multiple agencies hold partial responsibilities, but none has clear authority or sufficient capacity to enforce water allocation or infrastructure management. With the shift of authority from the Awash Basin authority to a local MILLs office, which lacks a formal handover of responsibilities or resources, no single agency is clearly in charge. This situation evidences a failure in the multi-level water management structure and indicates that the scheme's decline is partly institutional in nature. The local MILLs office's limited capacity—in terms of manpower, expertise, and formal authority—underscores a loss of institutional capacity in the aftermath of the restructuring. Governance theory suggests that this fragmentation of formal responsibilities and erosion of institutional memory leave the scheme in a liminal state, characterized by unclear mandates and inadequate oversight. Such an absence of designated authority and clear rules not only constitutes a governance gap but also exacerbates mismanagement of the irrigation system.

One stakeholder captured this reality by remarking, 'Now nobody knows under whose control the scheme is. It is open.' This blunt observation highlights how the scheme currently operates in a vacuum of formal governance, lacking clear authority, accountability, and enforcement mechanisms. Given that water governance is defined as 'the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society' (Rogers and Hall 2003), the Amibara case exemplifies a collapse of such systems. The classical pillars of governance identified by Rogers and Hall (2003) and others have faltered, exposing deficits in regulatory structures and coordination mechanisms (Rogers and Hall 2003, Ul Hassan 2011). Any effort to revitalize the scheme must therefore address this governance failure by re-establishing clear authority and accountability alongside appropriate regulatory instruments and administrative frameworks. In the absence of effective formal governance so far, some water users have even begun to self-organize to manage the scheme informally—a dynamic that is explored in the next section.

3.3. Emerging institutions for collective water use

Fieldwork revealed that small groups of adjacent small-scale irrigators have spontaneously implemented rotational water-sharing arrangements to cope with water scarcity and reduce conflict. Discussion with a group of these farmers indicated that they established a shift system wherein some irrigate plots by day and others at night, ensuring equitable water use and preventing disputes. They are practicing this due to the shortage of water and to use available water equitably by avoiding conflicts. This ad hoc system emerged recently and is enforced internally: users violating the agreed schedule (e.g. by taking water out of turn) face penalties in kind or cash imposed by their peers. These informal arrangements succeed because they operate at a local scale where social relationships enable monitoring and enforcement, in contrast to the formal system, where such mechanisms are absent. Such grassroots conflict-resolution mechanisms underscore these farmers' readiness for collective action under supportive conditions. This capacity of local users to engage in collective action further demonstrates that the situation of individualized water use practices in the irrigation scheme is far from the 'tragedy of the commons' concept (Hardin 1968). Instead, it is a manifestation of failures that stem from large irrigation projects that prioritize infrastructure like dams and canals but overlook crucial institutional development with water users and suppliers (Ostrom 1992).

Thus, revitalization processes of irrigation schemes and stakeholder engagement should investigate what enabling conditions are available for self-organization. For example, important elements of self-organization may comprise agency along with the motivations, beliefs and values that shape the capacity of actors to enact, the demand that urges action and the resource that facilitates self-organization (Burnett 2023). It is also important to consider what factors affect reputations, trust and reciprocity among resource users, and how these affect cooperation and mutual benefits (Ostrom 2009).

Similarly, outside the main irrigation scheme in pump-fed areas (where gravity flow does not reach), farmers have institutionalized a comparable water-use rotation. There, user groups also alternate water use in shifts (morning versus night) due to shortages. The shift system is organized by farm owners through a hired water manager. The community hires and pays this manager to oversee the turns, selecting the individual via a nomination process that prioritizes good conduct, trustworthiness, and sociability. Several key informants indicated that the hired person is nominated by people in the area. The nomination process considers whether the person has good conduct, can be trusted, is sociable, and interacts with other people. This situation also indicates that users are willing to engage in collective action for irrigation water use.

These emerging collective practices suggest that irrigation scheme revitalization and stakeholder engagement efforts should reinforce the enabling conditions for self-organization. Key factors to promote include the agency of participants—shaped by their motivations, beliefs, and values the demand or impetus that initiates collaborative efforts, and the resources necessary for effective self-organization (Burnett 2023). Furthermore, it is important to evaluate how variables such as trust, reputation, and reciprocity affect cooperation and generate mutual benefits among water users (Ostrom 2009). Building on these local initiatives could help extend collective water management within the main scheme. This involves examining why collective action flourishes in pump-fed areas but remains limited in the main scheme, so that conducive conditions can be replicated or scaled. It also highlights the need for inclusive stakeholder engagement that integrates diverse knowledge systems, values, and interests shaping irrigation practices (Ricart and Gandolfi 2017). Establishing a stakeholder panel is one practical recommendation to facilitate lesson-sharing, information exchange, coordination, and collaboration among all parties involved (Nalumu *et al* 2021).

