

Qualitative Analysis of Implementation Constraints of Sustainable Irrigation Project in Agricultural Areas of Indonesia

Wulandari Alwinda Puspasari¹, I Putu Artawan²

^{1, 2}Teknik Sipil, Universitas Tomakaka Mamuju

Corresponding Author: Wulandari Alwinda Puspitasari, Puspitasari, e-mail: wulandariapuspitasari@gmail.com

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ABSTRACT

The study purpose was to analyze the obstacles in implementing sustainable irrigation projects in Indonesia's agricultural sector, considering the country's high dependence on stable and efficient water availability. Despite the urgent need for sustainable irrigation to support agricultural productivity and food security, numerous barriers remain in practice, reducing the effectiveness of irrigation systems. This research focuses on identifying and categorizing these obstacles into technical, social, economic, and policy aspects in order to provide comprehensive insights into the challenges faced by farmers and stakeholders.

Materials and methods A qualitative research approach was employed, using in-depth interviews with farmers and relevant stakeholders, focus group discussions (FGDs), and direct field observations in selected agricultural regions. The collected data were analyzed thematically to identify recurring issues and interrelated problem patterns. This methodological framework allowed the study to capture the perspectives of multiple actors and reveal systemic challenges in irrigation project implementation.

Results. The findings indicate that technical constraints are primarily due to aging infrastructure, leakage in irrigation channels, and lack of routine maintenance. From the social perspective, the main issues include limited community participation and low awareness of equitable water management. Economic barriers arise from inadequate government funding and minimal community contributions for infrastructure upkeep. On the policy level, weak institutional coordination and overlapping regulations were identified as significant impediments.

Conclusions. The study concludes that achieving sustainable irrigation in Indonesia requires a collaborative strategy that integrates government agencies, local communities, private sector involvement, and non-governmental organizations. A more holistic and participatory approach in planning, implementation, and evaluation processes is crucial to overcoming these obstacles. Such integrative efforts will be vital for strengthening agricultural resilience and ensuring national food security.

Keywords: sustainable irrigation, implementation constraints, agriculture, qualitative analysis

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INTRODUCTION

Sustainable irrigation is a prerequisite for increasing agricultural productivity while maintaining long-term food security. Reliable water supply reduces the risk of crop failure, minimizes yield volatility and opens up opportunities for the adoption of water-efficient cultivation practices such as irrigation scheduling and more precise water table management. Recent studies on Indonesian rice irrigation systems confirm that modernization and sustainable management-including infrastructure, operations and maintenance (O&M), and participatory governance-are correlated with increased yields and water use efficiency (Tirtalistyani et al., 2022). Indonesia's context as an agricultural country makes irrigation the backbone of national rice production. The latest BPS data shows that in 2024, the rice harvest area will be around 10.05 million hectares with a production of 53.14 million tons of GKG; this dynamic shows the sensitivity of production to water availability and the efficiency of irrigation networks (BPS, 2025). Climate change-through seasonal shifts, El Niño/La Niña events, and extreme events-increases the

uncertainty of water supply, increasing the urgency of strengthening sustainable irrigation (Ansari et al., 2023).

Land degradation and land use change complicate water management. Conversion of paddy fields, channel sedimentation and structural damage reduce service capacity, increase water losses and decrease distribution efficiency. Tirtalistyani et al. (2022) highlighted the high proportion of network damage that has a direct impact on water service reliability, making rehabilitation and preventive maintenance programs crucial for sustainability. In terms of institutions and policies, effective irrigation governance demands multi-actor collaboration-central-regional governments, river basins, village governments, and water user farmer associations. Recent evidence shows that mutual cooperation norms and local participatory practices can strengthen system performance, but require institutional design that is in line with local social- ecological dynamics (Paramita et al., 2023).

