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Waste Pollution in Irrigation Channels: A Stakeholder Engagement Perspective from Simpang Tiga, Aceh Besar

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ABSTRACT

This study aims to analyze stakeholder collaboration in managing irrigation waste in Simpang Tiga Subdistrict, Aceh Besar Regency. Using a descriptive qualitative approach, data were collected through in-depth interviews, observations, and document analyses. These findings indicate the active involvement of the Environmental Agency, Water Resources Agency, NGOs, and local communities in waste management. This collaboration reflects a multi-stakeholder approach, which is essential for addressing complex environmental issues. However, challenges, such as low public awareness and limited funding, continue to hinder their effectiveness. This study recommends a more systemic collaborative approach, strengthened environmental education, and the inclusion of vulnerable groups to support sustainable and inclusive irrigation governance.

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INTRODUCTION

Waste pollution in irrigation channels has become an increasingly urgent environmental issue, particularly in the rapidly developing agricultural areas. This problem has serious implications for food security, ecosystem health, and community well-being, especially in regions that rely heavily on irrigation systems for daily life. One such affected area is the Simpang Tiga Subdistrict in Aceh Besar Regency, where irrigation channels play a vital role in supporting agricultural productivity and the local economy.

Pollution in irrigation channels can originate from various sources, including household waste and unsustainable agricultural practices. According to Government Regulation Number 27 of 2020 on the Management of Specific Waste, irrigation waste is categorized as domestic waste, excluding fecal matter and hazardous waste. The practice of dumping waste into irrigation channels is common in many areas. This behavior results in clogged waterways, unpleasant odors, and increased risks of flooding and ecosystem degradation. Waste production in Aceh Besar Regency is expected to increase by 6% by 2024, reaching a total of 36,461 tons compared to the previous year (Aceh Besar Environmental Agency, 2024). This increase in waste volume has also affected irrigation channels, particularly in the Simpang Tiga Subdistrict. Improper disposal of waste into irrigation canals leads to water pollution, degradation of soil quality, and disruption of rice crop yields. Irrigation systems often become clogged because of the accumulation of waste materials, such as plastic, food residues, and other organic matter.

In addition to domestic waste, pollution is exacerbated by excessive use of synthetic fertilizers and pesticides in farming practices. Previous studies have shown that compounds from fertilizers, such as nitrogen and phosphorus, can contaminate water sources and trigger eutrophication (Band et al., 2020; Shi et al., 2020). Moreover, contamination by heavy metals and pathogenic microorganisms, such as *Salmonella,* poses serious threats to food safety and public health (Hassani et al., 2023; Muhammad et al., 2021).

Addressing irrigation pollution requires a holistic approach that goes beyond technical solutions and includes both social and institutional dimensions. Several studies have highlighted that the active involvement of diverse stakeholders, including farmers, local governments, community members, the private sector, and environmental organizations, is key to sustainable water resource management (Starkl et al., 2015). In the local context, Aceh Besar Regency enacted Regional Regulation (Qanun) No. 7 of 2022 on irrigation, which emphasizes the importance of cross-sectoral collaboration in all stages of irrigation management, from problem identification to solution implementation.

Technological advancements such as wireless sensor networks for water quality monitoring can support the early detection of pollution and facilitate data-driven decision-making (Lin et al., 2020). Meanwhile, public education strategies and environmental awareness campaigns are critical instruments for encouraging behavioral change and enhancing community ownership of irrigation management programs (Yadav et al., 2016).

Supportive policies and institutional frameworks, including incentives for environmentally friendly practices and sanctions for violators, are essential for strengthening accountability and management effectiveness (Costa et al., 2017;

Özerol & Bressers, 2017). However, challenges, such as limited capacity, conflicting interests, and power imbalances, often hinder optimal stakeholder engagement. Therefore, participatory platforms are needed to bridge these differences, build trust, and foster long-term collaboration (Alsinjari, 2024).

Given this context, this study aims to explore the dynamics of stakeholder engagement in managing irrigation waste pollution in Simpang Tiga and Aceh Besar. This research is expected to contribute to the development of participatory and contextually grounded environmental governance approaches and enrich the literature on sustainable irrigation management in developing regions.