3.4. Stakeholder identification and mapping

The results show a diverse set of stakeholder groups interested in revitalizing the Amibara irrigation scheme (table 5). Among these stakeholders, 30% were government development organizations and decision makers, comprising national and local government authorities (17.5%) and water resources management agencies (12.5%). The second-largest stakeholder categories were NGOs and Ethiopian investment holdings, followed by research and university systems, community leaders, and financing institutions (figure 3). This broad stakeholder base provides a solid foundation for multi-sectoral collaboration, greater investment potential, and a supportive environment for sustainable and inclusive scheme reutilization. Studies from other contexts (e.g. Woldesenbet 2020, Shrestha *et al* 2021, Sigalla *et al* 2021) likewise indicate that broad stakeholder involvement and cross-sector collaboration are crucial for addressing infrastructure challenges, resolving water conflicts, and establishing effective governance. Engaging such a wide range of stakeholders ensures that the scheme's revitalization efforts are locally grounded, socially equitable, and institutionally sustainable, thereby enhancing its long-term viability (Thabane *et al* 2025).

Based on the perceived interest-influence matrix, the majority of stakeholders (43%) were classified as high interest but low influence, with equal smaller groups (23% each) categorized as high interest/high influence and low interest/high influence (figure 3, table 5). The predominance of stakeholders in the high-interest but low-influence category (43%) helps explain the persistence of governance challenges, as those most affected by water management lack the power to influence decision-making. In addition, this distribution suggests a need for differentiated, rather than uniform, engagement: the largest group requires regular updates and consultation during planning, design and implementation; low interest/high influence actors should be strategically kept satisfied to maintain support and avoid opposition; high interest/high influence actors should be closely involved as partners in co-designing and implementing revitalization initiatives; and low interest/low influence actors require only minimal but timely information.

The distribution also varied by stakeholder group type: most national and local government authorities were perceived as low interest/high influence (table 5, figure 4), indicating that these powerful actors require targeted attention to secure policy and resource support for the scheme's revitalization, while all water resources management agencies were rated as high interest/high influence (table 5, figure 4), providing an opportunity to engage them as partners and champions for sustainable implementation, By contrast, all NGOs were perceived as having low interest and low influence, which might reflect their minimal contribution to the scheme to date or a lack of alignment with current government development priorities in the area; their role should therefore8 be monitored while opportunities to increase their involvement are explored. Meanwhile, the high interest shown by financing institutions should be sustained through regular high-level dialogues, joint visibility initiatives, and continuous sharing of evidence-based progress.

Overall, these findings underscore that effective and sustainable revitalization of the Amibara irrigation scheme depends on aligning stakeholder engagement with each group's interest-influence profile (Ufitimfura and Juma Amolo 2025), particularly by mobilizing support from powerful but currently less interested actors (Mwendera and Chilonda 2013), while building ownership, reducing conflict, and ensuring the scheme's long-term sustainability (Conway *et al* 2024).

3.5. Stakeholder analysis

This section examines the motivations, needs, contributions, and constraints of stakeholders involved in revitalizing the Amibara irrigation scheme. It highlights key factors influencing their participation and the risks affecting implementation and long-term sustainability.

3.5.1. Stakeholder motivation

The results indicate that stakeholders' motivation is largely driven by the expected benefits and the alignment of the revitalization initiative with their institutional and local priorities. In particular, stakeholders with high interest and influence view revitalization as a means to (i) enhance agricultural productivity and water use efficiency, (ii) fulfill institutional mandates to rehabilitate underperforming schemes, and (iii) ensure the scheme's long-term modernization and sustainability. More broadly, stakeholders anticipate that revitalization will spur positive changes such as the adoption of modern, water-saving technologies (e.g. automated irrigation systems), improved agricultural inputs (better seeds, mechanization), higher water productivity, expanded cultivated land area, and greater use of research findings to inform management decisions. Moreover, our findings show that most stakeholders are motivated because the revitalization initiative aligns closely with both community and institutional priorities by supporting goals such as increased agricultural productivity, improved nutrition, sustainable food security, local economic development, and environmental conservation. It complements institutional missions and

Table 5. Stakeholder mapping and communication strategies.

