Kwame Nkrumah University of Science and Technology

College of Engineering

Department of Civil Engineering

Targeting and Scaling-up of Agricultural Water Management Interventions in the Black Volta Basin - Ghana

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MSc. Thesis

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Targeting and Scaling-up of Agricultural Water Management Interventions in the Black Volta Basin - Ghana

By

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CERTIFICATION

I hereby declare that this thesis is my own work towards the Master of Science (MSc) degree in Water Resources Engineering and Management and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

To my most loving family especially my mum for her unflinching support and prayers

and

Pax Romana Choir, KNUST - Kumasi

ABSTRACT

The Upper West Region (UWR) of Ghana covers a geographical area of 18,476km^2. Out of this, an estimated area of 12,933.2 km^2 representing 70% is arable with about 80% of the populace engaged in agriculture. Majority of these people are small-scale farmers who depend mainly on rain-fed agriculture for their livelihood. However, the area falls within the semi-arid region of Ghana which is characterized by variable and uni-modal (April-September) rainfall pattern. These conditions have therefore become the major sources of risk in the agricultural enterprise. This has resulted in the region being characterized as poor with food insecurity and migration down south being on the ascendency especially during the dry season. This study therefore sought to identify the existing Agricultural Water Management (AWM) interventions available in the region, assess their biophysical and socio-economic parameters and up-scale the successful ones to other areas that have similar characteristics. Both primary and secondary data were used in the study. Primary data was collected from key informants and stakeholders using Participatory Geographic Information Systems (PGIS) techniques which included administration of questionnaires, interviews, mental mapping and transect walk with hand held GPS. The selected AWM interventions were chosen based on some criteria including: areas with high rural poverty, rain-fed areas, large group of beneficiaries, spontaneous uptake and large coverage in terms of area. The success or otherwise of these AWM interventions was based on indicators including high adoption rates, improved livelihoods, gender and sound environmental management. The model builder in ArcGis 9.3 was employed using overlay analysis to identify areas for up-scaling with soil, slope, landuse/cover and runoff maps being the main inputs/parameters. For the purposes of comparing the various parameters, all the input maps were reclassified into five suitability classes namely; optimally suitable (5), highly suitable (4), moderately suitable (3), marginally suitable (2) and not suitable (1). From the study, six AWM interventions namely small reservoirs, shallow wells, tied ridges, stone, earth, and grass bunding were identified. The results show that the adoption of the AWM interventions were very high due to the participatory nature of implementation and the fact that the use of these interventions have helped to improve livelihoods among communities/farmers by simultaneously reducing poverty and increasing food security. Vulnerable and marginalized groups like women have been empowered and are now included in decision making at the household and community levels. From the model builder in ArcGIS 9.3, dominant soil types most suitable (optimal and high) for small reservoirs and stone bunds were luvisols with acrisols and lithosols respectively. Most suitable areas (optimal and high) for small reservoirs and stone bunds were on slopes of 0-8% and 2-16% for small reservoirs and stone bunds respectively. Areas optimally suitable for small reservoirs and stone bunds were recorded as being 1.25% and 3.14% respectively whilst highly suitable areas for small reservoirs were 57.25% and that for stone bunds were 85.45% of the total area constituting the Upper West region.

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Praise the Lord my soul! All my being, praise His holy name! Praise the Lord, my soul, and do not forget how kind He is. (Psalm 103:1-2) Indeed the Lord has been kind and faithful to me by ensuring that this work has come to fruition. All praise, glory, honour and adoration be unto His holy name.

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LIST OF ABBREVIATIONS

AEA	Agricultural Extension Agent
AWM	Agricultural Water Management
CPWF	Challenge Program on Water and Food
CSI	Compound Suitability Index
DANIDA	Danish International Development Agency
DEM	Digital Elevation Model
DID	Directions in Development
FAO	Food and Agricultural Organization
FGDs	Focus Group Discussions
GIDA	Ghana Irrigation Development Authority
GMA	Ghana Meteorological Agency
GoG	Government of Ghana
GPS	Geographic Positioning System
GSS	Ghana Statistical Services
ICLOD	International Commission on Large Dams
IFAD	International Fund for Agricultural Development
ITDG	Intermediate Technology Development Group
IWMI	International Water Management Institute
KARI	Kenya Agricultural Research Institute
LULC	Landuse/Landcover
LWM	Land and Water Management
MDGs	Millennium Development Goals
MoFA	Ministry of Food and Agriculture
NGOs	Non- Governmental Organizations
NHIS	National Health Insurance Scheme
PGIS	Participatory Geographic Information Systems

RIW	Relative Importance Weight
RWH	Rain Water Harvesting
SARI	Savannah Agricultural Research Institute
SCWM	Soil Conservation and Water Management
SRI	Soil Research Institute
SRID	Statistics, Research and Information Directorate
SWC	Soil and Water Conservation
UER	Upper East Region
UN	United Nations
UWR	Upper West Region
WOCAT	World Overview of Conservation Approaches and Technologies
WUA	Water Users Association

1 INTRODUCTION

1.1 Background

In large parts of Africa, the fight against poverty and the prospects to reach the Millennium Development Goals (MDGs) crucially depend on the development and sustainable management of irrigated crop farming and livestock production to supplement rain-fed agriculture. In rural areas, where the majority of the population depends on agriculture, raising the production of crops and livestock remains the most promising strategy to achieve broad-based pro-poor growth, which is required to halve hunger and poverty by 2015, as required by target one of the first MDG (Birner *et al.*, 2005). However, in many developing countries of which Ghana is no exception, water remains a major constraint for increasing agricultural output for the populace especially for smallholder farmers who depend on rain-fed agriculture (Birner *et al.*, 2005).

In arid areas such as the UWR of Ghana where rainfall is highly variable, adoption of agricultural water management (AWM) interventions is essential for improving the profitability of smallholder farmers. This could simultaneously reduce poverty, increase food security and help in adapting to climate changes and variability (ACPC, 2011). Rural poverty however, has rendered communities weak in their financial capacity to invest in water and agricultural inputs hindering the adoption and dissemination of good AWM interventions. The need to therefore strengthen communities' capacity to adopt and disseminate AWM interventions especially those that integrate crops and livestock production cannot be over emphasized.

Interventions that favour this mixed system of agriculture should be promulgated since livestock production constitutes a very important component of the agricultural economy and contributes to the development of rural areas in many developing countries (FAO, 1993). This contribution goes beyond direct food production to include multipurpose uses, such as means of transport and traction, skins, fiber and fertilizer as well as capital accumulation. FAO (1993) stated further, that livestock are closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability. Sustainable land management, reliable water control systems, soil fertility improvement and better agricultural policies could also assist in improving smallholder farmer profitability (CGRFA, 2002).

With the aforementioned benefits, it will be prudent for the GoG and other interested organizations to invest in agriculture which is the main engine of economic growth in many countries. This will create employment opportunities especially for people living in rural areas whose major hope of getting out of poverty is through agriculture. This in turn will help in the alleviation of poverty and reduce food insecurity in the UWR. This project will contribute immensely towards the achievement of these goals since it seeks to target smallholder farmers at the basin level who practice AWM interventions. Again, it targets areas with similar biophysical and socioeconomic characteristics within the UWR that would be identified for the replication (up-scaling) of these AWM interventions to help policy makers and donors in decision making.

1.2 Problem Statement

Generally, rural poverty tends to be significantly higher in the northern parts of several countries in West Africa (IFAD 2001). In these countries, the northern parts lay in the savannah zones whilst the southern part lay in the forest zones. In Ghana, poverty incidence and rural-urban migration are higher in rural savannah areas than the forest areas. The study area in particular and the savannah in general is not only faced with this problem, but also poor success in the alleviation of hunger and poverty efforts.

Majority of the populace in the region are poor small-scale farmers who depend on rain fed agriculture for their livelihoods. However the region is located in the Guinea savannah agro-ecology, which makes drought and variable rainfall the major sources of agricultural risks. The onset of rains is usually not predictable and the first rains are usually torrential with only a small amount percolating into the soils while unexpected droughts lead to crop failure (Braimoh, 2004). Again, the uni-modal rainfall pattern (April to October) of the region affords farmers only one cropping season. However, farmers relate production of agriculture to frequency, intensity and duration of rainfall and these are held to have a direct influence on the yield of crops. All these, together with poor soil fertility, contribute to the prevalence of poverty in the region.

1.3 Justification

One of the most crucial steps towards ensuring food security in the world and for that matter Ghana is through irrigated agriculture. This makes it possible for farmers to have double cropping seasons instead of one. Other AWM interventions such as soil and water conservation techniques and practices should be implemented and disseminated by all stakeholders to build farmers' capacity and make agriculture more sustainable. This will help in achieving the first MDG and bring to a minimum, the problem of rural-urban migration. In addition, upon completion of this research, areas that are suitable for agriculture in the UWR would be mapped using GIS and remote sensing for proper/effective planning and monitoring.

1.4 Objectives

The main objective of this study is to target and up-scale successful AWM interventions in the UWR.

1.4.1 Specific Objectives

- To identify existing agricultural water management interventions in the UWR
- To assess biophysical and socio-economic parameters in the UWR that influences the success of these interventions
- To map areas in UWR for the up-scaling of successful AWM interventions.

1.5 Research Questions

Questions that would be answered by the study in order to achieve the set objectives include:

1. What are the types and details of AWM interventions available in the study area, their adoption rates, their impacts on crops and livestock?
2. What are the biophysical and socio-economic parameters that could influence the success or failure of these AWM interventions?
3. Which locations within the region have similar biophysical and socio-economic parameters for the up-scaling of successful AWM interventions?

1.6 Scope of Study

The study is limited to six communities which fall under five districts in the UWR of Ghana. The study basically looks at identifying the different types of AWM interventions in the region, up-scaling the successful ones and replicating them in areas which have similar biophysical and socio-economic parameters.

2 LITERATURE REVIEW

2.1 Definitions

2.1.1 Agricultural Water Management

"Agricultural water management" (AWM) can be defined as the range of technologies and practices whose objective is to ensure that adequate water is available in the root zone of crops when needed. It therefore includes capture and storage (in dams, in groundwater) as well as drainage of any water used for agriculture (crops, livestock, fish); lifting and transporting water from where it is captured to where it is used for agricultural production or removing excess water from where agriculture is practiced; and in-field application and management of water, including land management practices that affect water availability to crops (IWMI, 2006).

2.1.2 Household Livelihood Security

Household livelihood security is defined as adequate and sustainable access to income and resources to meet basic needs (including adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration) (Drinkwater and McEwan, 1992). Livelihoods can be made up of a range of on-farm and off-farm activities which together provide a variety of procurement strategies for food and cash. Thus, each household can have several possible sources of entitlement which constitute its livelihood. These entitlements are based on the household's endowments and its position in the legal, political and social fabric of society. According to Chambers and Conway (1992), a livelihood is sustainable, when it "can cope with and recover from the stress and shocks, maintain its capability and assets, and provide sustainable livelihood opportunities for the next generation."

2.1.3 Participatory Geographic Information Systems (PGIS)

Cinderby (2009) defines PGIS as the process that creates dialogue between local stakeholders, planners, environmental modelers and policy makers to improve decision outcomes. In other words, it is a process that integrates local knowledge into GIS or a process of providing public access to spatial data. Overall, PGIS represent a flexible suite of tools with different approaches relevant to particular contexts and issues.

2.2 Groundwater Irrigation Systems

The use of groundwater for agricultural purposes is on the ascendency in Ghana (Namara *et al.*, 2010). They asserted further that the northern regions of Ghana have been using shallow groundwater for irrigation purposes as far back as 1960. The major challenges in developing groundwater-based irrigation include drilling technology, lack of energy and cost of development. Groundwater irrigation can be grouped into different sub typologies. These are seasonal shallow-well systems, permanent shallow-well systems, shallow-tube wells systems and communal borehole systems (Namara *et al.*, 2010). Each group is dominant in specific agro-ecological, socioeconomic and institutional (mainly land tenure) settings. In inland valleys, a lot of these shallow groundwater wells can be found due to the fact that the alluvial material close to rivers can retain a lot of water which is used for dry season cultivation of crops. The use of the shallow groundwater wells provide many farmers especially those in the northern regions an alternate means of income during the dry season. It is however sad to note that the development of these shallow groundwater irrigation systems have received little or no support from government and/or donors.

For the purposes of this research, seasonal groundwater shallow-wells would be further elaborated on.

2.2.1 Seasonal Shallow-Wells Systems

In Ghana, seasonal shallow-well irrigation systems can be subdivided into two categories namely in-field and riverine seasonal shallow-wells.

In-Field Seasonal Shallow-Wells: These wells are usually dug in low-lying high water table areas with a diameter of about 0.5-1.2 m and a depth of 3-6m. They are mostly close to rivers, swampy areas or even at the tail-end of existing irrigation schemes. In-field seasonal shallow wells can irrigate land area of about 200-1000 meters square (Namara *et al*., 2010). Shallows wells are mainly used for dry season gardening for vegetable production. Thus they are constructed such that they do not last beyond that season. The same land area is used mostly for the cultivation of rice and maize during the rainy season. The water is generally lifted from the wells by use of bucket and rope. Other water lifting devices are different types of pumps including hand or foot operated ones and small motorized pumps. With the use of this intervention, crops are usually planted in series of furrows or sunken beds which are specially made in the field with the size of the furrows ranging from 0.10 to 0.15m in width and 0.7 to 1.7m in depth.

Plate 2.1: Shallow-Well System at Busa in the UWR of Ghana

From observation, many irrigated fields are small and this could be due to a lot of factors. Some of the contributory factors include lack of financial resources to buy inputs for cultivation, water availability, labour availability and scarcity of suitable land. There are variations in the number of wells that could be on a field. There can be 2-3 wells or 3-5 wells on smaller irrigable fields (200-500m^2). In some cases, there could be as many as 15 wells on a field. The trial and error method is mainly used for location of wells thus experience in the availability of water from previous years is very essential. The wells could be located at a distance of 15-20m from a river source.

Riverine Shallow-Wells: These wells are found on rivers that are ephemeral and are used for dry season cultivation of crops. The wells are reconstructed every season due to their structure being destroyed by the river during the rainy/wet season. For riverine shallow-wells, the size of the plot is usually larger as compared to that of the in-field shallow-well system. This is particularly so when pumps which are less labour intensive are used instead of buckets in the application of the water to the fields.

Plate 2.2: Riverine Shallow-Well Systems

Source: Gumma (2007).

Wells with depth of about 0.5-1.5m are used initially by farmers for irrigation and they are further deepened to about 6m depth below the level of the riverbed when the water level recedes or decreases. Generally, farmers who are able to purchase pumps that can be transported at the back of a motor bike or bicycle use this kind of irrigation system.

2.3 Treadle Pump

According to Hussain *et al*. (2000) a treadle pump is a foot-operated device that uses bamboo or flexible pipe for suction to pump water from shallow aquifers or surface water bodies. Since it can be attached to a flexible hose, a treadle pump is useful for lifting water at shallow depths from ponds, tanks, canals or catchment basins, tube wells, and other sources up to a maximum height of 7 meters (m). It performs best at a pumping head of 3.0–3.5m. It can lift up to 100 liters/ min at depths of around 4m. The design is less tiring to use than other human powered water lifters because it generally uses the leg muscles which are stronger than arm muscles. The treadle pump is relatively simple and economical to build because most of the parts can be manufactured locally and user friendly especially towards women and children.

Plate 2.3: Use of Treadle Pump in Kasongo in the UWR of Ghana

The introduction of the treadle pump for irrigation has been shown to have a positive impact on household income. In Bangladesh, a simple treadle pump costs around US$20 but this investment allows families to generate US$100 additional income annually. In Africa where treadle pumps cost between US$50-80 additional income rises to between US$200 – 500 each year (Olley, 2008).

2.4 Rain Water Harvesting (RWH)

Rainwater harvesting (RWH) is a technology whereby rainwater is collected and stored and made available for domestic and productive purposes. Prinz and Singh (2000) defined rainwater harvesting as the process of collecting and concentrating water from runoff into a run-on area where the collected water is either directly applied to the cropping area or stored in the soil profile for immediate use by the crop. This intervention aims to minimize seasonal variations in the availability of water such as droughts and dry spells to enhance the reliability of agricultural production (WOCAT, 2009). RWH system generally has three components;

- the collection/catchment area which produces the runoff because the surface is impermeable or there is reduction in infiltration
- the conveyance system which directs the runoff, e.g. by channels, bunds etc.
- a storage where water is accumulated/stored for, use e.g. dams, ponds, soil etc.

To reduce evaporation losses and increase infiltration rates, additional measures in areas where rainwater is accumulated must be ensured, e.g. mulching. RWH also helps in the adaptation of changes in climate: reducing the risk of crop failures and shortages in water associated with high rainfall variability in semi-arid regions.

2.4.1 Main Benefits of RWH

The stored rainwater has multiple impacts, e.g. less risk of crop failure, increased water availability and increased crop yield. Its uses also include livestock watering and domestic purposes. Other advantages are reduced off-site damage such as flooding, erosion and groundwater recharge.

2.4.2 Origin and Spread of RWH in Africa

There are several traditional and innovative systems which exist in the Sahelian zones e.g. Sudan, Somalia, Egypt and Kenya. RWH is mainly traditional but has been re-introduced by projects and/or through self-initiative of land users. Countries which are applying the technology also include Ethiopia, South Africa, Uganda, Ghana and Burkina Faso (WOCAT, 2009).

2.5 Reservoirs

Water impounded behind dams is stored by reservoirs. These dams are constructed across rivers and streams and range from major structures that store billions of cubic meters of water to small impoundments behind simple earth bunds (IWMI, 2010).

Plate 2.4a: Large Dam/Reservoir

Plate 2.4b: Small Dam/Reservoir

Source: ICOLD (2003)

2.5.1 Large Reservoirs

According to ICOLD (2003), large reservoirs are usually defined as those with storage capacity exceeding three million cubic meters ($3Mm^3$). These reservoirs supply water for irrigation and domestic purposes in addition to supplying water for industrial purposes and for the generation of hydropower. However, in some instances, they are used in controlling and managing flood. When the mean annual runoff is greater, some large reservoirs provide storage and hence provide multiyear carryover of water. This can be mostly vital where flow varies considerably from year to year, and prolonged dry periods are common.

2.5.2 Small Reservoirs

Small reservoirs are typically formed by constructing simple earth dams. More often than not, these dams do not have outlets thus water from the reservoir is generally used for livestock watering and pumping for irrigation (IWMI, 2010). Again, water in the reservoir is depleted as a result of seepage, spilling and evaporation. Most small reservoirs empty every year since they store relatively low volumes of water. They tend to be shallow, with relatively large surface areas, so that, in common with many ponds/tanks, a significant proportion of the water is lost through evaporation.

2.6 Soil and Water Conservation (SWC) Interventions

Soil and water conservation methods are practices which aim primarily at controlling erosion and retaining soil moisture for cultivation of crops and plants. SWC measures include but not limited to bunding, terracing, mulching and reduced tillage. These techniques are in-situ rainwater management practices which reduce runoff and enhance infiltration and water retention in the soil profile (AgriInfo, 2011). Morgan (1995), also refers to structural barriers made of stones or vegetation installed along contour lines as mechanical erosion control measures. These structural barriers may not necessarily reduce the runoff amount but retard its velocity and hence infiltration is enhanced and facilitates the formation of natural terraces (Lal, 1990).