Field facts show that some irrigation projects have not achieved performance targets due to technical constraints such as damage to primary-secondary-tertiary channels, siltation, leakage, and limited O&M. These conditions are often exacerbated by mismatches between design, institutional management capacity, and rapidly changing cropping patterns (Tirtalistyani et al., 2022). Thus, project effectiveness is not only determined by initial construction, but by the asset life cycle and O&M capacity. Funding constraints remain dominant-especially for routine and long-term O&M. Financing gaps cause rehabilitation backlogs and reduce the reliability of water services to downstream rice plots. The experience of irrigation modernization programs in Indonesia shows the need for more flexible and accountable financing models to maintain post-construction service performance (World Bank, 2024).

Inter-agency coordination is often a bottleneck. The Ministry of PUPR through the Directorate General of Natural Resources manages the central authority network, while the provincial/village district authorities manage the secondary-tertiary network and field operations. Without solid spatial-institutional coordination, there is a gap between capacity building upstream and distribution reliability downstream (Ministry of PUPR, 2024). Community acceptance and participation are key factors. Recent studies have shown that variations in P3A/GP3A/IP3A functioning are influenced by clarity of rights/obligations, transparency of decision-making, and perceived benefits. When substantive participation is achieved- through village musrenbang, cropping agreements and water sharing-service performance tends to improve (Akbar et al., 2020; Paramita et al., 2023).

Recent national data signals the importance of accelerating rehabilitation and efficiency. The Ministry of Agriculture reported that the achievement of Tertiary Irrigation Network Rehabilitation (RJIT) in 2023 reached ± 928 thousand ha, albeit down from 2022-signaling financing and implementation challenges at the site level (MOA, 2024). On the other hand, the handbook of the Ministry of PUPR (2024) summarizes the national irrigation area and the portion of authority, showing the large scale of the system that needs to be maintained (Ministry of PUPR, 2024). From an agronomic perspective, increasing productivity is not just about varieties and fertilizers, but also water productivity. Experimental and applied evidence confirms that network improvements, irrigation scheduling and water management techniques (e.g. AWD) can increase yield and water use efficiency without reducing productivity (Nabipour et al., 2024; Tirtalistyani et al., 2022).

The dimension of environmental sustainability cannot be ignored. More water-efficient water management has the potential to reduce wetland methane emissions - an important co-benefit in the agriculture sector's carbon-neutral target - while maintaining yields when applied in the local context (Tirtalistyani et al., 2022). This requires project designs that integrate environmental indicators alongside technical and economic indicators. Performance inequalities between regions-especially between Java and outside Java-reflect differences in infrastructure, institutional capacity and access to services. Studies of the technical efficiency of rice farming on irrigated land in Indonesia show significant room for improvement in input management, including water,

across locations and growing seasons (Sumaryanto et al., 2023). Thus, constraint analysis needs to be sensitive to spatial and institutional variations.

At the project level, various non-technical factors-such as land delays, conflicts over customary irrigation norms, and inter-program coordination-often explain why construction outputs do not automatically become service outcomes. Lessons from local participation cases in Karangasem (Bali) emphasize the importance of aligning technical design and local social institutions for sustainability (Scott Jansing et al., 2020). Given the above context, this research focuses on identifying and analyzing the technical, social, economic and policy constraints to the implementation of sustainable irrigation projects in Indonesia's agricultural regions. Specifically, the study will map: (1) technical/O&M constraints on water channels and structures; (2) financing and budget governance constraints; (3) intergovernmental coordination dynamics; and (4) community acceptance/participation factors that affect service sustainability.

Scientifically and practically, this research is expected to contribute to the formulation of project and policy design recommendations: strengthening risk-based O&M, financing schemes that maintain asset life cycles, operational cross-government coordination mechanisms, and farmer participation models rooted in local practices. The success of these efforts is measured by the alignment between construction output targets and measurable water service outcomes on system productivity, resilience, and sustainability (BPS, 2025; MOA, 2024; Ministry of PUPR, 2024).

THEORETICAL FRAMEWORK

Sustainable Livelihood Framework (SLF)

The Sustainable Livelihood Framework (SLF) is used to analyze how farming communities utilize their capital or assets - including human, social, physical, financial and natural capital - to achieve economic, social and environmental resilience in a sustainable manner. In the context of sustainable irrigation in Indonesia, SLF helps understand the extent to which irrigation projects increase agricultural productivity, improve farmers' access to markets and technology, and strengthen their resilience to risks such as climate change and price fluctuations (Reed & Fazey, 2021). SLF promotes a holistic approach by taking into account the vulnerability context, institutional structures and the synthesizing aspects of community assets.