Categories	Stakeholders	Interest	Influence (power)	Communication strategy	Basis for interest-influence profile
Farmers (communities)	Smallholder irrigation farmers	High	Low	Keep informed	Depend on the scheme's water for their livelihoods (high interest) but have no authority or resources to shape decisions (low influence).
	Farmers in the downstream areas	Low	Low	Monitor	Receive minimal direct benefits from the scheme (low interest) and have no representation or authority in its management (low influence).
Community leaders	Clan leaders	High	High	Manage closely	Clan leaders and irrigation water user associations have a strong interest in the scheme's success due to its community and irrigation benefits. Their leadership and roles in local decision-making and water management also give them high influence.
	Irrigation water user associations	High	High	Manage closely	
	Cooperatives and unions	Low	Low	Monitor	Core activities lie outside the scheme (low interest), and they have no formal role or authority in scheme governance (low influence).
	Water and environmental advocates	High	Low	Keep informed	Committed to sustainable water use and environmental protection in the basin (high interest) but operates via advocacy only, with no formal decision-making power (low influence).
National and local government authorities	Afar regional administration	High	High	Manage closely	Views revitalizing the scheme as vital for economic development and local livelihoods (high interest); holds jurisdiction and political authority to mobilize resources, providing strong influence (high influence).
	Dam administration	Low	High	Keep satisfied	The dam administration, Ministry of Finance, and Ministry of Planning have limited direct interest in the scheme, as their focus is on broader water management, budgeting, and national development priorities, respectively (low interest). However, their control over water releases, funding, approvals, and development priorities gives them substantial influence over the scheme and its resources (high influence).
	Ministry of Finance	Low	High	Keep satisfied	
	Ministry of Planning	Low	High	Keep satisfied	

(Continued.)

Table 5. (Continued.)

	Ministry of Defense	High	High	Manage closely	Invested in regional stability and security, making the scheme's success a national interest (high interest); has substantial authority and resources to support or intervene in the project (high influence).
	Disaster management and planning	High	Low	Keep informed	Strong interest in mitigating flood risks and disasters in the scheme area (high interest), but only an advisory/emergency response role with no direct control over irrigation operations (low influence).
	Ministry of Health	Low	Low	Monitor	Only an indirect stake in irrigation outcomes (low interest) and no operational role or authority in scheme management (low influence).
Ethiopian investment holdings	Wonji sugar factory	Low	High	Keep satisfied	Wonji and Metehara sugar factories are upstream, state-linked sugar enterprises with limited direct interest in Amibara's scheme (low interest), as their operations focus on their own production systems. However, their large scale, economic importance, and strong government connections give them considerable influence over basin-level water allocation and related regional decisions (high influence).
	Metehara sugar factory	Low	High	Keep satisfied	
	Middle Awash agricultural development enterprise	High	Low	Keep informed	State farming enterprise in the Middle Awash area, directly interested in the scheme's productivity (high interest) but with no regulatory authority and dependent on higher bodies for decisions (low influence).
	Ethiopian engineering corporation	High	Low	Keep informed	Stands to gain work from scheme rehabilitation (high interest), but despite its technical expertise it has no decision-making authority in irrigation policy (low influence).
	Ethiopian electric utility	Low	Low	Monitor	Focuses on electricity supply (the scheme's status does not affect its mandate, low interest) and plays no part in irrigation governance or water management (negligible influence).

(Continued.)

Table 5. (Continued.)

Categories	Stakeholders	Interest	Influence (power)	Communication strategy	Basis for interest-influence profile
Water resources management agencies	Ministry of Irrigation and Lowlands	High	High	Manage closely	The Ministry of Irrigation and Lowlands, the Ministry of Water and Energy, the Ministry of Agriculture, Awash Basin administration office, and regional and district irrigation and agriculture offices all have a strong interest in the scheme due to their mandates related to irrigation development, water management, food security, and scheme implementation (high interest). Their formal mandates, policy authority, regulatory control over water allocation, and operational responsibilities across national, basin, and local levels give them substantial influence over planning, resource allocation, and day-to-day management of the scheme (high influence).
	Ministry of Water and Energy	High	High	Manage closely	
	Ministry of Agriculture	High	High	Manage closely	
	Awash Basin admin office	High	High	Manage closely	
	Regional and district-level irrigation and agricultural offices	High	High	Manage closely	
Non-governmental organizations	Farm Africa	Low	Low	Monitor	Farm Africa, SNV, World vision, WaterAid, and CARE Ethiopia are not currently engaged in the Amibara scheme or its revitalization efforts and therefore have low direct interest in its outcomes. In addition, as they have no formal roles, mandates, or operational involvement in the scheme, they exert little to no influence over decision-making, implementation, or resource allocation (low influence).
	SNV	Low	Low	Monitor	
	World vision	Low	Low	Monitor	
	Water aid	Low	Low	Monitor	
	CARE Ethiopia	Low	Low	Monitor	
Research institutions	Ethiopian Institute of Agricultural Research	High	Low	Keep informed	The Ethiopian Agricultural Research Institute and the International Water Management Institute (IWMI) have a strong interest in the scheme due to their focus on agricultural improvement, innovation, and applied research (high interest). However, as advisory and research institutions without formal decision-making or governance authority, their influence over scheme implementation and resource allocation remains limited (low influence).
	International Water Management Institute	High	Low	Keep informed	
University systems	Samara University	High	Low	Keep informed	The university system (Samara, Addis Ababa, Haramaya, and Arba Minch Universities) has a strong interest in the scheme for research, training, and knowledge generation (high interest), but limited influence due to its lack of formal governance or decision-making roles in scheme implementation and management (low influence).
	Addis Ababa University	High	Low	Keep informed	
	Haramaya University	High	Low	Keep informed	
	Arba Minch University	High	Low	Keep informed	

(Continued.)

