

Problem Structure Analysis of Irrigation Systems in the Upper West Region of Ghana

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Ghana's agricultural sector is heavily dependent on rainfall, but the rainfall pattern is erratic, making the sector a high-risk venture for many investors. The Upper West Region annually experiences a short rainy season and a relatively long dry season (i.e., October to April). Irrigation is therefore essential for enhancement of agricultural production. A number of earth embankments have been constructed as dams and dugouts have been excavated throughout the region to create water reservoirs for irrigation, especially for dry season farming. However, the irrigation facilities are beset with problems. This paper presents a problem structure analysis of the irrigation systems in the region with the aim of proposing a feasible and sustainable scheme of irrigation infrastructure management. Additionally, a framework for institutionalizing Water Users Associations (WUAs) is developed. A reconnaissance study of selected irrigation facilities across the region identified the major problems. Interview sessions were also conducted with farmers who maintain irrigated plots, and the existing infrastructure was observed. Major challenges identified include a low sense of ownership and responsibility toward the management of the irrigation facilities on the part of the users, leading to their poor maintenance. For sustainable irrigation management, clarification of responsibilities and appropriate role sharing between the users and the Ministry of Food and Agriculture following the principles of Participatory Irrigation Management is recommended. The ministry should be responsible for provision of technical support services, effective monitoring and supervision of the WUAs, whereas the WUAs should ensure adequate maintenance and operation of the irrigation facilities.

Key words: Maintenance and Operation, Participatory Irrigation Management, Water Users Association, Sense of Ownership

1. Introduction

1.1 Background

Irrigated agriculture has accounted for less than 17% of the world's farmland but for approximately 40% of the world's food production over the past half century (FAO, 1996). Thus, the average yield of irrigated land is about more than two times that of non irrigated lands. In 2006, the ratio of irrigated to non irrigated land was 20% (FAOSTATS, 2006). Thus, irrigation agriculture plays a large role in food security owing to its high productivity in comparison with that of rain-fed agriculture. Despite the high development cost of irrigation, devel-

oping countries have promoted its development in order to increase food production in response to population growth. The use of irrigation technology in Ghana is not widespread, but it is considered of great importance in view of the seasonal and intermittent occurrence of drought in the country. Most of Ghana's agricultural sector is rain-fed, and most farmers cultivate small plots with an average area of less than 1.2 ha. Thus, small-holder farms dominate the sector, accounting for about 80% of total agricultural production in Ghana (AQUASTAT Survey, 2005). The sector contributed 32% of the gross domestic product of Ghana in 2007, which in that year was USD 16.12 billion (World Bank,

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2009), and in 2003 about 56% of the economically active population was employed in the sector (AQUASTAT Survey, 2005)

1.2 Development of Irrigation in Ghana

The development of formal irrigation in Ghana began in the 1960s, and by 2003, 22 public irrigation projects has been completed throughout the country however no public irrigation project has been established in the Upper West Region (UWR). Formal irrigation refers to those projected that was initiated by the Government. The estimated total potential irrigable area in Ghana is 1.9 million ha (AQUASTAT Survey, 2005), of which the estimated area with irrigation facilities is 30,900 ha: 8,587 ha in public schemes (GIDA, 2001), 10,413 ha in private schemes (FAO, 2005), and at least 11,900 ha of peri-urban irrigation around the Kumasi Metropolitan District (Wallingford, 2002). It is estimated that 24,600 ha have surface irrigation facilities (8007 ha in public schemes; 4,693 ha in private schemes; 11,900 ha of informal peri-urban irrigation, which includes 6,300 ha irrigated by sprinklers, 580 ha in public schemes, and 5,720 ha in private schemes). Surface irrigation systems distribute water primarily by gravity or pumping, or a combination of the two. Most irrigation projects have constructed dams and reservoirs to store water for irrigation because streams cannot supply enough water during the dry season. In a few cases, weirs have been built across perennial rivers to divert irrigation water. The major irrigated crop is rice, with a harvested area of 5,238 ha in 2002. Other frequently produced irrigated crops include tomatoes, okra, peppers, sugar cane, cucumbers, cowpeas, and maize (AQUASTAT Survey, 2005).

The Ghana Irrigation Development Agency (GIDA), part of the Ministry of Food and Agriculture (MoFA), is responsible for formulating, developing, and implementing irrigation and drainage plans for year-round agricultural production in Ghana.

1.3 Irrigation Agriculture Problems in Ghana

Of the 30,900 ha of land with irrigation facilities, only about 27,900 ha (90%) were actually irrigated in 2000, and of the 8,587 ha of land in the 22 public irrigation schemes, only 5,600 (65%) were actually irrigated (AQUASTAT Survey, 2005). Moreover,

by 2003 the actual amount of land under irrigation in public irrigation schemes had decreased to approximately 5,200 ha (Miyoshi and Nagayo, 2006). It is clear, therefore, that irrigated agriculture in Ghana has a serious problem in terms of sustainability. Miyoshi and Nagayo (2006) attributed the decreasing irrigated land area to the declining capacity of aging facilities to convey and distribute water, the abandonment of irrigated agriculture due to the complete collapse of facilities (e.g., pump failure), and suspension of irrigation owing to the inability of the users to bear the cost of operating pump stations.