Stakeholder Theory

Stakeholder Theory helps map and understand the roles and interests of the actors involved in the implementation of sustainable irrigation projects. This theory emphasizes that interactions and legitimacy between stakeholders-such as central and local governments, farmers, NGOs, private sector technology providers, and donor agencies-are crucial to successful implementation. With this approach, analysis can map potential conflicts of interest, detect vulnerable or marginalized groups, and strengthen communication, collaboration and accountability throughout the project cycle (Dedeurwaerdere, 2020; Khoiriyah et al., 2023).

METHOD

This research used a descriptive qualitative approach to explore in depth the constraints faced in the implementation of sustainable irrigation projects in Indonesian agricultural areas. The qualitative approach was chosen because it is able to reveal the meanings, perceptions and subjective experiences of stakeholders directly involved in the project. The main focus of this research is on understanding the context, social interactions, and factors that influence the success or failure of the implementation of sustainable irrigation projects. The research locations were determined purposively in three agricultural areas that have different characteristics, namely Central Java, South Sulawesi, and West Nusa Tenggara. Central Java was chosen because it is a food production center with a fairly extensive irrigation network, South Sulawesi represents an area with a high dependence on irrigation for rice and horticulture, while West Nusa Tenggara was chosen because it faces the challenge of limited water resources. This variety of

locations is expected to provide a more comprehensive picture of the constraints faced in various geographical contexts.

The research subjects consisted of various stakeholders directly related to the implementation of sustainable irrigation projects. They include farmers who are members of the Water User Farmers Association (P3A), project implementation contractors, officials of the local Public Works Office or Agriculture Office, and community leaders who have a role in water management. The selection of informants was done using purposive sampling technique based on the criteria of their direct involvement and knowledge of the planning, implementation and evaluation process of irrigation projects. Data collection was done through three main techniques: in-depth interviews, focus group discussions (FGDs) and field observations. In-depth interviews were used to obtain detailed information on individual experiences, FGDs were conducted to facilitate discussions and identify common problems, while field observations aimed to record the real conditions of irrigation infrastructure and operational processes. Documentation in the form of photographs, irrigation network maps, and project technical reports were also used to enrich the data.

In addition, observation sheets were used to record field findings related to the physical and operational conditions of the irrigation system. Data were analyzed using thematic analysis using the Miles and Huberman model, which includes three main stages: data reduction, data presentation, and conclusion drawing/verification. In the data reduction stage, researchers filtered relevant information from interview transcripts, FGD notes and observation results. The reduced data was then presented in the form of a matrix or thematic chart to facilitate pattern identification. The final stage was conclusion drawing by considering the interrelationships between themes and confirmation through triangulation.

Data validity was maintained through source triangulation (comparison of information from various informants) and method triangulation (interviews, FGDs, observations). Researchers also conducted member checking by confirming the findings with informants to ensure accuracy of interpretation. Ethical aspects were maintained by asking for voluntary participation, maintaining the confidentiality of informants' identities, and using the data only for academic purposes. The research process was conducted in a way that did not interfere with the informants' normal activities and respected the local wisdom in the research area.

The research methods used in this study were designed to provide a comprehensive picture of the constraints to the implementation of sustainable irrigation projects in Indonesia's agricultural areas. A descriptive qualitative approach was chosen because it allows researchers to explore in depth the perceptions, experiences and dynamics of interactions between various stakeholders. To facilitate the presentation of the method, the study is presented in the form of a table containing the research indicators, an analysis of the anticipated problems, as well as a detailed description of the implementation. This table aims to provide methodological transparency and make it easier for readers to understand the research steps systematically.