Table 5. (Continued.)

Private sector	Investors	High	Low	Keep informed	Investors and input suppliers have a strong interest in a revitalized scheme due to the potential for increased investment and agribusiness opportunities (high interest). However, as they are not part of the scheme's governance or implementation structures, they currently have no formal role or direct influence over decision-making (low influence).
	Input suppliers	High	Low	Keep informed	
Financing institutions	World Bank	High	Low	Keep informed	Financing institutions (World Bank, FAO, IFAD, and African Development Bank) have a strong interest in the scheme due to their mandates in agricultural development and food security (high interest), but limited influence as they are not directly engaged in financing, implementation, or governance of the Amibara scheme (low influence).
	FAO	High	Low	Keep informed	
	IFAD	High	Low	Keep informed	
	AfDB	High	Low	Keep informed	

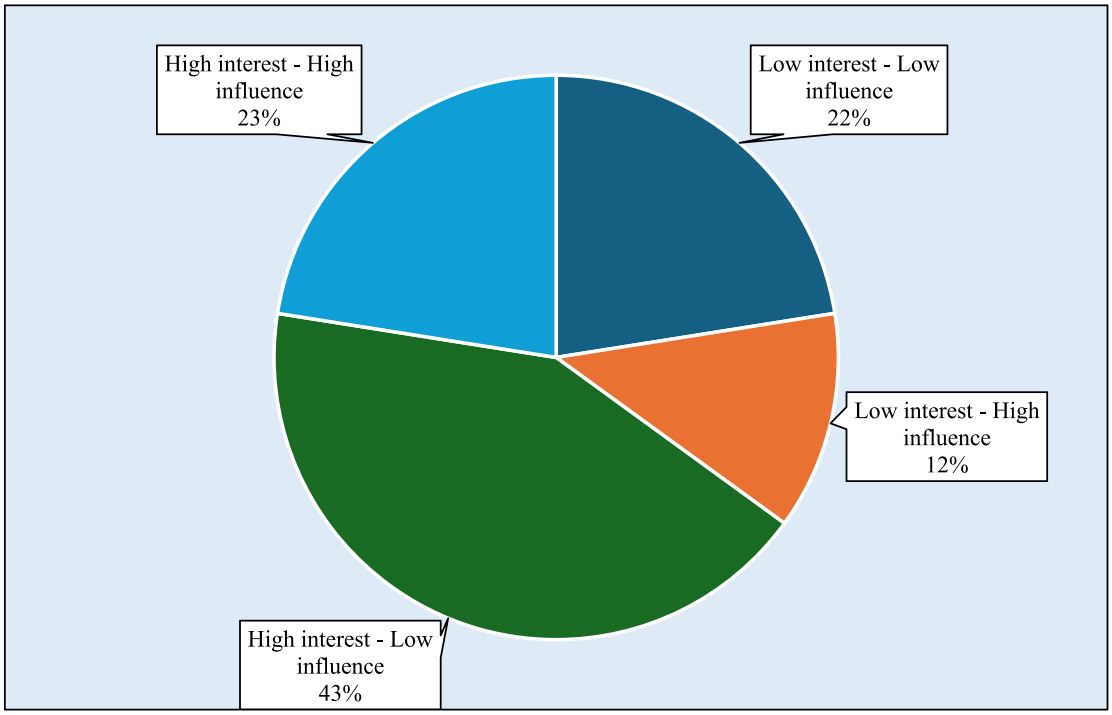

Figure 3. The perceived interest-influence matrix of the stakeholders identified for the revitalization of the Amibara irrigation scheme.

