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RESEARCH ARTICLE

Criterion-Based Evaluation of Water Management Performance of Irrigation Cooperatives in Pasinler District, Erzurum

Halil İbrahim Arslan[1]✉ • Yasemin Kuşlu[2]

[1]Erzurum Pasinler Directorate of Provincial Agriculture and Forestry, Erzurum/Türkiye
[2]Atatürk University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, Erzurum/Türkiye

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ABSTRACT

The performance of irrigation cooperatives is pivotal in ensuring sustainable water management in agriculture-dependent regions. Pasinler district, located in the Eastern Anatolia Region of Türkiye, is one of the key agricultural production areas, with the local economy largely reliant on agriculture and livestock. In this context, the efficiency of irrigation systems plays a critical role not only in enhancing agricultural productivity but also in improving the quality of life and socioeconomic well-being of the local population. This study aims to assess the water management performance of irrigation cooperatives in the Pasinler district of Erzurum, Türkiye, based on five critical dimensions: physical and technical infrastructure, land and irrigation area management, irrigation methods and practices, operational maintenance and management, and economic-financial management. Data were collected from nine cooperatives operating in the region through structured evaluations and cooperative records. Findings reveal significant disparities in infrastructure capacity, with large cooperatives such as Pasu owning up to 120 wells and pumps, whereas others, like Alvar and Porsuk, operate with minimal or no infrastructure. Despite differences in scale, all cooperatives rely on traditional surface irrigation methods, indicating low water-use efficiency. Furthermore, none of the cooperatives have undergone land consolidation, leading to inefficient irrigation practices due to fragmented land structures. Most cooperatives depend on electricity for irrigation, yet lack renewable energy integration, creating financial vulnerabilities amid rising energy costs. Additionally, the absence of digital payment systems and structured fee collection mechanisms undermines financial transparency and sustainability, with some cooperatives consistently operating at a loss. This study underscores the necessity of targeted improvements in infrastructure modernization, renewable energy integration, institutional capacity building, and financial governance. Encouraging land consolidation, adopting smart irrigation technologies, and strengthening managerial frameworks are essential steps toward enhancing irrigation efficiency and agricultural sustainability. These findings suggest that future interventions should prioritize integrated policy frameworks that align technical upgrades with institutional and financial reforms to ensure the long-term viability of irrigation cooperatives.

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1. Introduction

In regions where agriculture is heavily reliant on irrigation, the performance of irrigation cooperatives holds critical importance for effective water management (Molle & Berkoff, 2007). Evaluating the performance of these cooperatives reveals the complex and multifaceted nature of agricultural water governance. Irrigation cooperatives play a crucial role in efficiently managing water resources, enhancing agricultural

✉ Correspondence
E-mail address: halilibrahimarslann@gmail.com

productivity, and promoting sustainable practices (de Deus Ribeiro et al., 2024). Key performance indicators often include irrigation coverage rates, cost recovery ratios, and the effectiveness of water fee collection (Bos et al., 2005). For instance, studies conducted in different regions have shown significant variations in irrigation rates and cost recovery levels, highlighting the role of financial management efficiency as a prominent performance criterion (Aydın & Akçay, 2023). The physical and technical infrastructure of irrigation cooperatives is fundamental to their overall performance. Core indicators include the condition of irrigation canals, water distribution systems, and drainage infrastructure. Research indicates that the physical performance of cooperatives varies considerably depending on regional characteristics and management practices (Gondwe & Mayo, 2018). These disparities underline the need for tailored strategies that align infrastructure capacity with localized environmental and operational demands. Therefore, a comprehensive understanding of both technical and managerial dimensions is essential for enhancing the effectiveness and sustainability of irrigation cooperatives.