Table 1. Research Methodology Design

Indicators	Problem Analysis	Description
Research Approach	Requires a method that can explore the meaning and experience of the research subject.	Using a descriptive qualitative approach to deeply understand the constraints of sustainable irrigation project implementation through narrative data from stakeholders.
Research Location	Geographical variations affect the types of constraints that arise.	Locations were determined purposively in Central Java, South Sulawesi and NTB to represent differences in climate, water resources and socio-economic conditions.

Research Subjects	Informants who understand the process of planning to project evaluation are required.	The research subjects include P3A farmers, project contractors, officials of the Public Works Agency/Agriculture Agency, and community leaders who are directly involved in irrigation management.
Data Collection Technique	A single data source has the potential to cause bias.	Using in-depth interviews, FGDs, field observations, and documentation to obtain comprehensive and complementary data.
Research Instruments	Tools are needed to maintain the focus of data collection.	The main instrument was the researcher with the help of semi-structured interview guidelines and observation sheets covering technical, social, economic and irrigation policy topics.

The presentation of the methods in the form of a table shows that this research does not only focus on the technical aspects of data collection, but also considers variations in geographical context, diversity of informants, and validity of findings. The combination of in-depth interviews, FGDs, observation and documentation is expected to produce rich and in-depth data. In addition, the application of triangulation and the principles of research ethics are key to ensuring that the results obtained are reliable and relevant for policy development and practice in the field. Thus, the designed method is expected to be able to comprehensively reveal the various barriers that affect the successful implementation of sustainable irrigation projects in Indonesia.

FINDING AND DISCUSSION

Based on the results of thematic analysis using the Miles and Huberman model, four main themes were found as obstacles to the implementation of sustainable irrigation projects in Indonesian agricultural areas. The first theme is technical constraints, which include low construction quality, leaking irrigation channels, rapid sedimentation, and delays in project completion. These findings were obtained from interviews with farmers and contractors, who mentioned that the use of substandard materials was often the cause of early failure, while poor technical planning resulted in delays.

The second theme is social constraints, which include conflicts between farmers over water distribution, low participation in maintenance, and resistance to the application of new technologies. Data from FGDs showed that conflicts over water distribution often escalate during the dry season, while low collective awareness hampers infrastructure maintenance. Resistance to water-saving irrigation technologies also emerged, mainly because they were perceived as complicated and requiring new skills.

The third and fourth themes were economic constraints and policy constraints. Economic constraints include limited budgets, high maintenance costs and farmers' dependence on government subsidies. Meanwhile, policy constraints include weak inter-agency coordination, regulatory inconsistencies, and changing political priorities that result in unsustainable projects. This shows that the success of sustainable irrigation projects is not only determined by technical aspects, but also requires consistent social, economic and policy support.

Table 2. Thematics Analysis Results

Theme Constraints	Data Code	Narrative of Findings
Technical Constraints	Poor construction, leaking channels, rapid sedimentation, delays in project completion	It was found that the quality of construction in some locations was low due to the use of non-standard materials. Channels leak in a short time, sedimentation impedes water flow, and projects are often behind schedule

Social Constraints	Conflict between farmers, low participation, resistance to new technology	Farmers often dispute over water distribution, especially during the dry season. Participation in joint maintenance is low. Introduction of water- saving irrigation technologies is resisted as they are considered difficult to use.
Economic constraints	Limited budget, high maintenance costs, subsidy dependency	Limited funds hamper routine maintenance. Repair costs of modern irrigation components are relatively high, discouraging farmers from using them without government assistance.
Policy Constraints	Weak coordination, inconsistent regulations, changing political priorities	Coordination between agencies (Public Works, Agriculture, Local Government) is often not synchronized. Policies sometimes change following a change of regional head, causing the program to be unsustainable.