Like other developing countries, Ghana has focused on the construction of physical irrigation facilities, but it has neglected the development and dissemination of user-related technology necessary for the effective utilization of the existing irrigation systems. As a result, irrigation schemes have been implemented without the participation of farmers and without charging them for the use of the facilities. Therefore, farmers who have been the beneficiaries of the irrigation schemes have had poor awareness of their responsibilities and have instead been heavily dependent on the government. This lack of awareness has been a major hurdle to the development and enhancement of farmers' organizations.

In the early 1990s, Ghana introduced "Participatory Irrigation Management", under which farmers' organizations assume responsibility for the management of irrigation facilities. However, owing to the lack of effective policy, laws, and technical support, neither farmers nor the government have taken responsibility for the management of irrigation projects. This study is a structural analysis of irrigation systems in the UWR of Ghana. In this paper, an effective course of action for sustainable irrigation management in the region is developed, with a special focus on the introduction of Participatory Irrigation Management (PIM).

2. Profile of the Study Area

2.1 Location and Size

The UWR (latitude 10° 43'–10° 31' 53.05" N, longitude 2° 54'–1° 31' 53.46" W) is in the northwestern corner of Ghana and is bordered on the south and southeast by the Northern Region, on the northeast by the Upper East Region, and on the north and

northwest by the Republic of Burkina Faso. It is one of the 10 regions of Ghana and covers an area of 18,476 km², constituting 7.7% of the total land area of the nation. Its capital and largest city is Wa (latitude 10° 3' 0" N, longitude 2° 29' 0" W), which is the region's only urban center. The region is administratively divided into nine districts: Wa Municipal, Wa East, Wa West, Jirapa, Lambussie-Kani, Lawra, Nadawli, Sissala East, and Sissala West. According to the 2000 Population and Housing Census (Ghana Statistical Services, 2000), the population of the region is 576,583, and the average population density is 34 persons/km², which is far below the national average of 77 persons/km². The population is growing at a rate of 1.7%, and it is demographically a fairly young population. However, 7% of the population is 60 years old or older, which means that the economically active population has a high proportion of the population dependent on it.

2.2 Rainfall and Climate

The same climate is shared by the three northern regions. There are two seasons, the dry and wet season. The region experiences a relatively short wet season from May to September, during which approximately 80% of the total precipitation occurs. Rainfall during this season is characterized by relatively few, high-intensity storms, particularly at the start of the season, leading to high levels of runoff and soil erosion. A dry spell of 3 to 5 weeks after the early rains in April and May is common, which results in serious losses and delays to early planted crops, particularly millet (GIDA-Wa, 2005). The wet season is usually followed by 7 months of dry weather, spanning the period from October to April. According to available rainfall data from three weather stations, Wa, Babile, and Tumu, covering 28 years (Figs. 1–3), the rainfall pattern shows only slight differences from place to place; total rainfall ranged from 1,100 mm in the south to 900 mm in the northeast. The monthly average rainfall during the wet season suggests that the rainfall might be sufficient for agriculture, but because much of the rain is concentrated in a few heavy rainfalls, the distribution of rainfall is uneven and the minimum monthly rainfall is far less than the average. As a result, irrigation is necessary for stable agricultural production, even during the wet season.

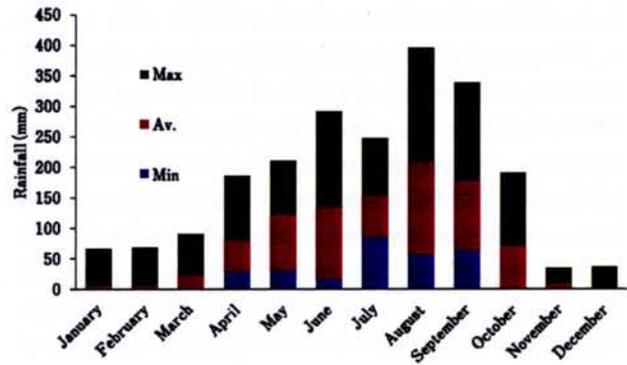


Fig. 1. Monthly rainfall at Wa (1979–2007).

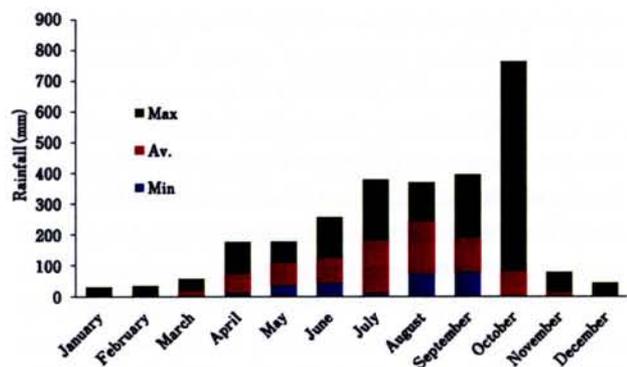


Fig. 2. Monthly rainfall at Babile (1979–2007).

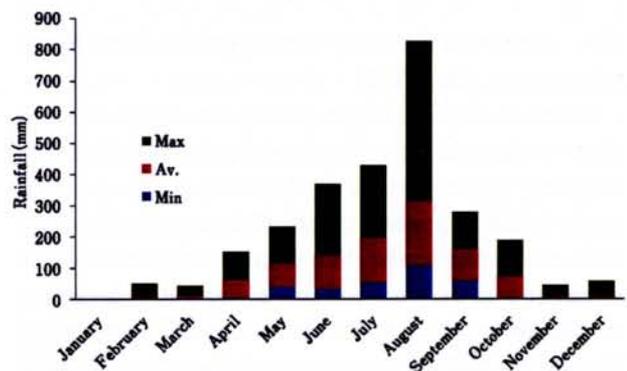


Fig. 3. Monthly rainfall at Tumu (1982–2007).

