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IMPACT EVALUATION OF COMMUNITY-MANAGED IRRIGATION SCHEMES

by

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A Thesis Submitted to the Department of Agricultural Engineering,
Kwame Nkrumah University of Science and
Technology
in partial fulfillment of the requirements for the degree
of
MASTER OF SCIENCE
Faculty of Mechanical and Agricultural Engineering
College of Engineering

Under the supervision of

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March 2008

ACKNOWLEDGEMENT

This research was very much a joint effort, with many people contributing their time, skills and knowledge.

First and foremost, I would like to thank the Almighty God for what He has made me, the users of Dorongo and Nasia irrigation projects and the communities visited as a whole.

My special thanks to Alhaji Ahmed (Regional MoFA Director) Bolgatanga, who warmly received and introduced me to Mr. Zimi, MoFA Officer, and Mr. Hamza Akurubila the IDA officer in charge of the Dorongo scheme.

Furthermore, I thank my supervisors. Ing. Professor N. Kyei-Baffour and Dr. E. Ofori, both of the Department of Agricultural Engineering, KNUST.

Finally, I am grateful to my wife, Jemiama, and my beautiful lovely daughters, Bridita and Emmanuella and the entire Ayaala family for their prayers and support.

DEDICATION

This work is dedicated to my wife Jemiama, my two daughters Bridita and Emmanuella, and the entire Ayaala family, especially my father and mother who sacrificed their precious resources and time for what I am today.

DECLARATION

I, the under signed, declare that this thesis, my original work, has not been presented for a degree in any other University, and all sources of material used for the thesis have been duly acknowledged.

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ABSTRACT

This study was prompted by the observation made on how public infrastructure quickly falls into a state of disrepair in Ghana. The premature deterioration of these capital assets results in further drain on the already scarce resources of the country. This infrastructure, particularly irrigation facilities are left to deteriorate long before their useful life span is completed. To understand the complex issues of water and land resources management, the study sought to focus on socio-economic benefits and problems affecting the sustainability of these schemes. In addition, attempts were made determine how the quality of operation and maintenance services influence the sustainability of these projects and also identify options to improve irrigation performance. For the purpose of the study, two community-managed schemes, Nasia and Dorongo were selected from Northern Ghana based on their accessibility, experience and type of scheme.

Both primary and secondary data were gathered for the study. Secondary data such as baseline information was obtained from government and development agencies (for example Irrigation Development Authority and Meteorological Service Agency). Literatures related to the theme of study were also gathered from different sources including the Internet. Primary data was gathered using formal/informal interviews and household interview survey. The household survey was conducted using questionnaires which covered socio-economic factors, management of scheme and maintenance of scheme, external supporting services (Credit accessibility, Extension services and Co-operative market promotion) and technical know-how of users. In addition, physical environmental effects of irrigation like impact of flood, siltation, and erosion were directly observed.

Data was analysed using SPSS. Further statistical analysis were conducted to support the analysis on certain identified variables, (average farm input cost per ha, average land preparation/labour cost per ha and field water supply cost per ha), which were considered as principal components of sustainability of the schemes by using Multiple Linear Regression method.

From the study of the two irrigation schemes, there are indications that farmers and their communities have benefited a lot from the projects. Such benefits include increase in household incomes, employment creation, food security and performance of some social responsibilities (for example payment of school fees). The major findings associated with the sustainability of the two schemes are related to operation and maintenance, water allocation, water distribution, decision-making and conflict management, land rights, inadequate supporting services, problems in produce market and local institutions.

The study indicated that eventhough an irrigation scheme may be well designed, other issues such as operation and maintenance, water allocation, water distribution, decision-making, conflict management, land allocation, access to credit, input supply, high cost of maintenance and repairs, market situation, health situation and the problem of location and accessibility of the scheme to traders can affect the sustainability of such community managed irrigation schemes.

Based on the Multiple Linear Regression analyses, it was concluded that the Nasia scheme is sustainable while Dorongo scheme is unsustainable. In conclusion therefore, for farmers to realise the potential socio-economic benefits and enhance the sustainability of these schemes, beneficiaries should not be taken as passive recipients of external intervention, as to simply follow pre-planned and laid-down rules, and that irrigation technologies socially constructed, have social requirements for use and social implications.

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Acronyms

ACQUASTAT FAO's	Global Information Systems of Water and Agriculture of FAO.
ADB	Agricultural Development Bank
FAO	Food and Agricultural Organization
HH	Households
GIDA	Ghana Irrigation Development Authority
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IDA	Irrigation Development Authority
ISSI	Intervention in Small Scale Irrigation
IWMI	International Water Management Institute
LACROSEP	Land Conservation and Smallholder Rehabilitation Project
NAFAFA	Nasia Farmers and Fishermen Association
NGO	Non-Governmental Organisation
SEISI	Socio Economic Impact of Smallholders Irrigation
SRI	Savannah Research Institute
Km^2	Kilometre square
y	Year
m	Metre
m^3	Metre cubed
MOA	Ministry of Agriculture
MoFA	Ministry of Food and Agriculture
MEST	Ministry of Environment, Science and Technology
MWHWR	Ministry of Works, Housing and Water Resources
O&M	Operation and Maintenance
UER	Upper East Region
UWR	Upper West Region
WUA	Water Users Association

CHAPTER ONE

INTRODUCTION

1.1. Background

In Ghana irrigated agriculture has been given high priority by the government for some years now, as stated in the Ghana Poverty Reduction Strategy (GPRS) policy document 2003-2005 (FAO, 2005). The emphasis here is geared towards small and micro-scale irrigation schemes that can be managed by the farmers themselves through the establishment of cooperative societies or farmer associations.

Irrigation development aims to bring about increased agricultural production and consequently to improve the economic and social well being of the rural population. Like most projects, irrigation has a wide range of beneficial and harmful effects on the environment. The beneficial effects are often reflected on the welfare gains by farmers due to increased crop output and multiplier effect of this on national incomes and food security (WRI, 1992) such benefits include increase in food security and adequate nutrition for the population, increasing employment opportunities and income of rural population, generating resources for general economic and social development and reducing the effect of rural-urban drift. These schemes further provide raw materials for other sectors of the economy which serve as source of employment to others working outside the schemes and also contributing to export earnings of the country. With these benefits that might be gained by the farmers, in the form of increase in household income level, could be used to contribute towards sustainability of the schemes by purchasing improved farm inputs and also contributing effectively towards operation and maintenance of the scheme instead of relying on external support that might not come. For the above benefits to be realised, appropriate sustainable practices such as water allocation or distribution, crop water needs, resource mobilisation for system maintenance, conflict management, catchment protection, and accountability to community by management should be effectively executed.

Negative environmental impacts of irrigation occur on-site as well as off-site. Water-borne diseases are commonly associated with introduction of irrigation. The diseases most directly linked with irrigation are malaria and bilharziasis (schistosomiasis). Other harmful effects are the problem of waterlogging and soil erosion causing siltation, the disposal of excess water that may contain harmful concentration of salts, organic wastes, pathogenic organisms, and agro-chemical residues with their associated health risks due to the deterioration of water quality. These may have adverse effects on the potential benefits that might be gained by farmers and hence sustainability suffers.

Therefore for the sustainability of these schemes, the Ghana Government has realised the need to conserve water resources through technologies that can easily be managed by the rural community as stated in the GPRS document. The idea is to rehabilitate existing viable water resource facilities and to construct small earth fill dams in the rural communities to serve as sources of water supply for the development of irrigated agriculture. It is envisaged that this initiative will boost food production and help in retaining a large proportion of the annual rainfall that is lost as surface run-off.

The declining productivity in rain-fed agriculture and the need to increase food production and alleviate poverty in the rural areas especially in Northern Ghana has raised the need for effective and efficient irrigation management and its sustainability. However, there are important issues associated with water and land resources management, like salinisation, nutrient depletion, water pollution, and loss of vegetation cover, soil erosion, over grazing, and groundwater depletion. These processes could lead to long-term deterioration and reduction of the potential and actual productivity of the land, with adverse effects on agricultural productivity and serious food security implications both at the national and local levels (Kamara and McCornick, 2002).

It is widely agreed in principle that community participation in planning and implementation of irrigation projects tends to improve their technical, economic, and social outcomes, thereby increasing sustainability. Why is it that irrigated farming in some areas fail to achieve its potential benefits? The problem is not inherent in the principle of irrigation as such, but in the frequently inappropriate of it and failure to involve farmers who are sole beneficiaries of the project during the planning and construction stages. Due to the top-down approach by governments/development agents, this goes to affect the sustainability of schemes as farmers consider the schemes as government's own. Therefore, properly implemented smallholder irrigation with appropriate technologies may have a considerable potential in improving rural livelihood, yet the viability of such systems becomes questionable when the financial responsibility rest entirely on the community in the absence of institutional support services that enhance market orientation (Kamara *et al*. 2002). Given the complex set of constraints facing smallholder producers, providing access to irrigation water by itself is not enough; smallholders also require a broad range of support services (access to credit, input and output market) capacity building, soil and water management. The issue of smallholder expansion should focus on institutional linkages, and other supporting services including access to markets, provision of strong extension services, supply of input and training, strengthening organisational capacity of management, conflict resolution, access to finance and provision of access roads. These may enhance production on sustainable basis in addition to providing irrigation water and land.

Water related policies, programmes, strategies and laws, are already in place to combat these trends. But the current challenge is implementation and harmonisation of the water sector with other sectors, capacity gaps and opportunities in linking existing research and capacity building activities (Gulilat, 2002).

For water resources management, sustainability implies a notion of equilibrium that simultaneously satisfies water demands and the preservation of the water resource system. In general, sustainability of the management of water supply schemes is a challenge for the irrigation sector. This is because irrigation practice consist of supplying and applying of water to that part of the soil profile that serves as root-zone, for immediate and subsequent use of the crops. There is therefore the need for well-managed irrigation systems which must be properly controlled both spatial and temporal supply of water, so as to promote growth and yield, and to enhance the economic efficiency of crop production. Such systems apply water in amounts and at frequencies calibrated to answer the time variable crop needs. The aim is not merely to optimise growing condition in specific plots or seasons, but also to protect the field environment practice as a whole against degradation in the long-term. It is for this reason that water and land resources need to be efficiently and sustainably managed.

For the success of the GPRS policy, irrigation, crop production, and the environment should together be considered as an integral system, of which irrigation sustains crop production systems (Cai *et al*, 2001). However, a sole focus on irrigation development, without taking environmental preservation into consideration, will be doomed as occurred in many parts of the world. For this reason, a sustainable irrigation scheme should simultaneously achieve two objectives: sustaining irrigated agriculture for food security and preserving the associated natural environment *(ibid).* Therefore a stable relationship need to be maintained between these two objectives now and in the future, while potential conflicts between these objectives should be mitigated through appropriate irrigation management practices.

1.2. Statement of the Problem

Like other innovations, irrigation development brings about increased agricultural production and consequently seek to improve the economic and social-well being of the rural population. For these potential benefits to be realised, it requires the irrigation system living up to its designed life span, but this is normally not the case due to inappropriate irrigation practices as the case may be in Dorongo and Nasia. Currently, the sustainability of irrigated agriculture is being questioned, both economically and environmentally. This because the increased dependency on irrigation has not been without its negative environmental effects. In Sub-Saharan Africa more land is going out of irrigation each year than can be developed, because of the difficulty of planning and implementing sustainable schemes (ISSI, 2000). The survival and performance of these schemes are affected by difficulties of planning due to failure to fully involve farmer participation in planning of the project at the early stage. Also, some professional (consultants) normally lack skills in participatory approaches that are very important as far as smallholder agricultural development is concerned. Such consultants do not have the time to invest in doing the necessary social investigations in consultation with the farmers. As such, this has created a lot of social problems, such as land tenure and social setting issues currently causing conflicts among users at the Dorongo scheme. Because farmers are not involved in planning there is a lack of sense of ownership and lack of commitment to participate in the operation and maintenance of such schemes in the area.

Applying sustainable practices involve controlling water allocation /distribution, applying the required crop-water needs, resource mobilisation by Water Users' Association for maintenance of system, conflict management (total conflict resolution) and capability of institutional setting of management body resulting in effective performance such as catchment protection and accountability to the community. Some of these problems in the area may be attributed to lack of participation by users.

While many techniques are available for the 'hardware' component of development projects, this is not the case for their institutional components in the area, which, in no way, are less important for the projects' ultimate success. In the light of this, there has been over-reliance on physical engineering and technical aspects of water project to solve development and conservation issues, resulting in the condition that most of the important decisions have been made solely by technical experts (Dessalegn, 1999). As a result, many of the major dams and reservoirs under water development programmes in Sub-Saharan Africa in the last three decades are performing poorly and have failed to meet their original objectives (*ibid*). This might be attributed to inadequate or lack of external support such as organised market institutions, provision of extension services and NGOs support (in terms of inputs**,** technical support, training and education) and also inadequate or lack of institutions assisting and strengthening the organisational capacity of management, financial institutions and their accessibility as these have been the situation in the study area. Another issue is the location of the Dorongo scheme. Its site has been a problem to both farmers and traders in terms of its accessibility to services such as extension, input and output marketing due to the poor nature of the access road linking it to the market centres.

According to Gebremedhin and Pedon (2000), most problems of small-scale irrigated agriculture that hinder the further development of this sub-sector arise from its operational method and not from its design and construction. This is not necessarily the case, for certain systems are well designed but poorly constructed, examples are the laterals at Dorongo**.**

In Ghana, water development is a priority for agricultural transformation, but poor practices of irrigation management relegate efforts to improve livelihood, and expose people and the environment to risk. Since there are extremely complex, public policy issues confronting nearly all developing countries, the problem of insufficient maintenance of rural infrastructural facilities, where maintenance and public investment is inadequate, systems deteriorate long before their useful life span are completed. This premature deterioration in capital asset results in further drain on the already scarce resources of low income countries for which Ghana for that matter, Northern Ghana, is not an exception. Because of lack of inadequate skills and institutions to manage common property resources, irrigation infrastructure quickly falls into a state of disrepair, conflicts over access to water constrain smallholder farmers (ILRI, 2002). In addition, the problems of provision of input services and technical advice are difficult because small-scale irrigation systems are often scattered widely. Also there are lack of viable product markets and marketing institutions, and also lack of access to credit facilities in the area.

In most cases water users associations manage the irrigation schemes. However, un-economic plots, over-use of water and conflict over the basis of land allocation were observed at Dorongo. In the study area, problems of input and output market, conflicts over water distribution and ownership of the scheme, significantly varied motivation among farmers for structural maintenance were observed as problems prevailing in the management practices of the schemes. At Dorongo, farming has been a problem the reason being the past governments' inability to acquire the land or resettle land owners within the catchment at the planning stage. This has resulted in management's inability to protect the catchment and has affected the quality of water entering the reservoir particularly the sediment content and chemical composition. The sediment content has particularly reduced the capacity and performance of the reservoir. For years, there has not been any attempt by management to arrest this situation so as to improve the performance of the reservoir. In the study some of the hydraulic structures such as the main canals and laterals require repair. For example at Nasia, the reservoir contains cracks. Furthermore, in Nasia, the frequent breakdown of the electric powered pump and the high cost of electricity, repair and maintenance have been a problem affecting water supply. These have affected the effective performance of the scheme resulting in low output.

The negative environmental impacts associated with introduction of irrigation schemes has been a problem to users in the area. These are malaria, bilharzias (schistosomiasis), and diarrhea. Other problems generated are waterlogging and soil erosion that has caused siltation into the reservoir at Dorongo, and disposal of the excess water that may contain harmful concentrations of salt, organic wastes, pathogenic organisms, agro-chemical residues and deterioration of water quality with associated health risks.

The sustainability of small-scale irrigation depends on the maintenance of the implemented schemes and mitigation measures taken such as protection of catchment, desilting of reservoirs and maintaining breakdown canals.

1.3. Justification

Improved irrigation access is a powerful instrument in reducing rural poverty, not only through the direct impact of increased yields and farm returns, but also through indirect impacts, such as increased rural employment and the feedback of multiplier effects associated with the provision of irrigation infrastructure.

Despite the challenges faced, there exist abundant scope of expanding access to irrigation and improving access to water for both domestic and particularly irrigated agriculture in the area. This may reduce vulnerability to droughts through appropriate interventions in the rehabilitation and expansion of irrigated agriculture. For this reason the government has recognised the economic importance of both agriculture and irrigation in transforming the rural economy, improving food security, reducing vulnerability and enhancing livelihood opportunities for the rural population. Based on this, the government has realised the need for the development of new schemes and rehabilitation of existing viable irrigation systems as one of the most important components of agriculture in the GPRS 2003-2005 policy document. The implementation of this policy, the benefits that might be gained may serve as a source of motivation to farmers to stay in employment.

In line with the objectives and priorities of the government, several initiatives have already been put in place to improve irrigation delivery. Together with the Government, several bilateral and multi-lateral donor agencies are now engaged in rehabilitation and expansion of irrigation systems, mostly the community-based traditional irrigation systems.

This research is timely, because it meets the government's policy on poverty alleviation which mentions irrigation development and rehabilitation of existing viable facilities especially small-scale projects to attract private sector management as part of its package of infrastructure enhancement. The acceptance of community managed irrigation schemes as stated in the policy, may serve as incentives to farmers to increase their produce and perhaps the youth may enter into irrigation farming and enhance employment and income opportunities. This may control the rural-urban drift in the long run. With improvement in market facilities for selling produce from irrigated farms, farmers' income and their purchasing power will increase.

Besides this, the outcome of the study will serve as a pointer to the barriers in the operation of small-scale irrigation schemes and to make it attractive in order to achieve its intended benefits. The outcome could further be used as a guide to the development of new schemes and also in the rehabilitation of existing ones. Based on this the standard of living of those involved in irrigation farming will improve greatly and the nation can earn some foreign exchange by taking advantage of existing large markets outside the country in the sale of products.

This study was prompted by the observation made on how public infrastructures quickly fall into a state of disrepair in Ghana. The premature deterioration of these capital assets result in further drain on the already scarce resources of the country. These infrastructures, particularly irrigation facilities are left to deteriorate long before their useful life span are completed. To understand the complex issues of water and land resources management, the study soughts to focus on socio-economic benefits and problems affecting the sustainability of these schemes. In addition, the study seeks to determine how the quality of operation and maintenance services influence the sustainability of these projects, and to identify options to improve irrigation performance. For the purpose of the study, two community managed schemes, Nasia and Dorongo were selected from Northern Ghana based on their accessibility, experience and type of scheme.

1.4. Hypothesis

The sustainability of farmer managed irrigation scheme depends on

- Resource or facility management or Maintenance of scheme
- External support services (NGOs, Credit accessibility, Extension services, market accessibility and Co-operative market promotion) and
- Technical know-how; to manage production.

1.5. General Objective

The purpose of the research was to study the impact of existing small-scale irrigation system in Northern Ghana on the basis of socio-economic benefits and identifying problems associated with their sustainability and to ensure sustainable food production.

1.5.1. Impact Evaluation –Aims and Objectives

1. To determine the socio-economic benefits.
2. To determine the sustainability of the schemes.
    - Environmental impact,
    - Level of sustainable practices and
    - Support services.