2.6.1 Contour Ridges

According to Ruffino (2009), contour ridges which could also be referred to as contour furrows or micro watersheds are used for crop production. The ridges only need be as high as necessary to prevent overtopping by runoff. As the runoff is harvested only from a small strip between the ridges, a height of 15-20cm is sufficient. However, the ridge height must be increased if the bunds are spaced at more than 2 meters. Ridges usually follow the contour at a spacing of 1 to 2 meters. Runoff is collected from the uncultivated strip between ridges and stored in a furrow just above the ridges. Crops are then planted on both sides of the furrow. If the ridges are properly constructed initially, minimal maintenance is needed otherwise the lines and ridges must be reconstructed upon collapse.

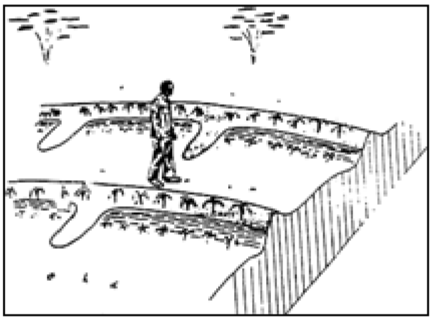


Plate 2.5a: Contour Ridges in Kenya

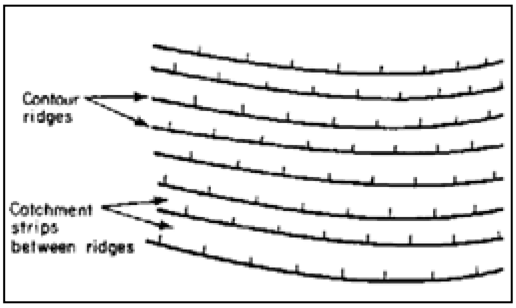


Plate 2.5b: Contour Ridge (Field Layout)

Source: Ruffino (2009).

An estimated number of 32 persons days/ha is required with regards to human labour. When machinery is used, the time required to cultivate a hectare of land is reduced and costs $100/ha. Conditions for the usage of contour ridges for the production of crops include; flat areas with up to 5% slope, field rainfall in the range 300-700mm and avoidance of undulating fields.

Table 2.1: Advantages and Disadvantages of Contour Ridges

Advantages	Disadvantages
Intervention is low cost	Intervention does not work well on steep slopes
Potential to increase food security in below normal rainfall years	Intervention has relatively low planting density which discourages farmers

2.6.2 Contour Stone Bunding

Contour stone bunding involves lining stones or making stone bunds along a contour. This intervention does not concentrate runoff but spreads it and also reduces the rate of runoff allowing infiltration. Stone bunding for crop production can be used under the following conditions:

- Location: Arid to semi–arid areas
- Rainfall: 200mm – 750mm per annum
- Soils: Agricultural soils
- Slopes: Preferably below 2%
- Topography: Need not be completely even
- Availability of Stones: Good local supply of stones

The structures for the contour stone bunds are laid to a height of 2.5m with a base width of 3.5-4.0m.To increase stability; the stones are set in trenches of about 0.5-1.0m depth. The stone bunds are usually 1.5-3.0m apart. Because the stones are not vulnerable to erosion, maintenance is very minimal however; silting behind the bunds requires that the stones be re-laid from time to time (Ruffino, 2009).

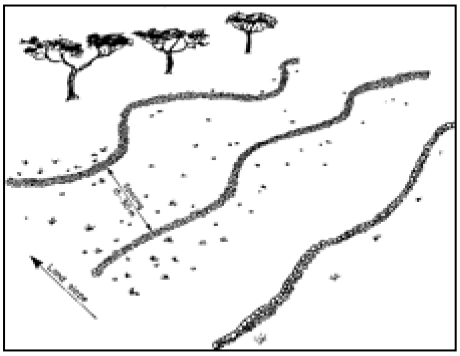


Plate 2.6a: Contour Stone Bunding

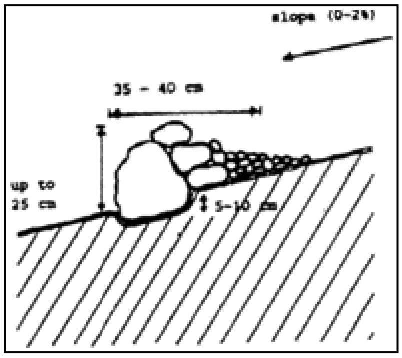


Plate 2.6b: Detail of Stone Bunding

Source: Ruffino (2009).

Table 2.2: Advantages and Disadvantages of Stone Bunding

Advantages	Disadvantages
Intervention is easy to implement at the local level	Cost for latecomers could be high since the popularity of the intervention could result in shortage of stones
Intervention is not vulnerable to unusual and variable rainfall intensity events thus the stone bunds are not washed away easily	Stones may have to be re-arranged from time to time as a result of silting behind the stones

The use of the contour stone bunding has visible positive environmental impacts e.g. for the rehabilitation of degraded lands, for reducing soil erosion and for recharging of groundwater.

2.6.3 Terracing Contour Bunds

Ridges and ditches made of soil and dug across slopes of contours are referred to as terracing contour bunds. The main purpose of this intervention is to decrease runoff and increase infiltration, reduce soil erosion and conserve soil and water for crop production with the crops planted on the land between the bunds. According to Ruffino (2009), the trench for the bunds should be 60cm wide by 60cm deep and the bund 50cm high by 150cm across the base. The distance between the bunds vary from 5m apart steeply sloping lands to 20m apart on more gently sloping lands.

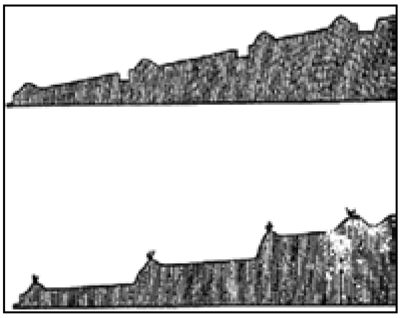
Terracing contour bunds are suitable for use under the following conditions and recommendations:

- Soils should be light or medium in texture with moderate slope (5% - 30%)
- Low rainfall areas (<700mm per year) where monsoon runoff can be impounded by constructing bunds
- Fodder grasses should be planted to stabilize the bunds
- Installation of cut-off drain to protect terraces from surplus rainfall if need be
- Soil bunds should be well compacted and reinforced with stones.

It costs between $60-460/ha to construct terrace bunds and cut-off drains. Bunds should however be maintained and repaired regularly to keep them in good condition. The advantages and disadvantages involved in this intervention are listed in Table 2.3.

Table 2.3: Advantages and Disadvantages of Terracing Contour Bunds

Advantages	Disadvantages
Generally results in reliable increase in crops	May create water logging problems in heavy soils
Intervention is very simple to construct	Intervention is costly in terms of labour



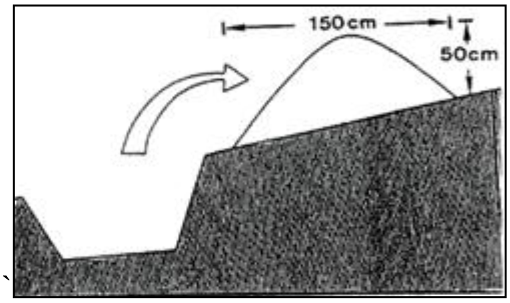


Plate 2.7a: General View of Terraces **Plate 2.7b: Bund Construction**

Source: Ruffino (2009).

Vegetative barriers are also usually constructed as single line or in the form of strips of several meters wide (Junge *et al*., 2008). Investigations into the effectiveness of vertiver by Malgwi (1992, 1995) indicated that vertiver (*Vetiver zizanioides*) which is a perennial grass with a deep and fibrous root system is an appropriate soil conservation intervention for semi-arid zones. The study recommends this because it can withstand denudation, fire, drought and flood; and on-farm records with vertiver in the derived savannah of Nigeria were also made by Kolade (2006) to emphasize the beneficial effects on soil conservation and economic advantages.

2.6.4 Tied Ridges

It consists of soil ridges of varying width and height, average being 30cm width and 20cm height. At regular intervals, crossties are built between the ridges. The ties are about two-thirds the height of the ridges, so that if overflowing occurs, it will be along the furrow and not down the slope (ITDG, 2002). The crop rows determine the spacing between ridges but the height of the ridges is 30cm high. Upon the construction of the ridges, the ridge ties are spaced at 2m intervals to prevent runoff from flowing along the furrows. The intervention works well in clay to clay-loam soil types (KARI, 2008).

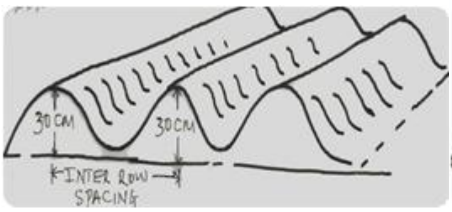


Plate2. 8a: Tied Ridges Spacing

Plate 2.8b: Tied Ridges

Source: KARI (2008).

2.6.5 Mulching

Mulch can be said to be a shallow layer at the soil/air interface; its composition generally includes dry grass; crop residuals (straw, leaves, etc.); fresh organic material from trees, bushes, grasses, and weeds; household refuse and live plants (cover crops, green manures) (De Souza Filho *et al*., 1998). It is an essential technique for improving soil microclimate; enhancing soil life, structure and fertility; conserving soil moisture; reducing weed growth; preventing damage by impact from solar radiation and rainfall (erosion control); and reducing the need for tillage.

3 STUDY AREA

3.1 Location and Size

The study area is located in the Upper West Region of Ghana which falls within the Black Volta Basin. This region, as shown in Fig. 3.1, is located at the north-western corner of the country. It is bordered to the south by the Northern Region, to the east by Upper East Region, to the north by the Republic of Burkina Faso and to the west by Republic of Cote d'Ivoire. It lies between longitudes $1^{o}25'$W and $2^{o}50'$W and between latitudes $9^{o}35$N and 11^{o}N respectively. The region covers a geographical area of 18,476km^2, constituting 7.7% of the total land area of Ghana (MoFA, 2011).

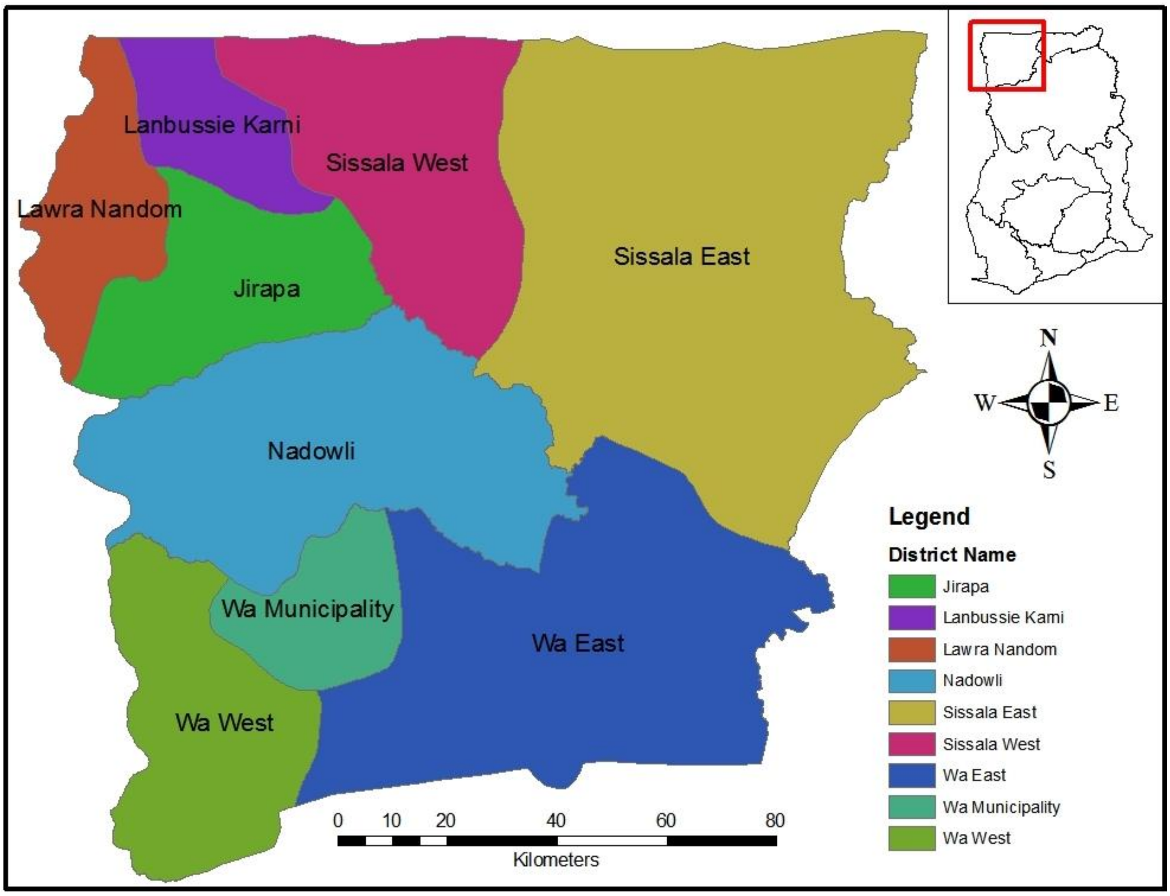


Figure 3.1: Districts in UWR

3.2 Topography and Drainage

Geologically, the UWR forms part of the high plains that cover most of the north-western part of Ghana. It is characterized by a series of wide plateaus made up of Birimian and post-Birimian granites and their weathered materials. The surfaces have been leveled by denudation with occasional granitic outcrops (SRI, unpublished). Altitudes vary from 200m (Black Volta) to 350m for the ridge that stretches from Wa in the south to the Burkina Faso border in the north and that forms the watershed between the Black Volta in the west and the Kulpawn river and White Volta in the east. The Upper West Region has both high and lowland areas with well drained lands. The highest point in the region is the cone-shaped granitic Kaleo hill (north of Wa) with an altitude of 435m. There are a number of water bodies that flow through the region. The two major rivers are the Black Volta River and the Kulkpong River which flow along the western and eastern ends of the region respectively (MoFA, 2011).

3.3 Geology and Soils

The soils in the UWR are formed over Birimian rocks, post-Birimian granites and associated basic rocks and mixed recent alluvium. Soils formed over recent alluvium are found on the flood plain of the Black Volta and of other major rivers and fall under the Bala-Yipiani Association. The series of this association found along river levees are mainly coarse sand, while those occupying lower points of the flood plains are poorly drained, greyish brown fine sandy clay or silty clay barns. These soils would approximately fall under Fluvisols, Arenosols or Gleysols in the FAO classification system (MoFA, 2011).

3.4 Climate

The climate of the Upper West Region is characterized by a short, single-peak rainfall regime and a long dry season from October to the end of April. The rainfall pattern is a result of the region's location in the sub-equatorial zone with changing wind regimes in the course of the year. During the dry season, the area is under the influence of the dry North-Eastern trade wind (Harmattan); as a result, relative humidity drops to a minimum of 16% in January. During the rainy season the maritime air from the South West monsoon and strong convection cause high rainfall and relative humidity levels, reaching 69% in August (MoFA, 2011). The average annual rainfall increases from north to south. The total annual rainfall and the rainfall distribution vary considerably from year to year. In some years, the first rains in April and May are followed by a short dry spell of three to five weeks, resulting in serious crop damage. The long term mean annual temperature for Wa is about 27.2°C, the mean maximum is about 35.5°C and the mean minimum is about 18.8°C (Agorsah, 2003).

3.5 Vegetation

The UWR can be subdivided into two agro-ecological zones: the Guinea Savanna in the southern part and the Sudan Savanna in the northern and north eastern parts. The Sudan Savanna is characterized by scattered trees and a sparse ground cover of grasses. The trees found include baobab (*Adansoniadigitata*), Dawadawa (*Parkiaclappertoniana*) and shea (*Butyrospermum paradoxum subsp. Parkii*). The Guinea Savanna is however characterized by a higher density of pro-climax tree species. The predominant trees include *Isoberina doka*, mahogany (*Khaya* *seneqalensis*), ebony (*Diospyros mespilliformis*), dawadawa (*Parkia clappertoniana*) and shea trees (*Butyrospermum paradoxum subsp. Parkii*) (SWCM, MoFA, 2011).

As a result of annual bush fires, the vegetation has been degrading in both areas. In the northern part of the region, where slopes are steeper and population pressure is higher, severe soil erosion is becoming a problem. However, primary vegetation can still be found in the south of the region, especially east of the Kulpawn River (MoFA, 2011).

3.6 Land Use

Out of the total land area of 18,476 sq. km, it is estimated that 12,933.2 sq km is arable constituting 70% of the total land size. However, the fertility of the land is generally questionable with farmers requiring high doses of fertilizers for satisfactory crop performance (MoFA, 2011). Aside agriculture, other uses of land include forest reserves and mining. Typically, lands are held by families, whose leadership gives them out under various conditions for developmental purposes (MoFA, 2011).

3.7 Demography, Ethnicity and Religion

According to the results of the 2010 Population and Housing Census, the population of the region is 702,110. There are 360,928 females and 341,182 males representing 51.4% and 48.6% respectively (GSS, 2010). According to Agorsah (2003), ethnic groups are generally considered as units of people who identify themselves by a shared name, differentiating themselves from all other groups. They usually share social behavior patterns and value systems, such as language and religious affiliations. According to MoFA (2011), the UWR is ethnically heterogeneous with the different ethnic groups forming part of the over hundred groups that are found in Ghana. The main ethnic groups include the Dagaaba, Sissala, Wala, Chakali and Lobi. There are other smaller ethnic groups like the Hausa, Fulani, and Moshie who are settlers from neighbouring countries. The major ethnic groups in the region are predominantly patrilineal (SRID, MoFA, 2011). Christianity, Islam and Traditional beliefs are the predominant religions found in the region.

3.8 Economic Activities

Basically, the region is agrarian with about 80% of the economically active population engaged in agriculture directly and/or indirectly (production and processing). Other economic activities are commerce, weaving and manufacture of traditional textiles, basket weaving, pottery, shea butter processing and lately mining, which is fast catching up with the other activities (MoFA, 2011).

3.8.1 Major Crops Produced

The major crops cultivated in the region are basically cereals, tubers and nuts. These include maize, rice, sorghum, millet, yam, cowpea, groundnut and soya bean. Minor crops include sweet potato, bambara beans and cassava. Vegetables such as okra, pepper, tomatoes, onions and leafy vegetables are also an important set of crops cultivated especially in the dry season. Industrial/cash crops production include cashew, mango, cotton and shea (MoFA, 2011).

3.8.2 Livestock Production

The major poultry/livestock types produced in the region include cattle, sheep, goats, pigs, poultry (local) and guinea fowl. Donkeys, rabbits, ducks, turkeys and pigeons are however reared on a minor scale. The environment is conducive for the rearing of these species, which is basically done the traditional way through free range grazing/feeding (MoFA, 2011).

3.8.3 Fish Production

The production of fish is mainly done in the region's numerous dugouts and reservoirs in its nine (9) districts. The total number of the dugouts and reservoirs is 91 with a total water surface area of about 455.9ha which benefits ninety-one (91) communities (MoFA, 2011). According to MoFA (2011), the fisheries commission estimated that the region produced 161.73Mt of fish in 2010. The report stated further that the fish catch is usually a combination of tilapia and catfish.

4 RESEARCH METHODOLOGY

This chapter discusses the criteria used in selecting the study communities, AWM interventions, and the indicators for measuring success as well as the materials and methods employed in the research work. The data required for analysis was obtained through Participatory Geographic Information System (PGIS), desk studies, reconnaissance survey and field visits.