The water management performance of irrigation cooperatives is of vital importance for the sustainability of agriculture, efficient utilization of water resources, and rural development in Türkiye (Kirmikil, 2025). This study examines the performance of irrigation cooperatives across five critical dimensions: physical and technical infrastructure, irrigation area and land management, irrigation methods and practices, operational maintenance and management, and economic and financial administration. Previous research has also been evaluated in the context of these dimensions. Findings from earlier studies indicate that physical and technical infrastructure plays a decisive role in determining the efficiency of irrigation systems. It has been observed that many irrigation cooperatives in Türkiye operate with outdated and inefficient infrastructure, which contributes to significant water losses. For instance, a study conducted in the province of Aydın revealed that irrigation coverage rates among cooperatives ranged from as low as 7% to as high as 94%, and in some cases, the return on investment was found to be far from sustainable (Aydın, 2019). These results highlight the critical need for infrastructure modernization and targeted investment to enhance system performance and long-term viability.

Land and irrigation area management remain ineffective, particularly due to the lack of land consolidation practices and the prevalence of fragmented land structures. These conditions hinder the uniform distribution of water and significantly reduce overall efficiency. In regions where land planning is not aligned with irrigation project implementation, water wastage increases, and the cost-effectiveness of irrigation systems declines (Rogy et al., 2022). The adoption of modern irrigation methods also has a substantial impact on the performance of cooperatives. Although surface irrigation systems are still widely used, more efficient techniques such as drip and sprinkler irrigation have not been broadly adopted due to high initial costs and a lack of technical expertise. A study conducted in Şanlıurfa revealed that farmers face significant financial and technical barriers in transitioning to drip irrigation systems (Aydoğdu et al., 2021). These constraints have negative implications for water conservation and crop productivity, underscoring the need for supportive policies and capacity-building initiatives to enhance the uptake of modern irrigation technologies.

Operational maintenance and management capacity plays a critical role in the overall success of irrigation cooperatives. This capacity directly influences the efficient operation of infrastructure, the regular execution of maintenance activities, the rational use of resources, and the sustainability of service quality. For example, a study conducted in Aydın province found that cooperatives demonstrating higher water use efficiency and financial sustainability also possessed stronger operational maintenance and management capabilities. Specifically, indicators such as the proportion of maintenance expenses relative to income and the irrigated area per staff member were found to significantly reflect cooperative performance (Aydın & Akçay, 2023). Similarly, research on cooperative systems in Tanzania emphasized that limited managerial capacity and institutional shortcomings hindered the potential of cooperatives to alleviate poverty and ensure sustainable agricultural production (Zhang et al., 2021). Moreover, the strategic capacity development framework developed by the FAO underscores the importance of training cooperative managers and technical personnel as a vital prerequisite for the efficient operation of modern irrigation systems (Facon et al., 2008). In this context, the long-term success of irrigation cooperatives depends not only on physical infrastructure investments but also on institutional capacity building to effectively operate and sustain that infrastructure.

Economic and financial management capacity is considered a fundamental element for the long-term sustainability of irrigation cooperatives (de Deus Ribeiro et al., 2024). It is not sufficient for cooperatives to merely generate income; they must also effectively plan and allocate these revenues, establish structures capable of covering operational and maintenance costs, and maintain financial resilience against unexpected expenditures. These factors are critical for ensuring the overall sustainability of the irrigation system. A field study conducted in Nepal revealed that effective financial management and accounting practices in agricultural cooperatives not only contribute to economic sustainability but also strengthen institutional capacity and trust among cooperative members. The use of computerized accounting systems, regular financial reporting, staff training, and managerial transparency were identified as key factors that positively influence cooperative performance (Pandey et al., 2024). These findings suggest that financial management should not be viewed merely as an administrative necessity, but rather as a cornerstone for rural development and the continuity of agricultural services.