1.6. Relevance of the Study

The planning process for irrigated agriculture should assess the socio-economic, institutional and management issues as well as technical issues. The following are some of the benefits that can be derived from of the study,

- `Information on the impact of irrigation on individual farm households in terms of food security and incremental income, farmers interest in small-scale irrigation, level of government and NGOs support, community groups and water user associations, access to credit and other services and environmental effects of small-scale irrigation need to be well documented for future planning purposes.
- Information collected from the study will help policy makers, development agents, and NGOs to formulate appropriate policies and design effective extension and development programmes.
- Farmers and researchers could also use the results of the study to improve their activities and maintain farmer managed schemes.
- Findings would add to the body of knowledge in irrigation.
- Findings could be used by government, development agents, and NGOs in the field to promote sustainability of community managed irrigation schemes in Ghana and other third world countries.

CHAPTER TWO

LITERATURE REVIEW

2.1. Irrigation Development in Ghana

In Ghana, the Ministries that deal with water and irrigation include Ministry of Food and Agriculture (MoFA), Ministry of Works and Housing (MWH) (now Ministry of Works, Housing and Water Resources) and Ministry of Environment, Science and Technology (MEST). In MoFA, Ghana Irrigation Development Authority (GIDA) is the main institution in charge of irrigation. This institution started in the early 1960s as the Land Planning Unit (LPU) of the Ministry, and was upgraded in 1964 to become the Irrigation, Reclamation and Drainage Department (IRDD). It later became the Irrigation Department (ID) in 1974. Finally, in 1977 Ghana Irrigation Development Authority (GIDA) was established by the Supreme Military Council (SMC) Decree No. 85. GIDA has been entrusted with irrigation development and it provides all agricultural inputs and extension services, delivers water to farmers, and secures the repayments of credits. It is expected to exercise management control over its irrigation dams and the associated catchment area as well as the drainage of the irrigated area, and general water quality. Due to its scope of operation versus available scarce resources, GIDA offers poor services to farmers and its irrigation projects.

2.2. Current Status of Small-scale Irrigation

In the 1950s through 1970s was the *era of capital intensive expansion of irrigation worldwide*. In those days, large irrigation schemes were the order of the day and irrigation management was an after-thought. By the 1970s construction costs were rising and at the same time, rapid deterioration and poor management schemes were widespread. The rate of growth in financing irrigation operation and maintenance did not keep pace with enormous growth in irrigated area. As a result, some of the big schemes that existed failed to live up to expectation. Institutional weaknesses also led to high cost of irrigation development and inefficient operation and maintenance of these schemes resulted in complete breakdown of the irrigation system.

In the 1970 and 1980s which could be characterised as the *era of irrigation improvement* wherein the emphasis was on increasing rehabilitation, introduction of new technology and management techniques, training, introduction of irrigation service fee and farmer participation. Yet the problem of deterioration, under-financing and poor management performance persisted. From the late 1980s until the present, a new paradigm of irrigation development came to the fore-front. It has now been understood that irrigation system will not be able to perform as needed without basic institutional reforms, and this generally means giving out some responsibilities to Water users' associations.

Economic and social changes are advancing at ever-accelerated rate and these have created increasing pressure to devolve management of irrigation systems to local groups. Largely driven by government fiscal shortages and a common inability to raise sufficient revenues from collection of water charges, has led to governments around the world adopting programmes to devolve responsibility of irrigation management to Water Users' Associations (Johnson *et al*, 1995). Also for the purpose of structural adjustment strategies, irrigation management transfer has been supported by the major international development banks (EDI, 1996). Due to the poor result of government management, together with reduced national budgets and general move towards decentralisation promoted by international donors agencies, many countries have switched to participatory approaches for irrigation management. In this approach the responsibility and authority of the irrigation system management are transferred in varying degrees to water users associations or private sector entities and with great preference to small-scale irrigation schemes. The underlying idea was that, by increasing the involvement of local communities and water users in construction and management of irrigation schemes, a sense of ownership might be created making it possible to improve maintenance and monitoring, and also increase availability of funds for operation and maintenance thus empowering local farmers to enhance the sustainability of schemes.

The issue of high population growth rates, the level of poverty and the prospects of world climatic change, could make rain fed agriculture especially in Northern Ghana more insecure. Government emphasis has now been geared towards small-scale schemes that could be better managed by farmers. In Ghana, farmer participation in management of irrigation projects commenced in 1987 with the passing of legislative Instrument (L.I) 1350, which legalised and streamlined the GIDA staff management role and incorporated farmer participation in project management (FAO, 2005). The government of the National Democratic Congress (NDC) planned to embark on an ambitious policy of irrigation development, based on Vision 2020. The plan was to put 136,000 ha of land under irrigation by 2020 (MWH, 1996). To achieve this ambitious goal, some older and larger irrigation schemes were to be rehabilitated and expanded, but the goal was also to be achieved by the expansion of medium and small-scale irrigation schemes.

In general, there are no reliable data on small-scale irrigation systems as few small systems have been technically monitored or have had their performance analysed (Turner, 1994), such is the situation in Ghana. For it is difficult to estimate, how much irrigable land that exist particularly under small-scale irrigation schemes. FAO (2005), put the total irrigation potential area for small-scale irrigated sawah rice farming in inland valley watersheds as 0.7 million ha, with no records on floodplains. As according to Gyasi *et al* (2006), most of these small-scale schemes are severely deteriorated or broke down completely in the past due to insufficient maintenance, hence no much records are available.

Table 2.1.Some of the small-scale irrigation schemes in Ghana

Region	Irrigation scheme	Potential area (ha)	Developed area (ha)	Irrigated area (ha)		Crop Type	Source
				Rainy	Dry		
Brong Ahafo	Tanoso	115.0	64	25	31	Vegetables	de Nooy, 1996
Ashanti	Sata	50.0	30	20		Vegetables	
Northern	Libga	22.0	22	22	12	Grains /vegetables	IDA Tamale
Northern	Bungulung	10.0	10	10		Grains/Vegetables	
Upper West	Sankana		--	--		Grains/Vegetables	IDA Wa
Upper West	Suri	20.0	---	---		Grains/Vegetables	
U pper East	Tanga	10.6	10.6	1.6		Grains/Vegetables	Liebe, 2002
Upper East	Weega	11.9	11.9	6.0		Grains/Vegetables	
Upper East	Duri	10.0	4.5	4.5		Grains/Vegetables	IDA - Bolga

2.3. National Policy on Irrigation

The Policy Reform Strategy within the irrigation sub-sector was to increase agricultural production through development of water resources for irrigation by;

1. Limiting the cost of irrigation projects to no more than US $ 600/ha,
2. Recovery of at least operation and maintenance cost,
3. Handing over the management of projects to farmers' associations,
4. Involving farmers from inception, selection of technologies through to the decision-making stage of irrigation projects and
5. Contribution of between 10 and 25 % of project cost by beneficiary communities or associations for small-scale projects (FAO, 2005).

This policy was being driven by five key objectives *(ibid).*

1. Ensuring food security and adequate nutrition for the population,
2. Promoting the supply of raw materials for other sectors of the economy,
3. Increasing employment opportunities and incomes of the rural population,
4. Contributing to export earnings and
5. Generating resources for general economic development.

The Draft Water Policy identifies the availability and ease of access to water in sufficient quantities for cultivation of food crops, watering of livestock and sustainable freshwater fisheries as major production sources for the achievement of food security and sufficiency to meet the nutritional needs of the population. Towards this, the Government is determined to:

- Support the establishment of micro and valley bottom irrigation schemes among rural communities,
- Strengthen district assemblies to assume a central role in supporting community operation and maintenance of small-scale irrigation and other food production facilities,
- Promote partnership between the public and private sector in the provision of large commercial irrigation infrastructure,
- Encourage the efficient use of fertilisers to reduce pollution of water bodies, as well as high-yielding crop species and agricultural extension services to ensure conservation of water,
- Promote and encourage water use efficiency techniques in agriculture and reduce transmission loses of water in irrigation schemes,

- Manage land use and control land degradation, including bushfires, to reduce soil loss and siltation of water bodies and
- Develop pricing system and mechanism for delivering irrigation water that is affordable to farmers and also ensure cost recovery on investment made in infrastructure.
- Utilise data and information on water cycle, land cover/use, soil and socio-economic elements for planning, design and development of agricultural schemes (FAO, 2005).

From the above it is clear that the current irrigation policy of the country emphasises on small-scale irrigation schemes and the formation of cooperative farmers' union/WUA. Farmers are to be involved at the inception stage of projects and to be trained and assisted by the Irrigation Development Authority (IDA) to operate and manage the system *(ibid).*

2.4. Constraints facing Small-scale Irrigation Projects

Irrigation development aims to bring about increased agricultural production and consequently to improve the economic and social well being of the rural population. Properly implemented smallholder irrigation with appropriate technologies may have a considerable potential in improving rural livelihood, although the viability of such systems becomes questionable when the financial responsibility rest entirely on the community in the absence of institutional support services that enhance market orientation (Kamara *et al*. 2002). Given the complex set of constraints facing smallholder producers, providing access to irrigation water by itself is not enough, smallholders also require a broad range of support services (access to inputs, credit, and output market), capacity building, and soil and water management.

FAO (1997) pointed out that many Sub-Saharan African countries have realised the critical role of irrigation in food production, but a number of constraints have been responsible for a relatively slow rate of irrigation development in this region. These constraints are:

- Relatively high cost of irrigation development (construction of its hard components and infrastructure associated with irrigation development).
- Inadequate physical infrastructure and markets
- Poor investment in irrigation
- Lack of access to improved irrigation technology
- Lack of cheap and readily available water supply.

It further identified the following constraints as affecting the capacity of farmers to invest and manage irrigation projects:

- Poor resource base of farmers,
- Fragmented and small size of land holdings,
- High interest rates and
- Poor transportation and marketing facilities.

From a study (SEISI, 2003), a number of constraints were identified, that hamper smallholder irrigation development in Zimbabwe. They are:

- High cost of capital investment in irrigation works when one considers that communal farmers are resource poor.
- Rural infrastructure to facilitate input procurement and produce marketing is weakly developed in some areas, for example roads, telecommunications and electricity.
- Lack of reasonably priced appropriate irrigation technology for the smallholders.

- Inadequate human resources at both technician and farmer levels and
- Poor catchment management which results in siltation of some water bodies.

2.5. Socio-Economic Benefits of Small-scale Irrigation Schemes

Like most projects, irrigation has a wide range of beneficial and harmful effects on the environment. The beneficial effects are often reflected in the welfare gains by farmers due to increased crop output and multiplier effect of this on national incomes and food security (WRI, 1992). However, in the assessment of the smallholder irrigation sub-sector in Zimbabwe, it was found out that smallholder irrigation has brought many successes to farmers (ESISI, 2003). The following observations were made:

- Smallholder farmers are able to grow high value crops both for local and export markets, thus effectively participating in the mainstream economy,
- In areas of very low rainfall, farmers enjoy producing their own food instead of depending on food handouts from the NGOs,
- Irrigation development has made possible for other rural infrastructure to be developed in the areas of roads, telephones, schools and clinics,
- Smallholder irrigators developed a commercial mentality and
- Crops yields and farmer incomes want up manifold.

The successes of smallholder irrigation development are many and varied. Some of these are quantified whilst others are not Kennedy (2001), in his study on the of socio-economic impact of small-scale irrigation in Zimbabwe has listed his findings:

- Smallholder irrigation can be beneficial and economically viable if it is planned, implemented and managed properly,

- The major determining factors for viability in smallholder irrigation include planning and construction, type of technology, appropriateness of design, institutional support, cropping programmes, availability of markets, marketing strategies, and commitment of farmers,
- Crop yields and farmer incomes under smallholder irrigation can increase many folds with irrigation,
- Crops unknown to communal farmers can now be grown under irrigation,
- Smallholder irrigators are now able to grow high value crops for both local and export markets, thus effectively participating in the mainstream economy,
- In times of severe droughts, smallholder irrigation schemes act as a source of food security at the household level.
- Farmers in successful irrigation schemes have acquired physical assets (improved housing, farm implements, furniture, electrical appliances) and their standard of living has improved substantially and
- Irrigation schemes provide an alternative source of employment to the rural people, thereby discouraging rural-urban migration.

Often the outcomes are mixed, and the assumption that communities and user groups will manage the systems sustainably may not hold in all cases. Evidence of success specially in the context of small scale irrigation systems is limited in Ghana. From previous experiences with community managed irrigation schemes in northern Ghana, it has not always been positive. Many of these schemes are severely deteriorated or broke down completely in the past due to insufficient maintenance. Gyasi *et al* (2006).

According to Webb (1991), from A study of an irrigation scheme in the village of Chakunda in the Gambia, the found the following benefits:

- Increased income that was translated into increasing expenditure, investment, construction and trade,
- Backward and forward linkages: traders were reportedly went in to purchase irrigation produce (rice) and in turn sold cloth, jewelry and other consumables and
- Increasing material wealth. At the village level, this was in the form of construction of large mosques, built through farmers' donations and an improvement of the village clinic. At household level, increased in wealth could be seen in houses built in the village, fourteen with corrugated metal roofing-sheets.

In their study, Gebremedhin and Pedon (2000), found out that small-scale irrigation increases the intensity of input use, especially labour, improved seeds and fertilisers. By promoting increase in use of such inputs, irrigation contributes to increased crop production. Their findings were that the predicted average impact of irrigation on use of inputs was 18% increase in crop production relative to rainfed field plots and the main impact of irrigation on crop production was through promoting increased intensity of farming, rather than through increased productivity of farming practices.

In a similar study, Benin *et al* (2002) indicated that irrigation was associated with increased intensification through greater use of fertility-improving technologies (fertiliser and manure), and other purchased inputs (improved seed and pesticides) and labour and draft power. Another study by Mintesinot (2002) indicated that irrigation, in addition to rain fed cultivationc ensures year round food security, although, off-farm employment during part of the year is a common practice to obtain extra money.

2.6.0. Sustainable Irrigation Management Practice: Concept and Analytical Framework

Irrigation water planning and management should balance short-term and long-term objectives. They are neither totally consistent nor totally in conflict with each other. Short-term objectives focus on current benefits, while long-term objectives aim to sustain current and expected benefits into the future. Long-term decisions must account for the long-term consequences of short-term decisions in a way that avoids possible negative future effects of current decisions.

2. 6.1. Concepts of Sustainability: Development versus Preservation

Irrigation, crop production, and the environment together form an integral system, of which irrigation sustains crop production systems. However, a sole focus on irrigation development, without taking environmental preservation into consideration, seriously has environmental effects as occurred in many parts of the world. For this reason, a sustainable irrigation schemes should simultaneously achieve two objectives: sustaining irrigated agriculture for food security and preserving the associated natural environment. A stable relationship should be maintained between these two objectives now and in the future, whilst potential conflicts between these objectives should be mitigated through appropriate irrigation management practices. Extensive irrigation practices may suppress the potential opportunities to develop the crop production system, as this may result in an increase soil and water salinity. Although, human societies did achieve a relatively stable balance between irrigation development and environmental preservation for several thousand years, yet this relationship could not stand the test of time in some regions due to inappropriate irrigation practices that emerged during the last half of the 20^{th} century.

It is widely agreed in principle that community participation in the planning and implementation of irrigation projects tends to improve their technical, economic, and social outcomes, thereby increasing sustainability. Why is it that irrigated farming in some areas fails to achieve its potential benefits? The problem is not inherent in the principle of irrigation as such, but in the frequently inappropriate practices of it. Its sustainable operation is just as dependent on the 'soft' environment (education, institutional building, legal structures and external support services). These are all powerful tools to ensure sustainability in conjunction with well-designed and well managed hardware.

More often than not, the fault lies in deliberately maintaining a low price for water, and users perpetuate the false notion that fresh water is a free commodity, rather than the scarce and expensive resource that it really is. In irrigation (as indeed in many other activities), just enough is best, and by that is meant a controlled quantity of water that is sufficient to meet the requirements of the crops and to prevent accumulation of salt in the soil, no less and certainly no more. The application of too little water is an obvious waste, as it fails to produce the desired benefits. Excessive flooding of the land, however, is likely to be still more harmful, as it tends to saturate the soil for too long. It inhibit aeration, leach nutrients, induce greater evaporation and salinisation, and ultimately raise the water-table to a level that suppresses normal root and microbial activity and that can only be drained and leached at great expense. Instead of achieving its full potential objectives, irrigation in such situation performs poorly and its sustainability becomes questionable.

The purpose of sustainable water resources management is to sustain both the water supply capability and the environment, now and in the future. Water supply capability encompasses both the availability of water and the infrastructure to sustain water supply and use. The environment takes into account the water source and the land and air systems that support human production activities. As water demands in agriculture and other sectors (municipal, industrial, etc.) for change over time because of policy and technological changes, among them the relationship between water use and the environment needs to be continually reviewed and adapted. Where irrigation is the major water use, sustainable water management should ensure a long-term, stable, and flexible water supply to meet crop demands, as well as other growing demands, while at the same time mitigating or preventing negative environmental consequences from inappropriate irrigation activities.

Sustainability reflects a system concept for irrigation management practices, which is, applying a set of elements that interact in interdependent fashion. Moreover, sustainability, by its nature, implies a dynamic system whose status is determined by a balance of opposing forces or trends (Svendsen, 1987). When an accelerating flow of negative forces reach a threshold beyond which it is impossible or inordinately costly to reverse the direction of the change and return to a more favourable equilibrium, the system becomes unsustainable.

According to FAO (1991), sustainability is defined as "the management and the conservation of natural resources base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and the future generation. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable."

Furthermore, Viederman (1994), defined sustainability as: “A participatory process that creates and pursues a vision of community that respects and makes prudent use of its resources-natural, human, human-created, social, cultural, scientific, etc. Sustainability seeks to ensure, to the degree possible, that present generations attain high degree of economic security and can realise democracy and popular participation in control of their communities, while maintaining the integrity of the ecological system upon which all life and all production depends, and while assuming responsibility to future generations to provide them with the where-with-all for their visions, hoping that they have the wisdom and intelligence to use what is provided in an appropriate manner.”

WCED (1987) defines sustainability as:

- Land use which maintains production at or above its present level while at the same time, conserving the natural resources (water, soil, pastures, forest, etc.) on which the production depends,
- Land use which does not progressively degrade its productive capacity and
- Land use which meets the needs of the present while at the same time conserving resources for future generations.

It is now obvious to any one who has thought about these issues that the present destructive relationship with the environment can not continue. There is thus growing crescendo of calls to move towards the simplistic and the ecosystem thinking, sustainable development, sustainable agriculture, sustainable society, and in general a sustainable future (Marien, 1994), as should be the case in the study schemes.

2.6.2. Measuring Sustainability Indicators

This section examines how sustainability can be measured and how it can be achieved in the context of irrigation management practices. This may require a set of manageable indicators of sustainability, based on broad guidelines and principles that might be necessary to detect problems as they arise and to provide an early warning system for decision makers. The indicators should be monitored and measured on the basis of the performance of natural systems and anthropogenic interactions, and action should be taken once specified thresholds are passed. In particular, the indicators should be helpful in tracing long-term cumulative environmental changes due to irrigation practices, which can potentially create irreversible problems. In this context, Cai *et al*, (2001), indicated that, areas where irrigation is the dominant water use, sustainability in irrigation water management are:

- water supply system reliability and vulnerability,
- environmental system integrity,
- equity in water sharing, and
- economic acceptability.