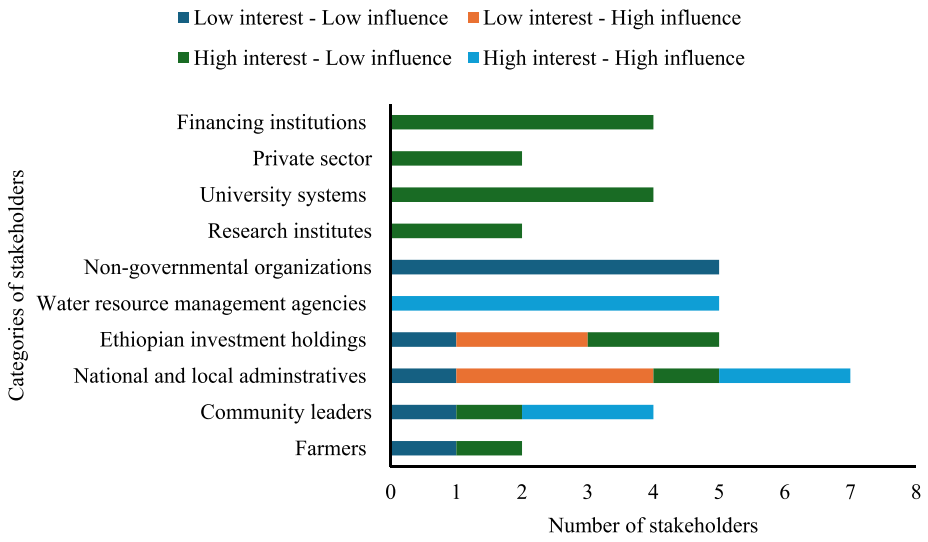

Figure 4. Number of stakeholders from each group assigned to the different categories of the interest-influence matrix.

strategies (e.g. MILLs initiatives), aligns with national policy objectives, and promotes stronger linkages between universities, industries, and community engagement.

Overall, these results imply that the revitalization of the Amibara irrigation scheme has a strong foundation for sustained stakeholder support, provided it is framed as a benefit-driven and goal-aligned intervention. Stakeholders' motivation, rooted in expected productivity gains, improved water-use efficiency, institutional performance, and long-term sustainability, creates favorable conditions for mobilizing resources, fostering partnerships, and accelerating the uptake of modern technologies and research-based solutions. The close alignment of revitalization objectives with community needs, institutional mandates, and national policy priorities further enhances ownership and reduces resistance to change. Similar evidence from other countries, for example, Kenya and Iran, shows that stakeholder commitment is strongest when initiatives reflect stakeholders' priorities and deliver tangible benefits (Awino and Mungai 2024, Sarami-Foroushani *et al* 2024), underscoring the importance of designing revitalization

efforts that resonate with stakeholder expectations and community goals to secure long-term cooperation and sustainable outcomes.

3.5.2. Stakeholders' needs for enhanced participation

The results showed that stakeholders require a combined support and enabling conditions to fully engage in the revitalization efforts. Although needs vary by each actor's mission and role, their common categories emerge: (i) access to information and data (e.g. timely water availability, agronomic information), (ii) technical and financial support (including funding for improvement and expert assistance), and (iii) capacity building through targeted training (for instance, in modern irrigation management and technologies). Other urgent needs include addressing environmental challenges (including poor water quality, waterlogging, salinity, invasive species, and flooding), mobilizing sufficient financial resources, raising community awareness, and clearly defining stakeholder roles and responsibilities for all stakeholders in the revitalization process. Regarding external support, stakeholders emphasize the importance of financial and technical assistance, with expectations that government agencies will actively engage academic institutions for research and innovations, and that NGOs and development partners will contribute both funding and technical know-how.

Addressing these needs is essential for boosting stakeholder participation, highlighting that stakeholders' empowerment depends on information access, capacity-building, coordination, and other supportive conditions. Similar experiences elsewhere demonstrate that limited local technical capacity and insufficient resources can severely hinder community participation and the long-term success of water interventions (Ali and Kamraju 2024). In water management projects across Asia and Africa, for instance, inadequate training and funding have been found to render community initiatives dysfunctional or unsustainable (Shunglu *et al* 2022). Therefore, meeting the identified needs—from training and technical guidance to improved data sharing and resource mobilization—is critical for enhanced stakeholder engagement in the Amibara scheme's revitalization.

3.5.3. Stakeholders' contributions to the revitalization process

The results indicated that stakeholders could contribute a variety of resources and strengths to the revitalization of the Amibara irrigation scheme, including specialized technical expertise, skilled human resources on the ground, critical financial support (e.g. through funding from programs hosted by MILLs, and donors, such as FAO, IFAD, World Bank and African Development Bank), key data and analytical tools, and capacity-building capabilities. Many stakeholders are well-positioned to raise public awareness and facilitate access to technical knowledge and financial resources. These contributions could be further strengthened through targeted training and knowledge-sharing in areas such as advanced water management technologies (e.g. efficient water delivery and monitoring systems), digital tools for decision support (like irrigation scheduling dashboards), design and contracting for rehabilitation works, integrated watershed and natural resource management, and hands-on learning through field demonstrations.