The dry season is characterized by cold, hazy Harmattan weather; dry dusty Harmattan winds usually blow from early November. In the latter part of March, intense hot weather begins, and it ends only with the onset of the early rains in April. Irrigation development is thus vital for agriculture in the dry season and for farmers to be able to work throughout the year.

2.3 Water Resources in the UWR

Water resources in the UWR consist of surface waters and groundwater. The UWR lies within the Volta River basin, and all three main rivers in the region flow southwards: the Black Volta River (forming part of the border with Burkina Faso), the Kulpawn River, and the Sisili River (which forms the border with the Upper East Region). Only the Black Volta is perennial. Small earth dams in the region are located on minor tributaries, which flow only intermittently and only during the wet season. There are no hydrological data from small streams in the region, but reservoir depth, which is constrained by local topography, is shallow, and evaporation is high in relation to storage volume.

The groundwater potential in the region is variable and depends on the degree of decomposition and fracturing of the impervious granite and hard limestone that constitute the bedrock. Some groundwater can be found at most locations, and the water table is generally less than 10 m from the surface. The quality of groundwater is generally good, and well yields are often adequate for hand-pumping. Past experience indicates that 60–70% of boreholes in the region yield usable water when well sites are selected by geophysical techniques (GIDA-Wa, 2008).

2.4 Irrigated Facility Development and Management in the UWR

From the 1950s to the 1960s, an extensive program was implemented to construct small dams for trapping water for use by both humans and livestock in the dry season, with little regard to irrigation of arable lands, but some of these facilities were later converted for use in irrigated cropping by the government of Ghana. Since 2000, over 200 dams have been constructed and dugouts excavated by various government agencies, nongovernmental organizations, and private companies to create water reservoirs for dry season irrigation farming, domestic use, fishing, and livestock watering (Fig. 4) (GIDA-Wa, 2008). For example, since 1996 the National Livestock Service has constructed nine dams, the Agriculture Sub-Sector Investment Project has constructed five, the National Disaster Management Organization Project and the Village Infrastructure Project have each rehabilitated two dams, and Plan Ghana has recently constructed eight dams. Around the dam sites, mainly vegetables are cultivated during

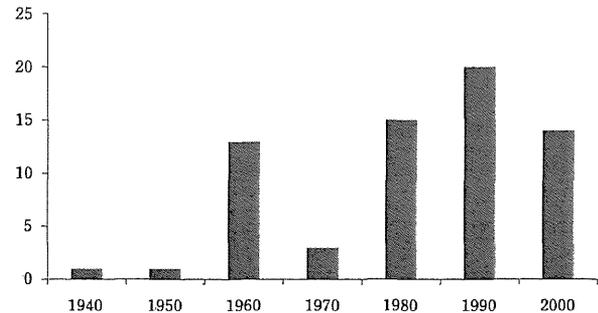


Fig. 4. Number of dams constructed each decade from 1940 to 2007 in the UWR (Same dams were not included because the years of construction were not available).

the dry season, most commonly onions, tomatoes, peppers, okra, cabbage, lettuce, pumpkins, cucumbers, and leafy vegetables such as alefu (*Amaranthus* spp.), bra (*Hibiscus sabdariffa*), and bean leaves. Onion cultivation is particularly common, and onions are one of the most important agricultural exports from the region. Watermelon and maize are also cultivated around some dam sites in the dry season.

Despite the construction of many facilities over the past decades, 25% are in disrepair (GIDA-Wa, 2008), suggesting that serious water management problems are reducing the sustainability of irrigation systems in Ghana. However, no overall inventory of problems and very few analyses, especially ones based on field surveys, have been conducted to ascertain the present situation.

2.5 Irrigation Development: the UWADEP/IFAD Project

In 1995, MoFA and the International Fund for Agricultural Development (IFAD) formulated the Upper West Agricultural Development Project (UWADEP), creating a Water Resources component to handle irrigation. Among other infrastructure achievements, the project has successfully rehabilitated 19 of the 20 earth dams targeted. As a result, a total irrigable area of 154 ha of the appraisal target of 220 ha has been made available for dry season gardening. According to the draft project completion report (MoFA/IFAD, 2005), 455 family units now crop 41.5 ha of the 154 ha currently available during the dry season, but the irrigation facilities are not fully utilized because of insufficient participation of communities, a low sense

of ownership and responsibility for the dam facilities on the part of the users, and poor functioning of Water Users Associations (WUAs). GIDA-Wa (2005) further described several general problems with regard to WUA participation: (a) the WUAs were poorly guided and informed and did not really grasp the concept of farmer participation and involvement in the design and implementation of the irrigation systems, or their management after completion; (b) they mistakenly believed that all irrigation facilities that were pre-identified as in disrepair would be selected for eventual rehabilitation; and (c) they were not fully committed to the project's objectives to ensure the sustained use of facilities after rehabilitation, as Letters of Undertaking between GIDA/Project Support Unit (PSU) and the WUAs were never signed.