According to FAO (1995), there are Environmental and Socio-economic indicators of sustainability depending on the type of land use or non-use. The Environmental indicators are:

- Land cover related (absence of the natural vegetation or of its bio-diversity),
- Land surface related (absence of wind or water erosion, constancy run-off),
- Soil quality related (absence of human induced salinisation, acidification, compaction or loss of soil biologic activity) and
- Sub-stratum related (absence of human induced waterlogging or pollution, constancy of depth and quality of groundwater),

The Socio-economic indicators includes:

- Absence of rural-urban migration,
- The stability or increase in rural labour opportunities for all working age,
- The increase in the level of attendance in primary school,
- The maintenance of food sufficiency and well-balanced diets,
- Stable herd structures in grazing areas,
- The absence or decrease of unhealthy conditions within rural population groups and
- Harmonious relation between different land users over land use issues.

Most small-scale irrigation projects have been operating below the required economic efficiency and have affect the environment without any mitigation measures. This low level of efficiency and lack of sustainability may have been due to the following factors (Girmay *et al*, 2000).

- Economics of small-scale irrigation are not well understood.
- Provision of inputs, services and technical advice is difficult because Small-scale irrigation systems are often scattered widely.
- Lack of efficient utilisation of water resources.
- Lack of viable product market and marketing institutions.

These indicators reflect environmental changes important to the continuing successful performance of specific forms of land-use such as irrigation. They also show steady responses to environmental change and are a clear measure of a cause having well understood effect on the level of sustainability that can be measured or determined. In this direction, the sustainability indicators stated affect irrigation, crop production and the environment of which are considered as an integral system; hence, their application in Ghana.

2.6.3. Decision-making Analysis in Irrigation Management Practices,

In this section, we discuss a modeling framework for sustainability analysis of irrigation management practices. Water basin forms a natural boundary for water resources planning and management. Water being a scarce resource in terms of quality interacts with and to a large degree controls the extent of other natural components in the landscape such as soils, vegetation and wildlife. This may require organising and co-ordinating human activities within the water basin unit, in order to control physical processes, such as flow and constituent balances, that are governed by natural laws, and are also affected by human actions, including impoundment, diversion, irrigation, drainage, and discharges from other areas. Therefore, decision-making in irrigation management practices should be based on artificial infrastructure (hardware) and management policies (software). A modelling framework can help to identify and analyse the issues affecting decision-making in the context of the irrigation practices

Batchelor (1999) suggested several ways to improve physical and economic efficiency at the farm level:

- Agronomic (for example, improving crop husbandry and cropping strategies);
- Technical (for example, installing an advanced irrigation system);
- Managerial (for example, adopting demand-based irrigation scheduling systems and better maintaining equipment); and
- Institutional(for example, introducing water pricing and improving the legal environment)

This framework should be a dynamic system that includes modeling components capable of analysing the effects of the proposed policies and strategies over periods of time long enough to see the cumulative, long-term effects on the system.

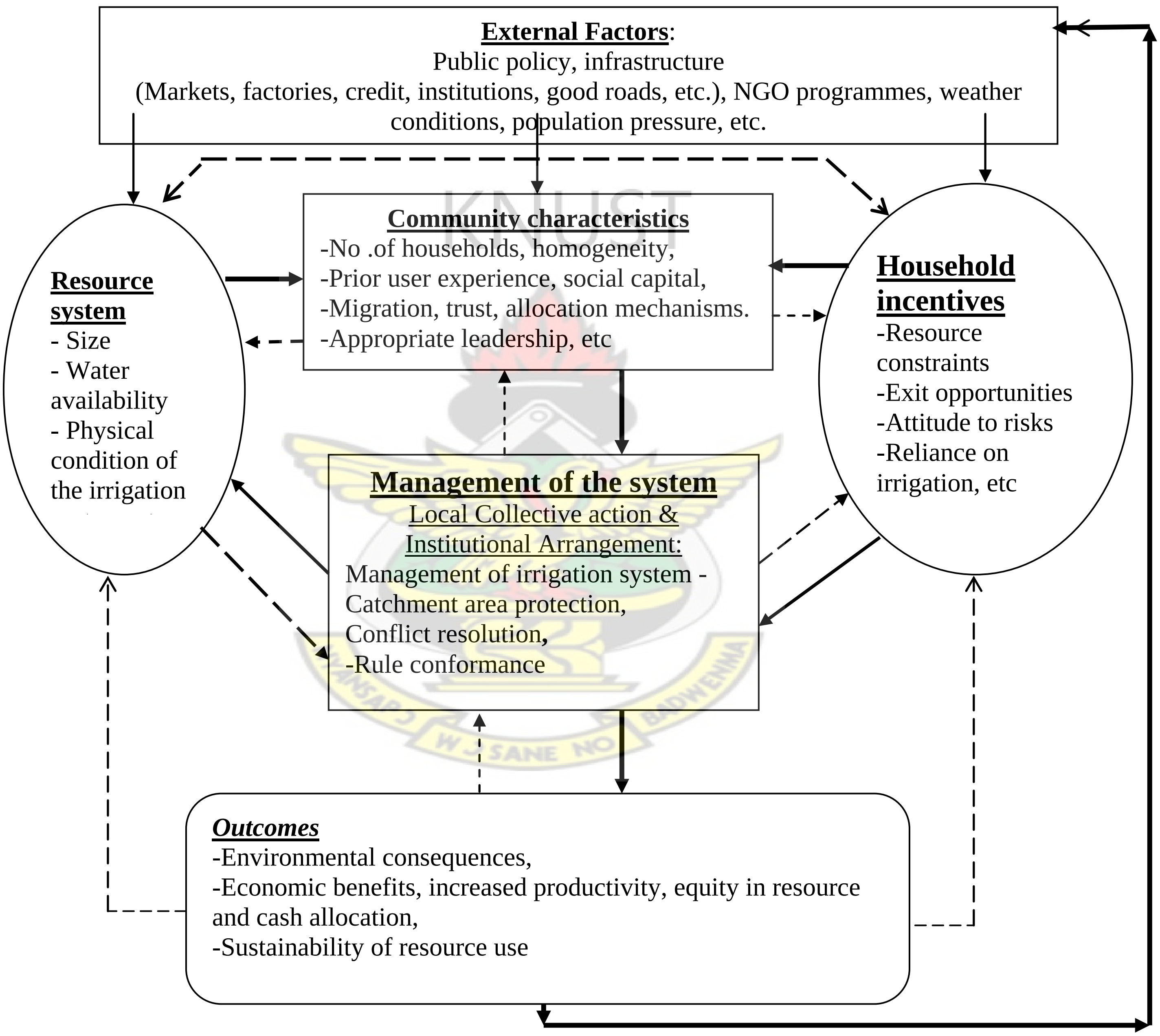

Figure 2.1: A decision framework for sustainability of Irrigation system (Gyasi, 2003)

The components shown in **Figure 2.1** are interrelated, and the interrelationships vary as external inputs change over time, (for example, climate variation, population increase and investment in infrastructure).

The analytical framework of this study considers five groups of variables that have been hypothesized to condition sustainability of community-based resource management. These are the physical attributes of the resource system, characteristics of the user group, household incentives, external factors, collective decision-making and outcomes. External factors such as public policy, population pressures, etc, affect decision-making at all levels - the resource system, community level characteristics and household incentives. The attributes of the resource system itself together with community level factors and household incentives shape the opportunity costs and constraints that irrigators face, because all these influence collective decision-making which in-turn determine outcomes. On the other hand, collective decisions and outcomes in turn are determining factors in explaining community and household incentives.

2.7.Water Related Diseases and their effects on Project sustainability

Water-related diseases are a tragedy to mankind, killing millions of people each year, preventing millions from leading healthier lives, and in turn undermining development efforts (Nash, 1993; Olshansky *et al*, 1997).One of the most serious problems on irrigation is the potential health hazards resulting from the use of open water for drinking, bathing, washing of clothes and disposal of human and animal wastes. It has been said that "wherever water goes, disease follows". Unfortunately, water storage and conveyance structures present favourable breeding grounds for disease vectors (such as mosquitoes and snails) and for pathogens of some of the most debilitating illnesses rampant in the developing world. Among these are schistosomaisis (bilharziais), onchocerciasis (river blindness), malaria, cholera, dysentery and other intestinal diseases. There is therefore the need for Public Health specialists to participate in the design and operation of all irrigation schemes, as well as in the rehabilitation or modernisation of existing schemes.

Generally, four groups of diseases are distinguished based on their way of transmission (Boelee 2002):

- Water-borne or faecal orally transmitted diseases, such as cholera, typhoid and diarrhea.
- Water-washed diseases such as louse-borne infections and infectious eye and skin diseases.
- Water-based diseases with an intermediate host living in water, such as guinea-worm and schistosomaisis, which causes bilharziasis.
- Water-related insect-borne parasitic diseases such as river blindness, filariasis and malaria.

Water-washed diseases are widespread in arid and semi-arid regions, where irrigation systems may be the main source of water for all purposes. Environmental control measures have been applied for ages in many countries till the first half of this century (Takken *et al.* 1990; Konradsen *et al.* 2002). Nowadays help has come to rely on environmental management as a part of integrated disease control approaches (Boelee, 2002). Most of the recommendations are focused on preventive measures that can be incorporated into the design of new irrigation systems. In the existing irrigation systems, the main option to control vector breeding and water related diseases lie in maintenance and water management. Instead of planning agricultural water systems separately from drinking water supply, the different sectors should work together at national and local level and plan for integrated multi-purpose systems. This reduces overall investments and contributes significantly in improving the health of rural populations.

The main diseases in the Ghanaian context are malaria, schistosomaisis, water borne disease (gastroenteritis, intestinal parasites, typhoid, etc.) and lymphatic filariasis. Water contact diseases, such as schistosomaisis, depend on immediate host with transmission occurring when people have contact with the infected water. Projects that increase the likelihood of pools of stagnant water provide rich breeding grounds for malaria carrying mosquitoes. Projects which require large numbers of construction workers run the risk of increasing exposure to disease through contaminated potable water and poor sanitation facilities. Irrigation projects increase the amount of stagnant water and, have been associated with the potential to increase the prevalence of malaria. Among factors that may contribute to the control of water-borne diseases are the following:

- Concrete lining and shaping of the conveyance and drainage channel to prevent stagnation along the banks(as well as, incidentally, to reduce seepage losses),
- Control of riparian vegetation within the channels, to prevent clogging, stagnation and habouring of disease causing organisms,
- Protection of the channels from wading animals that may breach the banks and pollute the water,
- Control of waste disposal by humans, who must be provided with environmentally safe sanitary facilities and

- Treatment of water used directly for human needs (filtration and, where necessary, use of chemicals to control parasites).

2.8. Multiple Linear Regression Analysis

In many practical cases or projects, the response variable, Y, is influenced or affected by two or more predictable variables or factors. These eventually improve the precision of the desired results. This will include

- fitting an appropriate model to the collected set of data,
- testing for the adequacy of the model,
- using it for the estimation of the mean value of Y and
- also to predict some particular value of Y to be observed in future for some given values of the predicted variables.

The general linear model for a multiple regression analysis is in the form:

$$Y= \beta_0 + \beta_1 X_{1i} + \beta_2 Xi_2 + \beta_3 Xi_3 + \ldots\ldots\ldots + \beta_k Xi_k + \epsilon_{\mathbf{i}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where, i). Y is the response variable wishing to estimate or predict,

ii). $\beta_{0,}$ $\beta_{1,}$ β_2, $\beta_{3\,,\ldots}\beta_{k\,,}$ are the constant and the co-efficients of $X_{1,}$ X_2 , X_3 , ….X_k respectively that are to be determined,

iii), i = (0, 1, 2, 3 …….. k)

iv). $X_{i1,}$ X_{i2}, Xi_3….X_{ik} are the predicted variables that are measured without error

v). $\epsilon_{\mathbf{i}}$ is a random error for any given set of values of $X_{i1,}$ X_{i2}, Xi_3….X_{ik}.

Assumptions:

An important part of regression analysis comprises several statistical techniques that evaluate how well the model fits the data (Keller and Warrack, 2000). These techniques require the following conditions:

1. The probability distribution of ϵ is normal,
2. The mean of the distribution is zero, that is $E(\epsilon) = 0$,
3. The standard deviation of ϵ is σ_ϵ, which is a constant no matter the value of X and
4. The errors are independent.

2.8.1. Assessing the Regression Model,

According to Keller and Warrack (2000), there are several methods to evaluate the model; they presented two statistics and one procedure to determine whether a linear model should be employed. They are:

- Standard error of estimate,
- T-test of the slope, and
- The co-efficient of determination.

All these methods are based on the sum of squares for errors (SSE). This least squares method is based on finding the co-efficients that minimize the sum of squared differences between the points and the line defined by the co-efficient. This can measure how well the straight line fits the data by calculating the value of the sum of squared differences. The differences between these points and the line are called residuals and is expressed as

$$\text{Residual} = (Y_i - \hat{Y}) \text{……….............} \quad (2.2)$$

Where Y_i represents the actual value and $\hat{Y}$ represents the predicted value and are the observed values of the error variable. The minimized SSE is expressed as

$$SSE = \sum (Y_i - \hat{Y})^2 \ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

From the above assumptions, it has been stated that, the error variable ϵ is normally distributed with mean zero and standard deviation σ_ϵ**.** If σ_ϵ is large, some of the errors will be large. That means that the model's fit is poor. If σ_ϵ is small, the errors tend to be close to the mean (which is zero), as a result, the model fitS well. Hence, one could use σ_ϵ to measure the suitability of using a linear model, but σ_ϵ is a population parameter and like most population parameters, is unknown. For this reason one can estimate σ_ϵ from the data and is based on SSE. This unbiased estimator of the variance of error variable σ^2_ϵ is

$$S^2_\epsilon = (SSE / (n-2)) \ldots\ldots\ldots\ldots\ldots\ldots (2.4).$$

then

$$S_\epsilon = \sqrt{(SSE / (n-2))} \ldots\ldots\ldots\ldots\ldots\ldots (2.5),$$

where S_ϵ is the standard error of estimate.

According to Bluman (2004), the strength of the relationship between dependent variable and independent variables in multiple regressions is measured by multiple correlation co-efficient, denoted by R, with its values ranging from 0 to +1 and can never be negative.

- The closer the value of R to +1, the stronger the relationship, and
- The closer the value of R to zero the weaker the relationship.

This analysis is used when statisticians think there are several independent variables contributing to the variation of the dependent variable (*ibid).*

The formula for R is

$$R = \sqrt{(1- (SSE / (\sum (Y_i - \hat{Y})^2))} \ldots\ldots\ldots\ldots\ldots (2.6)$$

Then, the test statistic denoted by R^2 being the multiple co-efficient of determinations is expressed as.

$$R^2 = (1- (SSE / (\sum (Y_i - \hat{Y})^2)) \ldots\ldots\ldots\ldots\ldots (2.7)$$

where R^2 is multiple co-efficient of determinations. When R^2 is

- exactly 1.0, means that the model is perfect, (i.e. 100% of the total variation is accounted for by the regression model).
- closer to exactly 1.0, means that the model is good
- far below 1.0 , means that the model is poor or weak (i.e. it has a poor relationship)

2.8.2.Testing for the Validity (or viability) of the Regression Model

When there are more than one independent variables, one needs another method to test the overall validity of the model and the technique is a version of the Analysis of Variance (ANOVA) (to Keller and Warrack, 2000). Here F-distribution test is used to validate the significance of the regression model at a Confidence Interval of (1-α)*100%, **(**where α is the level of Significance). We specify the following hypotheses.

$$H_o: \beta_0 = \beta_1 = \beta_2 = \beta_3 = \ldots\ldots\ldots\ldots = \beta_k = 0,$$

$$H_1: \text{At least one } \beta_i \text{ is not equal to zero.}$$

Where H_o is the null hypothesis and H_1 is the alternative hypothesis.

The test enable one to conclude on how the dependant variable are linearly related to the independent variables. The test procedure is to compute the F-statistic value as,

$$F_{statistic} = MSR/MSE \ldots\ldots\ldots\ldots\ldots (2.8)$$

or

$$F_{statistic} = (R^2/k) /((1- R^2)(n-k-1)) \ldots\ldots\ldots\ldots (2.9)$$

F is derived as indicated below. If $\boldsymbol{H_o}$ is true**,** then none of the independent variables X_1, X_2, X_3,…X_k is linearly related to Y, and therefore the model is useless. If at least one β_i is not equal to zero**,** then the model does have some validity. It further stated that, the total variation in the dependent variable (measured by $\sum (Y_i - \hat{Y})^2$ can be decomposed into two parts:

- the explained variation (measured by SSR) and
- The unexplained variation (measured by SSE).

That is:

$$\text{Total Variation} = SSR + SSE \ldots\ldots\ldots\ldots \quad (2.10)$$

It is further established that, if SSR is large, the co-efficient of determination will be high, signifying a good model. On the other hand, if SSE is large, most of the variation will be unexplained, which indicates that the model provides a poor fit and consequently has little validity. To judge whether SSR is large relative to SSE allows one to infer that at least one co-efficient is not equal to zero. This therefore requires the computation of the two mean ratios, given as:

$$MSR = SSR/k \ldots\ldots\ldots\ldots (2.11)$$

and

$$MSE = SSE/(n-k-1) \ldots\ldots\ldots\ldots (2.12)$$

Where k is the degree of freedom of regression (or the number of independent variables in the regression model), and the ratio of the two mean squares of equations (2.9) and (2.10) represents the $F_{statistic}$ value, as long as the underlying population is normal and is expressed as:

$$F_{statistic} = MSR/MSE \ldots\ldots\ldots\ldots (2.13)$$

or

$$F_{statistic} = (R^2/k) /((1- R^2)(n-k-1)) \ldots\ldots\ldots\ldots (2.14)$$

Where n, is the number of observations and k, the number of predicted variables. This is a required condition for this application. A large value of $F_{statistic}$ indicates that most of the variation in Y is explained by the regression equation and that the model is useful. Small value of $F_{statistic}$ indicates that most of the variation in Y is unexplained. The rejection region allows us to determine whether $F_{statistic}$ is large enough to justify the rejection of the null hypothesis, $\boldsymbol{H_o}$. For this test, the rejection region is

$$F_{statistic} > F_{\alpha, (k,(n-k-1))} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.15)$$

Table 2.2:**Analysis of Variance (ANOVA) for Regression Analysis**

Source of Variation	**Degrees of Freedom**	**Sum of Squares**	**Mean Squares**	$\mathbf{F}_{statistic}$
Regression	k	SSR	MSR= SSR/k	F=MSR/MSE
Residual	(n-k-1)	SSE	MSE=SSE/(n-k-1)	
Total	(n-1)	$\sum (Y_i\text{-}Y')^2$		

Generally, the above procedures are usually summarised in an Analysis of Variance (ANOVA) table as in **Table 2.2** below. For an **ANOVA** table for Multiple Regression model for k independent variables.

