INNOVATIVE SYMBIOTIC RICE–FISH COLLABORATION MODEL AS A CONFLICT RESOLUTION STRATEGY FOR WATER USERS IN THE KELINGI IRRIGATION AREA, INDONESIA

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Highlight

In Kelingi, South Sumatra, decades-long conflicts between rice farmers and fish farmers stem from water scarcity, weak and poorly enforced governance, and self-interested user behavior. A mixed-method case study recommends an integrated rice–fish symbiotic collaboration model to replace zero-sum competition with positive-sum benefits and stronger informal water governance.

Abstract

Limited water availability and competition in the Kelingi Irrigation Area (DI Kelingi), South Sumatra, Indonesia, have triggered prolonged conflicts for more than two decades between rice farmers and fish farmers. These conflicts reflect weak water governance, limited stakeholder participation, and inadequate water allocation mechanisms. The objective of this study is to develop an integrated water resource governance model for Kelingi. This research employs a mixed-method (qualitative and quantitative) case study approach, with data collected through field observations, in-depth interviews, and focus group discussions (FGDs) at locations actively experiencing water-use conflicts. Findings reveal that the roots of the conflict lie in water scarcity (water deficits during droughts), weak governance (non-adaptive regulations and poor enforcement), and user ethics issues (destructive behaviors and self-interest). Sectoral interventions have been ineffective because they are partial and unable to transform the "win–lose" (zero-sum game) relationship between the two water user groups. The study recommends a "rice–fish symbiotic collaboration model" based on integrated water governance, offering a comprehensive solution by shifting the paradigm from competition to collaboration, integrating the economic interests of both parties, and strengthening informal governance mechanisms.

Keywords

Water Conflict, Symbiotic Collaboration, Integrated Water Governance, Rice–Fish Irrigation System, Kelingi Irrigation Area.

Introduction

Water is a vital resource for food security and economic activities, yet increasing scarcity has intensified competition among users. In the Kelingi Irrigation Area of South Sumatra, this scarcity has triggered more than two decades of conflict between rice farmers and fish pond farmers. Originally built in 1941 to support rice cultivation, the irrigation system has since been used for intensive aquaculture, creating socio-ecological tensions due to differing water-use needs [1].

Conflicts over the use of water in irrigation areas still resurfaced, triggering even greater conflicts in 2010. The implication is that the pattern of water management for irrigation areas that have been formed is to build and then ignore, then rebuild and ignore, and so on [2]. This shows that there is a pattern of improper management in the water management of the Irrigation Area of Kelingi Tugumulyo. So that conflicts over the use of irrigation water still occur, and the planning and organizing process is not running. As shown in the following figure:

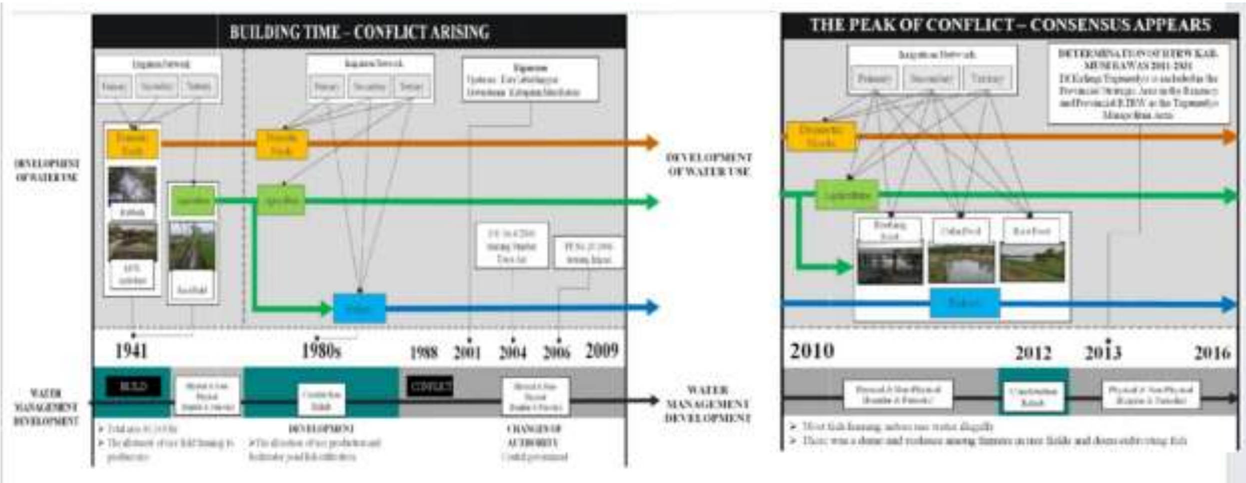

Figure 1: Development of Pattern and Conflict in Irrigation Area Water Utilization Period of Establishment Until Conflict Appears and Pattern and Conflict of Utilization in Irrigation Areas: The Peak Period of Conflict Until Consensus Appears
Source: Firma Rizki, Doddy Aditya Iskandar ICOSEAT 2023

