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Community Management of Irrigation Infrastructure in Burkina Faso: A Diagnostic Study of Six Dam-Adjacent Irrigation Areas

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Abstract: In Burkina Faso, small-scale, community-managed irrigation systems play a crucial role in stabilizing agricultural production and improving food security. Over the past three decades, the state has transferred the management of these irrigation systems to local farmer organizations in the hope of improving efficiency and sustainability. This study assesses the long-term performance of six irrigation perimeters Dakiri, Gorgo, Itenga, Mogtedo, Savili, and Wedbila through an in-depth analysis of governance models, infrastructure conditions, and financial sustainability. Performance indicators such as relative water supply (RWS), gross production per unit of irrigation water (PbIr), and water charge recovery rates were used to assess the effectiveness of farmer-led irrigation management. The results reveal persistent governance and financial challenges as well as issues such as water wastage and low yield persisting, despite decades of implementation of farmer-led management. The degradation of irrigation infrastructure, coupled with declining water fee collection rates, threatens the sustainability of these systems. A comparative analysis of international cases suggests that a hybrid governance model, in which the state provides technical and financial support while strengthening accountability mechanisms, could improve the performance of these irrigation systems. This study recommends a shift towards greater state intervention, improved financial mechanisms, and the adoption of digital monitoring tools to ensure a more efficient and sustainable management framework.

Keywords: community-managed irrigation; hydraulic infrastructure maintenance; irrigation fee recovery; performance assessment; sustainability of irrigated systems; water use efficiency

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Received: 22 January 2025
Revised: 14 February 2025
Accepted: 18 February 2025
Published: 22 February 2025

Citation: Baki, C.B.; Keïta, A.; Palé, S.; Traoré, F.; Bambara, A.; Moyenga, A.R.; Wellens, J.; Djaby, B.; Tychon, B. Community Management of Irrigation Infrastructure in Burkina Faso: A Diagnostic Study of Six Dam-Adjacent Irrigation Areas. *Agriculture* **2025**, *15*, 477. https://doi.org/10.3390/agriculture15050477

1. Introduction

Irrigation is vital to agricultural practices, ensuring crop growth and food security in regions facing water scarcity. However, the overexploitation of water resources in irrigation systems has led to significant challenges requiring more efficient and rational water management approaches. To address these issues, it is crucial to evaluate the performance of irrigation systems to determine areas where water is used efficiently and where improvements are required [1,2]. It is compulsory to conduct such evaluations to identify areas of inefficiency and prioritize interventions for more effective water use [3].

In Burkina Faso, according to results from a survey conducted among irrigation stakeholders from the "Regional Support Project for the Sahel Irrigation Initiative" (PARIIS), 87% of the problems related to the degradation of irrigation infrastructure and equipment, as well as water wastage, are linked to insufficient financial as well as technical support and the inability of producers to manage and maintain irrigated systems [4]. Indeed, several countries have been encouraged by international financial institutions to restructure the irrigated agriculture sector and promote farmer self-management or privatization [5,6]. According to Reference [7], the underlying rationale was that governments lack the incentives and responsiveness necessary to optimize management performance, whereas farmers are directly interested in doing so. When management transfer occurs in a favorable socio-technical context, it will result, according to these authors, in improved quality and profitability of irrigation management. Moreover, management transfer would also allow the government to save money by relieving itself of the responsibility to fund the operation and maintenance (O&M) of irrigation systems [8,9].

Performance evaluation of irrigation systems is essential to determine whether the system is meeting its objectives and whether available resources are being used efficiently [10–13]. Additionally, performance evaluations help identify inefficiencies and guide interventions to improve water management and infrastructure. Over the years, researchers have developed methodologies such as the "Rapid Participatory Diagnosis and Planning for Irrigation Performance Improvement" [14]. This methodology was developed as part of the "Improvement of Irrigation Performance in Africa" project (APPIA) and aimed at organizing diagnostic assessments with stakeholders, especially farmers, who play a central role in managing irrigation systems. Through their participation, the involved actors can collaboratively plan actions to improve performance. Other approaches, such as Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA), have also been proposed for broader development contexts [15]. These participatory methods allow for a more inclusive and effective process to improve irrigation performance by directly engaging system users in the decision-making process.

Improving the performance of irrigation systems requires a thorough evaluation and diagnosis in order to propose practical solutions [16]. Various approaches have been detailed in key publications such as "Irrigation System Performance Assessment and Diagnosis" [17], "Development Process for Improving Irrigation Water Management on Farms: Problem Identification Manual" [18], and "Methodologies for Assessing Performance of Irrigation and Drainage Management" [19]. These authors have provided valuable frameworks for understanding the operational challenges of irrigation systems. Additionally, methods such as the logical framework approach, objective-based planning, and problem tree analysis have been proposed, though not specifically for irrigation systems [20]. Most of these methods depend on field data collection, which is vital for accurate system performance assessment and identifying improvement areas. Furthermore, remote sensing technologies have become essential for performance evaluation, with algorithms like the Surface Energy Balance Algorithm for Land (SEBAL) [21–23] and Mapping Evapotranspiration at High Resolution with Internalized Calibration (METRIC) [24] helping to understand water use efficiency and crop evapotranspiration better.

The International Irrigation Management Institute, through the "Irrigation Management in Burkina Faso (PMI-BF)" project, developed a strong methodology for diagnosing and evaluating the performance of irrigation systems [16]. This methodology's advantage is the provision of a clear and comprehensive assessment based on specific indicators that measure several dimensions of an irrigation system's management: water management, infrastructure management, agronomic management, and organizational management. In 1997, this methodology was successfully applied to evaluate the performance of five irrigation systems located around dams in Burkina Faso: Dakiri, Gorgo, Itenga, Mogtedo, and Savili [25]. These systems are classified as Type 3 according to the classification of the Permanent Interstate Committee for Drought Control in the Sahel [26]. Type 3 systems refer to small- and medium-scale irrigation systems managed by village communities to meet local food needs. Typically, these systems cover less than 100 hectares and are financed externally, although the local community often participates in their operation via their inclusion in schemes such as Village Irrigated Perimeters (PIV) and Small Market Gardening Perimeters (PPM).

The methodology developed under the PMI-BF project was also applied to assess the performance of the Karfiguela and Kou Valley irrigation systems in southwestern Burkina Faso. Unlike Type 3 systems, Karfiguela and Kou Valley are classified as Type 4 systems [11,26]. Type 4 systems are large-scale irrigation systems, covering between 100 and more than 1000 hectares, primarily intended for rice production. These infrastructures are financed by public funds and managed by the government's development companies, with beneficiaries being involved in the management. Farmers operating within these systems are usually organized into associations or cooperatives to manage production. Given their larger size and complexity, these systems require rigorous management and the farmer's active participation in the organizational and technical decision-making process. The evaluation of these systems using the PMI-BF methodology helped identify areas for improvement while highlighting the differences between small-scale community irrigation systems and large public systems.

After more than thirty years of implementing farmer-led management of irrigation systems and applying various tools and methodologies to support agricultural communities, it is important to evaluate the overall impact. It is reasonable to expect that these methods would have led to measurable improvements in system performance. However, questions remain: How have these farmer-managed systems evolved over time and across regions? Did these strategies significantly improve water management and infrastructure maintenance? Regular performance evaluations allow stakeholders to monitor progress, adjust strategies, and ensure that the systems continue to meet the growing demands of agricultural productivity. Evaluations are also essential to assess the sustainability of these systems in the face of climatic and economic challenges. Without continuous assessments, irrigation systems risk stagnating or becoming less efficient, negating the benefits of community-based management.

The objective of this paper is to evaluate the long-term performance and sustainability of community-managed irrigation infrastructure in Burkina Faso by analyzing six dam-adjacent irrigation sites over 30 years (1991–2024). Specifically, the aim of this study is to achieve the following:

Assess whether water from irrigation systems is being used efficiently by measuring key performance indicators, such as relative water supply (RWS) and production per unit of irrigation water (PbIr), to determine whether water is being used effectively.

Evaluate changes in agricultural productivity by comparing rice yields over time and determine whether productivity has improved, remained stable, or declined in these irrigation systems.

Analyze the financial sustainability of irrigation schemes by investigating water fee recovery rates and assess whether local irrigation cooperatives can sustainably fund infrastructure maintenance and operations.

Identify key governance and operational challenges by examining the effectiveness of community-led management, highlighting organizational weaknesses, and determining the impact of management transfer policies on irrigation system performance.

Document infrastructure degradation and maintenance issues by conducting field assessments to analyze the physical conditions of irrigation canals, water reservoirs, and drainage systems as well as identifying causes of deterioration.

Compare past and present irrigation performance by using historical data from the PMI-BF (1996) project to track long-term trends in irrigation system performance and management efficiency.

Propose new strategies for sustainable irrigation management, through institutional reforms, technical innovations (e.g., remote sensing), and improved governance models to enhance the long-term sustainability of irrigation systems.