2.9.3.Testing for the Individual Co-efficient (β_{ij})

If it is concluded from the F-Ratio test that the multiple regression relationship is significant (ie reject $\boldsymbol{H_o}$: $\beta_1= \beta_2= \beta_3=\ldots\ldots\ldots\ldots=\beta_k=0$), it may be interesting to conduct further tests to note the individual parameters which are significant. The hypotheses for testing the significance of an individual regression parameter β_i are

$$\boldsymbol{H_o}: \beta_i=0$$

$$\boldsymbol{H_1}: \beta_i \neq 0, \ i =1,2,3,\ldots\ldots..,k$$

This requires the use of t-distribution test. The t-statistic is given by

$$\mathbf{t}_{statistic} = \beta_i \ / \ S_{\epsilon \ (\beta i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.16)$$

where S_ϵ is the standard error of estimate of the co-efficient (β_i i =1,2,3) .

The rejection region allows us to determine whether $|t_{statistic}|$ is large enough to justify the rejection of the null hypothesis, H_o. For this test, the rejection region.

$$|t_{statistic}| > t_{(\alpha/2),(n-2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.17)$$

CHAPTER THREE

MATERIALS AND METHODS

3.1 General Description of the Study Area

The study area lies within the Volta basins made up of Northern, Upper East and Upper West Regions. It extends approximately from longitude 03º 00’ W to 00º 30’E and latitude 8º 00’ to 11º 10’N. It falls within the Guinea and Sudan Savannah zones which are mainly semi-arid. It covers an area of 70,380km^2 corresponding to 29.5% of the total land area of the country. (MoFA, 1998).

In this area, the largest irrigation schemes are Tono and Vea in the Upper East region, and Botanga and Golinga in the Northern region. According to MoFA, (1998), Tono and Vea schemes irrigate close to 1.1% of cultivated land. Whilst the schemes in Northern region irrigate just about 0.48% of cultivated land. Both Tono and Vea projects are managed by Irrigation Company of the Upper-East Region (ICOUR), a semi-autonomous government agency, which is expected to increasingly commercialise its operation and become self-financing (Ditto, 1998).

3.2. Situation before Intervention of the Schemes

Nasia and Dorongo like other areas in Northern Ghana, agriculture is the mainstay of the economy, not only economic growth in general but also growth of the agricultural sector that has been of greater importance to their livelihood before the intervention of schemes. The area predominantly uses smallholder farming systems, and in most cases a mixed system is used. The farm households in this area were mainly subsistence farmers and grew rain-fed crops mainly rice, millets, groundnut, maize and beans. A stretch of land immediately around the compound wall were reserved for crops such as hibiscus, okro, tobacco, gourd, water melon, tomato, pepper and sweet potato. Outside this ring, some 2-6m from the compound, early and late millet, guinea corn or maize growing in mixed farming with cow-peas and bambarra beans were planted (Adu, 1975). In the valley flood plains rice is grown during rainy season

Farming in the area was done on small holdings by farmers using traditional and inefficient agricultural practices and technology. Here land belongs to either the royal skin and various clans or families and the average farm size was between 0.8 and 1.6 ha. The seeds they planted were obtained from the previous year harvested crops, or purchased from local markets. Labour shortages were acute, as there were virtually no landless people and everyone worked on the family farm. Ridging was done with a hoe or with bullock or donkey traction. A few hoe farmers were able to hire bullocks or donkeys for ridging, but the demand for these animals were very high during this period because they were labour saving.

The crop-storage techniques used by them were basically traditional and have not changed much over the years. They stored at least some of their crops at home and on the farm as well. The crops were stored for varying lengths of time in different types of containers. This variation was influenced by the space available, the quantity of crop output, sales, and losses to fungi, insects, and pests. Some farmers were forced by short-term cash shortages to sell produce soon after harvest when prices were low. Many farmers did not produce enough to last them throughout the year and therefore sold their livestock to purchase food during the lean season. Harvested farm produces were sometimes transported by carts pulled by donkeys or bullocks. These carts were used as means of transportation to carry goods to and from the market. Livestock were mainly kept as insurance against crop failure or as a customary and religious practice. Livestock production received inadequate technical support from Ministry of Agriculture's Department of Animal Health and Production, which became noticeable during outbreaks of livestock disease.

The constraints to sustainable production are the dry spells during the cropping seasons, low fertility of farmlands and farming practice that exacerbate the effects of drought and low soil fertility. They improve the soil structure by the use of farm-yard manure from the cattle kraal, compost manure and also fallow the abandoned land for longer periods (Adolph *et al*, 1993), for better crop production. This was done by the use of various crop residues, such as, cereal residues that were often burned in the field, and the ash sprinkled on the soil. In some cases, cereal residues were used for making compost or were buried in the soil. Groundnut and bean residues were commonly fed to animals. In those days, they cultivated vegetables during dry season but not on a small-scale within the basin by the use of water from dug-out wells in Dorongo, while in Nasia from the river. Their source of drinking water for both domestic and livestock as at then, was the stream that has been dammed for irrigation in Dorongo and in Nasia from the river.

3.3. Climate Characteristics of Northern Ghana

The climate within this area is characterised generally as tropical continental, or Savannah, with a single rainy season, from May to October, followed by a prolonged dry season. In this area, there is spiral and temporal rainfall variability to the extent of causing low agricultural productivity. It is associated with total annual rainfall of about 800-1300mm/annum, and with mean annual precipitation within the Guinea savannah zone of 1000mm declines to a mean of 800mm within the Sudan Savannah zone with average annual variability of 20-30%. This explains that rain-fed agriculture suffers from moisture deficiency and also the effect of dry spells during the rainy season. Therefore the rainfall pattern and the intensity during the season in this area necessitates the harvesting of rain water as well as the conservation of soil water in order to supply enough water for the purpose of domestic and livestock, as well as irrigation activities during dry season.

The climate within this area is characterised generally as tropical continental, or Savanna, with a single rainy season with both the onset and cessation of the rains as irregular. The rainy season begins from May to October, followed by a prolonged dry season with high potential evapo-transpiration putting enormous pressure on the water resources for irrigation systems. In this area, rain fed farming under an erratic uni-modal rainfall pattern is the dominant practice and the highest rainfall is received between June and September and only within these humid months does soil moisture surplus occur.

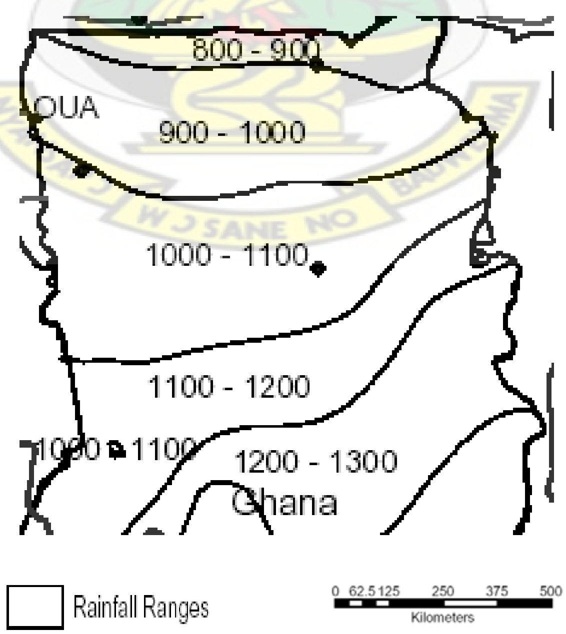

Figure 3.1: Distribution of rainfall in Northern Ghana in 1990

3.4. Rainfall Characteristics

In Northern Ghana, rainfall variability is high both spatially and temporally. It increases from north to south with mean annual values ranging from less than 800 mm in the extreme north to more than 1300 mm in the south as shown in **Figure 3.1**. The rainy season is 140-190 days in duration and usually punctuated by long dry spells during the season. The peak rainfall period is usually late August or early September. About 60% of the rainfall occurs within the three months (July to September), with torrential rains creating serious drainage problems. In most cases, absorptive capacity of the soil cannot withstand the intensity of the rain, thus creating high amounts of runoff, with erosion being one of the most significant agricultural constraints in the area. Precipitation, however considerably outstrips evapo-transpiration during the main period of the growing season (July– October).

3.5. Temperature

Temperatures in the region are consistently high, with relatively small seasonal variations, particularly in the southern part. The annual average temperatures increase from south to north, alongside an increase in solar radiation, and a decrease in annual rainfall. The hottest month in the year is March or April, just before the beginning of the rainy season, whilst the coolest period of the year is in August. There are wide diurnal fluctuations in temperature during the dry season, which are pronounced more as the latitude increases. The mean diurnal range of temperatures in January and December is from 14-20ºC. Most irrigated crops exhibit poorer germination during this period compared with crops grown during the rainy season.

3.6. Relative Humidity

The humid season in the area under study extends from April to the end of October. Maximum (night-time) values of relative humidity in this period range from 69–95%, with the afternoon records between 32–69%. During the dry season, night–time relative humidity is generally below 50%, whilst afternoon values are less than 18%. This increases evapo-transpiration and crop-water-needs. As such the healthy growth and the production potentials of the crop will be adversely affected. Thus sustainability will be in danger.

3.7. Surface wind velocity

Surface wind velocities are generally low in the study area with the average below 8km/h. Wind velocities are lower at night and during early mornings. They reach their maximum usually in the early afternoons, when average values rise to 8-16 km/h. This will increase the rate of evaporation, transpiration and hence high evapo-transpiration and crop-water-needs with adverse effects on crop production.

During the Harmattan season, wind blows from the Sahara Desert (from north-east towards south-west). It is relatively cool and dry at the beginning of the season, but becomes progressively hotter and drier as the rainy season approaches. In the Harmattan period, the relative humidity may drop to as low as 10% due to extreme dryness of the wind laden with dust particles. Under this situation the rate of evaporation, transpiration and evapo-transpiration will be higher than expected and this will result in high crop-water-needs that might have negative impact on the healthy growth and the production potentials of the crop.

3.8. Potential Evapo-transpiration

Mean monthly potential evapo-transpiration exceeds mean monthly rainfall for most of the year for the entire area and creates a great seasonal deficit every dry season. In the critical dry period of October to May, potential evapo-transpiration exceeds precipitation accompanied by mean day time temperatures of 38ºC. Potential evapo-transpiration in this area varies both spatially and temporally with an annual mean varying from about 2000 mm in the north to about 1500 mm south as shown in **Figure 3.2**.

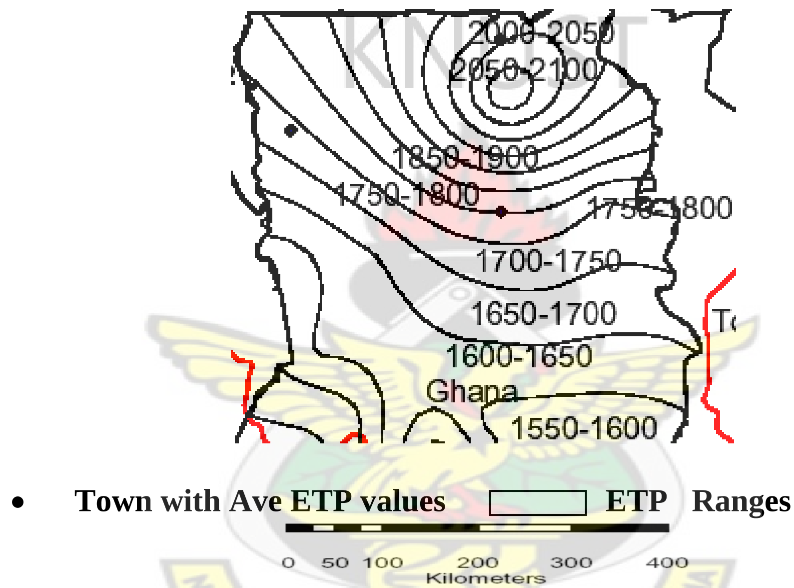

Figure 3.2: Spatial distribution of Potential Evapo-transpiration in Northern Ghana

3.9. Topography

Most of Northern Ghana is very gently undulating, with broad, poorly drained valleys and extensive flood plains adjacent to the Volta and Nasia rivers where altitudes vary from between 108 to 138 m above mean sea level. Within Gambaga highlands and out a little, lies the Upper Voltaian sandstone formations, with the land gently rolling and rising to a maximum height of just over 523 m above mean sea level in the north-eastern part of the region. At the northern edge of the hills is a scarp overlooking the White Volta and the Morago Rivers which lies about

308m below. The crest of the scarp forms the northern boundary of the Nasia Basin. Neither of the other scarps along the lines Walewale-Parago-Bunkpurugu and Pigu-Gushiegu is such as prominent topographical feature, as they rarely exceed a height of 30m above the rivers and do not give rise to a range of hills on their deep slopes.

3.10. Soil and Geology of Northern Ghana

3.10.1. Main Geological Formations

The Sudan Savanna is mostly underlain by indigenous and metamorphic rocks of Precambrian age. The rocks consist primarily of granite, and the group of metamorphic rocks referred to as the Birimian, which are the oldest in the region.. These rocks were intensely folded and are often sheared and faulted. There are large areas in which the bedrock has been weathered in *situ*. The pattern of the weathering is quite irregular and its extent depends on the nature of the underlying rock. Most of the Guinea Savanna zone consists of Voltaian formation.

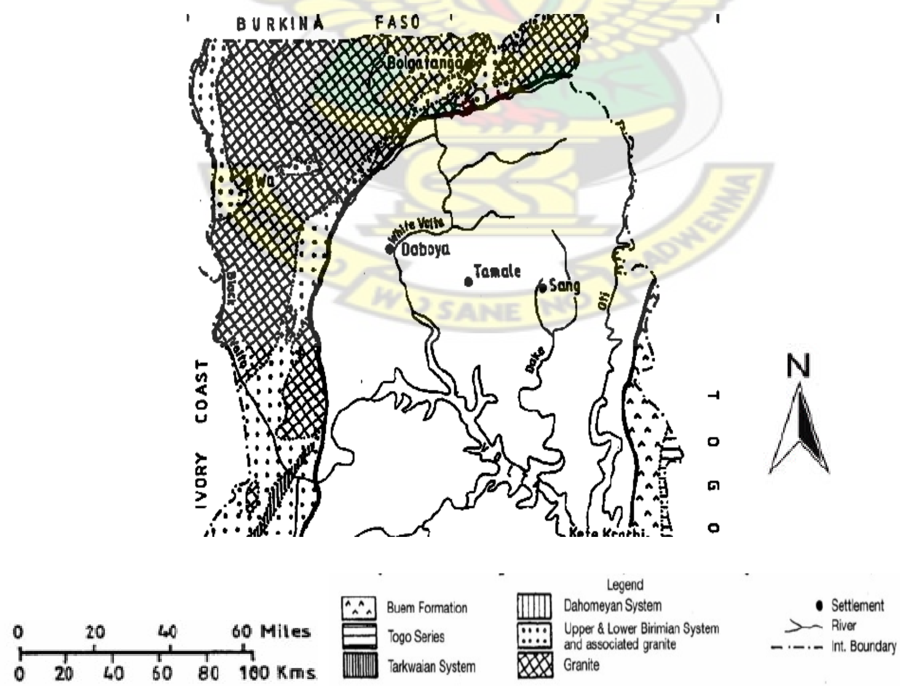

Figure 3.3: Map of Geological formation in Northern Ghana (Ghana Geological Survey1960)

The principal characteristics are the presence of a more or less cemented layer of ironstone ("iron pan") at generally shallow depth below the surface of the soil, through which rainwater does not penetrate easily. Thus the top layers of soil become waterlogged right up to the surface in the rainy season, but dry up quickly in the dry season. Where the underlying iron pan is not continuous, water logging in the rainy season occurs only in the layers just above the iron pan. The flooding of the land above the shallow depth iron pan may saturate the soil (root-zone) for too long, inhibit aeration, leach nutrients, induce greater evaporation, suppress normal root and microbial activity. Hence the performance, growth and production potentials of the crop and sustainability of the scheme suffer.

3.11. Drainage

The drainage system runs mainly from north-east to south-west. It has subsequently become incised and modified to the present alignment by various topographical influences. Erosion has caused the emergence of the Gambaga scarp and the resultant strike-stream development diverted the course of the White and Red Volta to the West. This river capture is incomplete, as the eastward extension of the Morago River is slowly shifting toward the head-waters of the Oti River. The western part of the Northern Regions is drained by Black Volta and its tributaries, while the central part is drained by River Sissily and its tributaries. At two points, the Volta River is currently developing a marked change of course. Both of these points suggest an eventual "softening" of the sharp angle of the Volta at Du. The loop of river corresponds to the shatter-zone along the face of the Tongo hills, and a projection of the line brings it to another large actively eroding loop of the river at Buliba. There is some evidence to suggest that the present is a period of renewed downward erosion after a period of infilling.

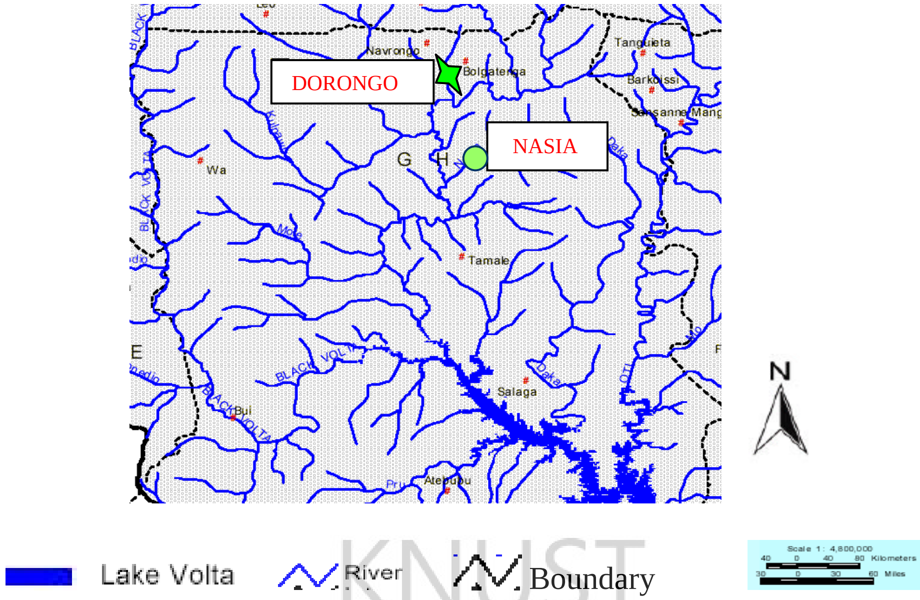

Figure 3.4: Drainage System of Northern Ghana (VBRP, 2002)

In the lead waters of the Gambaga River, where the Gambaga-Nalerigu road crosses the stream, it can be seen that the stream runs on the rock bed between very deep vertical banks composed of alluvial and colluvial material. The same applies in most parts of Northern Ghana Rivers, except that many of the south bank rivers do not reach the bedrocks on the lower parts of their courses.