These competing demands become critical during the dry season, when limited water availability cannot satisfy both sectors simultaneously. Climate change, land-use intensification, and illegal water extraction further worsen the situation, reducing irrigation reliability and heightening competition. The conflict has grown into a complex institutional and socio-economic problem characterized by weak governance, limited stakeholder participation, and inadequate allocation mechanisms. Government responses have been mostly technical and reactive, failing to address underlying governance issues or foster cooperation between farmers [3]. Therefore, an integrated and symbiotic collaboration model is necessary, one that strengthens institutions, enhances adaptive capacity, improves infrastructure, and supports appropriate technologies.

This study aims to develop a comprehensive integrated water resource governance model for the Kelingi Irrigation Area to promote sustainable water sharing and provide a strong foundation for policymaking at local and regional levels. This study originates from a fundamental problem concerning water-use conflicts between rice farmers and fish farmers in the Kelingi Irrigation Area [4]. These conflicts stem from an imbalance in water distribution, exacerbated by deteriorating irrigation infrastructure, illegal water extraction, weak institutional capacity, and the absence of a collaborative mechanism capable of reconciling the interests of the two sectors. In response, this research formulates a “paddy–fish symbiosis collaboration model” as an alternative solution that not only reduces conflict but also enhances the efficiency of water distribution and improves the economic well-being of both sectors simultaneously [5].

To build this model, the study poses the central question: *How do water-use conflicts between rice farmers and fish farmers unfold in the Kelingi Irrigation Area, and what factors constitute their root causes?* This question is followed by an exploration of how irrigation infrastructure, formal and informal rules, user behavior, and socio-economic conditions contribute to the tensions that arise. The study also investigates the extent to which a symbiotic collaboration model has the potential to improve water governance, increase distribution efficiency, and create more constructive relationships between user groups [6].

To address these questions, the study proposes the hypothesis that the paddy–fish symbiosis collaboration model will produce a significant improvement in water distribution efficiency while simultaneously reducing conflict when compared to existing sectoral approaches. The study also tests several subsidiary hypotheses: that irrigation network deterioration significantly decreases distribution efficiency; that illegal water extraction increases the likelihood of conflict; that weak rule enforcement and institutional fragility worsen relations among users; and that strong institutional participation contributes positively to the success of integrated water governance. Furthermore, the study assumes that if the collaboration model is implemented, rice and fish productivity can increase simultaneously, creating a positive-sum outcome [7].

The conceptual framework of the study illustrates that conflict intensity and water distribution efficiency are influenced by a series of interrelated factors: water scarcity, infrastructure deterioration, user behavior, and institutional governance. These four factors do not operate in isolation; rather, they reinforce one another, producing distributional imbalances that trigger conflict. Damaged infrastructure leads to unstable water flows, sedimentation reduces channel capacity, and dysfunctional control gates weaken discharge regulation [8]. Under these conditions, behaviors such as illegal water extraction or the construction of unauthorized weirs become more frequent, particularly in the aquaculture sector. When governance and enforcement are weak, such actions go unchecked and create unfair disadvantages for downstream rice farmers. Meanwhile, fish farmers have strong economic interests in maintaining a stable water supply, which often positions them as the dominant user group [9].

The framework then positions the symbiotic collaboration model as an intervention capable of breaking the causal chain of conflict. By integrating the water needs of rice and fish farming, aligning planting schedules and pond-filling cycles, strengthening informal norms, rehabilitating critical infrastructure, and establishing negotiation and joint monitoring forums, the model aims to restructure inter-sectoral relations into a more cooperative and mutually supportive form. As a result, water distribution can become more efficient, non-compliant behavior can be reduced, and conflict can be mitigated structurally. To explain the expected process of change, the study develops a structured Theory of Change. This theory begins with the premise that the root problems lie in water deficits, damaged irrigation infrastructure, uncontrolled water extraction behavior, and weak governance. From this initial condition, the study assumes that change can only occur if the two sectors are brought together through a clear collaborative mechanism, informal rules are strengthened, and water allocation decisions are negotiated based on data. In addition, the support of local institutions and government agencies is considered essential.