4.1 Sources of Data and Information

Primary and secondary data/information was obtained from directors, Agricultural Extension Agents (AEAs), and other personnel from MoFA, Ghana Irrigation Development Authority (GIDA), Ghana Statistical Service (GSS), Savannah Agricultural Research Institute (SARI), Soil Research Institute (SRI). At the local level, information was sought from chiefs (tindanas), opinion leaders and farmers.

4.2 Desk Studies

Relevant literature such as peer reviewed journals and articles, reports on previous works, MSc and PhD thesis conducted in Ghana (especially the three northern regions) and elsewhere and text books were obtained via the internet and library were used. Published and unpublished consultation reports from NGO's, MoFA, SARI, SRI and the research funder, Challenge Program on Water and Food (CPWF V1 Project) were also reviewed.

4.3 Field Visits

Reconnaissance survey was undertaken to have a fair idea on the AWM interventions being practiced in the study area through direct observation. Brief interviews were conducted with personnel from the regional MoFA Office, GIDA and SARI to know the various locations of the AWM interventions. Contacts were also established with district directors and AEAs of MoFA where subsequent data and/or information were obtained.

Plate 4.1: Different AWM Interventions (A) Shallow Wells, (B) Permanent Well with Manual Pump and (C) Motorized Water Pump

4.4 Data Collection Techniques and Materials Used

Basically, PGIS which includes administration of questionnaires, interviews, mental mapping and transect walk with hand held GPS was used in collecting data. The materials used included;

- A1 sized background maps (topographic maps; 1:50)
- Tracing sheets and masking tapes
- Mapping pens (permanent markers), pencils and erasers
- Voice recorders, flip charts and clipboards
- Notepads, pens, scissors and sharpening knives

4.4.1 Conduction of Interviews and Administration of Questionnaires

Semi-structured interviews were conducted with regional and district personnel from MoFA under the following sections and/or departments:

- Engineering
- Crops
- Monitoring and Evaluation
- Fisheries Commission

Personnel from GIDA, SARI and other key informants were also interviewed. All interviews conducted bordered on issues on AWM interventions which included the types of interventions practiced in the region, projects that brought the interventions, number of households still using the interventions, agents and/or organizations that implemented the interventions, etc.

Plate 4.2: Interviewing Personnel from GIDA

Questionnaires were also administered to high level stakeholders from MoFA, GIDA and SARI. Some of the topics under which questions were asked included characteristics of the projects, adoption and adaptation of interventions and water use management. All questionnaires used for the research are shown in Appendix A.

Plate 4.3: Administration of Questionnaire

4.4.2 Focus Group Discussions

FGDs were held for stakeholders from MoFA at the regional and districts levels, SARI and SRI based on the results obtained from the administration of questionnaires and interviews. This was done primarily to select appropriate communities for the research. At the community level, FGDs were held in communities to authenticate results from interviews and questionnaire administration.

For easy moderation of the FGDs, eight people were invited. They included the chief or his representative, the chairman and secretary of Water Users Associations (WUAs) and/or Land and Water Management Committee, women representative, representative for farmers and/or gardeners, fishermen representative and livestock representative. It must however be noted that in almost all the communities, over twenty people were present for FGDs held in each study community. Agricultural Extension Agents (AEAs) were also brought on board to help in the translation of both English and local languages. Issues discussed included impacts on crops and livestock, land use and technological details of the interventions.

Plate 4.4: FGDs with Stakeholders: High Level and Community Level

4.5 Selection of Study Communities

Selection of communities with successful AWM interventions was guided by the following criteria;

- Areas with high rural poverty
- Rain-fed areas
- Intervention should be more than 18months
- Large group of beneficiaries and coverage in terms of area
- Uptake should be spontaneous

The selected locations with AWM interventions that met the criteria for UWR were discussed with the country and basin coordinators of the CPWF V1 Project. Table 4.1 presents the districts and geographic coordinates of the specific communities where the study was undertaken whilst Fig. 4.1 shows a map of the study areas.

Table 4.1: Geographic Coordinates of Study Communities

District	Community	GPS Coordinates (Decimal Degrees)	
		Latitude	Longitude
Lawra-Nandom	Kusele	10.821583	-2.826417
	Kunyukuo	10.546333	-2.863861
Wa West	Yeliyiri	9.884694	- 2.591361
Wa Municipal	Busa	10.019444	-2.387917
	Biihee	10.025833	-2.400528
Jirapa	Yagha	10.479558	-2.790572

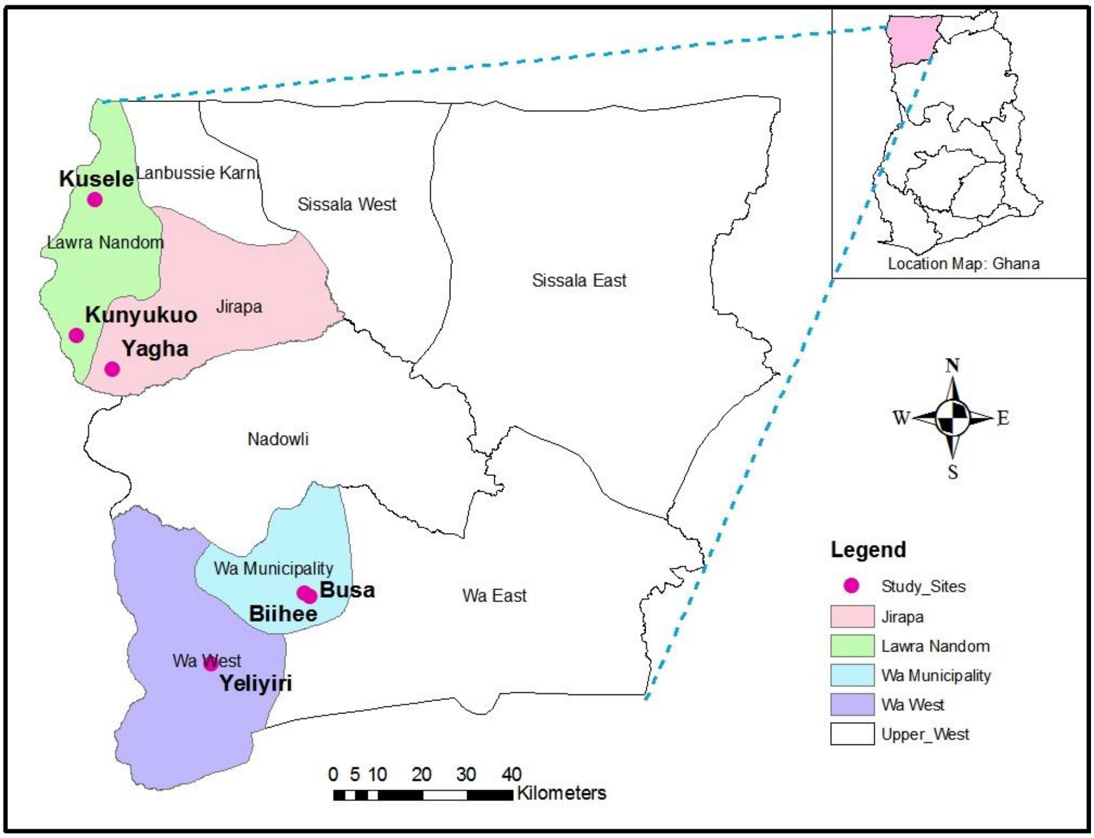


Figure 4.1: Map of UWR with Study Districts and Communities

All stakeholders involved were tasked to go through the process of mapping which is also a subsidiary of the Participatory GIS approach. This was carried out to spatially capture features of the project such as soil type, schools, markets, health centers, etc that contributed to the success of the intervention. The mapping was done on images of the areas printed from Google Earth.

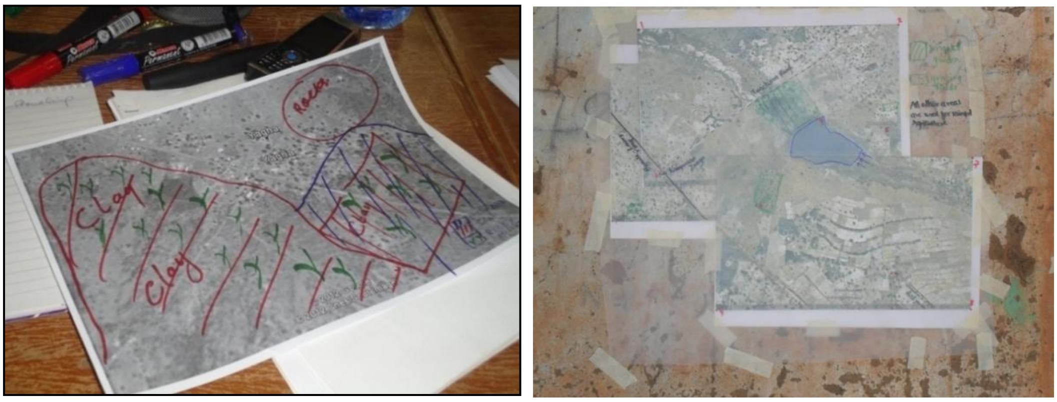


Plate 4.5: Mental Maps

4.5.1 Indicators for Selection of Successful AWM Interventions

For an intervention to be said to be successful for up scaling, the under listed indicators were used:

- High Adoption Rate
- Improved Livelihood
- Gender
- Sound Environmental Management.

4.6 Data Analysis

Analysis of both qualitative and quantitative data categorized into different components was carried out after the field work. Results obtained from questionnaires, interviews, observations and FGDs were formulated into graphics and tables to assess the successfulness of the AWM interventions.

4.7 Data Collection Limitations

Several challenges were encountered during the data collection phase of the research but the major ones were lack of available data on crop yields and language barrier. Almost all the farmers were illiterates thus Agricultural Extension Agents (AEAs) and local interpreters were employed to translate the questions from English to the various local dialects which brought about loss of information through translation.

4.8 GIS and Remote Sensing Component

For the purposes of identifying potential areas for the up-scaling of the successful interventions, the model builder in ArcGis 9.3 was used. The input parameters into this builder were mainly runoff, soil type, slope and land use or vegetation cover (Prinz *et al*., 1998). For comparison of the various parameters, all the criteria maps were reclassified into five suitability classes namely; optimally suitable (5), highly suitable (4), moderately suitable (3), marginally suitable (2) and not suitable (1). The selections of the suitability levels for the various criteria are discussed below. Shown in Fig. 4.2 is the flow chart showing how the GIS component of the study is used in identifying the potential areas for up-scaling.

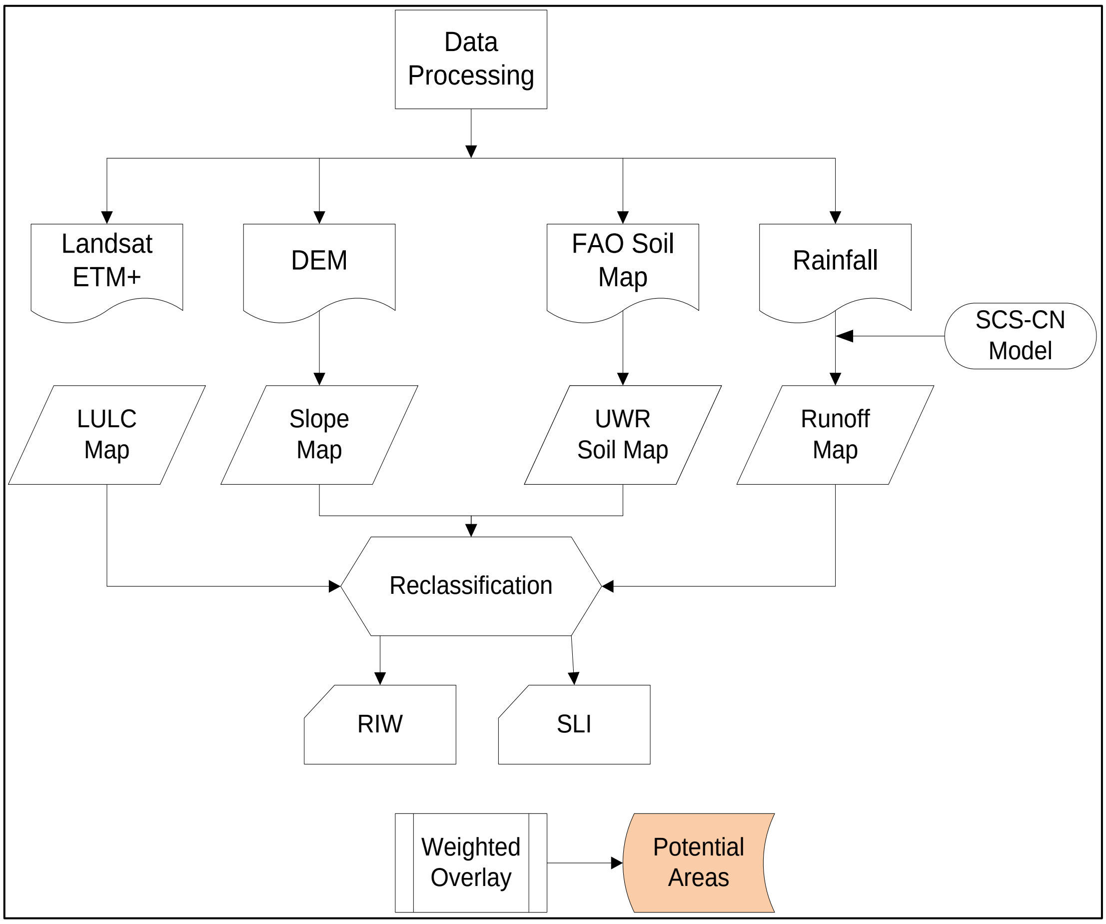


Figure 4.2: Flow Chart for Identification of Potential Areas for Agriculture.

Source: By Author

4.9 Selection of Suitability Levels

Potential areas of only two interventions namely small reservoirs and stone bunds would be identified. These interventions were selected because of their dominance in the study areas and the fact that data is available for validation.

4.9.1 Land Use/Cover

The LULC was determined through interpretation of aerial photographs of 1983 at a scale of 1: 65,000. Visual interpretation employing size, pattern, texture, shadow, tone and shape (Tumbo *et al.*, 2005) were used in identifying the LULC types namely cropland with open woody vegetation, deciduous woodland and deciduous shrubland with sparse trees (Fig. 4.3). The suitability levels for the landcover types are as shown in Table 4.2.

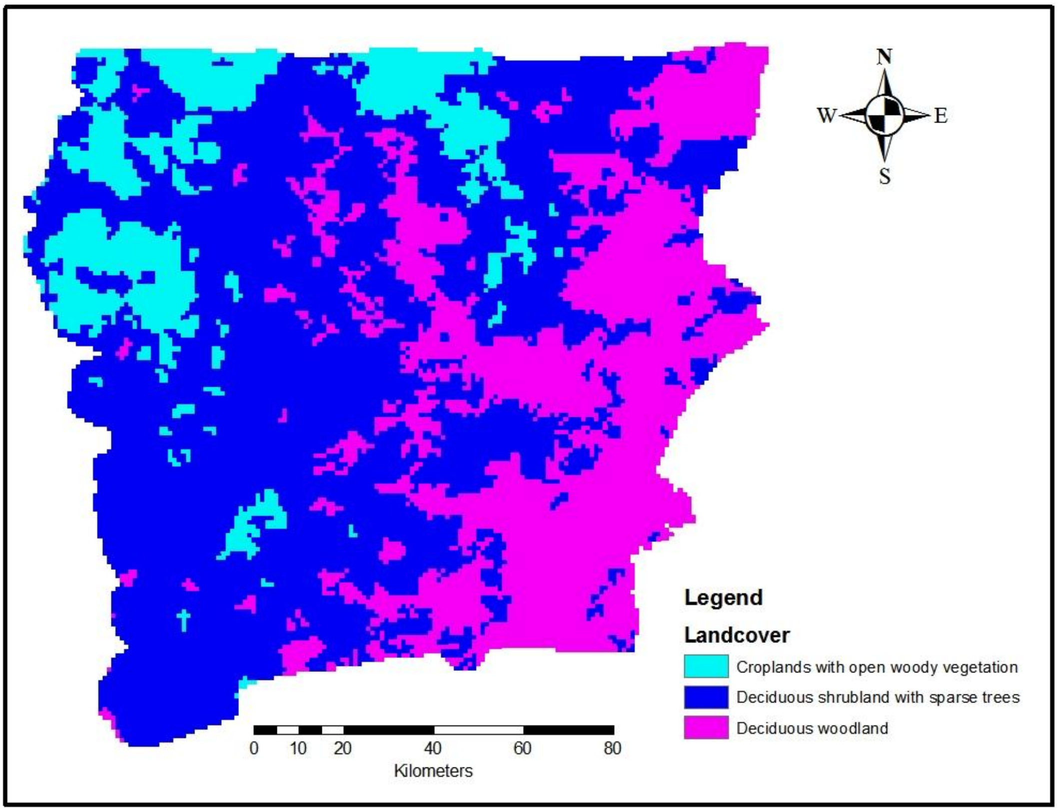


Figure 4.3: Landcover Map

Table 4.2: Suitability Level for Landcover

Landcover Types	**Suitability Levels**	
	Small Reservoir	**Stone Bunds**
Deciduous woodland	2	1
Deciduous shrubland	4	3
Cropland	5	5

Source: Adapted from Tumbo *et al.*, 2005

4.9.2 Slope

Generally, the slope of land is an important parameter in the site selection and implementation of AWM interventions. Thus, the slope map of the study area was generated through the surface analysis operation from the spatial analyst tools using the digital elevation model (DEM) in Fig. 4.4 as the input parameter. The map was then reclassified into five classes (Fig. 4.5) using the classification proposed by FAO (2002) namely: flat (0 – 2%), undulating (2 – 8%), rolling (8 – 16%), hilly (16 – 30%) and mountainous > 30%. The suitability level for slope with regards to small reservoirs and stone bunds is shown in Table 4.3. The steepness of the slope was used in identifying preferable areas.