3.12 Soil Fertility

Before the removal of subsidies on imported inorganic fertiliser, some farmers, especially those in highly populated areas and large scale rice farmers were strongly dependent on the inorganic fertiliser for the maintenance and improvement of soil fertility. Following the removal of government subsidies for agriculture (World Bank, 1993a and b), majority of the farmers were forced to fall back on the traditional methods of maintaining soil fertility. According to Adolph *et al*,(1993), resource poor farmers, especially those in highly populated areas, rely on the following soil fertility strategies:

- Inter-cropping cereals with legumes
- Incorporation of weeds in mounds
- Use of manure and household wastes (especially on compound farms)
- Pseudo rotation
- Utilisation of crop residues
- Short-term land fallow.

However, the effectiveness of these measures and the proportion of farmers who use soil recuperation practices are yet to be fully determined.

3.13. Description of Irrigation Schemes Studied.

3.13.1. Nasia Irrigation Scheme

The Nasia basin is a drainage basin of the left bank tributary of the White Volta. It is located on the north-eastern part of Ghana between latitude 09º 55' and 10º 40' N and longitude 01º 05' and 00º 15' E and about 86km north of Tamale on the Tamale-Bolgatanga highway. The total area is approximately 8,320km² and the altitudes of the Nasia River vary from between 108 to 138 metres above mean sea level. Most of the basin overlies lower Voltaian strata characteristics of Oti beds which, briefly, comprise a variety of shales, sandy shales, and mudstones. Such rocks give rise to soils that are mainly of silty and clayey texture (Adu, 1975)

Its western boundary lies along the White Volta where it extends from Du village in the north to Nasia White Volta River confluence in the south. From Du the northern boundary runs east across low-lying country to reach the Gambaga hills, then along the crest of the north facing the scarp of those hills to the of Togo frontier. The southern boundary runs eastwards from the confluence to the White Volta and Nasia River along the low crest of a scarp through Pigu village and as far as Gushegu. From there, it swings in an area north and east along low watershed separating the Nasia and Oti river valleys until the Togo frontier is reached.The Nasia irrigation project has been part of the proposed integrated Pwalugu project described in the report. An area of 40.5ha was developed to serve as a springboard for the development of 810ha by this company. They later handed over the operation of the project to the then Irrigation, Reclamation and Drainage Division (IRDD) of the Ministry of Agriculture in February 1967.

However, between 1970 and 1978 the project suffered water shortages due to `frequent breakdown of the pump and serious leakage from the reservoir. The Irrigation Development Authority GIDA in 1980 made an effort to solve the water problem by constructing a concrete weir across the river and installing a new pump, but could not complete the construction due to lack of funds. It therefore could not retain enough water for dry season irrigation activities. This led to low agricultural activities until 1984 when the Nasia Rice Company expressed interest in the Project. In 1986, this company took over from IDA and later gave up rice production, and altogether abandoned the site in 1990. The main reason for this action was their perceived lack of interest of farmers in partnership.

With the coming into effect of the Agricultural Sector Investment Project (ASIP), the Nasia Community organised themselves to seek ASIP assistance under a group name, the Nasia Farmers and Fishermen Association (NAFAFA). GIDA was retained as consultants to the project. ASIP further developed the project by completing the storage reservoir main canals and lateral with structures, drains and drainage structures by the end of January 1998.The community undertook bush clearing, removal of stumps, roots and rubbish, cut and fill, field bunding and head ditch excavation, as their contribution towards the development of the project. Finally, it was handed over to the beneficiary community. However, NAFAFA reported of some leakage when the reservoir was filled with water.

The scheme has a storage reservoir capacity of 3000m^3. Water is pumped by means of electrical pump from the Nasia River into the storage reservoir. Water is released by gravity to irrigate about 810.0 ha of land but currently about 41.0 ha is being irrigated. The area is suitable for conventional surface irrigation. However, in the rainy season, most of the land is cultivated using rain fed cropping.

According to FAO (1992), the total seasonal water needs of tomatoes is approximately between 300-600mm for the total growing period of 135-180 days. The ratio of the reservoir capacity to the irrigable area of 41.0ha will be about 73.17 m^3 per ha in a day, for water is pumped over night into the reservoir, which is about 7.32mm/day**.** Then the mean water needed for the total growing period of 135-180 days will be approximately 1152.9mm which is even more than the approximated total seasonal water needs of tomato.

The farmer Water Users Association (WUA) is responsible for water management, operation and maintenance of the irrigation scheme. The management skills of WUA officials involves activities such as organising groups of farmers for maintenance, resolving conflicts, organising and delegation of responsibilities for daily distribution of water to the beneficiaries. Operation of the scheme includes keeping the designed types and methods of irrigation, when to irrigate, number of hours to irrigate a particular farm and number of hours water should flow in a given canal. Maintenance includes all works necessary to keep the irrigation system operating as required. The supply of drinking water for domestic (human) consumption is a critical issue in terms of its quality and impact on human as well as animal health, since the only source of water is the river. As such, the effect of water borne and water transmitted disease are common in the area.

3.13.2. Dorongo Irrigation Scheme

The Dorongo project is located about 4km south-west of Bolgatanga in the Upper-East Region (UER). It was constructed in 1963 to serve as a source of water supply for the community and their livestock and purposely for irrigation. The supply of water to the field is by gravity. The total area developed was 12.0 ha for the irrigation, purposely for vegetable irrigation. Initially, there was no management in place. As such, maintenance suffered, and siltation gradually affected the reservoir capacity. The project was finally abandoned, leading to further deterioration of the infrastructure

The community realised the need to revisit the scheme, so IFAD was constructed for assistance to rehabilitate of the project. IFAD repaired the canals, the spillway and raised the dam wall but could not desilt the reservoir. The management of the scheme was solely left to the community to regulate the activities on site by the Water Users Association (WUA) that was formed thereafter.

The scheme has a reservoir capacity of 435,000m^3 to irrigate about 12ha of land. The area is suitable for conventional surface irrigation methods. The ratio of the reservoir capacity to the total irrigable area is 36,250 m^3 per ha per season, which is about 3625mm/total growing period of 135-180 days. This was be enough to meet the water needs of tomato during the cropping season. Currently, additional 4ha have been developed outside the command area and water is supplied to this area by means of small motorised pumps. In the rainy season, most parts of the land is cultivated using rain fed cropping, and livestock production is an integral part of the crop production as already and described.

The farmer Water Users' Association (WUA) has the same responsibilities stated above as in the Nasia irrigation scheme. In the Dorongo schemes, additional maintenance including the removal of silt from canals and laterals, cleaning of weeds from the canals and the laterals, protection of catchments and repairing embankment are also part of the responsibilities of WUA.

Based on the background of the two schemes, there is enough water for the crop water needs for the total cropping season. Unfortunately, due to lack of proper maintenance and effective irrigation management practice, Such as inefficient use of water, unresolved conflicts and failure in keeping the design types and methods of irrigation, when to irrigate, number of hours to irrigate a particular farm and the number of hours water should flow in a given canal. The resultant effect is that the schemes perform poorly and their potential benefits are not realised by the farmers. In conclusion, the issue of sustainability becomes important and hence the need to carry out a study.

3.14 Methods

In order to carry out the research, the following procedure was needed:

1) The study areas in Northern Ghana were Nasia and Dorongo schemes. Thirty (30)

farmers each from the two projects were randomly sampled and structured questionnaires shall be administered. A total of six (60) farmers were interviewed

2. a) Primary data shall be collected using structured questionnaires, formal/informal interviews of farmers and stakeholders and personal observations

   b) Secondary data shall be collected to buttress the primary findings from institutions and organizations such as MOFA and GIDA

3. Data shall be analysed using SPSS (Statistical Package for Social Scientists).

3.15. Data Sources and Collection Procedure

3.15.1. Study Design

This study included two community managed irrigation schemes in the study area. In line with the purpose of the study, the schemes were chosen on the basis of their long service experience in terms of management and mode of operation like water supply and maintenance of the system.

3.15.2. Data Collection Methods

Both primary and secondary data were gathered and used for the study. Secondary data such as maps, baseline information of the schemes, national policies and development plans and other studies were collected from government and development agencies. Secondary data from Irrigation Development Office, Meteorological Service Agency and information about the study sites were also collected. In addition, Internet sources were also employed.

The primary data sources included key formal/informal interviews and household interview survey. The first step in the data collection task was a rapid reconnaissance, where by the scheme topology was formed and familiarised with the study area. Key activities done during reconnaissance were looking at available documents on the schemes services and performance, identifying key informants for further use and stratifying schemes on age of service and performance bases. The following information was gathered as major findings of the reconnaissance visit.

- In the study it was observed that some of the schemes were performing better than others.
- Those not performing will attribute their performance to water shortage or outright lack of water.
- It was further observed that water shortage, conflicts over water/land distribution, problems of infrastructure maintenance, output and input market, and less interest to engage in irrigation practices by some irrigators were the main problems at the schemes.

The reconnaissance step comprised methods of secondary data reference and key informant interviews. The next step was conducting second round informal interviews at each scheme. The key informant interview gave the researcher a general picture of the affairs pertaining to the theme of the study before and after the introduction of project and the kind of management practices of the irrigated system.

Lastly, a household survey was conducted. Thus, the data collection methods have been triangulated into three forms: secondary source reading work, key informal interview, and household survey.

3.15.3. Sampling Method

Among the number of community managed irrigation schemes in Northern Ghana visited, Nasia and Dorongo schemes were selected for the study based on

- Accessibility
- Experience, and
- Type of scheme.

Thirty (30) farmers each from the Nasia and the Dorongo schemes were selected by using random sampling techniques. The current registered members of WUA in Nasia are 100, of which 72% are males and 28% females and that of Dorongo being 120, of which 68.3% are males and 31.7% females using the facilities.

3.15.4. Household Sample Survey

The household survey was conducted using questionnaires which covered socio-economic factors, management of scheme (Resource/facility management), maintenance of scheme, external supporting services (NGOs, Credit accessibility, Extension services and Co-operative market promotion) and technical know-how of users. In addition, physical environmental effects of irrigation like impact of flood, siltation, erosion, and gully formation were assessed by direct observation of farms.

3.15.5. Instrument

Structured interview questionnaire,(Appendix I) organised in a logical order of presentation was used as instrument of data collection. The structured questionnaire was used for the household interview survey. For the purpose of gathering household interview survey data, four enumerators were recruited three days on the basis of command of local language and English, and the knowledge of the local people and their way of life as well as relevant knowledge of the study theme.

3.15.6. Methods of Data Analysis and Presentation

Data was analysed using SPSS (Statistical package for social scientists). Further Statistical analysis was conducted on key identified variables which were considered as principal components of sustainability of the schemes by using Multiple Linear Regression method.

3.16. Scope and Limitation of the Study

The research was conducted to assess the technical, socio-economic impact and sustainability of the projects in the study area. However, this study was subject to the following limitations.

- Most information was difficult to collect from the farmers because no past records were kept. Thus they only remembered the most recent ones. It was not possible to take more than five years data.
- Pesticide residue, water quality and soil analysis, which are very important in determining the environmental effect of irrigation, were not considered because of lack of funds.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This part of the report presents survey results of Nasia and Dorongo. The study aimed at finding out the socio-economic benefits associated with the project to the beneficiary communities and identifying issues associated with the sustainability of the two projects selected in Northern Ghana and further determine if these schemes were sustainable.

4.2 Socio-Economic Benefits of the Project

Like most other projects, irrigation has a wide range of benefits and is often reflected in the welfare gains by farmers due to increased crop output and multiplier effect on national incomes and food security (WRI, 1992). From the household survey, the schemes have been very beneficial **(Table 4.1).** It was further observed during focus group discussions that, it has enabled farmers to have enough food due to the increase in household income level. It has also enabled them to increase the number of their children at school as they are able to pay their school fees, instead these children would have been loitering around. **Table 4.1** show responses by users on the number of their children at school.

Table. 4.1.: Responses by users on the number of children attending school.,

Scheme	**Dorongo**		**Nasia**	
Response	**No of children**	**% of children**	**No of children**	**% of children**
One	5	16.7	3	10.0
Two or more	21	70.0	27	90.0
None	4	13.3	-	-
Total	**30**	**100**	**30**	**100**

From **Table. 4.1** at least all users had a children in school except in Dorongo where 13.3% of users had no children in school. All those who had their children in school also reported that they paid their children's school fees from the sales of their produces. According to them, with the increased in household income, they have been able to purchase the following items as shown in the tables below since joining the scheme.

Table. 4.2: Responses by users at Dorongo on purchases since joining the Scheme

Response	Roofing sheet		Household Assets		Bicycles		Motor-bikes		Solving social Problems		Farm Inputs		Tractors	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Yes	19	63.3	27	90	17	56.7	4	13.3	27	90	21	70	-	-
No	11	36.7	3	10	13	43.3	26	86.7	3	10	9	30	30	100
Total	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**

Table. 4.3 Responses by users at Nasia on purchases since joining the Scheme

Response	Roofing sheet		Household Assets		Bicycles		Motor-bikes		Solving social Problems		Farm Inputs		Tractors	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Yes	13	43.3	27	90	18	60	6	20	28	93.3	23	76.7	3	10
No	17	56.7	3	10	12	40	24	80	2	6.7	7	23.3	27	90
Total	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**

From the **Tables 4.2 and 4.3**, 56.7% and 60% of users from Dorongo and Nasia respectively purchased bicycles. Also 13.3% and 20% of users from Dorongo and Nasia respectively purchased motor-bikes and only 10% purchased tractors in Nasia. For the sake of sustainability of the schemes 70 % and 76.7% of users in Dorongo and Nasia respectively, responded that they use part of their benefit from the increase in income level to purchase farm inputs a**s shown in Table. 4.2** and **Table. 4.3.**

4.2.1. Employment

The development of the rural sector, increases employment opportunities and further reduces the rate of rural-urban drift. Cash crops grown under irrigation also create employment through forward and backward linkages, and indirectly through multiplier effects. Users reported during household survey that, the schemes have served as a source of employment to their communities as they engage the services of labourers on their farms as indicated in **Table .4.4. and 4.6**.

Table .4.4. Responses by users if they hired labourers on their farms,

Scheme	Dorongo		Nasia	
Response	**No**	**%**	**No**	**%**
Yes	23	76.7	28	93.3
No	7	23.3	2	6.7
Total	**30**	**100**	**30**	**100**

From this **Table 4.4**, 76.7% of users in Dorongo engaged the services of hired labourers but 23.3% did not. In Nasia, 93.3% of users reported engaging the services of hired labourers whilst 6.7% did not. The reason given for not engaging the services of labourers in both schemes was that they used family labour.

4.2.2. Backward and forward linkages

Irrigation farming has created economic backward and forward linkages. Irrigation depends heavily on improved purchased agricultural inputs from input market. During focus group discussions that this has encouraged some members of the beneficiary communities to engage in the business of supply of farm inputs to farmers. This, however, has increased the cost of labour in marketing and the distribution sectors. Forward linkages occur when it contributes extra income to the farmers which enables them to have access to food.

4.3. Identified Problems associated with the Sustainability of the Projects

The following were identified as problems associated with sustainability of the studied schemes.

4.3.1. Planning stage of the Irrigation Scheme

In order for farmers to realise and tap the potential socio-economic benefits and enhance the sustainability of these schemes, beneficiaries should not be taken as passive recipients of external intervention, as to simply follow pre-planned and laid-down rules, and that irrigation technologies are socially constructed, have social requirements for use and social implications. It is widely agreed in principle that community participation in the planning and implementation of irrigation projects tends to improve their technical, economic, and social outcomes, thereby increasing sustainability. From the study, the schemes were constructed by the government, but the government failed to involve the beneficiaries at conception, planning and the construction stages of the project. The involvement of the farmers in the planning stage, properly guided by purposive community development programmes, also creates the foundation for sound grass-root farmers' cooperatives, that may look after their own interest. **Table 4.5** shows the response of the farmers when asked whether the construction of the project had affected them or not. From the response in **Table 4.5**, 26.7% of the farmers in Dorongo, had been affected by the construction of the scheme whilst 73.3% had not. They further reported that, they were neither compensated nor resettled, for the government failed to acquire the land from landlords. During focus group discussion it came up that all landlords within the catchment were neither resettled nor compensated for their lost farmlands or residence plot of land as a result of the project at Dorongo

Due to the top-down approach taken by government, farmers considered the schemes as governments, as reflected in **Table 4.8** during household survey, regarding their responses on who was responsible for the maintenance of the schemes.

Table .4.5.: Responses by users if they had been affected by the construction of the Project in Dorongo.

Response	No	%
Yes	8	26.7
No	22	73.3
Total	**30**	**100**

This has led to a lack of a sense of ownership, lack of commitment to participate in the operation and maintenance of the schemes in the area and has subsequently contributed to conflicts in Dorongo. It is obvious that, had these farmers participated in the planning process they would have strongly regarded the project as theirs. As shown in **Table 4.6,** 73.3 % of users responded having conflict with neighbouring farmers. In their responses, they reported in **Table 4.7** that, the sources of conflict were water allocation, water and land distribution.

4.3.2. Construction Stage

The performance and the sustainability of irrigation scheme depend on how well its components are constructed. A clear problem has been that some contractors have little experience in the construction of irrigation facilities. Cash constraints affect access to and use of proper equipment and long delay in making payments bring a strain on the already weak resources of these firms. These contractors have been struggling to keep afloat in the construction industry because of financial constraints limiting their growth and performance (Osie, 2000). This may affect the quality of construction works and performance of the facilities, since they might not stand the test of time or the construction work may be abandoned due to inadequate finance or delay in paying the contractor.

Figure 4.1: Poorly Constructed lateral at Dorongo

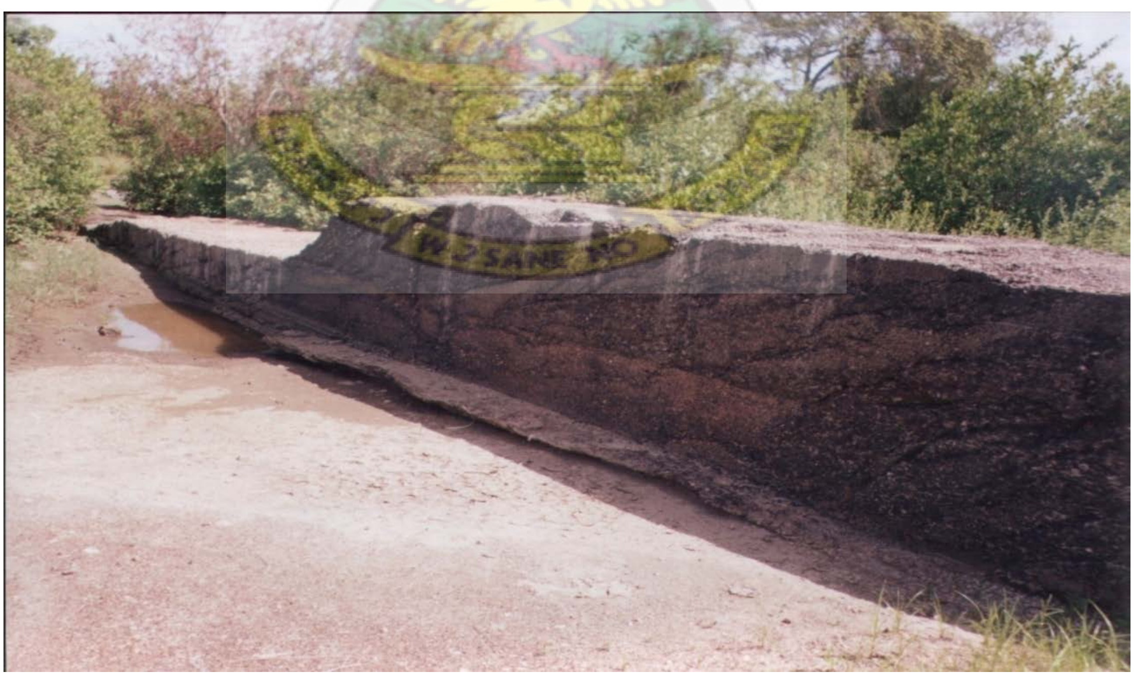

Figure 4.2: Incomplete construction of Weir across the Nasia River

In Dorongo it was observed that most of the laterals were poorly constructed, usually due to the contractor's inability to follow the design specifications. They may end up altering the design specifications with the connivance of the supervising agency. As a result some structures such as the laterals in Dorongo **(Figure 4.1)** may not stand the test of time. In Nasia, the problem of lack of funds resulted in the incomplete construction of the weir across the river as shown in **Figure 4.2** above.