Through a series of inputs—such as water-demand data, policy support, institutional capacity, and facilitation processes—the collaboration model is operationalized. Key activities include spatio-temporal mapping of water needs, the establishment of coordination forums, the formulation of water-use agreements, the rehabilitation of key channels, and the application of incentive–disincentive systems. These activities are expected to produce outputs such as a collaboration protocol, joint water allocation schedules, a permanent coordination forum, and a more transparent discharge-monitoring mechanism. In the medium term, these outputs are expected to generate more equitable water distribution, increased compliance, reduced illegal extraction, improved social relations, and higher rice and fish productivity. Ultimately, the anticipated long-term impacts include the sustained reduction of conflict, the emergence of integrated and adaptive water governance, and the development of a water-use system that enhances food security and economic well-being in the Kelingi Irrigation Area.

Research Methodology

Based on the research problems formulated in the previous chapter, this study employs a mixed-methods design, combining qualitative and quantitative approaches. The use of a mixed-methods approach is intended to comprehensively answer the research questions. This design is adopted because the researcher seeks to obtain a more holistic understanding of the research issues. Through the qualitative method, the researcher aims to address questions related to the irrigation system, farming practices, fish pond aquaculture systems, farmer organizations, and fisheries organizations within the Kelingi–Tugumulyo Irrigation Area that are connected to irrigation water use. This method involves observing and documenting the behaviors and activities of individuals and groups in the research location. In addition, interviews are conducted using open-ended questions directed to selected informants. The qualitative approach is used to understand the behavioral system of the Kelingi–Tugumulyo community in managing irrigation water.

Through the quantitative method, the researcher aims to identify the most influential factors in irrigation water management for agriculture and aquaculture, allowing an assessment of irrigation water adequacy and the prevailing patterns of water use practiced by the local community. By integrating both qualitative and quantitative data, the study seeks to gain a comprehensive understanding of irrigation water management strategies as the basis for developing an optimal irrigation water allocation simulation model. This research is carried out in three stages. The first stage involves collecting secondary data related to irrigation network conditions, irrigation water availability, and irrigation service policies, including water distribution regulations. The second stage consists of gathering primary data related to the field conditions of the irrigation network, water availability, water distribution practices, responses from Water User Associations (P3A), and perceptions of rice farmers and fish pond farmers. The third stage involves data analysis to determine the root causes of conflict, identify alternative solutions, and formulate recommended policy options.

Expanded Methodology Narrative for the Study

To strengthen the methodological framework of the study on the proposed “paddy–fish symbiosis collaboration model” in the Kelingi Irrigation Area, this section provides a detailed narrative of the qualitative data collection design, interview structure, sampling techniques, FGD protocols, data analysis framework, and the operationalization of SWOT and fishbone diagrams. It also addresses the study’s current weaknesses regarding the limited discussion of reliability and validity procedures. This enriched methodological description aims to ensure the rigor, transparency, and credibility of the study. Number of Interviews, Types of Informants, and Sampling Techniques. The study is planned to incorporate 30–40 in-depth interviews, selected through a combination of *purposive sampling* and *snowball sampling*. Purposive sampling ensures that interviews include key actors directly involved in water use and irrigation governance, while snowball sampling enables access to informants who may be difficult to reach, such as unregistered or informal fishpond operators drawing water directly from irrigation channels.

Key Informant Categories Rice farmers (12–15 individuals) represent upstream, midstream, and downstream plots, allowing variations in water access, conflict perception, and adaptive strategies to be captured. Fish farmers (8–10 individuals), including operators of running-water (arus deras) and still-water ponds, especially those who extract water from the irrigation network formally or informally. Water user associations (P3A/GP3A/IP3A) leaders (3–5 individuals). To provide insight into local irrigation institutions, scheduling practices, and enforcement challenges. Public Works and Spatial Planning Office (2–3 officials). To explain technical conditions, infrastructure deterioration, and water allocation policies. Agriculture and Fisheries Departments (2–3 officials). To contextualize sectoral interests, production data, and programmatic interventions. Community leaders / former farmer group organizers (2–3 individuals). To provide historical context, social dynamics, and informal rules governing water use. Sampling Strategy is Purposive sampling for formal actors and institutional stakeholders. Snowball sampling for informal or hard-to-reach fish farmers. Stratified purposive sampling for rice farmers, based on their location along the irrigation network (upstream, midstream, downstream).