LITERATURE REVIEW

Waste pollution in irrigation systems has become a critical global issue, particularly in relation to the agricultural sector and environmental sustainability. The growing reliance on wastewater for irrigation, particularly in regions with limited access to clean water, presents both opportunities and risks. This study examined the role of stakeholder engagement in addressing solid waste disposal in irrigation channels, emphasizing the importance of cross-sector collaboration. Numerous studies have shown that effective waste management depends heavily on the active involvement of diverse actors, including governments, the private sector, civil society organizations, and local communities.

Stakeholder engagement is crucial for balancing agricultural productivity and environmental protection. In many developing countries, the use of untreated wastewater for irrigation is common because of the scarcity of clean water. Although this practice can boost crop yields, it also contributes to environmental degradation and poses significant health risks (Evers et al., 2010; Li et al., 2016; Zayd & Said, 2016). For example, research conducted in Khartoum, Sudan, found that irrigation with wastewater led to the accumulation of heavy metals in soil, which can be absorbed by crops, potentially harming human health and disrupting the ecosystem balance (Negim & Moursy, 2023). These findings highlight the urgent need for stakeholders to develop safe, sustainable irrigation policies.

Furthermore, stakeholders play a pivotal role in designing innovative solutions to mitigate the negative impact of irrigation pollution. Community-based approaches have proven to be effective in improving the quality of irrigation water. In Karanganyar, Indonesia, participatory dialogues between water user groups and local government officials resulted in practical recommendations, such as stricter water quality monitoring and routine maintenance of irrigation channels (Rustinsyah & Prasetyo, 2019; Suminar et al., 2023). These studies demonstrate that open and collaborative communication can lead to more inclusive and sustainable solutions.

Stakeholder engagement has also been instrumental in promoting the adoption of improved wastewater treatment technologies. The implementation of systems such as sedimentation ponds, decentralized sanitation systems, and integrated water treatment facilities has shown potential in reducing irrigation water pollution (Hagenvoort et al., 2019). Countries like Spain have successfully

integrated wastewater recycling into irrigation practices, not only conserving clean water but also enhancing water cycle efficiency. This success is largely attributed to the active participation of local governments, private sector actors, and academic institutions in building adaptive and effective systems.

From a policy perspective, evidence-based approaches have been shown to improve the effectiveness of irrigation waste management. Stakeholder participation—including environmental experts, scientists, and community representatives—in policy development processes leads to more practical and publicly accepted technical guidelines (Umar Hayat et al., 2015). Stakeholders can also play a critical role in ensuring the establishment of clear and implementable water quality standards in irrigation practices.

Addressing irrigation waste pollution requires a comprehensive, cross-sectoral, and collaborative approach. The involvement of a single stakeholder group is insufficient to achieve optimal outcomes. The literature consistently shows that successful irrigation waste management depends on multistakeholder partnerships that integrate technical, social, and institutional dimensions. Such collaborative efforts form the foundation for building sustainable irrigation systems and ensuring the long-term health and well-being of communities.

METHODOLOGY

This study employed a qualitative approach to gain an in-depth understanding of stakeholder engagement in addressing waste pollution in irrigation systems, specifically in the Simpang Tiga Subdistrict, Aceh Besar District. This approach was chosen for its capacity to comprehensively uncover social dynamics, interactor interactions, and policy contexts (Creswell & Creswell, 2018). The research was conducted in Simpang Tiga Subdistrict, Aceh Besar District, Aceh Province. This location was selected purposively because of the ongoing cases of waste pollution in irrigation channels, which have had direct impacts on local agriculture and public health. Data collection took place over a two-month period from November to December 2024.

Informants were selected purposively based on their level of direct involvement and capacity in matters related to waste management and irrigation systems in the study area. The primary informants included representatives from three key stakeholder groups: (1) government agencies, namely, the Environmental Agency of Aceh Besar District and the Water Resources Agency of Aceh Besar District; (2) a non-governmental organization, Sahabat Hijau, representing the civil society sector; and (3) local community representatives directly affected by pollution. Each informant plays a strategic role in policy formulation, program implementation, and environmental advocacy efforts in the Simpang Tiga Subdistrict.