4.3.3. Water sources and Irrigation Technology

The Nasia scheme takes its source of water from Nasia River and uses electric powered pump to pump water into a reservoir, while that of Dorongo is from a Dam. Both schemes released water by gravity into the main canals on to the field.

From the focus group discussion, it was reported that water supply to the scheme was not reliable in Nasia due to the frequent breakdown of the electric powered pump. The problem of seepage was also reported due to the cracks in the floor and the walls of the reservoir in Nasia as can be seen in **Figure 4.5** below. They further complained of water shortage during the dry season and this is attributed to the low level and the incomplete nature of the weir built across the river to retain water up-stream. For this reason, the water retained up-stream for the purpose of dry season irrigation farming was not enough, since the height of the highest part of the weir is about 2.0m.

4.3.4 Water Allocation and Distribution

Water management in irrigation system requires collective and a form of joint actions, which can hardly be optimum, if operated on distorted resources distribution.

From the household interview survey, it was reported by users in Dorongo that water allocation and distribution was based on checking the soil moisture by feeling and appearance, while Nasia, it was based on when the soil is dried.

For the purpose of sustainability, the application of water to the field must be based on crop-water-requirement rates, the soil type, growth stage which includes germination, transplanting and fruit bearing stages. This will avoid over or under estimation of the required crop water needs, which will have adverse effect on the growth and development of the crop.

Figure 4.3 Broken canal at Nasia.

Figure 4.4 Pool of excess water in the field at Nasia after irrigation

Figure 4.5 Cracks in the floor and the walls of storage reservoir at Nasia

4.3.5 Inefficient Use of Water

Over watering is probably the most significant causes of water loss in any irrigation system. No matter how well the system is designed, if more water is applied than can be beneficially used by crops, efficiency will suffer. Thus proper irrigation scheduling is important if high efficiencies are to be achieved. Other source of possible water loss are specific to the type of irrigation system used.

Aside from over watering, the major losses associated with surface irrigation system are direct evaporation from wet soil surface, run-off losses, seepage losses from water distribution and storage systems. Direct evaporation losses can be important when irrigating young crops .Run-off losses can be virtually eliminated with a return flow system that captures the run-off and directs it back to the original field or to other fields.

From the household interview survey, respondents in both schemes responded that there is equity in water distribution, yet they responded they over use water on their plots. This was observed especially in Nasia, where pools of water could be seen, leakage from broken canals and cracks within the floor and the walls of the storage reservoir (**Figures 4.3, 4.4** and **4.5)**. The application of too little water is an obvious waste, as it fails to produce the desired benefit.

From the household survey, on the criteria based on which both schemes allocate and distribute water now confirms the over application of water to the field. In irrigation (as indeed in many activities) just enough is the best, and by that is meant to control quantity of water that is sufficient to meet the requirement of the crop and to prevent accumulation of salt in the soil, no less and certainly no more. The application of too little is an obvious waste, as it fails to produce the desired benefits.

Excessive flooding of land could be as a result of compaction, salination or over-irrigation that may however be more harmful as it tends to saturate the soil for too long. This inhibit aeration, leaches nutrient, induces greater evaporation and salination. Ultimately, will raise the water table to a level that may suppress normal root and microbial activity and also re-drained and leached at great expense. Apart from wasting water, excessive irrigation contributes to its own demise by twin (scourage) of waterlogging and soil salination. Instead of achieving its full potential to increase and stablise food production, irrigation in such cases is in danger of sustainability.

4.3.6. Conflict Management

With regard to conflict management, it is the sole responsibility of the water management committee to resolve conflicts. It was only in Dorongo that users responded during household survey that conflict was frequent. **Table 4.6** captures the responses of the farmers as to whether they faced any conflicts with neighbouring farmers.

Table 4.6: Responses by users if they faced any conflict with neighbouring farmers at Dorongo

Response	No	%
Yes	22	73.3
No	8	26.7
Total	**30**	**100**

From **Table 4.6**, 73.3 % responded having conflict with neighbouring farmers. This confirms their response to how conflict is so frequent among users in Dorongo. Further their response to the causes of conflict in the study is shown in **Table 4.7** below

Table 4.7: Responses by users on the main causes of conflict in Dorongo

Responses	**No**	**%**
Water Distribution	9	30
Water Allocation	7	23.3
Water Allocation/Distribution	11	36.7
Land /Water Distribution	3	10
Total	**30**	**100**

Form **Table 4.7,** the main causes of conflicts are water allocation, water distribution and land, with the major ones being both water allocation and water distribution. From the focus group discussion it came out that, there has been conflict between farmers whose land was affected by the construction of the project.

This is confirmed in **Table 4.5,** where 26.7% of the farmers in Dorongo, reported to have been affected by the construction of the scheme and were neither compensated nor resettled, especially those within the catchments and down-stream. This resulted in conflicts among users and management, when it comes to irrigable land and water allocation or distribution.

The existence of these conflicts, may affect the cohesion of the association, since it is reported by users that management has failed in resolving conflicts. Therefore, the issue of unity among users and achieving the required objective of sustainability of the scheme then becomes questionable. Hence, there is the need to arrest this situation for the sake of the performance and the sustainability of the scheme.

4.3.7. Strength and functions of Management Committee

For the sake of sustainability of a scheme, there is the need for an effective and efficient management committee. Management, being the most important driving force that enables any system to succeed, plays an important role in running the schemes. The management committees of the study area have been very productive and have played a great role in the successes gained by these schemes. These achievements were due to the mutually bilateral relationship with the association and the community as well. Though this relationship exist, it has not been all that good, for it was reported in the case of Dorongo that there have been conflicts between management and land owners (farmers) in the catchment

The responses by users in both schemes indicated that the committees have a Saving Accounts, and they render accounts and also ensure the accounts are audited. They further reported that they participate in decision making, communal labour organised by WUA in desilting and clearing weeds in and along the canals. All these are indicators of effective management of schemes by WUA. Also, as a result of effective implementation of laws and regulations by management, the problem of conflict is non-existent in Nasia. However, this is not the case in Dorongo, as it is reported that total conflict resolution has not been achieved due to the fact that offenders are left unpunished.

From the study, some of the challenges faced by management include, improper water allocation, poor water distribution, lack of repairs of broken canals and laterals, lack of effective check of erosion and protection of the catchment, no cooperative market and failure to desilt the reservoir in the case of Dorongo as reported above.

4.3.8 Maintenance

Activities like operation and maintenance of the system requires commitment, co-ordination and collective action on the part of the users (Gyasi, 2003). Sustainability of any scheme depends on how operation and maintenance are carried out by beneficiaries.

Table 4.8: Responses by users as to who is responsible for maintenance of the scheme

Scheme	Nasia		Dorongo	
Response	**No**	**%**	**No**	**%**
Community	28	93.3	20	66.7
Government /Community	2	6.7	10	33.3
Total	**30**	**100**	**30**	**100**

In the study, operation and maintenance is the sole responsibility of the water management committee. From the household interview survey, response by users in Nasia indicated that maintenance was solely the responsibility of the community, while in Dorongo the response was different as shown in **Table 4.8**.

From the table, 93.3% responded in Nasia that it is the responsibility of the community to maintain the scheme, while 6.7% believed is both the government and the community.In Dorongo 66.7% believed that maintenance of the scheme is solely the responsibility of the community and 33.3% also believed it is both the government and the community. This differences in their response may cause lack of commitment among users towards maintenance and further result in conflict as reported in Dorongo.

Further more, users responded in the positive when asked if they had ever participated in maintenance as a group and as individuals. This was confirmed under **Table 4.9**, on the maintenance of soil fertility by users on their own plots, and checking erosion in the catchment and their plots **(Appendix I).**

4.3.9. Soil Fertility and quality maintenance problems,

The soil fertility and the maintenance of quality give the farmer options for second or third seasonal cropping. As a result of intensive agricultural production, the quality and the fertility of the soil of the irrigable land has been adversely affected over the years. This was the case in Dorongo, as can be seen in **Figure 4.6**.

Figure 4.6: Adverse effects on fertility of soil.

From the focus group discussion, it came out that without the use of fertiliser the yield will be low. This means that nutrients are removed more rapidly than they are replaced over the years. All crop residues and green by-products from vegetable production are removed for livestock and also used as a source of domestic fuel. The only source of nutrient is the use of fertiliser. Few farmers having livestock apply manure in the case of Dorongo.

Table 4.9: Responses by users on the number of bags of fertilizer used per hectare

Scheme	Dorongo	Nasia
Type of fertilizer	**Number of bags**	**Number of bags**
Compound	2-4	2
Urea	1	1

From their responses during focus group discussion on the number of bags of fertiliser used per hectare for a good yield, the seven farmers of Dorongo stated that, they applied between two (2) to four (4) bags of compound fertiliser and one (1) bag of Urea per hectare, while the nine members of Nasia stated that they require 2 bag of Compound fertilizer and a bag of Urea per hectare during the cropping season as shown in **Table 4.9**.

4.3.10. Soil Erosion and Siltation

Soil erosion and siltation have been among the drawbacks in the performance and the sustainability of irrigation schemes. Soil erosion has been observed in the study, but the severity of its effect is disproportionate. In Nasia it was observed that the effect of erosion was severe at one end of the weir across the river and its bank and this has resulted in loss of water upstream for the purpose of dry season irrigation.

In Dorongo the catchment has not been spared of erosion due to farming activities, as can be seen in **Figure 4.8.** Some effects of erosion were observed in the field particularly in the catchment where farming activity is reported going on as indicated in **Figure 4.7** .The resultant effect has led to the siltation of the reservoir as can be seen in **Figure 4.9** below

Figure 4.7. Farming activities in the catchment at Dorongo

Figure 4.8. Effects of Erosion within the catchment at Dorongo.

The water collected in it would spread to cover larger surface area and also take-over farmlands. This however creates favourable condition for rapid evaporation of water from the reservoir, due to higher temperature and wind speed existing in the study area

Figure 4.9 Silted Reservoir at Dorongo

4.3.11. External Supporting Services

Agencies such as MoFA, financial institutions, NGOs, research institutions etc. have roles ranging from facilitating the process of problem analysis and crafting solutions. They do provide information on rationale for adopting new institution or modifying existing ones, offering a broader perspective of potential benefits and cost of doing so, supply of technical knowledge, assisting and in strengthening the organisational capacity.

A significant factor that affects irrigation project's performance and its sustainability is accessibility of the rural poor farmer to information, capital, and agricultural inputs. The elite, most often might monopolise the benefits aimed at the vulnerable-the poor, the rural women and children. Often the poor group see no point in competing with the more affluent for services and benefits which are brought from outside. The supporting services like credit, savings and agricultural extension (technical support, training and education) is the key to success in irrigation projects.

From the study as can be seen in **Table 4.10**, below. 76.7% of users at Dorongo reported that they had training/education in irrigation production practices and irrigation management whilst 23.3% did not. In the case of Nasia, 90% of them reported to have had training/education in irrigation production practices, marketing of output and irrigation management and 10% claimed not to have. Their reason for not undergoing any training/education was that they had just joined the association. They further reported that they received extension services from MoFA and help from GIDA officers. Dorongo scheme was upgraded by IFAD while ASIP upgraded the scheme at Nasia.

Table 4.10: Responses by users, regarding training/education related to irrigation practices.

Scheme	Dorongo		Nasia	
Responses	No	%	No	%
Yes	23	76.7	27	90
No	7	23.3	3	10
Total	**30**	**100**	**30**	**100**

It was reported by users during household survey in Dorongo that they do receive support from an NGO in the form of inputs, but it was not the case in Nasia. In addition, Dorongo reported to have access to credit services from the Agricultural Development Bank (ADB) and Naarah Rural Bank in Bolgatanga. **Table 4.11** shows the responses by users in Dorongo as to whether they benefited from credit service or not.

The table shows that 23.3% of users did benefit from the facility while 76.7% did not. The reason of not benefiting was that the facility was not easily accessible and it required forming a group for ten members each in order to have access to a loan of ten or fifteen million Cedis for a group. This has been the difficulty involved. However, Nasia members responded that they had no such opportunity.

Table 4.11: Responses by users regarding credit services at Dorongo.

Response	No	%
Yes	7	23.3
No	23	76.7
Total	**30**	**100**

4.3.12. Marketing

With regard to market, Nasia has co-operative market promotion that is responsible for organising and facilitating the marketing of irrigation produce. According to Users in Dorongo there is no organised marketing system for output product, nor are there any other forms of organized activities concerning market.. This confirms why they have not had any training/education related to marketing output as mentioned earlier in the study. Therefore outputs are sold individually at the prevailing market price determined by traders or buyers. They further stated that, the price of farm output is low due to the location and the poor nature of its roads linking Dorongo scheme to market centres. This has given traders or buyers the advantage to determine the market price of the output. The farmers further reported that they are at a great disadvantage when they send their output to the market centres due to lack of storage and transport facilities. They incur high cost of transportation on this perishable produce which is highly sensitive to marketing situation where there is low patronage and produce being in abundant on the market. This is very critical for perishable products has compelled the farmers to accept any market prices determined by traders or buyers in order to avoid losses. This has resulted in price differences between the studied schemes for the first three consecutive cropping seasons. Based on their responses during focus group discussion, users in Nasia enjoyed better market price per crate for the first three consecutive cropping seasons than Dorongo as shown in **Table 4.12** below.

Table. 4.12: Differences in prices for five consecutive cropping seasons in the study areas.

Schemes	**Price per crate of tomatoes in Cedis.**					
	Dorongo			**Nasia**		
Season	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
2002-2003	45 000	180 000	112 500	60 000	180 000	120 000
2003-2004	50 000	200 000	125 000	60 000	200 000	130 000
2004-2005	50 000	180 000	115 000	60 000	185 000	122 500
2005-2006	100 000	300 000	200 000	100 000	300 000	200 000
2006-2007	150 000	300 000	225 000	150 000	300 000	225 000

During the focus group discussion, it was reported that most of the traders preferred produce from neighbuouring Burkina Faso, with the reason that they are of higher quality and low priced. This particularly affected 2004-2005 cropping season as compared to the 2003-2004 cropping season.

They further reported that the higher price they had in the 2005-2006 cropping season was due to the presence of two tomato processing firms on the market, the Northern Star Company at Pwalugu (formerly Pwalugu Tomato Factory) in the Upper East Region and the other at Wenchi in the Brong Ahafo Region. In addition to this, farmers in Dorongo reported that in the 2005-2006 cropping season, the Bolgatanga Metropolitan and the Kassena-Nakani District Assemblies in the Upper East Region instituted a task force to check and prevent traders from purchasing tomatoes from neighbouring Burkina Faso. This also contributed to the high price both schemes enjoyed in the season.

The differences in mean prices might be attributed to the fact that, Nasia has a market co-operative system in place that bargains on behalf of farmers on the market price. Another assumption is the location of the schemes; Nasia is located on the Tamale-Bolgatanga highway and easily accessible to traders whilst Dorongo is not accessible.

Therefore, any future intervention in the promotion of irrigation production should consider the issue of marketing and other necessary facilities like storage, access road and factories that will use the output. As it is the desire of government to rehabilitate existing viable or construct irrigation projects or construct new ones, the survival, performance and sustainability of these projects without corresponding rehabilitation or construction of infrastructures such as roads, storage facilities, markets and processing industries would be of no help to farmers. As can be seen in the 2005-2006 cropping season, the presence of the two firms on the market resulted in the higher mean price than the first four consecutive seasons **(Table 4.12)**. Therefore, it is necessary to rehabilitate existing infrastructure or construct new ones and resource them purposely for their sustainability.

4.3.13 Cohesion of Group

From the study, the cohesiveness within the associations has been strong, but it was observed that Nasia was stronger than Dorongo. This was due to the cordial relationship that existed between management, association and the community as a whole. All this was due to management being pro-active in achieving its objectives. In Dorongo it was revealed that there was no cordial relationship between management and land owners (farmers) within the catchment and also among members. Furthermore, based on the result obtained in **Table 4.8 (page 73)**. The lack of cohesion was demonstrated by the fact that about 67% of the water users believed that the maintenance of the system was the responsibility of the community while 33% believed that it was the responsibility of both the government and the community. Finally, it was reported by users in Dorongo that they had no cooperative market promotion and that purchasing of farm inputs and the sale of produce are done individually.

4.3.14 Irrigation Water and Health

Water borne diseases account for substantial part of the total incidence of diseases among rural population on irrigation schemes. It is directly related to water systems adopted by the farming communities. The greatest of which is associated with source of drinking water, that may be contaminated by human and animal excreta. Fecals of humans as well as animals are left in the open, in the field and around homes. Rainfall and inefficient ultilisation of irrigation water may wash the excretes and the coliform bacteria into source of drinking water. The presence of fecal coliform in drinking water may be a source of concern because many diseases can be spread through fecal transmission.

From the study, it was observed that, there were pools of stagnant water in the field that may have adverse health impacts on users and the beneficiary communities and affect the sustainability of the schemes. For this reason, water breaks and pool of water in depressions on the project sites (as shown in **Figures 4.4** and **4.11**), may create favourable conditions for vector and water borne diseases like malaria, diarrhea, schistomiasis, and lung worm**.** As reported by users in **Table 4.13,** 93.3% of them suffered from malaria in Dorongo and 63.3%

in Nasia. In addition, 6.7% of users in Dorongo also suffered from diarrhea and 10**%** in Nasia. It was further reported that 26.7% of users in Nasia suffered from both malaria and diarrhea.