2. Materials and Methods

2.1. Use of the Database of the Department in Charge of Hydro-Agricultural Development and Irrigation to Analyze Type 3 Irrigated Areas in Burkina Faso

Before an in-depth analysis using performance indicators, a preliminary phase was devoted to understanding the specific dynamics of Type 3 irrigation schemes. The database of hydro agricultural schemes in Burkina Faso was used as the primary source of information [27]. This database covers various aspects, including the developed areas by type of development, the physical condition of the infrastructure, the rate of use of the plots, the situation of producer organizations in the developed areas, and suggestions for appropriate organizations. The statistics on the development of community irrigation schemes are based on consolidated data from this database and reports from previous studies [28].

2.2. Study Sites

IIMI/PMI-BF carried out studies in five small irrigated areas: Mogtedo (Ganzourgou Province), Itenga and Gorgo (Kouritenga), Savili (Boulkiemdé), and Dakiri (Gnagna). Figure 1 shows the location of these sites. The PMI-BF selected these sites based on the volume and durability of the reservoir, the irrigated perimeter, the age of the irrigated perimeter, the effective presence of a producer organization, the cropping system, the distance from the urban center, etc. [25]. The Wedbila site, with an area of 44 hectares, is located in the province of Kadiogo. It also meets the selection criteria for the five PMI-BF study sites. Table 1 presents some general characteristics of these irrigation systems. The performance of two of these irrigated schemes (Mogtedo and Savili) has been re-evaluated by Reference [29].

Table 1. Main characteristics of the irrigated areas studied.

		Dakiri	Gorgo	Itenga	Mogtedo	Savili	Wedbila
Geographical coordinates	Latitude North	00°16′	00°22′	00°23′	00°50′	02°02′	1°25′
	Longitude West	13°18′	12°02′	12°11′	12°18′	12°05′	12°09′
The year of dam construction		1959	1980	1987	1963	1979	1975
Year of development		1984	1991	1989	1967	1984	1979
Gross capacity of the reservoir (m^3)		10,460,000	1,350,000	2,500,000	6,560,000	2,280,000	2,480,000
Irrigated perimeter (ha)		112	50	48	123	42	44
Type of irrigation		gravity	gravity	gravity	gravity	mid-pressure/mid-gravity	gravity

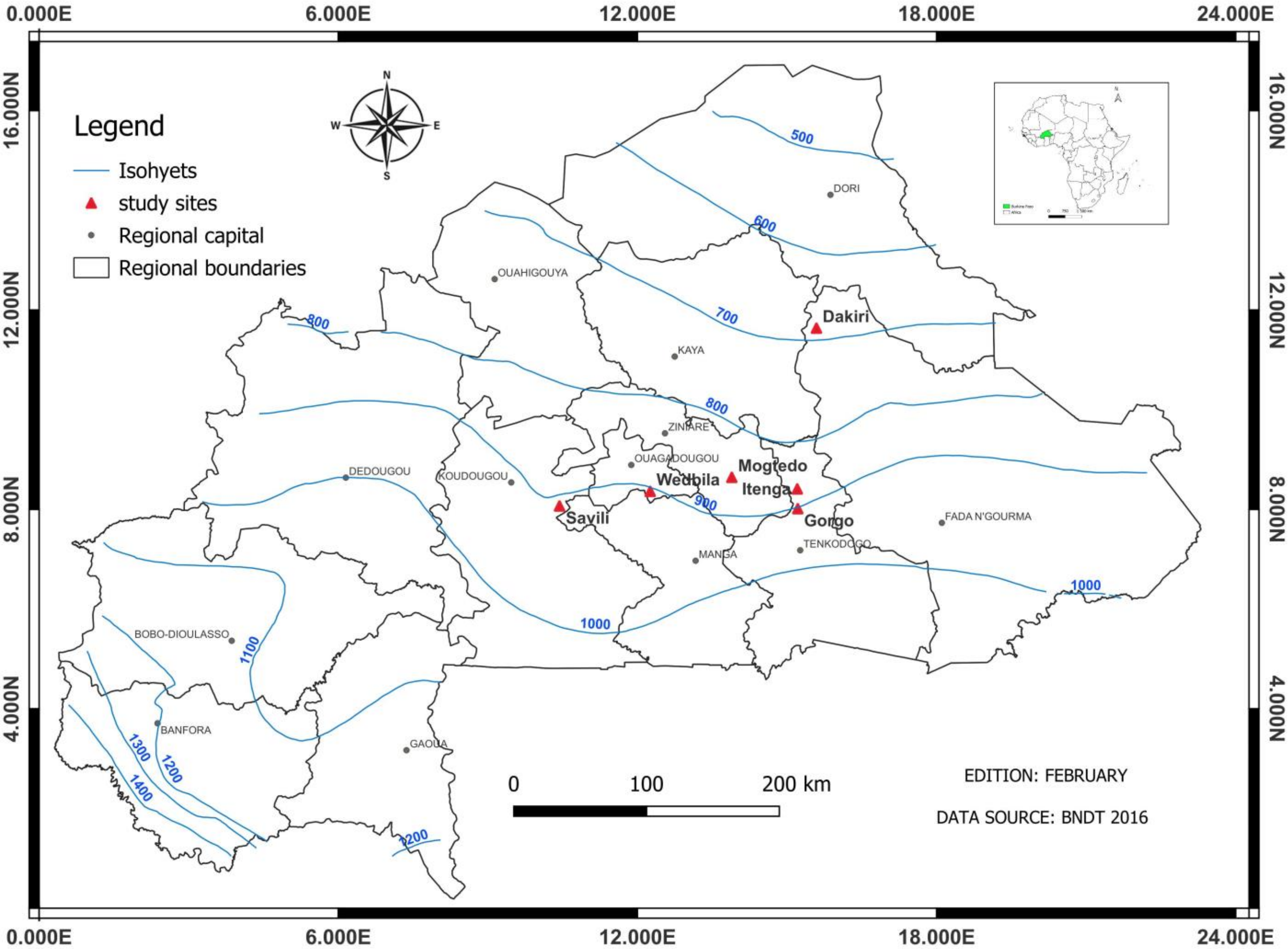


Figure 1. Location of study sites.

2.3. Performance Analysis

The IIMI/PMI-BF (1996) approach to performance analysis was adopted in this study. Before the introduction of the PMI-BF in 1991, there were no precise methods using quantitative techniques that were easy to implement to assess the performance levels and operational status of irrigation systems in Burkina Faso [16]. The PMI-BF methodology is based on a limited set of performance indicators (PIs) built around the main output of an irrigation system: production. These PIs are then compared with benchmarks aligned with the irrigation system's objectives, covering hydraulic, agricultural, and economic functions. Performance indicator benchmarks are established by comparing and analyzing several irrigation schemes to establish a satisfactory benchmark level for each defined indicator [16,30]. The objectives of an irrigation system include various categories such as production and productivity, profitability, resource use, sustainability, equity, and non-agricultural objectives.

2.4. Additional Surveys

Surveys were conducted in all the study sites using questionnaires and semi-directive interviews with people managing these irrigation areas. These included simple managers, members of irrigation committees or cooperative offices, some farmers, and agricultural agents. These surveys allowed us to assess the organizational dynamics of the sites. They made it possible to collect data such as the average rice yield, the members' participation rate in activities serving the collective's interest and the cooperatives' General Assemblies, the collection rates of agricultural fees, including water fees, the levels of application of sanctions, etc. In addition to these surveys, a physical diagnosis of the irrigation and drainage network was carried out in order to identify deterioration and assess the level of maintenance of these irrigated areas.

2.5. Parameters Measured

According to the recommendations of IIMI-PMI/BF (1996), the monitoring process must be operational; it must not be too cumbersome, and the number of indicators must be relevant and adapted to the context. To assess the performance of an irrigation system, PMI-BF proposes to collect ten basic parameters, the criterion being that they should be easy to collect by the farmers themselves, in line with the concept of self-management. At the Wedbila site, five parameters were collected and measured, namely, (i) the quantity of each crop produced per season, (ii) the area sown to each crop, (iii) the daily water level at the head of the primary canal, read on a limnimetric scale, and the daily duration of irrigation, (iv) the income received by the producers for each type of crop, and (v) the royalties collected by the farmers' organization (pre-cooperative group or cooperative) that manages the irrigation system. The hydraulic system operator recorded the daily water levels at the head of the primary canal using a water level record form, read on the water level gauge installed on a thick weir at the head of the primary canal, and the total irrigation times. This operation was carried out on each irrigation day throughout the 2014–2015 crop year. The total production obtained per crop was weighed using scales or determined using standard 100 kg bags. These parameters were used to calculate four performance indicators (Table 2): two on production and productivity, one on resource use, and one on sustainability. Table 3 provides an interpretation of these four performance indicators.