In conclusion, achieving sustainable and effective water management through irrigation cooperatives in Türkiye requires a comprehensive, multidimensional assessment. Enhancing both the technical and managerial capacities of these cooperatives necessitates the modernization of physical infrastructure, optimization of land use, promotion of modern irrigation technologies, professionalization of operational maintenance processes, and the establishment of a robust financial management framework. This study evaluates the performance of irrigation cooperatives in the Pasinler district of Erzurum across five critical dimensions: physical and technical infrastructure, irrigation area and land management, irrigation methods and practices, operational maintenance and management, and economic and financial governance. By analyzing these aspects, the study aims to identify best practices, existing challenges, and areas in need of improvement, offering insights that can inform more effective and sustainable irrigation governance strategies. Accordingly, the study hypothesizes that the water management performance of irrigation cooperatives in the Pasinler district is significantly influenced by disparities in infrastructure capacity, irrigation practices, land fragmentation, operational management, and financial sustainability.

2. Materials and Methods

This study analyzed nine irrigation cooperatives in the Pasinler district of Erzurum across five critical dimensions: (1) physical and technical infrastructure, (2) irrigation area and land management, (3) irrigation methods and practices, (4) operational maintenance and management, and (5) economic and financial administration. Data were obtained directly from cooperative officials through structured inquiries and documentation.

Within the physical and technical infrastructure category (Bos et al., 2005), the following indicators were assessed: number of wells, average well discharge, electrical power capacity, number of pumps, quantity of tools and equipment, and the method used for measuring water consumption. For the irrigation area and land management dimension (Garces-Restrepo et al., 2007), key variables included the size of the irrigated area, the proportion of land being irrigated, and the status of land consolidation efforts. The irrigation management and practices dimension (Pereira et al., 2012) covered the type of water source, irrigation method (e.g., surface, drip, sprinkler), and energy source used (electric or gravity-based systems). Regarding operational maintenance and management (Ashine et al., 2025), data were collected on the construction institution, well maintenance and repair status, and the number of technical staff employed. Lastly, the economic and financial management dimension (Kirmikil, 2025) focused on how water fees are determined, the financial balance status (profit/loss), and the methods used for fee collection. These parameters were used to comprehensively evaluate the cooperatives' capacity to deliver sustainable irrigation services.

3. Results

The data collected were analyzed and presented across five critical dimensions: physical and technical infrastructure, irrigation area and land management, irrigation methods and practices, operational maintenance and management, and economic and financial administration.

2.1. Physical and Technical Infrastructure

This section presents findings related to the current physical capacity and technical adequacy of the irrigation cooperatives. Key indicators assessed include the number of wells, average discharge rates, electrical power of pumps, total number of pumps, and the availability of tools and equipment owned by the cooperatives. The status of these indicators across different cooperatives is detailed in Table 1. These metrics provide valuable insights into the operational capacity of the irrigation systems and the adequacy of their supporting infrastructure.

The findings presented in Table 1 highlight significant scale-based differences in infrastructure capacity among the irrigation cooperatives. In particular, large-scale cooperatives such as Pasu (Central) possess a high number of wells and pumps, whereas cooperatives like Alvar and Porsuk operate with notably fewer resources. This indicates that cooperatives serving larger areas have made substantial infrastructure investments, while smaller-scale cooperatives rely on lower-cost, localized solutions. Technical indicators such as well discharge rates and pump capacity directly affect irrigation efficiency. Therefore, infrastructure improvements are necessary in regions with low discharge levels. Although high electrical power increases irrigation speed, it also leads to elevated energy costs. Thus, integrating renewable energy sources is of critical importance for long-term sustainability. Additionally, the lack of equipment and inadequacies in water measurement systems represent key weaknesses in operational efficiency and resource management. In this context, infrastructure investments must be strategically planned by local conditions, while improvements in metering accuracy and the adoption of sustainable energy alternatives should be prioritized in both academic and policy-oriented frameworks.

Table 1. Physical and technical infrastructure information of the irrigation cooperatives.