The revitalization initiative stands to gain significantly from the active engagement of these diverse stakeholders, leveraging their established partnerships with government ministries, financing institutions, and their experiences from similar projects. Effectively harnessing each stakeholder's competencies and resources can create synergies: for instance, research institutions can supply evidence and innovation while local authorities enable policy support, resulting in more robust interventions. Our results reinforce the broader understanding that aligning interventions with community needs and priorities is key to sustainable outcomes (Thabane *et al* 2025) and that long-term planning and continuous maintenance are fundamental to lasting success (Darghouth 2005, Faurès *et al* 2013). These insights echo other multi-stakeholder irrigation initiatives, which have shown that broad stakeholder involvement and cross-sector collaboration are crucial for addressing complex infrastructure and governance challenges. Practical lessons drawn from local experiences—such as flood protection measures by the Awash Basin Administration or drainage rehabilitation efforts led by MILLs—also provide valuable guidance for designing effective and resilient revitalization actions in Amibara. By building existing collaborations and knowledge networks, the project can accelerate improvements, enhance innovation uptake, and ensure that interventions are well-adapted to local conditions.

3.5.4. Barriers for enhanced participation and risks to sustainability

The analysis finds that multiple barriers—both internal and external—could inhibit stakeholders' effective participation in the revitalization process, and several risks could threaten the scheme's sustainable operation. Internal barriers (challenges within the stakeholder organization and institutions) include

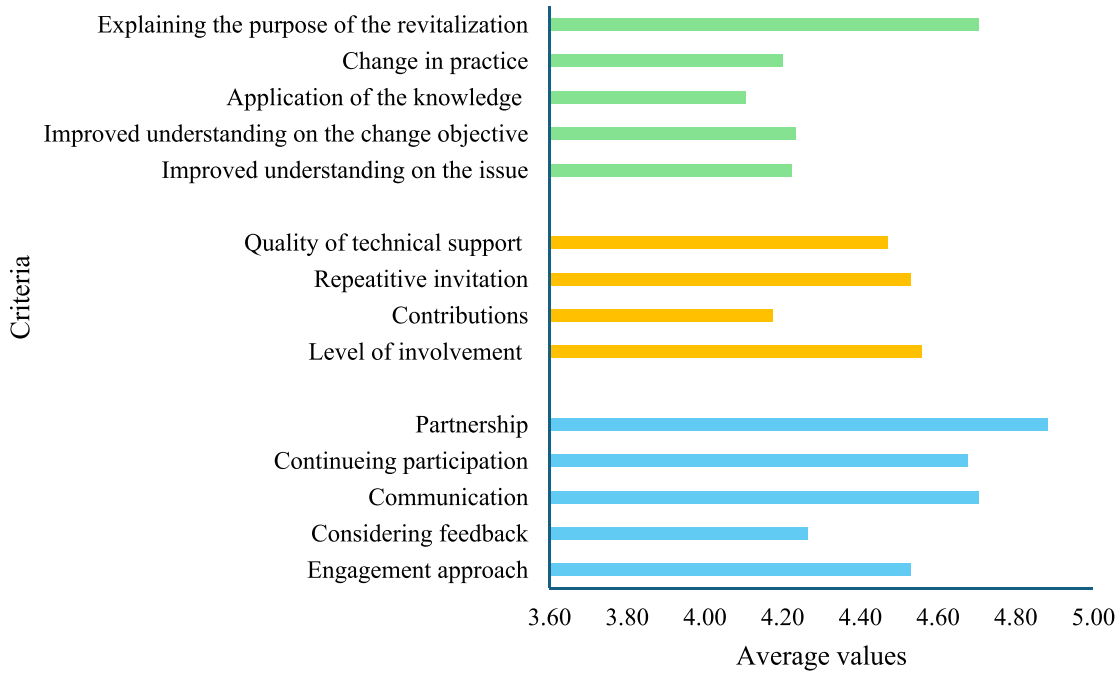

Figure 5. The effectiveness of past engagement strategies of the revitalization processes as evaluated using three criteria: satisfaction, participation, and knowledge uptake. *The blue bar graphs indicate the level of agreement to the statements used to evaluate the level of satisfaction, orange—level of participation, green—knowledge uptake.*

unclear institutional mandates, the currently limited roles of universities and research bodies in decision-making, financial constraints, logistical challenges, and gaps in technical capacity for implementing modern technologies. External barriers (contextual factors beyond any single stakeholder's control) included difficult social dynamics, such as weak coordination and trust among groups, insufficient funding for research and capacity building, and broader social, political and logistical issues, including peace and security concerns. These hurdles can dampen stakeholders' willingness or ability to participate fully.