Table 2. Four performance indicators were used to assess the six sites studied.

Objectives	Indicators		Expressions
	Name	Symbol (Units)	
Production and productivity	Yield	Y (kg/ha)	$= \frac{production}{Total\ cultivated\ area}$
	Gross production per unit of irrigation water consumed	PbIr (kg/m^3)	$= \frac{Gross\ production}{Total\ volume\ of\ irrigation\ water\ withdrawn}$
Resource use	Relative water supply	RWS	$= \frac{\frac{Total\ volume\ of\ irrigation\ water}{Cultivated\ area} + Effective\ rainfall}{Crop\ evapotranspiration}$
Sustainability	Water fee recovery	RR (%)	$= \frac{The\ fees\ collected\ by\ the\ ISMO\ (Irrigation\ System\ Management\ Organization)}{Amount\ due}$

Source: Reference [16].

Measurements of flows through the irrigation canals were not carried out at every PMI-BF site as part of this study [31]; these measurements were performed at the Mogtedo and Savili sites. However, the values obtained from the studies conducted between 1991 and 1996 were used as a basis for comparison and evaluation, taking into account the physical condition of the irrigation infrastructure through a diagnosis carried out in 2024.

In this results section, the evolution of Type 3 irrigation systems in Burkina Faso will be presented. In addition, the results of the calculation of the performance indicators such as the rice yield on the irrigation systems studied, gross production per unit of irrigation water consumed, relative water supply, and royalty collection will also be presented.

Table 3. Interpretation of the four performance indicators.

Category	Indicators	Values Obtained by PMI-BF	Suggested References	Interpretation of the Indicator
Production and productivity	Y (kg/ha)	5000 (paddy)	5000	A value below the reference value means that the perimeter is not productive; otherwise, yields on the perimeter are good.
	PbIr (kg/m^3)	0.39 (paddy)	0.6 (paddy)	A value higher than the reference indicates good irrigation water use on the perimeter. A value below the reference indicates either poor production (see yield) or excessive volumes of water withdrawn for irrigation (see RWS).
Use of resources	RWS	2.9 (wet season)	2.3 (paddy)	A value close to the benchmark is a good indication of water management performance. A value well above the reference indicates water wastage and a value below indicates water scarcity. This may be because farmers find it difficult to manage irrigation and rainfall together. It may also be due to insufficient rainfall or irrigation (water loss in the network).
		2 (dry season)	1.4 (dry season market gardening)	
Durability	RR (%)	88	100	A value close to the benchmark suggests a reasonable collection rate. It also makes assessing compliance with the OGSI's internal regulations possible. If RR is below the reference value, then there is a shortfall in the Irrigation System Management Organization (OGSI)'s financial resources. The reasons for this may be a lack of motivation on the part of the farmers, as a result of a level of water charges that is too high for their income, or a lack of credibility on the part of the OGSI Board.

Source: Reference [16].

3. Results

3.1. Evolution of Type 3 Irrigated Perimeters in Burkina Faso: From the 1975 Agricultural Water Policy to the Present

According to data from the hydro-agricultural infrastructure census [28], the earliest irrigated perimeters in Burkina Faso, formerly Upper Volta, were initiated with the Type 3 classification. Among the oldest sites are Tougouri (120 hectares, 1950), Zeguedeguin (40 hectares, 1952), and Yalgo (204 hectares, 1954), all located in the Centre-North region. Type 3 systems constitute approximately 27% of the total irrigated area. Despite this percentage, Type 3 irrigation infrastructure is widely distributed across the national territory, covering nearly 11,000 hectares from 1950 to 2019, with consistent growth (see Figure 2).

The expansion of Type 3 developments became particularly evident in the 1980s, driven by the severe droughts of the early 1970s. These droughts significantly impacted agricultural production and livestock, leading to a major famine in 1973. In 1975, the government adopted an agricultural water policy to develop small and medium-scale hydraulic systems [32].

Between 1995 and 2001, the developed irrigated areas decreased. This decline can be attributed to the implementation of Structural Adjustment Policies in the agricultural sector (PASA), which promoted private initiatives in hydro-agricultural developments [6]. Starting in 1995, small private irrigated perimeters expanded significantly, often at the expense of other irrigation systems. However, from 2002 onward, an upward trend emerged, culminating in a peak of approximately 800 hectares between 2015 and 2016. These irrigated perimeters, typically developed downstream of dams with gravity-fed irrigation networks, experienced notable growth from the 2000s onward. This expansion coincided with the introduction of the semi-Californian irrigation system, characterized by pumping mechanisms designed to elevate water to higher lands, primarily upstream and around reservoir areas or along.

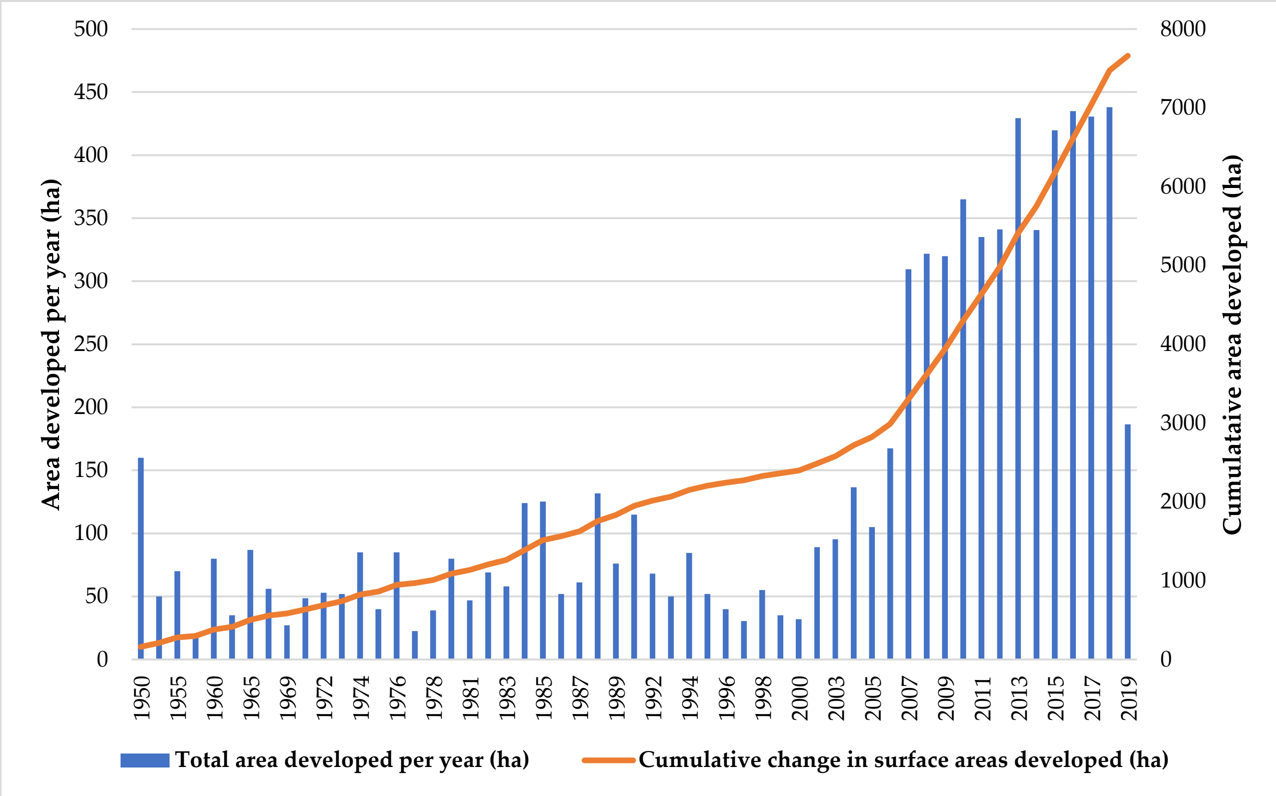


Figure 2. Evolution of areas developed as Type 3 irrigated perimeters from 1950 to 2019.

3.2. On the Dynamics of Water Reservoirs Associated with Irrigation Sites

The water reservoirs of Itenga, Gorgo, Mogtedo, and Wedbila, like most small reservoirs in Burkina Faso, are not perennial [33]. They fail to support two dry-season production cycles. Several factors contribute to this issue, the first being the expansion of irrigated areas which increases pressure on these reservoirs, resulting in significant water losses through the irrigation network. This is an issue that is always acknowledged by the users. The second issue is the silting of reservoir basins and substantial evaporation losses which further exacerbate the problem. Finally, multiple competing uses such as drinkable water supply, livestock watering, domestic chores, and industrial activity withdrawals add to the strain.

According to the 2024 inventory of water reservoirs, only 23.76% of the 1145 surveyed were considered perennial [33]. PMI-BF's socio-economic sectoral report highlights that water unavailability for off-season vegetable production was an issue present at the Gorgo site in the first year of operation [16]. At the Itenga site, water scarcity is partly attributed to its use for the supply of drinkable water to Koupela and Pouytenga.