Data collection techniques included observations, in-depth interviews, and document analysis. Observations were conducted through direct inspection of the physical condition of irrigation channels, surrounding community activities, and potential sources of pollution to gain contextual understanding and up-to-date field visualization. In-depth semi-structured interviews were

conducted with key informants to explore their perceptions, roles, challenges, and forms of collaboration in addressing irrigation waste. The interview guide was developed on the basis of predetermined research themes. Document analysis involved gathering secondary data from various official sources, such as agency annual reports, minutes of coordination meetings, environmental policy planning documents, and relevant publications from NGOs and local governments, to validate and complement the data obtained through observation and interviews.

The collected data were analyzed thematically by following the stages of data reduction, data display, and conclusion drawing (Miles, Huberman, & Saldaña, 2014). The analysis was conducted iteratively and reflectively to identify patterns, relationships, and meanings within the field findings. Data validity was ensured through the triangulation of sources and methods.

RESULTS AND DISCUSSION

Stakeholders in Irrigation Waste Management

This study found the active involvement of various stakeholders in addressing irrigation waste pollution in Simpang Tiga Subdistrict, Aceh Besar District. The key stakeholders identified included the Environmental Agency of Aceh Besar District, the Water Resources Agency, the NGO *Sahabat Hijau*, and local community members. This inter-stakeholder collaboration reflects a multi-stakeholder approach that is essential for tackling complex environmental issues with direct implications for the sustainability of agricultural irrigation systems.

These findings are consistent with the existing literature, highlighting that irrigation waste management is a multifaceted issue, involving the interaction between urban wastewater systems and agricultural water use. (Dellavia et al., 2023) emphasized the importance of integrating wastewater reuse into water planning and management, particularly for crop irrigation. However, stakeholder analyses often reveal overlapping authorities and conflicts of interest among actors, which hinders management effectiveness (Jumiati et al., 2018).

Conventional approaches tend to overlook farmers as primary actors, even though their participation in wastewater management systems can significantly enhance the effectiveness of interventions (Evers et al., 2010). However, financing remains a major challenge. As noted by (Starkl et al., 2015), while full cost recovery from farmers and consumers is difficult to achieve, government support is critical since stakeholders often prioritize health and environmental concerns over economic costs.

In the local context of Aceh Besar, each actor plays a specific role, in line with its mandate and capacity to manage irrigation waste, as illustrated in Figure 1.