However, despite the underutilization of the facilities, by 2000, farmers were carrying out both dry and wet season gardening at eight of the rehabilitated dam sites, which generated economic benefits to the farmers beginning in 2001. At the Busa dam site, for example, 120 farmers were cultivating 10.8 ha with tomatoes, okra, and leafy vegetables during the 2000/2001 dry season, for a total net income of ₵ 8,314,400 (USD 3,451.02). During the wet season, 21 farmers cultivated a high-yielding rice variety, TOX 3107, and made a net income of ₵ 2,166,000 (USD 154.71). In 2002, farmers earned income during the dry season for okra, ₵ 33,381,600 (USD 2,384.4); tomatoes, ₵ 105,000,000 (USD 7,500); and leafy vegetables, ₵ 25,155,000 (USD 1,796.79). The net income from rice and maize cultivation was ₵ 14,152,500 (USD 1010.89) and ₵ 29,864,500 (USD 2,133.18), respectively. A total of ₵ 17,200,000 (USD 1,228.57) was also earned during the period by 12 fishermen at the Busa dam site. Similar benefits were realized in 2003 (MoFA/IFAD, 2005).

3. Methodology

Twelve small-scale irrigation facilities and earth dams were selected across the UWR in consultation with GIDA. The criteria for selection included the geographic location and targeted both open channel and closed conduit systems of irrigation water delivery. The projects are located in six districts in the region and were funded through government interventions and organizations such as Agricultural Sub-Sector Investment Program (AgSSIP), IFAD,

Action Aid, and Plan Ghana. The selected facilities were in the communities of Nyimati, Tiwii, Karni, Busa, Chaare, and Han. Other communities visited and analyzed were Babile, Jeffisi, Pingbenbem, Zini, Fian, and Yeliyiri. A reconnaissance study was conducted in late January 2009 to see what crops were actually being cultivated in the dry season. The irrigation infrastructure, including the water reservoir, the dam wall, the water delivery and distribution channels, and the farm plots, were observed, and interviews and discussions were conducted with farmers who maintained irrigated plots around the dam sites, WUA leaders, and leaders of the various communities in which the facilities were located.

4. Results

4.1 Irrigation Facilities in the UWR

In the UWR, a typical irrigation system consists of a water reservoir behind an earth dam in which surface runoff generated in the catchment area during the wet season is collected. An emergency spillway at each reservoir allows the safe release of excess water. At most dam sites, irrigation water is designed to be diverted directly from the reservoir and delivered to the cropped area by gravity via open, concrete-lined trapezoidal canals, and sometimes via farm ditches. These canals are designed to be filled for application to individual plots by operation of an adjustable valve on the main outlet from each reservoir. However, water conveyance and delivery systems are not uniform across the region. At most dam sites in the Sissala West and East districts, in the northeastern UWR, water delivery is by gravity via subsurface closed conduits into concrete storage tanks constructed in the irrigable area. These storage tanks have a capacity of about 2.5 m³ and usually are about 20 m apart.

Seedbed preparation and cultivation are performed manually with a hoe. Water management practices and the operation and maintenance of the system are performed by the farmers themselves or by members of the local WUA. The WUAs elect a small number of officials to carry out fee collection and management decisions. All farmers cultivating a plot within the irrigation system may be asked to pay a set fee per plot to the local WUA. These fees are saved for use for canal repair and maintenance. The studied projects and the field observations are summarized in Table 1.

Table 1. Summary of the Problems of Each Project

Community	Technical State of the Dam	Water Use	Potential Irrigation Area (Ha)	Actual Irrigation Area (Ha)	Water Delivery System	Year of		Observed State of the Facilities*	Remarks*
						Construction	Rehabilitation		
Nyimati	Good	I, F, L	20	20	Closed conduit (tank)	2007		—	Well-organized WUA
Tiwii		I, F, L	20	20	Closed conduit (tank)	2007		—	Well-organized WUA
Karni	Good	I, F, L	15	10	Open canals	1989/ 1989	1998	Broken, silted-up canals, weak WUA, high dam seepage	
Busa	Good	L, G, F, I, D	15	10	Open canals	1971	1998	Broken, silted-up canals, weak WUA,	
Chaare	Good	L, I, D, F	5	5	Closed conduit (tank)	1987	2004	Low storage capacity, high siltation, weak WUA	
Han	Good	L, I, F, D	12	8	Open canals	1985	2004	Deteriorated & abandoned canals, weak WUA	No water delivery
Babile	Breached	L, I, F	15	3		1991	1999	Dam wall breached by a crocodile	No Farming activity noticed
Jeffisi	Good	I, F, L	20	20	Closed conduit (tank)	2007			No farming activity noticed
Pingbenbem	Good	L, I, D	7	5.5	Open canals	1960	2004	High dam seepage, low storage capacity, un-completed canal works	
Zini	Good	L, I, D	5	5	Closed conduit (tank)	2007			No farming activities noticed at the time of the visit
Fian	Good	L, I, D	15	8	Open canals	2001		Parts of canal system silted, choked, and collapsed less maintained canals, low storage capacity, Weak WUA	
Yeliyiri	Fairly Good	L, G, I, F	—	—	Delivery canal system	1964	1996	Low storage capacity, parts of canal system collapsed and silted up, poorly maintained canals, weak WUA	Dredging required

L=Livestock Watering, G=Gardening, F=Fishing, I=Irrigation, D=Domestic.