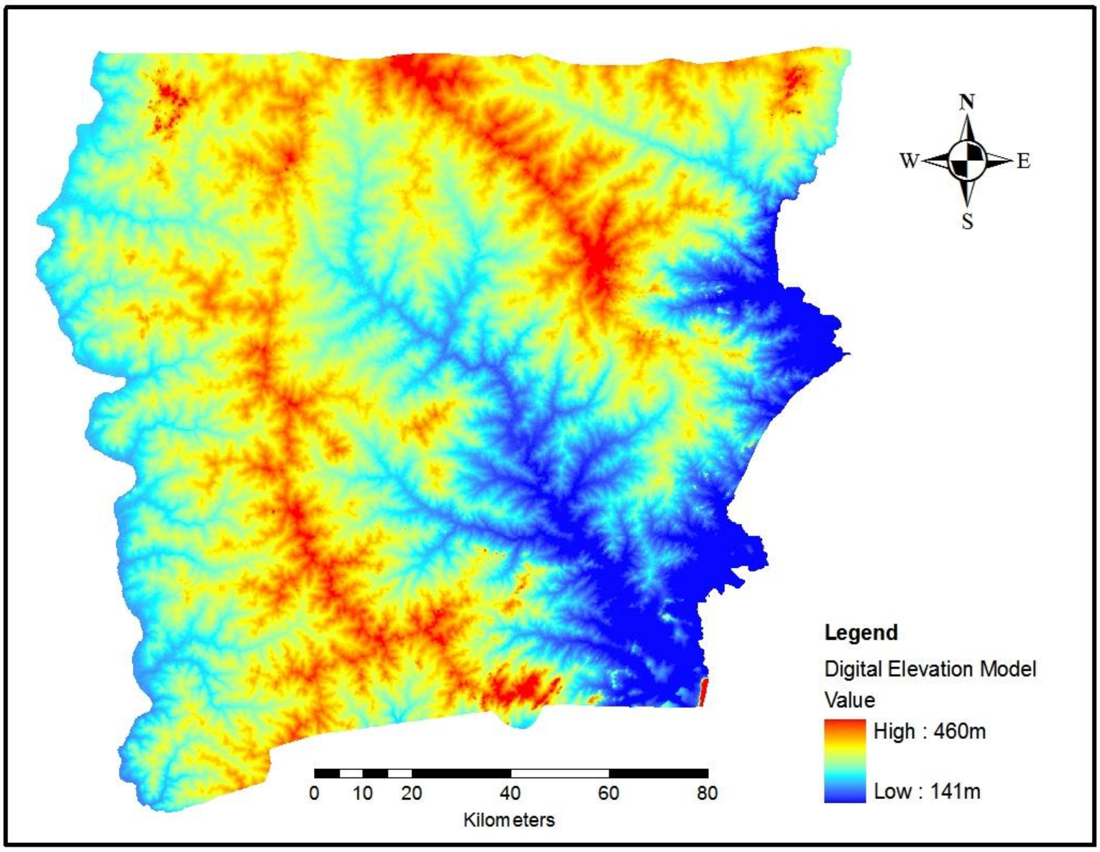


Figure 4.4: DEM of Study Area

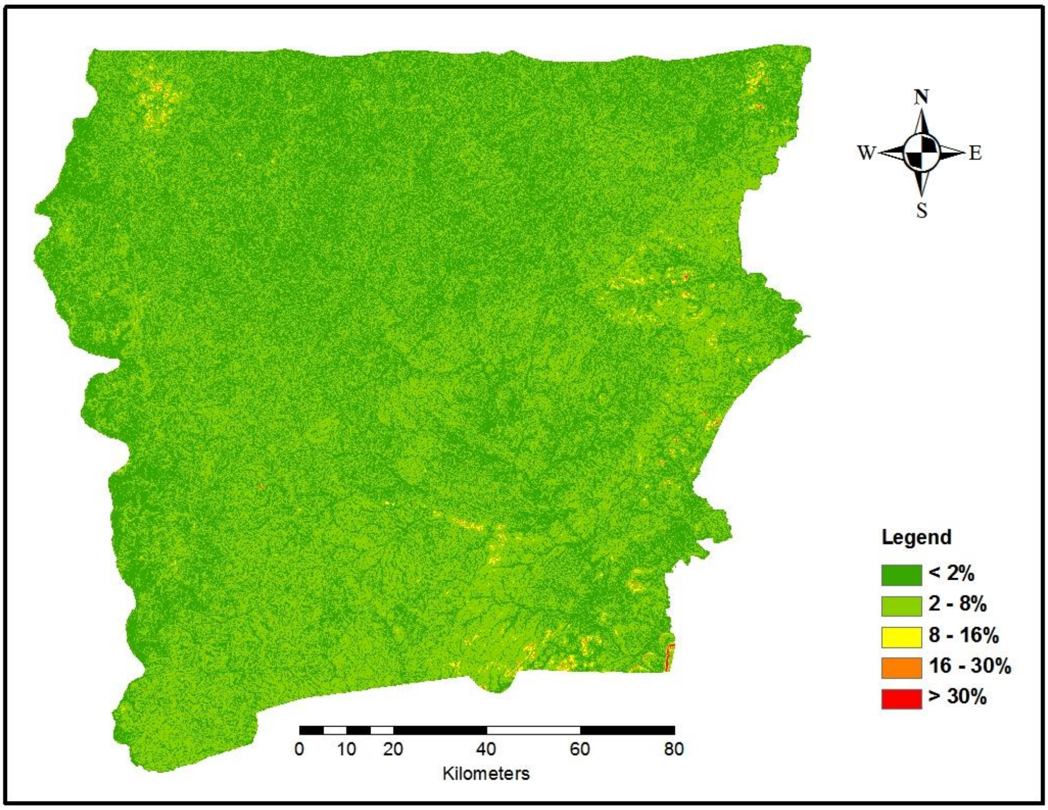


Figure 4.5: Reclassified Slope Map

Table 4.3: Suitability Level for Slope

Slope class	Slope (%)	Suitability Levels	
		Small Reservoir	Stone Bunds
Flat	<2	5	1
Undulating	2-8	4	3
Rolling	8-16	3	5
Hilly	16-30	2	5
Mountainous	>30	1	5

Source: Adapted from FAO, 2012

4.9.3 Soil Type

The suitability of an area for the implementation and up scaling of any AWM intervention, to an extent depends on the soil type thus careful consideration was given to it. According to Girma (2009), soils with high infiltration rates are not suitable for most types of AWM interventions. It is thus deduced that soils with higher water holding capacity are more desirable when considering implementing and up scaling of AWM interventions. For the purposes of this work, the FAO soil map of the world was used (Fig. 4.6). The soil types identified were Luvisols, Vertisols, Acrisols, Nitosols and Lithosols. Depending on the soil texture proportions (Table 4.3) established by FAO (2012), the identified soil types were assigned suitability classes (Table 4.4).

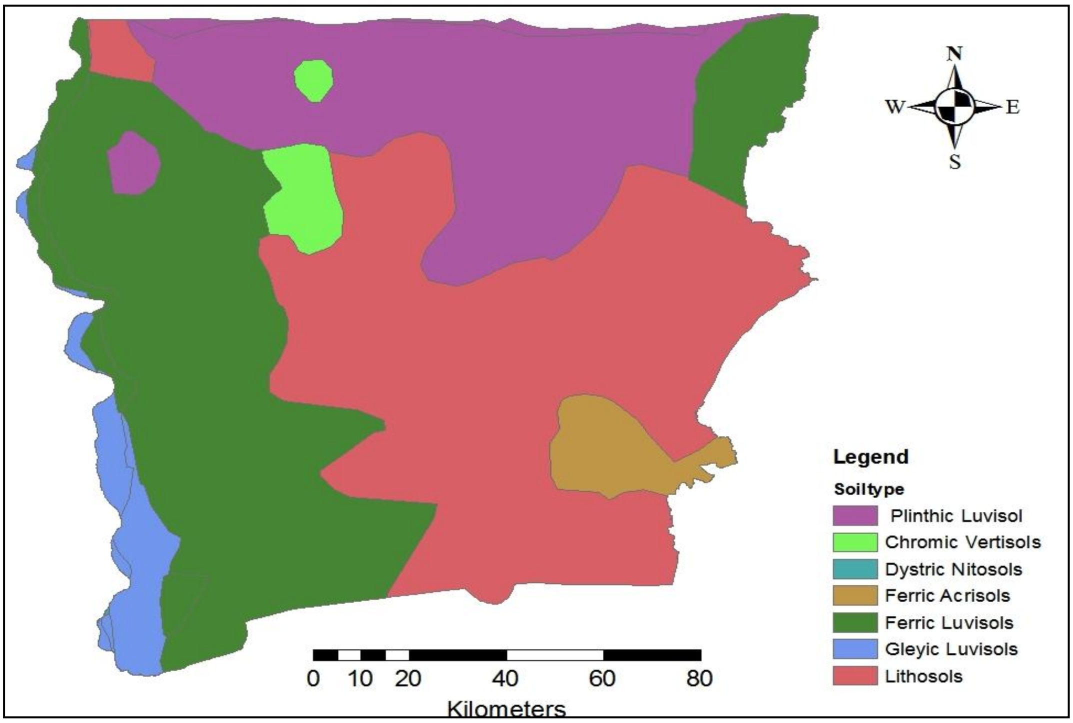


Figure 4.6: Soil Map of Study Area

Table 4.4: Soil Texture Proportions in Soil Types

Soil Type	Soil Layer	Sand Fraction (%)	Silt Fraction (%)	Clay Fraction (%)	Dominant soil texture
Acrisols	Topsoil	73	16	11	Sand
	Subsoil	61	11	28	
Luvisols	Topsoil	58	11	31	Sand,Clay
	Subsoil	51	7	42	
Vertisols	Topsoil	21	25	54	Clay
	Subsoil	20	24	56	
Lithosols	Topsoil	77	14	9	Sand
	Subsoil	67	16	17	
Nitosols	Topsoil	37	24	39	Clay, Sand
	Subsoil	30	31	39	

Source: Modified from FAO (2012).

Table 4.5: Suitability Levels for Soil Type

Soil Type	Suitability Levels	
	Small Reservoir	Stone Bunds
Luvisols	4	5
Vertisols	5	3
Acrisols	2	2
Nitosols	4	4
Lithosols	2	2

By Adapted from FAO, 2012

4.9.4 Rainfall-runoff Model

One of the most important parameters that need to be estimated when considering potential areas for AWM interventions is runoff. The model adopted in this study for runoff estimation is the Soil Conservation Service - Curve Number (SCS-CN) method. This model makes use of landcover and the hydrological soil groups in determining the weighted CN. The weighted CN is then used in equation 1 to determine the maximum retention (S). The runoff is finally estimated using rainfall (P) and the maximum retention (S) in equation 2. To aid the use of the runoff values in the weighted overlay analysis, they are converted into a runoff map using surface analysis in ArcGis Interface.

$$\mathrm{S} = \frac{25400}{\mathrm{CN}} - 254 \ldots\ldots\ldots\ldots.\text{Equation 1}$$

$$\mathrm{Q} = \frac{(\mathrm{P} - 0.2)^2}{\mathrm{P} + 0.8\mathrm{S}} \ldots\ldots\ldots\ldots\ldots.\text{Equation 2}$$

Where Q = Runoff depth (mm); P = Rainfall (mm); S = Maximum retention (mm); and CN = Curve Number.

In the process of calculating the runoff, the soil map is reclassified into four hydrological soil groups namely; A, B, C and D based on the infiltration and runoff generating potentials (Niehoff *et al.,* 2002).

4.9.5 Determination of Relative Importance Weight (RIW)

Another important factor that needs to be addressed before the weighted overlay analysis is the determination of the RIW of the various data input parameters. These parameters are weighted on a 9 point continuous scale (Fig. 4.6) ranging from extremely less important to extremely more important (Saaty, 1980).

1/9	1/7	1/5	1/3	1	3	5	7	9

Extremely less important ← — — — — Extremely more important →

Figure 4.7: Continuous Rating Scale

Using the continuous scale, the thematic layers are weighted based on the comparative importance of each parameter with respect to the other parameters (Harshi *et al.*, 2010). The weight index of comparative importance is estimated using the pair-wise comparison matrix (Tables 4.6 and 4.7) by determining the principal eigen vector (Table 4.8) using the process of averaging over normalized columns (Saaty, 1980). The formula is given as;

$$w_i = \frac{\sum_{i=1}^{I}\left(a_{ij}/\sum_{j=1}^{J} a_{ij}\right)}{j} \text{ .... Equation 3}$$

Where, W_i = weighted priority for component I; j = index number of columns; I = index number of rows; and a_{ij} = input parameter.

Table 4.6: Pairwise Comparison for Small Reservoirs

Parameter	**Runoff**	**LULC**	**Slope**	**Soil type**
Runoff	1	9	9	9
LULC	1/9	1	6	1/7
Slope	1/9	1/6	1	8
Soil Type	1/9	7	1/8	1

The different thematic layers (slope, soil type, runoff and landuse/cover) were compared using Saaty's (1980) Pairwise Comparison where he recommended that a scale of 1 to 9 be used to compare two components. A score of 1 represents indifference between the two components and 9 is the overwhelming dominance of the component under consideration (row component) over the comparison component (column component). If a component has some level of weaker impacts, the range of scores will be from 1 to 1/9 where 1 represents indifference and 1/9 being an overwhelming dominance by a column element over the row element. When scoring is conducted for a pair, a reciprocal value is automatically assigned to the reverse comparison within the matrix.

Table 4.7: Pairwise Comparison for Stone Bunds

Parameter	Runoff	LULC	Slope	Soil type
Runoff	1	8	8	8
LULC	1/8	1	1/7	1/5
Slope	1/8	7	1	6
Soil Type	1/8	5	1/6	1

Table 4.8: RIW of Input Parameters for AWM Interventions

Parameter	Relative Importance Weight (RIW)	
	Small Reservoir	Stone Bunds
Runoff	0.58	0.62
LULC	0.13	0.04
Slope	0.15	0.23
Soil Type	0.14	0.11

The RIW is an indication of the percentage influence of the various input parameters (i.e runoff, LULC, slope and soil type) under consideration for a particular type of intervention. The summation of the RIW for all input parameters considering a particular type of intervention should be equal to 1 when expressed as a fraction or 100 when expressed as a percentage. Shown in Table 4.8 is the RIW of input parameters for both small reservoirs and stone bunds.

4.9.6 Determination of Compound Suitability Index (CSI)

By combining the SLI and RIW, the potential site (CSI) for a particular intervention is identified by means of the weighted overlay analysis using ArcGIS 9.3. The higher the CSI, the more suitable an area would be for a particular intervention. The underlining equation used in the weighted overlay analysis is given by;

$$\mathbf{CSI = \sum (RIW \times SL)} \quad \text{……………………………………………………..Equation 4}$$

Where RIW = weight index for thematic layer for small reservoir/stone bund; and SL_{Sit} = suitability level of thematic layer for small reservoir/stone bund.

5 RESULTS AND DISCUSSIONS

This chapter discusses the findings obtained from the study in line with the set objectives. The study is basically aimed at up-scaling successful AWM interventions used by smallholder farmers in the UWR of Ghana. The results would be presented in the form of maps, tables and charts.

5.1 General Overview of Study Communities

Distributions of the different livelihood strategies employed in Biihee, Busa, Kusele, Kunyukuo, Yeliyiri and Yagha are shown in Fig. 5.1. The results show that 90% of the inhabitants in the study communities are engaged in agricultural activities. The major activities being crop and livestock production with a small percentage engaged in non-farm activities such as trading and hunting.

It was also reported in all communities that livelihood strategies were not necessarily limited to agriculture. Seasonal (dry season) migration was another livelihood strategy employed in order to diversify income to support household needs. The youth especially and some men are the major people who engage in the migration business to Wa and some towns in the southern parts of Ghana.

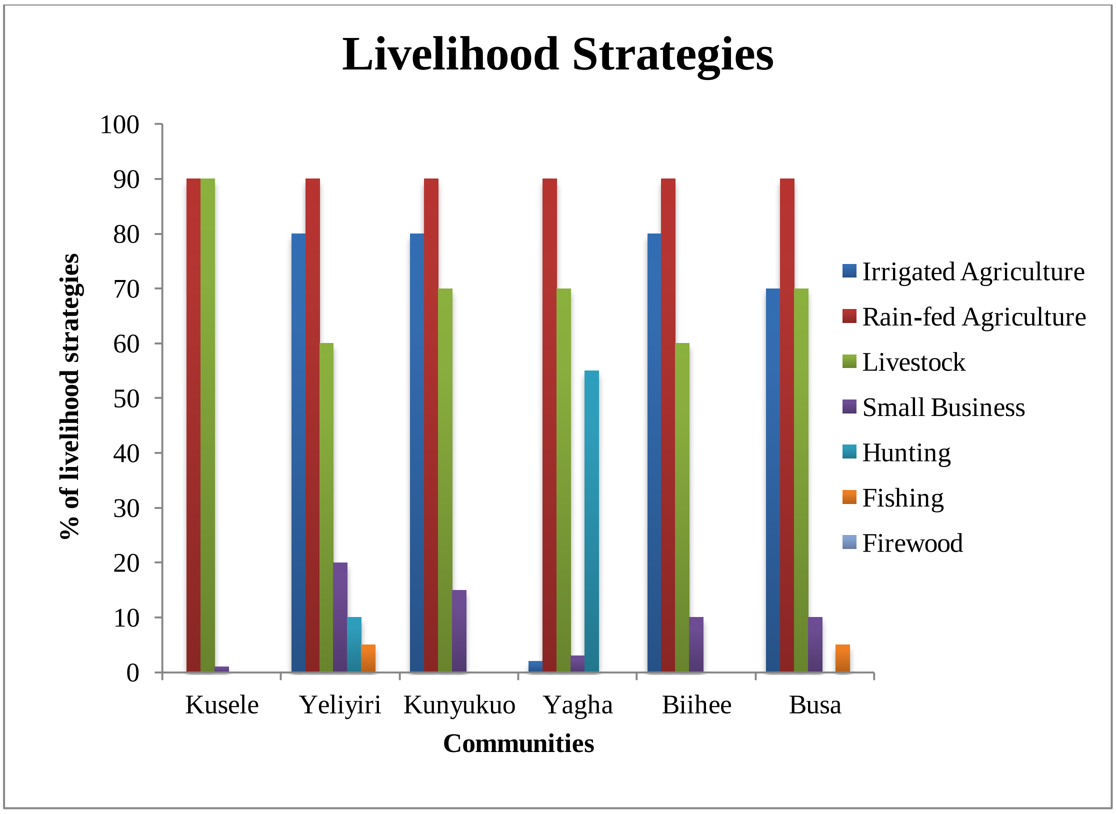


Figure 5.1: Distribution of Livelihood Strategies in Study Communities

5.1.1 Location of Interventions

Several AMW interventions were reported to be available in the study communities but for the purposes of this study, six AWM interventions were considered. These include stone, earth and grass bunds and tied ridges (water and soil conservation interventions). The rest are shallow wells and small reservoirs (water storage interventions). Table 5.1 shows the interventions considered in each community whilst Fig. 5.2 also presents a map with the communities and the interventions.