FGD Protocol, Number of Sessions, and Participant Composition

FGDs are designed to validate early findings, identify potential collaborative solutions, and co-develop the proposed symbiosis model. Number of FGD Sessions: A total of three sessions, each lasting 1.5–2 hours. FGD 1 Identifying the Root Causes of Water Conflict Participants: 10 individuals (mixed rice farmers and fish farmers). FGD 2 Exploring Solutions and Collaboration Options Participants 12 (P3A leaders, PU Office, Agriculture/Fisheries Offices, community figures). FGD 3 Validation of the Proposed Model and Feasibility Assessment Participants: 10 key stakeholders. FGD Protocol (Narrative Form) Each FGD begins with an introduction to the study’s objectives. A facilitator then guides the session using a semi-structured set of questions designed to explore perceptions regarding the roots of water conflicts, experiences with past sector-based governance, aspirations for a collaborative paddy–fish water-sharing system, and institutional and technical requirements for model adoption. Visual facilitation tools such as sticky notes, fishbone diagrams, and SWOT matrices are employed to stimulate evidence-based discussion and collective problem-solving.

Qualitative Data Analysis Framework

The study adopts the Miles and Huberman (1994) interactive model, consisting of data reduction, data display, and conclusion drawing and verification. The technical procedures include Immediate transcription of each interview and FGD, inductive–deductive coding, using preliminary categories such as infrastructure conditions, user behaviors, institutional strength, enforcement, water access, adaptation strategies, and conflict dynamics, and Pattern matching to establish relationships. Source triangulation, achieved by comparing upstream vs downstream farmers, rice vs fish farmers, interview data vs field observations, vs government documents.

Operationalization of SWOT and Fishbone Analysis Fishbone (Ishikawa) Diagram

The fishbone diagram is used during early diagnostic stages to categorize root causes of conflict under six themes: Infrastructure (damaged channels, non-functional control gates) Irrigation technical issues (unstable schedules, reduced discharge), User behavior (illegal water tapping, private blockages), Institutional factors (weak P3A, absent enforcement), Regulatory gaps (non-compliance with SIPA, <5% legal pond permits), Environmental factors (sedimentation, drought periods, climate variability) This produces a comprehensive causal map used in FGD 2 to design targeted solutions. SWOT Analysis is applied during model formulation: Strengths: high economic potential of rice–fish sectors, existing farmer groups, Weaknesses: weak coordination, deteriorated infrastructure, moral hazard among pond operators, Opportunities: IPDMIP projects, rising market demand, BBWS support, Threats: climate change, land conversion, social tensions, worsening sedimentation, The SWOT matrix generates SO, WO, ST, and WT strategies, which FGD participants then evaluate for feasibility and acceptability.

Weaknesses: Limited Reliability and Validity Measures
Based on the initial research narrative, the design currently shows insufficient articulation of reliability and validity mechanisms, which are essential for qualitative rigor. Reliability Gaps: Lack of inter-coder reliability checks, no mention of audit trails documenting analytical decisions, and Absence of peer debriefing procedures

Validity Gaps
Limited description of member checking, triangulation (sources, methods, time), rich contextual descriptions (thick description), and negative case analysis. Without these mechanisms, interpretations of water-use conflicts may be vulnerable to bias, especially given the economic and political sensitivity of water allocation disputes.

Results and Discussion
Periods of Water Deficit and Surplus
Based on the calculations and graph analysis, the following information is obtained:

- Water deficit period: Second week of May – Second week of October (approximately five months). During this period, available discharge is lower than irrigation needs.
- Water surplus period: November – Early May. During this period, water availability exceeds irrigation requirements. [10]

The summary table below describes water discharge conditions relative to irrigation needs in DI Kelingi Tugumulyo:

Period	**Water Discharge Condition**	**Description**
January – Early May	Discharge > Demand	Water Surplus
Mid-May – Mid-October	Discharge < Demand	Water Deficit
November – December	Discharge > Demand	Water Surplus

Implications for Conflict Resolution
Given the multi-dimensional nature of the conflict, mitigation efforts must adopt a coordinated and multi-disciplinary approach. The following strategies are essential:

1. Infrastructure Rehabilitation and Modernization. Repairing damaged canals, dredging sedimented channels, and installing flow measurement devices will improve distribution accuracy and reduce inequities between upstream and downstream areas.
2. Stricter and More Adaptive Regulatory Enforcement Regulations must be updated to integrate agricultural and aquaculture needs, with clear sanctions and routine monitoring to reduce unauthorized water use.
3. Strengthening Institutional Coordination. Active communication forums involving farmers, aquaculture operators, irrigation authorities, and local government should be established to ensure transparency in water allocation decisions.
4. Behavioral Change and User Awareness Programs Training, community-based monitoring, and awareness campaigns are needed to promote responsible and equitable water use practices.
5. Adaptive Water Management in Response to Climate Variability Water allocation strategies must consider seasonal fluctuations, with contingency plans for drought periods to minimize conflict during scarcity.