Source: GIDA, UWR.

*Field observations by the author.

4.2 Problems Found

4.2.1 Condition of the Delivery Canals

At all sites except Tiwii, Nyimati, and Jeffisi, collapsed and poorly maintained canal networks, sometimes choked with weeds and mud, were observed (Fig. 5). As a result of this insufficient maintenance of the canals, farms downstream were prevented from benefiting from the irrigation system. However, despite what must be a serious problem for the downstream farmers, these problems were not being properly handled. At Tiwii, Nyimati, and Jeffisi, water is delivered to the fields via a closed-conduit system from small reservoirs (concrete tanks) that are shared by several farmers (Fig. 6). Thus, open, shared canals are not well maintained in the UWR.

4.2.2 Water User Association Activities

Among the WUAs, only those at Tiwii and Nyimati seemed to be well organized. Some WUAs exist in name only, conduct no activities, and appear to lack a basic understanding of users' obligations and rights. Others are not serving the purposes for which they were established, such as collection of user fees, ensuring timely repairs, and facility maintenance. At Karni, the WUA leader interviewed ascribed ownership of the facility to MoFA, and thus expected to receive regular financial support from the ministry for routine repairs and maintenance of the hydraulic structures. The Tiwii and Nyimati WUAs collected regular maintenance charges from the farmers who benefited from the facilities, but those of the other communities wait until problems with infrastructure occur before taking appropriate action. The low sense of ownership and the apathy to payment of operations and maintenance (O&M) fees are directly reflected in poor operation and maintenance of the facilities.

Additionally, most WUAs and farmers do not seem to have sufficient knowledge and skills for O&M of the structures, in part because of weak supervision and inadequate delivery of extension services by MoFA to WUAs and users at the district level. MoFA's front line staff, that is, agricultural extension agents, themselves lack adequate knowledge and skills with regard to the appropriate maintenance of hydraulic structures and soil and water conservation engineering, and therefore are unable to deliver the requisite services to the farmers. Most extension officers have received training mainly

in the agronomic aspects of crop production and very little in irrigation water management. Monitoring, supervision, and technical backstopping of district extension workers by MoFA with regard to irrigation system O&M are virtually nonexistent. Moreover, major repairs and maintenance may require heavy equipment, such as an excavator for dredging, which is beyond the technical and financial capacities of the local people. Another major contributory factor to irrigation system problems in the UWR is inadequate irrigation water delivery and distribution to most farm plots because of leakage and choked or broken delivery canals. Some farmers have thus resorted to hand-dug wells and dugouts as sources of water (Fig. 7 shows dugouts; Fig. 8 shows a well in Han).

4.2.3 Design and Construction of Facilities

MoFA/IFAD (2005) attributed the malfunction of some of the canal systems to faulty design and construction. During the IFAD/UWADEP project, most dam facilities were constructed by local feeder road contractors with poor technical capacity, inadequate equipment, and little or no knowledge of dam construction. Community leaders, for example, informed us that the canals at the Han dam and reservoir have never been used for irrigation water delivery to farm plots since their construction and subsequent rehabilitation in 2004. They reported that even when the adjustable valve was completely opened, no water flows into the canals. During the study visit, it was observed that most of the canals had collapsed and been abandoned, or were in a bad state of repair (Fig. 5). High water seepage levels were also noticed at some dam sites (e.g., at Karni, Han, and Fian (Fig. 9). Andanye (2005) observed that the main irrigation pipe at the Chaare dam seemed to be buried at a higher ground level than the intake.

4.2.4 Reservoir Capacity Maintenance

The irrigation systems in the UWR are also underutilized because of the low storage capacity of some reservoirs. For instance, during the study period, in January, 2009, very little water was observed in the Chaare dam reservoir, which according to one farmer, normally dries up before March. The area around the water level measuring stick was dry (Fig. 10), and the reservoir was heavily silted up. The high siltation can be also attributed to inappropriate cultivation in the reservoir's catchment



Fig. 5. Broken Canal in Busa.



Fig. 8. Using a well in Han.



Fig. 6. Storage tank of the closed-conduit system in Nyimati.



Fig. 9. Water leakage from the reservoir in Karni.



Fig. 7. Dugouts in Busa.



Fig. 10. Low storage in the Chaare dam reservoir.

area. Three farm plots were found within the catchment area, close to the dam. As a result, during the wet season, loose top soil is carried by runoff from high-intensity rainfall events into the reservoir. The reservoirs at Yeliyiri, Fian, and Pingbenbem were also found to have low storage capacities.

5. Discussion

User-related challenges based on the results regarding the farmers' sense of ownership and understanding of O&M of existing irrigation systems, and on the institutional capacity necessary for their effective utilization, in the Upper West Region of Ghana, are the focus of this discussion.

5.1 Problem Structure

Observations of the targeted irrigation projects revealed many problems. To determine a course of action for solving the problems and improving the situation, the problem structure, which can reveal causal relationships between factors and independent factors, must be analyzed. For this purpose, a problem tree based on four basic classes of factors, natural, facility-related, WUA-related, and governmental, was developed (Fig. 11).

5.2 Implementation of Participatory Irrigation Management in the UWR

PIM can be applied at three stages to a target

area to achieve sustainable management and effective utilization of irrigation infrastructure: (1) before the start of an irrigation project; (2) during project planning, design, and construction; and (3) during project operation and maintenance.