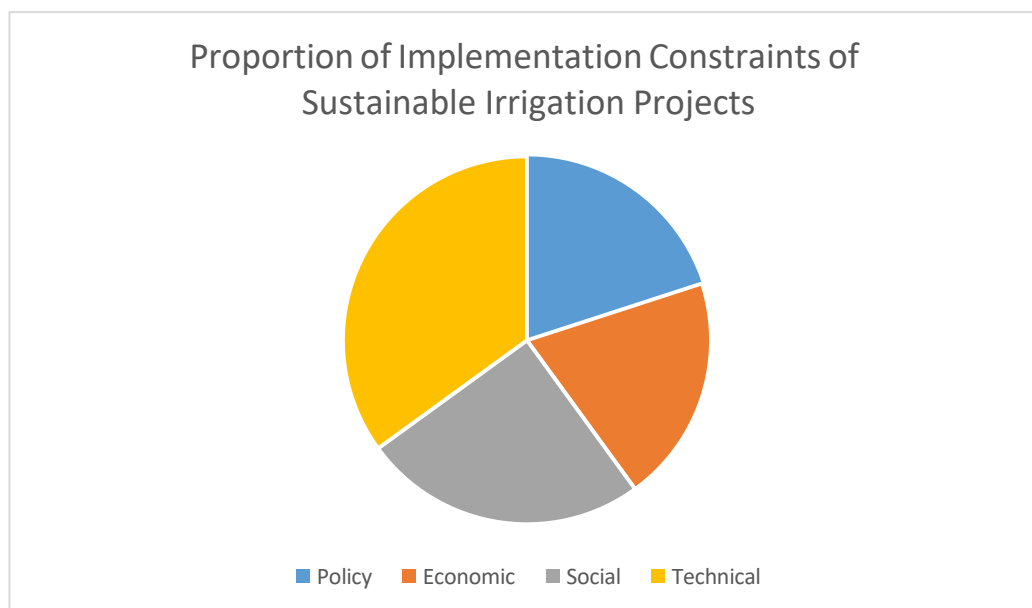


Figure 1: Proportion of Sustainable Irrigation Project Constraints

The proportion of constraints graph shows that technical constraints are the most frequently mentioned by informants, with a percentage of 35%. This indicates that construction quality, maintenance and timeliness of project completion are still major problems that need to be addressed immediately. This proportion is in line with field observations, where many irrigation channels were damaged within a short time after the project was completed.

Social constraints came in second with a proportion of 25%, indicating that factors such as farmer- to-farmer relations, participatory awareness, and acceptance of new technologies play an important role in project success. Although not as large as technical constraints, social aspects have the potential to become a major obstacle if not managed well, especially in areas with complex community dynamics and limited water distribution.

Economic and policy constraints have the same proportion, at 20% each. This shows that although financial and policy factors do not dominate, they still significantly affect project sustainability. Economic constraints mainly relate to the availability of funds for maintenance, while policy constraints arise from regulatory inconsistencies and weak cross-sector coordination. The combination of these four factors illustrates that problem solving requires an integrated approach involving technical, social, economic and policy aspects simultaneously.

1. Dominance of Technical Constraints in Project Sustainability

Technical constraints occupy the highest proportion (35%) in influencing the sustainability of irrigation projects. This shows that construction quality, material selection, and labor skills are crucial factors. Many cases of early damage to irrigation networks are due to weak construction supervision, low quality of materials, and lack of routine maintenance (Wahyuni & Hidayat, 2021). Technical improvements can be made by training field operators, applying sensor technology for monitoring water discharge, and setting stricter construction standards (Fitria & Pramono, 2022). On the other hand, global climate change is worsening the condition of irrigation infrastructure due to increased frequency of floods and droughts, so technical solutions must be combined with adaptive strategies (Hanjra & Qureshi, 2020). Thus, the dominance of technical constraints is a major concern in maintaining irrigation sustainability.

2. Social Factors as Determinants of Water Management Effectiveness

In addition to technical aspects, social factors also determine the success of irrigation management. Water distribution conflicts, low participation of farmers in management groups, and differences in interests between land users often hamper the effectiveness of irrigation (Roidah & Purnomo, 2020). Because irrigation is a *common pool resource*, its success is highly dependent on the level of cooperation, collective rules, and a sense of justice in water distribution (Susanto & Nurrochmat, 2021). Farmer participation in local institutions such as P3A has been shown to increase ownership and responsibility, resulting in more sustainable management (Nugroho & Subejo, 2022). This shows that technical intervention alone is not enough, but must be accompanied by strengthening social capacity. Thus, participatory approaches are a key strategy to improve the effectiveness of water management.