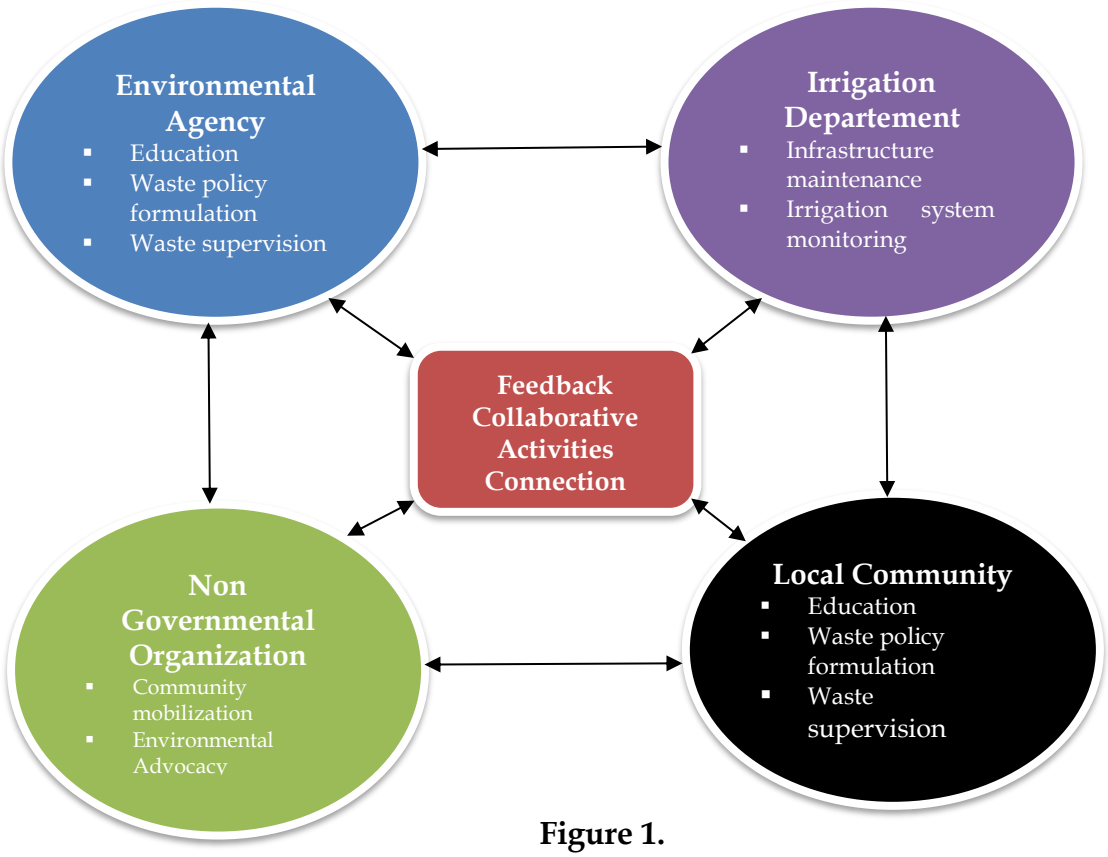

Figure 1.
The Role of Stakeholders in Handling Irrigation Waste

The Environmental Agency is responsible for policy formulation, implementation of public outreach, and provision of sanitation facilities**.** This agency also coordinates public education efforts regarding the importance of keeping irrigation channels free of domestic waste. The Water Resources Agency plays a technical role in infrastructure maintenance, identification of clog-prone areas, and channel cleaning. It also provides technical input for collaborative forums to support efficient and sustainable interventions.

The NGO *Sahabat Hijau* plays an educational and advocacy role by raising environmental awareness through community activities, training, focus group discussions (FGDs), and campaigns. The organization also acts as a bridge between the community and the government, voicing local needs and aspirations regarding environmental management. Meanwhile, local communities participate directly through on-the-ground actions, such as communal clean-ups of irrigation channels, monitoring illegal dumping behavior, and active involvement in outreach and educational programs organized by both the government and NGOs.

The forms of participation identified across these four actors include the following.

1. Infrastructure participation, such as the provision of trash bins and cleaning equipment
2. Outreach participation, either as organizers or active participants in public campaigns.

3. Labor participation, through mass clean-up efforts (gotong royong); and
4. Educational participation through dissemination of information and environmentally conscious waste management practices.

This synergy reinforces the notion that irrigation waste management cannot be addressed using a sectoral approach alone. The complexity of the issue and the overlapping mandates, as highlighted in the literature, further underscore the need for a collaborative approach and inclusive policy interventions. The complementary roles of the various actors form a critical foundation for achieving clean and sustainable irrigation management. Moreover, this emphasizes that environmental stewardship is a shared responsibility that requires the commitment and active involvement of all stakeholders.

Inhibiting Factors in Handling Irrigation Waste

Irrigation waste management in Simpang Tiga Subdistrict, Aceh Besar District, faces a range of interrelated challenges that hinder effective stakeholder collaboration. These barriers can be broadly categorized into three main dimensions.