Environmental Condition Graph of the Kelingi Tugumulyo Irrigation Area

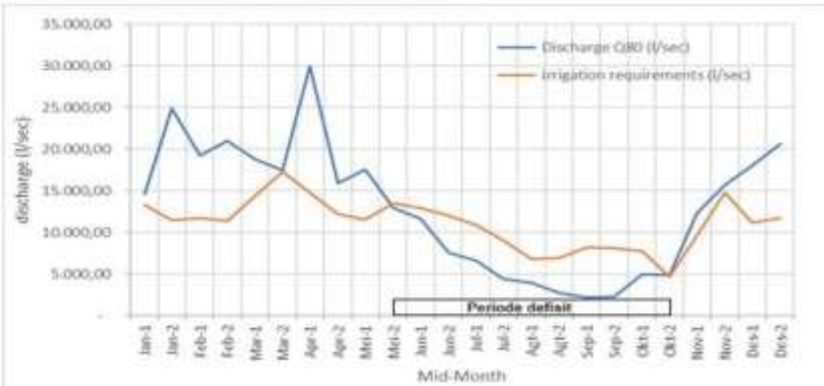

Figure 2. Environmental Condition Graph of the Kelingi Tugumulyo Irrigation Area (DI Kelingi Tugumulyo)

The Kelingi Tugumulyo Irrigation Area (DI Kelingi Tugumulyo) is one of the key irrigation regions supporting agricultural activities in Musi Rawas Regency. The availability of irrigation water in this area is highly dependent on local hydrological conditions, particularly the discharge of the Kelingi River, which serves as the main source of irrigation water. Based on the results of hydrological data analysis, the maximum water intake capacity in DI Kelingi Tugumulyo is 17.15 m³/second [11]. This value indicates the maximum capability of the canal system to distribute water to agricultural areas under normal conditions without significant disturbances or water losses. However, the evaluation of water availability and irrigation requirements shows that there are periods of water deficit at certain times of the year. This deficit indicates that the available water discharge is lower than the water requirement needed for crop irrigation [12].

Analysis of Discharge Patterns and Irrigation Water Requirements
The analysis of the relationship between dependable discharge (Q80) and irrigation water requirements is presented in Figure 29. The graph shows two main curves:

- The blue line, representing the dependable discharge (Q80) in liters per second (l/s), and
- The orange line represents irrigation water requirements in liters per second (l/s).

Based on the graph, it can be observed that from January to early May, the Q80 discharge remains higher than the irrigation water requirement. This condition indicates that during this period, the water supply is sufficient to meet the needs of agricultural land [13]. However, beginning in the second week of May, the Q80 discharge experiences a significant decline and falls below the irrigation requirement line. This condition indicates the occurrence of a water deficit lasting until the second week of October. After this period, the Q80 discharge increases and, from November to December, once again exceeds irrigation requirements, indicating a water surplus. [14]

Periods of Water Deficit and Surplus
Based on the calculations and analysis of the graph, the following information is obtained:

- The water deficit period occurs from the second week of May to the second week of October, lasting approximately five months.
- The water surplus period occurs from November to early May, during which water availability exceeds irrigation requirements.
-

The table below summarizes the condition of water discharge relative to irrigation requirements in DI Kelingi Tugumulyo:

Period	Condition of Discharge vs Irrigation Requirement	Description
January – Early May	Discharge > Requirement	Water Surplus
May (2nd week) – October (2nd week)	Discharge < Requirement	Water Deficit
November – December	Discharge > Requirement	Water Surplus

Based on the research and analysis conducted regarding the environmental conditions and water availability in the Kelingi Tugumulyo Irrigation Area, several conclusions can be drawn:

1. The water intake capacity in DI Kelingi Tugumulyo is 17.15 m³/second. This value represents the maximum capability of the irrigation system to channel water to agricultural areas under normal conditions.
2. A water deficit occurs from the second week of May until the second week of October. During this period, the available dependable discharge (Q80) is lower than the irrigation water requirement, resulting in unmet irrigation needs. This deficit lasts for approximately five months, coinciding with the dry season in the study area.
3. A water surplus occurs from November to early May, when Q80 discharge exceeds irrigation needs. This condition provides an opportunity to optimize planting activities at the beginning of the rainy season.
4. The pattern of water discharge and irrigation requirements indicates that irrigation water management in DI Kelingi Tugumulyo still needs improvement, particularly during the dry season. Planning cropping patterns that align with water availability is essential to maintaining sustainable agricultural production in the area.