Indicator	Status by Cooperative	Commentary and Recommendations
Number of Wells	Highest: Pasu (120 wells) Medium: Tepecik (30), Yiğittaşı-Pusudere (7), Karakoç (5) Lowest: Alvar (2), Porsuk (0)	Large cooperatives tend to have higher infrastructure investments; smaller ones operate with simpler and lower-cost systems.
Average Well Discharge (L/s)	High discharge: Alvar (65), Tepecik (55) Low discharge: Karavelet (22)	Cooperatives with higher discharge rates have advantages in irrigation efficiency. Improvements are needed in low-discharge regions.
Electrical Power (kW)	Highest: Alvar (47.5 kW) Lowest: Pusudere (23.5 kW)	Higher power consumption increases irrigation performance but also raises energy costs; energy-efficient alternatives should be considered.
Number of Pumps	Highest: Pasu (120), Tepecik (27) Medium: Yiğittaşı (7) Low: Alvar (2) None: Porsuk (0)	A large number of pumps implies high maintenance costs; effective maintenance and management systems are essential.
Number of Tools and Equipment	Generally unavailable or very limited	Lack of equipment poses risks to operational continuity; this gap should be addressed through targeted investments.
Water Measurement Practice	In most cooperatives, water usage is measured at the distribution point (e.g., Karavelet, Pasu, Yiğittaşı, Alvar, Tepecik)	More accurate monitoring of water use should be ensured through advanced metering systems such as flow meters.

2.2. Irrigation Area and Land Management

This section presents findings related to the service area of irrigation cooperatives, the extent to which these areas are irrigated, and the status of land consolidation. Key indicators such as total irrigated land (in decares), the proportion of irrigated to total service area, and whether land consolidation has been implemented are detailed in Table 2. These metrics are evaluated in terms of their implications for irrigation efficiency, production capacity, and resource utilization effectiveness.

Table 2. Irrigation area and land management by cooperative.

Indicator	Status by Cooperative	Commentary and Recommendations
Irrigation Area (decare)	Largest: Pasu (75,000 decares) Medium-sized: Alvar (20,000), Tepecik (15,000) Smallest: Karavelet (600), Karakoç (1,700)	Managing large-scale areas is challenging; although economies of scale are beneficial, specific policies are needed for effective management.
Proportion of Area Irrigated	Karavelet: 58%, Yiğittaşı: 67%, Pasu, Tepecik, Porsuk, Karakoç: 100%. In some areas, data is unavailable (e.g., Büyüktüy-Küçüktüy-Saksı)	In areas where full capacity is not utilized, planning and management processes should be improved.
Land Consolidation Status	No land consolidation has been implemented in any cooperative (e.g., Karavelet, Pasu, Yiğittaşı, Pusudere, Alvar, Tepecik, Porsuk, Karakoç, Büyüktüy-Küçüktüy-Saksı)	Land consolidation efforts should be initiated, as they are essential for improving irrigation efficiency.

The data on irrigation area and land management (Table 2) reveal significant scale disparities and structural challenges among the cooperatives. Cooperatives such as Pasu (Central), which serve large irrigation areas (75,000 decares), benefit from economies of scale but also face complex management processes and high operational costs. In contrast, smaller cooperatives like Karavelet and Karakoç, operating on more limited land, may offer more manageable systems but are constrained in terms of production capacity. In terms of the proportion of irrigated land, some cooperatives (e.g., Pasu, Tepecik, Porsuk, Karakoç) have achieved full capacity (100% irrigation), while others, such as Karavelet (58%) and Yiğittaşı (67%), remain below potential. This discrepancy points to management or technical issues that prevent full utilization of existing infrastructure. A key structural deficiency is the absence of land consolidation in all cooperatives. Without consolidation, the equal, rapid, and efficient distribution of water becomes significantly more difficult. Therefore, land consolidation should be viewed as a strategic intervention essential for improving irrigation efficiency.

2.3. Irrigation Methods and Practices

This section presents findings on the irrigation methods employed by the cooperatives, the types of water sources they utilize, and the forms of energy used in water delivery. Variables such as irrigation technique (surface, sprinkler, drip), source of water (groundwater or surface water), and energy type (electricity or gravity-fed systems) are detailed in Table 3. These findings are assessed in the context of water-use efficiency and environmental sustainability.

Table 3. Irrigation methods and practices by cooperative.