3.3. On the Dynamics of the Operation and Maintenance of Irrigation Infrastructure

Table 4 presents the findings from surveys conducted in 2024 at pilot sites for the Irrigation Management Project in Burkina Faso, which was implemented between 1991 and 1996. This table highlights specific characteristics of irrigation management cooperatives across four localities: Itenga, Gorgo, Dakiri, and Mogtedo. It includes essential information such as the irrigated perimeter and utilized areas, the type and date of the establishment of the organizations, the number of members, organizational structure, and management practices. The table sheds light on various aspects of irrigation infrastructure management, conflict resolution mechanisms, the state of infrastructure, and each cooperative's financial and operational performance. These data enable a comparative evaluation of these local organizations' effectiveness and challenges in ensuring sustainable water and hydro-agricultural infrastructure management.

Table 4. Findings from the 2024 Surveys on Irrigation Scheme Management by local cooperatives at PMI-BF study sites (1991–1996).

Attribute	Itenga	Gorgo	Dakiri	Mogtedo
Irrigated Perimeter (ha)	48	50	120	123
Utilized Area (ha)	48	50	170	123
Organization Name	Namalgb-Zanga	SCOOPS Wend-Panga	USCPR-Dakiri	-
Type of Organization	Simplified Cooperative	Simplified Cooperative	Union of Cooperatives	Simplified Cooperative
Date of Establishment	17 April 2020	1 May 2016	22 December 2022	-
Last Executive Renewal Year	2021	2021	No renewal since the creation	-
Total Membership	230 (192 men, 38 women)	212 (152 men, 60 women)	747 (644 men, 103 women)	422 (250 men, 172 women)
Organizational Structure	1. Management Council 2. Control Committee 3. Irrigators' Committee 4. Local Facilitators	1. Management Council	1. Management Council 2. Control Committee 3. Irrigators' Committee 4. COGES	1. Management Council 2. Control Committee 3. Irrigators' Committee
Irrigators' Committee Members	8	3	15	-
Activity Program in Place	Yes	No	Yes	No
Action Plan in Place	Yes	No	No	No
Key Activities of CI	Manages water distribution (valves); Reports to Executive Board for repairs	Maintenance of infrastructure; Water management	Maintenance of infrastructure	Maintenance of infrastructure
Frequency of Meetings	1. Six General Assemblies (AGO) per year; 2. Extraordinary Assemblies (AGE) as needed	General Assemblies (AGO)	1. Two AGOs per year 2. AGE as needed	Only Extraordinary Assemblies (AGE)
Average Participation Rate in Assemblies	60%	65%	33%	30%
Management Tools Used	1. Meeting and Assembly Minutes 2. Activity Programs 3. Asset Management Documents 4. Membership Registry 5. Bank Account Records	Activity Programs	1. Meeting and Assembly Minutes 2. Activity Programs	Membership Registry
Participation in Association Activities	Good	Average	Good	Average
Participation in Communal Work (%)	75	33	48	25
Types of Sanctions Applied	Fines; Plot Withdrawal	Plot Withdrawal	Fines; Plot Withdrawal; Exclusion	Fines; Plot Withdrawal
Conflict Resolution Mechanisms	By Executive Board and General Assembly decision	Amicable Settlement	Amicable Settlement; Intervention of CI	By Cooperative Board Leaders
Condition of Irrigation Infrastructure	Poor	Poor	Poor	Poor
Average Rice Yield Over 5 Years (t/ha)	4	4.8	5	3.5
Funding Sources	Self-funding; Loans; Water fees; Profit from rice and input sales	Water fees	Equity Capital; Loans; Water fees	Water fees
Water Fee Recovery Rate (%)	82	97	N/A	50

Notes: N/A: Over the past two years, water fee payments have ceased due to insecurity in the area. According to testimonies, all members previously made payments. SCOOP: Cooperative Society. AGO: Ordinary General Assembly. AGE: Extraordinary General Assembly.

3.3.1. Site of Itenga

The irrigation scheme at Itenga, managed by the simplified cooperative Namalgb-Zanga, exhibits diverse characteristics and performance indicators. Established in 2020, the cooperative renewed its executive board in 2021 and currently comprises 268 members, including 38 women. An eight-member irrigators' committee is active, overseeing water distribution and identifying repairs needed within the irrigation network.

The cooperative convenes six Ordinary General Assemblies (AGO) annually, with an estimated 60% participation rate. Members actively contribute to communal works, with a participation rate of 75%, reflecting a strong engagement. The cooperative's primary funding sources include profits from rice and agricultural input sales, loans, and water fee recovery. The water fee recovery rate was 82% in 2023, a slight decline from 96% in 1996, a trend that calls for close monitoring. The maintenance of the Itenga irrigation scheme faces challenges, as evidenced by the deterioration observed (see Figure 3). Insufficient infrastructure maintenance remains a critical concern for the scheme [34].

Collapse of the Walls in a Segment of the Secondary Canal

Absence of On-Off Gate Valves

Wall of a Secondary Canal Collapsed Over Approximately 3 Meters

Figure 3. Some deterioration of structures in the Itenga irrigation scheme (photos taken in March 2024).

Sanctions outlined in the cooperative's regulations are strictly enforced, reflecting a rigorous governance approach. For instance, the withdrawal of plots of land has been implemented as a disciplinary measure. Historical records indicate that a leadership change in 1995 was prompted by the lack of transparency within the financial management [16]. Monetary fines continue to be applied to maintain financial accountability. This strict enforcement of sanctions is considered to be the best practice at this site. It could serve as a model for other irrigation schemes to foster the sustainable management of shared resources [35–41].

Despite the Itenga irrigation scheme's positive aspects, such as high participation rates and effective sanction enforcement, critical challenges remain regarding infrastructure maintenance and the declining recovery of water fees. These issues require continuous attention to ensure the irrigation scheme's sustainability and overall performance.

3.3.2. Site of Gorgo

At the Gorgo site, the simplified cooperative Wend-Panga was established on 1 May 2016, with the last executive board renewal occurring in 2021. The cooperative has a total membership of 212, including 60 women. An irrigators' committee comprising three members has been established within the cooperative, operating with an annual activity program. This committee is responsible solely for managing water distribution.

Ordinary General Assemblies are held twice yearly with an average participation rate of 65%. However, communal work participation is relatively low, estimated at 33%, indicating a lack of motivation among members.

The primary funding sources for the Gorgo irrigation scheme include profits from rice and input sales, loans, and water fee recovery. The water fee recovery rate is estimated at 97%, an improvement from the 85% reported in 1996 [25]. Despite this financial success, the management of the Gorgo irrigation scheme faces significant shortcomings, particularly in infrastructure maintenance. Observations indicate substantial organizational deficiencies in executing maintenance tasks, as evidenced by various deteriorations in Figure 4. These issues are attributed to a lack of regular upkeep. [42] reported similar challenges in irrigation scheme management regarding the Agricultural Development Group (GDA) in the governorate of Sousse, Tunisia, highlighting the need for stronger governance and maintenance practices.

Collapse of the walls in a segment of the secondary canal over approximately 10 meters

Demolished wall of a secondary canal

Aging and collapse of a primary canal crossing slab

There is absence of a protective grate, debris in the downstream basin, and a rusted intake

Figure 4. Some deterioration of structures in the Gorgo irrigation scheme (photos taken in March 2024).

At the Gorgo site, organizational management remains a significant challenge. The cooperative's executive board has not undergone a renewal, with testimonies revealing that the current president has held the position since the irrigation scheme was first developed in 1991. Initially established informally, the board was described as well-organized, with specialized commissions handling input supply, marketing, infrastructure maintenance, weighing, and water rotation management. It was formally re-elected for a second term in 1993, according to the socio-economic report by [43].

However, the current management faces criticism from members, raising questions about the causes of dissatisfaction. A critical issue appears to be the lack of renewal of executive members and the influence of an "all-powerful" president, feared by cooperative members according to reports. The centralization of power likely undermines cooperative principles and has significantly impacted the irrigation scheme's management.

The same socio-economic report highlighted that power-sharing among members previously fostered improved relations and adherence to cooperative principles. Restoring this balance is essential to address governance challenges and improve the overall performance of the Gorgo irrigation scheme.

3.3.3. Site of Mogtedo

At the Mogtedo site, a simplified cooperative was established in 1968, with the most recent executive board renewal occurring in 2018. Testimonies indicate that the current president, concerned about losing their position, employs strategies to avoid the board's renewal. The cooperative has a total number of members of 422, including 172 women.

The cooperative has established a management council of three members, a supervisory council of three members, and an irrigators' committee of three members. However, these groups lack annual activity programs. The irrigators' committee focuses primarily on managing water distribution.