Table 5.1: AWM Interventions in Study Communities

District	Community	AWM Interventions					
		SB	EB	GB	TR	SW	SR
Lawra-Nandom	Kusele	√	X	√	√	X	X
	Kunyukuo	X	X	X	X	X	√
Wa West	Yeliyiri	X	X	X	X	X	√
Wa Municipal	Busa	X	X	X	X	X	√
	Biihee	X	X	X	X	√	X
Jirapa	Yagha	√	√	√	X	X	X

Note: √ - Considered X – Not considered

Note: SR: Stone Bund GB: Grass Bund ER: Earth Bund

Note: TR: Tied Ridge SW: Shallow Well SR: Small Reservoir

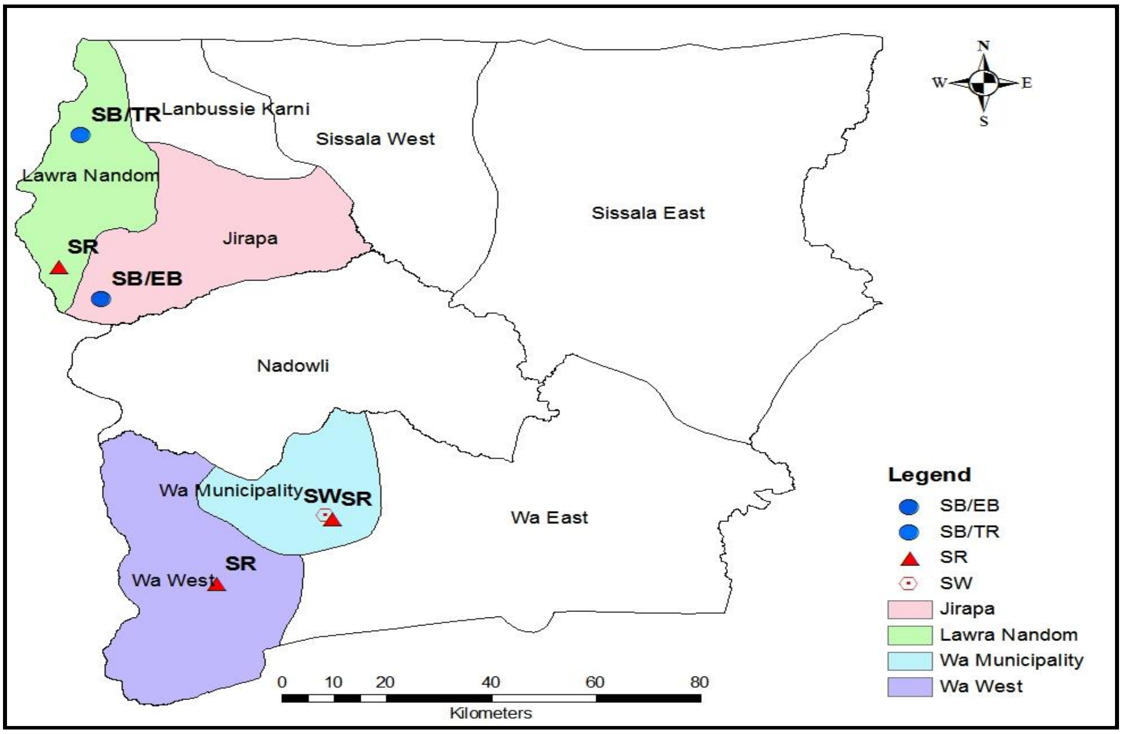


Figure 5.2: Map of Interventions

5.1.2 Implementation and Ownership of Interventions

All the AWM interventions implemented in the study communities were mostly initiatives undertaken by MoFA and donor organizations to enhance farmers' agricultural productivity with the exception of shallow wells which are indigenous. The implementation of these AWM interventions was done using the bottom-up approach. The project implementers involved the inhabitants (tindanas, opinion leaders and farmers) from the initial to the final stages of implementation. This was done through meetings, discussions, field demonstrations and tours to other regions where the interventions were being practiced already. Interventions that needed to be adapted to suit local standards and conditions were also done by farmers. The management and ownership of these interventions are done by either the community or individuals, e.g. shallow wells in Biihee are owned and managed by individual farmers whilst small reservoir management is by the water users associations (WUAs) present in communities which own small reservoirs. The WUAs are formed by beneficiaries of the intervention to see to the management and maintenance of the facility. The participatory nature of implementing the interventions and the fact that the reservoirs were handed over to communities thus gave them control and ownership of the interventions.

5.1.3 Benefits of the AWM Interventions

The use of the water and soil conservation interventions namely stone bunding, earth bunding, grass bunding and tied ridges mainly help to conserve soil water for cultivation of crops and for the reduction of soil erosion. The major crops grown using these interventions are cereals and legumes (rice, maize, millet, groundnuts, cowpea etc.) and tubers (yam, potatoes, cassava etc.) and sometimes vegetables (pepper, tomatoes, and onions) for home consumption only during the rainy season. The water storage interventions (shallow wells and small reservoirs) have multiple uses e.g. small reservoirs considered in this study are used to manage periods of drought and flood to make water available for irrigation, livestock watering, fishing and for domestic purposes. These interventions are mainly used during the dry season to produce high value crops. The crops cultivated during this season include onions, carrots, leafy vegetables, green pepper, green beans and maize.

Overall, the uses of the interventions (both water and soil conservation and water storage) have provided several benefits for beneficiaries. Farmers have enough food (especially grains) to last them till the next cropping season. Cash earnings accrued from the sale of farm produce and sometimes livestock are used to cater for basic necessities in life e.g. food, shelter, health, education and transportation. Sometimes farmers also use the cash earnings to reinvest in agriculture. For instance more cattle can be bought to add to one's livestock population which provides prestige and security to farmers. Others also purchase seedlings of some high value crops e.g. cabbage and lettuce for cultivation.

5.1.4 Operational and Maintenance Cost of Interventions

The operational and maintenance cost for interventions depends on farmers and to a lesser extent, some government organizations. The cost for operating and maintaining small reservoirs are carried out from contributions made by farmers to the various WUAs. The WUAs use the contributions for fixing minor problems e.g. damaged canals or faulty valves. GIDA only comes in to help if the problem is beyond their capabilities. The operation and maintenance for the other interventions are the sole responsibility of farmers.

5.1.5 Wider Impacts of AWM Interventions

Generally, the uses of the interventions promote positive environmental management e.g. the use of stone and earth bunding in Yagha has helped to reduce soil erosion. The use of small reservoirs did not have any adverse effects although evaporation and siltation are the challenges beneficiaries have to deal with.

The use of the interventions has enhanced farmers' knowledge and skills thus strengthening their capacities. For instance in Yagha and Kusele, there is transferability of knowledge on land and water management between farmers. Beneficiaries of the AWM interventions formed groups, committees and associations which serve as platforms to help access loans from banks and other credit facilities for agricultural purposes. These groups also help each other when the need arises e.g. in Yagha, farmers help each other in arranging stones for the cropping season.

The use of the interventions has neither brought conflicts nor increased its severity among the different livelihood strategies. The committees and associations formed by farmers have laid down rules and regulations which govern them. For instance it is a must for livestock owners to tether their animals during the main cropping season to prevent them from destroying cultivated fields. Again, the WUAs which manage small reservoirs are responsible for the equitable allocation of land and water for dry season gardening.

5.2 Indicators for Measuring Performance of AWM Interventions

5.2.1 Adoption of Interventions

Generally, the adoption of the AWM interventions were based on the settings/terrain peculiar to a particular community and farmer interest e.g. farmers in Yagha adopted the stone bund intervention due to the hilly and slopy nature of the terrain. Fig. 5.3 shows the adoption rate of the interventions in four communities. The results show that 14 households in Yagha adopted the stone bunding intervention in 1997; however 9 households are presently practicing it. The reason for the decrease is solely due to land tenure problems with landowners taking over their lands for no apparent reason. In 1999, 5 households in Kusele adopted tied ridges and 30 households are currently practicing it. This increment is more than 100% and the reason for the high adoption was due to farmer interest and the apparent improvement in livelihoods of those who started first.

In Yeliyiri and Kunyukou, the adoption rates increased tremendously after rehabilitation of the dams in 1996 and 2001 respectively. Adoption increased from 21 to 71 households and 45 to 120 households in Kunyukou and Yeliyiri, respectively. Data was not available for Busa, however, there are 650 farmers currently using the reservoir. In Biihee where the intervention (shallow well) was farmer driven, interactions with farmers and observation on the field showed that every farmer had a well in his/her farm. The reason behind the high patronage was the ability to farm even in the dry season. Across board, the over 100% increase in adoption was attributed to the numerous benefits reservoirs and shallow wells brought. This includes double cropping season, livestock watering and domestic uses for the water.

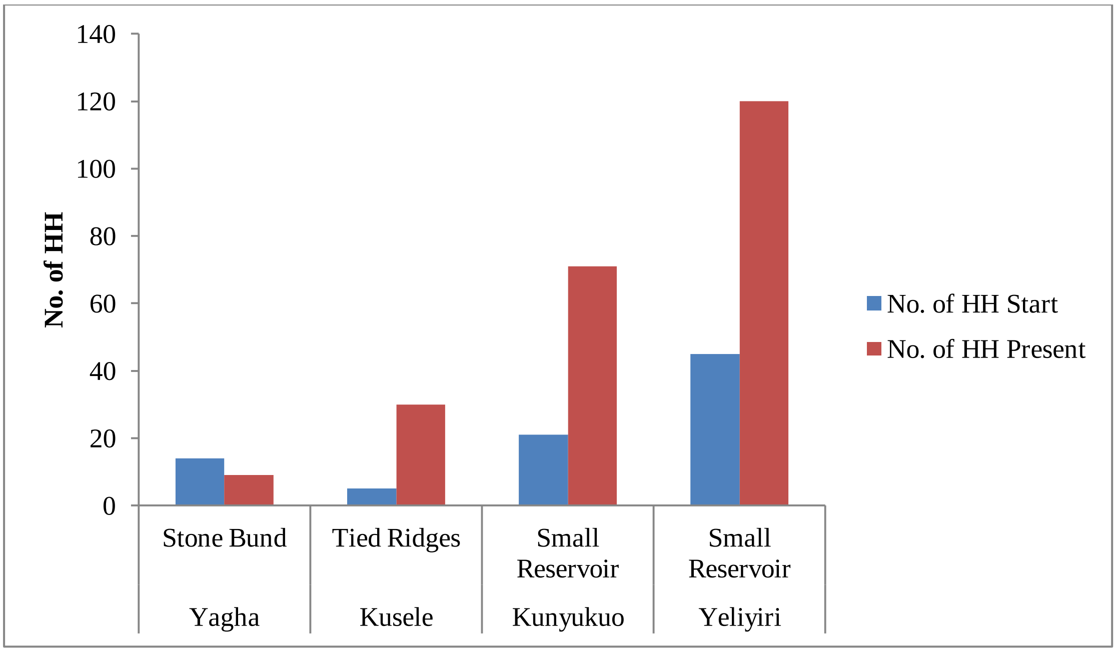


Figure 5.3: Adoption of Interventions in Study Communities

5.2.2 Gender

According to FAO (1998), gender is a socio-economic variable used to analyze roles, responsibilities, constraints, opportunities and incentives of people involved in agriculture. It further reported that part of the gender analysis procedure is the determination of women's ownership of assets within households. In line with this definition, there were no specific roles for men and women with respect to use of the AWM interventions except in Yagha, Biihee and Kusele communities. In Biihee, the men dig the wells whilst the women carry the sand away and in Yagha, men break the stones whilst women carry the stones and make the bunds. In all communities, however, women and children are mainly responsible for sowing/planting and irrigation of crops. Communities and farmers thus view the interventions as being gender friendly especially towards women and children.

According to DID (2006), women are stakeholders in AWM—and a poverty target group. They are important stakeholders in food production in irrigated and nonirrigated agriculture and in nutrition at the household level. This can also be said to be true in all communities as women participation in the adoption of the interventions have helped to achieve this purpose. For instance at the Busa dam site, there are 650 farmers of which 350 are women, representing 55% of the farmers. In Biihee, women dominate in the growth of high value crops and even landless women do intensive inter-copping of crops in small household/compound gardens. The participation of women in the use of the interventions especially the irrigated ones have impacted positively on households in all communities. The women provide more than half of the food consumed at the household level, support in catering for children, buying clothes and even renewing their NHIS cards. In all communities, women are represented in all the committees, groups and/or cooperatives. Generally, the livestock owned by women include pigs and poultry whilst men own cattle. However, some female headed households also own cattle. This has resulted in women being included in decision making within household and community levels. This goes to confirm the statement made by DID (2006) and Lipton *et al*. (2005), that women produce two-thirds of the food in most developing countries, and in Sub-Saharan Africa as much as 80% and that irrigation has been associated with greater power for women in household decisions, and in greater female school enrolment.

5.2.3 Sound Environmental Management

As part of the process of implementing the AWM interventions in the study communities, farmers were educated on some environmental management measures that could help in preserving the environment and also help in sustaining agricultural practices. Some of these measures were however not new to the communities as they already had some rules and regulations in place that helped to address the problem of environmental degradation e.g. indiscriminate felling of trees especially economic ones.

Vertiver grass (*Vetiveria zizanoides*) which according to Webb (2009) is a densely tufted, perennial clump grass with stiff leaf bases which overlap was introduced to all communities to help address the problem of erosion. This is made possible because the vertiver grass has narrow dense hedges which slow down runoff when planted along the contours of sloping lands and helps the water to infiltrate into the soil rather than washing off the slope (Webb, 2009). In Yagha and Kusele, farmers practice soil and water conservation interventions (tied ridges and grass, stone and earth bunding) and as a result of these, they recounted that soil fertility and water holding capacity have improved with soil erosion also reducing. In addition, the adoption of the interventions in Yagha has helped to reclaim degraded lands into productive states. This goes to confirm similar success stories elsewhere in the world e.g. in Australia, the vertiver has been used for stabilization of steep slopes, spreading of flood flows on cropped flood plains, trapping sediment and reducing sedimentation of water storages and reducing dust and wind erosion (Loch, 2006). Furthermore, the vertiver and thatch grasses are widely used in all communities because they serve as fire breaks and it's backed by what Loch (2006) and Starr *et al.* (2003) reported that these grasses are aggressively fire adapted and tolerate a wide range of climatic and edaphic conditions including water logging, drought and salinity. In Kusele, the pigeon pea tree also serves as hedge growth for windbreaks.

Plate 5.1: Vertiver Grass

Source: Loch (2006) and author's field survey

5.3 Water Storage Interventions

Table 5.2 shows the project characteristics of small reservoirs located at Busa, Kunyukou and Yeliyiri. In Biihee however, the shallow well intervention was indigenous thus the project characteristics do not apply.

Table 5.2: Summary of Small Reservoirs and Shallow Wells

District	Community	Sponsor & Date of Construction	Date of Rehabilitation	Consultant	Project/Donor/ Implementing Organization
Wa Municipal	Busa	GoG -1972	1998	GIDA	UWADEP/IFAD /MoFA
Wa West	Yeliyiri	GoG -1964	1996	GIDA	AgSSIP/MoFA
Lawra-Nandom	Kunyukou	GoG -1991	2001	GIDA	MoFA
Wa Municipal	Biihee	N/A	N/A	N/A	N/A

Note: N/A – not applicable

5.3.1 Small Reservoirs

The small reservoirs considered for this study are located at Busa, Kunyukou and Yeliyiri as shown in Table 5.2. The reservoirs in these areas have multiple uses e.g.

dry season irrigation, livestock watering, construction and for domestic purposes but not drinking. For irrigation purposes, water is abstracted using intake valves and flows by gravity into canals which transports the water to the irrigable areas. Water is applied to crops by the use of furrows, water pumps and watering cans. According to beneficiaries of the schemes, the interventions are successful because the reservoirs make water available throughout the year for all purposes especially for dry season gardening. It is however interesting to note that farmers at Busa had constructed shallow wells in their farms for dry season gardening irrespective of proximity to the canals. They claim the level of water in the canals is low and that water cannot flow by gravity to their farms thus they tend to rely more on the shallows wells rather than the reservoir during the dry season. The reservoir is thus mainly used for livestock watering, fishing and other domestic activities.

Plate 5.2a: Busa Reservoir

Plate 5.2b: On-farm Shallow Well

5.3.2 Uptake and Spread of Intervention in Communities

Uptake and spread of the small reservoir intervention was quite spontaneous as increments of over 100% were recorded. In Yeliyiri, uptake increased from 45 households to 120 households whilst in Kunyukou, number of households using the intervention increased from 21 to 71. In Busa, 110 households started using the reservoir in the year 2000 and by 2002 the number had increased to 270. Adaption to the intervention was easy for farmers at Busa and Kunyukou as they did not have to change their cropping system. However in Yeliyiri, it was quite difficult for farmers as they had to modify their cropping system by using mulch, planting in rows and raising of beds for planting.

The uptake and spread of the interventions were also due to the education and sensitization given to the communities during the implementation of the interventions. Communities were involved through meetings and discussions from the start to the finishing phases of the projects. Through the sensitization and education, WUAs were formed to see to the equitable allocation of water and land for dry season gardening and watering of livestock. They are also responsible for conflict resolution among different water users. Members of the WUAs make monthly contributions ranging from GH ¢1 to GH ¢5 for repairs and routine maintenance of the dams and canals.

5.3.3 Water Use and Water Management

During the main cropping season, farmers make use of rainwater and surface water since they are easily accessible but the reservoirs are used during periods of low rainfall and drought. During the dry season, there is allocation and distribution (daily, every other day or weekly) of water for cropping by the WUAs. Water is however distributed daily during the nursery and maturing stages of planting as farmers consider these times to be very critical. There are no barriers to the use of the reservoirs for livestock watering and domestic activities. Efficient use of the water for irrigation is ensured as there are canals in all three communities to transport water unto cropping fields. Generally, there is enough water in the reservoirs throughout the year for all on and off farm activities.

5.3.4 Management of Conflict

There has not been any severity or increase in conflict between the different water users resulting from the use of the intervention. The only challenge is that livestock keepers are sometimes not vigilant thus the animals stray to cropping fields when they are being watered from the reservoir and cause destruction. The WUAs resolve these issues whenever they arise since they were educated on conflict resolution. There are also rules and regulations that guide the users of the water thus members who go contrary to this are dealt with accordingly.

5.3.5 Impacts and Benefits on Crops and Livestock

Generally**,** impacts on livestock and crops were greatly felt after one and two years of usage of the reservoirs respectively. With the intervention, production of tomatoes and maize increased from 75kg/acre to 225kg/acre and 4bags/acre to 6bags/acre respectively in Yeliyiri. In Kunyukou, tomato production on a 10m×30m plot size recorded an increment from 30kg to 90kg per season. With the interventions, livestock owners have recorded increase in population and weight gain of animals. This was attributed to better quality of grazing lands and the availability of water. Livestock reared by farmers include cattle, donkey, goats, sheep, pig and poultry. Since more than 50% of crop farmers doubled as livestock owners, they use residue from their farms to supplement livestock feed. All these helped to reduce the number of livestock that die or get missing during the search for feed and/or water.

Livestock ownership, which is considered as a major household asset provides farmers with many benefits. These benefits include cash, means of savings, security, prestige, dowry, medium of exchange, manure, traction, food, skin and for religious purposes. Due to improvements in the farmers' (livestock and crop) financial capital, they are able to educate their children (up to senior high and tertiary levels), clothe and acquire NHIS cards for their families. In addition, farmers' housing conditions have improved (replace thatch roofing with Aluminium ones) and they are able purchase certain consumer durables such as bicycles to ease transportation challenges.

5.3.6 Enabling Environment

According to farmers, the success of the intervention was also linked to some infrastructure and availability of certain off-farm inputs such as fertilizer, pesticides and better agronomic practices. The infrastructure included schools, boreholes, roads, storage facilities (at Yeliyiri), electricity, markets, clinics and/or health posts.

Farmers sell their produce at markets that were nearest to their communities (Table 5.3). The distances covered by farmers for sale of produce range between 3km-20km and they do this by means of bicycles, motorbikes, donkey carts, on foot and sometimes lorries.

Table 5.3: Markets for the Sale of Farm Produce.

Community	Markets
Busa	Wa, Biihee and Busa
Kunyukou	Babile and Lawra
Yeliyiri	Wa and Vea

The provision of boreholes has made supply of water especially for drinking very accessible to the communities. The positive impacts are mainly felt by women and children whose burden of fetching water has reduced significantly.

5.4 Shallow Wells

The shallow well intervention is used in Biihee (Table 5.2) and it's purely the community's initiative. The wells are mainly used during the dry season for irrigation, livestock watering and domestic activities. Although the quality of the water from the wells is poor, farmers use it to cook in the farm and drink sometimes. The main crops cultivated during this season include onions, green beans, tomatoes, okra and leafy vegetables (pumpkin, cabbage, etc.). The wells are constructed with equipment such as pickaxe, shovel and head pan/ basin. When the dry season starts (November), the water table is quite high thus water is fetched straight from the wells with just a bucket. However, as the season progresses (February-March), the water table drops thus ropes are attached to the buckets before fetching for irrigation and other activities. Before the main cropping season (rainy season) starts, farmers fill the wells with soil. This is mostly done because some farmers cultivate on leased lands during the dry season thus they have to reclaim the lands before the landowners take over. It also prevents stray livestock from falling and sometimes dying in the wells.