Indicator	Status by Cooperative	Commentary and Recommendations
Type of Water Source	Groundwater: Most cooperatives Surface water: Only Porsuk	Groundwater sources pose sustainability risks. Surface water is more vulnerable to drought but offers more sustainable management.
Irrigation Method	All cooperatives (Karavelet, Pasu, Yiğittaşı, Pusudere, Alvar, Tepecik, Porsuk, Karakoç, Büyüktüy-Küçüktüy-Saksı) use surface (flood) irrigation methods.	Surface irrigation has low water-use efficiency. Transition to drip or sprinkler systems is recommended for improved sustainability.
Type of Energy Used	Electricity is used in most cooperatives (e.g., Karavelet, Pasu, Yiğittaşı, Pusudere, Alvar, Tepecik, Karakoç). Only Porsuk uses gravity-fed systems.	Cooperatives relying on electricity should consider renewable energy alternatives. Gravity systems are environmentally advantageous.

The findings related to irrigation methods and practices (Table 3) reveal the current status of water and energy use among the cooperatives, as well as the sustainability risks they face. The majority of cooperatives rely on groundwater sources, with only the Porsuk cooperative operating through a surface (gravity-fed) water system. The widespread dependence on groundwater presents a serious environmental sustainability concern, as it may lead to the depletion of underground reserves in the long term. In contrast, although surface water sources are more susceptible to climatic fluctuations, they offer a more environmentally friendly alternative when managed responsibly.

Moreover, all cooperatives currently utilize traditional surface (flood) irrigation methods, indicating low water-use efficiency. This approach not only results in considerable water loss but also diminishes irrigation effectiveness. Transitioning to more efficient irrigation techniques—such as drip or sprinkler systems, which are widely used in modern agriculture—would significantly enhance water conservation and crop health.

In terms of energy use, electricity dominates across the cooperatives, with only Porsuk utilizing a gravity-based system. Reliance on electricity for irrigation poses a financial burden, especially during periods of rising energy prices. For this reason, the adoption of renewable energy sources—such as solar or wind power—at the cooperative level is essential. Such integration would not only reduce operational costs but also enhance environmental sustainability. Overall, modernization in both irrigation techniques and energy use is fundamental to achieving long-term sustainable agricultural development.

2.4. Operational, Maintenance, and Management Information

This section presents findings related to the administrative and technical management capacities of the cooperatives, including the institution responsible for construction, the entities in charge of well maintenance and repair, and the number of employed personnel. These indicators are evaluated to assess the organizational sustainability and operational management adequacy of the cooperatives. Detailed data for each cooperative are provided in Table 4.

Table 4. Operational, maintenance, and management information by cooperative.

Indicator	Status by Cooperative	Commentary and Recommendations
Constructing Institution	All cooperatives (Karavelet, Pasu, Yiğittaşı, Pusudere, Alvar, Tepecik, Porsuk, Karakoç, Büyüktüy-Küçüktüy-Saksı) were established by the State Hydraulic Works (DSİ).	Support from central institutions (e.g., DSİ) is beneficial; however, strengthening local management capacity is necessary.
Well Maintenance and Repair Responsibility	Maintenance is generally handled by private individuals (e.g., Karavelet, Yiğittaşı, Karakoç, Pusudere), while DSİ support is observed in Tepecik, Alvar, and Büyüktüy-Küçüktüy-Saksı.	Professionalizing and standardizing maintenance procedures can enhance service quality and operational reliability.
Number of Personnel	Pasu employs 12 staff; Tepecik employs 3 staff; most other cooperatives do not have permanent personnel.	Lack of personnel poses risks to operational continuity; staffing needs should be addressed to ensure effective management.