(1) Stage 1

Before the start of an irrigation project in a target area, adequate awareness needs to be created and common water management goals need to be formulated and understood. When people have input on decisions that affect their lives and resources, they develop a sense of ownership that motivates their sustained commitment. It is thus necessary to engage prospective users in shared decision making before the start of any irrigation project. The reality in the UWR was far different from this idea. For instance, during the IFAD project, WUAs were poorly prepared and informed and therefore did not grasp the concept of farmer participation and were not fully committed to the project's objectives (GIDA-Wa, 2005). The intended beneficiaries of an irrigation project should be made aware of their long-term responsibility through collaboration with other stakeholders, including the implementing agency, district assemblies, GIDA, Regional Agricultural Development Unit (RADU), District Agricultural Development Unit (DADU), consultants, and community elders/chiefs. The procurement of services for the construction of irrigation project facilities should also

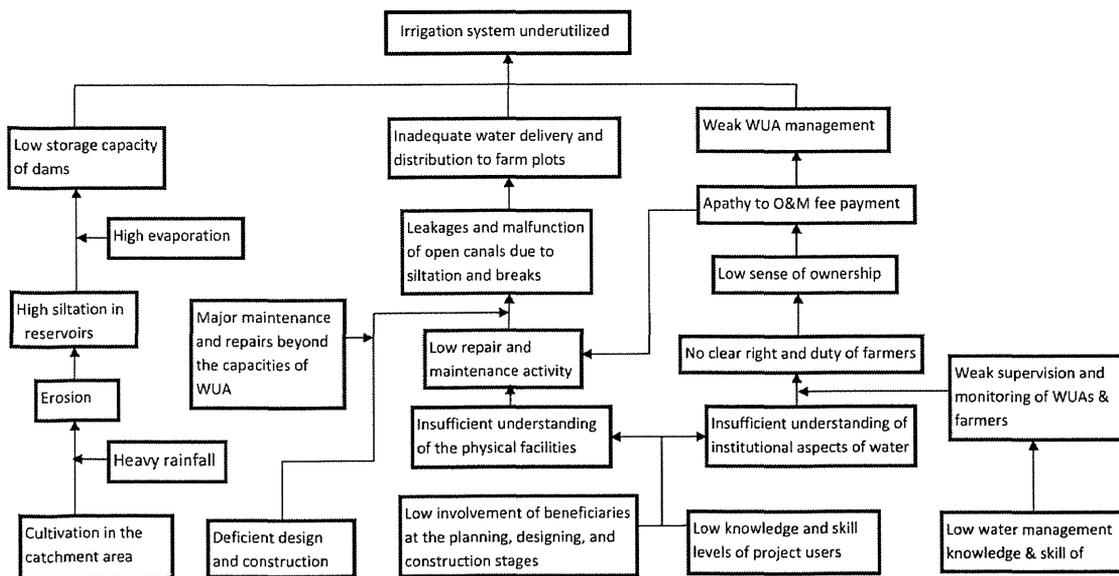


Fig. 11. Water management problem tree in the UWR.

conform to the requirements of the Ghana Public Procurements Act No. 663 (2003), as pointed out in the IFAD UWADEP Interim Evaluation Report (2006). This would ensure competitive bidding from a wide range of competent professional companies.

(2) Stage 2

All stakeholders should be deeply involved in the initial planning, design, and construction of irrigation projects, particularly the prospective users. Farmers are the direct users of the irrigation facility; thus, the planning and design of the irrigation facilities should reflect their concerns and inputs regarding site selection, survey, alignment of canals according to existing topography, type of water delivery system to be employed, and so on. Data collection and engineering design can be effectively improved by taking advantage of their knowledge of local soil type and depth and topography, and of where outlets and intakes should be located. This also has the advantage of giving the farmers a firm mental picture of the nature of the irrigation system to be established, and an idea of the amount of water that can be expected to be available for irrigation. Experience in Sri Lanka and the Philippines suggests that from 9 to 12 months of preparation is needed to involve farmers in new projects. Where farmers have no prior experience with irrigation, time is needed for them to learn new forms of cooperation (Lowdermilk, 1986). Their participation from the initial stage strengthens their sense of ownership in the project (JIID, 2007) and tends to eliminate technical malfunctions due to faulty design. It is thus recommended that the extent of planned farmer participation be a consideration when awarding contracts to appropriate construction firms. Furthermore, WUAs, an essential element of PIM, should be established at this stage. Moreover, they should be informed as to the benefits of irrigation and the rights and obligations of members, as well as given guidance on how to conduct general meetings and elect officers, and training on water allocation planning and O&M.

Moreover, farmers should be made to make some financial contribution, as a commitment fee, toward project construction because farmers that have a financial stake in a project develop a deep sense of involvement in it (Asian Productivity Organization, 1980). In Japan, farmers are obliged by the Land Improvement Law enacted in 1949 to share

the cost of a typical irrigation project. Though the government greatly subsidizes the project's cost, farmers have to bear some part of the cost at every level, from the main canal to the field facility. The cost of a national project is typically shared by the government at central (67%), regional (17%), and municipal (6%) levels, and by the Land Improvement District (LID) (10%) (Unpublished document of Masayoshi Satoh, 2009). Small-scale dams can be constructed at relatively low cost, and they improve the lives of poor people living under adverse conditions as well as confer a degree of social protection (IFAD, 2006). Thus, to enhance the sense of ownership and responsibility of prospective irrigation project beneficiaries in the UWR, future projects in the region should not be completely donor or government funded. Prospective users in the region should be made to contribute a portion of the full cost. An "involvement" fee should be levied on each beneficiary household. Those who are not able to contribute money can contribute labor for the facility's construction and operation.