Plate 5.3: Shallow Wells at Biihee

5.4.1 Uptake and Spread

Since the intervention is indigenous, the uptake and spread is very high. Men, women and even children of school going age engage in dry season gardening due to the benefits they derive from the farming activities. Farmers have groups which help them to access loans from banks for agricultural activities. They receive education on better agronomic practices from MoFA through SARI on vegetable production and utilization. Some farmer groups also received improved seeds and watering cans from SARI to boost their activities.

Plate 5.4: Farming Activities at Biihee

5.4.2 Construction and Maintenance Cost

The cost for constructing and maintaining shallow wells ranges between GH¢ 50 – 80 and GH¢ 20 – 30 respectively. Most often, the men construct and maintain the wells themselves but women on the other hand either hire labour or help their husbands with the construction works.

5.4.3 Water Use and Water Management

There are no groups or associations that manage the use of the water as such the wells are managed by farmers individually. There are thus no limitations on the use of the water. Water is applied to the crops directly with the use of buckets, calabashes and watering cans.

5.4.4 Management of Conflict

Conflicts among crop farmers and livestock owners are resolved by farmer groups and chiefs (tindana) of the community. That notwithstanding, crop farmers usually fence their cropped fields to prevent livestock from destroying their crops.

5.4.5 Impacts and Benefits on Crops and Livestock

Improvement in crops and livestock production has been recorded since farmers started using the intervention. Farmers are able to farm all year round especially during the dry season since there is enough water for crops and livestock. Aside water availability, improvements in yields are also attributed to application of fertilizer, pesticides and better farm management practices. Income levels of farmers normally shoot up during the dry season because of the vegetables they produce and the fact that their packaging is good e.g. farmers harvest tomato before it ripes to make handling easier. Generally, about 95% of the vegetables produced by farmers are sold and incomes accrued are normally used to provide the basic necessities for their families as well as purchase certain consumer goods such as motorbikes, bicycles and radio sets.

5.4.6 Enabling Environment

For the sale of crops and livestock especially on market days, farmers travel to Wa which is about 20km from Biihee by way of walking, using bicycles and/or motorbikes. They also sell some of their produce at Busa market (4km away).

Boreholes, health facilities and schools are among some of the infrastructure that farmers link the success of the intervention to.

5.5 Soil and Water Conservation Interventions

Table 5.4 gives as a summary of the project characteristics of the soil and water conservation interventions in Kusele and Yagha.

Table 5.4: Summary of Land and Water Management Interventions

Community	Intervention	Donor	Project/Implementing Organization	Start & End Dates of Project
Kusele	Tied Ridges Stone Bunds	IFAD World Bank /DANIDA	LWMP/MoFA LWMP/FAO/MoFA	1996 – 1999 2008 - 2010
Yagha	Stone/Earth Bunds	IFAD/DANIDA	LWMP/FAO/MoFA	1994 - 1997

Note: LWMP – Land and Water Management Project

5.5.1 Tied Ridges

Farmers in Kusele had no knowledge on tied ridges prior to the implementation of the intervention. The intervention taught farmers how to conserve water for cultivation by using ridges which are tied to each other at regular intervals by cross-dams. This intervention is used for cultivation during the main cropping season (April – September) and particularly used for the production of cereals especially maize. In addition, farmers were also introduced to the pigeon pea plant (*Cajanus cajan*) to supplement livestock feed and taught how to plant in rows. The pigeon pea plant is drought tolerant and is thus able to thrive well in the community (grown in dry seasons exceeding six months) and serves as an excellent green manure for improving soil structure and quality (Nene *et al.*, 1990 and Duke, 1981). The seeds of the pigeon tree also served as food which helped to supplement the nutritional needs of farmers and their families.

Plate 5.5a: Tied Ridge

Plate 5.5b: Pigeon Pea Plant

Source: Tau'olunga (2007)

5.5.2 Uptake and Spread

Farmers had to change their cropping systems in order to use the intervention thus it was difficult for them to adopt but once they did, the spread was quite spontaneous. Although the construction of the ridges is quite tedious, farmers do it because of the benefits they derive from the usage of the intervention and the fact that it is gender friendly. As part of the project implementation, farmers were given some support in the form of grants, spraying machines and improved maize seeds to offset the investment cost. Farmers have formed committees and groups to help in knowledge sharing among them and to also serve as platforms for loan acquisition.

5.5.3 Water Use and Water Management

Rainfall is the only source of water used for cropping activities thus farmers construct the ridges to reduce runoff. This enhances infiltration and increases soil moisture for crop production. Boreholes are used for livestock watering and this is supplemented by water collected in pools during rainfall.

5.5.4 Management of Conflict

The use of the intervention has not brought any conflicts among the different water users neither has it increased its severity. However, the land and water management committees have adopted the community's by-laws on conflict management to help resolve any conflicts that may arise.

5.5.5 Impacts and Benefits on Crops and Livestock

Improvements in the production of livestock and crops were recorded after two years of using the intervention. Maize production has increased from 5-6bags/acre to 8-10bags/acre. Because of the advantages of row planting which includes maximum absorption of light which enhances photosynthesis thus improving crop yield, women are no longer abused by their husbands for practicing scatter planting and consequently having low crop yields.

Farmers recounted that supplementing feed given to livestock with the pigeon pea plant has helped in the weight gain of the animals, and studies done by Nene *et al.* (1990) and Duke (1981) in Brazil confirm this. Because of the presence of pigeon pea plants in the community, distances covered by caretakers and livestock in search for feed especially during the dry season have reduced. Consequently, farmers get better prices for the sale of livestock which helps them to cater for their families by way of providing food, shelter and education. The livestock especially cattle are used for traction during land preparation and their dung also used as manure for planting thereby reducing farmers' workload and cost of purchasing fertilizer. Farmers especially women and children also use donkeys to cart farm produce and other goods to and from farms and/or market centers.

5.5.6 Enabling Environment

The main market for the sale of crops and livestock are Babile and Nandom markets which are 2km and 7km respectively away from Kusele. Motorbikes, bicycles, lorries and walking are among some of the transportation modes used by farmers to convey crops and livestock for sale at the market centers. The presence of schools, boreholes, though not adequate and health post in the community has helped in making the intervention successful.

5.6 Stone Bunds

The use of stone bunds is practiced by farmers in Yagha and Kusele. In Yagha, the stone bunds were introduced because of the hilly and slopy nature of the terrain and the fact that the stones used for the construction of the intervention was available. The stone bund intervention in Kusele was however initiated because of availability of stones only. In general, the underlying reason for the implementation of the intervention was to help solve the problem of erosion which made farming activities in these areas a challenge. Farmers in these areas have only one cropping season (April – September) and used to practice subsistence farming till the interventions were introduced.

Farmers in Yagha already had some knowledge on stone bunds prior to the implementation of the intervention. In contrast, farmers in Kusele had no idea on the use of stone bunds for farming activities. Farmers in Yagha who had adapted to the situation farmed at the base of the slopes by arranging stones in a circular way to trap runoff thus reducing erosion and increasing soil moisture for crop production.

Plate 5.6a: Old System

Plate 5.6b: Current Intervention

The intervention is labour intensive thus men, women and children help in the making of the bunds. The men dig and break the stones whilst the women and children transport and line them. The main equipments used for the construction of the bunds are mattock, wheel barrow and basins/head pan. The major crops cultivated using the stone bunds are cereals (maize, millet, sorghum, etc), tubers, legumes and nuts (beans, groundnut, and cowpea). Vegetables are cultivated mostly by women on flat lands near their homes for home consumption only.

5.6.1 Uptake and Spread

The implementation of the intervention was done using approaches that were participatory through meetings, discussions and field demonstration in both communities. Farmers were taught how to determine contours for the bunds using the “A” frame and the importance of mixing large and small stone during the construction of the bunds. In addition, farmers were supported with subsidies and equipments during the implementation stages. In Yagha, uptake and spread of the intervention was easy for farmers as they were already equipped with some knowledge on the usage of stone bunds. The fact that the main equipments needed for up-scaling the intervention was available on the local markets also contributed to the spread of the intervention.

In Kusele however, adoption and adaptation to the intervention was not very easy because farmers had to change their cropping systems. New farmers' groups were formed in Kusele through the spread of the intervention. Notable among them are the Tongoh, Kogle, Betaglu and Tolibri farmers' groups. In view of this, farmers are very willing to adopt new AWM interventions whenever the opportunity arises.

5.6.2 Construction and Maintenance Cost

On average, the investment cost for constructing stone bunds in Yagha and Kusele ranges between GH₵ 200 -275 for about half an acre of land. Approximately, half of the investment amount is needed in the maintenance of the bunds for the same size of land. Most farmers however depend on family and friends for the construction and maintenance of the bunds since it is more economical.

5.6.3 Water Use and Water Management

The only source of water for farming activities is rain thus farmers use this intervention to help conserve water for cultivation. They also construct dugouts during the rainy season for livestock watering and irrigation. First come, first serve principle is used by borehole water management committees available in the communities to manage water. For the efficient use of the water that may go unused, crops are cultivated near borehole sites to make use of this water.

5.6.4 Management of Conflict

The adoption and use of the intervention have not brought any conflicts among farmers in Kusele and Yagha. The communities as well as the land and water management committees have rules and regulations that stipulate that livestock be tethered during the main cropping season thus conflicts that might have resulted from destruction of crop fields by livestock are avoided.

5.6.5 Impacts and Benefits on Crops and Livestock

On average, improvements in crop and livestock production were recorded within two years of the existence of the intervention. Soil erosion and runoff were greatly reduced to help conserve water for crop production and protection of the environment. Maize yields increased from 150kg/acre to 600kg/acre with the use of the intervention. With these improvements, farmers especially women are able to provide three square meals for their families. Generally, about 70% of harvested produce (particularly grains) is kept for home consumption whilst 30% is sold. Residue left after harvesting are used to supplement livestock feed. Monies earned from the sale of both livestock and crops are used by farmers to improve their livelihoods i.e. educating their children, registering their families under the NHIS, enhancing housing conditions and acquiring motorbikes and bicycles. In all two communities, increments in yield of crops are linked to on-farm inputs such as fertilizer pesticides and better agronomic practices.

5.6.6 Enabling Environment

For the sale of crops and livestock, farmers in Yagha go to Jirapa, Babile and Tangasie markets whilst those in Kusele go to Nandom and Babile. This is done with the help of bicycles and motorbikes, donkey carts and by walking. The presence of schools, clinics and storage facilities were also associated with the success of the intervention.

5.7 Earth Bunds

Earth bunding was introduced in Yagha due to the availability of earth material in the community. The farmers were already using the interventions prior to its implementation. This intervention is practiced in low lying areas mainly for the production of rice. Other crops cultivated are cowpea, groundnut and beans (soya and bambara) and cashew. The main tools needed for the construction of the bund are pickaxe and head pans/basins. The labour requirement for the use of the intervention is mainly provided by family and friends.

5.7.1 Uptake and Spread

Uptake and spread of the intervention was very easy and spontaneous because farmers only modified their cropping system and the fact that it was gender friendly. The involvement of the community, through meetings and discussions during the introduction stages also helped in making adoption and use of the intervention very easy. The fact that farmers were given fertilizer subsidies and improved seeds also helped in making the intervention a success.

5.7.2 Construction and Management Cost

According to farmers, it costs an average of GH¢130 and GH¢65 annually for the construction and maintenance of the bunds respectively. However, almost all farmers employ family labour which is inexpensive and reliable.

5.7.3 Impacts and Benefits on Crops and Livestock

Generally, farmers recorded improvements in agricultural production after two years of using the intervention. The earth bunds helped to conserve soil water for crop production by reducing runoff and increasing infiltration. Rice yields have increased from 50kg/acre to 300kg/acre with the inception of the intervention. Residues from harvested produce are also used as feed supplement for livestock. Farmers store about 90% of the rice produced for home consumption which goes a long way in improving food security at household levels. Income generated by farmers from the sale of livestock and crops is used in catering for their families and purchasing bicycles, radio sets and motorbikes. This is confirmed by studies carried out by Barron *et al*. (2009) that increase in income by persons who adopt this intervention invest the money in physical capitals.

5.7.4 Enabling Environment

For the sale of agricultural outputs, farmers travel to Babile, Jirapa and Tangasie markets via bicycles, motorbikes, donkey carts and walking. The provision of store house and/or barns, boreholes, clinics and schools in the communities has contributed to the success of the intervention.

5.8 Grass Bunds

Grass bunding was introduced in Yagha and Kusele to help in addressing the issue of soil erosion by the use of the vertiver grass (*Vetiveria zizanoides*). However, the vertiver did not thrive well in Yagha thus they adopted the thatching grass (*Hyparrhenia rufa*) instead. These grasses are planted on the ridges and bunds farmers construct for planting. They are also planted along the contours of slopy areas in

Yagha and on banks of reservoirs located at Busa, Kunyukou and Yeliyiri for protection.

Plate 5.7: Earth Bunds with Grass Protection

5.8.1 Uptake, Spread and Benefits

The uptake and spread of the intervention was very spontaneous due to the benefits derived from the use of the intervention. The benefits include using the grass as feed for livestock and control for erosion. It also serves as fire breaks and demarcation for farmers plots.

5.9 GIS and Remote Sensing Component

5.9.1 Soil Suitability Mapping for Small Reservoirs

Soil suitability for small reservoirs was mapped (Fig. 5.4) using the FAO soil map as already discussed in the methods. From the analysis, as shown in Fig. 5.5, vertisols with a corresponding percentage area of 2.03% is said to be optimally suitable for small reservoirs. Luvisols and nitosols with a cumulative percentage area of 58.60% were also found to be highly suitable for small reservoirs. Marginally suitable soil types were lithosols and acrisols with corresponding percentage areas of 36.53% and 2.85% respectively.

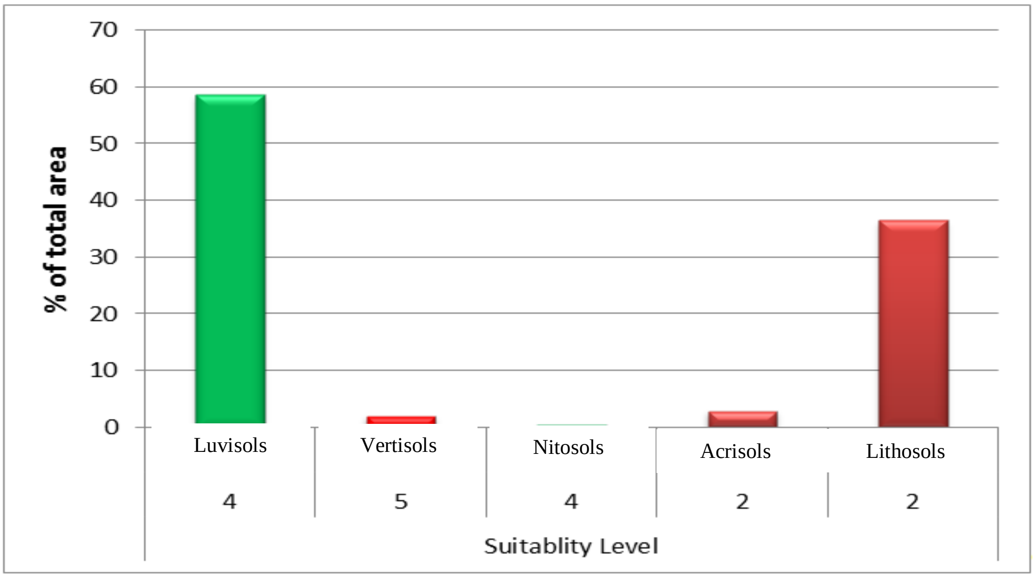


Figure 5.4: Percentage Soil Suitability for Small Reservoir

According to FAO (2012), since small reservoirs are meant to hold water, the underlying soil types should have a higher water holding capacity. This, thus makes vertisols which contains a greater proportion of clay (topsoil: 54% clay fraction and subsoil: 56% clay fraction) the optimally suitable soil type for this AWM intervention.

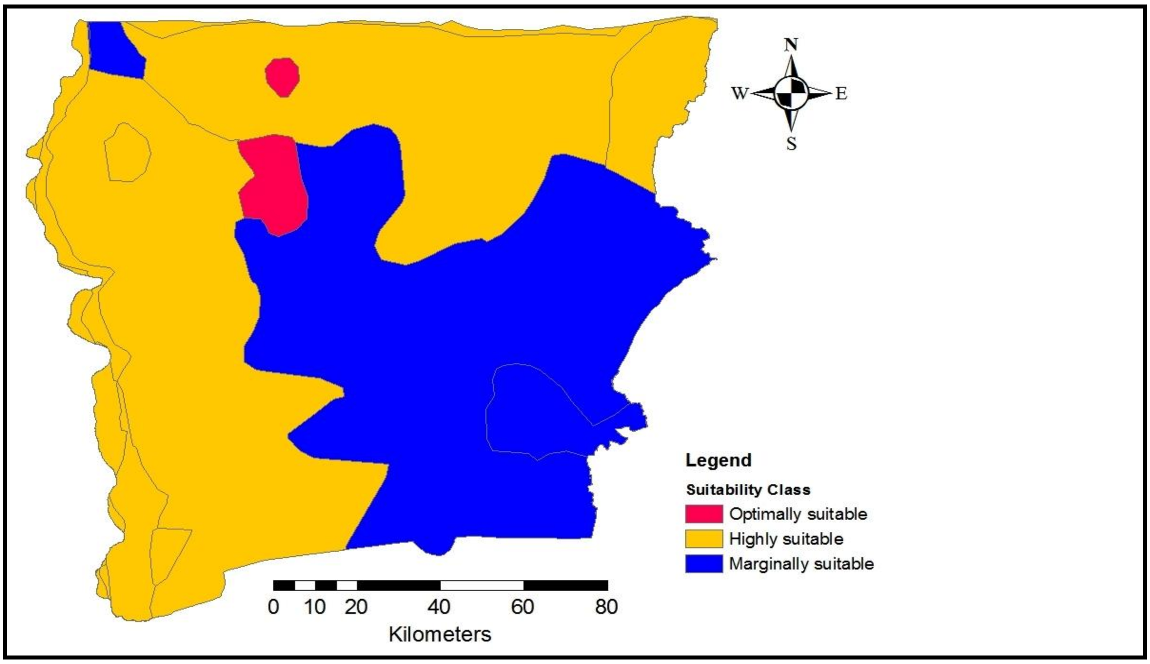


Figure 5.5: Soil Suitability Map for Small Reservoir

5.9.2 Soil Suitability Mapping for Stone Bunds

Suitability of soils for stone bunds in the order of optimal suitability to marginal suitability was luvisols, nitosols, vertisols, lithosols and acrisols (Fig. 5.7). From Fig. 5.6, the optimally suitable soil, luvisols covers a percentage area of 58.58%. The construction of stone bunds is to create small retention basin for runoff and sediment (Bosshart, 1997) and hence luvisols which has in greater proportion a mixture of sand and clay is a suitable soil type for this intervention. According to a study carried out by Nyssen *et al*. (2001), it was detected that stone bunds enhance the soil moisture especially in sandy and loamy soils and at a depth of 1.5m, soil moisture persist for at least two months after the end of the rainy season. Thus it is conclusive that stone bunds as an AWM intervention enhances soil moisture which consequently increases the availability of water for dry season farming.