3. Economic Constraints Limit Maintenance Capacity

Economic factors also provide significant barriers to irrigation sustainability. Budget limitations, high operational costs, and dependence on government subsidies are the main problems (Hermanto & Astuti, 2020). If fiscal policy changes, the sustainability of irrigation is threatened due to the lack of funding allocation for maintenance. Meanwhile, farmers' economic limitations cause their financial contribution to irrigation network maintenance to remain low (Setiawan & Wardhana, 2023). An alternative solution is the implementation of joint financing schemes, for example through *public-private partnerships* that are able to guarantee the availability of long-term funds (Purwanto & Rahmawati, 2021). With innovations in financing, the sustainability of infrastructure maintenance can be better ensured. Therefore, economic factors need to be addressed with a collaborative and innovative approach.

4. Policy Inconsistency and Inter-Agency Coordination

The sustainability of irrigation projects is also often constrained by policy factors. Regulatory inconsistencies, changing political priorities, and weak coordination between agencies lead to overlapping programs and budget inefficiencies (Rochman & Widianingsih, 2020). This problem is exacerbated by weak monitoring and evaluation mechanisms, so that the achievement of development targets is often not maximized. Cross-sector coordination and policy harmonization between levels of government are urgently needed (Arifin & Hadi, 2021). Previous research has shown that synergy between agencies can improve the effectiveness of water resources management, especially on a regional scale (Lassa & Nugroho, 2022). Therefore, policy consistency and strengthening institutional coordination are key factors in supporting the sustainability of irrigation projects.

5. Need for a Multi-aspect Integrated Approach

The analysis shows that technical, social, economic and policy constraints interact with each other and cannot be solved partially. An integrated approach involving technological innovation, strengthening local institutions, diversifying financing, and policy consistency is needed to achieve sustainability (Saptanto & Darwis, 2020). In addition, environmental aspects such as water resource conservation and climate change adaptation must also be integrated in planning (Adrianto & Subekti, 2021). Thus, a multi-faceted approach can increase the resilience of

irrigation to long-term challenges, both technical and nontechnical (Darmawan & Suryani, 2023). This overall strategy will provide a strong foundation for the development of sustainable irrigation in Indonesia.

CONCLUSIONS

The conclusion of this study shows that the implementation of sustainable irrigation projects in Indonesia faces a variety of complex challenges, both in terms of technical, institutional, and socio-economic. The obstacles found are not only related to the limitations of infrastructure and technology, but also to the capacity of human resources and management systems that have not been optimized. This condition causes many irrigation projects to not be able to provide results in accordance with the initial objectives, namely increasing agricultural productivity in a sustainable manner. In addition, financing constraints are also a major factor hindering the effectiveness of irrigation projects. Budget limitations, dependence on government funding, and lack of private sector participation have created a gap between development needs and realization. This has an impact on the slow pace of repairing damaged irrigation networks and building new infrastructure needed by the farming community. On the social side, the low level of community participation in irrigation planning, management and maintenance is also a serious challenge. There are still many farmers who have not been actively involved in decision-making, so the level of concern for irrigation sustainability tends to be low. This condition is exacerbated by the weakness of local institutions that should play an important role in regulating water distribution in a fair and efficient manner.

The results also confirm that the success of sustainable irrigation projects depends on the synergy between government policies, institutional support, appropriate technology and active community involvement. Without good coordination among stakeholders, irrigation projects are unlikely to achieve their goals optimally. Therefore, a collaborative and participatory approach is key in addressing irrigation challenges in Indonesia. Considering these findings, this study recommends the need for more integrated planning, innovation in environmentally friendly irrigation technology, and strengthening local institutional capacity. In addition, increasing community participation in every stage of the project needs to be encouraged so that the sustainability of the irrigation system is truly maintained. With these steps, sustainable irrigation is expected to become an important pillar in supporting national food security and farmers' welfare in the future.

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