1. Limited Knowledge, Skills, and Public Awareness
   One of the most significant barriers is the low level of environmental literacy of local residents. This limits their active participation in waste management efforts. Successful environmental participation often involves collaboration between local governments and non-profit organizations, as well as institutional commitment to public engagement (Kasymova & Gaynor, 2014).
   A lack of understanding of basic waste management principles, such as the 3Rs (Reduce, Reuse, Recycle), contributes to the continued practice of dumping waste into irrigation channels. Furthermore, the absence of formal and informal environmental education has resulted in limited awareness-based behavioral changes.
2. Budgetary and Operational Resource Constraints
   From an institutional perspective, waste management is highly dependent on the availability of fiscal and operational resources. Budget limitations at technical agencies restrict efforts such as procuring trash bins, maintaining heavy equipment for waste transport, and funding sanitation workers.
   In addition, budget allocations often fail to reflect actual field needs because of weak data-driven planning and lack of integration of environmental issues into regional development planning documents (RPJMD). As a result, irrigation waste remains a low priority for local development agendas.
3. Challenges in Implementing Outreach and Environmental Campaigns
   Environmental communication and educational strategies are facing serious obstacles. Outreach programs tend to be top-down and fail to consider the sociocultural context of the community, resulting in public messages that are neither fully received nor internalized.

The limited involvement of educational institutions, NGOs, and communication experts in designing campaign strategies further weaken the effectiveness of public messaging. Without participatory and locally grounded approaches, outreach efforts struggle to foster sustainable behavioral change.

CONCLUSION

This study reveals that the management of irrigation waste in Simpang Tiga Sub-district, Aceh Besar District, involves multiple stakeholders, each playing a role in accordance with their authority and capacity. The Environmental Agency and Water Resources Agency are responsible for implementing technical policies and managing infrastructure, while the non-governmental organization (NGO) *Sahabat Hijau* contributes through environmental advocacy and education. Local communities also play an important role in waste management practices at the grassroots level. Collaboration among these stakeholders includes participation in providing infrastructure and facilities, conducting public outreach, contributing to manpower, and supporting educational initiatives within the community.

However, the effectiveness of such collaboration is constrained by several significant challenges. These include a lack of public knowledge, skills, and awareness; limited operational budgets and facility availability; and insufficient implementation of environmental campaigns and socialization programs. These barriers are interconnected and reflect weaknesses in the social, financial, and institutional capacities of the local area.

To ensure sustainable irrigation waste management in Simpang Tiga, it is essential to strengthen cross-sectoral collaboration through community empowerment, development of innovative funding mechanisms, and formulation of evidence-based and participatory policies. A structured, continuous, and context-sensitive collaborative approach is the key to achieving clean, healthy, and sustainable irrigation governance at the community level.

RECOMMENDATION

Based on the findings of this study, it is recommended that irrigation waste management be approached through a systemic and cross-sectoral strategy, considering existing barriers related to social, fiscal, and institutional capacities. Accordingly, the following key strategies are proposed.

1. Enhancing environmental education and community empowerment by integrating relevant content into formal education curricula, providing community-based training, and utilizing local social networks as platforms for strengthening environmental literacy.
2. Developing a collaborative financing model that actively involves the government, private sector, and civil society to support infrastructure provision and ensure the sustainability of operational activities in irrigation waste management.
3. Implementing participatory and context-specific risk communication strategies that incorporate local cultural perspectives and engage

community groups directly as partners in the design and implementation of environmental awareness campaigns.

FURTHER STUDY

This study offers an initial understanding of the dynamics of stakeholder collaboration in managing irrigation waste in Simpang Tiga Subdistrict, Aceh Besar District. However, to enrich the body of scientific knowledge and support the development of more comprehensive policy recommendations, the following suggestions are proposed for future research.

1. Conducting quantitative or mixed-methods research. To complement the qualitative approach adopted in this study, future researchers should use quantitative or mixed-methods approaches. These methods would allow for a more objective and measurable assessment of the effectiveness of stakeholder collaboration, the level of community participation, and the impact of pollution on public health and the environment.
2. Expanding the Research Scope. Follow-up studies may be conducted in a broader geographical area, including several subdistricts or neighboring districts. This would facilitate contextual comparisons and identification of best practices that could be replicated in other regions.
3. Explore the perspectives of vulnerable groups. It is essential to further investigate the perspectives of vulnerable groupssuch as women, children, and small-scale farmersin the management of irrigation waste. This will contribute to the formulation of more inclusive and socially just policy recommendations.

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