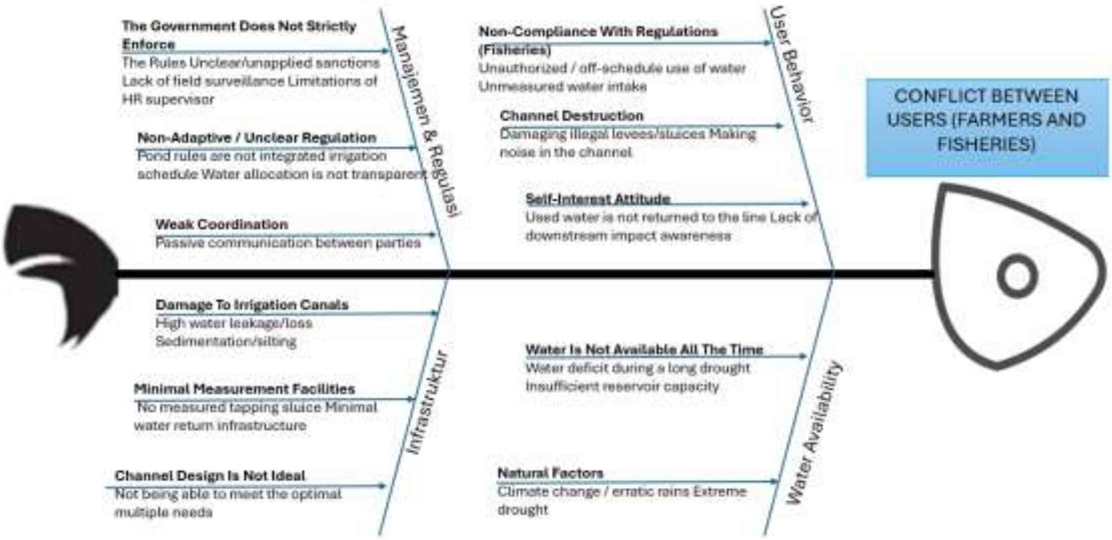

Figure 3. The root of the conflict between consumers (farmers and Fisheries)

Analysis of the Cause–and–Effect Model of Conflict Among Water Users
Figure 3 illustrates the cause-and-effect model of conflict among water users (farmers and aquaculture operators), depicting various key factors that contribute to disharmony in the utilization of water resources within the irrigation area. These conflicts arise from an imbalance between water demand, availability, and suboptimal management of irrigation resources.

1. Management and Regulatory Factors
Management problems and weak regulatory enforcement are among the main drivers of conflict. Factors within this category include a lack of firm government enforcement. Sanctions for water-use violations are often not implemented, and field supervision is ineffective due to limited human resources among irrigation managers, Unclear and non-adaptive regulations. Regulations governing water use for fish ponds are not fully integrated with agricultural irrigation schedules, and water allocation between sectors lacks transparency and weak coordination. Communication among stakeholders—farmers, aquaculture operators, and technical agencies—is passive, making it difficult to reach mutual agreements. These conditions lead to conflicting interests over water allocation, especially during periods of reduced discharge in the dry season.

2. Infrastructure Factors
Infrastructure-related issues are also significant contributors to conflict among water users. Several problems identified include damaged irrigation canals. High levels of leakage or water loss occur due to sedimentation and channel deterioration, Limited measurement facilities, The absence of water-discharge measurement tools at intake points and inadequate return-flow infrastructure make water distribution difficult to control, Suboptimal channel design, The existing irrigation network is not designed to optimally support multi-purpose use

(agriculture and aquaculture), These infrastructure problems exacerbate the gap between upstream water availability and downstream demand, frequently triggering disputes.

3. User Behavior Factors
User behavior in both the agricultural and aquaculture sectors further intensifies the conflict. Identified behavioral issues include Non-compliance with regulations. Water is often used without permits, outside scheduled irrigation times, or without clear discharge calculations. Channel damage caused by users. Some individuals construct illegal dams or water gates to divert flow, disrupting supply to other rice fields. Self-centered attitudes. Water from fish ponds is not returned to the irrigation system, accompanied by low awareness of the impacts on downstream users. The lack of shared awareness regarding fair and sustainable water use contributes to social tensions among water-user groups.