Ordinary General Assemblies are held twice yearly, with an average participation rate of only 30%. Participation in communal works is similarly low, at 33%. Multiple producer organizations also mark the Mogtedo irrigation scheme, leading to frequent conflicts [44].

These challenges highlight the need for improved governance, conflict resolution mechanisms, and enhanced member engagement to ensure the irrigation scheme's effective management and sustainability.

The cooperative's primary funding source is the recovery of water fees. In 2023, the water fee recovery rate was estimated at 50%, a decline from 75% in 1996. This decline reflects adverse dynamics within the irrigation scheme, particularly regarding infrastructure maintenance.

The observations reveal significant organizational shortcomings in executing maintenance tasks for the irrigation scheme. Figure 5 illustrates various deteriorations observed in the Mogtedo irrigation infrastructure, which directly result from inadequate maintenance.

Collapse of the walls in a 21-meter segment of the secondary canal with significant debris accumulation

Collapse of the walls in a 5-meter segment of the secondary canal with soil and debris accumulation

Figure 5. Some photos of degraded canals in the Mogtedo irrigation scheme (photos taken in May 2024).

Addressing these issues requires strengthened organizational capacity and proactive maintenance strategies to ensure the irrigation scheme's sustainability and functionality.

3.3.4. Site of Dakiri

At the Dakiri site, the Union of Cooperative Societies of Rice Producers of Dakiri (USCPR-Dakiri) was established on 22 December 2022, with the next executive board renewal scheduled for 2025. The cooperative comprises 747 members, including 103 women.

The cooperative has established a 15-member irrigators' committee, including three women. The committee operates under an annual activity program focused on infrastructure maintenance and irrigation water management.

Ordinary General Assemblies are held bi-annually, with Extraordinary General Assemblies that will hold a meeting based on whether there is a need or at the producers' request. However, the average participation rate in General Assemblies is relatively low at 33%, while participation in communal works is 48%.

These figures indicate moderate member engagement, with room for improvement in participation and involvement to enhance the cooperative's functionality and effectiveness.

The cooperative's primary funding sources include equity capital, loans, and water fee recovery. Before 2022, this site's water fee recovery rate was consistently 100%. However, the deteriorating security within the country has significantly impacted this dynamic through the sharp decline of the members paying water fees.

According to the plains manager, insecurity has hindered maintenance work and disrupted the cooperative's operations, resulting in the interruption of water fee payments for at least two years. This situation poses serious challenges to the cooperative's financial sustainability and the effective management of the irrigation scheme.

The dynamics of the Dakiri irrigation scheme regarding infrastructure maintenance are unfavorable, reflecting significant organizational shortcomings concerning the execution of the maintenance tasks. Figure 6 illustrates several observed irrigation system deteriorations directly linked to inadequate maintenance efforts.

The concrete lining of the walls and floor of the primary canal completely disintegrated

Irrigation canal completely ruptured in the downstream section

Cooperative office unroofed, building degraded and abandoned

Figure 6. Some deterioration of structures in the Dakiri irrigation scheme (photos taken in March 2024).

According to Reference [45], aside from newly established agricultural water user organizations (OUEA), which currently provide relative satisfaction to their members, most existing professional agricultural organizations (OPA) managing hydro-agricultural developments face substantial operational and management difficulties. These include challenges in maintaining hydro-agricultural infrastructure, managing water resources, and collecting water fees.

Similar conclusions about the poor management of transferred community irrigation systems have been reached in multiple studies. [41,46–54] provide a comparable assessment, highlighting poor management practices in the pilot irrigation schemes of the Niger Irrigation Management Project (PMI-Niger, 1991–1996).

These findings underscore the need for enhanced organizational capacity and governance mechanisms to address persistent maintenance and operational challenges in the Dakiri irrigation scheme.

3.4. Rice Yield Dynamics

Rice yields evaluated across the studied irrigation sites show significant variations. These figures are compared against the national average and the reference values suggested by PMI-BF studies.

- Wedbila: The average rice yield is estimated at 4500 kg/ha in 2023, compared with a reference value of 5000 kg/ha.
- Mogtedo: The average yield declined from 3725 kg/ha in 1996 to 3500 kg/ha in 2023.
- Itenga: Yields dropped significantly, from 6903 kg/ha in 1996 to approximately 4500 kg/ha in 2023.
- Dakiri: An increase was recorded, with yields rising from an estimated 3945 kg/ha in 1996 to 4500 kg/ha in 2023.
- Gorgo: Yields increased slightly from 4680 kg/ha in 1996 to 4800 kg/ha in 2023.

These yield trends highlight diverse performance dynamics across the irrigation sites, reflecting the impacts of varying management practices, infrastructure conditions, and external factors on productivity.

A general trend of declining rice yields has been observed across all studied sites. The average yield for these sites is 4325 kg/ha. Small-scale irrigation schemes near dams rarely achieve rice paddy yields exceeding 5000 kg/ha. According to the Ministry of Agriculture, the national average rice yield for all irrigated schemes is 5239 kg/ha [55]. Rice yields at the studied sites fall below the suggested reference values. The overall decline in yields can be attributed to several factors, including agricultural practices, changing climatic conditions, irrigation infrastructure issues, and soil depletion caused by the repetitive cultivation of the same crop.

3.5. Evaluation of Irrigation Efficiency: Gross Production per Unit of Irrigation Water Consumed (PbIr)

The gross production per unit of irrigation water consumed (PbIr) for rice is 0.56 kg/m^3 at the Wedbila site. This value is 0.04 points below the reference value of 0.6 kg/m^3 for rice paddy, as suggested by PMI-BF studies. This value indicates a higher water usage for relatively low production, reflecting water wastage. The inefficiency may be attributed to the producers' difficulty in effectively combining rainwater with irrigation water as well as significant water losses during transport and/or on the field.

The irrigation network at this site shows advanced degradation, with observed cracks and breaks in specific structures. More than half of the regulation valves are either missing or damaged, contributing significantly to water losses. During the dry season and for vegetable crops, the PbIr is 0.27 kg/m^3. Compared with the PMI-BF reference value of 0.6 kg/m^3, this figure highlights insufficient production relative to the large volumes of water used.

This inefficiency is further supported by the relative water supply (RWS), which will be analyzed in subsequent sections. In 1996, none of the sites examined by PMI-BF achieved a PbIr equal to or greater than the reference value (see Figure 7). Surveys conducted in 2024 on these sites reveal a bleak image, justified by the poor state of infrastructures. The advanced degradation of irrigation networks at these sites suggests that the PbIr has not improved in over two decades.

Overall, these findings demonstrate the inefficient use of water resources. Recent studies by [31] on water management performance at the Savili and Mogtedo irrigation schemes reached similar conclusions regarding water inefficiency. Water application efficiencies were reported below 20% at Savili and between 41% and 55% at Mogtedo. However, in 2023, the Savili site benefited from rehabilitating its pumping station and irrigation network under the Regional Support Project for the Sahel Irrigation Initiative (PARIIS), which may improve its performance in the future.