This problem of diarrhea in Nasia, is attributed to their source of drinking water as stated in **Table 4.14.** The issue of malaria could be related to the pools of water found on the field that may serve as favorable source of breeding mosquito as can be seen in **Figures 4.4** and **4.10.**

Table 4.13: Diseases commonly affecting farmers and their community

Scheme	Dorongo		Nasia	
Response	**No**	**%**	**No**	**%**
Malaria,	28	93.3	19	63.3
Diarrhrea,	2	6.7	3	10
Malaria/diarrhrea	----	----	8	26.7
Total	30	100	30	100

Farmers in Nasia reported that, their source of drinking water was the river which might be contaminated by coliform bacteria that might have resulted to a total of 36.7% of farmers suffering from diarrhea as from **Table 4.13**, while in Dorongo their source of drinking water was the well/borehole and that might be the reason why this problem of diarrhea was less pronounced only 6.7%. This adverse health impact, affected farmers will have their limited financial resources and time on medication instead of investing on the farm for better crop yield. The resultant effect will be reduction in crop yield, low household income level and finally sustainability suffers.

Table 4.14: Responses by users on the community's source of drinking water

Scheme	Dorongo		Nasia	
Response	**No**	**%**	**No**	**%**
Well/borehole	30	100	--	--
Stream/river	--	--	30	100
Total	30	100	30	100

Farmers from the schemes stated that they use agro-chemicals (pesticides/fungicides chemicals) on their fields. It was further reported that some of them do not use protective clothing and did not have the knowledge of the concentration of the chemical to be used during field application (**Table 4.15**) and this is a source of worry to their health Since lack of protective clothing and lack of knowledge of the chemical concentration to be used may serve as potential sources of negative health impact on the individual farmer and the community as a whole.

The study revealed that, most of the farmers had no knowledge of pesticide/fungicides concentration to be used or applied to protect or prevent the crops so as to increase production for better performance and sustainability of the schemes as shown in **Table 4.15** below. This could be attributed to weak extension services and the illiteracy level of farmers.

Table 4.15.: Responses by users on knowledge of the concentration of pesticide/fungicide to be used on plots

Scheme	**Dorongo**		**Nasia**	
Response	**No**	**%**	**No**	**%**
Yes	6	20	7	23.3
No	24	80	23	76.7
Total	**30**	**100**	**30**	**100**

The effect is that users may be tempted to either over or under use the required concentration. This may have an adverse effect on the health of farmers, traders, and the consumers as a whole and also on the sustainability of the schemes. The effect is that, consumers may not patronise produce from such schemes.

In the case of the users (the farmers), this may affect yield as a result of either over or under using the required concentration. When the concentration is higher or lower than required, it may affect the healthy growth of the crops and might result in reducing crop yield. This also may have a negative impact on the soil fertility and the environment. For lower concentration, most of the pests or fungi may survive, and the adverse effect is that they may suppress the healthy growth and production potentials of the crops resulting in poor yield. This impact may have effect on the production and yield of the next cropping seasons in terms of farmer’s investment on pests/fungi control and the fertility of the soil. Hence, the sustainability of the schemes suffers. It may pollute to their source of drinking water with its accompanied negative health hazards to farmers and the community as a whole. On the part of consumers, if the concentration of the fungicides/pesticides is higher than the required, it may have health impact on consumers. This may result in low patronage of produce from such schemes and as such traders and farmers are directly affected.

For sustainability, there is the need to ensure the good health of the people through provision of good drinking water source and health facilities for the beneficiary communities. There is also the need to avoid these threats by involving institutions and agencies in the planning and design of the scheme, training/educating farmers on irrigation production practices, and establish the needed institution where there is none and which should be well resourced, to take up the required challenge.

4.3.15. Limitation of the Schemes affecting their Sustainability

Non-availability of water and high water charges have been a major problems. Physical infrastructure and storage facilities for the preservation of perishable produce. Also market structures where these perishable produce might be bought to feed the factories may either be inadequate or not existing at all. This is reflected on the variation of market prices for the cropping seasons in the study, as indicated in **Table 4.12**. In addition, land has also been a major problem, since on average each farmer in Dorongo is limited to 0.10 ha, while for Nasia each farmer limited to 0.50ha of land for irrigation.

In the study, the non-availability of water in the stream in Nasia and the reservoir in Dorongo schemes during the dry season has a negative effect on the performance and sustainability of the projects. In Nasia this due to the incomplete construction of the weir across the river, has resulted in the low retention of water upstream and the present of plants occupying the space just immediately behind the weir upstream reduces the volume of water retained for irrigation purposes. Further, there exist the effect of erosion at the lower end of the weir and its banks, and has created a channel for the flow of water downstream. This also reduces the volume of water retained for the purpose of irrigation.

Furthermore, it was revealed during focus group discussion that farmers in Nasia complained about the frequent breakdown of the electric powered pump, the high cost of electricity and the high cost of repair and maintenance of the pump. All these have sometimes contributed to the non-availability of water for the system. For these reasons, electric powered pumps might be too costly for smallholder farmers to maintain. There is therefore the need for a system that might require a low cost like gravity diversion system to be considered as an alternative

In the case of Dorongo, siltation of the reservoir is highly pronounced. This has reduced the capacity of the reservoir and the water collected in it spreads to cover a very large surface area including parts of farmlands at shallow depths. This therefore creates a favourable condition for rapid evaporation, since the rate of evaporation in this area is high, due to higher temperature and wind speed. The effect of this is that the expected water needed for the scheme might not be sufficient for purpose of the scheme.

Figure 4.10. Mango trees on irrigable land at Dorongo.

Figure 4.11.Pond to retain water at Dorongo

At the Dorongo scheme land has been a limiting factor, as part of the irrigable land has been taken by mango trees planted by land owners as shown in **Figures 4.10 and 4.11**. As a result of this limiting problem, some of the farmers have developed 4.0ha of land outside the command area to be used as irrigable land.

These farmers have dug a pond at the lower end of the command area to retain used or excess water from the scheme to irrigate these outside farms by means of motorised pumps as shown in the **Figure 4.11.** For the sake of sustainability and the potential benefits being realised, there is therefore the need to extend irrigation development to include the farms outside the command area by constructing and extending the canals that will supply water to such area. This will reduce the adverse effect of stagnant water on health and sustainability as a whole.

4.4. Statistical Analysis

In an attempt to carry out further statistical test on sustainability of the schemes to buttress the above discussion, certain variables were considered to be principal components of sustainability of the schemes.

4.4.1 Principal Components of Sustainability

In irrigation practices, there are many components or factors that have influence on the crop optimal growing conditions. These conditions include, a uniform crop, actively growing, completely shading the ground, free of diseases, and favourable soil. Under such given environment the crop will reach its full production potential. This may result to high crop production yield and hence positive impact on farmers.

The components or factors that have influence on the crop optimal growing conditions include: inputs cost, land preparation cost, labour cost, field water supply cost, commodity price, market access, transportation cost, and external climatic factors (such as sunshine, temperature, humidity and the wind speed). The time of the year during which crops are grown is also very important, since these effects may vary during the cropping season particularly the climatic factors . The variability of these climatic factors may have influence on evapo-transpiration that affects the crop water needs, the kind of crops grown and further affect the growth and the production potentials of tomatoes and other crops.

From the study it come out that certain components or factors were considered as the principal components or factors of sustainability of the schemes. These variables were average farm inputs cost per ha, **(X_1),** (comprising cost of fertiliser and agro-chemicals), average land preparation and labour cost per ha, (**X_2**), and field water supply cost per ha, **(X_3).** All these variables will yield total average gross cost of output per ha, (**Y**), all in millions of old Ghana Cedis. Climatic factors, commodity price, market access and transportation cost were not considered as principal components of sustainability of the studied schemes. Because the influence of the climatic factors do not vary much within the cropping season, information on commodity price and transportation cost were difficult to obtain from the farmers and the issue of market access may not be necessary since most traders purchased produce on site**.**

Then, based on the above, the general Multiple Linear Regression Model with k independent variables is expressed as:

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots + \beta_k X_k \quad \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(5.0)}$$

Where $\beta_0, \beta_1, \beta_2, \beta_3, ... \beta_k$, are constant and the coefficients of $X_1, X_2, X_3, ... X_k$ respectively and i = (0, 1, 2, 3 …….. k).

It will be possible to conclude that, for a crop to reach its full production potential then, the identified principal components (X_1, X_2, and X_3) and these climatic factors are assumed to be appropriate for crop production under the environment of crop optimal growing conditions. This healthy and productive growth of the crop will result in high crop production yield and hence higher total average gross income per ha will be realised and will have a positive impact on farmers. This will serve as a good indication of the sustainability of the scheme.

4.4.2. Statistical Output Analysis

Based on the SPSS Summary output with 95% confidence interval as shown in **Tables 4.16 and 4.17**,

- The regression models for Nasia and the Dorongo Projects were estimated
- The **F**-distribution test was used to test for the validity of the models, and
- The **t**-distribution test was carried-out to test for the significance of the co-efficients β_i, (β_1, β_2, and β_3) or their respective influence on the models.

Table 4.16.: Coefficients for Nasia

Model	Unstandardized Coefficients		standardized Coefficients		
	β_i	Std. Error	Beta	$t_{statistic}$	Significance
1 Intercept (Constant)	36.500	2.978		12.248	0.052
Average Input Cost(X_1)	-33.271	2.218	-1.264	-15.002	0.042
Average land Preparation/Labour Cost(X_2)	-12.727	1.000	-2.909	-12.724	0.500
Average Field Water Supply Cost(X_3)	191.907	8.282	5.038	23.172	0.027

For Nasia, the estimated co-efficient $\boldsymbol{\beta_i}$**,** of the intercept $\boldsymbol{\beta_0}$ (Constant) is 36.500, average input cost per ha ($\boldsymbol{\beta_1}$) is -33.271,average land preparation/labour cost per ha ,($\boldsymbol{\beta_2}$) is -12.727,and field water supply Cost per ha ,($\boldsymbol{\beta_3}$) is 191.907 are obtained from T**able 4. 16.**

Then the estimated regression model for Nasia is

$$Y= 36.500 - 33.271X_1 - 12.727X_2 + 191.907X_3 \quad \ldots\ldots\ldots\ldots\textbf{(4.1)}$$

From model (4**.1),** any slight increase in the value of $\mathbf{X_1}$ or $\mathbf{X_2}$ and keeping $\mathbf{X_3}$ constant, will have a negative impact on the value of Y (that is the value of Y < 36.500). This is because of the negative signs attached to the co-efficients ($\boldsymbol{\beta_i}$) of average input Cost **(**$\mathbf{X_1}$**)** and the average land preparation/Labour Cost **(**$\mathbf{X_2}$**)**. On the other hand, any slight increase in the value $\mathbf{X_3}$ and keeping of $\mathbf{X_1}$ and $\mathbf{X_2}$ constant, will have a positive impact on the value of **Y**, (that is the value of **Y** > 36.500).

When $\mathbf{X_1} = \mathbf{X_2} = \mathbf{X_3} = 0$ (no investment is done), then the value of **Y** becomes 36.500 million Cedis. Under such a situation, the value of **Y** will be affected by the soil type in terms of fertility, moisture content during cropping season, level of salinity and also the effect of pests on the crops. In addition, the variation of the climatic factors (temperature, humidity, sunshine and wind-speed) during the season of the year, will have higher adverse effect on the growing crops. This variation will result in higher evapo-transpiration of the crop which will result in high crop water need that may also varies during the cropping season and also depends on the crop growth stage. This implies that the only source of the crop water needs for the season will solely be from the soil water content, which might not be sufficient support the healthy and productive growth of the crop throughout the season. Hence the crop will wilt and die off and this will have a negative effect on the calculated value of **Y** when $\mathbf{X_1} = \mathbf{X_2} = \mathbf{X_3}=0$ (when no investment is done). This means that the value of **Y** will not be 36.500 million Cedis, but rather greater than or equal to zero or less than 36.500 million Cedis ($0 \leq \mathbf{Y} < 36.500$).

Similarly, for Dorongo, the estimated co-efficient $\boldsymbol{\beta_i}$, of the intercept $\boldsymbol{\beta_0}$ (Constant) is 71.137, input cost ($\boldsymbol{\beta_1}$) is -54.186, land preparation/labour cost ($\boldsymbol{\beta_2}$) is 5.910,and field water supply Cost ($\boldsymbol{\beta_3}$) is 79.389 are obtained from **Table 4.17.**

Table 4. 17. : Coefficients for Dorongo

Model		Unstandardized Coefficients		standardized Coefficients	$t_{statistic}$	Significance
		β_i	Std. Error	Beta		
1	**Intercept (Constant)**	71.137	257.589		0.276	0.828
	Average Input Cost (X_1)	-54.186	196.408	-1.908	-0.276	0.829
	Average land preparation/Labour Cost (X_2)	5.910	22.870	1.159	0.258	0.839
	Field Water Supply Cost (X_3)	79.389	156.856	1.648	0.506	0.702

Then the estimated regression model for Dorongo is

$$Y= 71.137 - 54.186X_1 + 5.910X_2 +79.389X_3 \quad \ldots\ldots\ldots\ldots\ldots \textbf{(4.2)}$$

The multiple co-efficient of determination, $\mathbf{R^2}$**,** obtained for Nasia is 1.00 and Dorongo 0.799. The closer the value of $\mathbf{R^2}$ to 1, the stronger the relationships between dependent variable and independent variables (an indication that the fitted model **(4.1)** and **(4.2)** passes through all the data points).

For the purpose of the validity of the Models in **(4.1)** and **(4.2)**, an F-distribution test was used for the test of the Models at 95% confidence interval with the appropriate hypotheses being

$$\boldsymbol{H_o}: \beta_1= \beta_2= \beta_3=0, \text{ (not significant)}$$

$$\boldsymbol{H_1}:, \beta_1\neq \beta_2\neq \beta_3\neq 0, \text{ (significant).}$$

Then the decision is to reject $\boldsymbol{H_o}$, if $F_{statistic}$.> $F_{(0.05\ (k,\ (n-k-1))}$, where k is number of independent variables and n is the number of observations. This will mean that the model is significant if

$F_{statistic} > F_{(0.05\ (k,\ (n-k-1))}$. Then the critical value F_{table} from tables is $F_{(0.05\ (3,1))}=215.3$, for both schemes.

Table. 4.18. : ANOVA for Nasia

Model	Sum of Squares	d.f.	Mean Squares	$F_{statistic}$	Significant
1 Regression	67.814	3	22.605	1051.530	0.023[a]
Residual	2.150 E-02	1	2.150 E-02		
Total	67.835	4			

For Nasia (**Table 4.16)** above, $F_{statistic}$ is 1051.530, which means that $F_{statistic} > F_{(0.05\ (3,1))}$, we therefore reject $\boldsymbol{H_o}$, since there is enough evidence to support the conclusion that total average gross income is linearly related to average farm inputs cost per ha, average land preparation and labour cost per ha, and field water supply cost per ha. Clearly, there is great evidence to support the validity of the model in **(4.1).**

$$Y= 36.500 - 33.271X_1 - 12.727X_2 + 191.907X_3 \quad \text{………….. } \mathbf{(4.1)}$$

Table 4.19. : ANOVA for Dorongo

Model	Sum of Squares	d.f.	Mean Squares	$F_{statistic}$	Significant
1 Regression	56.565	3	18.855	1.328	0.551[a]
Residual	14.195	1	14.195		
Total	70.761	4			

In the case of Dorongo (**Table 4.19),** $F_{statistic}$ is 1.328, which means that $F_{statisticl}.< F_{(0.05\ (3,1))}$, we therefore fail to reject $\boldsymbol{H_o}$, since there is no enough evidence to support the conclusion that total average gross income per ha is linearly related to average cost of input per ha, average cost of land preparation and labour per ha, and cost of field water supply per ha. Clearly, there is not enough evidence to support the validity of the model in **(4.2).**

$$Y= 71.137 – 54.186X_1 + 5.910X_2 +79.389X_3 \quad \text{………….. } \mathbf{(4.2)}$$

The **t**-test was further used to test for the significance of the individual co-efficient β_i, (β_1, β_2, and β_3) or their respective influences on the models in **(4.1)** and (4.**2)** for Nasia and Dorongo schemes respectively at 95% confidence interval with the appropriate hypotheses being:

H_o: $\beta_i = 0$, (not significant)

H_1: $\beta_i \neq 0$, (significant), where i= (1, 2, 3…… k)

The decision is reject H_o, if $t_{statistic} > t_{(0.025, 1)}$. This means there exist linear relationship between X_i and Y. From tables the critical value $t_{(0.025, 1)}$, is 12.706, for both schemes.

For Nasia Project the values of $t_{statistic}$, for β_1 is -15.002, β_2 is -12.724, and β_3 is 23.172 were obtained from **Table 4.16** above. Based on these individual values of $t_{statistic}$ for β_1, β_2, and β_3 respectively it is clear that all the values of $t_{statistic}$ are greater than $t_{(0.025,1)}$. ($|t_{statistic}|$ of β_1, β_2, and β_3) > $t_{(0.025,1)}$.) which means, we reject H_o, and conclude that there is enough evidence to support the conclusion that the individual values of β_1, β_2, and β_3 have respective influences on **Y** or the respective average farm inputs cost per ha, (X_1), average land preparation and labour cost per ha, (X_2), and field water supply cost per ha, (X_3) are linearly related to total gross cost of output per ha, (**Y**). Hence β_1, β_2, and β_3 in equation model **(4.1)** are said to be significant. Similarly, for the Dorongo Project the values of t_{cal}, for β_1 is -0.276, β_2 is 0.258 and β_3 is 0.506 (**Table 4.17).** above. Based on these individual values of t_{cal}, for β_1, β_2, and β_3 respectively. It can be seen clearly that, all the $|t_{statistic}|$ for (β_1, β_2, **and** β_3) < $t_{(0.025, 1)}$. Clearly, all the respective $|t_{statistic}| < t_{(0.025, 1)}$, which means, we fail to reject H_o, and conclude that there is lack of evidence to support the conclusion that the individual values β_1, β_2, and β_3 have their respective influences on **Y** or the respective average farm inputs cost per ha, (X_1), average land preparation and labour cost per ha, (X_2), and field water supply cost per ha, (X_3) are not linearly related to total gross cost of output (**Y**). Hence β_1, β_2, and β_3 in model **(4.2)** are said to be not significant.

In conclusion the Nasia Project is said to be sustainable, for there is enough evidence to support the validity of the model in **(4.1)**, of which $F_{statistic} > F_{(0.05\ (3,1))}$ and also there exist greater influences of the individual β_1, β_2, and β_3 since all their respective $|t_{statistic}| > t_{(0.025,\ 1)}$, or the individual independent variables X_1, X_2, and X_3 are respectively linearly related to **Y**. But that is not the case in Dorongo Project, since there is no evidence to support the validity of the model in **(4.2),** of which $F_{statistic} < F_{(0.05\ (3,1))}$ and there exist no influences of the individual β_1, β_2, and β_3 since all their respective $|t_{statistic}| < t_{(0.025,\ 1)}$, or their individual independent variables X_1, X_2, and X_3 are not linearly related to **Y**. Hence it can be concluded that the Dorongo Project is said to be unsustainable as indicated in model **(4.2).**

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This study was conducted to assess the impact of community managed irrigation schemes in Northern Ghana. In order to achieve this, the investigation focused on getting answers to the socio-economic benefits and problems associated with the sustainability of the projects.