4. Water Availability Factors
Unstable water availability throughout the year is also a major source of conflict. Two key aspects influence this condition: Limited water availability during certain periods. During prolonged dry seasons, water discharge decreases drastically, making the irrigation network insufficient to meet agricultural and aquaculture needs simultaneously. Natural factors. Climate change leads to unpredictable rainfall patterns, while extreme drought worsens water deficits during the dry months. These conditions create competition for water between farmers and aquaculture operators, especially when supply is limited.

5. Conclusion of the Model Analysis
Based on the cause–and–effect diagram analysis, it can be concluded that conflicts among water users in the Kelingi Tugumulyo Irrigation Area are driven by a combination of technical, institutional, and behavioral factors. The dominant factors include:

- Weak management and poor inter-agency coordination
- Lack of strict enforcement of water-use regulations
- Damaged irrigation infrastructure and limited measurement facilities
- User non-compliance with irrigation schedules
- Irregular water discharge due to climate variability and limited network capacity

Thus, conflict resolution efforts must be carried out in an integrated and multidisciplinary manner, including infrastructure improvements, strict regulatory enforcement, increased user awareness, and adaptive water-management systems tailored to dynamic water-resource conditions.

Weighting of SWOT questionnaire results

			External Factors	
			Opportunity (O)	Threat (T)
			2,60	0,76
Internal Factors	Strength (S)	2,24	SO	ST
			4,84	3,00
	Weakness (W)	1,05	WO	WT
			3,65	1,81

The results of the SWOT matrix analysis indicate that the system's external factors are more strongly dominated by opportunities (score 2.60) than threats (0.76). This means that the external environment is generally supportive of program development, whether through policies, institutional support, or community needs. At the same time, internal conditions show that strengths (2.24) outweigh weaknesses (1.05), indicating that the organization has a sufficiently strong foundational capacity to carry out the program.

When these internal and external factors are combined, the SO (Strength–Opportunity) strategy produces the highest score of 4.84, suggesting that the most effective approach is to leverage internal strengths to capitalize on external opportunities. In other words, the organization's existing capacity should be directed toward accelerating service improvements, enhancing collaboration, and optimizing the potential of the surrounding environment. The WO (3.65) and ST (3.00) strategies occupy the middle positions. The relatively high WO value indicates that substantial external opportunities can be used to overcome internal weaknesses, for example, through training, institutional strengthening, and technology adoption. Meanwhile, the ST strategy shows that existing internal strengths are still needed to mitigate threats, particularly those related to operational risks or resource-use conflicts.

The WT strategy has the lowest score, at 1.81. This indicates that a defensive approach—reducing weaknesses while avoiding threats—is not a primary priority, as neither the threats nor the weaknesses are at a critical level. Overall, the analysis shows that the system is in a relatively strong position and has significant opportunities for growth. Therefore, development strategies should focus on optimizing internal strengths and utilizing external opportunities as the main drivers of improvement.

Water source analysis and irrigation water availability

There are several main things that are indicated as the cause of the problem of reduced availability of irrigation water or excessive availability of water that results in flooding in the area in Kelingi Tugumulyo. Problems and follow-up efforts are presented in the table below:

Table 3. Description of the problem of sources and availability of water in Kelingi

No	Aspect	Description Of The Problem	Follow-Up Efforts
1.	Source and availability of irrigation water	In the 2nd planting season, not all rice is irrigated from a functional area of 6800 ha	1. Review the needs/capacity of existing intakes and channels. 2. Normalization of the channel (cleaning garbage, wild plants along the channel) 3. Conservation of forests.
2.	Weir	Several main buildings (weirs and taps) suffered minor to severe damage.	Repair/rehab of weirs and auxiliary buildings (mud bags, drain doors, intakes)
3.	Channels	Sedimentation in channels and around buildings	Sedimentation dredging
4.	Fish Pond	Free harvesting is carried out by Pond farmers along the primary and secondary networks, which has an impact on the lack of water availability to farmers ' fields downstream.	Made regulations related to licensing, usage limits, and technical pool building. Made special tapping building Kola mikan heavy water and calm water.
5.	Multipurpose	Use of water for fish ponds and not returned to the channel	Planned irrigation system that accommodates rice farmers and fish pond owners.

Source: BBWS Sumatera VIII

The table above illustrates the sources and availability of irrigation water that are less efficient in regulation and utilization for both agriculture and fisheries in the DI region. Kelingi Tugumulyo. It is expected that follow-up efforts can be implemented so that farmers can feel the benefits of the existence of the irrigation network.