We also identified diverse risks to the effective implementation and long-term sustainability of the revitalization. These encompass economic, environmental, and social dimensions, notably (i) unresolved land ownership and tenure issues, (ii) limited financial resources for operation and maintenance, (iii) invasive weed infestations, (iv) periodic flooding and associated sedimentation in canals, (v) water scarcity and poor water quality, (vi) technical gaps, and ineffective scheme management. Additional concerns include insecurity stemming from illegal water abstraction (which can exacerbate conflicts) and lingering uncertainty over each stakeholder's roles and contributions, particularly how to engage them meaningfully and apply their expertise in the revitalization efforts.

Overall, the results underscore that effective, sustainable revitalization of the Amibara irrigation scheme will depend on proactively addressing both internal and external barriers to stakeholder participation, as well as mitigating the associated risks to the project's success. By tackling the institutional and social barriers alongside the technical challenges, the revitalization efforts can be made more resilient and equitable, and better aligned with stakeholder expectations and national development priorities. These social-institutional issues, such as breakdowns in communication or lingering mistrust, have been noted as formidable obstacles to stakeholder collaboration in analogous irrigation projects. For instance, experiences from Ghana's Weija irrigation scheme reveal that inadequate communication channels, negative attitudes, and exclusion of key actors can significantly hinder effective partnership among stakeholders (Nalumu *et al* 2021).

3.6. Engagement strategies

An evaluation of past engagement strategies by MILLs and collaborating organizations assessed stakeholder satisfaction, participation, and knowledge uptake using a five-point Likert scale. The results showed consistently high agreement across all criteria, with mean responses ranging from 4.26 to 4.88 for satisfaction, 4.18–4.56 for participation, and 4.11–4.71 for knowledge uptake (figure 5). These results indicate the strong performance of existing approaches, providing a solid basis for refining and sustaining stakeholder involvement, collaboration, and knowledge integration in practice.

Beyond this evaluation, the study also identified stakeholders' preferred engagement strategies to tailor approaches for different groups (table 6). For stakeholders with low interest but high influence, strategies emphasized tailored communication, clear benefits, evidence-based information, and financial transparency to build trust and maintain their support. Those with high interest and high influence require collaboration through decision-making, formal partnerships, and coordinated implementation. Stakeholders with high interest but low influence should be empowered through inclusive participation, capacity building, knowledge sharing, and continuous communications, while those with low interest and low influence should be gradually engaged by raising awareness, monitoring their context, offering learning opportunities, and fostering potential future collaboration.

In terms of partnerships and collaborations, the findings highlighted the importance of public-private partnerships, community-government collaboration, and alliances focused on co-design, research, knowledge co-generation, and capacity building. Additional recommendations include clarifying roles and responsibilities, formalizing partnerships, strengthening coordination mechanisms (e.g. steering and technical committees), ensuring transparent communication, establishing stakeholder platforms, and implementing monitoring and evaluation systems.

4. Conclusions and recommendations

This study demonstrates that institutional arrangements, governance processes, and stakeholder engagement profoundly shape water access, management practices, and revitalization outcomes in the Amibara irrigation scheme. Our findings show that irrigation water use, currently characterized by fragmented and individualized practices under weak institutional oversight and governance gaps, has resulted in persistent water shortages and conflicts that undermine equitable access and the scheme's sustainability. The results clearly indicate that technical rehabilitation alone does not ensure lasting results without concomitant institutional and governance reforms; infrastructure improvements are unlikely to be sustained. A central finding is that the absence of well-structured local water institutions—notably operational IWUAs—combined with unclear and overlapping institutional mandates, has created a governance gap. This gap facilitates unregulated water usage and leaves disputes unresolved. These governance failures directly shaped water distribution patterns and conflict dynamics, thereby constraining effective revitalization. Beyond the Amibara case, this finding contributes to the broader understanding that irrigation systems function as socio-technical systems, where governance and institutional coherence are as critical as physical infrastructure for achieving sustainable outcomes.

Based on these findings, the study proposes the following prioritized actions for improving irrigation scheme revitalization:

First, establish and operationalize IWUAs in line with the 2014 Federal proclamation, ensuring they are legally recognized and adequately supported to coordinate water allocation and maintenance. Second, clarify the streamlined institutional roles and responsibilities by assigning clear authority to a local irrigation management body with sufficient technical and financial capacity. Third, implement transparent and enforceable water allocation mechanisms, including scheduling, monitoring, and conflict resolution systems, to reduce competition and improve equity. These actions are essential to strengthen collective action, enhance accountability, and ensure sustained infrastructure management.