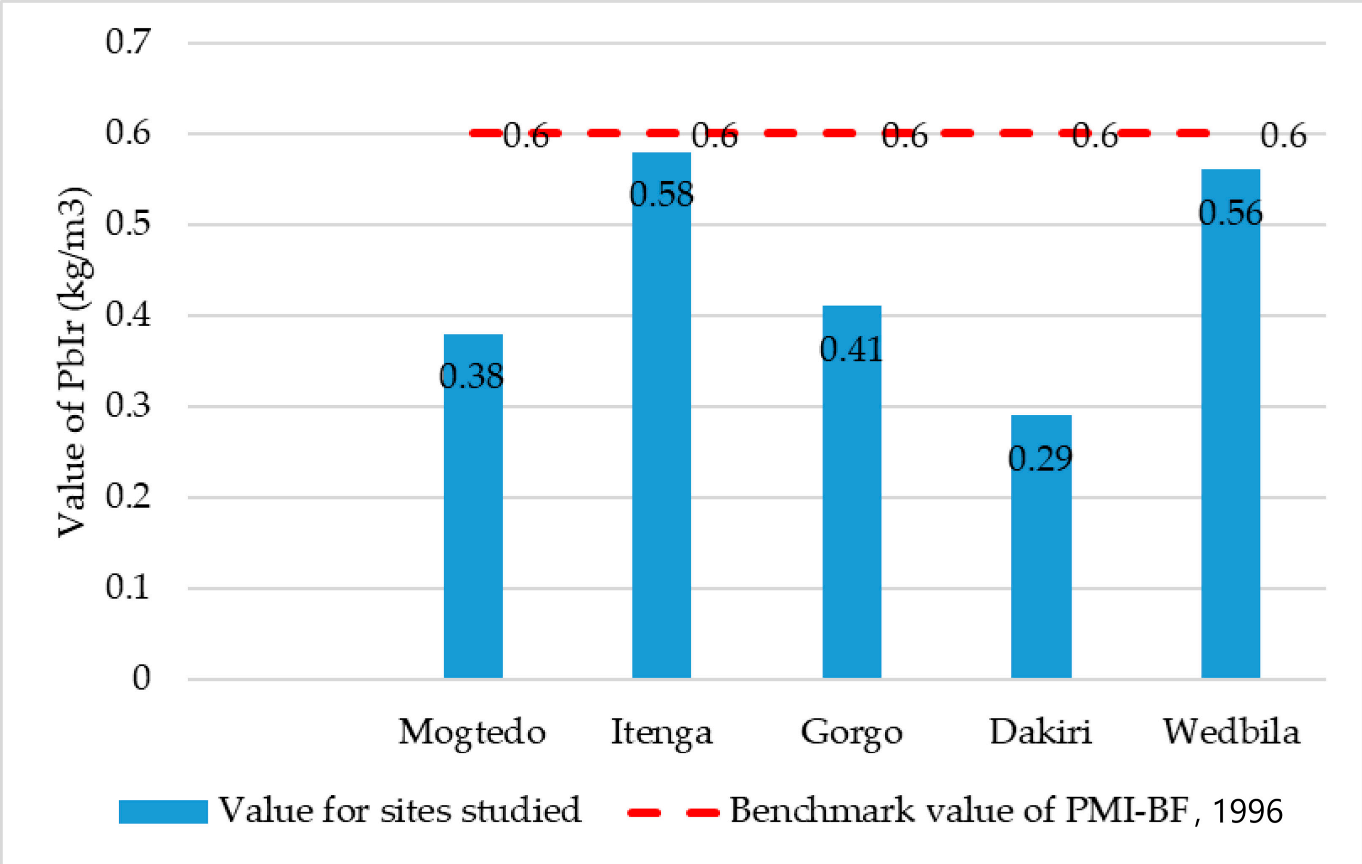


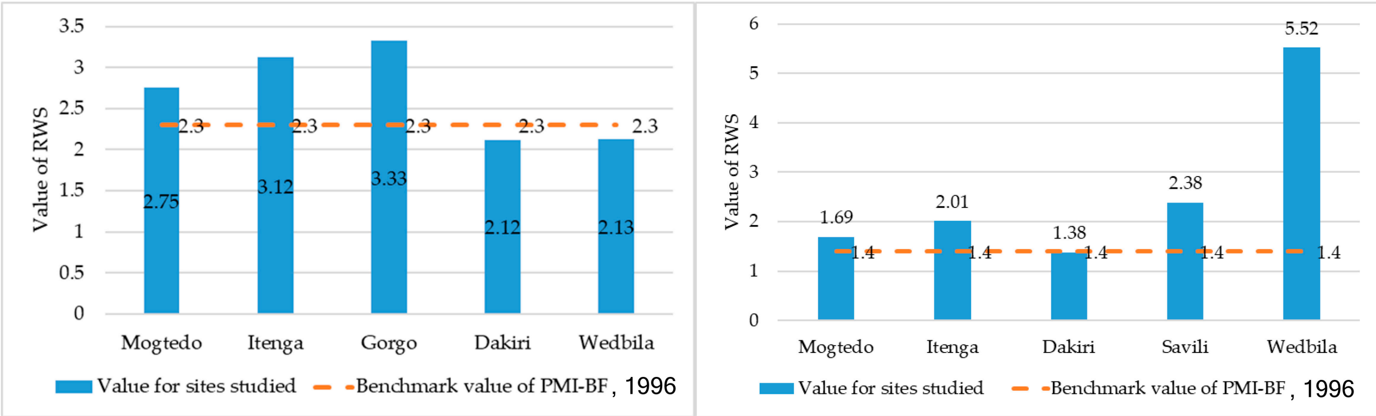
Figure 7. Comparison of gross production per unit of irrigation water consumed (PbIr, kg/m^3) for rice production at studied sites to the benchmark suggested by PMI-BF [16].

3.6. Analysis of Relative Water Supply (RWS): Performance and Water Wastage in Irrigation Management Across Studied Sites

At the Wedbila site, during the wet season (CH) for rice production, the RWS value (2.13) is close to the PMI-BF reference value (2.3) (Figure 8a). This value indicates acceptable water management performance during the wet season on this site. A similar observation was made in 1996 at the Dakiri site, where the RWS was 2.12. These relatively low performances can be attributed to the absence of irrigation during this period.

In contrast, the RWS values for Mogtedo (2.75), Itenga (3.12), and Gorgo (3.33) exceeded the PMI-BF reference, indicating water wastage during the rainy season at these sites. This wastage could result from deficiencies in the irrigation network or inefficient water use by farmers at the plot level. Farmers likely resorted to supplementary irrigation during this period.

For off-season vegetable farming, the RWS values far exceed the PMI-BF reference of 1.14 at the sites of Wedbila (5.52), Savili (2.38), Itenga (2.01), and Mogtedo (1.69) (Figure 8b). These elevated values reflect significant irrigation water wastage during the dry season at these sites.



(a) **(b)**

Figure 8. Relative water supply (RWS) values for wet-season rice production (**a**) and dry-season vegetable farming (**b**) across all sites compared with the benchmark value suggested by PMI-BF studies [16].

Research by [31] shows that water application efficiencies are below 20% at Savili and between 41% and 55% at Mogtedo. Since water application efficiency is inversely related to the relative water supply (RWS), the corresponding values were 5 at Savili and ranged from 1.82 to 2.44 at Mogtedo. These figures indicate a significant increase in water wastage over time, even though users were expected to improve their water management practices. This ongoing inefficiency persists despite the availability of various management methods, tools, and support from the government, NGOs, and other associations.

Efforts must reduce water wastage through improved irrigation infrastructure, farmer training, and stricter adherence to water management protocols.

4. Summary of Results and Discussion

4.1. Performance Gaps and Challenges in Small-Scale Irrigation Systems

The underperformance of small-scale irrigation systems is a widely recognized issue [41,56,57]. Performance indicators (see Table 5) reveal that these systems require intensive management and significant infrastructure improvements to enhance productivity and ensure sustainability.

Several hypotheses can be proposed to explain the observed performance gaps in irrigation systems:

- Farmers may not have received adequate support and guidance;
- The support provided may have been inappropriate or not aligned with their needs;
- The guidance may not have been followed through with proper implementation;
- Farmers may be demotivated regarding communal management practices;
- A lack of technical skills could hinder the adoption of efficient management practices.

Additionally, diagnostic and solution-finding methods may not sufficiently consider local factors, such as farmers' educational levels, social classes, context, individual aspirations, or the prioritization of actions.

An innovative tool known as WASO was developed [58] to help diagnose and resolve issues related to the operation and maintenance of irrigation systems to address these aforementioned challenges [58]. This approach places farmers at the center of the process, aligning with the principles of the Sahel Irrigation Initiative [26]. This producer-focused methodology enhances the sustainability and performance of irrigation management systems.

Table 5. Summary of calculated and reference values for performance indicators across sites, covering production and productivity, resource utilization, and sustainability.

Aims and Objectives	Indicators	Values of the Indicator						Reference Values
		Wedbila	Dakiri	Gorgo	Itenga	Mogtedo	Savili	PMI-BF
Production and productivity	R: Average rice paddy yield (Kg/ha) in 1996		3945	4680	6903	3725		≥5000
	R: Average rice paddy yield (Kg/ha) in 2023	4500	4500	4800	4500	3500		
	Gross production per unit of irrigation water consumed (PbIr, kg/m^3) for rice	0.56	0.29	0.41	0.58	0.38		≥0.6
Utilization of resources	Relative water supply (RWS) for rice during the wet season	2.13	2.12	3.33	3.12	2.75		≈2.3
	Relative water supply (RWS) for dry-season vegetable farming	5.52	1.38		2.01	1.69	2.38	≈1.4
Sustainability	Water fee recovery rate (RR, %) in 1996		92%	85%	96%	75%	96%	100%
	Water fee recovery rate (RR, %) in 2023	4%		97%	85%	50%		100%

According to Reference [19], improving the performance of irrigation systems requires satisfying three key conditions:

1. The existence or establishment of a framework that managers can use to assess performance;
2. A set of practical and meaningful indicators to measure performance;
3. An incentive and reward system to motivate managers to enhance current performance levels.

However, most of the studied irrigation systems lack a formal framework to evaluate the performance of irrigation schemes. Future research should prioritize developing and implementing operational, maintenance, and monitoring frameworks for communal irrigation systems.

These irrigation systems are shared resources, so Elinor Ostrom's (1990) principles offer valuable guidance for addressing governance challenges. Ostrom's work highlights universal principles for sustainable socio-ecological systems. Her insights, detailed in published books "Governing the Commons" (1990) and later expansions [59,60], emphasize the importance of collective action and self-governance for managing shared resources effectively.

Incorporating Ostrom's principles into the governance of communal irrigation systems can facilitate the development of sustainable frameworks that ensure ecological balance and operational efficiency.