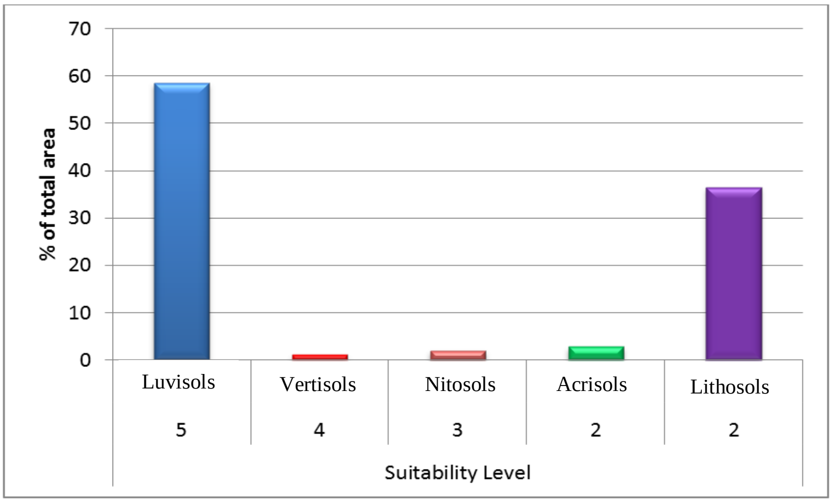


Figure 5.6: Percentage Soil Suitability for Stone Bunds

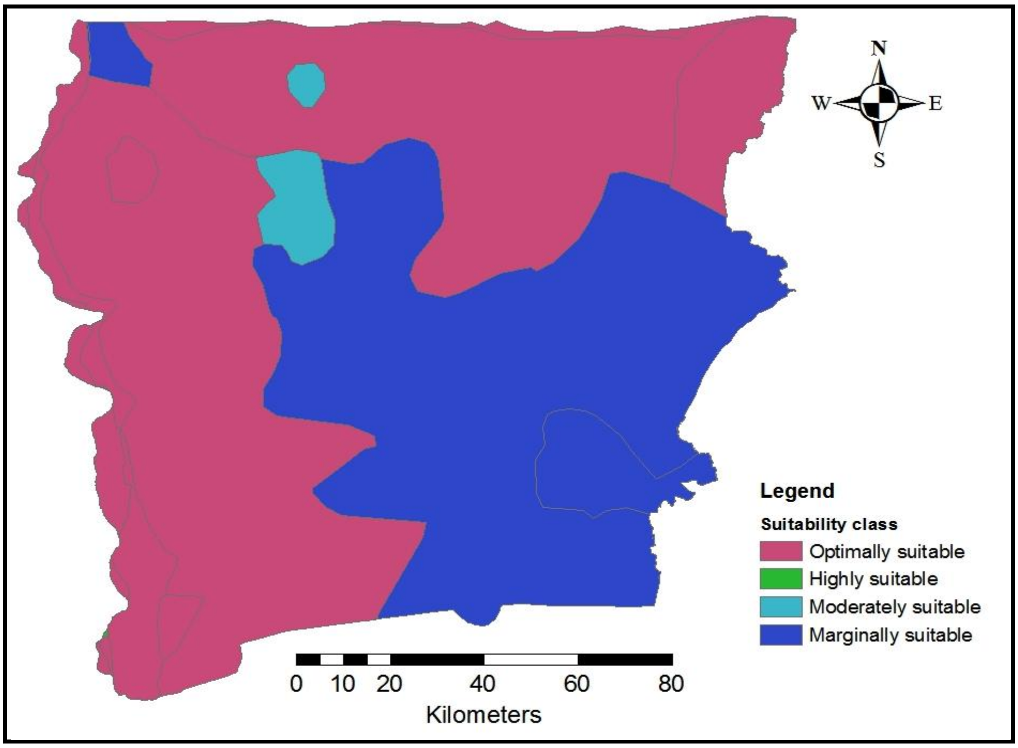


Figure 5.7: Soil Suitability Map for Stone Bunds

5.9.3 Landcover Suitability Mapping

Identified landcover types were deciduous woodland (28.99%), deciduous shrubland with sparse trees (59.29%) and cropland with open woody vegetation (11.72%). From the suitability analysis, the optimally suitable area for small reservoir was determined to be the cropland. Deciduous shrubland were determined to be highly suitable with deciduous woodland being marginally suitable. The areas corresponding to each landcover type, together with their suitability levels are as shown in Table 5.5.

Table 5.5: Percentage Area and Suitability Levels for Landcover Types

Landcover Types	Area (km^2)	Area (%)	Suitability Levels	
			Small Reservoir	Stone Bunds
Deciduous woodland	5496.41	28.99	Marginally suitable	Not Suitable
Deciduous shrubland	11242.62	59.29	Highly suitable	Moderately suitable
Cropland	2221.65	11.72	Optimally suitable	Optimally suitable

Since the interventions (small reservoir and stone bunds) are geared towards improving cropping seasons and consequently crop yield, it thus becomes imperative to give higher considerations to cropland. From Table 5.5, cropland which is the optimal landcover type has a total area of 2221.65km^2. This forms only 11.72% of the total landcover types.

5.9.4 Potential Areas for Small Reservoirs and Stone Bunds

The potential areas were determined through the model builder in ArcGis 9.3. By using slope, landcover, soil type and runoff as input variables, weighted overlay analysis was done to determine the potential areas for small reservoirs (Fig. 5.9) and stone bunds (Fig. 5.10). From the analysis, the potential areas for small reservoirs had suitability levels of optimal, high and moderate whiles that for stone bunds were optimal, high, moderate and marginal. The percentage areas corresponding to optimal, high and moderate suitability levels for small reservoirs are 1.25%, 57.25% and 41.50% respectively (Table 5.6). On the other hand, the percentage areas with respect to the suitability levels of optimal, high, moderate and marginal for stone bunds are 3.14%, 85.40%, 11.04% and 0.42% respectively (Table 5.6). In both cases, the higher suitability level was predominant. Shown in Fig. 5.8 is a comparison of the suitability areas for small reservoirs and stone bunds.

Table 5.6: Percentage Suitable Areas for Small Reservoirs and Stone Bunds

Suitable Area	Small Reservoirs		Stone Bunds	
	Counts	Area (%)	Counts	Area (%)
Optimal	194	1.25	489	3.14
High	8920	57.25	13306	85.40
Moderate	6467	41.50	1720	11.04
Marginal	0	0	66	0.42

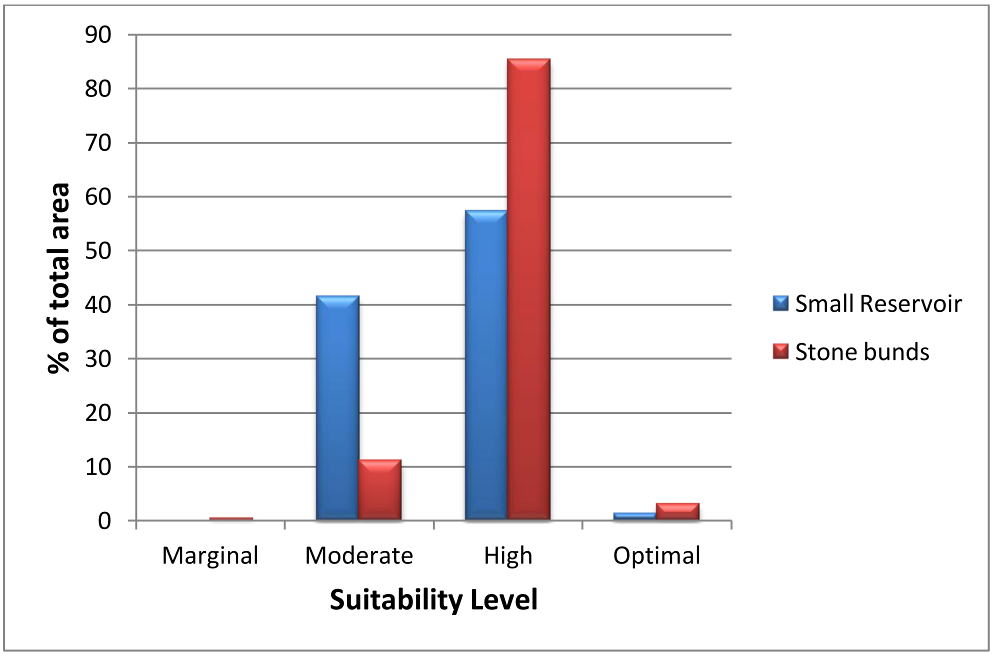


Figure 5.8: Percentage Area per each Suitability Level for Small Reservoirs and Stone Bunds

The optimal and high suitable sites for small reservoirs are located in areas with undulating slopes (0–8%). This is in agreement with the findings by Mbilinyi, *et al*. (2005), which assert that small reservoirs are constructed in areas where the slopes are such that water can easily enter and exit by gravity. The soil types located in areas with optimal and high suitability levels are luvisols which have relatively greater proportions of sand and clay. According to Ball (2001), soils with smaller particles like clay have a high water holding capacity and thus are deemed appropriate soil types for the construction of small reservoirs. The results also indicate that almost all the croplands located in the study area were located in areas described as highly suitable for small reservoirs. It could thus be deduced that farmers cultivate close to areas where there exist small reservoirs in order to have access to water for their farming activities.

Considering stone bunds, optimal and high suitability areas were located where slopes were undulating (2-8%) and rolling (8-16%). These findings fall within the range 5-30% stipulated by Mbilinyi *et al*. (2007), to be suitable slopes for stone bunds. Also according to Hudson (1981), stone bunds as an intervention are practiced on sloping areas where the soil type is unstable. In line with Hudson's (1981) assertion is the fact that soil types identified in the optimal and high suitable areas for stone bunds are mainly lithosols, acrisols and luvisols. These soil types contain in higher proportion sandy loam which makes them suitable for the intervention. The landcover type that was found in the optimal suitable areas was cropland with deciduous shrubland and deciduous woodland which occupy the high suitable areas.

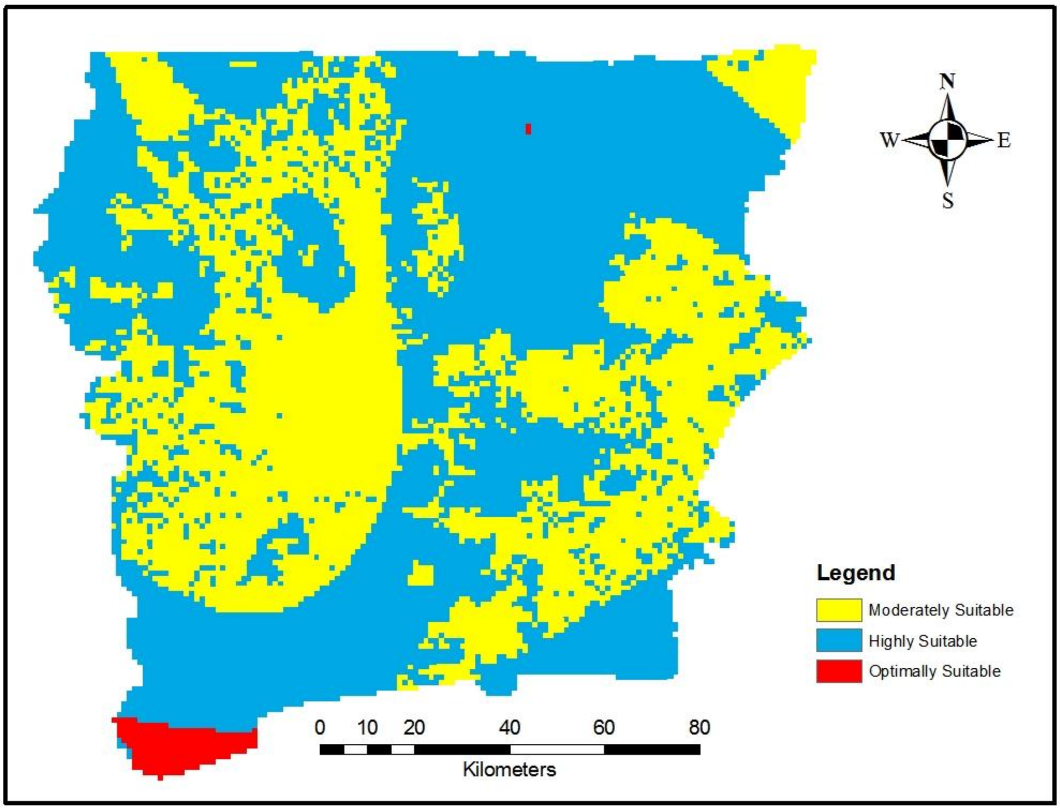


Figure 5.9: Map of Potential Areas for Small Reservoirs

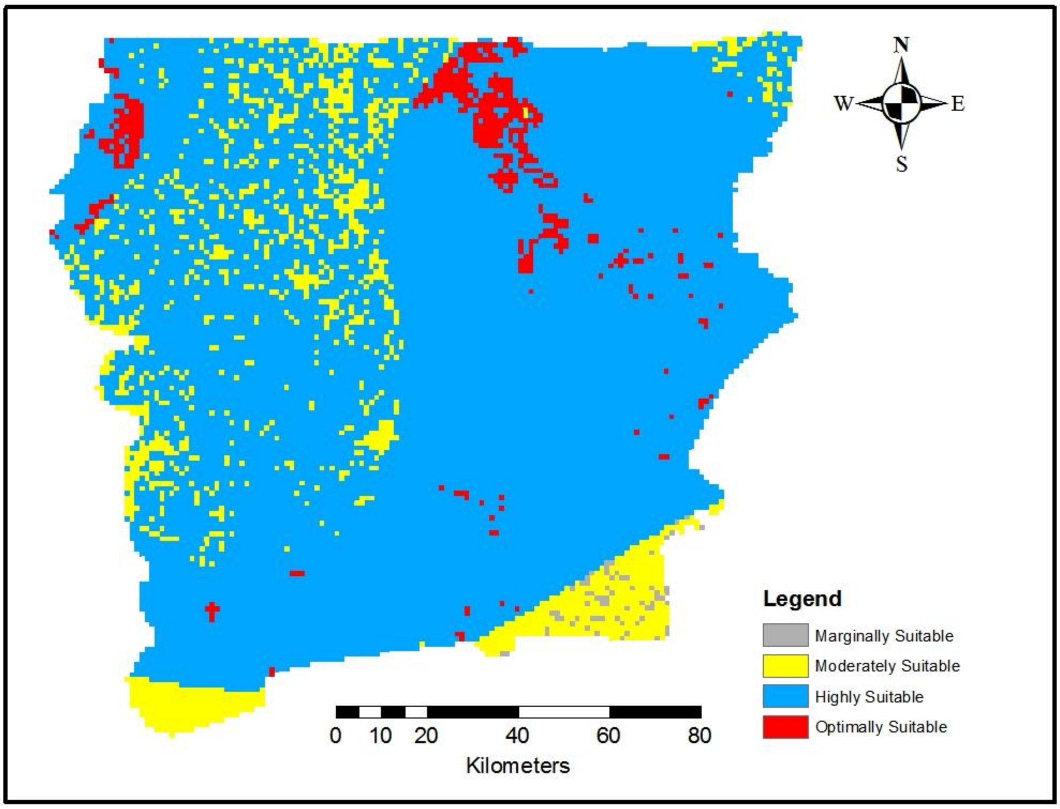


Figure 5.10: Map of Potential Areas for Stone Bunds

5.9.5 Validation of Potential Areas for Small Reservoirs

The validation of the potential areas for small reservoirs was carried out by assessing the number of small reservoirs per each suitability area indentified during the weighted overlay analysis. By superimposing the location of small reservoirs on the potential map generated for small reservoirs (Fig. 5.11), it was found out that twenty-three (23) out of the 66 reservoirs in the region were located at moderately suitable areas. This represents 34.85% of the total number of reservoirs in the region. Forty-three reservoirs were found in the highly suitable areas were representing 65.15% (Table 5.7). It is interesting to note that no reservoir was located in areas identified to be the optimal areas for small reservoirs. This could be attributed to the fact that reservoirs are sometimes sited based on other factors and/or reasons e.g. political or community demand and not necessarily on bio-physical factors.

Table 5.7: Number of Small Reservoirs per each Suitability Area

Area Suitability	No. of Small Reservoirs	% of Small Reservoirs
Moderate	23	34.85
High	43	65.15
Optimal	0	0

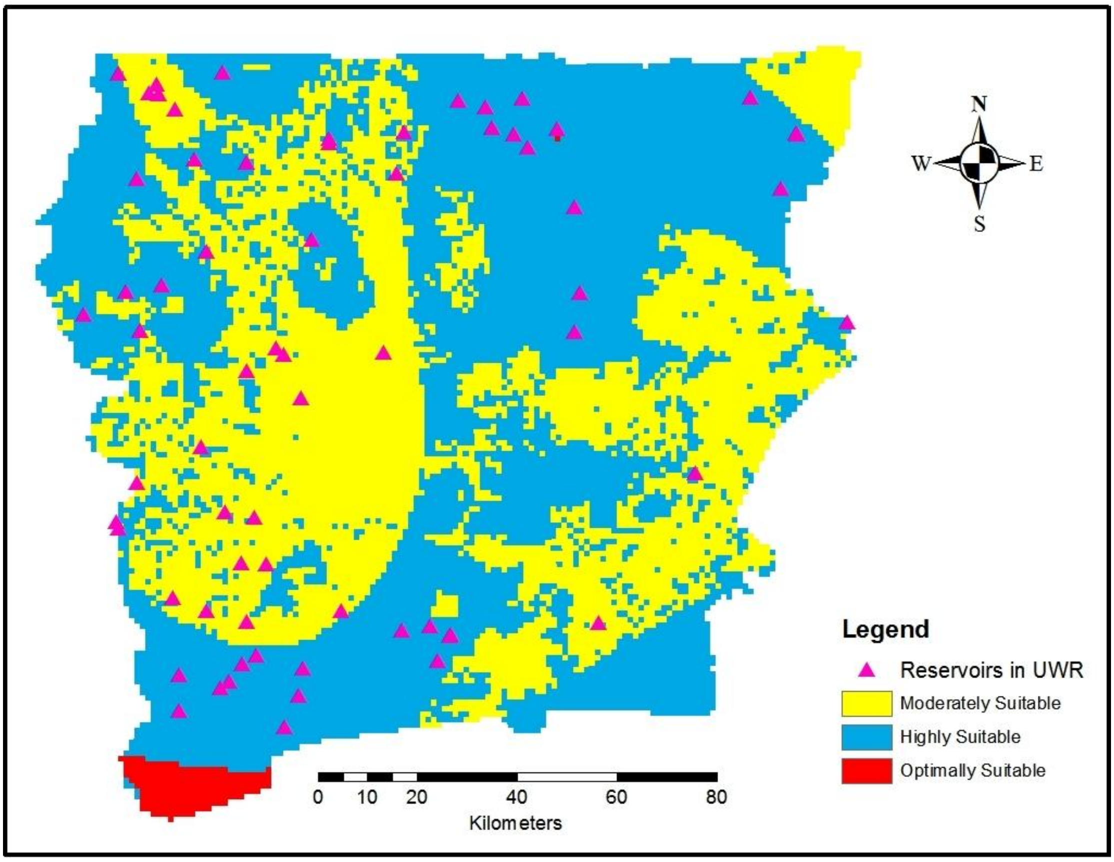


Figure 5.11: Validated Map for Small Reservoirs

6 CONCLUSIONS AND RECOMMENDATIONS

This chapter of the thesis presents the conclusions drawn from the study based on the results and the proposed recommendations.