5.2.Conclusion

Irrigation development aims to bring about increase agricultural production and consequently to improve the economic, social and environmental well being of the rural population. Small-scale irrigation plays a major role in meeting the growing need for food and to achieve long-term food security. The high yields obtained from these projects and other socio-economic benefits, such as employment, increase in household income level and food security, are indications that these schemes are beneficial and can result in sustainable agriculture and socio-economic development with little negative impacts on the environment.

The outcome of the analyses indicates that farmers benefited from the studied schemes, since they serve as sources of employment to the farmers and the communities. Also, the gain from the sale of produce leads to an increase in household income. This has enabled them to purchase items such as roofing sheets, bicycles, motor bikes, tractors, farm inputs and even solve other social problems. It has further enabled them to send their children to school, pay school fees, and also provided enough food for their families.

The study revealed that, enhancing sustainability of the projects depended also on factors such as the planning and construction stages of the projects, government's policies on infrastructure (good roads, market, factories, access to health facilities and institutions.), irrigation (agriculture), water source and the kind of technology applied, land acquisition, and source of drinking water. The outcome of the study, identified that, there is enough supportive evidence that sustainability of farmer managed scheme depends on:

- Management of scheme (Resource/facility management),
- Maintenance of scheme
- External supporting services (NGOs, Credit accessibility, Extension services and Co-operative market promotion) and
- Technical know-how of users.

The Nasia Project is viable or sustainable. This is not the case in Dorongo, because there is not much evidence to support the validity of the model in equation **(4.2)**, since the individual independent variables average input cost per hectare **(X_1)**, average land preparation and labour cost per hectare **(X_2)** and field water supply cost per hectare **(X_3)** are not linearly related to total average gross cost of output per hectare **(Y)**. Hence it is concluded that the model in equation **(4.2)** established for the Dorongo Project is not viable or is unsustainable.

Schemes that practice flooding system may aggravate the erosion along sloping plots. High electricity bills, repair and maintenance cost of pump at Nasia which are borne by users showed that electric powered pumps might be too expensive for smallholder farmers. Therefore systems that require less cost, such as gravity diversion system could be taken as an alternative.

A sustainable irrigation projects should achieve a two part objectives, simultaneously sustaining both irrigated agriculture (for food security) and preserving the associated natural environment. The way to achieve sustainability is to resolve

- Management of scheme (Resource/facility management),
- Maintenance of scheme,
- External supporting services (NGOs, Credit accessibility, Extension services and Co-operative market promotion),and
- Technical know-how of users
- Users participation in the planning and construction of the project,
- government's policies on infrastructure (good roads, market, factories, access to health facilities and institutions., agriculture (irrigation)) and water,
- water source and the kind of technology applied,
- land acquisition,
- source of drinking water,
- Input cost,
- land preparation and labour cost, and
- field water supply cost

arising from irrigation practices and the environment in order to balance the benefits between current and future generations. Also, decisions at all the various levels from crop field management to water allocation at the basin scale and agricultural policy at the regional and national scale must follow already established sustainable principles. This would enhance a better performance, sustainability and viability of the schemes, and increase household income levels of users as well as the beneficiary communities.

The study has shown that in future, all smallholder irrigation development should take an integrated rural development approach covering infrastructure and associated communication and health facilities. These may minimise the cost of transportation as experienced at Dorongo. Improving communication facilities will enhance the farmers access to market information. Given the fact that irrigation might be associated with water borne vectors, there is the need to provide health facilities and good source of drinking water which should be an integral part of the design of the irrigation project.

Lack of knowledge in irrigation and water managements, high price and inadequate provision of inputs, lack of credit services, and lack of storage facilities are problems affecting performance of management of the scheme. Farmers have financial need for farm inputs and labour. Most of them in the study area have no access to credit services because it is difficult to form groups in the case of Dorongo with Nasia having none at all. The problem in the performance of the Dorongo scheme is output market, unorganised market, and low price of output.

From the study no matter the level of sustainability that existed, members and their respective communities have benefited a lot. It has improved their communication level as some of them posses bicycles, motor bikes and even tractors (**Tables 4.2 and 4.3).** The tractors owners could use them as a means of transport to convey passengers and farm produce to nearby market centres and as well as conveying farm inputs.

In the area, the level of support services is inadequate, in terms of training/education and availability of financial institutions and their accessibility to farmers. In this regard, had farmers and WUA management committee members received training/education on control systems such as operation and maintenance, this could have minimised the issue of over flooding, maintenance of hardware components, erosion and siltation as occurred in the study (**Figures 4.4, 4.5, 4.8 and 4.9) .** The reason is that the type of control structure within the conveyance and the distribution system strongly governs the irrigation scheduling that may be possible for maximum use of water within the irrigation system for better crop production. The services of financial institutions indicate that farmers at Dorongo had the facility available but it was inaccessible (**Table 4.11).** Therefore, this do not augur well on the part of beneficiary farmers who are poorly resourced. Access to credit facilities could promote better irrigation farming and application of much higher level of fertiliser and other agro-chemicals. This could translate to higher crop yields that may lead to better returns and higher ability to pay economic rates for such services provided by the irrigation agency or management. With regards to IDA and MoFA technical supporting services, their extension officers do not reside in the community and they do not normally have means of transport. They therefore rely on public transportation to visit the schemes and sometimes it is only during market days, such is the situation in Dorongo. Their absence could be a contributory factor to the over-usage of water in the study by farmers. To avoid this, some of the development agencies could consider buying bicycles and motorbikes for the technical officers and also provide in-service training some the technical officers most of whom are not well vest irrigation systems which will improve the level of sustainability in the study.

Sustainable practices in the schemes require resolving the conflicts arising from the interactions between water users and the environment, and to balance the benefits between current and future generations. The study revealed that poor water management and distribution system, insufficient knowledge, operation and maintenance work, weak community participation, inadequate external supporting services are among the factors affecting sustainable practices.

Social cohesion and social relationships also matter in the sustainability of community-based resource management. Articulation between users appears to be high among members at Dorongo scheme. Indeed, the results of the study suggest that rule conformance is difficult to achieve when grievances of members are not resolved. To overcome these challenges and ensure sustainability, it is necessary to undertake human resources capacity building works to maximise the use of water in the schemes. This could lead to the efficient utilisation of water by WUA members and the communities in order to increase productivity, income level and the health conditions of farmers.

From the study, the reasons that are behind the result of the models could be the location of the schemes, the kind of training/education undergone by members, access to input and output markets and existing of cooperative union. In the line of training/education, Nasia members were trained/educated in marketing output. This necessitated the formation of a cooperative union that bargained on behalf of members for better market price and the purchase of farm inputs at reduced cost on individual members. The effect of this union is reflected in the seasonal price disparity for the first three consecutive cropping seasons per crate of tomatoes (**Table 4.12**) that made Nasia enjoy better market prices. However, this was not the case with the Dorongo scheme, hence, this adversely affected their bargaining power as individuals. This resulted in high cost of input and low output market prices. The level of soil fertility also had effect on the models (**Table 4.9**), since farmers at Dorongo used two (2) to four (4) bags of compound fertiliser per hectare this increased the cost of inputs.

5.3. Situation after Intervention

From the analysis, it points out that there has been a tremendous positive impact in the lifestyle of the two communities with the intervention of the irrigation projects. As it is reflected in their technical, social and economic upliftment as revealed in the study. Previously, the level of technology was virtually poor as farmers relied on farmyard-manure, compost manure and fallow the abandoned land for longer periods in order to improve the soil structure for a better crop production. They were limited in the mode of food crop preservation; however, after the intervention, they now use input fertiliser to increasing soil fertility and agro-chemical for better crop yield. Some of these chemicals are also used to increase the preservation period of harvested food crops during storage. They have also benefited a lot from external assistance through training/education, NGOs, extension services from IDA and MoFA officials as revealed from the study. Some of these trainings/education has led to the adaption of new technologies that has improved crop and livestock production, hence positive socio-economic impact. Water has now been in abundant all year round in Dorongo for their livestock, other domestic purposes and the construction or maintenance of buildings during the dry season.

With the increased in agricultural technology resulting in high rainfed crop production coupled with the dry season output of irrigation projects, their level of food security has improved greatly as revealed in the study. This has prevented most of them from selling their livestock in order to secure food for their families. This intervention has increased the level of social interaction within and also farmer-trader relation.

As stated earlier, the level of communication has improved among members of the communities where formerly carts pulled by donkeys or bullocks were the only means of transportation. This has increased the labour level in the area, since -there are other job opportunities for the beneficiary communities during dry season. This has encouraged some of them to take trading and also lowered the level of rural-urban drift as it use to be during dry season.

Since the projects have been beneficial to users and their communities, there is the need to resolve all the identified problems affecting the sustainability and the viability or performance of the schemes. For this reason, the complexity involved in irrigation management system as an integral one necessitates a systematic approach to water management analysis. This translates broad guidelines towards sustainable irrigation practices in terms of environmental conservation, which could take into account the required water supply needed. Therefore, the improvement of current infrastructure, such as support institutions, market accessibility, access roads, and improving water conveyance/distribution efficiency, upgrading irrigation efficiency and drainage investment may enable sustainable practices in the study area.

5.4. Suggestions for improving the schemes

The following suggestions when taken might enhance the sustainability of farmer managed irrigation projects for better socio-economic development of the communities:

- A bottom-up approach is ideal for irrigation development, treating farmers as "owners" and not as "beneficiaries" of the projects, Farmers should participate throughout the project planning, implementation and evaluation phases,
- In the planning stage, there is the need to thorough social investigations by involving sociologists or social anthropologists prior to any irrigation development,

- Consultants, with no Participatory Rural Appraisal (PRA) and smallholder irrigation development experience should not be engaged to plan smallholder irrigation schemes,
- In future irrigation development, affected farmers and landlords should be adequately compensated or resettled to avoid future conflicts as occurred at Dorongo.
- Construction works should be given to qualified contractors who have the capabilities to execute the work without shortcutting the specifications, and must be supervised by a competent, reliable, and qualified agency,
- Efficient use of irrigation water system should be practiced to avoid stagnant water as a result of excess used water and also control conditions that may lead to vector breeding and water related diseases,
- Training in water management, marketing, conflict management (total conflict resolution) and general crop production are important for new and old schemes,
- All laws and regulations of the scheme should strictly be followed by the management committee in charge of the scheme and offenders should be sanctioned by paying a fee,
- Farmers should be encouraged to pay extra fee for maintenance after harvest, for desilting the reservoir or maintenance of break down of electric pump as well as payment of electricity bills,
- The rising electricity cost in Ghana calls for the development and testing of irrigation technologies with low energy requirements, such as gravity dams,
- Only projects which are technically, socially and economically sound should be handed over to farmers
- NGOs involved in irrigation development should be transparent and they should completely handover upgraded or newly developed irrigation schemes to the beneficiary farmers,

- Training of development agents and water user association officials is essential to build local understanding, management capabilities and community responsiveness,
- To avoid inefficient use and shortage of water in the scheme, farmers should follow the required crop-water requirement rates and also protect the catchment by afforestation through their initiative or external support,
- In any future irrigation development, the economics of small-scale projects should be properly explained and well understood by users for the sake of its socio-economic potentials and the sustainability of the projects,
- The government, given the budgetary constraints facing it, should come up with a clear, transparent and systematic policy that may encourage NGOs, and especially the District Assemblies to use part of its share of the Development fund to rehabilitate or construct irrigation facilities, market and industrial infrastructure and also source these infrastructures so that users could identify the socio-economic potentials of these projects and the need for its sustainability,
- The government should facilitate market access for farmers through a range of interventions such as:
    i. Facilitating farmers access to market information and storage facilities,
    ii. Facilitating marketing arrangement between WUAs and Co-operative Unions and improving access to banking facilities (credit, saving etc.),
    iii. The credit and paying system needs to be reviewed and more clarified to the farmers and
- Public health specialists should also participate in the design and operation of all irrigation schemes, as well as in the rehabilitation or modernisation of existing schemes.

5.5. Recommendation

Based on the outcome of the study, it should not be assumed that farmers have access to the information they require, they need to be supported with more adaptive and applied research on water use efficiency, improved marketing and crop production; hence, the need to further conduct research on the "Economic viability of the studied schemes".

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APPENDIX I

Impact Evaluation of Community-Managed Irrigation Schemes

Level Questionnaire
Questionnaire Household

Number ________________ Month________________ Year________________
Scheme ________________ Interviewed by ________________

Section 1: General Information

Age ________ Marital Status ________________ Farmer's Sex________________

1. How long have you practiced irrigation? (Years)
2. How many wives do you have?
3. How many children do you have?

Section 2: Water management, Operation and Maintenance

1. What is the method of field application of water?
   1=flooding 2=splashing 3=others
2. What criteria do use to decide when to irrigate crops?
   1=wait until see sign of wilting on leaves 2= when the ground is dry,
   3= check the soil moisture by feel and appearance
3. What is limiting you from expanding your irrigated plot?
   1=water level in the reservoir is low 2=high water rate charges 3=developed area is small
   4=number of farmers have increased 5=both 1&2 6=both 1&3
4. Who maintains the scheme? 1=government 2=NGOs 3=community
   4=both 1&2 5=both 1&3 6=both 2&3
5. Do you have Water Users Association responsible for management of the scheme?
   1= Yes 2=No
6. Are there laws and regulation governing the association?
   1=Yes 2=No
7. If yes, do they apply the laws when appropriate?
   1=Yes 2=No
8. Have you ever faced conflict with neighbouring farmer?
   1=Yes 2=No
9. Is it frequent on the field?
   1=Yes 2=No
10. What are normally the main causes of conflict? (Pleased tick the appropriate ones)
    1=Water allocation 2=Water distribution 3=storage sharing 4=Land redistribution
    5=both 2&4 6=1& 2 7=1 & 4 8=others (state)
11. Were the conflicts resolved?
    1=Yes 2=No
12. Was the offender punished?
    1=Yes 2=No
13. Do you pay any water charges? 1=Yes 2=No
14. Does the association have savings accounts? 1=Yes 2=No
15. What do you use it for?
    1=maintenance 2=administration 3=I do not know 4=both1&2
16. Do they render accounts to the association?

1=Yes 2=No

17. Do you participate in decision-making?

1=Yes 2=No

18. Have you ever-participated in maintenance of the irrigation scheme?

1=Yes 2=No

19. Do you have equal share of water of supply on your plots?

1=Yes 2=No

20. Do you over use water on your plot?

1=Yes 2=No

Section 3: Socio-economic Information

1. How many of your children attend school?

1=one 2=two or more 3=none

2. Who pays the school fees?

1=myself 2=mother 3=both parents 4=others (state)

3. What is your source of finance?

1=sales of produces 2=loan or other source

4. Has the scheme been beneficial to you?

1=Yes 2=No

5. If yes, which of the following have you been able to purchase since you joined the scheme, from the sales of produces? (Pleased tick whichever is appropriate)

1=Roofing sheet 2=Household assets (TV, radio, clothing, etc.)
3=Bicycle 4=Motor-bike 5=solving social problems
6=Tractor 7=farm inputs 8=others (state)

6. Do you hire labourers on your plot?

1=Yes 2=No

Section 4: Technical Information

1. Do you use pesticides for crop protection? 1=Yes 2=No
2. Do you use protective clothing when spraying pesticides?

1=Yes 2=No

3. Do you have any knowledge of the concentration to use?

1=Yes 2=No

4. If yes, from which source? 1=Extension/IDA officer 2=co-farmer 3=Agro-chemical seller 4=both 1&2 5=both 1&3 6=1, 2&3 7= none above
5. Do you improve the fertility of your irrigation plot?

1=Yes 2=No

6. Do you check erosion on you plot?

1=Yes 2=No

7. Do you check erosion within the catchment? 1=Yes 2=No
8. Have you ever taken training/education related to irrigation?

1=Yes 2=No

9. If yes, what is it specifically related to? (Pleased tick the appropriate ones)

1=Irrigation production practice 2=Irrigation management
3=Marketing of output 4=2 &4 5=1 & 2 6=1& 4 7= none above

10. Are Extension or IDA officers helping you in irrigation practice?

1=Yes 2=No

11. Is/are NGO/s or community-based organisation/s helping you in irrigation practices?
1=Yes 2=No
12. If yes, how do they help you? 1=input 2=finance
13. What is your source of drinking water?
1=Well/borehole 2=Dam 3=Stream/river 4=both 1&2 5=both 1&3
14. What are the diseases on site? 1=malaria 2=schistosomiasis 3=diarrhea 4=typhoid 5=both 1&3 6=others (state)

Section 5: Market Information

1. What is your most important source of market information for your agricultural products?
1=Radio 2=Newspaper 3=Traders at the market 4=Fellow farmers 5=Extension officers. 6=both 3&4
2. Where do you obtain most of your inputs?
1=Input market 2=Traders at farm steam 3=Out-growing arrangements.
3. Do you receive the inputs on time?
1=Yes 2=No
4. Does the community have a co-operative market promotion?
1=Yes 2=No
5. In what form do you market your irrigated products?
1=as an individual 2=as a member
6. As an individual, do you send your produce to the market?
1=Yes 2=No
7. If yes, is transportation cost high?
1=Yes 2=No
8. Who decides the price at the market?
1=traders 2=farmers 3=farmers co-operative 4=both 1&3 5=both 1&2

Section 6: Credit System

1. Is/are there credit services in your area?
1=Yes 2=No
2. Have you ever taken credit for irrigation purpose?
1=Yes 2=No
3. If no, why? (Pleased tick the appropriate ones)
1=because the interest rate is high 2=because I couldn't secure the collateral
3=because I have sufficient money 4= because it isn't easily accessible

Interview Guide for Focus Group Discussion

1. How are water rates charged?
2. Are you levied at the beginning or after harvesting season?

3 Cost per labourers

Season	Dorongo	Nasia
2002-2003		
2003-2004		
2004-2005		
2005-2006		
Etc.		

4. Number of labourers required per ha……..
5. What is cost per labourer in a season (Cedis)?

Season	Minimum	Maximum
2002-2003		
2003-2004		
2004-2005		
2005-2006		
2006-2007		

6. What is the average yield per ha. (in terms of numbers of crates) for a cropping season?
7. What is cost per crate in a season (Cedis)?

Season	Minimum	Maximum
2002-2003		
2003-2004		
2004-2005		
2005-2006		
2006-2007		

8.

Season	Fertiliser Type	No. of bags per ha	Cost per bag	Insecticide Type	Amt. per ha	Cost per ha	Cost of land preparation per ha
2002-2003							
2003-2004							
2004-2005							
2005-2006							
2006-2007							

9. What is cost per ha in a season (Cedis)?

Season	Minimum	Maximum
2002-2003		
2003-2004		
2004-2005		
2005-2006		
Etc.		

DORONGO

1. Which organisation is in charge of giving credit?
2. What are the criteria for accessing credit facilities?
3. What amount is given as loan per head?
4. What is/are the term/s of payments?
5. Is it farmer organisation?
6. Why are the credit facilities not easily accessible?
7. What are the problems associated with the scheme?

NASIA

1. How do you manage the pump?
2. How do you pay the electricity bills?
3. Is the association able to pay the bill in full or is there external support?
4. Is the capacity of the reservoir enough for the scheme?
5. What are the problems associated with the reservoir?
6. Why was the construction of the weir not completed?