The data presented in Table 4 provide important insights into the institutional structures and human resource capacities of the irrigation cooperatives. All cooperatives were established by the State Hydraulic Works (DSİ), indicating the existence of a centrally coordinated and standardized infrastructure. While this foundation represents a significant initial advantage, insufficient development of local management capacity may undermine the long-term operational sustainability of these systems in the field. In terms of well maintenance and repair, responsibilities are often outsourced to private individuals, as observed in cooperatives such as Karavelet, Yiğittaşı, Karakoç, and Pusudere. In contrast, cooperatives like Tepecik, Alvar, and Büyüktüy-Küçüktüy-Saksı receive direct support from DSİ. Maintenance systems reliant on private individuals are prone to inconsistent practices and lack quality control, highlighting the need for institutionalization and the establishment of standardized technical protocols in maintenance procedures.

Regarding staffing, only the Pasu cooperative (12 personnel) and Tepecik (3 personnel) employ permanent staff, while other cooperatives exhibit a notable lack of dedicated personnel. This shortage poses a significant risk to operational continuity, particularly in situations requiring urgent intervention or scheduled maintenance. Consequently, human resource planning within cooperatives should be restructured, and support should be provided for the recruitment of both technical and administrative staff. Furthermore, enhancing the training levels of personnel and clearly defining their roles are essential steps to improving overall management quality.

2.5. Economic and Financial Management

This section presents findings on the financial management systems of the irrigation cooperatives, including their fee-setting mechanisms, collection methods, and profit/loss status. Whether fees are determined based on electricity bills or alternative approaches, along with how payments are collected and how financial balance is maintained, are analyzed in terms of long-term financial sustainability. Detailed cooperative-specific results are provided in Table 5.

Table 5. Economic and financial management by cooperative.

Indicator	Status by Cooperative	Commentary and Recommendations
Method of Determining Water Fees	The electricity bill-based method is commonly used (e.g., Karavelet, Pasu, Yiğittaşı, Pusudere, Tepecik, Karakoç). No clear pricing system exists in Porsuk and Alvar cooperatives.	A fair pricing system based on water meters and actual consumption should be adopted.
Profit–Loss Status	Most cooperatives operate at break-even. However, some (e.g., Alvar, Büyüktüy-Küçüktüy-Saksı) consistently operate at a loss.	Cooperatives with ongoing losses should reassess cost-control measures and revenue management strategies.
Water Fee Collection Method	Collections are made manually with receipts (e.g., Karavelet, Yiğittaşı, Pusudere, Tepecik, Karakoç). No digital payment systems are in use.	Transitioning to digital payment systems is recommended to enhance transparency and efficiency in tracking payments.

The findings related to economic and financial management (Table 5) indicate several challenges faced by irrigation cooperatives in maintaining a balanced income-expenditure structure, collecting payments from users, and ensuring sustainable financial practices. The widespread use of electricity bill-based pricing systems (e.g., Karavelet, Pasu, Yiğittaşı, Pusudere, Tepecik, Karakoç) suggests that fixed costs are distributed evenly among users. However, this approach may create inequities between farmers who use varying amounts of water, and it fails to encourage efficient resource use.

In contrast, the absence of any structured pricing system in cooperatives such as Porsuk and Alvar poses a serious risk to financial sustainability. Without a clear and fair fee structure, these cooperatives are unable to secure the revenues needed for continued operation. Regarding profit and loss, while most cooperatives can break even, others, such as Alvar and Büyüktüy-Küçüktüy-Saksı consistently operate at a loss. These deficits are often driven by high energy costs, low fee collection rates, and unplanned expenditures. To address this, these cooperatives implement improved cost control mechanisms, adopt revenue-enhancing strategies, and conduct detailed efficiency analyses.

As for collection methods, most cooperatives rely on manual, receipt-based systems (e.g., Karavelet, Yiğittaşı, Pusudere, Tepecik, Karakoç). While functional, this method presents drawbacks in terms of tracking, transparency, and time efficiency. Transitioning to digital payment systems would facilitate more reliable and accessible transactions while enhancing financial accountability. In conclusion, strengthening the economic and financial structure of cooperatives, establishing fair and consumption-based pricing systems, and integrating digital financial tools are critical steps for ensuring the long-term sustainability of irrigation services.