In line with this perspective, the Sahel Irrigation Initiative advocates for "solutions" to establish efficient and sustainable irrigation and drainage systems [26]. An irrigation solution encompasses the approach, implementation modalities, and activity specifications required to develop and manage high-performing irrigation systems (see Figure 9).

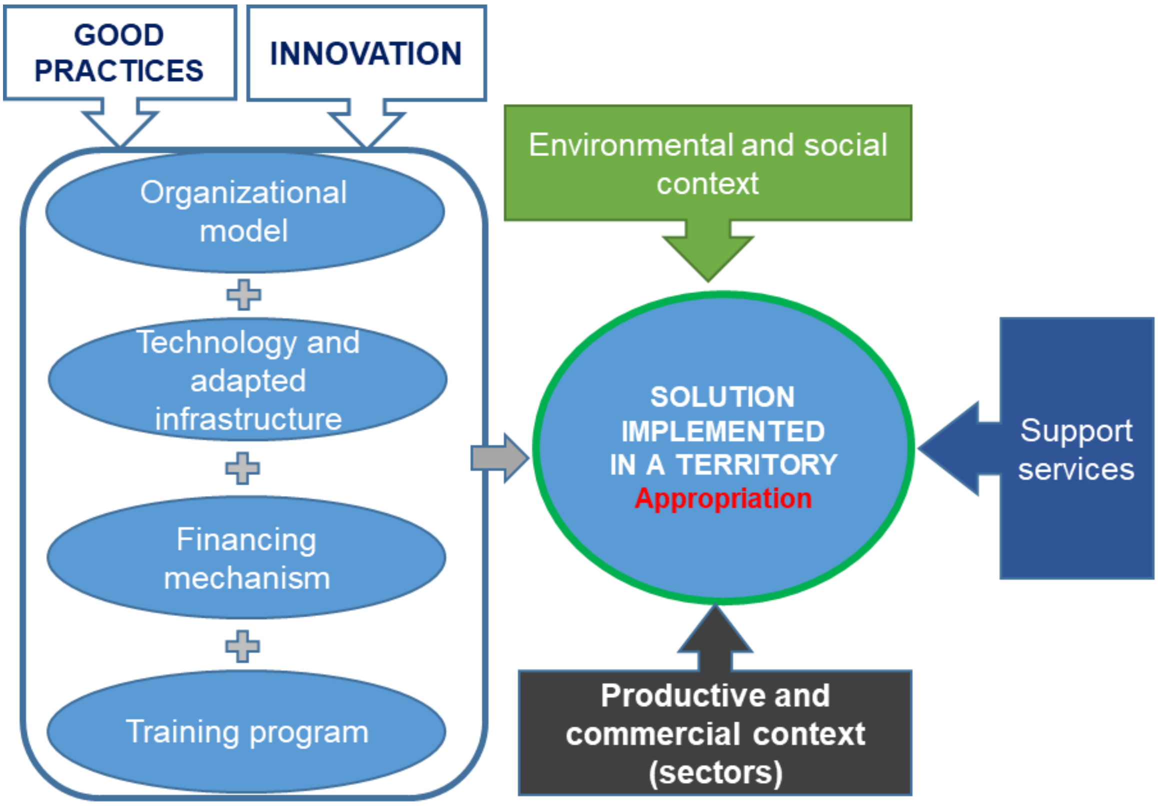


Figure 9. The concept of irrigation solutions derived from the strategic framework for agricultural water in the Sahel [26].

This concept is built on four key components:

1. An organizational framework that defines the roles and responsibilities of stakeholders.
2. A technical irrigation system with infrastructure and equipment necessary for efficient operation.
3. A financing mechanism to support both the investment phase and the coverage of operational and maintenance costs.
4. Capacity-building actions to equip stakeholders with the knowledge and skills needed to implement and manage the solution effectively.

An irrigation solution should therefore provide a comprehensive implementation approach tailored to a specific irrigation system, addressing both technical and organizational dimensions for long-term performance.

4.2. Comparative Analysis of the Management of Community-Irrigated Perimeters: Burkina Faso vs. International Experiences

Community irrigation systems in Burkina Faso face structural and institutional problems similar to those observed in other regions of the world (see Table 6). Numerous studies have highlighted the recurrent challenges faced by these irrigation schemes, particularly in terms of governance, infrastructure maintenance, user participation, and financing [61–63].

Table 6. Comparison of challenges in community-managed irrigation systems: Burkina Faso vs. international experiences.

Challenge	Burkina Faso	International Experiences
Management model	Community management with limited state oversight for Type 3 irrigation schemes	Hybrid models: community participation and government support (Morocco, China, Nepal)
Governance and accountability	Lack of effective leadership in some associations	Stricter governance rules and penalties for non-compliance (Nepal, Peru)
Maintenance and sustainability of infrastructure	Rapid deterioration due to lack of funding and maintenance	Maintenance financed by public–private partnerships (Morocco, Mexico)
Involvement of users	Low involvement in decision-making	Greater involvement of farmers through financial and technical incentives (India, Philippines)
Water fee collection	Low payment rates, dependence on subsidies	Graduated charges and compulsory maintenance funds (Brazil, China)
Managing water resource-related conflicts	Lack of effective conflict resolution mechanisms	State intervention to arbitrate conflicts (Benin, Ghana, Tunisia)
Adaptation to climate change	Lack of alternative solutions in the event of drought	Drip irrigation systems and water-saving solutions (Israel, Australia)

In addition, several case studies highlight the critical role of the state in managing irrigated land. Community management alone does not always ensure the sustainability and performance of infrastructure. According to [42], farmers unanimously believe that state involvement facilitates the resolution of conflicts over resource use. A similar study by [64] on the Malanville irrigation system in Benin showed that cooperation between self-governing structures and the State is essential for effective conflict management.

In another case, [65] demonstrated that improvements in canal maintenance and operational efficiency were possible in a hydropower unit in the Office du Niger as a result of a co-construction approach between the state and farmers. While producers recognized the benefits of this approach, they also stressed that this mobilization should not replace the institutional responsibilities of the state.

Ref. [66], who studied decentralized water management in the Jeffara region of Tunisia and the Aït Bouguemez valley in Morocco, highlighted the difficulties faced by local institutions in a participatory management framework and concluded that strategic state intervention is essential to maximize the success of community management systems.

Finally, the study by Ref. [67] of two community irrigation projects in Ghana (Bontanga and Golinga) showed that sustainable management depends on the adoption of an integrated approach involving all users, the participation of local communities, and appropriate incentives to ensure producer commitment.

According to Reference [61], the sustainability of irrigated perimeters rests on three main pillars:

1. Effective local governance, combining user participation and institutional support.
2. Sustainable financing, through effective collection mechanisms and appropriate incentives.
3. Optimized management of infrastructure to ensure its long-term maintenance.

International experience shows that effective coordination between state and local structures is essential to ensure the economic and environmental viability of community irrigation schemes.

4.2.1. Similarities and Common Issues

An analysis of the case studies in Burkina Faso and elsewhere shows that many challenges are common to most community irrigation schemes, regardless of the geographical context. Obstacles related to infrastructure degradation, financing difficulties, local governance, and farmer participation have been widely documented in several countries in Africa, Asia, and Latin America.

1. Deterioration of infrastructure and insufficient funding for maintenance

As emphasized in the study by [62] in Ethiopia, irrigated infrastructures are rapidly deteriorating due to insufficient funding for maintenance. This phenomenon is exacerbated by the absence of a structured, long-term funding mechanism. In Burkina Faso, canals, dykes, and pumps are also affected by a lack of maintenance. The same situation has been observed in Peru, where [68] highlights the need for stable funding and a strengthened institutional framework. In the study of Mali by [65], the application of a co-construction approach between the state and farmers improved infrastructure maintenance, although this approach requires methodical support and sufficient financial resources.

2. Difficulties in collecting water charges

The collection of water royalties is a persistent problem in several African and Asian countries. Ref. [63] analyzed the situation in China, where the non-payment of irrigation fees undermines the viability of the systems and jeopardizes their sustainability. Similarly, in Burkina Faso, the rate of fee collection is extremely low, preventing adequate funding for infrastructure maintenance. As demonstrated by refs. [42,64] in Benin, greater state involvement can facilitate the collection of funds and reduce conflicts over access to water.

3. Low farmer participation in decision-making

In Burkina Faso, farmers' participation in irrigation cooperatives is limited, which reduces their capacity for self-management and undermines the effectiveness of local governance. Ref. [68] shows that, in Nepal, self-managed irrigation systems perform better when users play an active role in governance, suggesting that farmer empowerment is a key factor in achieving success. Ref. [67], studying community irrigation systems in Ghana, concluded that sustainable management depends on an integrated approach involving the state and local authorities, and a well-structured incentive system.