6.1 Conclusions

AWM interventions practiced among communities are labeled as being successful because of the all inclusive approach used during the implementation of these interventions. As a result, interventions that were suitable for different settings and conditions were available in the communities. Positive impacts were recorded in the lives of beneficiaries and notable among them is the fact that sustainable and diversified production of crops and livestock are being promoted by the usage of these interventions. This has resulted in helping to address the issue of food security especially at the household level. Again, vulnerable and marginalized groups in the communities especially women and children have been empowered (inclusion of women in decision making at household and community levels and children attend school) with the inception and use of these AWM interventions. Among the interventions, farmers labeled small reservoirs as the most successful intervention. This is due to the fact that the small reservoirs helped to manage droughts and floods periods to make water available for agriculture throughout the year especially for dry season gardening.

Unfortunately, these reservoirs are sometimes poorly managed, for instance in Busa community, farmers refuse to use water in the reservoir for irrigation and have left the canals to be choked with weeds. They rely rather on shallow wells resulting in farmers wasting extra time and effort in the digging and drawing of water from the wells for irrigation. The successes of the interventions were not only attributed to the use of the interventions alone but also linked to other factors including application of fertilizer, access to loans, transportation and markets and better agronomic practices.

For the up-scaling of the interventions, the most suitable areas (optimal and high) for small reservoirs are areas with undulating slope (0-8%) whilst that for stone bunds is on undulating to rolling slopes (8-16%). The soil types determined to be optimally and highly suitable for small reservoirs are luvisols and acrisols whilst lithosols were the dominant soil types considered to be suitable for stone bunds. Considering area suitability for small reservoirs and stone bunds, areas classified as highly suitable was dominant compared to optimal, moderate and marginal areas. High suitable areas recorded for small reservoirs and stone bunds are 57.25% and 85.45% respectively. Optimal suitable areas for small reservoirs are 1.25% and that of stone bunds is 3.14%.

6.2 Recommendations

1. For the implementation of further AWM interventions to be successful, participatory approaches including meetings and discussions with beneficiaries should be employed as this has been shown to be effective. Again decision makers and stakeholders should strongly promote the implementation of AWM interventions in other communities and create sustainable platforms to enhance farmers' accessibility to agricultural inputs (both on and off farm) as this has been shown to be one of the surest ways of fighting poverty, food insecurity and seasonal migration.

2. Validation of the potential maps for stone bunds and small reservoirs needs to be carried out to ensure that the maps have higher degrees of accuracies. This will thus serve as a first point of call and inform decision makers on locations where these AWM interventions are very likely to be successful.

3. GIS and remote sensing techniques could be employed in identifying potential areas for other AWM interventions in other studies as the certainty and precision of these techniques are high.

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APPENDIX

Questionnaire for Stakeholders in the UWR - Ghana

This questionnaire seeks to gather data which will contribute to a better understanding of what has made successful Agricultural Water Management (AWM) interventions a success in the Black Volta basin. It aims to answer what social, economic, bio-physical and organisational factors are critical for different interventions and lead to successful adoption, proliferation and appropriate local adaption among smallholder farmers.

Name(s) of respondent: ……………………………………………………………

Organization: ……………………………………………………………………

Position in Organization: …………………………………………………………

Phone number: …………………………………… Interview Date: ………………

1 Characteristic Of Project

Tick the Agricultural Water Management Intervention(s) available in your district/communities

1.1 Fill in the Project that brought the AWM Interventions, the location and the start & end years for the project.

Project	AWM Intervention	Yes	Location	Start/End Year
	Shallow Wells			
	Permanent Wells			
	Mechanized Wells			
	Water Pumps			
	Treadle Pumps			
	Earth Bunds			
	Stone Bunds			
	Grass Bunds			
	Tied Ridges			
	Small Reservoirs			

1.2. Fill in the number of households that started the interventions, the number that are still using the interventions and organizations that the project worked with.

Agricultural Water Management Intervention	No. of HH Intervention started with	No. of HH still using Intervention	Organizations
Shallow Wells			
Permanent Wells			
Mechanized Wells			
Water Pumps			
Treadle Pumps			
Earth Bunds			
Stone Bunds			
Grass Bunds			
Tied Ridges			
Small Reservoirs			

2 Design and Implications of the Intervention

Name of AWM Intervention: ………………………………………………

Location: ………………………………………………………………

2.1 Were communities involved in the introduction and selection of interventions?

Yes [ ] No [ ]

2.2 If yes, give reasons ……………………………………………………………

2.3 If no, give reasons ……………………………………………………………

2.4 Were communities involved in the designing of interventions?

a. Yes [ ] b. No [ ]

2.5 If yes, at what stage and how was it done?

Stage: ………………………………………………………………………………

How: ………………………………………………………………………………

2.6 Was there existing knowledge of the project intervention already present in the participating communities? …………………………………

2.7 Were there considerations for specific implications of the interventions for men and women?

a. Yes [ ] b. No [ ]

2.7. 1 If yes state implications on men: ………………………………

2.7.2 State implications on women: ……………………………………

2.8 For the intervention to be out scaled – was all the required equipment available to the local communities?

a. Yes [ ] b. No [ ]

2.8.1 Could they out scale the intervention if they wanted to?

a. Yes [ ] b. No [ ]

2.8.2 If no, were there barriers? ………………………………

3 Adoption and Adaptation

3.1 How did the project get communities or people involved in the use of the intervention?

a. Incentives [ ]

b. Meetings [ ]

c. Loans [ ]

d. Training [ ]

e. Other specify...

3.1.1 What worked and what didn't? ……………………

3.2 How easy was it for communities or people to adopt the intervention?

a. Very easy [ ]

b. Quite easy [ ]

c. Not easy [ ]

d. Not very easy [ ]

e. Not easy at all [ ]

3.3 Did they have to modify/change their farming/cropping system?

a. Yes [ ] b. No [ ]

3.3.1 If no, could it work in their existing approach?

a. Yes [ ] b. No [ ]

3.3.2 If yes, what modifications/changes were made? ……………………………

3.3 Did the community or people involved in the intervention modify or adapt the intervention to local conditions/preferences?

a. Yes [ ] b. No [ ]

3.3.1 If yes, how was it done? ………………………………

How did you ensure ownership of the intervention by the community or people?

....

3.4 What were the main challenges for adoption? ....

3.5 How did the project overcome these challenges? ……………………………………

4 Technological Requirements

4.1 Soil types

4.1.1 On what soils did the intervention work? ➲<u>If possible mark the appropriate and inappropriate soils on the first acetate.</u>

a. Loamy [ ]

b. Sandy [ ]

c. Clayey [ ]

d. Other, specify ……………………………………………………………………

4.1.2 Where did it not work?➲<u>If possible mark the appropriate and inappropriate soils on the first acetate.</u> ……………………………

4.2 Soil erosion

4.2.1Is the intervention affected soil erosion?

a. Yes [ ] b. No [ ]

4.2.2 If so where?➲<u>If possible mark the soil erosion issues on the first acetate.</u>

....

4.3 Slope

4.3.1 On what slopes did the intervention work?

a. flat- (0-2 %) [ ]

b. gentle (2-5%) [ ]

c. moderate (5-8%) [ ]

d. rolling (8-16%) [ ]

e. hilly (16-30%) [ ]

f. steep (30-60%) [ ]

g. very steep (>60%) [ ]

4.3.2 Where did it not work? ➲<u>If possible mark the suitable areas first acetate.</u>

…………………………………………………………………………………………

4.4 Water Table

4.4.1Where does the intervention work in terms of the depth of the water table?

…………………………………………………………………………………………

4.5 Surface Water

4.5.1 How far away from the watercourse do you think the intervention could work?

…………………………………………………………………………………………

4.6 Water Quality

4.6.1 Is water quality a problem?

a. Yes [ ] b. No [ ]

4.6.2 If so, which water quality problems exist in the communities?

a. Sediment load [ ]
b. Salt [ ]

c. Heavy metal [ ]

d. Faecal matter [ ]

e. None [ ]

f. Other, specify ………………………………………………………………………

4.7 Resilience of the Intervention

4.7.1Has the intervention been damaged by livestock/wild life?

a. Yes [ ] b. No [ ]

!! Make sure the legend is clear on the acetate !!
4.7.2 If yes, where and how is the problem resolved? ……………………………

Switch to the SECOND acetate. Add ground control points (for example: the corners of the map, a crossing of a river and a road, or you can draw a few features of the topographic map unto the acetate)

5 Land Use Classification

5.1 Where are the following land use ➲Mark the different land uses on the second acetate

a. Crop fields

b. Crops types

c. Vegetable gardens

d. Grazing land

e. Other specify …………………………………………………………………

5.2 What are the institutional arrangements for managing each land use?

……………………………………………………………………………………………

5.3 Where are the other resources the communities access for their livelihoods:

5.3.1Forest resources including:

- Fuel wood,
- Building materials
- Wild foods
- Medicinal plants

➲Mark the different resources on the second acetate

5.4 What are the institutional arrangements for managing these other resources?

……………………………………………………………………………………………

5.5 Has the use and demand of these resources changed since the intervention?

a. Yes [ ]　　　　b. No [ ]

5.6 Livelihood Mix

5.6.1What is the mixture of livelihood strategies in the communities in the project area?

a. Farmers utilising the irrigation intervention [ ]
b. Traditional rain-fed farmers [ ]
c. Livestock keepers [ ]
d. Small businessmen [ ]
e. Other specify...

5.6.2 What proportion of the community practice these different strategies?

Community livelihood	Number /Percentage
1. Farmers utilising the irrigation intervention	
2. Traditional rain-fed farmers	
3. livestock keepers	
4. Small businessmen	
5. Hunting	
6. Fishing	
Other	

!! Make sure the legend is clear on the acetate !!

6 Water Use and Water Management

6.1What are the institutional arrangements for water use? …………………………

6.2 Where do farmers access water from during the cropping season?

a. Rain [ ]

b. Surface [ ]

c. Ground water [ ]

d. Other specify...

➲If possible mark these locations on the second acetate.

6.3 How accessible are the water sources?

a. Easily accessible [ ]

b. Quite accessible [ ]

c. Not accessible [ ]

d. Other specify……………………………………………………………………………..

6.3.1 Are there any barriers to use?

a. Yes [ ] b. No [ ]

6.3.1a.If yes, comments...

6.4 How reliable are these water sources?

Water source	Very reliable	Quite reliable	Not reliable	Other, specify
Rain				
Reservoir				
River/stream				
Temporal Shallow well				
Permanent Shallow well				
Permanent deep well				
Mechanized well				
Other				

6.5 How is the water used?

a. Crop irrigation [ ]
b. Watering livestock [ ]
c. Household/domestic use [ ]
d. Other specify...

6.6 How frequently is it used?

a. Daily [ ]

b. Two time a week [ ]

c. Three time a week [ ]

d. Four time a week [ ]

e. Other, specify…………………………………………………………………………

6.7 Is there enough water available for crops and livestock?

a. Yes [ ] b. No [ ]

6.8 If no, comments ……………………………………………….

6.9 Are there any water quality issues affecting their use?

a. Yes [ ] b. No [ ]

6.9a. If yes, give reason...

6.10How do people transport water to their fields/livestock (focus on additional delivery systems used in conjunction with the intervention)? ……………

6.11 How did the years of the project run in terms of water availability?

a. Good [ ]

b. Normal [ ]

c. Bad [ ]

6.12 Comment ……………………………………………………………………….

7 Details of the AWM Intervention

7.1How is the intervention powered?

a. Electricity [ ]
b. Diesel [ ]
c. Human [ ]
d. Animal [ ]
e. Solar [ ]
f. Other, specify...

7.2 How reliable is this power source?

a. Very reliable [ ]
b. Quite reliable [ ]
c. Unreliable [ ]
d. Other, specify...

7.3 Are there any problems with accessing power reliably?

a. Yes [ ] b. No [ ]

7.3.1 If yes, what problems are encountered? ……………………………………

7.4 What labour inputs are required to utilise the intervention successfully?

…………………………………………………………………………………………

7.5Who provides this labour in the project communities (gender balance, labourers etc)?

7.6 Has the required amount of farm labour changed since the intervention was introduced?

a. Yes [ ] b. No [ ]

7.6.1 Comment on any chosen answe

………………………………………………………………………………

7.7 Has the change been positive or negative (eg. farmers can now achieve an additional harvest, but this requires that they work in the fields throughout the year)

……………………………………………………………………………………………

7.8 Did the project team provide training to the community?

a. Yes [ ] b. No [ ]

7.9 If yes what kind(s) of training?

a. Intervention [ ]

b. Maintenance [ ]

c. Farm management [ ]

d. Other, specify……………………………..

7.10 In general, what level of support did the project team and partner organisations provide to the communities to help ensure the successful implementation of the intervention? ………………………………………………………………

7.11What support in terms of funds, grants, subsidies, access to loans etc did the project provide to help fund the investment in the intervention for farmers?

……………………………………………………………………………………………

7.12 What is the financial cost for farmers to adopt intervention (investment, maintenance)? ……………………………………………………………

7.13 Were farmers willing and able (financially) to make investments in AWM interventions improvements?

a. Very willing [ ]

b. Quite willing [ ]

c. Not willing [ ]

d. Other, specify…………………………………………………………………

Comment(s)……………………………………………………………………………

8 Impacts – Crop Production

Only answer these questions if the AWM intervention is focussed on crop production.

8.1 Overall has the intervention resulted in any improvement in cropping?

a. Yes [ ] b. No [ ]

8.2 If yes, is this due to change in number of **harvests** and/or changes in average **yields** for each crop? ➲Mark the locations of these improvements in relation to the landuse/crop fields mapped on the acetate for Land Use Classification.

	Number of Harvests		**Average Yield**	
Crop	***Before***	***After***	***Before***	***After***

8.3Did the introduction of the intervention result in changes in water management?

a. Yes [ ] b. No [ ]

8.4. If yes/no, give reason(s) ……………………………………………………..

8.5 What crop growing stage is now most critical to water availability?

a. Nursing [ ]

b. Transplanting [ ]

c. Maturing [ ]

d. Other, specify ………………………………………………………………….

8.6 Was this different before the AWM intervention(s) was introduced?

a. Yes [ ] b. No [ ]

8.7 If yes, comment ………………………………………………………………

8.8Were these improvements also linked to changes in other farm inputs

Farm input	**Yes**	**No**
Fertilisers		
Pesticides		
Machinery		
Other		

8.9 In what year, after farmers got the intervention, did improvements happen?

……………………………………………………………………………………..

8.10 Overall has the project increased sustainability of crop production?

…………………………………………………………………………………………

9 Impacts – Livestock Production

Only answer these questions if the AWM intervention is focussed on livestock production.

9.1 Did the AWM intervention result in a change in the quality of grazing land?
➲<u>Mark these locations these improvements in relation to the landuse/grazing areas mapped on the acetate for Land Use Classification</u>

a. Yes [ ]   b. No [ ]

9.2 Comment on answer ……………………………………………………………

9.3 How has the intervention improved livestock management and/or yields (meat, milk, quality of livestock) and if so by how much?

…………………………………………………………………………………………

9.4 Did the introduction of the intervention result in changes in water management?

a. Yes [ ]   b. No [ ]

9.4 If yes/no, give reason ……………………………………………………….

…………………………………………………………………………………………

9.5 In what year, after farmers got the intervention, did any improvements in livestock production occur?

....

9.6 Overall has the project increased sustainability of livestock keeping?

…………………………………………………………………………………………

10 Infrastructure – Crop Production

Only answer these questions if the AWM intervention is focussed on crop production.

10.1Where are the markets farmers sell their produce at?➲Where possible mark the locations on the acetate - else just record the place names

………………………………………………………………………………………………

How do the farmers transport their produce to market?

a. Bicycle [ ]

b. Motorbike [ ]

c. Lorry/bus [ ]

d. Donkey/ cart [ ]

e. Walking [ ]

f. Other, specify ....

10.3 On average how much of their crop is sold (this can be the % of the crop sold)? Has this percentage changed since the intervention?

	Amount Sold (GH)		**Amount Sold (%)**	
Crop	***Before***	***After***	***Before***	***After***

10.2 Which other changes in infrastructure in the project communities could have helped achieve the successful implementation of the AWM intervention?

a. New/improved roads [ ]

b. Schools [ ]

c. Change in government policies [ ]

d. Subsidies [ ]

e. Health Centres [ ]

f. Other, specify

…………………………………………………………………………..

➲Where possible mark the locations of these changes on the second acetate

11 Infrastructure – Livestock Production

Only answer these questions if the AWM intervention is focussed on livestock production.

11.1 Where are the markets farmers sell their livestock at?➲Where possible mark the locations on the acetate - or else just record the place names

……………………………………………………………………………………….

11.2 On average what (financial) income do farmers get from their livestock? Has this changed since the project intervention?

	Income	
Livestock	***Before***	***After***

11.3Are there any other non-financial benefits of owning livestock? Have these changed since the project intervention?

	Non-Financial Benefits	
Livestock	***Before***	***After***

11.4 Were there any other changes in infrastructure in the project communities that could have helped achieve the successful implementation of the AWM intervention?

a. New/improved roads [ ]

b. Schools [ ]

c. Change in government policies [ ]

d. Subsidies [ ]

b. Health Centres [ ]

c. Other, specify ………………………………………………………………

➲Where possible mark the locations of these changes on the second acetate

12 Conflict Management

12.1 Have there been changes in the nature or severity of conflicts between different livelihood strategies or communities resulting from the introduction of the intervention?

a. Yes [ ] b. No [ ]

12.2 If yes/no, give reason(s)

…………………………………………………………………

12.3 Have there been changes in conflicts related to water between different livelihood strategies or communities resulting from the introduction of the intervention?

a. Yes [ ] b. No [ ]

12.4If yes, comment

….……………………………………………………………………………...

12.5Did the project manage/address these conflicts?

a. Yes [ ] b. No [ ]

12.6 If so how? …………………………………………………………………………

13 Wider Impacts of the AWM Intervention

A. Environmental Impacts

13.1Have there been wider environmental impacts resulting from the introduction of the AWM intervention?

		Environmental Impacts		
		Positive	***Negative***	***Mixture***
1.Water availability	Upstream			
	Downstream			
	Between different livelihoods			
2.Water quality	Upstream			
	Downstream			
	Between different livelihoods			
3.Salinity	Upstream			
	Downstream			
	Between different livelihoods			
4.Biodiversity				
5. Pests				
6. Other				

13.2In case of negative ones – how have these been managed (by the community and/or project)?

Negative ones	**Community**	**Project**

B. Human Impacts

13.3 Were there any health related issues resulting from the introduction of the AWM intervention? (These could be positive – or negative – or a mixture).

....

13.4Did the introduction of the AWM intervention result in any new community or farmers groups being established?

a. Yes [ ] b. No [ ]

13.5 If yes, what new communities or groups of farmers?

……………………………………………………………………………………

13.6Did the introduction of the AWM intervention result in farmers collaborating or working together more than before?

a. Yes [ ] b. No [ ]

13.7 If yes how was it done?…………………………………………………

14 Key Lessons Learnt

14.1Were there any **critical factors** that made the project a success?

…………………………………………………………………………………………………

14.2 What do they feel are the key factors for **wider uptake?**

…………………………………………………………………………………………………

14.3What **main lessons** were learned by doing this project?

………………………………………………………………………………………………….

14.4 Any more critical points to share?

………………………………………………………………………………………………….