(3) Stage 3

In irrigation projects, water management, in the broad sense, consists of the operation, maintenance, and management (i.e., organization and financing) of the irrigation facility. Among these, operation of the facility can be regarded as the core water management activity because it is the action that actually brings the water to farmers (Satoh *et al.*, 2007). Operation involves the manipulating of the structures that convey, distribute, and apply irrigation water according to the design specifications. In the target area there are two types of gravity irrigation system, subsurface closed-conduit systems in which water is delivered by gravity into surface tanks, and open-channel systems that deliver water by gravity into canals. In practice, O&M differs between these two types of system but nevertheless follows the fundamental principles of PIM. Here, water management responsibilities and appropriate role sharing between users and the MoFA are clarified by considering four processes: decision making, operation, monitoring, and feedback.

First, the decision making process determines how much water should be distributed to canals or surface tanks on the basis of an evaluation of water demand and supply. Since farmers are the ultimate users of the water, they must themselves carry out

this process. It is the responsibility of MoFA to provide the requisite technical information on hydrology, hydraulics, and agronomy to help the farmers to make appropriate decisions.

Second, the operation of irrigation facilities, including the opening and closing of adjustable valves, is the responsibility of the WUA officers and should be done in accordance with an agreed plan. The time and date of operation as well as the water level in the reservoirs should be recorded. Regular maintenance of the irrigation system is necessary for sustained performance of an irrigation project because a system that is not maintained deteriorates. It is thus necessary for the WUAs to adopt a comprehensive program of maintenance to assure protection of the investment. Maintenance activities such as canal cleaning (dredging and weeding) should be carried out by the WUAs before irrigation commence seasonally. Particular attention should also be given to surface erosion of the earth dams. Excessive weed growth should be checked by mowing or cutting the weeds, and trees should be prevented from growing on or near the dam embankment. An O&M levy for routine maintenance should be imposed on users, and the farmers should be made to understand the necessity of these O&M fees. As part of O&M income generation, a water user fee should also be levied on communities of Fulani herdsmen who periodically water their cattle at reservoirs. Tolls should also be collected from local civil contractors who draw water for their projects. Major repairs and maintenance that are beyond the capacity of WUAs and farmers must necessarily be performed with the support of District and Municipal Assemblies in collaboration with MoFA.

Third, responsibility for monitoring the facilities should be shared between MoFA and the users. A regular inspection and monitoring program should be established to ascertain how well the project is fulfilling the objectives/common goals set during the planning stage. Farmers have an important role in this process, by watching for illegal operation or destruction of the irrigation facilities, as well as by monitoring their operational state.

Fourth, during the feedback process, the information gathered during monitoring should be used to improve system performance. The distribution of irrigation waters should be adjusted whenever

there is a discrepancy between the initial agreed plan and the monitoring results.

5.3 Institutional Capacity

Commitment and knowledge on the part of the technical support staff with regard to community participation and development are crucial to ensure that responsibility for project planning and implementation is entrusted to farmers at an early stage.

5.3.1 Water Users Organizations

When farmers are organized and have a sense of ownership in the system, they will not only maintain the system but also assure that the structures and facilities are not damaged (Lowdermilk, 1986). Since farmers engaged in irrigated agriculture share water resources and facilities, they must organize themselves and jointly manage irrigation facilities in order to carry out irrigated agriculture and to raise its efficiency.

As already discussed, WUAs should be established and launched as early as possible in the planning stage. Since operation and maintenance are intrinsic roles of the WUA, its members need to receive technical support, training, and education from MoFA (GIDA) in *organizational management* and O&M of the facilities after their construction. Currently existing but weak WUAs can be strengthened and made effective by training and guidance on the benefits of irrigation and basic agronomy relevant to irrigation.

5.3.2 Bylaws and the Role of the WUA

At present most WUAs in the region have not formulated any bylaws, which is reflected in the weakness of these user groups. The process of formulating bylaws provides WUA members with a better understanding of the roles and responsibilities of the WUA. Items covered by the bylaws generally include the name of the organization, its purpose and activities, requirements for membership, and the rights, responsibilities, and obligations of members and officers and their roles, conduct and frequency of meetings, prohibitions, and penalties. The WUA should be helped to define its own rules and bylaws and to generate income so as to be able to fulfill the purpose of its establishment. Records of O&M funds, water delivery schedules, and water levels should be carefully maintained by the WUA officers. Moreover, conflict management among

water users should fall under the authority of the WUA. Furthermore, as the water is used by various users and for various purposes, the WUA should ensure effective coordination among the users and be capable of arranging an equitable and proportional distribution of water in an effective and efficient way. In short, the WUA should be involved in all physical, institutional, and water management aspects of the irrigation system.

5.3.3 Roles of the Ministry of Food and Agriculture (GIDA, RADU, DADU)

The specific roles of MoFA include the provision of technical support services, monitoring and supervision of the WUAs, and training and development of users to improve their skills in irrigation water and facility management. Major maintenance of the irrigation facility requires the intervention of the respective Municipal and District assemblies.