Conclusion

The cause-and-effect analysis highlights that the prolonged conflict between rice farmers and aquaculture operators in DI Kelingi Tugumulyo is driven by intertwined issues of governance, infrastructure, behavior, and natural variability. Addressing only one factor will not resolve the conflict; instead, a comprehensive, integrated, and collaborative solution is required. This analysis provides a foundational understanding for developing the proposed “paddy–fish symbiotic collaboration model”, which seeks to harmonize interests, improve water governance, and reduce conflict through structured multi-stakeholder engagement, upgraded infrastructure, and adaptive water allocation mechanisms. Moreover, the model emphasizes the importance of establishing clear feedback loops that allow community actors to articulate challenges, negotiate resource allocation, and make collective decisions regarding priorities for flood mitigation. Through these feedback mechanisms, the model assumes that participation is not merely symbolic but becomes a substantive process that shapes policy directions and operational decisions. Over time, these governance arrangements are expected to strengthen accountability, foster a sense of shared ownership, and enhance community resilience toward future hydrometeorological risks. Taken together, the Theory of Change posits that if institutional collaboration is strengthened, community empowerment is systematically enhanced, and policy implementation becomes more adaptive and responsive, then the overall effectiveness of flood-risk mitigation will significantly improve. These interconnected pathways are expected to reduce the severity of flood impacts, enhance community preparedness, and contribute to a more sustainable and inclusive model of urban water-risk governance in Palembang. The management of irrigation water conflicts in the Kelingi Tugumulyo Irrigation Area has progressed from the planning stage to actual implementation. The local government has developed regulations, rehabilitated the irrigation network, strengthened Water User Associations (P3A), and begun testing the mina padi (rice–fish) system to meet both agricultural and aquaculture needs. However, the effectiveness of these efforts is still constrained by illegal water extraction, weak monitoring, and inconsistent enforcement of permits—resulting in recurring conflicts, especially during low-flow periods. At the technical level, hydrological uncertainty, infrastructure limitations, and network efficiency of only around 60% lead to unstable water supply throughout the year. Competition for water between rice fields and fish ponds increases the risk of drought in downstream plots, while occasional flooding damages crops. Rice productivity, at approximately 6.65 tons/ha/year, remains vulnerable to declining water availability and deteriorating irrigation infrastructure. Institutionally, P3A/GP3A organizations have been established, but their capacity, participation, and compliance with regulations vary widely. Instruments such as pond permits, sanctions, and gate operation rules have not been fully effective, making equitable water distribution difficult to maintain. Meanwhile, the aquaculture sector holds significant economic potential, but its intensive dependence on irrigation water increases vulnerability and the risk of conflict. Nevertheless, opportunities for synergy remain open through network rehabilitation, institutional strengthening, community participation, and the integration of technology and the mina padi approach. In this context, the most suitable model is the performance-based collaborative IWRM for rice–fish systems, which integrates environmental scanning, strategy formulation, implementation, and evaluation into a single cycle based on indicators of water service performance, permit compliance, P3A activity, and productivity stability. This model can be implemented in phases through quick wins, strengthening, and consolidation. The main recommendations focus on governance, infrastructure–operations, and empowerment. Regional regulations are needed to govern permits and water-use quotas for fish ponds, supported by a cross-sector coordination forum acting as a command post for water allocation and rapid dispute resolution. Network rehabilitation, normalization of critical points, data-driven gate operations, and watershed conservation are essential to improve supply reliability. At the same time, P3A/GP3A must be strengthened through O&M training, conflict mediation, the formation of water management task forces, and the provision of aquaculture technology to increase productivity without raising water demand. Enforcement of irrigation regulations must be tightened, including mandatory pond licensing, installation of water-measuring devices, limits on the number of ponds, and modification of pond structures to ensure return flows to the canal. Clear SOPs for gate operations are needed, along with retention ponds/reservoirs, adjusted cropping patterns based on actual discharge, and community-based monitoring to address illegal water extraction and maintain water quality. Promoting water-saving practices, expanding mina padi in suitable areas, and strengthening coordination between villages and sectors are crucial to maintain upstream–downstream balance. All of these efforts require simple yet reliable data and technology support—from registries of licensed ponds and gate-opening records to transparent water distribution schedules and an irrigation information dashboard for rapid decision-making during critical periods.

Author Contributions

IYP: Writing, compiling, and designing concepts, collecting data, conducting analysis. IRP: compiling and designing concepts, Supervision. TY: compiling and designing the analysis. BPP: compiling and designing methodology.

Conflict of Interest

We declare that there is no conflict of interest whatsoever related to financial and personal interests with other people or organizations related to the discussion of the material in the manuscript.

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