The stakeholder analysis further highlights that successful revitalization depends on an inclusive and well-targeted engagement strategy. Given the diversity of stakeholders, each with varying interests, influence, and capacity, effective engagement must go beyond consultation to actively empower less influential groups, foster trust, and support collaborative decision-making. While stakeholders demonstrate strong interest in improving the scheme, this potential can only be realized if institutional ambiguities, capacity limitations, resource constraints, and external environmental pressures are systematically addressed. Overall, the study concludes that irrigation scheme revitalization outcomes are fundamentally determined by governance quality and institutional effectiveness. Robust local institutions, clear accountability structures, and meaningful stakeholder engagement are not complementary but foundational conditions for equitable water access and sustainable irrigation management. This reinforces a broader scientific insight: investments in irrigation infrastructure must be accompanied by deliberate investments in governance systems and collective action mechanisms to achieve lasting development outcomes.

Table 6. Suggested engagement strategies for stakeholders with varying interests and influence and monitoring indicators.

Interest-influence matrix	Engagement strategies for stakeholders assigned to each category	Change dimensions	Monitoring indicators
Low interest but high influence (the group needs to be satisfied)	**Maintain engagement through targeted communication:** To achieve this, it was suggested to use letters, emails, media, and the traditional engagement approach to keep these stakeholders satisfied. **Raise awareness strategically:** Suggested to visit their office and show clear benefits to them, organizing kickoff meetings and workshops to build understanding and buy-in. **Provide evidence-based information:** This covers sharing factual data to support decision-making and build trust. **Clarify benefits and roles:** Clearly communicate the expected benefits of the scheme's improvement, along with the roles of donors and national stakeholders. **Ensure financial transparency:** This includes presenting a clear and realistic financial plan to enhance confidence and support.	Awareness, satisfaction, accountability, commitment	- Frequency and quality of formal communication - Evidence of increased awareness of scheme objectives and benefits - Clarity of roles and expectations reflected in official correspondence - Perceived trust in financial transparency and planning processes
High interest and high influence (the group needs to be closely engaged and managed)	**Establish formal partnerships:** This includes using MoUs to define roles and responsibilities clearly. **Promote joint learning and visibility:** Conduct site visits, co-pilot projects, and demonstrations to showcase progress and encourage engagement. **Foster active participation:** Organize workshops and forums to co-design and collaboratively plan rehabilitation activities at all levels. **Ensure ongoing engagement:** Involve stakeholders in activity implementation, progress sharing, and continuous dialogue. **Strengthen coordination and accountability:** Set up a joint steering committee, develop a common action plan, and establish shared monitoring, evaluation, and re-planning mechanisms.	Participation, coordination, joint decision-making, accountability	- Existence and functioning of MoUs or formal agreements - Regularity of joint planning, review, and steering committee meetings - Degree of shared decision-making in revitalization actions - Responsiveness to agreed action plans and monitoring results
High interest but low influence (keep informed)	**Promote inclusion through participation:** Involve stakeholders in implementation activities and pilot sites to build ownership and learning. **Build capacity:** Offer targeted training, workshops, and exposure visits to strengthen knowledge and skills. **Ensure continuous communication:** Use diverse platforms (e.g. Telegram, WhatsApp, email) to keep stakeholders informed and engaged. **Encourage knowledge exchange:** Facilitate access to knowledge-sharing platforms for ongoing learning and collaboration. **Co-create solutions:** Involve them in co-designing research and implementation initiatives to enhance relevance and impact.	Inclusion, capacity, voice, empowerment	- Participation in implementation, pilots, or co-design activities - Changes in stakeholder capacity (skills, knowledge, confidence) - Frequency and quality of information exchange - Perceived ability to influence decisions and raise concerns

(Continued.)

Table 6. (Continued.)

Low interest and low influence (Monitor)	**Raise awareness and interest:** Involves conducting campaigns and briefings to inform stakeholders about the scheme's relevance and benefits. **Build capacity gradually:** Provide continuous learning opportunities to enhance their understanding and potential contribution. **Engage selectively:** Invite to workshops and interviews to keep them connected and informed. **Understand stakeholder context:** Monitor their motivations, needs, capacities, and challenges to tailor future engagement. **Foster opportunities for collaboration:** Identify pathways for partnership to gradually increase their involvement and influence.	Awareness, gradual engagement, emerging roles	- Exposure to awareness-raising activities and briefings - Participation in selected meetings or consultations - Changes in interest, motivation, or engagement over time - Emerging opportunities for collaboration or partnership

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Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Conflict of interest

The authors declare no competing interests.

Accordance statement

Our research adheres to the guidelines of the Committee on Publication Ethics (COPE).

Consent to participate

All participants involved in this study provided informed consent before participation. Participation was voluntary, and participants were fully informed of the purpose and non-invasive nature of the study.

Ethical statement

This research received ethical approval from the International Water Management Institute (IWMI). Verbal informed consent was obtained from all key informants and participants involved in focus group discussions before data collection. Our research adheres to the guidelines of the Committee on Publication Ethics (COPE).

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