4.2.2. Differences and Good Practice Elsewhere

Although there are common challenges, some international experiences offer innovative solutions that could inspire improvements in the management of irrigated areas in Burkina Faso.

1. Hybrid governance model (China, Morocco, Tunisia)

In contrast to the model seen in Burkina Faso, where community structures manage Type 3 irrigation systems on their own, in China the state also plays an active role in supervising and supporting these types of irrigation systems. It provides technical support to agricultural cooperatives and facilitates access to funding for infrastructure maintenance [63].

In Morocco, the participatory management model is based on the strong involvement of irrigators' associations, supported by the state, which provides technical advice, subsidies to modernize equipment, and training programs to improve irrigation efficiency [61].

In Tunisia and Morocco, ref. [66] have shown that decentralized local structures have difficulties ensuring sustainable infrastructure management and equitable access to water. State intervention, through a regulatory framework and financial support, compensates for these limitations and enables more effective and sustainable management of water resources.

2. Incentive strategies for financing irrigation (Brazil, Peru, India)

In certain regions of Brazil and Peru, farmers who actively participate in irrigation management benefit from tax reductions and financial support to purchase equipment [68]. In India, irrigators' associations receive public funds linked to management performance, which ensures better maintenance of infrastructure. Reference [67] show that the introduction of financial and organizational incentives ensures efficient and sustainable management of community irrigation schemes.

4.2.3. Recommendations Based on Comparison

Based on this international experience, some recommendations can be made to improve the management of community irrigation schemes in Burkina Faso:

1. Strengthening local governance
    - Create an autonomous structure responsible for the management of irrigated areas;
    - Establish a stricter legal framework for the management of irrigated land;
    - Introduce a system of penalties and incentives to improve the collection of fees and make farmers more accountable.
2. Encouraging sustainable financing models
    - Test a progressive charging model where farmers pay according to their ability to pay;

Explore public–private partnerships (PPPs) to finance infrastructure maintenance.

4.3. Comparative Analysis of Type 3 and Type 4 Irrigated Perimeters (Karfiguela and Kou Valley) in Burkina Faso

The comparative analysis between community irrigation schemes (Type 3) and irrigation schemes with strong state involvement (Type 4, such as Karfiguela and Vallée du Kou) allows for an assessment of the extent to which community management and state management influence the performance of irrigation systems.

4.3.1. Comparison of Performance Indicators

The results of Reference [11] on Karfiguela and Vallée du Kou, two Type 4 schemes, show that the performance indicators in these Type 4 schemes are below the PMI-BF benchmarks, despite the strong involvement of the state. This suggests that the sole presence of the state does not necessarily guarantee a better performance if technical, financial, and institutional support is insufficient.

Table 7 compares the performance of Type 3 and Type 4 schemes according to the PMI-BF indicators:

Table 7. Comparison of performance indicators for Type 3 and Type 4 irrigation schemes in Burkina Faso.

Indicators	Type 3 (Community Management)	Type 4 (Karfiguela and Kou Valley, [11])	Reference PMI-BF
Average rice yield (kg/ha, 2023)	3500–4800	4200–4900	≥5000
Gross production per unit of irrigation water (PbIr, kg/m^3)	0.29–0.58	0.42–0.56	≥0.6
Relative water supply (RWS) wet season	2.12–3.33	2.4–3.1	≈2.3
Water charge collection rate (%)	4–97%	50–85%	100%

Type 4 irrigation schemes do not always perform as expected, despite state involvement. Results from Reference [11] show that state-run schemes such as Karfiguela and Vallée du Kou continue to underperform, suggesting that state involvement is not sufficient if the support system is not effective. This is consistent with observations on municipal schemes (Type 3), where local management without strong government oversight also leads to weaknesses in maintenance, fee collection, and water management.

Weaknesses common to both types of systems include

- Poor water management: RWS values above 2.3 indicate inefficient use of water resources in both Type 3 and Type 4 schemes;
- Low productivity: Neither type of scheme achieves the target yield of 5000 kg/ha set by the PMI-BF;
- Funding and maintenance problems: Although the state is present in Type 4 schemes, fee collection rates remain low (50–85%), affecting the financial sustainability and maintenance of the infrastructure.

4.3.2. Challenges and Perspectives for Improvement

The analysis of Type 4 irrigation systems shows that the mere presence of the state does not necessarily guarantee better management. For its intervention to be truly effective, it is essential to strengthen its supportive role through more rigorous supervision, backed by performance monitoring mechanisms to regularly assess the state of infrastructure and the effectiveness of management practices. In addition, the introduction of financial and technical incentives would encourage the improvement of infrastructure and its long-term maintenance. Finally, the adoption of a more effective royalty collection strategy, based on successful experiences in China and Morocco [61,63], would ensure sustainable funding for the maintenance of irrigated areas under state management.

In the case of Type 3 community schemes, the aim is not to abandon local management but to strengthen and structure it further to overcome its current limitations. This means better training farmers in water resource management so that they can make informed decisions and optimize water use. In addition, the introduction of charging systems tailored to the financial capacity of farmers would ensure better cost recovery and hence the better maintenance of infrastructure. In addition, closer cooperation with local authorities and the private sector could enable the co-financing of facilities through public–private partnerships (PPPs) [66]. International experience shows that hybrid models combining government support and community empowerment achieve better results when they are based on transparent governance and clear economic incentives.

Study limitations and perspectives for future research

Despite providing valuable insights into the performance of irrigation schemes, our study has certain limitations. A major limitation is the lack of continuous monitoring data for the entire period from 1991 to the present. Such data would have allowed a more detailed longitudinal analysis of the evolution of irrigation systems. However, alternative approaches, such as the analysis of historical photographs from 1991, could help to assess structural and spatial changes in the irrigation areas studied over time.

Another limitation lies in the methodology used to evaluate the performance of irrigation systems, in particular the one developed by PMI-BF. Its need for manual programming for each application makes it less user-friendly and limits its widespread adoption. To overcome this limitation, future research should focus on integrating automated and dynamic tools that combine real-time field measurements with remote sensing techniques. This approach would improve the accuracy and efficiency of performance assessments while making the assessment process more accessible and scalable for irrigation managers.

5. Conclusions

The evaluation of small-scale, community-managed irrigation schemes in Burkina Faso over the past three decades highlights critical gaps in governance, financial sustainability, and infrastructure maintenance. Relative water supply (RWS) values indicate significant water wastage, while gross production per unit of irrigation water (PbIr) remains below optimal levels, reflecting inefficiencies in water use. In addition, the low and declining water tariff collection rates illustrate the financial fragility of these systems, preventing adequate infrastructure maintenance and long-term sustainability.

Comparative analysis with international experience shows that successful irrigation systems often involve a hybrid governance model, with local management structures operating under government supervision and technical support. In contrast, the limited involvement of the Burkinabè government in community-managed irrigation has not led to the expected improvements in performance, highlighting the need for enhanced institutional support.

To address these challenges, the study suggests

- Strengthening governance frameworks by formalizing farmer-led irrigation management structures with clear accountability mechanisms;
- Developing sustainable financing mechanisms, such as incentive-based fee collection strategies and public–private partnerships (PPPs) for infrastructure maintenance;
- Modernizing irrigation management through the use of remote sensing technologies and automated performance monitoring tools;
- Encouraging state involvement in technical training, conflict resolution, and infrastructure investment, without fully replacing community management.

While farmer-led management remains a key component of irrigation governance, government intervention and institutional oversight are needed to improve efficiency, ensure financial sustainability, and increase resilience to climate variability. Future research should focus on integrating real-time data collection and performance monitoring systems to facilitate decision-making and optimize water resource management.

Author Contributions: Conceptualization, C.B.B., A.K., S.P., J.W., F.T., and B.T.; methodology, C.B.B., A.K., J.W., F.T., B.D., S.P., A.R.M., and A.B.; investigation, C.B.B., A.B., and A.R.M.; resources, C.B.B., A.R.M., A.B., and S.P.; data curation, C.B.B. and A.K.; writing—original draft preparation, C.B.B.; writing—review and editing, F.T., S.P., B.D., J.W., A.R.M., A.B., A.K., and B.T. All authors have read and agreed to the published version of the manuscript.

Funding: Wallonie–Bruxelles International (WBI) of Belgium and the Ministry of Agriculture of Burkina Faso funded this study (grant number SUB/2021/496004).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data from this study are available from the Directorate General of Hydro-Agricultural Development and Irrigation of the Ministry of Agriculture of Burkina Faso.

Acknowledgments: We are grateful to the late Dial Niang for his support in the early stages of formulating my research project. May his soul rest in peace. Peace be upon him. We also acknowledge Wallonie–Bruxelles International (WBI), a Belgian organization that supported our PhD studies. Thanks to Josué Sawadogo and Benaissa Paloute Zampaligré for proofreading the English version of this paper.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study, the collection, analysis, or interpretation of data, the writing of the manuscript, or the decision to publish the results.

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