6. Conclusions and Recommendations

In an effort to mitigate the risks associated with rain-fed agriculture, the government of Ghana has promoted the development of irrigation schemes across the country since the 1960s. However, irrigated agriculture in Ghana has not been implemented in such a way as to be sustainable. This structural problem analysis of irrigation systems in the UWR of Ghana was performed to identify the major factors preventing full utilization of the facilities and causal relationships among these factors. Major problems identified include weak water users associations, caused by low user involvement and poor training and guidance; inadequate water delivery and distribution caused by poor maintenance of the facility and deficient facility design and construction; and decreased water storage capacity, with both natural and farmer-related causes.

In this paper, the roles and responsibilities of the water users and MoFA have been clarified in terms of the three stages of PIM to address the identified user-related challenges. The first stage calls for adequate awareness and understanding of the common goals of the project before it is initiated. The second stage concerns the involvement of prospective beneficiaries during the planning, design, and construction stage, and the third stage deals with the shared responsibility of the farmers and MoFA in the operation, management, and monitoring of the system. Basis of the principles of PIM, the

operation and maintenance of the hydraulic structures remains the intrinsic roles of the WUA, while the role of the Ministry is to provide technical support services, supervision of the WUA, training and development of user's skills in the irrigation water and facility management. Monitoring is a shared responsibility between the Ministry and the users.

It is recommended that the capacities of water users as well as MoFA extension staff should be built on appropriate irrigation facility management. Additionally, problem maps of existing problems should be developed using a participatory rural appraisal approach in which the users identify physical damage to the facility and determine the appropriate line of action to be taken for facility repairs.

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References

- Andanye, J.E., 2005. Report of an Assessment of the Construction/Rehabilitation of Dams under the Upper West Agricultural Development Project (UWADEP). http://www.fidafrique.net/IMG/pdf/UWADEP_PROJECT_DAM_ASSESSMENT.pdf, accessed June 2009.
- AQUASTAT Survey, 2005. FAO's Information System on Water and Agriculture <http://www.fao.org/nr/water/aquastat/countries/ghana/index.stm>, accessed June 2009.
- Asian Productivity Organization, 1980. Farm-level water management in selected Asian countries: Report of a multi-country study mission. APO Project code OSM/III/79 June 12-28, 1979, Tokyo, Japan. FAO, 2005. AQUASTAT country profile Ghana, FAO, Rome, <http://>

- [//www.fao.org/ag/agl/aglw/AQUASTAT/countries/index.stm](http://www.fao.org/ag/agl/aglw/AQUASTAT/countries/index.stm), accessed February 2009.
- FAO, 1996. Technical Background Documents 6-11, Vol. 2 No. 7, World Food Summit.
- FAOSTATS, 2006. Food and Agriculture Statistics Global Outlook. Prepared by the Statistics Division (as of June 2006) http://faostat.fao.org/Portals/_Faostat/documents/pdf/world.pdf, accessed October 2009.
- Ghana Statistical Services, 2000. Population Housing and Census.
- Ghana Irrigation Development Authority (GIDA), 2001. General information on public irrigation projects in Ghana.
- GIDA-Wa, 2005. Technical Review on UWADEP completion, Wa, Ghana.
- GIDA-Wa, 2008. Inventory of Usable Water Bodies and their Distribution in the Upper West Region.
- IFAD, (2006). Republic of Ghana Upper West Agricultural Development Project (UWADEP) Interim Evaluation Report. Document of the International Fund for Agricultural Development. Report No. 1758-GH http://www.ifad.org/evaluation/public_html/eksyst/doc/prj/region/pa/ghana/Ghana_uwadep.pdf, accessed July 2009.
- Japanese Institute of Irrigation and Drainage (JIID), 2007. Guidelines for On-farm Irrigation Development and Management in Monsoon Asian Countries. p 74. JIID, Tokyo, Japan.
- Lowdermilk, K.M., 1986. Improved Irrigation management: why involve farmers? Proceedings of Invited Seminar Series on Irrigation Management in Developing Countries: Current Issues and Approaches. Studies in Water Policy and Management, No. 8, pp 427-456.
- Miyoshi, T. and Nagayo, N., 2006. A study of the effectiveness and problem of JICA's technical cooperation from a capacity development perspective. Case study of support for the advancement of Ghana's Irrigated Agriculture Research Group, Institute for International Cooperation, JICA, Tokyo, Japan.
- MoFA/IFAD, 2005. Upper West Agricultural Development Project Draft Project Completion Report. http://www.ifad.org/evaluation/public_html/eksyst/doc/prj/region/pa/ghana/Ghana_uwadep.pdf, accessed May 2009.
- Satoh, M., Kono, S. and Ounvichit, T., 2007. Principles and Method for Participatory Irrigation Management and Role Sharing Between Government and Farmers. Proceedings of the 4th Asian Reg. Conference and 10th Int. Sem. on PIM. 2-5 May 2007, Tehran, Iran.
- Wallingford, HR 2002. Informal Irrigation in Peri-Urban Areas. Institutional Aspects and Options For Improvement. KAR Project R7132.
- World Bank, 2009. Ghana Country Data Profile. http://ddp-ext.worldbank.org/ext/ddpreports/ViewSharedReport?REPORT_ID=9147&REQUEST_TYPE=VIEWADVANCED, accessed October 2009.