4. Discussion and Conclusion

The research findings reveal significant variations in the physical and technical infrastructure capacities of irrigation cooperatives, depending on their scale. While large-scale cooperatives operate with more wells and high-capacity pumping systems, smaller cooperatives function with more limited resources. Although high energy consumption enhances irrigation efficiency, it also increases operational costs, thereby jeopardizing long-term sustainability (Stashuk et al., 2024). The integration of renewable energy sources—particularly solar power—into irrigation systems is crucial both for reducing costs and ensuring environmental sustainability. Solar-powered irrigation systems significantly reduce energy consumption and greenhouse gas emissions while improving water use efficiency and crop yields (Daraz et al., 2025; Karnib et al., 2024; Thokal et al., 2024). In this context, solar energy offers a strategic pathway toward achieving sustainable development goals in agriculture. Moreover, deficiencies in water metering systems hinder proper planning and monitoring, emphasizing the need for infrastructure investments tailored to local conditions.

The size of the irrigated area directly affects the managerial effectiveness and operational efficiency of cooperatives. While large cooperatives benefit from economies of scale, they also face more complex management processes and higher operational costs (Ministry of Agriculture and Forestry, 2021). In contrast, smaller cooperatives are easier to manage but are limited in terms of production capacity. The fact that some cooperatives achieve 100% irrigation rates while others remain below capacity points to managerial or technical shortcomings. The absence of land consolidation in all cooperatives is a fundamental structural weakness. Without consolidation, it is difficult to distribute water equitably and efficiently. Therefore, land consolidation must be considered a strategic requirement for improving irrigation performance (DSİ, 2017; Patlar, 2018).

Current water and energy use practices within irrigation cooperatives present notable sustainability risks. The widespread reliance on groundwater could lead to resource depletion and ecological imbalance in the long run. This underscores the need for alternative approaches to ensure sustainable water management (Ministry of Agriculture and Forestry, 2021). The continued use of traditional surface irrigation methods results in water inefficiency and waste. Replacing these with drip irrigation systems would not only improve water efficiency but also support plant health (Kaur et al., 2024; Swadia, 2017). Heavy dependence on electricity also places financial pressure on cooperative budgets, particularly during periods of rising energy prices. Thus, incorporating renewable energy sources such as solar energy would support both cost reduction and environmental sustainability (Abu-Nowar, 2020; Bhatt & Kalamkar, 2017; Guno & Agaton, 2022).

Data on operational, maintenance, and management processes reveal key institutional and human resource deficiencies. Although all cooperatives were established by the State Hydraulic Works (DSİ), which ensured a standardized infrastructure, the lack of investment in local management capacity undermines operational sustainability (Ministry of Agriculture and Forestry, 2021). In many cooperatives, maintenance and repair services are handled by private individuals, raising concerns over non-standard practices and quality control. Institutionalizing these services and implementing technical standards are critical steps (Büyükbaş, 2015). A shortage of personnel, particularly for urgent or scheduled maintenance, also threatens operational continuity. Therefore, cooperatives must restructure their human resource planning, support the hiring of technical and administrative staff, and ensure their training and role clarity to enhance management quality (Everest et al., 2019).

The financial management practices of irrigation cooperatives also highlight critical challenges for long-term sustainability. The widespread use of electricity bill-based pricing creates inequality, as it does not account for actual water usage, potentially penalizing low-usage farmers (Büyükbaş, 2015). While some cooperatives operate at break-even, others, such as Alvar and Büyüktüy-Küçüktüy-Saksı suffer from persistent deficits driven by high energy costs and poor fee collection rates. To address these issues, improvements in cost control, revenue enhancement, and energy efficiency are necessary (Ministry of Agriculture and Forestry, 2021). The prevalent use of manual, receipt-based payment systems also leads to issues in record-keeping and transparency. Implementing digital payment systems would enhance both convenience and accountability (Everest et al., 2019).

Compliance with Ethical Standards

Ethical committee approval is not required for this type of study.

Conflict of Interest

The authors declare no conflict of interest.

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